

Letter to the Editor

Second generation energy crops and farmland birds – Central and East European perspective

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Abstract: The development of cellulosic bioethanol and other second-generation (2G) biofuels has gone through various phases during the last few years. The prospect of technological breakthroughs stimulates extensive research on turning cellulose into bioethanol or biodiesel. Agricultural or forestry residues and some plants, referred to as 'lignocellulosic energy crops' or 'second generation (2G) energy crops' can provide feedstock for new types of biofuels. The impact of lignocellulosic energy crops on farmland birds has been relatively well studied. This is surprising since the technology of converting these crops into fuel has so recently been developed. However, we believe that some questions regarding potential bird use of 2G energy crops have still not been answered. In Europe, most research has been carried out in agricultural areas of Western Europe. However, Central & Eastern Europe host the highest densities of farmland birds and, in general, the highest biodiversity. There is huge potential for 2G energy cropping due to large areas of mainly marginal land. We have outlined possible discrepancies between the results obtained from W. Europe and potential relationships between birds and 2G energy crops in Central Europe.

Key words: birds, economy, energy crops, farmland heritage

What are energy crops?

Expansion of energy crops (i.e. crops cultivated for providing feedstock for energy production – from direct combustion to liquid fuel production) recently has profoundly transformed rural landscapes throughout the world. Bioenergy cultivation drives massive direct and indirect land use changes, and involves a switch in crops, agricultural expansion to marginal lands, and vast destruction of natural habitats such as rainforest or savanna (Miyake *et al.* 2012). While the impact in regions with highly-developed agriculture merely includes a transformation of the existing cultural landscape, such transformation has a drastic, although indirect impact in biodiversity-rich countries with natural ecosystems (Miyake *et al.* 2012). Disregarding global impacts, local impacts on biodiversity and functioning ecosystem services, including plant protection problems in existing farmland, are also considered crucial for environmental management in developed countries (Fargione *et al.* 2009; Pedrolí *et al.* 2013). Transformation of farmland which can be hazardous to its biodiversity includes landscape simplification, the abandonment of traditional cultivation schemes, increased pesticide and herbicide usage, and the usage of previously uncultivated land or land which had been abandoned. All this is collectively referred to as agricultural intensification (Stoate *et al.* 2001). Most changes

driven by bioenergy expansion correlate with this phenomenon. Agricultural intensification studies show that birds are useful indicators of farmland habitat quality. The presence of just a few species can be very useful for identification of so-called High Nature Value Farmland (Morelli *et al.* 2014), where farming supports high species and habitat diversity (EEA 2004).

What are lignocellulosic energy crops/second generation energy crops?

Currently, a great deal of research is being done on producing ethanol from cellulose. Potential feedstocks for cellulosic bioethanol can be agricultural or forestry residues, as well as some dedicated energy crops (lignocellulosic energy crops/second generation energy crops, herein referred to as 2G energy crops). Such crops grown in Europe include short-rotation willow *Salix* sp. and poplar *Populus* sp. coppice, miscanthus (*Miscanthus x giganteus*) reed canary-grass (*Phalaris arundinacea* L.) and a few other plants, usually fast-growing perennial grasses. Most 2G energy crops are currently grown to provide combustible biomass only, but conceivably they can provide substantial parts of cellulosic bioethanol feedstock. Compared to more traditional crops, their cultivation areas remain limited, and they are rarely mentioned in national agricultural statistics. For instance, in the United Kingdom the

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area covered by short-rotation coppice and miscanthus comprised approximately 0.06% of the total arable land (DEFRA 2013). However, on a local scale the abundance of such crops may significantly affect the farmland bird habitat (Dauber *et al.* 2010 and references therein).

The future of lignocellulosic energy crops. Energy cropping on marginal lands

The 2G energy crops, such as short-rotation willow coppice, miscanthus, and red canary-grass are still grown only locally. Recent amendments to the Renewable Energy Directive made by the European Parliament (EP) promotes the use of second-generation biofuels (including ethanol from lignocellulosic crops) (EP 2013). However, the European Union (EU) goals to provide certain values of second-generation biofuels in the energy mix still have not been met, since the technology is developing more slowly than expected. In the USA, the situation is analogous. The recent drop in oil prices could mean the end of lignocellulosic biofuels, since their production costs have become very high compared to traditional fuels (Reboredo *et al.* 2016). On the other hand, a technological breakthrough in the near future remains possible, because new ways of extracting fermentable sugars from the woody biomass are being developed (Marriott *et al.* 2016). Genetically modified lignocellulosic plants are also being engineered (Badhan and McAllister 2014).

Although the future of second generation biofuels is still unknown, they can still fundamentally reshape agriculture throughout the world. One of the great advantages of 2G energy crops is that they require low input and can be grown on lands unsuitable or unprofitable for traditional agriculture. 'Marginal lands' are usually defined as land unsuitable for agricultural production, but the term has various meanings and assumptions in different contexts (Shortall 2013). In fact, each paper modelling potential bioenergy supplies from marginal lands has its own definition of the term (Lewis and Kelly 2014). Despite such discrepancies, there is a growing body of research on possible areas of bioenergy crops on so-called marginal lands (reviewed in: Lewis and Kelly 2014), both on a national (e.g. Qin *et al.* 2015) and local scale (e.g. Saha and Eckelman 2015).

However, few studies include potential biodiversity risks, even though they are well described (Dauber *et al.* 2012). Research on the potential effects of energy cropping on farmland birds often deals only with first generation (1G) energy crops (e.g. maize and oilseed rape), which have a well-known negative impact on bird communities. The aim of this paper is to draw attention to the importance of research on 2G energy crops expansion in Central and Eastern Europe. Central and Eastern Europe is a stronghold for many European farmland birds, and can tentatively hold extensive 2G energy crops plantations. However, we would like to highlight the differences in the ecology of farmland birds in different parts of the European continent that may affect the impact of 2G energy crops on avifauna. The paper contains two parts: a review of existing empirical and modelling papers on impacts of 2G energy crops on European farming birds,

and our commentary discussing possible differences between Western and Central-Eastern Europe.

