The Biodiversity Benefits of Organic Farming

The Soil Association

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WWF -UK

WWF-UK supports organic farming because it benefits people and nature. It is a system that is essential for conserving biodiversity, especially in the centre of fields. It avoids the release of toxic pesticide residues into the environment, and it supports rural development, fair trade, food safety, animal welfare, and market-oriented production. No other farming system encapsulates all these benefits and in a way that the public can easily recognise.

WWF-UK believes that organic farming is fundamental to sustainable rural development and crucial for the future development of agriculture and global food security.

As a result, WWF-UK supports the Organic Food and Farming Targets Bill. This bill sets targets of 30 per cent of UK farmland to be organic or in conversion by 2010 and 20 per cent of the food consumed to be organic by 2010.

WWF-UK will continue to encourage organic farming, by encouraging people to buy organic food, by pressing government to give more support to organic farming, and by working with organic farming organisations, retailers and others.

THE BIODIVERSITY BENEFITS OF ORGANIC FARMING

Contents

executive summary

The UK's farmland biodiversity is in steep decline and there is an urgent need to identify effective, widely applicable and cost efficient ways of reversing this trend. Organic farming accounts for only three per cent of UK agricultural land, but it is a widely applicable system and its adoption is growing rapidly. However, comprehensive evidence of its biodiversity benefits has not been available until now. This report presents and reviews the findings of nine studies on the biodiversity supported by organic farming in the lowlands, compared to conventional farming systems. From the individual findings, general conclusions are drawn.

Research findings

In most of the studies, important differences were found between the biodiversity on the organic and conventional farms, with generally substantially greater levels of both abundance and diversity of species on the organic farms (pages 13–23, summary on page 25):

- Plants: five times as many wild plants in arable fields, 57 per cent more species, and several rare and declining wild arable species found only on the organic farms, including some Biodiversity Action Plan species.
- Birds: 25 per cent more birds at the field edge, 44 per cent more in-field in autumn/winter; 2.2 times as many breeding skylarks and higher skylark breeding rates.
- Invertebrates: 1.6 times as many of the arthropods that comprise bird food; three times as many non-pest butterflies in the crop areas; one to five times as many spider numbers and one to two times as many spider species.
- Crop pests: significant decrease in aphid numbers; no change in numbers of pest butterflies.
- Distribution of the biodiversity benefits: though the field boundaries had the highest levels of wildlife, the highest increases were found in the cropped areas of the fields.
- Quality of the habitats: both the field boundary and crop habitats were more favourable on the organic farms.
  The field boundaries had more trees, larger hedges and no spray drift; the crops were sparser, with no herbicides, allowing more weeds; there was also more grassland and a greater variety of crop types.
- Organic farming was identified as having many beneficial practices, reversing the trends in conventional farming that have caused the decline in biodiversity: crop rotations with grass leys, mixed spring and autumn sowing, more permanent pasture, no use of herbicides or synthetic pesticides and use of green manuring.

Discussion

- Widespread and common farmland species are declining; there is a need to conserve the abundance of all species, and not simply maintain diversity.
- As farmland covers 76 per cent of the UK area, the type of agriculture that is predominant is currently the most important factor in the conservation of the UK's biodiversity.
- The cropped area of fields accounts for 95 per cent of the farmland area, so the amount of biodiversity found in the in-field areas (as opposed to the margins) is highly important. Similarly, the general abandonment of mixed farming is a significant factor in the declines of national biodiversity and needs to be addressed.
- The consistency and total sample size suggest the research findings are representative of the effects of organic farming. The overall conclusion is that the lowland organic farms support substantially more abundance and diversity than lowland conventional farms, including declining species.
- The results may underestimate the total benefits, due to insufficient consideration of: the field centres, the mixed farming aspect, the length of organic management, the most intensive farms, and the effects of the surrounding farmland.

- The mixed farming and extensive nature of organic farming also suggest important benefits for the UK's upland areas.
- Organic farming also offers biodiversity benefits for: the soil and aquatic ecosystems; it insures against the effects of further intensification and GMOs; and it reverses the dangerous trend of falling agricultural genetic diversity.
- The total biodiversity benefits of organic farming are delivered by the whole system, not just by individual practices required by the standards.
- Because of its total biodiversity and other environmental advantages, organic farming should be the preferred farming system for targeted conservation objectives which require additional or special management practices.
- Considering the cost of other conservation approaches, the actual cost of conventional agriculture, and the range and quality of its biodiversity and other benefits, organic farming is a cost efficient way to deliver these benefits.

Conclusion

There is now a large body of evidence that organic farming in the lowlands supports a much higher level of biodiversity than conventional farming systems, including species that have significantly declined. Major benefits also seem likely in the uplands. The benefits are across the cropped areas as well as at the field margins.

As well as these major biodiversity benefits, widespread organic farming should also be a cost efficient, secure and straightforward policy option for reversing the overall declines in the UK's farmland biodiversity.

1 introduction

Overview

Over the last 13 years, at least 23 studies have been undertaken in Europe to investigate the comparative biodiversity benefits of organic and conventional farming. Despite the importance of this subject, they have never been reviewed and presented together. The Soil Association has fully reviewed seven UK and two Danish studies. They are presented in chapter three of this report and between them cover a wide range of farm wildlife. The methodology and results of each study are summarised from the research reports and the findings are reviewed for each. The aim was to see if there are any commonalities between the findings of the studies from which general conclusions about the effects of organic farming can be drawn. The studies' findings and their context are discussed in chapter six, before the final conclusions are drawn. In addition the key findings of the 14 additional studies which are not fully reviewed are briefly summarised at the end of chapter three.

Background to the report

The report was written for a number of specific reasons:

- There is an urgent need to identify widely applicable and efficient ways of reversing the current decline in farmland wildlife.
- Organic farming currently accounts for only a small proportion of UK farmland, but is rapidly growing in significance. Three per cent of the agricultural land is now managed organically; this is growing by an additional one per cent of the total agricultural land each year.
- The organic movement has long claimed important biodiversity benefits from organic farming but insufficient evidence has been available.
- There is a large and growing public interest in organic farming and its benefits.
- A number of studies have been carried out investigating the biodiversity levels of organic farms. Their findings were consistent and important but not well known.

