Reconciling food production and biodiversity conservation in Poland

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PhD Research Project

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Conceptual Background

Two alternative directions have been proposed to address the conflict between food production and biodiversity conservation: **land sharing** or "wildlife-friendly farming" which integrates both objectives on the same land; and **land sparing**, which involves increasing yield on existing farmland, whilst protecting natural habitats from conversion to agriculture[1-4] (**Box 1**).

The debate around this issue is often polarised into two extremes: advocates of land sharing argue that farmland should be made as hospitable to other species as possible through the reduction of inputs (fertilisers and pesticides) and the on-farm retention of areas of non-crop habitat (such as hedgerows, copses and ponds). However, this typically produces lower overall yield (i.e. production per unit area) and therefore requires a greater area under cultivation in order to meet production targets.

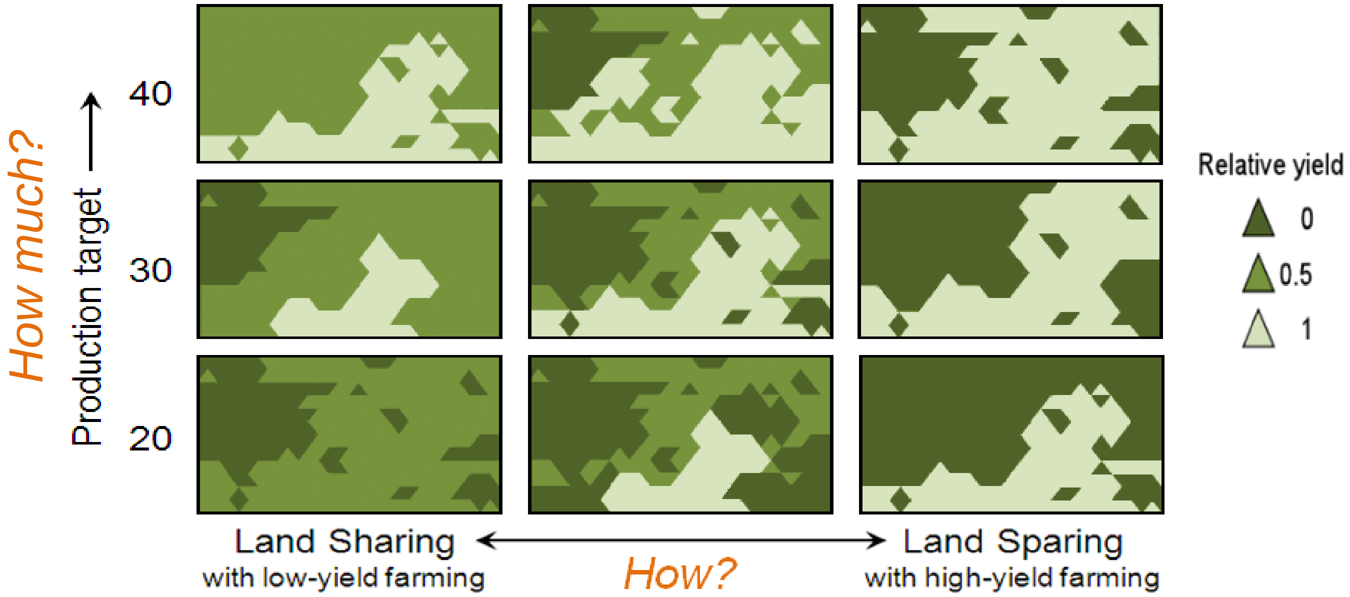
Proponents of a land sparing approach instead argue that greater biodiversity benefits may be delivered if yields were increased on some areas of existing farmland, enabling natural habitat elsewhere to be spared from future conversion and/or liberating redundant farmland for habitat restoration[2-4].

However, these are two opposite ends of a continuum of possible land-use strategies, and it may be the case that an intermediate scenario that includes elements of both approaches would deliver the greatest biodiversity benefits.

Box 1. The Land Sparing – Land Sharing Continuum

Land sparing and sharing represent extremes of a range of approaches to the problem of reconciling food production and biodiversity conservation.

The figure below illustrates ways in which different food production targets ("**how much?**") can be met by a range of different land-management approaches across a landscape ("**how?**"). Shading denotes food production per unit area: lighter shades represent higher yields, darkest green represents 'spared' land available for habitat protection/restoration.



