Balancing agricultural production and conservation

Setting out the production and environmental challenges facing farming

Globally, agriculture is facing an unprecedented set of pressures over the coming decades. Global population currently stands at seven billion people, and is predicted to rise to over nine billion by 2050. Demand for food will increase while competition for land, water and energy intensify. Farming will have to adapt to climate change, while reducing its own contribution to greenhouse gas emissions, and playing its part in enabling the adaptation of wildlife and society to changing climate conditions. The production and environmental challenges facing farming are inextricably linked: the natural environment provides the resource base on which production is completely dependant, and farming itself plays a major role in shaping the environment.

Production

The UK's Government Office for Science published its Foresight report on "The Future of Food and Farming" in 2011[1]. This major piece of work explores the pressures on the global food system between 2011 and 2050. The report emphasises that, to date, the food system continues to provide plentiful food for the majority of the world's population. However, the system is failing in two major ways: hunger remains widespread, while simultaneously a billion people are risking damage to their health by *over*-consuming. Secondly, many systems of food production are unsustainable, degrading the environment and compromising the world's ability to produce food in the future.

The Foresight report states that in future more food will need to be produced globally to feed the growing population. However, this is far from being the full story. The report stresses that food production systems must be *sustainable*, and must also address climate change: "Nothing less is required than a redesign of the whole food system to bring sustainability to the fore". The report recommends "sustainable intensification": increased production without the use of substantially more land and with diminishing overall impact on the environment. This raises the question of *where* intensification can and should take place. While future advances in science and technology may be able to raise the upper limits of sustainable production, it is estimated that simply applying existing knowledge and technology could increase average yields two- to threefold in many parts of Africa. In developing countries, increasing the productivity of agriculture through sustainable farming systems using appropriate technology has the potential to lift people out of poverty through creating jobs, increasing incomes, reducing food prices and empowering socially excluded groups, as well as improving physical access to food. Although the term "intensification" is usually associated with high-input, high-technology farming, it can equally well be applied to an increase in yields through intensification of *knowledge* and *labour* input[2].

[1] Foresight: The Future of Food and Farming (2011) Final Project Report. Government Office for Science, London.
[2] An approach advocated, for example, in the FAO's "Save and Grow" report (2011) and referred to in Phalan, B. *et al.* (2011) Reconciling food production and biodiversity conservation: land sharing and land sparing compared. Science 333: 1289

As well as sustainably increasing total global production, tackling food security will require addressing issues of waste and consumption. If current estimates are correct, halving the amount of waste we currently produce could reduce the food required by 2050 by an amount approximately equal to 25% of today's production. Changing people's diets through policy mechanisms is acknowledged to be difficult, but not impossible, and could play a significant role in achieving food security because different foods vary in the resources required for their production.

The Foresight report sets out the challenges facing the food system, and makes an extensive set of policy recommendations. As stated in the report: "The solution is not *just* to produce more food, or change diets, or eliminate waste. The potential threats are so great that they cannot be met by making changes piecemeal to parts of the food system." *Sustainable intensification* (where this term is not restricted to increasing artificial inputs but can include a shift to more knowledge- or labour-intensive systems) certainly seems to be a desirable approach in those parts of the world where productivity is currently extremely low. It is more questionable whether there is much potential to *sustainably* increase yields further in high-input systems such as those dominant in many parts of the UK, or indeed whether this is necessary to improve global food security.

Environment

The Foresight report highlighted that "many systems of food production are unsustainable"[3]. The National Ecosystem Assessment, also published in 2011, paints a more detailed picture of the condition of the UK's ecosystems, including agricultural habitats[4]. It states that enclosed farmland is a vital habitat in the UK in terms of food production and provision of cultural benefits, but also imposes important negative effects including greenhouse gas emissions, diffuse water pollution and losses to biodiversity. Food production is just one of a range of ecosystem services farmland can provide. In the past, policies that encouraged farmers to maximise food production have led to an increase in external environmental costs and a decrease in the other ecosystem services provided. For example, levels of carbon stored in arable and horticultural soils fell between 1998 and 2007, while populations of some pollinating insects such as honeybees are known to have declined significantly. Some environmental impacts of farming, such as non-carbon dioxide greenhouse gas emissions, ammonia emissions and nitrate pollution of waterways have been reduced (but not eliminated) since 1990, due to both improvements in farming practices and to a slowdown in the increase in total agricultural productivity.