Research methodology of the studies

In each study, the sampling was generally carried out over a number of years and using several farms. The UK studies were nearly all in lowland areas and mostly in southern Britain. Efforts were usually made to match or pair organically and conventionally managed sites, for example, for size, crop or soil type; the criteria for this varied. The sample size for each study varied from three organic and three conventional fields, up to 31 farm pairs. Sampling was carried out at both the field boundaries and in-field areas, and analysed for abundance and diversity depending on the study. In most cases statistical analysis was applied to the results to establish statistical significance.

2 wildlife covered in the studies

Arable flora

Many once common arable flowering plants are now rare or dramatically declining, and include some of Britain's most seriously endangered plants. As agricultural weeds, most are known to be affected by herbicides. There has been some concern over whether they are also affected by the weed control measures of organic farms.
As food for invertebrates and birds, arable plants form a vital part of the food chain on farmland. Broadleaved plants are, overall, more important than grass species: broadleaved weed seed is a much more important food resource for birds than grass seed, and many important farm invertebrates are reliant at some stage on broadleaved weeds as larval plant food or nectar sources, but not on grasses.

Birds

Many farmland birds have shown dramatic declines in both range and population size in northern Europe. Of the 28 species primarily associated with farmland in the UK, 24 have shown a contraction in range and, of 15 species which could be accurately censused, a decrease in population size was found between the late 1960s and early 1990s (Fuller *et al.,* 1995). These declines are far greater than for species associated with other habitats such as woodland or wetlands, and have been linked to the intensification of agriculture. Changes in arable cropping practices have been identified as causes, including a switch from spring to autumn-sown cereals, the loss of traditional rotations and winter stubbles, applications of pesticides and removal of non-crop habitats such as hedgerows, all of which have had significant impacts on ground nesting birds such as the skylark, grey partridge and many seed eating birds. Dramatic declines have also been recorded in Denmark in recent years.

The diet of most farmland birds is typically made up of invertebrates and plants, and there is growing awareness that the young of many species depend on a high protein diet. Thus bird populations are linked to the levels of invertebrate populations.

Skylarks *(Alaunda avensis)*

The skylark is a Biodiversity Action Plan species. It is one of the most ubiquitous breeding birds in Britain. However, in the 25 years from 1972 to 1996, numbers collapsed by 60 per cent across the UK and by 75 per cent in farmland only (BTO, Common Bird Census data), where most skylarks are found. This loss of about 2.3 million pairs of birds is a greater decline in absolute numbers than any other species of UK farmland bird. The decline is linked to the change from spring to autumn cropping, as shown by a recent Royal Society for the Protection of Birds study (Donald & Vickery, in press).

Yellowhammers *(Emberiza citrinella)*

The yellowhammer is still a common bird in Britain with an estimated 1.2 million breeding pairs in 1988-91 (Gibbons *et al.,* 1993). However, it was once much more common. The population began to decline in the late 1980s and the rate of decline has accelerated rapidly (Siriwardena *et al.,* 1998) to about ten per cent a year. The latest data from the Common Birds Census shows that the population is now at an all time low (Crick *et al.,* 1998) since the census started in 1961. The greatest declines have been in the northern and western parts of the UK, which have become increasingly specialised towards livestock production, losing their arable land (Gibbons *et al.,* 1993).

Invertebrates

Invertebrates are especially important for biodiversity. They form an important part of the diet of many birds, especially young birds, and predatory invertebrates have an important function in agricultural pest control. When considering the biodiversity of different farming systems, it is important that the effects on the abundance of pest species are identified separately from the effects on invertebrate biodiversity in general. Invertebrate predators, such as spiders, are essential for biological pest control, and it is considered that their abundance has been reduced by the widespread use of agro-chemicals.

Spiders

Agricultural intensification has been cited as causing reductions in spider populations. In a 20 year study of cereal fields in Sussex (Aebischer, 1991), an overall annual decline rate of spiders of 4.1 per cent was identified, effectively a halving of spider abundance over the period. Spiders have been shown to be useful in controlling aphid numbers (for example, DeClercq & Pietraszko, 1983).

Butterflies

The butterfly fauna of lowland arable farmland is of increasing conservation concern. It is considered that the reduction in plant diversity in hedge bottoms and grasslands has reduced the range and abundance of food plants for many species. Hedgerow butterflies are also considered susceptible to insecticide spray drift. Two common species, however, are economic pests, the large and small white.

Ground beetles

Ground beetles (carabid beetles) are the predominant group of epigaeic (soil surface) arthropod fauna in agro-ecosystems (Tischler, 1980). They are important invertebrate predators in biological pest control (Basedow *et al*., 1977). Several species feed on key agricultural pests, such as aphids and slugs. Others may aid weed control through seed-eating (Lund and Turpin, 1977).

3 research

The comparative biodiversity benefits of organic and conventional farming systems

3.1. Rare arable flora survey

Kay, S. & Gregory, S. 1998-99. (Funded by The Northmoor Trust and English Nature)

Aims and methodology

A two year study compared the diversity and abundance of plant species on neighbouring organic and conventional farms. Organic and conventional fields were paired for the same size, soil type and crop. 38 field pairs within eleven organic and eleven conventional farms in Oxfordshire, Berkshire, Wiltshire and Gloucestershire were used. Of the field pairs 31 were winter wheat, four were beans and three spring cereals. All the organic fields had been under organic management for at least five years. During June and July in 1998 and 1999, plants were recorded both at the edges of the fields and within quadrats positioned from one to five metres into the crop. Particular attention was paid to a list of 'target' species, arable plants which were rare or had significantly declined in abundance in England.

The results

The organic farms supported a substantially greater number of the rare and declining arable plant species than the conventional farms. Out of 21 'target' species present, eleven were found only on the organic farms and 8 were found on both but were more common on the organic farms. The species found only on the organic farms included four on the UK Biodiversity Action Plan (BAP): red hemp-nettle, corn buttercup, corn gromwell and narrow fruited cornsalad. One of these, corn buttercup, an arable plant identified as having experienced the most rapid decline of any British plant (Wilson 1992), was found on nearly a third of the organic fields in the first year. In contrast no BAP species were found on the conventional fields and only two 'target' species were found only on the conventional farms (great brome and small-flowered crane's bill). Importantly, many of the plants restricted to the organic farms were known to be sensitive to herbicides.