Farmland birds and 2G energy crops in Europe – empirical data

Miscanthus

Miscanthus (*M. x giganteus* and other lineages from the genus) is a tall (up to 3 m high), perennial grass, established in Europe in the 1930's as a decorative plant. Experiments on its field-scale cultivation have been conducted since the 1980's (Lewandowski *et al.* 2000). Miscanthus is not included in major agricultural statistics of the EU. In the UK, one of the former EU members leading in miscanthus cultivation, the crop is grown on approximately 0.1% of the total arable area (DEFRA 2013). Miscanthus is relatively popular also in Austria, Germany and Switzerland. The total area in Europe is estimated to be about 30,000 ha (OPTIMISC 2012), which is less than 0.1% of arable land in the EU (EC/Eurostat 2012). Due to the risk of invasion, most cultivated genotypes are sterile and are propagated vegetatively (Lewandowski *et al.* 2003). As a consequence, miscanthus *per se* does not add any new resources for farmland seed-eating birds (Anderson *et al.* 2004). Established miscanthus fields can provide annual biomass yields up to 25 t · ha⁻¹ for over 20 years, with limited fertilizer and herbicide input (Lewandowski *et al.* 2003). That, as well as its tall and dense spatial structure, has led to suggestions that miscanthus fields may act as refuges for some farmland animals (Lewandowski *et al.* 2000). Biomass harvest takes place in winter or early spring, so at least theoretically, birds nesting in the crop are not affected (Anderson *et al.* 2004). A future goal is to develop salt- and drought-tolerant genotypes, so future expansion of the crop on marginal lands can occur, especially in Southern Europe (OPTIMISC 2012).

To date, all field studies investigating bird use of miscanthus fields were conducted in the UK (Semere and Slater 2007; Bellamy *et al.* 2009; Sage *et al.* 2010; Bright *et al.* 2013).

According to Semere and Slater (2007) miscanthus fields were more attractive to birds than reed canary-grass fields, and hosted specialized open-habitat birds like skylarks (*Alauda arvensis*), lapwings (*Vanellus vanellus*) meadow pipits (*Anthus pratensis*) and gray partridges (*Perdix perdix*). However, the main reason was the existence of numerous bare patches and extensive weed cover caused by poor crop establishment during the first years of cultivation.

Bellamy *et al.* (2009) compared bird use of relatively young, 5-year or younger miscanthus fields and neighboring wheat fields, and found more species and higher densities in miscanthus both in winter and in breeding seasons. In winter, granivorous passerines were more numerous in miscanthus. This was also true for woodland birds in general. In terms of winter food supply, the numbers of invertebrates in miscanthus and wheat did not differ significantly, but they differed in weed cover (38.2% vs. 0.4%). Thus miscanthus provided more food for granivores. Skylark and reed bunting bred in higher densities in miscan-

thus than in wheat. Reed warbler (*Acrocephalus scirpaceus*) bred only in miscanthus. In general, during the winter miscanthus housed primarily woodland birds, and in summer it was used by common farmland birds. However, similar to Semere and Slater (2007), the authors point out that the relative attractiveness of miscanthus for birds, especially farmland specialists, is linked to early stages of crop establishment and is likely to disappear in the future.

In the work of Sage *et al.* (2010), conducted in well-established miscanthus fields, weeds were much less abundant (less than 20% cover), and bird numbers and densities were lower than in previous studies. In spite of this miscanthus exhibited more diversity than neighboring arable plots, similar to short-rotation coppice but in lower densities. All studies emphasize that in winter, miscanthus fields are attractive habitat for common woodland species [tits (*Parus* spp.), robins (*Erithacus rubecula*) etc.], but not for farmland specialists like skylarks. Furthermore, such species may establish territories on miscanthus fields after harvesting, but then abandon their nests due to the rapid growth of the crop (Anderson *et al.* 2004; Sage *et al.* 2010).

However, Bright *et al.* (2013) found similar densities of skylarks and lapwings in miscanthus and wheat fields or grassland throughout the season, and confirmed nesting of lapwings and yellow wagtails (*Motacilla flava*). These findings do not support the ecological trap hypothesis, although research has been conducted on miscanthus fields in their establishment phase. Further research on bird breeding performance and habitat suitability of mature stands is recommended.

Short-rotation willow coppice

Short-rotation coppice (SRC) is usually formed by lineages of willow *Salix* sp. or poplar *Populus* sp. and rarely, other fast-growing trees. The plants form shrubs up to 4 m tall that are re-cut every 2–5 years to obtain combustible woody biomass. *Salix viminalis* lineages are the most popular, and are widely grown in northern Europe, with substantial areas in Sweden (Mola-Yudego and Gonzalez-Olabarria 2010) and UK (DEFRA 2013). In some aspects, the structure of willow SRC plantations is similar to traditional coppice forests, which are regularly cut and then allowed to regrow. Such forests are confined to Western Europe and are considered to be biodiversity-rich (Pullin 2002).

Willow plantations located in agricultural landscapes may provide attractive habitats for gamebirds [e.g. pheasants (*Phasianus colchicus*)], which can be an additional incentive for farmers (Baxter *et al.* 1996). It is known that inclusion of SRC plantations into farmland increases bird diversity, adding woodland species into the species pool and hosting more species than arable fields in both winter and breeding seasons (Berg 2002; Sage *et al.* 2006). However, this elevated diversity can mask a decrease in the abundance of farmland specialists.