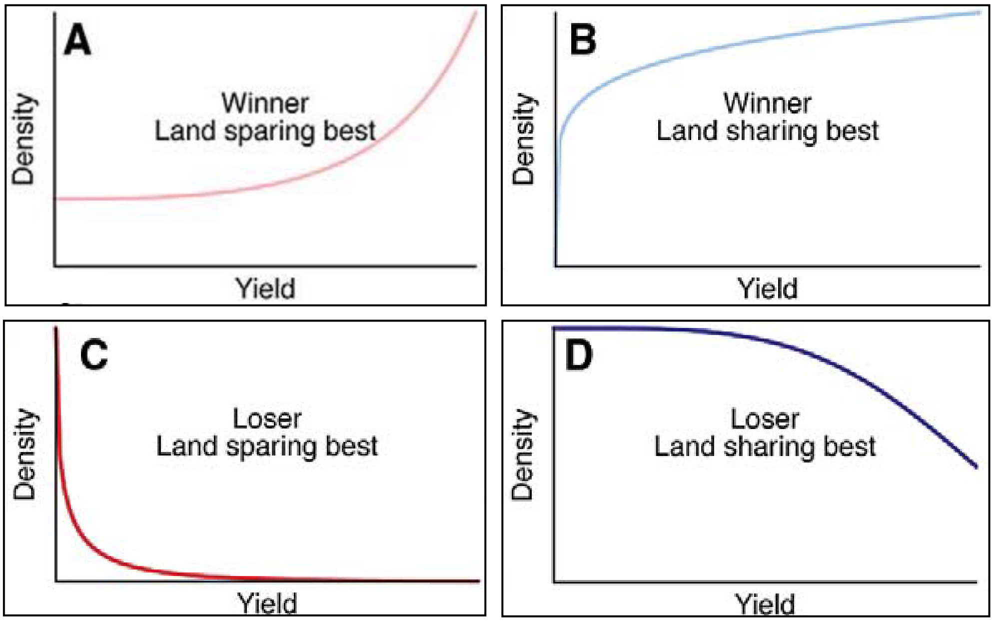
Production and conservation spatially integrated	Production and conservation spatially separated
Lower production per unit area of agricultural land	Higher production per unit area of agricultural land
Biodiversity benefits through reduction of inputs and retention of non-crop habitats on agricultural land	Biodiversity benefits through protection/restoration of natural habitats
Beneficial to species able to tolerate moderate levels of disturbance	Beneficial to species sensitive even to low levels of habitat disturbance

Figure from Phalan (2012) *Presentation to the ECCB, Glasgow*[5]

Box 2. Density-Yield Functions

Green *et al*. (2005)[2] developed a model to evaluate these different land-use strategies. They showed that the optimal land-use strategy to provide a **given amount of food** and **conserve as many species as possible** will depend on how each individual species' population density responds to increasing agricultural yields. This response is known as a **density-yield function**.

Some representative examples of such relationships are shown in below.



Type **A** and **B** species have higher population densities on farmland than in natural habitats: they are "**winners**" that benefit from agriculture.

Type **C** and **D** species have lower population densities on farmland than in natural habitats: they are "**losers**" that decline with agriculture. Losers are likely to be of concern because their populations are sometimes or always reduced by farming.

Type **A** and **C** species will have higher total populations under a **land sparing** strategy.

Type **B** and **D** species will have higher total populations under a **land sharing** strategy.

Figures taken from Phalan *et al.* (2011) *Science*[4]

Food Production and Biodiversity Conservation in Europe

Previous studies aiming to evaluate different land-use strategies using Green *et al.*'s model have focused on tropical and subtropical forest biomes where the greatest threat to biodiversity is the conversion of natural habitats to agricultural land[4]. Phalan *et al*. present results for bird and tree species in SW Ghana and N India. Population densities were estimated for a total of 341 bird species and 260 tree species at sites in forests, and low- and high-yielding farmland. In these two systems, most species (particularly those of conservation concern) would have larger populations under **land sparing**: their population densities were substantially lower even in low-yielding farmland than in natural habitats. This is perhaps unsurprising where many species are highly sensitive to habitat disturbance of any sort.

