Institution: University of Cambridge

Unit of Assessment: UoA5

Title of case study: A framework for establishing how to increase global food production at least cost to biodiversity

1. Summary of the impact (indicative maximum 100 words)

Meeting rapidly rising food demands at least cost to biodiversity is one of the greatest challenges facing humanity. Since 2005, research in the Department of Zoology has demonstrated that measures to reconcile biodiversity and agricultural production are sometimes best focused on spatial separation (land sparing) rather than integration (land sharing).This work has had a significant impact on policy debate, and has informed policy decisions relating to management of the agri-environment at both national and international levels. Policy statements on increasing food production at least cost to nature now make explicit the potential role that land sparing may have, and place greater emphasis on the need for clear scientific evidence of costs and benefits of different approaches.

2. Underpinning research (indicative maximum 500 words)

Since 2003, a major research programme within the Conservation Science Group (CSG) in the Department of Zoology has focused on identifying which farming methods provide sufficient crop yields to feed the world's population, whilst having the lowest impact on biodiversity. This work has been led by Professor Andrew Balmford (Professor since 2007), and Professor Rhys Green (Honorary Professor since 2003). Other group members who made a significant contribution have been Ben Phalan (PDRA since 2005, now Zukerman Research Fellow), Jörn Scharlemann (PDRA 2003-05), and Robert Ewers (Zoological Society of London Fellow 2005-07).

Food production accounts for roughly 37% of global land area and is by far the greatest current threat to biodiversity worldwide. Yet the debate has been polarised between conservationists and agriculturists. Conservationists have typically argued for wildlife-friendly farming, or land sharing, whereby existing farmland is made hospitable to other species. Agriculturalists are concerned that land sharing lowers crop yields and hence have argued for land sparing, increasing yields on existing farmland but sparing unmodified habitat from future clearance.

In 2005, the CSG produced a model[1] which enabled a quantitative comparison of the impacts of land sharing and land sparing on individual wild species, by evaluating the relationship between species' population densities and crop yields on both farmed and unfarmed land. By extrapolation, this modelling of density-yield functions also allowed the impacts of different farming systems on the overall biodiversity value of a particular area to be determined. This was the first publication in the scientific literature to quantify how land sparing could be more effective than land sharing in conservation terms, particularly for the large number of wild species whose numbers decline rapidly even on low-intensity farmland; it also demonstrated the importance of the shape of density-yield functions to making informed conservation choices. Parallel work[2] by the CSG established that future increases in crop yields will have a major impact on the area under agricultural cultivation (likely to decrease in the developed world, but increase in the developing world due to population growth and growing per capita consumption), illustrating the importance of considering crop yields and long term agricultural development in the design of land management schemes if these are to have a real net positive benefit on wildlife. Using pre-existing datasets, the CSG then demonstrated[3] (2009) that developing countries have historically displayed a weak association between increases in crop yields and decreasing per capita cropland area, and that this inadvertent land sparing had provided real conservation benefits. Follow-up work[4] in 2011 assessed how different existing land-use strategies could be more accurately evaluated in terms of their impact on wildlife, and set out the necessary improvements required of empirical studies to improve the complexity of the CSG's model and increase its applicability in real-world situations. At the same time, the CSG provided the first empirical tests of the model[5] using evidence gathered from Ghana and India to construct density-yield functions for different bird and tree species. The research demonstrated that most species were more likely to see a positive benefit from land sparing than land sharing, provided the habitats that were 'spared' were properly protected for

wildlife. The CSG has since undertaken further empirical studies in Mexico, Poland and Brazil, in order to expand the evidence base, and has also used the model to examine the consequences of proposed reforms to the EU's Common Agricultural Policy. Other academic groups now use the model to shape their own research in this area (see for example Hodgson et al. doi:10.1111/j.1461-0248.2010.01528.x).