There is contradicting information regarding SRC values compared to tall forests. In Western Europe, SRC habitats were inferior to tall forests in terms of bird diversity (Liesebach and Mulsow 2003, in: Schulz *et al.* 2010). However, in northern Europe (Sweden), Berg (2002) found a lower bird diversity in SRC compared to forests,

while Lindblath *et al.* (2014) found the opposite to be true. Also, while stimulating habitat diversity in a farmland landscape, SRC plantations located in a primarily forested landscape may act contrarily, replacing valuable open habitats such as meadows (Berg 2002). Due to high spatial and temporal heterogeneity of SRC plantations, most farmland specialists are not completely removed from plantations and remain there at relatively high densities, especially during the years following the harvest (e.g. skylarks in Sage *et al.* 2006).

Similar to miscanthus, for skylarks and other open-field specialists, SRC plantations after harvesting may act as ecological traps, with rapid growth of the crop preventing the birds from successful nesting (Sage *et al.* 2006). When comparing bird diversity and density in the two energy crops providing shrub-like habitat, willow coppice is more attractive to birds than miscanthus (Sage *et al.* 2010). Birds in willow SRC benefit from the rich diversity of invertebrates associated with both with willow and weed cover (Sage *et al.* 2010). Since willow SRC usually exhibits extensive weed cover, especially in the establishment phase, it may support granivorous birds in landscapes with low seed resources (e.g. in pastoral farmland of Wales; Fry and Slater 2011).

Reed canary-grass

Reed canary-grass (*P. arundinacea*) is a tall perennial grass with circumboreal distribution (Lewandowski *et al.* 2003). Cold-resistant, it is popular as an energy crop in northern Europe, especially Scandinavia (Lewandowski *et al.* 2003). In contrast to miscanthus, reed canary grass establishes almost complete canopy cover within two years after planting, which restricts weed growth even when there is low herbicide application (Semere and Slater 2007).

Dense stands of tall reed canary-grass are inhospitable to open farmland specialists (skylark, lapwing, meadow pipit, yellow wagtail). This grass provides habitat and winter seed resources not only for granivorous [e.g. linnet (*Carduelis cannabina*)] but also woodland species [e.g. wren (*Troglodytes troglodytes*)] (Semere and Slater 2007). However, in UK-based research the diversity and density of birds in reed canary-grass was lower than in neighboring miscanthus fields (Semere and Slater 2007). In Finland, reed canary-grass comprises over 1% of total arable area and that number is expected to increase (Vepsäläinen 2010). While hosting comparable numbers of field-edge and bush specialists in traditionally cultivated fields, reed canary grass fields showed lower densities of skylarks (Vepsäläinen 2010). Skylark numbers observed in reed canary-grass fields decrease rapidly in June, when birds lay their second brood and the crop canopy closes – this suggests that reed canary grass indeed acts as an ecological trap for this species and potentially other open habitat specialists (Vepsäläinen 2010).

Farmland birds and 2G energy crops in Europe – modelling approaches

We are aware of only three papers modelling farmland bird populations in European farming landscapes that in-

clude 2G energy crops in their scenarios. Due to different methodologies, the models are difficult to compare directly. However, each of these papers consider the expansion of both 1G and 2G energy crops, with overwhelming domination of the former. This reflects the recent expansion of bioenergy plants in Europe, but it is not necessarily a good predictor of the future.

Boatman *et al.* (2010) modelled skylark distribution in a 80,000 ha predominantly arable farming landscape in England, considering three different scenarios. In the 'market led' scenario, the current land use was further transformed by agricultural intensification, mainly through expansion of winter wheat and 1G energy crops. In the 'energy crops' scenario, the area of oilseed rape increased (though less extensively than in the 'market-led' scenario) as well as the area of short-rotation willow coppice. In the 'environment-led' scenario, more unproductive land was fallowed or entered agri-environment schemes. Therefore, the last scenario reverses the general trend to move set-aside/marginal land back into production.

Although the authors do not state it directly, the described model partly examines the effect of expansion of 2G energy crops into marginal lands. In the 'bioenergy scenario', short-rotation willow coppice replaced 80% of the area of set-aside lands and 50% of the area of temporary grasslands, reaching up to 5% of the total area. Expansion of 2G energy crops on areas that are currently uncropped or extensively managed is therefore in line with the trend to introduce those crops on marginal lands, even if the actual fields do not fit into that category. The habitat association models predicted a decrease in skylark numbers in both 'market-led' and 'energy crops' scenarios, with an average decrease of 11–14%. The numbers of skylarks remained relatively constant only in the 'environment-led' scenario.

Similar to the following models, the expansion of 1G and 2G energy crops is simultaneous, so it is impossible to disentangle the effect of the two crop classes. However, as set-aside fields were assumed to hold the highest numbers of skylarks, their replacement with 2G energy crops must have been an important factor in reducing the skylark population.

The model of Engel *et al.* (2012) was based on artificial landscapes ('landscape-creator'), but used real data from northern Germany as input values for baseline crop and land-use data. In contrast to the previous approach, Engel *et al.* (2012) compared the population trends for the baseline scenario with the scenario of elevated bioenergy production (expansion of maize and oilseed rape, reduction in crop type number, introduction of 2G energy crops: short-rotation willow coppice and Sudan grass, total elimination of 'integrated biodiversity areas', i.e. meadows, unmanaged grasslands, verges and flower strips). The simulated landscapes were characterized by either small or large field sizes, with field size having a considerable impact on skylark density. Small fields held considerably higher skylark numbers, but in both landscape types bioenergy-driven land-use changes caused a very steep decline (–82% and –86% for small and large fields, respectively).

This model does not explicitly deal with the problem of marginal lands conversion, although total removal of

'integrated biodiversity areas' fits into the definition. In the baseline scenario, all those habitats together cover 5.5% of the landscape, and disappear in the bioenergy scenario. Similar to the previous model, it is the IBAs/set aside fields that hold the highest skylark numbers and that disappear completely from the landscape. **Therefore, bird-rich marginal lands are pushed out of the landscape by energy crops in general, no matter if they are first or second generation biofuel plants.**

This is confirmed by the model of Everaars *et al.* (2014) for predicting the impact for four species: skylark, lapwing, yellow wagtail and corn bunting (*Millaria calandra*). Even though their model included only 1G energy crops (maize and oilseed rape), the two 'bioenergy scenarios' included replacement of set-aside areas with row crops. The introduction of extensive energy cropping had a strongly negative impact on skylarks (5–50% reduction), a moderately negative impact on yellow wagtails and corn buntings (0–30% reduction) and no impact on lapwings (0–2% reduction) (Fig. 1).