By contrast, in Europe the broad-scale conversion of natural habitats to agriculture largely occurred many centuries ago[6], and the greatest present threat is perceived to be the widespread intensification of extensive mixed farming systems to high-input, high-yielding arable land, which began in the early-twentieth century[7]. Here, it might be reasonable to expect that Quaternary glaciation alongside prolonged exposure to agriculture may have filtered out those species most sensitive to habitat disturbance. These processes may have yielded a more resilient biota that could potentially fare better under a land sparing approach.

In Europe such an approach, which aims to limit the negative effects of agricultural intensification, currently forms the basis of agri-environment payments to farmers (for which the EU allocated €22.2bn for the period 2007-2012[8]) as well as many certification schemes[2-4], and is advocated by a wide range of conservation NGOs. However, this position is not based upon **evidence** as to which approach best meets given production targets at the lowest cost to biodiversity.

An assessment of the relative merits for biodiversity of different land-use strategies in Europe is vital: the agricultural sector of the EU's new member states is changing rapidly, and the environment is a key driver in the debate surrounding the future of the EU's Common Agriculture Policy (CAP). In addition, the EU's Biodiversity Strategy suggests exploring ways in which its targets can be incorporated into other policy fields such as agriculture and land-use[9].

Project Information

This is a NERC funded Open CASE Studentship based at the Department of Zoology, University of Cambridge, UK, with BirdLife International as the CASE partner. Collaborating organizations include the Royal Society for the Protection of Birds (RSPB) in the UK and Ogólnopolskie Towarzystwo Ochrony Ptaków (OTOP), the BirdLife partner in Poland. The project is supervised by Prof. Andrew Balmford (University of Cambridge), Prof. Rhys Green (University of Cambridge & RSPB) and Dr. Ian Burfield (BirdLife International).

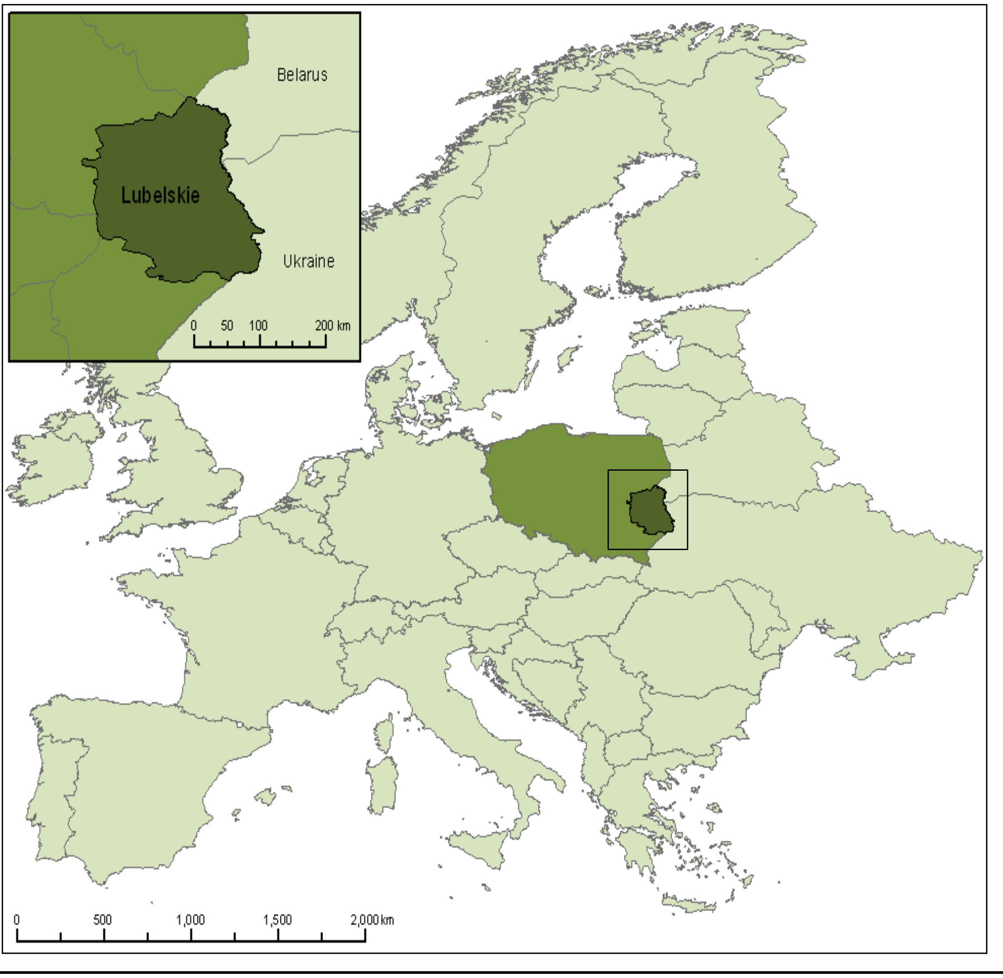
Project dates: 01/10/2011 – 01/10/2015.