A report in 2009[5] attempted to define the "safe operating space" for humanity with respect to the Earth's biophysical systems. The authors identified disruption to the nitrogen cycle and biodiversity loss as the two areas where we are most seriously exceeding our safe limits. Agriculture plays a key role in both of these areas.

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[3] Final project report, Executive Summary, p10

[4] UK National Ecosystem Assessment (2011). The UK National Ecosystem Assessment: Synthesis of the key findings. UNEP-WCMC, Cambridge.

[5] Rockström, J. *et al*. (2009) A safe operating space for humanity. Feature in Nature, Vol. 461.

The use of nitrogen fertilisers has allowed a growing world population, but has considerable adverse effects on the environment and human health. The European Nitrogen Assessment identified five key societal threats of reactive nitrogen: to water quality, air quality, greenhouse balance, ecosystems and biodiversity, and soil quality. A cost–benefit analysis concludes that the overall environmental costs of nitrogen pollution in Europe (estimated at €70–€320 billion per year at current rates) actually outweigh the direct economic benefits of nitrogen in agriculture[6].

Declines in populations of wildlife associated with farmed land are well-documented. In the UK, as in Europe as a whole, farming is the dominant land use and biodiversity is inextricably linked with how this land is managed. Agriculture has shaped Europe's biodiversity over the centuries, with the result that many of Europe's most valued species and habitats today are dependent on the continuation of certain agricultural practices. Of the 231 habitat types of European interest targeted by the EU Habitats Directive, 55 depend on extensive agricultural practices or can benefit from them. Similarly, 11 targeted mammal species, seven butterfly species and 28 plant species depend on a continuation of extensive agriculture.[7]

Changes in the countryside since the Second World War have been largely driven by policies targeted at increasing food production; in particular the Common Agricultural Policy. These changes can broadly be described as the intensification and specialisation of farms: removal of hedges, a shift from autumn to spring-sown crops, increased use of synthetic fertilisers and pesticides, and a decline in mixed farming (farms incorporating both livestock and arable crops). While these policies were highly successful in their aim of increasing food production, an unwanted side-effect was a decrease over time in the diversity and quality of wildlife habitats within the farmed landscape.[8] The Common Agricultural Policy has undergone successive reforms and now includes protecting the environment among its objectives. The shift away from production subsidies and the creation of a Rural Development funding strand represented significant steps towards a more environmentally sustainable policy. In particular, targeted agri-environment schemes have helped farmers and land managers to achieve great improvements for biodiversity and the wider environment in some places.[9] However, to date these improvements have not been enough to compensate for the preceding decades of intensification. Some species in some regions are increasing in response to wildlife-friendly measures put in place by farmers, but well-studied groups such as farmland birds and butterflies continue to decline across the farmed landscape as a whole. Between 1970 and 2009, populations of breeding farmland birds across the UK declined by 49%[10], while in England between 1990 and 2009 populations of specialist farmland butterfly species declined by 39%.[11]

[6] European Nitrogen Assessment (2011). Cambridge University Press, Cambridge, UK.
[7] 10 Messages for 2010: Agricultural Ecosystems. European Environment Agency (2010).
[8] Robinson, R.A. and Sutherland, W.J. (2002) Post-war changes in arable farming and biodiversity in Great Britain. Journal of Applied Ecology 39:157–176
[9] See for example Seeds of Success, Birdlife International (2011)
[10] http://jncc.defra.gov.uk/page-4235
[11] http://archive.defra.gov.uk/evidence/statistics/foodfarm/enviro/observatory/indicators/d/de6_data.htm