The researchers observed that plant density was generally less on the organic winter wheat fields than the conventional ones and that some scarce species were found that are normally only associated with spring crops. Finally, though the sampling was restricted to the outer five metres of the fields, it was observed that in the organic fields "plenty of the rare plants were present throughout the whole field".

Review

The results suggest that organic farms support a greater number and diversity of rare and declining arable plants than conventional systems. At the field and crop margins, the diversity of threatened species was twice that of the conventional fields, and 19 of the 21 target species were more common on the organic farms. Organic farming seems to provide habitats for many species that can no longer be found on many conventional farms, including UK BAP species and species that are sensitive to herbicides. This shows that such species can instead survive the weed control measures of organic farming. As well as the lack of herbicides, a contributory factor appears to be the lower densities of organic crops.

As the total in-field differences were not measured and as conventional farms have larger average field sizes, the total differences in plant biodiversity should be much greater than the differences shown by this study. Nevertheless, just the field edge differences suggest that many of the rare or declining species of once common arable flowers could be conserved through organic farming.

3.2 Bird food items in cereal fields - insects and weeds

Hald, A.B. & Reddersen, J. 1990. Denmark. 1987-88, Studies on Conventional and Organic Farms

Aims and methodology

This two-year Danish study evaluated the supply of invertebrate and plant food sources for birds on arable land. The project was conducted on 21 (in 1987) and 17 (in 1988) pairs of matched organic and conventional cereal fields with most major regions and soil types of the country represented. The vegetation was analysed at different distances from the field boundary during late June, following herbicide treatments on the conventional fields. The vegetation was also analysed before herbicide treatment in May 1988. The data was analysed for statistical significance.

The results

Overall, the biomass of wild plants in the organic fields was five times that of the conventional fields. In addition, the organic fields supported 57 per cent more plant species (130 versus 83 species). There were also in all cases more arthropod species. 25 wild plant species were found in over 50 per cent of the organic fields, compared to only 14 species in over 50 per cent of the conventional fields. Several rare species were found only in the organic fields. In contrast, the only species found in significantly higher numbers on the conventional fields were aphids and a type of leaf miner *(Hydrellia spp.).* In total, 159 plant species (wild and cultivated) and 291 arthropod or higher taxa species were identified.

The field margins in both farm types had a greater abundance of wildlife than areas within the fields. The difference between the margin and in-field areas was greater in the conventional fields, however, due to lower levels of wildlife in the in-fields areas than in organic fields. For the number of species, the differences were more extreme. While there was a marked effect with distance from the margins in the conventional fields for the diversity of both plant and animal species, there was no marked effect in the organic fields for plants and only a moderate one for animals.

The distribution patterns for the sub-set of arthropods that constitute bird food items were the same as for the plants. The total population of these was 1.4 - 1.8 times greater in the organic fields. Again, differences were greatest away from the margins. Herbivores constituted a major part of this sub-set and the larger number of these on the organic fields was associated with the greater presence of particular plant hosts (Fabaceae, Brassicaceae and Polygonaceae). The greater number of several non-herbivore arthropod taxa was ascribed to the greater presence of livestock manure.

Herbicide treatment was shown to have an immediate effect on species diversity and abundance: on the conventional fields, there was a decrease in the number and frequency of species recorded from May to June. In comparison, no marked change took place on untreated conventional fields.

Review

The results suggest that organic cereal fields support a more diverse and abundant plant and invertebrate community, including more rare plant species. They held five times as many wild plant numbers, one-and-a-half times as many plant species, and, with the exception of aphids, about one-and-a-half times as many of the arthropods that comprise bird food. Importantly, the greatest change was in the in-field areas, especially for species diversity. In addition, several rare species were found only on the organic farms and the numbers of aphids decreased significantly. These results are probably due to the whole complex of differences between the two farm systems, but the lack of herbicide use in organic farming appears to have a dominating beneficial effect in arable areas, especially for plant species in the field centres.

The study shows that an expansion in organic management should have a marked positive impact on the plant, arthropod and consequently bird populations of arable land, including those of now scarce species. The fact that organic fields are usually smaller than conventional fields should increase the national impact of these effects.

[This review was mainly based on the English summary of the full report.]

3.3. A comparison of bird populations on organic and conventional farm systems in southern Britain.

Chamberlain, D.E., Wilson, J.D. & Fuller, R.J. 1998. (Funded by MAFF & WWF)

Aims and methodology

In a three-year study, 22 organic and 22 conventional farms over a wide geographic range in southern England and Wales were surveyed to ascertain whether organic and conventional farms differ in the size and diversity of their bird populations. Each organic farm was coupled with a nearby conventional farm, though not on the basis of farm type. While most of the organic farms were mixed farms, the conventional farms were a mixture (for example grassland in the west, arable in the east). The abundance of 26 bird species was measured over three breeding seasons (April-July), two autumn and two winter periods. Between seven and 18 organic farms were analysed each season. At least three censuses were made at each site in each season, and both field boundary and in-field bird numbers recorded. Unfortunately, in the breeding season the height and density of the arable crops prevented the collection of data for in-field abundance of any species apart from the skylark. Data on habitat characteristics were also collected. The results were tested for statistical significance.

The results

At the field boundaries, there were on average 25 per cent more birds on the organic farms. The majority of species were more abundant on the organic than the conventional farms in every one of the seven seasons, and abundance for all birds together was higher in six of the seasons on the organic farms (significantly higher in two). On average in a season, 14.1 species were more abundant on the organic farms and 3.4 species more abundant on the conventional farms, though significance was only established for 12 individual cases (on average 1.7 per season, an individual case being the data for one species in one season). No species was significantly more abundant on the conventional farms. In total, 17 species were recorded in the breeding season and 18 in autumn and winter. In the breeding season, field boundary abundance was higher on the organic farms in 43 out of 51 individual cases, though significance was established only for three. A higher number of significant differences were found outside the breeding season. In 56 out of 72 species cases, abundance at the field boundaries on the organic farms exceeded that on the conventional farms, with nine individual cases showing significant differences - all with a higher density on organic farms.