Why Poland?

The field work for this project is focussed in Poland which is ideally suited as a starting point for tackling these research questions in Europe. Centrally located, the suite of species present has been influenced by two million years of habitat change- first natural, as a result of repeated glaciations, and then anthropogenic, due to the rise and spread of human civilizations. Poland still supports relatively large areas of intact wetland and forest habitats which can act as zero-yielding baselines, as well as providing a wide range of agricultural productivity, from low-yielding mixed farmland mosaics, to high-yielding arable land, and so is well suited for assessing species' population densities across a range of agricultural yields. Poland's average annual wheat yield (4.17t/ha in 2009[10]) is comparable to many other Central and Eastern European (CEE) countries including Hungary, Romania, Lithuania, and Slovakia[10], potentially helping to extend the relevance of the research into wider Europe, and in particular to a region with considerable latent potential for increasing agricultural yields[11]. Its accession into the EU in 2004 has meant that Poland is now undergoing rapid transformation within its agricultural sector, and can act as a useful case-study in terms of the role of the CAP in reconciling biodiversity conservation and food production in the EU.

Box 3. Study Region

The Lubelskie region in eastern Poland was selected as the focal area for this project as it includes a diverse range of land-use types: natural habitats including mixed/deciduous forests and wetlands; low- and mid-yielding farmland mosaics and high-yielding arable areas.