Butterflies and birds are indicators of the state of wider biodiversity, so a decline in these groups is taken as indicative of a wider decline in the species that make up agricultural ecosystems. The decline in farmland biodiversity represents a long-term threat to the productivity of agriculture. Biodiversity provides numerous services to farming, including pollination, pest control and nutrient cycling. The value of insect pollination services alone to UK arable farming has been estimated at £400 million per annum[12]. At least as important, although far less well understood, are the functions of soil. Soil is a living resource: its structure, organic content and fertility, its ability to store water or allow it to drain away, and its resistance to pest outbreaks, all depend on the organisms living in the soil. Agricultural management can have a profound effect on soil biodiversity. Inappropriate management such as overgrazing can damage soil biodiversity, with a resultant decline in the services provided by the soil, while good management practices like appropriate crop rotations can enhance soil biodiversity[13]. The precise relationships between biodiversity levels and provision of these ecosystem services are imperfectly understood, which makes it all the more important to halt biodiversity loss as a matter of urgency, rather than risk the collapse of agricultural ecosystems or the loss of key species if declines continue.

The extent to which biodiversity is valued by society, both for its economic and its intrinsic worth, is reflected in policy. The UK Government has signed up to a series of legal commitments and policy aspirations regarding the protection and restoration of biodiversity. As a party to the Convention on Biological Diversity, the UK agreed in October 2010 to a new set of goals and targets for the protection of biodiversity globally.[14] At the European level, a new target was adopted in March 2010: 'Halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, and restoring them in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss.' EU biodiversity targets are partly delivered through a range of legislative measures, which place obligations on Member States to protect biodiversity and the natural environment. The Birds[15] and Habitats[16] Directives provide a legally binding framework for the conservation and management of biodiversity in Europe. Government has set out its own ambitions for the UK in the Natural Environment White Paper: "We will work to improve the quality of our natural environment and will aim to halt the decline in habitats and species, degradation of landscapes and erosion of natural capital."[17]

In summary, now is an extremely challenging time for agriculture. Many current food production systems are unsustainable, and the environmental degradation they are causing is in itself a critical threat to food security[18]. Food systems must urgently be made more sustainable, while simultaneously meeting the challenges of a growing population and climate change. Declines in farmland wildlife are one issue that must urgently be addressed.

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[12] POST, 2010. Insect Pollination POST Note 348. Parliamentary Office of Science and Technology, London.
[13] Turbé, A. *et al.* (2010). Soil biodiversity: functions, threats and tools for policy makers. Bio Intelligence Service, IRD, and NIOO, Report for European Commission (DG Environment).
[14] COP 10 Decision X/2. Strategic Plan for Biodiversity 2011-2020
[15] Directive 2009/147/EC (Birds Directive)
[16] Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora
[17] Defra (2011) Biodiversity 2020: A strategy for England's wildlife and ecosystem services
[18] Foresight: The Future of Food and Farming (2011) Final Project Report. Government Office for Science, London.

The story of the turtle dove

Agri-environment schemes have brought some notable successes in reversing biodiversity declines in some places. For some species, however, populations have yet to show signs of recovery despite continuing efforts by farmers and conservation organisations. This could suggest that the right things are not being done for this species, they are not being done over a large enough area, or that there are other factors at work preventing population recovery. The turtle dove is one such species.

Turtle doves are birds of arable and mixed farmland, within the UK mostly seen in southern and eastern England. They have declined severely across Europe from the 1970s onwards, and have disappeared from many places where they had previously been common. The UK population declined by about 90% between 1967 and 2008[a]. Conservation effort in the UK has included maintaining the mature hedgerows and scrub they need for nesting. However, research has found that the breeding season is getting shorter, with about half the number of clutches and young produced per pair each year than formerly[b]. It is likely that this drop in reproductive output is related to a shortage of favoured food – the seeds of certain weeds such as fumitory – that have declined in farmland and in the diet of turtle doves since the 1960s[c]. Measures funded by agri-environment schemes exist to promote seed food availability on farmland, but these may not be providing the right kind of seed at the right time of year for turtle doves. Ongoing research is testing seed plots that provide key sources of food throughout the summer.