For abundance in the fields, during the breeding season, skylark numbers were higher in two years on the organic farms, though significantly only in one, and similar in the third year. Outside the breeding season, there were on average 44 per cent more birds in the fields of the organic farms. Abundance on organic farms exceeded those on conventional farms in 50 out of 68 individual cases, with significance established for two (17 species were recorded in total).

As regards species diversity, a significant difference was only established in the 1994 breeding season, when diversity was significantly higher on the organic farms.

The research revealed several habitat differences between the organic and conventional farms. The organic farms had more trees per field boundary and a greater proportion of high hedges (over 2m, with significance established in two of the seven seasons) and wide hedges (over 2m, with significance established in three seasons). There was also some differences in crop types throughout the year: the organic farms tended to have more winter stubbles, ley grass and spring cereals. Several species showed a statistical association with organic management in at least one year or season, including the linnet, tree sparrow, bullfinch, song thrush, yellowhammer, redwing, goldfinch, reed bunting, greenfinch and skylark (seven of these are UK BAP species). No species was strongly associated with conventional management.

Review

Although significance could only be established in a minority of individual species cases, the research indicates that organic farms support greater numbers of most bird species and more bird numbers overall. In total, 25 per cent more birds were found throughout the year at the field boundaries, and 44 per cent more in the in-fields areas outside the breeding season. The higher abundance of many species was associated with the higher level of non-crop habitats and certain farming practices in organic farms: organic farms tend to have larger hedges, more trees, spring cereals, winter stubbles and grass leys. A conclusion of the researchers was that "…farming practices which are characteristic of organic agriculture would greatly benefit several species of farmland bird."

3.4 Birdlife on conventional and organic farms

Brae, L., Nohr, H., & Petersen, B.S. 1988. Denmark

Aims and methodology

This three year Danish project studied the effect of modern agricultural practices on bird populations compared to organic systems, with particular attention to differences between the systems other than non-crop habitats. Census points were placed on 31 organic farms and points then selected on conventional farms which matched, as far as possible, in the occurrence of non-crop habitat features (such as hedgerows) in a 200m radius around the points. This matching for habitat features was done so that the results would reflect other differences in the farming systems (such as the use of agro-chemicals). Up to eight censuses of the bird populations were carried out annually at each point from mid April to mid June, 1984-87. Data on the habitat features and use of pesticides, fertiliser and manure was also collected. The results were analysed for statistical significance.

This approach was taken further with a sub-set of 35 bird species, by considering the results of those census points where minimum habitat differences had been recorded. (N.B. This involved a reduction in the number of census points used, reducing the ability to establish statistical significance).

The results

Out of 39 species for which significant differences between the two farm types were established, nearly all, 36 species, were most frequent on the organic land. The total abundance (density) of birds on the organically farmed land was 2-2.7 times that of the conventionally farmed land. 145 bird species were recorded in total.

In the additional sub-set analysis, the special selection of data tended to strengthen the differences between the farm types. For 20 of the 35 birds species, the difference in abundance between the two farm types increased in favour of the organic farms, while the reverse happened for five species. In total there were 24 species, which included all important farmland birds, where their numbers on the organic farms were higher than on the conventional farms in both the main and the sub-set analyses. 11 of these species had declined in Denmark since 1976. In comparison, of the 11 species which showed no difference in occurrence in the two farm types, seven had increased in Denmark over the same period.

When the results of the sub-set analysis were compared to the degree of pesticide use, 15 of the 35 species showed increasing abundance with decreasing use of pesticides. Only one had the reverse tendency. 13 of these 15 species were significantly more numerous in the organically farmed areas. A similar analysis for fertiliser and manure use showed a decline in eight of the 35 species with increasing intensity in the use of fertilisers/manures, while three showed the reverse.

Review

The results suggest that organic farming has a measurable and very positive effect on the populations of farmland birds. Furthermore, a large part of these effects are from the in-field differences in organic farming: even without major (non crop) habitat differences, there were 100-170 per cent more birds in total in the breeding season than on the conventionally managed areas, and the populations of a quarter of bird species (36 out of 145) increased significantly. For 24 birds, when minor habitat differences were also eliminated, their populations were greater on the organic farms.

The negative correlation between pesticide use and bird abundance suggests the effect on bird food supplies by pesticides might be a key factor behind the results. However, other differences might also have caused or contributed to the results. There are also, for example, important cropping differences between organic and conventional farming (crops types, structure, timings etc.). As there should anyway be a link between pesticide use and particular crops, these results could instead be due or partly due to the cropping benefits of organic farming.

[This review was mainly based on the English summary of the full report. The RSPB criticised the study for flaws in the methodology. These have been taken into account in this review. They related mainly to the ability to establish the significance of pesticides in accounting for the results as opposed to other differences in the farming systems, not to the general findings about bird populations.]

3.5 Territory distribution and breeding success of skylarks (alauna arvensis) on organic and intensive farmland in southern England

Wilson, J.D., Evans, J., Browne, S.J., King, J.R. 1997. (Funded by MAFF, WWF, BBSRC and Agriculture & Food Research Council)

Aims and methodology

This study examined the distribution and breeding success of skylarks in relation to the cropping of organic and intensively managed fields. The study was carried out from 1993 to 1995 on seven lowland farms in Suffolk and Oxfordshire. Three sites were under long-term organic management and four under conventional agriculture. Cropping on each site comprised combinations of autumn and spring arable crops, hay, silage and some set-aside. Skylarks were censused at least twice a month from March to July. Data on clutch and brood size, nest fate, crop type and boundary features were collected. The data was statistically analysed to identify correlations.

The results

The organic fields had higher skylark territory densities than the conventional fields, including on the set-aside, for all crop types where comparison was possible. The difference was significant for cereals, silage and pasture. Averaging the results of the crop types, there were 2.2 times as many territories on the organic farms. In the cereals, the difference was mainly correlated to the differing presence of spring sown cereals. In both farm types, the highest densities were on set-aside, then cereals, silage, rape and legumes, which had low densities, while grazed pasture had the lowest.