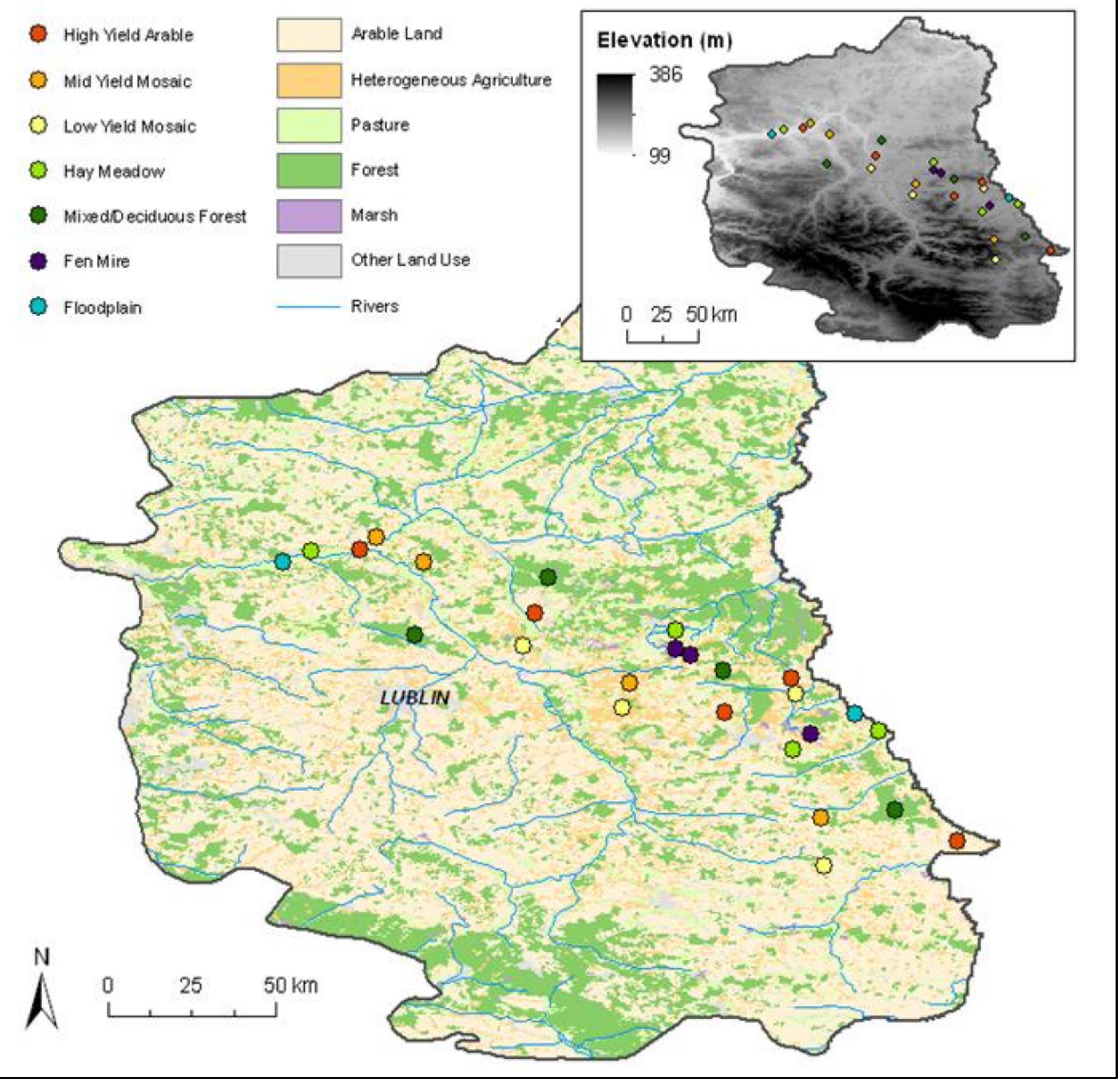
Site Selection

Based on similar studies, I selected 26 study sites 1km^2 in size (with the aim of estimating population density trends at a landscape scale). To minimise edge effects, I aimed to include a 250m buffer around each site. In order to limit the effect of other confounding variables, sites were matched climatically, topographically and in terms of soil type.

Zero-yielding baseline habitats were selected based on best available estimates of the habitats that would exist in Poland in the absence of agriculture. Following assessment of the available literature along with Potential Natural Vegetation maps of the region and consultation with a local expert (J. Krogulec, OTOP) **old-growth mixed/deciduous forests**, **fen mires** and **floodplains** were selected as baseline habitats.

Due to the range of baseline habitats, it was impossible to select all the study sites on a single soil type. In order to control for any confounding effects this may have on biodiversity, sites across a range of agricultural yields were selected on each broad soil type for which I had a baseline site. Agricultural sites include **high-yielding arable** land, and **low/mid-yielding mixed farmland mosaics** (comprising arable land, meadows, pastures, and areas of non-crop habitats). Managed **hay meadows** were also included as they are widespread in the study area and can act as the first stage of conversion from natural habitats to arable farmland

Box 4. Study Sites



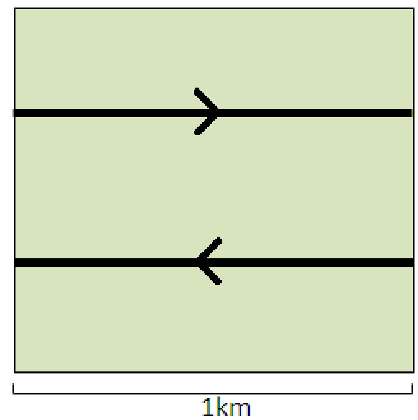
Data Collection

In order to quantify the relationship between food production and biodiversity conservation, data are needed on the **population densities** of a wide range of species in sites with **increasing agricultural yield**, from an intact-habitat baseline, through low and intermediate yielding, to high-yielding farmland.

Previous studies have focussed on birds and trees (often used as bioindicators), and this approach has formed the core of data collection for this project so far, although I also hope to include at least one additional taxonomic group.