In contrast to the artificial landscapes discussed earlier, Rivas-Casado *et al.* (2014) modelled bird populations of 19 species in a geographically-explicit area of 16,000 ha in England, using the functional space modelling framework from Butler and Norris (2013). The modelled bioenergy scenarios which were investigated included an extreme switch into grain production for bioethanol (all arable and grassland planted with wheat) and a moderate scenario with diverse energy crops (expansion of winter rape and small areas of short-rotation willow coppice and miscanthus). In the moderate bioenergy scenario, over 60% of fallow land and a whole area of spring oilseed rape was replaced with winter oilseed rape (71%), short rotation coppice and miscanthus (~8% each). Such changes increased the decline rate of 7 bird species and lowered the increase rate of 6 species. The only species which reacted positively was the woodpigeon (*Columba palambus*), a species benefitting from winter oilseed rape as a food resource (Inglis *et al.* 1997). Interestingly, other species that are able to exploit oilseed rape fields reacted negatively to their expansion at the expense of fallow land, like linnet or reed bunting (*Emberiza schoeniclus*) (Moorcroft *et al.* 2006; Gruar *et al.* 2006).

The results of this modelling approach show that removal of set-aside/marginal land by expansion of both 1G and 2G energy crops poses a significant threat not only for single species, but for whole farmland bird communities in Western Europe.

Concluding remarks

Further expansion of bioenergy crops in Western Europe involves significant risks to populations of farmland birds. However, we still lack research on the potential effects in Central and Eastern Europe. New European policies will probably slow down the expansion of the first generation energy crops (mainly maize and oilseed rape) in the near future. In contrast, if a technological breakthrough in cellulosic bioethanol production occurred, it would mean a massive expansion of the second generation energy crops. As presented earlier in this paper, energy crops expansion af-



Fig. 1. Yellow wagtail (*Motacilla flava*). This decreasing farmland specialist uses some first generation bioenergy plantation as breeding habitat, but is still declining throughout Europe

fects birds mainly by crops entering previously uncropped or extensively cropped land (set-aside, meadows, abandoned farmland). In Western Europe, most of these types of habitats have already been destroyed by agricultural intensification. In contrast, in Central and Eastern Europe such habitats still thrive on relatively large areas (e.g. abandoned cropland in the Baltic countries and Ukraine, subsistence farming areas in eastern Poland or central Romania). As a consequence, there are greater possibilities for expansion of 2G energy crops in Central and Eastern Europe than in Western Europe [e.g. Kukk *et al.* (2010) on potential area of 2G energy crops in Estonia]. Such processes could change the farming landscape of Eastern Europe in the same way 1G energy crops did, and put farmland birds in this part of the European continent at significant risk.

Therefore, we call for new research dealing with bird use of 2G energy crops in Central and Eastern Europe, using both empirical and modelling approaches. Here we will briefly highlight some phenomena specific to this region that should a) affect results of future studies on energy crops and birds, and b) prevent local ornithologists and policymakers from simply extrapolating from the results obtained in Western Europe.

It is important to stress that potentially negative effects of large-scale second generation energy cropping in Central and Eastern Europe might not be visible in the short term.

First, some species of farmland birds might benefit from limited agricultural intensification, especially in previously abandoned farmland. This is true for the corn bunting (Szymkowiak *et al.* 2014). However, this effect is likely to be reversed when intensification reaches a certain level, which in most areas of Western Europe has already been reached (Szymkowiak *et al.* 2014).

Second, 2G energy crops in their early stages of establishment are an attractive habitat for farmland birds due to numerous bare patches and extensive weed cover (e.g.

miscanthus in Semere and Slater 2007). Therefore, it is crucial to conduct research in areas where second generation energy cropping is well established, at least locally. Such areas already exist in Central and Eastern Europe (e.g. Vepsäläinen 2010).

Finally, relatively high densities of farmland birds in Central European landscapes might obscure the relationship between crop type and bird abundance. If birds remain numerous, some individuals might 'spill over' into a suboptimal habitat created by 2G energy crops (Fig. 2). Therefore, data on nesting success would be much more valuable to assess the real habitat potential of 2G energy crops than simple bird counts.

Another conceivable difference between the two European regions could be the composition of bird communities in 2G energy crops. Some birds numerous in Central and Eastern Europe but absent or rare in Western Europe might be able to utilize 2G energy crops as breeding habitats. For example, whinchat (*Saxicola rubetra*) often breeds in miscanthus fields in Poland (Kaczmarek J.M., unpublished data). However this species has never been reported in miscanthus fields in Great Britain (Semere and Slater 2007; Bellamy *et al.* 2009; Sage *et al.* 2010; Bright *et al.* 2013). Similarly, some warbler species that often exploit short-rotation coppice [marsh warbler (*Acrocephalus palustris*) and Blyth's reed warbler (*Acrocephalus dumetorum*); Berg 2002] or reed canary grass (marsh warbler; Vepsäläinen 2010) are absent from Great Britain and from all of Western Europe.

In contrast, some birds that readily colonize 2G energy crops in Western Europe might avoid them in Central and Eastern Europe. This is true for species that are common in human-modified habitats in the western part of their range while remaining confined to more natural woodland habitats in the east. Some examples include wren, blackbird (*Turdus merula*) or robin (Møller *et al.* 2014; Seress and Liker 2015).