3. References to the research (indicative maximum of six references)

1. Green, R.E., S. Cornell, J.P.W. Scharlemann & A. Balmford. 2005. Farming and the fate of wild nature. *Science* **307:** 550-555. DOI: 10.1126/science.1106049
2. Balmford, A., R. Green & J.P.W. Scharlemann. 2005. Sparing land for nature: exploring the potential impact of changes in agricultural yield on the area needed for crop production. *Global Change Biology*. **11:** 1594-1605. DOI: 10.1111/j.1365-2486.2005.001035.x
3. Ewers, R.M., J.P.W. Scharlemann, A. Balmford & R.E. Green. 2009. Do increases in agricultural yield spare land for nature? *Global Change Biology* **15:** 1716-1726. DOI: 10.1111/j.1365-2486.2009.01849.x
4. Phalan, B., A. Balmford, R.E. Green & J. Scharlemann. 2011. Minimising the harm to biodiversity of producing more food globally. *Food Policy* **36:** S62-S71. DOI:10.1016/j.foodpol.2010.11.008
5. Phalan, B., Onial, M., Balmford, A. & Green, R.E. Reconciling food production and biodiversity conservation: land sharing and land sparing compared. 2011. Science 333: 1289-1291. DOI: 10.1126/science.1208742

Relevant funding:

- RSPB, £42,000 (2003-2005): Balmford and Green (co-PIs)
- Newton Trust, £33445 (2009-2011); RSPB, £30,000 (2009-2011); UNEP-WCMC £5000 (2009-2010): Balmford (PI) to support Ben Phalan
- Zukerman Research Fellowship, King's College Cambridge: Ben Phalan (Oct 2012-present)

4. Details of the impact (indicative maximum 750 words)

Impacts on public policy and services

The research outlined above has had a significant influence on the policy debate surrounding the future of farming and associated conservation measures in the UK, the EU, and globally. The CSG was one of the initial advocates for land sparing to be considered alongside land sharing by both academics and policy makers, which in itself has considerably broadened the scope of the policy debate. The political relevance of this work was illustrated by the formal commissioning of the CSG in 2010 by the UK Government Office for Science to provide part of the evidence base for the Government's Foresight project into 'The Future of Food and Farming'. The resulting publication[4] (which acknowledges the commission), along with other published work of the group[1], was distilled into the final Foresight report[6] (2011), with Green and Phalan invited to a 'Stakeholders meeting' in July 2010 to provide formal inputs[13].

The Foresight report identified five challenges for ensuring sustainability in the global food system, each of which were supported by synthesis reports which provided detailed scientific evidence and analysis. One of the five identified challenges was 'maintaining biodiversity', the synthesis report for which[7] was underpinned by the work of Balmford and colleagues (specifically citing a number of publications by the group, including refs 1 and 3, section 3). The One Year Review of the Foresight project[8] (2012) cited a number of national and international impacts that are directly attributable to the 'maintaining biodiversity' strand of the 2011 report, namely:

- The **Department for the Environment, Fisheries and Rural Affairs (DEFRA)** used the evidence to 'support [international] action … to protect the world's resources and biodiversity', including 'identifying those species for which targeted conservation action will deliver a broad range of consequential benefits, including for ecosystem services'. In addition, following publication of the Foresight Report and a Natural Environment White Paper (June 2011), 'Defra has played a significant role in establishing a global indicator framework for biodiversity'
- The **Department for International Development (DfID)** 'has commissioned a number of systematic reviews in key areas to strengthen the evidence base for its policy and practice to link climate change, hunger, poverty, biodiversity and energy'
- **Natural England** 'has commissioned research into the ecosystem services provided by

agri-environment schemes'

- At the **United Nations Food and Agriculture Organisation**, 'The arguments on sustainable intensification and food security … particularly with regard to Challenge E [maintaining biodiversity] … contributed partly to the impetus for establishing at FAO a new initiative: the World Agricultural Watch Initiative (WAW) focused on monitoring the social, economic and agricultural impacts of the global phenomenon of agricultural transformations'.

Details of the media impact of the report itself can be found on the Foresight website[9].

