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Rethinking Agricultural Systems in the UK

Are land sparing and land sharing real alternatives for European agricultural landscapes?

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Summary

There is a lively debate on whether biodiversity conservation and agricultural production could be better reconciled by land sparing (strictly separating production fields and conservation areas) or by land sharing (combining both, agricultural production and biodiversity conservation on the same land). The debate originates from tropical countries, where agricultural land use continues to increase at the expense of natural ecosystems. But is it also relevant for Europe, where agriculture is withdrawing from marginal regions whilst farming of fertile lands continues to be intensified? Based on recent research on farmland biodiversity we conclude that the land sharing – land sparing dichotomy is too simplistic for Europe. Instead we differentiate between productive and marginal farmland. On productive farmland, semi-natural habitats are required to yield ecosystem services relevant for agriculture, to promote endangered farmland species which society wants to conserve even in intensively farmed regions, and to allow migration of non-farmland species through the agricultural matrix. On marginal farmland, high-nature value farming is a traditional way of land sharing, yielding high quality agricultural products and conserving specialized species. To conserve highly disturbance-sensitive species, there is a need for nature reserves. In conclusion, land sparing is not a viable solution for Europe in both productive and marginal farmland but because of different reasons in each type of farmland.

Key words: Farmland biodiversity, high nature value farming, organic farming, marginal farmland, semi-natural habitat

Introduction

The debate about whether land sharing or land sparing is more efficient to achieve the two objectives of (i) biodiversity conservation and (ii) agricultural production is a very lively one (e.g. Adams, 2012; Tscharntke, 2012; Balmford *et al*., 2012). The two approaches have been illustrated by Balmford *et al*. (2012) (Fig. 1). Land sharing represents the "traditional European approach", where both objectives are aimed for on the same area of land. It reflects the paradigm of multifunctional agriculture, which assigns a series of functions to farmland including production,

resource protection, cultural services, etc. (de Groot *et al*., 2010). The more recent approach of land sparing claims that the goal of biodiversity conservation could be more easily achieved by intensifying agricultural production. By attaining higher per-hectare yields, more land would then be available for biodiversity conservation (Green, 2005). This approach was motivated by observations in tropical developing countries, where at the "agricultural frontier" natural habitats continue to be transformed into farmland. Recently, Phalan *et al*. (2011) have concluded from observations in Ghana and India, that for the conservation of tree and bird species land sparing would be more effective for minimizing the negative impacts of food production than land sharing (but see Fischer *et al*. (2011) and Hayashi (2011)).

How relevant is this debate for European agriculture and should the paradigm of multifunctional agriculture be revised? We will examine the findings of some recent research projects under the perspective of the land sharing – land sparing debate.

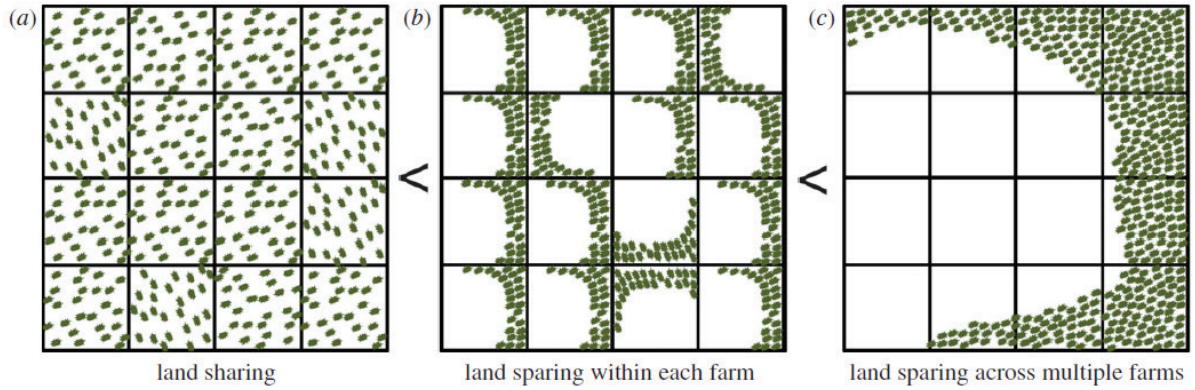

Fig. 1. Land sharing (a), land sparing at farm scale (b) and land sparing at the regional scale (c) as illustrated by Balmford *et al*. (2012). The dots represent areas dedicated to biodiversity conservation, the white background represents the productive farmland. Reproduced with permission from ©*Proceedings of the Royal Society B*.