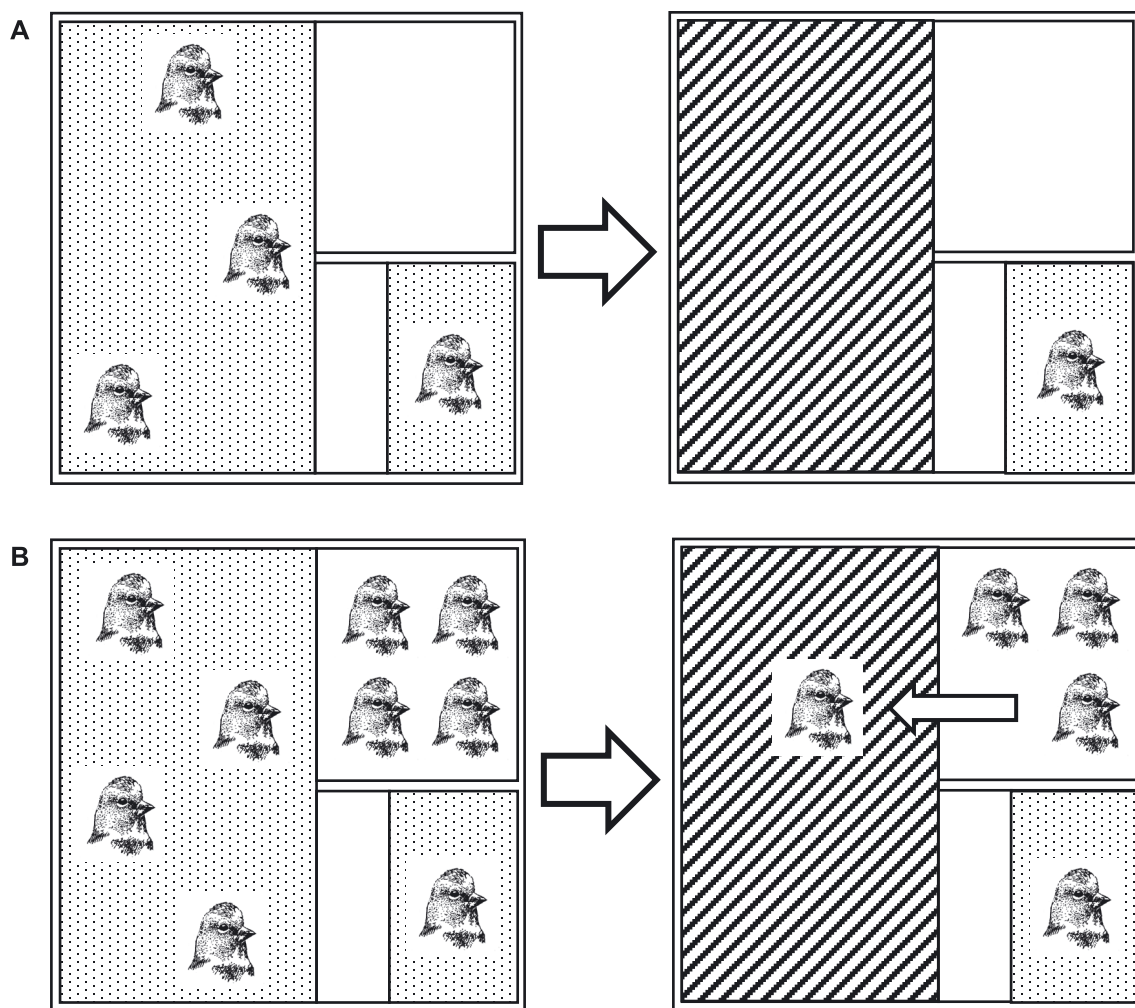


Fig. 2. In Central and East European habitats with abundant farmland birds, the 'spillover' effect may partially mask the negative impact of 2G energy crops in the landscape: A – Western Europe; fields of new crop (hashed) are devoid of birds; B – Central and Eastern Europe; fields of new crop (hashed) still hold a fraction of birds that 'spill over' from neighboring optimal habitats

In the case of modelling habitat change caused by expansion of 2G energy crops, we would like to discuss three areas where model developers should remain cautious in transferring their approaches directly from Western Europe.

First, keeping all other factors constant, in Central and Eastern Europe 2G energy crops might replace habitats which are much more valuable to birds than in Western Europe. For instance, in the model of Boatman *et al.* (2010), energy crops expanded at the expense of set-aside areas and temporary grasslands, while in Rivas-Casado *et al.* (2014) energy crops replaced set-aside and spring oilseed rape. In Central and Eastern Europe, areas such as unimproved, permanent grasslands or wood-pasture which are much more valuable for birds might be replaced (Hartel *et al.* 2014). Therefore, the impact on bird communities can be very severe (Fig. 3).

Second, in Central and Eastern Europe much higher bird densities correlate with much higher habitat heterogeneity (Báldi and Batáry 2011). This improved heterogeneity must be included in future models, even though the obtained results could be less powerful. It has already been mentioned that farmland birds are present in almost all kinds of habitats in Central and Eastern Europe, although only some are optimal for breeding or foraging.

Therefore, bird preferences are much more 'blurred', and building models based on their simplified parametrization, like in Everaars *et al.* (2014) might lead to misleading results.

Some, but not all, regions of Central and Eastern Europe are characterized by small field sizes. Field size is a factor often included in the models (Engel *et al.* 2012; Everaars *et al.* 2014), and has positive effects on farmland bird abundance. Even though, small field size is not able to mitigate losses caused by energy crops expansion (Engel *et al.* 2012; Everaars *et al.* 2014), birds remain relatively abundant. The risk in Central and Eastern Europe is that the policymakers could interpret these facts to mean that the expansion of energy crops can be encouraged because the bird population levels are not expected to fall 'dramatically enough'. As a consequence, more education and cooperation between ornithologists and policymakers is needed in Central and Eastern Europe in the context of predicted 2G crops expansion.

Finally, an important element of Central and Eastern European farming landscapes is marginal vegetation (shrubs, hedgerows, uncultivated field margins, lone trees) and other structures (e.g. manure heaps) that have largely disappeared from Western Europe (Fig. 4).