Specialist Advisory Roles

Other inputs into national policy debate have arisen from Balmford's invitation to discussions with various organisations such as Leaf (Linking Environment And Farming, UK; Dec 2011)[14] and the Royal Agricultural Society of England (Oct 2011)[15], and in late 2012, with Lord Cameron of Dillington, chair of the Strategy Advisory Board for the UK's Global Food Security Programme, an initiative of the UK's main funders of food-related research (primarily Government and the Research Councils). In 2012, the CSG's work was also the basis for a Parliamentary POSTNote[16], with Phalan providing substantial input into the finished document[10]. The CSG has also been asked to advise on studies from the British Trust for Ornithology (Uganda)[11] and RSPB (Kazakhstan) (currently under review).

Impacts on international development

In addition to the direct impact the 'maintaining biodiversity' strand of the Foresight report had on the UN FAO as stated above, CSG members have been invited to present the nature of the trade-off between land sharing and land sparing at various meetings of policy makers, national governments and national and international organisations outside of the UK, including:

- on the Common Agricultural Policy and biodiversity at 'Biodiversité et agricultures', Montpellier, 4-5 Nov 2008, a conference organised by the French Ministries of Higher Education and Research, and Agriculture and Fishing
- on the results of the 2011 work[4,5] from a policy perspective at the CIFOR (Centre for International Forest Research) Learning Event at the United Nations Conference on Sustainable Development (Rio+20) in Rio de Janeiro (June 2012).

Two of the Group's academic publications (including ref 2 section 3) are cited in the United Nations Environment Programme (UNEP) seven point plan to reduce the risk of hunger and of rising food insecurity, published in 2009[12]. The report was commissioned to support the then UN Secretary-General Ban Ki-moon's task force on the world food crisis, and one of the seven options it proposed was to 'support farmers in developing diversified and resilient eco-agriculture systems that provide critical ecosystem services (water supply and regulation, habitat for wild plants and animals, genetic diversity, pollination, pest control, climate regulation), as well as adequate food to meet local and consumer needs'.

Impacts on the environment

The above impacts on national and international policy debate and policy decisions on the environment, will have had an effect, and continue to have an effect on the environment worldwide.

5. Sources to corroborate the impact (indicative maximum of 10 references)

6. Foresight 2011. *The future of food and farming*. *Final project report.* The Government Office for Science, London. www.bis.gov.uk/assets/foresight/docs/food-and-farming/11-546-future-of-food-and-farming-report.pdf
7. Foresight 2011. *Foresight project on global food and farming futures. Synthesis report C13: Maintaining biodiversity and ecosystem services while feeding the world.* The Government Office for Science, London. www.bis.gov.uk/assets/foresight/docs/food-and-farming/synthesis/11-633-c13-maintaining-biodiversity-ecosystem-feeding-the-world
8. Foresight 2012. One Year Review January 2011-March 2012 – Global Food and Farming Futures. The Government Office for Science, London http://www.bis.gov.uk/assets/foresight/docs/food-and-farming/12-831-one-year-review-global-food-and-farming-futures.pdf
9. Media impact for Foresight project: www.bis.gov.uk/foresight/our-work/projects/published-projects/global-food-and-farming-futures/media-impact

10. Parliamentary Office of Science and Technology. Balancing Nature and Agriculture. POSTNote 418, September 2012. www.parliament.uk/briefing-papers/POST-PN-418
11. Hulme MF, Vickery JA, Green RE, Phalan B, Chamberlain DE, et al. (2013) Conserving the Birds of Uganda's Banana-Coffee Arc: Land Sparing and Land Sharing Compared. PLoS ONE 8(2): e54597. doi:10.1371/journal.pone.0054597
12. The environmental food crisis – The environment's role in averting future food crises. A UNEP rapid response assessment. 2009. United Nations Environment Programme, GRID-Arendal. www.grida.no/files/publications/FoodCrisis_lores.pdf

Corroborating contacts:

13. Chair of the 2011 Foresight Report 'The Future of Food and Farming'
14. Integrated Farm Management Development Co-ordinator, LEAF
15. Head of 'Practice with Science' at the Royal Agricultural Society of England
16. Parliamentary Office of Science and Technology (and one of the authors of the cited POSTNote)