Organic farming as an example of land sharing

Organic farming can be viewed as a land sharing approach insofar as management intensity is usually lower than on conventional farms, yields are lower and species richness tends to be higher (e.g. Bengtsson *et al*., 2005; Gabriel *et al*., 2013). Schneider *et al*. (in prep., see also Herzog *et al*. (2013)) compared the species richness of vascular plants, earthworms, spiders and wild bees on 205 organic and non-organic farms across 12 case study regions in Europe and beyond. Species richness was recorded in production fields and in semi-natural habitats (hedgerows, grassy strips, etc.) of the same farms. On organic farms similar amounts of semi-natural habitats were recorded as on non-organic farms. Species richness was higher on organically managed production fields but there was no difference in species richness between semi-natural habitats of the two farming systems. At the farm scale, including both production fields and semi-natural habitats, the species richness gain of organic farming was no longer statistically significant. Our interpretation is that the large majority of species is present in the semi-natural habitats in both management types. Some of these species can migrate into the adjacent organic production fields but not into the more intensively managed non-organic production fields. This leads to the observed higher species richness in organic agriculture at the field scale but not at the farm scale. On the same farms, the number of species which exclusively occur in semi-natural habitats was higher, in most case study regions, than the number of species which were exclusive to production fields (Jeanneret *et al*., 2012), although semi-natural habitats made up less than ten per cent of the area of most farms (Bailey *et al*., 2012). In most case study regions, the yields on organic farms were lower than the yields of the paired non-organic farms (P Pointereau, unpubl.).

Because (i) the low-intensity, organic management of production fields did not yield significant farm scale species gains, (ii) because those gains mostly went along with reduced yields and (iii) because the semi-natural habitats rather than the production fields harboured the majority of farmland

species richness, organic farming appears indeed not overly efficient for biodiversity conservation in the majority of case study regions investigated. Instead, it appears that agricultural production could be intensified without doing much harm to species richness as long as the semi-natural habitats are not affected. However, semi-natural habitats are not only important for biodiversity conservation on farmland but they also provide ecosystem services which support agricultural production. Removing semi-natural habitats from intensively managed farmland would deprive agricultural production from the supporting services they provide and might ultimately lead to decreased yields. To mention one example, across 41 farming systems worldwide the presence of wild pollinating insects increased fruit set and crop yield (Garibaldi *et al*., 2013). Further, ecological theory predicts that migration of non-farmland species though the agricultural matrix is crucial to balance the extinctions that occur even in large and well managed reserves (Perfecto & Vandermeer, 2010). Therefore, semi-natural habitats may also play an important role in the long-term effectiveness of nature reserves.

Based on the considerations above, we advocate an approach *sensu* Fig. 1a in which intensive agricultural fields for production are interspersed by semi-natural habitats. The latter should be targeted towards the provision of ecosystem services and the conservation of farmland species of which many are multi-habitat users (e.g. Coudrain *et al*., 2013) that could not survive in large protected areas. Further, society wants to maintain these farmland species even on intensively managed farmland, as illustrated by the numerous agri-environmental schemes in Europe (e.g. Aviron *et al*., 2009). However, conventional management intensification may result in a reduced ecosystem service provision even if semi-natural habitats are present, as species migration from semi-natural habitat into farmland seems to be lower in more intensified systems. Instead the ecological intensification of agricultural production aims at integrating the management of ecosystem services delivered by biodiversity into crop production (Bommarco *et al*., 2013). Within the agricultural fields, classical agronomic techniques such as increasing soil fertility, clever crop rotations, etc. contribute to ecological intensification. Innovations such as intercropping and/or agroforestry systems may generate an overyielding effect due to more efficient resource capture whilst providing ecosystem services (Hooper & Dukes 2003; Palma *et al*., 2007). Whether this approach (Fig. 1a) is termed "land sharing" or considered as small scale "land sparing" might be an interesting academic debate but has little practical relevance. Instead we should rather focus on investigating how many of those habitats need to be present and in what spatial arrangement (Bailey *et al*., 2011; Schüepp *et al*., 2011).