Fig. 3. Miscanthus field in northern Poland. The tall crop might increase heterogeneity of simplified farming landscapes, but its expansion can be detrimental to traditional, high nature value farmland of CE Europe



Fig. 4. Destruction of bird-rich roadside shrubs near miscanthus plantation in northern Poland. While bioenergy fields are valuable habitats to some birds, it might be not enough to balance the loss of such structures

Such small-scale structures are rarely included in spatial models that often concentrate on relationships between birds, field crops, grassland and set-aside or fallow land, ignoring smaller structures. However, such structures provide indispensable habitats for farmland birds [e.g. Goławski and Kasprzykowski (2011) for manure heaps], and their importance is quantifiable (Morelli 2014). Their abundance in Central and Eastern Europe might buffer the negative effects of energy crops expansion, provided that they are not destroyed by agricultural intensification (Fig. 5). When modelling bird abundance in eastern parts of the European continent, we strongly encourage

the inclusion of marginal structures in the models, like in Engel *et al.* (2012).

In conclusion, 2G energy crops expansion, while not certain, remains a potentially very important factor that could reshape farmland bird communities of Central and Eastern Europe. More field research is needed on emerging bioenergy plantations in the region, fueling new, locally adapted models. Caution is needed in extrapolating results from West European studies to Central and Eastern Europe (Báldi and Batáry 2011; Tryjanowski *et al.* 2011). This is especially true for the impact of second generation energy crops.

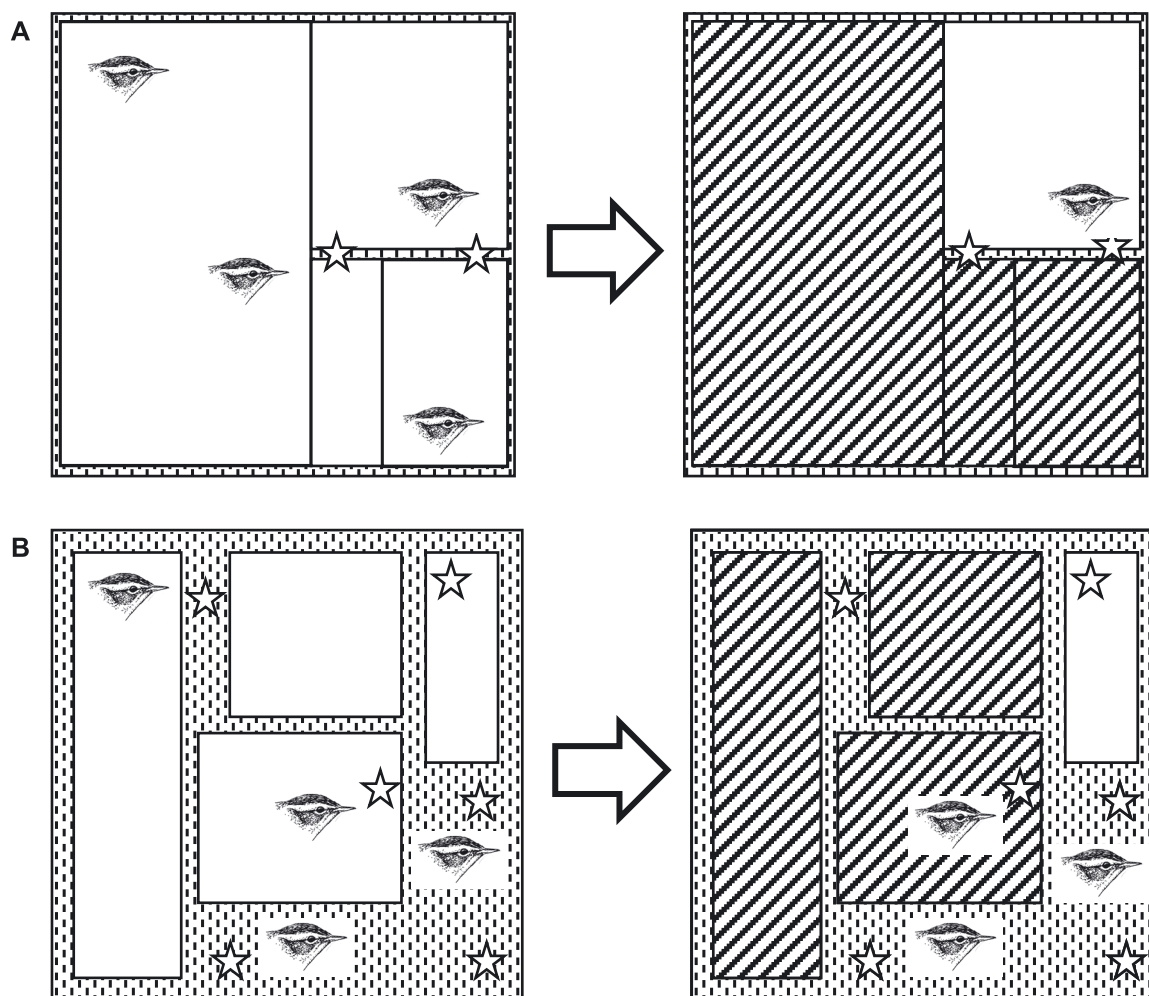


Fig. 5. In Central and East European habitats, numerous marginal structures and vegetation may partially buffer the negative impact of 2G energy crops: A – Western Europe; number of birds on fields falls drastically after replacing traditional crops with new ones (hashed fields). Marginal vegetation (dotted lines) and marginal structures (stars) are limited and are unable to sustain bird populations; B – Central and Eastern Europe; extensive marginal vegetation and numerous marginal structures provide habitat for birds in farming landscape even though fields of new crop provide fewer resources