While the drop in young fledged alone is sufficient to explain the population decline, it may be only part of the picture. Turtle doves are migratory: they arrive in the UK in April to breed and leave by September. They winter in west Africa, gathering in huge roosts of up to 1 million birds. In Africa, as in the UK, they eat crop and weed seeds. Research shows that turtle doves are sensitive to agricultural changes in their wintering grounds: in years with high cereal production in west Africa, turtle dove survival rate was higher[d]. During their migration, turtle doves can be shot by hunters as they travel through the Mediterranean region. Climate change may also be a growing threat, for example leading to more frequent and severe droughts in regions they migrate through, and changes in their wintering grounds. Conservation scientists do not yet understand the relative importance of each of these factors in driving turtle dove decline; scientific research (including satellite tagging of birds) is ongoing.

The story of the turtle dove illustrates that, in some cases, conservation objectives for UK farmland species may be only partially achievable within our borders. Like food security, species conservation must be addressed at multiple scales from local to global.

References

[a] BTO website, accessed 25 November 2011

[b] Browne, S.J., Aebischer, N.J. (2004) Temporal changes in the breeding ecology of European Turtle Doves *Streptopelia turtur* in Britain, and implications for conservation. Ibis 146: 125–137.

[c] Browne, S.J., Aebischer, N.J. (2003) Habitat use, foraging ecology and diet of Turtle Doves *Streptopelia turtur* in Britain. Ibis 145: 572–582.

[d] Eraud, C., Boutin, J.-M., Riviere, M., Brun, J., Barbraud, C. & Lormee, H. (2009) Survival of Turtle Doves *Streptopelia turtur* in relation to western Africa environmental conditions. Ibis 151: 186-190.

Approaches to balancing agricultural production and conservation

A variety of tools is deployed in the UK to meet environmental objectives. These may involve designating areas where conservation objectives are to be prioritised (such as Natura 2000 sites, Sites of Special Scientific Interest, Local Wildlife Sites etc); or attempting to influence land management outside of these protected areas through mechanisms such as agri-environment schemes. In the latter case, these efforts may be targeted within certain geographic areas to address a particular environmental need. For example, Catchment Sensitive Farming is an English government initiative that delivers support and advice to farmers within priority river catchments to reduce diffuse pollution from agriculture[19].

To address resource protection issues, it is usually necessary to implement measures in specific places within the farmed landscape; such as bringing fragile soil under appropriate management, stopping a point source of pollution, or introducing buffer zones to protect a waterway from diffuse pollution. In the case of biodiversity conservation, there may be more choice about where and how to target action. If the UK is to meet the needs of both agricultural production and conservation, society will need to consider how to *optimise* its use of land.

One model of land use that attempts to meet both production and biodiversity needs with maximum efficiency is *land sparing.* The idea behind land sparing is that yields should be optimised on existing agricultural land, allowing other land to be "spared" for conservation objectives. This requires *sustainable intensification*, discussed above. The contrasting approach is known as *land sharing*; attempting to meet both agricultural and conservation objectives from the same parcel of land through 'wildlife friendly farming'. A recent study compared the two approaches at study sites in India and Ghana, where remnants of the natural forest vegetation are surrounded by farmland.[20] The study concluded that in this particular situation, land *sparing* was the better strategy: "both countries could produce more food with minimal further negative impacts on forest species if they were to implement ambitious programs of forest protection and restoration alongside sustainable increases in agricultural yield."

As the authors state, this study "is not enough to argue that land sparing is the optimal strategy for reconciling food production and biodiversity conservation everywhere and for all taxa." The authors are also at pains to point out that the success of the land sparing approach depends on proper implementation: increasing yields on farmland does not in itself guarantee protection for other land against the expansion of agriculture. Other authors have raised further concerns about the land sparing model.[21] Land sparing may not be appropriate in countries that lack the means to effectively protect wildlife areas but have a history of sustainable land sharing; in

[19] See http://www.naturalengland.org.uk/ourwork/farming/csf/default.aspx
[20] Phalan, B. *et al.* (2011) Reconciling food production and biodiversity conservation: land sharing and land sparing compared. Science 333: 1289
[21] Fischer, J. *et al.* (2011) Conservation: Limits of Land Sparing. Science 334: 593

systems where both yields and biodiversity are high; where biodiversity depends on agriculture[22]; or where agricultural land is only suitable for non-intensive use (for example because of low rainfall or shallow soil). Furthermore, it is not the case that society must choose between land sparing and land sharing to feed the world's population. There is a continuum of approaches to land management, and each situation should be assessed on its own merits rather than attempting to apply one particular model across the board.