What about marginal regions?

The above mentioned considerations mostly apply to the rather fertile parts of European farmland with arable land, intensive grazing and/or permanent crops. However, more than 50 per cent of the utilized agricultural areas of Europe have been classified as "less favourable areas" where productivity is limited by e.g. topography, soil quality or climate (EU, 2012). A considerable share of this land has been mapped as High Nature Value farmland (HNV), which makes up almost one third of Europe's utilized agricultural area (Fig. 2) (Beaufoy *et al*., 2012). Examples are the Dehesas/Montados of Spain and Portugal, which are listed as Annex II habitats of the European Habitats Directive (EC, 1992), coastal salt marshes alongside the atlantic and baltic seas (Luick, 2012) or low-intensity mountain grasslands (Kampmann *et al*., 2012). The HNV farmlands by definition consist of a large share of semi-natural habitats. Numerous wild species depend on traditional low-intensity agricultural management, many of them being of conservation interest. Those species and landscapes are threatened by abandonment rather than intensification. They depend on large scale low-intensity agricultural management, an option which is missing in Fig. 1. Moreover, although productivity is low, many of the products are of high quality and often marketed at attractive prices under a regional label (e.g. PDO Protected Designations of Origin). The landscapes are often attractive for recreation and have allowed for the development of a local tourist industry.

Increasing farming intensity on marginal land is often not possible or would require drastic interventions such as drainage of wetlands, riverbed corrections, building of coastal dams, irrigation of drylands, etc. Such interventions were undertaken over recent centuries and have profoundly altered former European landscapes (Grünig *et al*., 1994). They are still happening in parts of Europe today (e.g. irrigated in-door production of vegetables in the Mediterranean) but in many regions they would be met by public opposition.