Skylarks make up to three nesting attempts per breeding season. In the study, most first clutches were in winter cereals, silage and set-aside, while second and third clutches were in a variety of crop types. There was a strong correlation between nesting attempts and vegetation height and cover: most attempts were in vegetation between 15 and 60cm in height with ground cover less than 90 per cent. Thus, most spring cereal fields were too sparsely vegetated in March and April for nesting. (Conversely, a recent RSPB study has confirmed that autumn sown crops are too dense in summer.) It was noted that organic cereals are generally slightly lower and sparser than conventional cereals. Demographic projections showed that skylarks need to make two to three nesting attempts in order to maintain their populations.

Breeding success for a total of 140 nests differed between the farm and crop types, though the sample was too small to establish overall significance. The nest survival rate (those lasting from clutch initiation until one chick left) was higher on the organic farms. For cereals, the difference was particularly high, about three times as high on the organic than the conventional cereals. Nest survival rates were lowest on the conventional winter cereals (where 9 of the 10 cases of brood starvation occurred).

Review

The study indicates that organically managed fields support significantly more skylark numbers throughout the breeding season than conventionally cropped or grazed land, with about twice as many breeding skylarks recorded. The organic farms also supported a much higher breeding success once eggs were laid - rates about three times as high were found on organic cereal fields. The results were attributed particularly to the diversity of crops. As skylarks make multiple breeding attempts, the availability of good nesting sites throughout the spring and summer is important. Organic farms combine both winter and spring-sown cereals, thus skylarks have more opportunities for second and third nesting attempts by moving between fields. An additional reason could be the greater abundance of invertebrate food resulting from the avoidance of agro-chemical use. The lower, sparser nature of organic crops may also contribute.

The researchers noted that organic farming reverses most of the agricultural trends that appear to have caused the decline in skylark numbers and concluded that “mixed farms, with mosaics of both winter and spring-sown cereals, and extensively managed pastures and meadows are more likely to support a self-sustaining skylark population, especially if farmed organically”. In contrast “skylark populations in arable landscapes in lowland England, are likely to be demographic sinks, unable to sustain their numbers”. It was noted that the capacity for organic farming to reverse the national decline of skylarks is dependent on the percentage of total agricultural land that is organic.

3.6 Habitat associations and breeding success of yellowhammers (Emberiza citrinella) on lowland farmland

Bradbury, R.B., Kyrkos, A., Morris, A.J., Clark, S.C., Perkins, A.J. & Wilson, J.D. In press. (Funded by BBSRC & the Rhodes Trust)

Aims and methodology

The study aimed to assess which changes in agricultural land use and management may have caused the decline in yellowhammer populations. The researchers noted that “organic farms retain many of the features characteristic of lowland agriculture systems prior to the onset of general and widespread intensification in the 1950s”. The study examined habitat preferences, distribution, abundance and breeding success on both organically and conventionally managed farms. It was known that British farmland yellowhammers typically build their nests along field boundaries.

The study was carried out from April to July 1994 to 1997 on nine lowland farms in Oxfordshire, Wiltshire and Warwickshire. Four farms were under organic management and five were managed intensively with agro-chemicals. The farms were all mixed. On all sites, yellowhammers were censused twice a month between April and June in 1996 and 1997. Four sites (two organic and two conventional) were also censused more frequently (every three days) in 1994 and 1995, from April to July. Territorial bird pairs and nests were located, and data on the eggs and chicks collected. The results were statistically analysed to identify correlations.

The results

There were 20 per cent more yellowhammer territories at the field boundaries of the organic farms when all the data is averaged, though this was less clear from year to year (the organic farms had higher numbers in two of the four years, but the opposite was the case in one year). Additionally, there was a slightly but significantly earlier breeding start. As with skylarks, it was observed that there can be up to three breeding attempts in the year. There was little difference in the success of eggs hatching or chicks surviving to fledging, and the numbers of nesting attempts were not recorded. However, extrapolations from the data collected suggested that the overall survival rates from egg laying to fledging, and thus the breeding success, was slightly greater on the organic farms, though significance was not established for these differences. Survival rates were calculated to be 48 per cent and 44 per cent for the organic and the intensive farms respectively, and the annual fledging numbers per breeding pair were 3.38 and 3.27 respectively (the figures for the organic farms were not published).

Yellowhammer territories increased significantly on field boundaries with hedges and with ditches, compared to boundaries that consisted simply of lines of trees. Densities also increased strongly with the width of uncultivated grass margins along the boundary, and there was a positive association with set-aside stubble fields. In contrast, yellowhammers avoided non-hedgerow field boundaries and boundaries adjacent to grassland. The preference for hedges matched previous studies but the preference against grassland contradicted other reports.

Review

The study suggests that organically managed sites support more yellowhammers, with around 20 per cent more territories found at the field boundaries than on conventionally managed sites. They also support a slightly earlier breeding start and maybe a slightly greater breeding success. The reasons are probably due to favourable habitat differences and greater food supplies. For example, when feeding young, yellowhammers prefer foraging in uncultivated field margins (Krykos, 1997) for invertebrates, and prefer grain and weed rich foraging habitats, such as stubble fields outside the breeding season. The researchers suggest that, in lowland farmland, populations should thus benefit from increases in hedges, grass strips, and seed resources such as spring sown cereals with over-wintering stubbles. The effects of extensive management of grassland are unknown.

The findings strongly favour organic farms as they generally have more hedgerows, more spring sowing, unsprayed field margins and are mostly mixed, as well as more extensive. Thus an expansion of organic farming should help the long-term conservation of yellowhammers throughout the country, but particularly in the grasslands of the north and west where the declines have been greatest and where mixed farming is probably the only way to bring back the benefits of arable land.

3.7 The effects of organic farming on surface-active spider (Araneae) assemblages in wheat in southern England, UK

Feber, R.E. Bell, J., Johnson, P.J., Firbank, L.G. & Macdonald, D.W. 1998. (Funded by NERC)

Aims and methodology

The study compared the spider communities of organic and conventional cereal fields. Three winter wheat fields on each of three organic and three nearby conventional farms in Gloucestershire and Oxfordshire were sampled in May and June, 1995. Spiders were collected with pitfall traps and data on the vegetation was recorded. The data was statistically analysed for correlations.