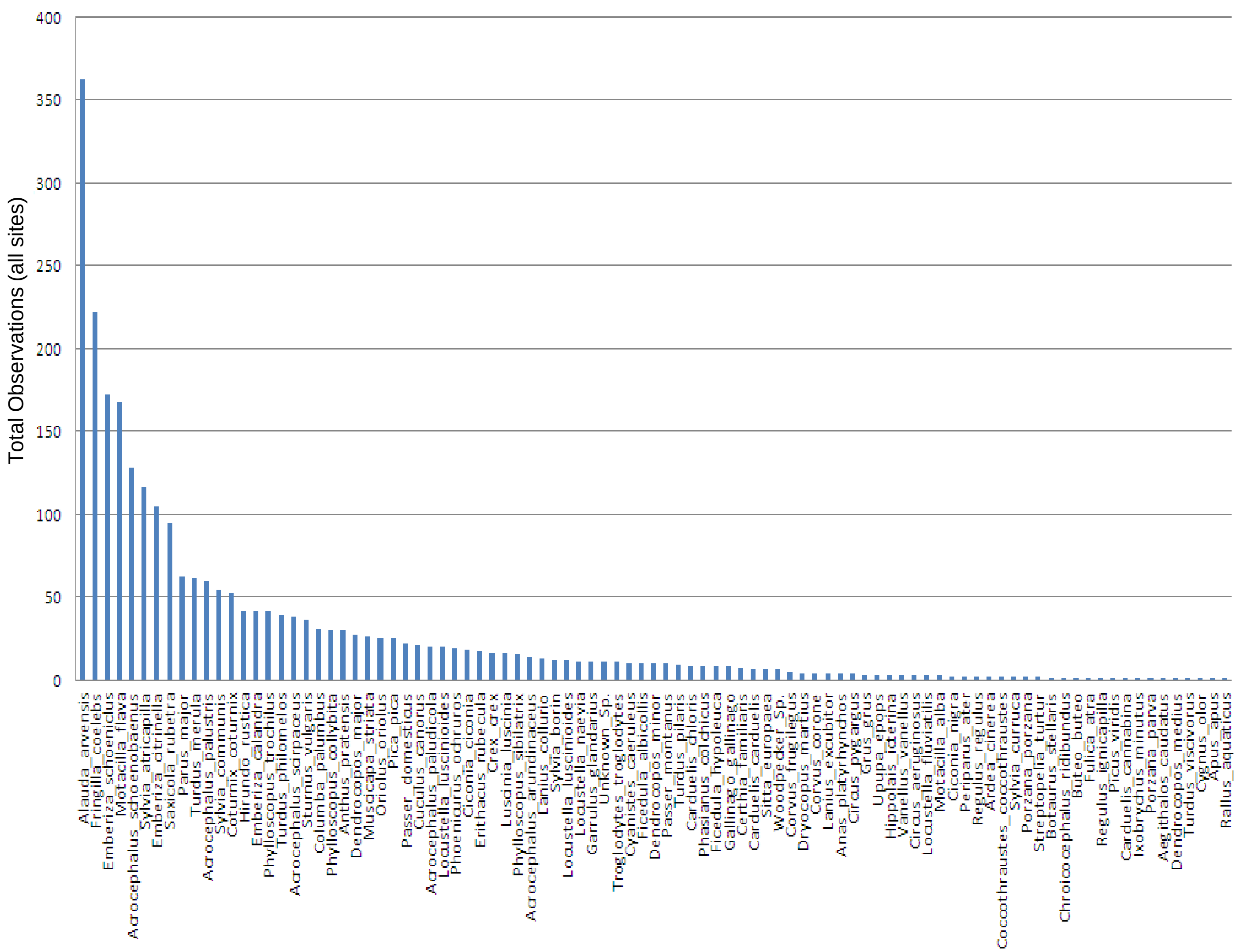
Box 5. Bird Data

All sites are surveyed following similar methodology of the Polish Common Bird Monitoring Scheme (*Monitoring Pospolitych Ptaków Lęgowych, MPPL*). Distance-sampling techniques are used to improve the accuracy of population density estimates



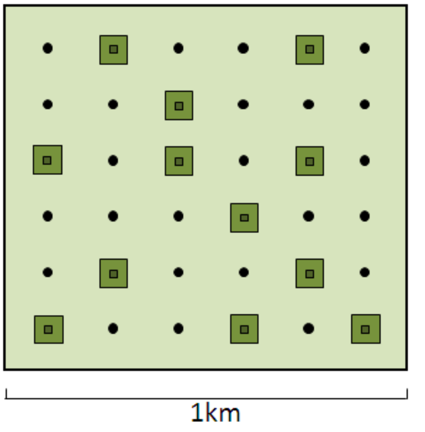
The breeding season is divided into "early" (mid-April to late-May) and "late" (early June to mid-July). Sites will be surveyed once during each of these periods in 2013, and both surveys will be repeated again in 2014 (208 transects in total). I also plan to include at least one evening survey per site, in order to improve density estimates for crepuscular and nocturnal species, some of which are among the species of highest conservation concern in the study area.