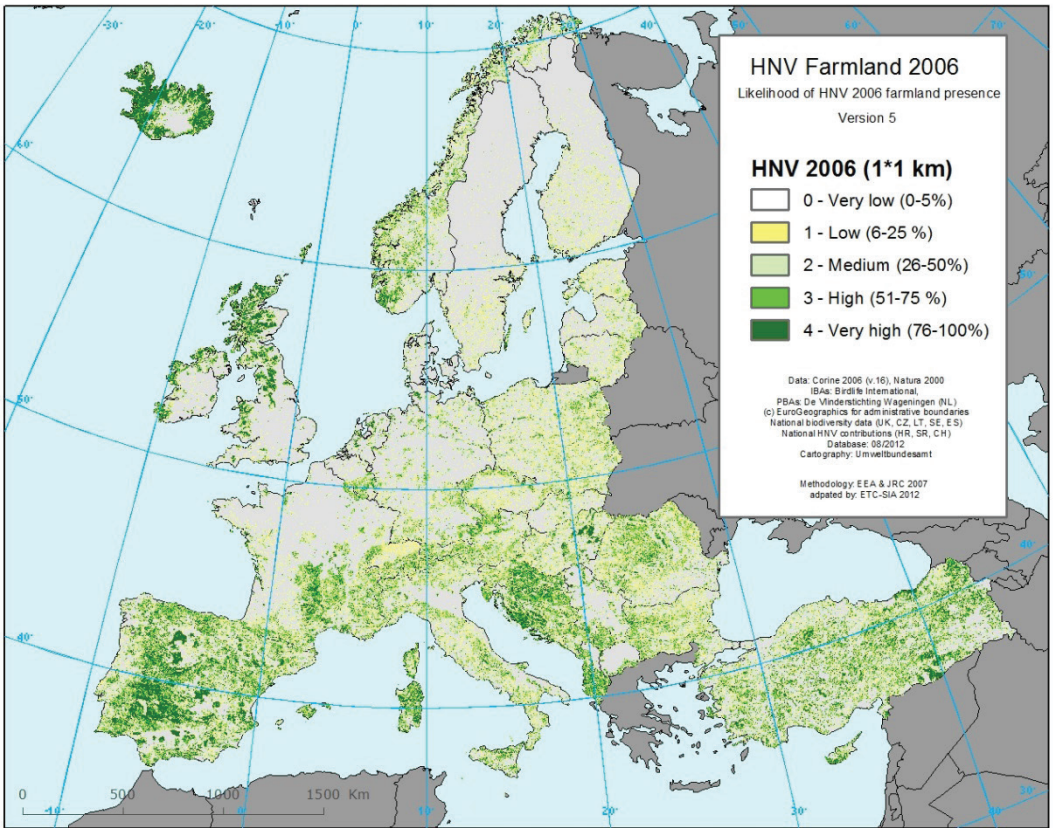

Fig. 2. High Nature Value farmland amounts to one third of the European utilized agricultural area (EU, 2012).

Protection of non-farmland biodiversity

In the preceding sections, we argue in favour of the conservation of farmland biodiversity by land sharing: small areas of semi-natural habitats on productive land and large scale low-intensity management on marginal land. Yet, beside the farmland biodiversity discussed above, there are numerous species of conservation interest which are not – or no longer – linked to agriculture. Examples include wetlands and reedbeds and their related fauna, forest species and large predators, to name just a few. Maintaining those species requires targeted conservation efforts and nature reserves. Could land sparing in Europe help to maintain and create such reserves?

First, there are already numerous conservation areas in Europe, with various extents and numerous regulations. In contrast to many nature reserves in tropical developing countries, the reserves in Europe are not threatened by agriculture and it is unlikely that they will be transformed to farmland in the near future. In particular, the few remaining natural habitat patches (e.g. virgin forests) are under strict protection. Therefore, land sparing is not a necessary strategy to maintain protected areas in Europe.

Second, the creation of additional reserves, following the logic of Fig. 1 would imply the removal of dispersed semi-natural habitats and their replacement with large, continuous biodiversity protection areas (Fig. 1c). From a practical point of view, these changes would be hard to attain and not lead to successful biodiversity conservation:

1. Creating large, continuous reserves on the basis of smaller semi-natural habitats (*sensu* Fig. 1c) is not a realistic option because of land ownership (dispersed private and public land owners) and de-centralised responsibilities of local and regional governments.

2. Creating conservation areas on fertile farmland requires massive interventions such as top soil removal in order to promote species of conservation value. Such efforts are feasible at a small scale (a few hectares) but would be quite difficult at a large scale. Without such interventions, the conservation value of those reserves would be rather limited due to the nutrient rich soils.
3. Semi-natural habitats (represented by the small black dots in Fig. 1a) are often located at small wet patches or boulders, which even occur in regions of productive farmland. It could be rather difficult to make those patches available for intensive agricultural production (to obtain the continuous white areas of Figs 1b and 1c).

Rather than on fertile farmland, new nature reserves should therefore be installed on less favoured area farmland (marginal farmland). Creating nature reserves on marginal farmland implies choosing between the species which are to be promoted: Farmland species of extensively managed agricultural land or species which thrive on unmanaged land (or on land managed for nature). Within areas of productive farmland, new reserves should be limited to already existing habitats of conservation value such as wetlands, specific forest types, etc.

A more differentiated approach is needed

We conclude that for Europe the dichotomy of land sharing – land sparing is too simplistic. Here, in contrast to many tropical regions, only very few natural habitats still exist (which would need to be spared from agricultural management) and many nature values depend on low-intensity agricultural management. We propose a more differentiated approach which at least distinguishes between fertile and marginal farmland (Fig. 3).