The results

The total number of spiders and the species diversity were higher, sometimes considerably, in the organic fields than the conventional fields. In May, more spiders were caught on the organic farms at two of the sites, though this was significant for only one site (North Aston, Oxfordshire, there were about three times as many); the third site had similar quantities. In June, significantly more were caught on the organic farm at one site (again North Aston, about five times as many); more were caught on the conventional farm at one site, though not significantly more, while the third had similar numbers.

Similarly, for species diversity, more spider species were captured in May on two of the organic farms, though the results were only significant at North Aston (about.50 per cent more); the third site had similar numbers of species. In June, significantly more species were captured on the organic farm at North Aston (about 100 per cent more), while the other two sites had similar numbers of species.

In total, 56 spider species were identified from 8609 individuals trapped. Most belonged to the Linyphiidae family; the Lycosidae were also well represented. Analysis suggested that the composition of the spider communities differed between the two farm regimes. The vegetation varied significantly between the organic and conventional sites and this was associated with a significant impact on the spider communities. Both for broadleaved and grass species, the understorey vegetation was "substantially more abundant" in the organic fields at two of the three sites. In contrast, the conventional fields had a higher crop density. Both the abundance and diversity of spiders increased with increasing understorey vegetation.

Review

The results suggest that organic cereal fields support a greater abundance and diversity of spiders. From about one to five times as many spiders and from one to twice as many spider species were found as on conventional cereal fields. This seems to be related to organic crops having substantially more understorey vegetation than conventional crops. The absence of pesticide use must also offer increased food for the spiders. In turn, the larger and more complex community of spiders should help control crop pests in the organic fields.

The researchers suggested that organic farming systems, as the extreme expression of low-input agriculture in the UK, "can potentially sustain larger and more diverse spider communities than intensive farming systems".

3.8 The effects of organic farming on pest and non-pest butterfly abundance

Feber, R.E., Firbank, L.G., Johnson, P.J., Macdonald, D.W. 1997. (Funded by NERC, WWF and SAFE Alliance)

Aims and methodology

The research set out to establish whether organic and conventional farming systems support different levels of pest and non-pest butterflies. Butterfly abundance was recorded across eight pairs of organic and conventional farms in southern England in the summer months of 1994 and also in 1995, when the survey was extended to include two more farm pairs. Sampling was carried out at approximately fortnightly intervals, following specified time and weather criteria. The variety and abundance of each species was recorded for both the uncropped field boundary and the crop edges. The crop types were recorded. The results were statistically analysed.

The results

In both years, significantly more non-pest butterflies were recorded on the organic than on the conventional farmland, but there was no significant difference in the abundance of pest species. Even for the same crop type, the total average numbers of non pest butterflies were usually several times those of the conventional sites. The difference in non pest numbers was greatest in the crop areas than in the margins (average abundance in the organic crop areas was roughly three times that of the conventional crop areas; in the margins, it was about two-thirds more in the organic sites). In both systems, more non-pest butterflies were recorded in the field margins than in the crop, but the difference was less in the organic farms because of the much greater abundance in the crop areas. The pests favoured the margins to a lesser extent than the non-pest species.

The cropping patterns and associated butterfly abundance differed between the organic and conventional farms. While cereal crops attracted similar numbers of pest and non pest individuals, oilseed rape and linseed attracted higher numbers of pests than non pests. On grass leys, non pest butterflies were more abundant than pests. No oilseed rape or linseed was recorded on the organic farms, but about six times as much grass ley was recorded than on the conventional farms. No significant correlations could be established as the sample sizes were low.

Review

The report indicates that organically farmed land supports much greater numbers of non pest species of butterfly than conventional land: from two thirds more at the field edge to three times as much on the outskirts of the cropped area, and presumably more in the field centres (as conventional field centres would be expected to be particularly sparse). Pest numbers, however, do not appear to increase. Even for the same crop, the numbers of non pest butterflies are usually several times that of the conventional sites, presumably due to the lack of herbicide use. An important factor for the overall differences could be the favourable cropping patterns in organic farming, for example the fact that grass clover leys are an integral part of organic systems. For the margins, possible positive factors of organic systems are the greater abundance and diversity of food plants and the avoidance of pesticide use.

While the benefits of sensitive management and boundary features on organic farms could probably be recreated on many conventional farms via conservation headlands and set-aside, this could not apply to the benefits that derive from the lack of herbicides and organic cropping patterns. It can be concluded that organic farming offers significant benefits for butterfly conservation, and without attendant increased costs from butterfly pests.

3.9 Review of the comparative effects of organic farming on biodiversity

Gardner, S.M. & Brown, R.W. 1998. (Funded by MAFF)

Aims and methodology

The study aimed to identify differences in the agricultural practices and in the occurrence of uncropped land of different farming regimes, in order to assess the consequent impact on the biodiversity of arable farmland. It comprised a review of literature from MAFF, research bodies and non-governmental organisations, in addition to consultation with farmers. The farming regimes reviewed were: organic; conventional arable; conventional mixed lowland; and two integrated crop management (ICM) regimes, namely Linking Environment and Agriculture Farms (LEAF) and techniques of the Integrated Arable Crop Alliance (IACPA).

The results

Several cropping practices were identified as bringing biodiversity benefits to arable land and were also associated with organic farming: crop rotations with grass leys, spring sowing, permanent pasture, the avoidance of agro-chemical inputs, green manuring, and intercropping. This was not the case for the other farming regimes.

The presence of uncropped areas such as sown grass strips ('beetle banks'), grass margins and conservation headlands was also seen as critical for the maintenance of farmland biodiversity. These are also more common on organic farms. In a survey by Brown (1998), of 480 farms surveyed 95 per cent of the organic farms had more than five per cent uncropped land, compared to only 45 per cent of the conventional arable farms. Furthermore, the report noted that "within conventional arable regimes … margins tend to be of a limited extent … In organic regimes, field margins, sown strips and hedges are all encouraged". ICM regimes also encourage margins and sown strips but the impact is "more limited".