Within the UK, it seems likely that a mixture of approaches will prove to be the most efficient use of land. Protected wildlife areas are a vital conservation tool, and if it is deemed necessary in future to increase agricultural production, this must not be achieved by expanding farming into wildlife areas. There would therefore be a case for increasing the productivity of existing farmland, *where this can be done sustainably* (the land sparing model). However, there are sectors and areas where intensification would not be sustainable. For example, in the UK extensive livestock systems based on semi-natural grazing and low intensity grassland are associated with high levels of biodiversity (including species that are *only* found in these habitats) as well as providing other valuable services such as carbon sequestration in soils.[23] Intensive livestock production, where livestock may be housed for a significant proportion of the time, does not provide these benefits. The negative environmental impacts of intensive systems may be significant and can extend well beyond the farm gate, in particular through growing crops for feed, both in the UK and abroad.[24] This is a clear case for adopting the land *sharing* model, where extensively grazed land provides food alongside other benefits, rather than attempting to pursue intensification.

Organic farming is sometimes cited as an example of land sharing. In terms of agricultural yield, there is much debate over the performance of organic compared to conventional farming. In general, however, the yields of organic farms are expected to be lower than their conventional equivalents in intensively farmed regions such as the UK (it should be noted that in developing countries, the adoption of organic techniques could lead to a significant *increase* in yields)[25]. Organic farming can be beneficial for wildlife due to severe restrictions on the use of chemicals, and perhaps more importantly because of the emphasis on landscape diversity and the inclusion of fallow periods in rotations[26]. Organic farming methods can also have benefits for resource protection, and for climate change mitigation through increasing carbon stores in the soil[27]. Organic farming should be given consideration as one possible way of optimising production and environmental outcomes from the same land parcel.

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[22] See also Wright, H.L. *et al* (2011) Agriculture—a key element for conservation in the developing world. Conservation Letters, DOI: 10.1111/j.1755-263X.2011.00208.x
[23] High Nature Value farming: how diversity in Europe's farm systems delivers for biodiversity. RSPB, Birdlife International and EFNCP, 2011.
[24] Exploring policy options for more sustainable livestock and feed production. Final report for Friends of the Earth. IEEP, 2009.
[25] Erb, K-H. *et al.* (2009). Eating the Planet: Feeding and fuelling the world sustainably, fairly and humanely – a scoping study. Commissioned by Compassion in World Farming and Friends of the Earth UK. Institute of Social Ecology and PIK Potsdam. Vienna: Social Ecology Working Paper No. 116.
[26] Norton, L. *et al*. (2009) Consequences of organic and non-organic farming practices for field, farm and landscape complexity. Agriculture, Ecosystems & Environment 129: 221-227
[27] Smith et al (2011) Soil Carbon Sequestration and Organic Farming: An overview of current evidence. Organic Centre Wales.

Conventional farmland managed under 'broad and shallow' agri-environment agreements could be considered to fall somewhere between the 'land sparing' and 'land sharing' extremes. Some parts of the farm (for example hedgerows, field margins) are managed for biodiversity, while the majority of the land continues to be farmed with the aim of optimising agricultural yields (see the Hope Farm case study below). This approach can prove successful in delivering both food and biodiversity (as well as other benefits such as protecting water courses from pollution), particularly in an arable context.[28] Experience in the UK demonstrates that the success of this approach depends on appropriate management of the non-food producing areas to deliver optimum benefits for biodiversity: the *quality* of the habitat provided is important as well as the quantity.[29] This insight needs to be reflected in future agricultural policy. For example, one of the proposals currently being considered for the Common Agricultural Policy after 2014 is a requirement for arable farmers to keep at least 7% of their land as "ecological focus area". This could include land left fallow, terraces, landscape features and buffer strips.[30] Ecological focus areas could be considered as land sparing at a sub-farm scale. As with any application of the land sparing model, for this approach to be efficient it is vital to optimise the environmental benefits of the 'spared' land. In this case, this could be achieved by using agri-environment schemes to pay for positive management of the land designated as ecological focus area, rather than simply taking this land out of production and doing nothing further with it.