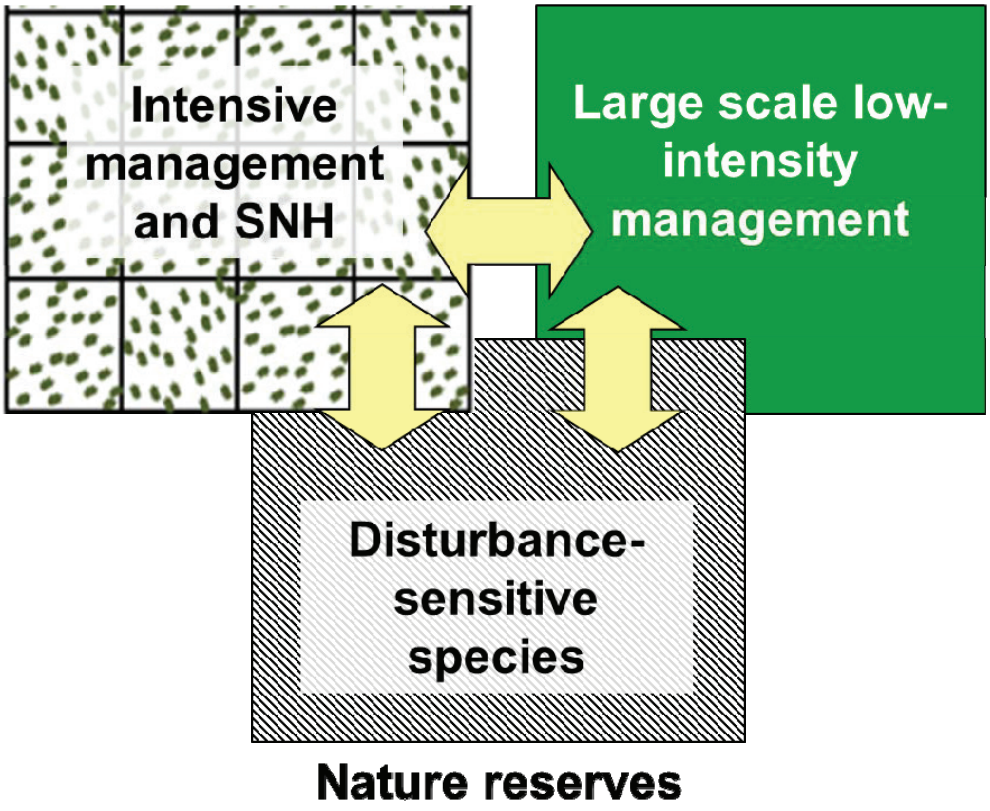

Fig. 3. Differentiated options for promoting both agricultural production and biodiversity conservation in Europe (modified after Balmford *et al*., 2012). SNH: Semi-natural habitats.

Our more differentiated approach, however, is still simplistic given that there is a gradient from productive to marginal farmland, between intensity levels of agricultural production, and from farmland to disturbance-sensitive species to be protected. Further, land sparing can be implemented

at different scales, changing the associated risks and opportunities. Additional aspects which we also neglected are:

- Limits to agricultural intensification imposed by resource protection and resource depletion (soil, water, climate, nutrients) and possible benefits of low-intensity and organic farming in this respect (e.g. Hansen *et al*., 2000; Milgrom *et al*., 2007);
- The value which organic farmers attach to wild farmland species, which affects the outcome of biodiversity conservation efforts (Kelemen *et al*., 2013);
- The cultural values which semi-natural landscape elements have even in intensively farmed regions (Junge *et al*., 2011);
- Threats for (farmland) biodiversity from climate change and urban sprawl (Pullin *et al*., 2009; Carlesi *et al*., 2013).

Refer to Tscharntke *et al*. (2012) for a comprehensive discussion of the issues related to global food security and biodiversity conservation.

Conclusion

We conclude that the dichotomy of land sharing – land sparing is too simplistic and will hardly be helpful to define biodiversity conservation strategies for Europe. Nevertheless, it puts two important objectives on the agenda: biodiversity conservation and agricultural production. In productive farmland, where intensification with agro-ecological techniques is desirable, the presence of semi-natural habitats adjacent to production fields is necessary to guarantee ecosystem services provided by farmland biodiversity, to protect farmland biodiversity and to allow migration of non-farmland species through the agricultural matrix. In marginal farmland, intensification is often associated with difficult interventions and the loss of high quality traditional products. Nature reserves are needed for the protection of highly disturbance sensitive species. In Europe, the existing reserves are not in danger of being transformed to farmland (as may be the case in developing countries) and land sparing is not needed to preserve them. Whether new reserves are to be established is a matter of societal choice between species types and landscapes to be promoted, i.e. between "wilderness" and "cultural landscapes".

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