Only two practices of organic farming were identified as having potential for negative impacts: inversion ploughing and mechanical weed control. This, however, does not imply greater negative impacts of organic farming from these practices: inversion ploughing is carried out to at least as great an extent in the other regimes, and mechanical weed control was considered as having a much less negative effect than the alternative of herbicide application, used in conventional and ICM regimes.

Overall, the practices adopted by organic farming were evaluated as having the highest potential to increase the biodiversity of arable farmland. Using scores for the overall biodiversity impacts, organic farming received by far the highest score of all the regimes: +13.5, compared to -5 for conventional arable, +1 for conventional lowland mixed and LEAF, and +4.5 for IACPA.

Review

The report concluded that "organic regimes have the greatest benefit for biodiversity at the farm level … Both in terms of their agricultural practices and the extent and management of uncropped land, organic regimes … exert a positive effect on the biodiversity of arable land. The effect derives from the lack of synthetic inputs, the occurrence of post cropping planting practices that benefit several organism groups and the widespread occurrence and sympathetic management of uncropped elements present within the regime. This combination of agricultural and structural elements is clearly one that can act to enhance the biodiversity of arable land".

In contrast, for conventional farming, the report concluded "The agricultural practices … have an overall negative impact on biodiversity. ... this regime effectively acts to maintain the impoverished status of biodiversity on arable land and may, in areas of particularly intensive management, act to further its decline."

The report highlighted how the contribution that organic farming can make to national biodiversity objectives is currently limited by the small percentage of farmland that is under organic management.

3.10 Key findings of other studies on the comparative biodiversity of organic and conventional farming systems

The key findings of fourteen additional studies are briefly summarised below. Note, in some cases, it was not clear that certified organic systems were being studied since the management differences seemed to be limited to agro-chemical use.

United Kingdom

1 Invertebrate and weed seed food-sources for birds in organic and conventional farming systems. Brooks *et al*., 1995 In a two year study of six cereal sites, the abundance and diversity of weed plants was significantly greater on the organic fields, and a larger proportion of weed seeds were broadleaved, unlike in the conventional fields. Total numbers of invertebrates did not differ significantly but, significantly more common species of carabid beetles, earthworms, and dipteran larvae were found on the organic fields, all important food sources for birds. Analysis of the faecal sacs of skylark chicks found that carabid beetles were a very important part of the chick diet, forming 47 per cent of identifications.

2 Botanical and invertebrate diversity in organic and intensively fertilised grassland. Younie & Armstrong, 1995. In a comparison of two pastures in Scotland over nine years, organic management resulted in a increased proportion of broadleaved legumes among the sown species, and a marked but inconsistent difference in abundance of three weed species. There was a small but insignificant difference in the diversity of weed species.

3 Carabid beetle *(Coleoptera carabidae)* Diversity and abundance in organic potatoes and conventionally grown seed potatoes in the north of Scotland. Armstrong, 1995. In a one year study of four fields, abundance and diversity of carabid beetles was greater on the conventional seed potato fields than the organic potato fields.

4 Effects of organic farming on the landscape. Entec, 1995 In a study of 12 lowland, mixed farms, there was a greater presence of unmanaged bushy hedges, recent woodland, and young and recent hedgerow trees on the organic farms. Little difference was found on a study of 24 upland, mixed farms.

5 The effect of organic farming systems on aspects of the environment. Unwin *et al*., 1995. This literature review concluded that organic farming has several practices which benefit biodiversity: crop rotations, maintenance of field boundaries, avoidance of agro-chemicals, the regular application of manure, use of solid manure systems for livestock production, and the non-use of (metal containing) growth promoters.

6 A comparison of the flora and arthropod fauna of organically and conventionally grown winter wheat in southern England. Moreby *et al*., 1994 In a two year study of eight farms, there was a significantly higher coverage (25 times as much) and diversity per 0.24<= (8.5 times as much) of broadleaved weeds on the organic farms. The arthropod population composition differed significantly; weed feeding chick food insects were usually more abundant in the organic fields.

Other European countries

7 Effects of farming systems on biodiversity. Frieben & Köpke, 1995. In a one year study of six arable farms in Germany, average abundance of typical weed species was more than twice as much and total diversity was 50 per cent higher on the organic fields. Endangered weed species appeared only in the organic fields. In a two year study of pastures, organic permanent pastures had 14 per cent more species than conventional permanent pastures and 45 per cent more than conventional sown pastures.

8 Biotic diversity in agroecosystems. Paoletti & Pimentel, 1992. In a study of peach orchards on four farms, there were 53 per cent more arthropod species on the organic farms (128 and 123 species versus 78 and 86 on the conventional orchards), especially of spiders *(Arachneae),* parasitic wasps *(Braconidae),* harvestmen *(Opilones)* and ground beetles *(Carabidae).*

9 Conventional and organic cropping systems at suitia VI: Insect populations. Helenius, 1990. In a one year study of barley plots in Finland, the abundance of the main cereal pest *Rhopalosiphum padi (L.),* an aphid species, was up to four times lower in abundance on the organic plots. But the organic crops were at a much earlier stage of development and their biomass was only 19 per cent that of the conventional crops.

10 Effects of different farming systems on the presence of epigeal arthropods, in particular of *Carabids (Coleoptera carabidae)* in winter wheat plots. Pfiffner, 1990. In a study of 12 plots since 1977 in Switzerland, the abundance and diversity of carabids, staphylinids and spiders caught was greater in the organic plots.

11 Carabid beetles *(Coleoptera carabidae)* as bio-indicators in biological and conventional farming in Austrian potato fields. Kromp, 1990. In a two year study of four potato fields in Austria, the numbers of carabid beetles were higher in the organic fields (26 per cent more in one field pair, and 94 per cent more in the other). Species diversity was also higher (16 per cent more).

12 Carabid beetle communities (carabidae coleoptera) in biologically and conventionally farmed agroecosystems. Kromp, 1989. In a two year study of winter wheat fields in Austria, three fields in 1982 and two in 1983, abundance of carabids beetles was considerably higher in the organic fields (131 per cent more) as was species diversity (15 per cent more).