Case study: Hope Farm

Agri-environment schemes support land managers in delivering environmental objectives alongside food production. By applying an appropriate mix of agri-environment options, it is possible to provide sufficient high-quality habitat within the farmed landscape to allow wildlife to flourish, while keeping impacts on food production to a minimum. The RSPB has had some success in applying this approach on its own Hope Farm, an arable farm in Cambridgeshire. This case study demonstrates both what can be achieved within conventional farming systems, and the extent of the challenge still to be addressed.

The RSPB has owned Hope Farm since 1999. It is a 181 ha arable farm, managed using conventional (as opposed to organic) techniques, and in most respects is typical of farms in this part of Cambridgeshire. The farm is currently under a four-year rotation of wheat: spring beans: wheat: oilseed rape. It has been in an Entry Level Stewardship agreement since 2007. The agreement includes 1 hectare of wild bird seed mix, 0.9 hectares of nectar flower mix, 0.05 hectares of beetle bank and 100 skylark plots. In addition, the farm has 1.5 hectares of wild bird seed mix, 1 hectare of nectar flower mix, 2 hectares of sown wild flower headlands and an extra

[28] See for example Agri-environment schemes in England 2009: A review of results and effectiveness. Natural England, 2009.
[29] See for example the 'Farm4bio' project: farm-scale management of uncropped land for biodiversity
[30] See Article 32 in Proposal for a regulation of the European parliament and of the council establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy. European Commission, 2011.

20 skylark plots managed as Campaign for the Farmed Environment voluntary measures[31]. In all, about 8.5% of the arable area is currently out of production, under either agri-environment options or scientific research trials.

The RSPB's original objective in acquiring this farm was to develop, test and demonstrate farming techniques that produce food cost-effectively and benefit wildlife. Success to date has been encouraging. The farmland bird indicator, which continues to show a significant decline in farmland bird populations over the UK as a whole[32], has increased by over 200% on Hope Farm since the RSPB took over management. In addition, ongoing monitoring suggests that butterflies, bumblebees, moths and fungi are benefitting from the way the farm is managed. Over the same period, crop yields have increased in line with other productive arable farms in the area, and compare very favourably with arable farms across England. The farm accounts, which are kept separate from the wider charity's accounts, are published annually on the RSPB's website and demonstrate that the farm is a profitable enterprise.[33]

Hope Farm's achievements to date demonstrate some success in delivering both food production and biodiversity objectives, through judicious use of agri-environment options combined with best practice in farm management. The RSPB, however, recognises that many challenges remain to be addressed to balance agricultural production and conservation on this farm. For example, the RSPB has assessed the ecological status of water bodies surrounding the farm as 'at risk', primarily from phosphate pollution. Measures are in place to reduce pollution in line with best practice for arable farms, but the RSPB is now investigating methods of further reducing diffuse pollution. In addition, the farm's carbon footprint was assessed in 2007. By far the biggest contribution to the farm carbon footprint arose from fertiliser applications, with emissions during both manufacture and application important. The report highlighted that cropping decisions made for both economic and biodiversity reasons in the past 10 years had the unintended positive consequence of reducing the farm's footprint. The RSPB has set an ambitious target of reducing emissions by a further 15% over 5 years.

Like all farmers, the RSPB is constantly faced with decisions on how to balance delivery of environmental public goods and yield – what is best for the farm's profit margin or production may not be best for the wider environment or food production over the longer term. The RSPB believes that agri-environment schemes, developed on the basis of sound scientific evidence, must continue to play a vital role in helping land managers to balance these objectives.

[31] See http://www.cfeonline.org.uk/
[32] http://jncc.defra.gov.uk/page-4235
[33] Source: RSPB website, accessed November 2011

Case study: Tarnhouse Farm

A key finding of the National Ecosystem Assessment[34] was that to maximise the value we gain from our land, society needs to consider the delivery of *all* ecosystem services. Focusing too exclusively on food production can mean we do not get the best from the land in terms of total services provided. On places like Hope Farm, food production is optimised while minimising conflicts with other objectives, like biodiversity and water quality. In other farming systems, the overall value of the land is increased by prioritising functions other than food production.