In 2012, preliminary data was collected from each study site during the late-breeding season (a total of 52 transects). This included a total of over 2,500 observations from more than 90 species (initial raw count data shown below). This data will be analysed prior to the next field season.



Box 6. Tree Data

The population densities of tree species will be estimated for each of the 26 study sites.



Within each site, a regular grid of 36 points spaced 160m apart were positioned using a GIS. Of these, points were randomly selected to act as centroids within the tree plots. A greater sampling effort was used for non-forest sites (24 plots) compared to forest sites (12 plots), as trees were present at much lower densities in wetlands and agricultural areas.

A nested sampling design was used: a $10m^2$ plot in which all trees with a diameter at breast height (DBH) >5cm were measured, within a $25m^2$ plot in which all trees with a DBH >10cm were measured.

A majority of tree data collection was completed in 2012. Trees were counted in a total of 576 plots across the 26 study sites. As well as collecting data on individual tree species densities', DBH measurements and height estimates were also taken for the purposes of estimating above ground carbon storage. This data will be analysed prior to the next field season.

Box 7. Agricultural Data

In order to then estimate the total yield for each square, detailed crop maps are required so that the total area under each crop-type can be calculated.

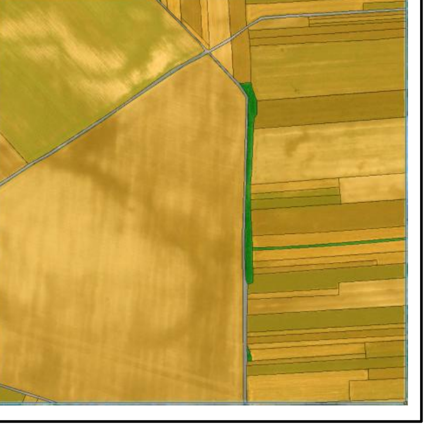
Preliminary crop mapping was completed during the first field season using land boundary data accessed via *maps.Geoportal.gov.pl* (cadastre data provided by *Centralny Ośrodek Dokumetacji Geodezyjnej i Kartograficznej Głównego Urzędu Geodezji i Kartografii, CODGIK*), although this data set often proved inconsistent.

Subsequently, improved field boundary maps have been produced for each site using a GIS and satellite imagery. Where possible, this will be combined with the preliminary crop data, and will be checked during the 2013 field season, and additional data collected where necessary.

Estimates of average yields for individual crops (based on soil type, climate, and locally reported yield figures) will then be used to produce a total yield estimate for each study site. Potential collaborators have been approached to begin this process.

These estimates will then be calibrated using data collected within each study site (farmer interviews/in-field yield estimates from a subset of the total area). For this process, I hope to collaborate with a Polish agricultural research institute.

A key aim of this research is to identify a set of plausible scenarios of future land-use change in the study region, based on realistic production targets and consistent with recent trends in land-use change and agricultural yields. As well as using available regional, national and international datasets, I am keen to collect additional data on how local farmers and agricultural experts predict that land management may change in the near future. This may also require collaboration with a Polish agricultural research institute.



Project Development

In addition to the current data collection focussing on birds and trees, I am also interested in studying the relationship between agricultural yield and population densities of **carabid beetles**. This invertebrate group contains species that specialise in a range of different habitat types, and could provide a valuable ecosystem service in the form of pest control. This is a key area of on-going project development.

I also hope to select an additional **herbaceous plant** group that is more appropriate for assessing the density-yield relationship in open habitats (in particular the wetland baselines and hay meadows). One possibility is to focus on *Cyperaceae* (sedge) species, although this is likely to be very time consuming and will require a specialist. Alternatively , a flowering plant group, e.g. *Silene* and related genera (the campions) may be more easily studied. I am happy to discuss research ideas in this area.