References

- Anderson G.Q.A., Haskins L.R., Nelson S.H. 2004. The effects of bioenergy crops on farmland birds in the United Kingdom: a review of current knowledge and future predictions. p. 199–218. In: "Biomass and Agriculture: Sustainability, Markets and Policies" (K. Parris, D. Poincet, eds.). Organization for Economic Cooperation and Development, Paris, France, 572 pp.
- Badhan A., McAllister T. 2014. Designer plants for biofuels: a review. *Current Metabolomics* 2 (3): 1–6.
- Báldi A., Batáry P. 2011. Spatial heterogeneity and farmland birds: different perspectives in Western and Eastern Europe. *Ibis* 153 (4): 875–876.
- Baxter D.A., Sage R.B., Hall D.O. 1996. A methodology for assessing gamebird use of short rotation coppice. *Biomass and Bioenergy* 10 (5–6): 301–306.
- Bellamy P.E., Croxton P.J., Heard M.S., Hinsley S.A., Hulmes L., Hulmes S., Nuttall P., Pywell R.F., Rothery P. 2009. The impact of growing miscanthus for biomass on farmland bird populations. *Biomass and Bioenergy* 33 (2): 191–199.
- Berg Å. 2002. Breeding birds in short-rotation coppices on farmland in central Sweden – importance of *Salix* height and adjacent habitats. *Agriculture, Ecosystems and Environment* 90 (3): 265–276.
- Boatman N.D., Pietravalle S., Parry H.R., Crocker J., Irving P.V., Turley D.B., Mills J., Dwyer J.C. 2010. Agricultural land use and Skylark *Alauda arvensis*: a case study linking a habitat association model to spatially explicit change scenarios. *Ibis* 152 (1): 63–76.
- Bright I.A., Anderson G.Q.A., McArthur T., Sage R., Stockdale J., Grice P.V., Bradbury R.B. 2013. Bird use of establishment-stage *Miscanthus* biomass crops during the breeding season in England. *Bird Study* 60: 357–369.
- Butler S.J., Norris K. 2013. Functional space and the population dynamics of birds in agro-ecosystems. *Agriculture, Ecosystems and Environment* 164: 200–208.
- Dauber J., Brown C., Fernando A.L., Finnan J., Krasuska E., Ponitka J., Styles D., Thrän D., Van Groenigen K.J., Weih M., Zah R. 2012. Bioenergy from "surplus" land: environmental and socio-economic implications. *BioRisk* 7: 5–50.
- Dauber J., Jones M.B., Stout J.C. 2010. The impact of biomass crop cultivation on temperate biodiversity. *Global Change Biology Bioenergy* 2 (6): 289–309.