The RSPB purchased Tarnhouse farm in the North Pennines in 2001. It is a working organic farm of 2041 hectares, with 92 breeding suckler cows and around 500 breeding ewes, and is managed by a tenant farmer. The farm forms part of the Geltsdale nature reserve and has several national and European conservation designations.

Tarnhouse is a mosaic of upland heath, blanket bog and rough grazing habitats. Since taking the farm on, the RSPB has made various changes including introducing cattle (the farm previously had only sheep), decreasing the intensity of heather grazing and rewetting some habitats. So far, the more varied structure created by cattle grazing has led to increases in breeding wader numbers. Black Grouse populations have increased from none in 2003 to 23 males in 2011, bucking the trend of decline the North Pennines generally. Habitats have become more botanically diverse. Wildlife on the farm now includes black grouse, lapwing, whinchat, cuckoo, grasshopper warbler, otter, red squirrel, green hairstreak butterfly, small pearl- bordered fritillary and dark-green fritillary.

Lying within the River Tyne catchment and with around two-thirds of the site based on peat soils, Tarnhouse is also important from both a water quality and carbon perspective. The site's heath and blanket bog is now recovering under current management, having been in unfavourable condition due to historic overgrazing with sheep.

By looking at *all* the functions this land can perform, it has been possible to increase the value of ecosystem services it provides. Although Tarnhouse is on land considered to be agriculturally marginal, it is now producing a wide range of valuable services including carbon storage, water quality, biodiversity and food.

What can government, farmers and conservation organisations do now in the UK?

All stakeholders recognise the extent of the challenges facing farming, although they may place a different emphasis on which challenges are most pressing, and on how they can best be addressed. As stated at the start of this paper, it must be recognised that the challenges of production and conservation are completely interlinked and we cannot address either one in isolation from the other. The Government recognised this in its commitment within the Natural

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[34] UK National Ecosystem Assessment (2011). The UK National Ecosystem Assessment: Synthesis of the key findings. UNEP-WCMC, Cambridge.

Environment White Paper to "bring together government, industry and environmental partners to reconcile how we will achieve our goals of improving the environment and increasing food production"[35].

To meet the challenges facing our food production system, it will be necessary both to raise the limits of agriculture in terms of yield and sustainability, and to bring farms that are currently under-performing up to best practice standards. This requires much more investment into agricultural research, with more focus on increasing the sustainability of productive farming systems and, critically, better communication of new science to the land managers 'on the ground'. New knowledge will be needed just to keep pace with the growing challenges, particularly climate change and associated impacts like the spread of new pests and diseases[36]. However, agricultural research and development is underfunded and public investment in particular has stagnated since the 1970s in most regions[37], particularly the developing world[38]. Private sector spending on R&D tends to be commercially orientated rather than being focused on maximising the benefits from agriculture to people and the environment, and is not a substitute for public investment. The International Fund for Agricultural Development's Rural Poverty Report 2011[39] concluded that "if sustainable intensification is to contribute effectively to increasing agricultural productivity, there needs to be greater research expenditure, and more of it needs to be spent on the challenges of sustainable intensification faced by smallholder farmers in countries dependent on agriculture." There is also concern from many quarters that current levels of investment in agricultural research in the UK and the wider EU are inadequate to address the challenges facing farmers in this region[40].

Future technologies should not be relied upon provide a 'quick fix' to solve all of the production and conservation challenges. A variety of approaches will be needed, including better application and dissemination of existing skills and knowledge. This needs to happen *now*. It takes a long time for a new technology to develop from initial research to widespread adoption by farmers. Nevertheless, new technology will undoubtedly play a part in meeting future challenges, and investment in agricultural research and development, along with effective mechanisms for disseminating knowledge to land managers, should be a priority for governments.