Potential for Collaboration

I am currently preparing for the project's second field season which will run from April to August 2013. I hope to find Polish institutions interested in collaborating on this research. In particular, I would like to find Undergraduate or Masters students interested in field research. Ideally, the student would be a native Polish speaker with basic English. I would welcome ideas on the exact focus of their research, but I can offer the most support in the following areas:

- Collection of population density data for **carabid beetles**
- Collection of population density data for an herbaceous **plant group**
- Collection of population density data for **crepuscular and nocturnal birds**
- Collection of data in relation to **agricultural yields**




The project offers a framework of 26 study sites (with potential to add additional sites if necessary) that are matched for variables including soil/climate/altitude/topography. For each site, data will be available on land use and crop cover in addition to the studied taxa. Study sites vary in terms of the proportions of non-crop habitats, as well as other variables associated with agricultural intensification (field size, field boundaries, variety of crops, management practices etc.), and so are potentially suitable for answering a range of research questions.

In addition to support and supervision from the research group at the University of Cambridge, I would be able to provide logistical support for the project (equipment etc.), and transport to the field-sites (either with myself, or we could offer payment for fuel). I may be able to cover some further expenses if necessary, for example accommodation or subsistence.

Should the field season prove successful, it may be possible for a student to visit the University of Cambridge for a few weeks during Autumn/Winter 2013. They would be able to work closely with our Conservation Science research group and help with the analysis of the data. We may be able to help build links with other research groups should they wish.

Box 8. Contact Information

I would be happy to provide further information on the project, and would be keen to discuss any potential research ideas. Please feel free to pass this information along to any colleagues or other research groups that may be interested in collaborating on this project.

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References

1. Godfray H. C., Crute I. R., Haddad L., Lawrence D., Muir J. F., Nisbett, N., Pretty, J., Robinson, S., Toulmin, C., Whiteley, R. (2010) The future of the global food system. Feeding the world healthily: the challenge of measuring the effects of agriculture on health. *Philosophical Transactions of the Royal Society, B* **365**:2769-2777.
2. Green, R. E., Cornell, S. J., Scharlemann, J. P. W., Balmford, A. (2005) Farming and the fate of wild nature. *Science* **307**: 550–555.
3. Balmford, A., Green, R. E. and Scharlemann, J. P. W. (2005) Sparing land for nature: exploring the potential impact of changes in agricultural yield on the area needed for crop production. *Glob. Change Biol.* **11**: 1594–1605.
4. Phalan, B., Onial, M., Balmford, A., & Green, R. (2011) Reconciling food production and biodiversity conservation: land sparing and land sharing compared. *Science* **333**, 1289-1291
5. Phalan, B. (2012) How Might We Make Space for Nature in Landscapes of the Future? *Presentation to the ECCB, Glasgow*
6. Kaplan, J., Krumhardt, K. M., & Zimmermann, N. (2009) The prehistoric and preindustrial deforestation of Europe. *Quaternary Science Reviews* **28**: 3016-3034.
7. Benton, T. G., Vickery, J. A. & Wilson, J. D. (2003) Farmland biodiversity: is habitat heterogeneity the key? *Trends in Ecology and Evolution* **18**: 182-188.
8. European Court of Auditors (2011) *Special Report No 7/2011: Is agri-environment support well designed and managed?* Luxembourg: Publications Office of the European Union.
9. European Commission (2011) Our life insurance, our natural capital: an EU biodiversity strategy to 2020. *Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of Regions*. Brussels .
10. GUS - Central Statistical Office (2011) *Statistical Yearbook of Agriculture 2011*. Halina Dmochowska (ed.) Warsaw. Available at: http://www.stat.gov.pl/cps/rde/xbcr/gus/sy_statistical_yearbook_agriculture_2011.pdf
11. Foley, J.A., Ramankutty, N., Brauman, K.A., Cassidy, E.S., Gerber, J.S., Johnston, M., Mueller, N.D., O'Connell, C., Ray, D.K., West, P.C., Balzer, C., Bennett, E.M., Carpenter, S.R., Hill, J., Monfreda, C., Polasky, S., Rockström, J., Sheehan, J., Siebert, S., Tilman, D., Zaks, D.P.M. (2011) Solutions for a cultivated planet. *Nature* **478**, 337–342.