- DEFRA (Department for Environment, Food and Rural Affairs). 2013. Area of crops grown for bioenergy in England and the UK: 2008–2012. London, UK, 36 pp. Available on: <https://www.gov.uk/government/publications/area-of-crops-grown-for-bioenergy-in-england-and-the-uk-2008-2012> [Accessed: August 20, 2016]
- Engel J., Huth A., Frank K. 2012. Bioenergy production and Skylark (*Alauda arvensis*) population abundance – a modelling approach for the analysis of land-use change impacts and conservation options. *Global Change Biology Bioenergy* 4 (6): 713–727.
- EC (European Commission). 2012. EU Agriculture – Statistical and economic information – 2012. Available on: <http://ec.europa.eu/agriculture/statistics/agricultural/2012/> [Accessed: July 15, 2016]
- EEA (European Environment Agency). 2004. High Nature Value Farmland. Characteristics, Trends and Future Challenges. Copenhagen, Denmark. EEA Report No.1/2004, 31 pp.
- EP (European Parliament). 2013. Fuel quality directive and renewable energy. Available on: <http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P7-TA-2013-0357+0+DOC+XML+V0//EN&language=EN> [Accessed: July 15, 2016]
- Everaars J., Frank K., Huth A. 2014. Species ecology and the impacts of bioenergy crops: an assessment approach with four example farmland bird species. *Global Change Biology Bioenergy* 6 (3): 252–264.
- Fargione J.E., Cooper T.R., Flaspohler D.J., Hill J., Lehman C., McCoy T., McLeod S., Nelson E.J., Oberhauser K., Tilman D. 2009. Bioenergy and wildlife: threats and opportunities for grassland conservation. *BioScience* 59 (9): 767–777.
- Fry D.A., Slater F.M. 2011. Early rotation short rotation willow coppice as a winter food resource for birds. *Biomass and Bioenergy* 35: 2545–2553.
- Goławski A., Kasprzykowski Z. 2011. The significance of cereal stubble and manure heaps for birds wintering in the farmland of eastern Poland. *Ardeola* 58: 277–286.
- Gruar D., Barritt D., Peach W.J. 2006. Summer utilization of oilseed rape by Reed Buntings *Emberiza schoeniclus* and other farmland birds. *Bird Study* 53: 47–54.
- Hartel T., Hanspach J., Abson D.J., Máthe O., Moga I.M., Fischer J. 2014. Bird communities in traditional wood-pastures with changing management in Eastern Europe. *Basic and Applied Ecology* 15 (5): 385–395.
- Inglis I.R., Isaacson A.J., Smith G.C., Haynes P.J., Thearle R.J.P. 1997. The effect on the woodpigeon (*Columba palambus*) of the introduction of oilseed rape into Britain. *Agriculture, Ecosystems and Environment* 61 (2–3): 113–121.
- Kukk L., Astover A., Muiste P., Noormets M., Roostalu H., Sepp K., Suuster E. 2010. Assessment of abandoned agricultural land resource for bio-energy production in Estonia. *Acta Agriculturae Scandinavica Section B – Soil and Plant Science* 60 (2): 166–173.
- Lewandowski I., Clifton-Brown J. C., Scurlock J. M. O., Huisman W. 2000. Miscanthus: European experience with novel energy crop. *Biomass and Bioenergy* 19 (4): 209–227.
- Lewandowski I., Scurlock J.M.O., Lindvall E., Christou M. 2003. The development and current status of perennial rhizomatous grasses as energy crops in the US and Europe. *Biomass and Bioenergy* 25 (4): 335–361.
- Lewis S.M., Kelly M. 2014. Mapping the potential for biofuel production on marginal lands: differences in definitions, data and models across scale. *ISPRS International Journal of Geo-Information* 3 (2): 430–459.
- Liesebach M., Mulsow H. 2003. Der Sommervogelbestand einer Kurzumtriebsplantage, der umgebenen Feldflur und des angrenzenden Fichtenwaldes im Vergleich. *Holzzucht* 54: 27–30.
- Lindblath M., Hedwall P.-O., Wallin I., Felton A. M., Böhlenius H., Felton A. 2014. Short-rotation bioenergy stands as an alternative to spruce plantations: implications for bird biodiversity. *Silva Fennica* 48 (5): 1135.
- Marriott P.E., Gomez L.D., McQueen-Mason S.J. 2016. Unlocking the potential of lignocellulosic biomass through plant science. *New Phytologist* 209 (4): 1366–1381.
- Miyake S., Renouf M., Peterson A., McAlpine C., Smith C. 2012. Land-use and environmental pressures resulting from current and future bioenergy crops expansion: a review. *Journal of Rural Studies* 28 (4): 650–658.
- Mola-Yudego B., Gonzalez-Olabarria J.R. 2010. Mapping the expansion and distribution of willow plantations for bioenergy in Sweden: Lessons to be learned about the spread of energy crops. *Biomass and Bioenergy* 34 (4): 442–448.
- Møller A.P., Jökimäki J., Skórka P., Tryjanowski P. 2014. Loss of migration and urbanization in birds: a case study of the blackbird (*Turdus merula*). *Oecologia* 175 (3): 1019–1027.
- Moorcroft D., Wilson J.D., Bradbury R.B. 2006. The diet of nestling Linnets *Carduelis cannabina* on lowland farmland before and after agricultural intensification. *Bird Study* 53 (2): 156–162.
- Morelli F., Jerzak L., Tryjanowski P. 2014. Birds as useful indicators of high nature value (HNV) farmland in Central Italy. *Ecological Indicators* 38: 236–242.
- Morelli F. 2014. Relative importance of marginal vegetation (shrubs, hedgerows, isolated trees) surrogate of HNV farmland for bird species distribution in Central Italy. *Ecological Engineering* 57: 261–266.
- OPTIMISC (Optimizing Miscanthus Biomass Production). 2012. Project supported by funding from the European Union's 7th Framework Programme (FP7/2007–2013) under grant agreement No. 28915. Available on: <http://miscanthus.anna-consult.de/> [Accessed: July 17, 2015]
- Pedroli B., Elbersen B., Frederiksen P., Grandin U., Heikkilä R., Krogh P.H., Izakovcova Z., Johansen A., Meiresonne L., Spijker J. 2013. Is energy cropping in Europe compatible with biodiversity? – Opportunities and threats to biodiversity from land-based production of biomass for bioenergy purposes. *Biomass and Bioenergy* 55: 73–86.
- Pullin A.S. 2002. *Conservation Biology*. Cambridge University Press. Cambridge, UK, 355 pp.
- Qin Z., Zhuang Q., Cai X. 2015. Bioenergy crop productivity and potential climate change mitigation from marginal lands in the United States: An ecosystem modeling perspective. *GCB Bioenergy* 7 (6): 1211–1221.
- Reboredo F.H., Lidon F., Pessoa F., Ramalho J.C. 2016. The fall of oil prices and the effects on biofuels. *Trends in Biotechnology* 34 (1): 3–6.
- Rivas-Casado M., Meas A., Burgess P.J., Howard D.J., Butler S.J. 2014. Predicting the impacts of bioenergy production on farmland birds. *Science of the Total Environment* 476–477: 7–19.

- Sage R., Cunningham M., Boatman N. 2006. Birds in willow short-rotation coppice compared to other arable crops in central England and a review of bird census data from energy crops in the UK. *Ibis* 148 (1): 184–197.
- Sage R., Cunningham M., Haughton A.J., Mallott M.D., Bohan D.A., Riche A., Karp A. 2010. The environmental impacts of biomass crops: use by birds of miscanthus in summer and winter in southwestern England. *Ibis* 152 (3): 487–499.
- Saha M., Eckelman M.J. 2015. Geospatial assessment of potential bioenergy crop production on urban marginal land. *Applied Energy* 159: 540–547.
- Schulz U., Brauner O., Gruss H. 2009. Animal diversity in short-rotation coppices – a review. *Landbauforschung – vTI Agriculture and Forestry Research* 59: 171–182.
- Semere T., Slater F.M. 2007. Ground flora, small mammal and bird species diversity in miscanthus (*Miscanthus x giganteus*) and reed canary-grass (*Phalaris arundinacea*) fields. *Biomass and Bioenergy* 31 (1): 20–29.
- Seress G., Liker A. 2015. Habitat urbanization and its effects on birds. *Acta Zoologica Academiae Scientiarum Hungaricae* 61 (4): 373–408.
- Shortall O.K. 2013. “Marginal land” for energy crops: exploring definitions and embedded assumptions. *Energy Policy* 62: 19–27.
- Stoate C., Boatman N.D., Borralho R.J., Rio Carvalho C., de Snoo G.R., Eden P. 2001. Ecological impacts of arable intensification in Europe. *Journal of Environmental Management* 63 (4): 337–365.
- Szymkowiak J., Skierczyński M., Kuczyński L. 2014. Are buntings good indicators of agricultural intensity? *Agriculture, Ecosystems and Environment* 188: 152–197.
- Tryjanowski P., Hartel T., Báldi A., Szymański P., Tobółka M., Herzon I., Goławski A., Konvička M., Hromada M., Jerzak L., Kujawa K., Lenda M., Orłowski M., 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): 1–12.
- Vepsäläinen V. 2010. Energy crop cultivations of reed canary grass – An inferior breeding habitat for the skylark, a characteristic farmland bird species. *Biomass and Bioenergy* 34 (7): 993–998.