In the meantime, there are already many excellent examples of farms where production and conservation challenges are being addressed in a holistic way. For example, in the Cambridgeshire Fens conservationists and farmers have come together to create a Farmland Bird Friendly Zone. The project involves at least 14 farmers, managing more than 3,700 hectares of high-grade arable farmed land, and is generating a lot of interest from other farmers in the area. Farmers participating in the project are using their Environmental Stewardship agri-environment agreements to implement land management options that meet all the needs of

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35 The natural choice: securing the value of nature. HM Government, 2011.
36 Foresight: The Future of Food and Farming (2011) Final Project Report. Government Office for Science, London.
37 World Development Report 2008: Agriculture for Development. THE WORLD BANK, Washington, DC, 2007.
38 Rural Poverty Report 2011, IFAD
39 *Ibid*
40 See for example Innovation in EU Agriculture, House of Lords European Union Committee Nineteenth report, 2011

farmland birds, while balancing this with the needs of the farm businesses. As well as helping farmland birds and bringing farmers together to discuss future plans, this project is generating a lot of positive publicity for farming in a part of the country where intensive agriculture dominates the landscape.

Agri-environment schemes are one mechanism for providing land managers with the support they need to maximise the potential of their land to provide both food and biodiversity. Although agri-environment in the UK has brought some notable successes, it is argued by many that it is not yet meeting its potential. Some of the issues are now being addressed, for example by Defra's project in England "Making Environmental Stewardship More Effective". Other projects, such as the Campaign for the Farmed Environment, aim to encourage uptake of existing scheme options to maximise the benefit of these schemes.

UK agri-environment schemes operate within the context of the Common Agricultural Policy (CAP). This policy will enter a new period in 2014, and the reforms agreed between now and then will be critical in determining the future direction of travel for agriculture. It is the RSPB's opinion that the Commission's proposals for CAP reform fail to address adequately either the production or the conservation challenges facing farming in the EU, and would not represent an efficient or justifiable use of taxpayers' money. The RSPB, alongside its Birdlife partners and others including many farmers, is calling for a real shift towards a policy that supports farming to become more sustainable, and meet all the challenges facing it. This will mean, among other things, more funding for measures like agri-environment schemes that have been proven to deliver benefits for farming and wildlife; more environmental improvement achieved from direct payments, and a shift of support towards farming systems that are delivering a variety of services to society.

Conclusions

The pressures on land are many and increasing. We need to optimise our use of land by considering *all* the services any given parcel of land could potentially provide. This will mean some difficult choices. In some places, we will find there are win-wins: it will be possible to maintain or increase production while simultaneously increasing the delivery of other ecosystem services. This is what the RSPB is trying to achieve at Hope Farm. In other places, however, we will find that to secure the full range of ecosystem services we need it will be necessary to accept some *loss* of food production. It remains an open question as to how society can best optimise land use while respecting the rights of private land managers to take decisions on the use of their land. There is an urgent need for all stakeholders to discuss what approach to land allocation society wishes to adopt for the future.

The market alone will not deliver an optimum solution: history shows that short-term price signals generally override more strategic considerations in guiding decision making. Furthermore, the market does not adequately reflect the value of the public goods farming provides to society, nor the costs of negative impacts such as pollution and biodiversity loss.

As emphasised by the Future of Food and Farming Foresight report[41], meeting the challenges of making our food supply system more sustainable will require "interconnected policy-making". Many policy areas outside the food system have an impact on land use, including transport, energy, housing, employment, education, health, water management, biodiversity conservation and energy generation. The report highlights that achieving closer coordination of all these policies, at all levels from local to national, will be a major challenge.

The case studies (Hope Farm and Tarnhouse) described in this paper show two farming systems that are very different; however both make valuable contributions to UK agriculture. There is no one model for the future of farming. Intensive and extensive farms, conventional and organic, arable and livestock, lowland and upland can all form part of the mix. Government, scientists and land managers must focus on addressing the conflicts between farming and conservation to make all farming systems more sustainable. An evidence-based approach, building on sound scientific research and efficient dissemination of new knowledge to land managers, will be critical.

[41] Foresight: The Future of Food and Farming (2011) Final Project Report. Government Office for Science, London.