13 Carabid species and activity densities in biologically and conventionally managed cabbage fields. Hokkanen & Holopainen, 1986. In a two year study of seven fields in Germany, the total biomass of captured carabid beetles was significantly higher (2–20 times) on the organic fields. There were some significant but inconsistent differences in abundance of the most common species.

14 Ground beetle abundance in organic and conventional corn fields. Dritschillo & Wanner, 1980. In a one year study of eight farms in the US, significantly greater numbers of carabid beetles were captured on the organic farms (from 20 per cent more to almost seven times more), and the diversity of species was about twice as much.

4 summary of the results

In most of the studies, the organically farmed areas had a much higher level of biodiversity than the conventionally farmed areas. The following results were obtained:

Summary of the biodiversity found on studied lowland organic farms		
	Abundance	**Diversity**
Plants	Five times as much biomass of wild plants in arable fields, including more rare and declining arable plants.	On arable fields, 57 per cent more wild plant species, two times as many rare or declining wild plant species and several rare species found only on organic farms.
Invertebrates	1.6 times as many of the arthropods that comprise bird food; about three times as many non pest butterflies and one to five times as many spiders in the crop area.	One to two times as many spider species in cereal fields.
Birds	25 per cent more birds at the field edge, 44 per cent more in-field in autumn/winter, 2.2 times as many breeding skylarks and on average more breeding yellowhammers	

Details of the findings:

Field boundaries: these areas supported the highest levels of wildlife in both farm systems, but the field boundaries on organic farms had higher levels than the conventional farms: recorded for plants, birds, arthropods and butterflies.
In-field areas: these areas were the most important in terms of percentage increases on the organic farms compared to the conventional farms: they supported 2–2.7 times as many birds in the breeding season, with significant increases recorded in 36 bird species; about three times as many non pest butterflies; one to five times as many spiders; also, the greatest increase in numbers of wild plants and arthropods was found here.
Biodiversity Action Plan species: four BAP plants found only on the organic land (for example corn buttercup and red hemp nettle) as were other rare arable species; also significantly more skylarks and some correlation with six other BAP birds.
Herbicide sensitive arable plants: though threatened on conventional farms, they clearly tolerate the weed control methods of organic farming.
Breeding success: breeding rates for ground nesting skylarks were higher, and for hedgerow nesting yellowhammers were calculated to be slightly higher.
Pest levels: aphid numbers were significantly lower; no effect on pest butterflies.

Reasons identified as accounting for the differences were as follows:

Quality of the habitats: the organic farms had more favourable field boundary habitats – more trees, larger hedges, and no herbicide spray drift; they also had more favourable crop habitats: slightly sparser, lower crops; more weeds between the crop plants; no herbicides or synthetic pesticides; more grassland and a greater variety of crop types.
Beneficial farming practices: organic farming was identified as having many beneficial practices, reversing the trends in conventional farming that have caused the declines in biodiversity: set-aside, crop rotations with grass leys, spring sowing, permanent pasture, avoidance of agro-chemical use, and green manuring.

5 organic farming practices

Examples that benefit biodiversity

Organic farming relies on different farming practices to conventional regimes. Since the whole approach is based on using natural processes positively, rather than combating 'negative' effects, many of these are also important for biodiversity:

Mixed farming

Mixed farming is the norm on organic farms, and this provides a range of wildlife habitats across the farm area and often even within fields. The majority of organic farms have both crops and livestock. Organic livestock farms often have both sheep and cattle. Horticultural fields often have a large number of different crops on the same fields, for example, if the farmer produces for vegetable 'box schemes'.

Mixed farming provides a greater variety of food sources and also food sources at different times of the year, as well as a variety of nesting habitats. For example, different invertebrates and seed sources are found on arable and grassland areas. A mixture of cattle and sheep is important for maintaining a variety of grassland vegetation. In conventional farming, though mixed farming was once the norm, it has now become standard practice for farms to be specialised in either livestock or crop production, and to also be increasingly specialised within that category. This has evolved into an extreme geographical distribution in the UK, with the east and the midlands being now predominantly arable, and the north, west and Wales predominantly grassland.

Crop rotations with grass leys

Rotations are required practice for all organic arable production and form an integral part of the system. They usually involve grass/clover leys and are a key means of achieving pest and weed control. The practice means grassland areas are introduced to areas of arable production. Although the grass often contains a high level of clover, it is in general of lower intensity than grassland on conventional farms (which is often intensively fertilised) and therefore provides more suitable nesting and foraging habitats. In conventional farms, crop rotation is carried out now in just a minority of farms; mono-culture is now common over much of the UK's arable land.

Spring sowing

Spring sown crops supply important nesting habitats for ground nesting birds and the stubble over winter provides important food sources (weeds and grain) for seed eating birds, even when it has been undersown or involves green manuring (see below). Spring sowing is very common practice on organic farms. It has, in contrast, largely died out on conventional farms as autumn sowing produces higher yields. There would once have been a roughly equal split between spring and autumn sowing, but between 1968 and 1996, the area of spring-sown cereals in Britain dropped from 73 per cent to 16 per cent of the total cereal area. Now only a small fraction of sowing is in the spring and even then the fast growth rates from the use of nitrate fertiliser (not allowed in organic systems) mean it is hard for nests to be established.

No use of herbicides or synthetic pesticides

The avoidance of agrochemicals is the best-known feature of organic crop production systems. It means there are higher levels of invertebrates and wild plants that form the base of food chains and support natural predators. In comparison, ICM uses perhaps 50 per cent less pesticides and herbicides than conventional farming.

Maintenance of trees, hedges and fields margins

These are an important part of organic farming and are protected under organic standards. Pest control is achieved through the maintenance of the habitats of natural predators, such as spider, birds and beetles. And, as the farming is mostly mixed, hedges are frequently used to provide stockproof boundaries between fields. The standards encourage good management of other farm habitats, for example farm woods and ponds. A large amount of non-crop habitats have been removed on conventional farms. For example, it has been estimated that between a quarter and a third of hedgerows in Britain have been removed since 1945 (Watt and Buckley, 1994).

Green manuring

This is the ploughing in of unharvested crops for fertility building/retention and is valuable for supporting invertebrate populations. It is common practice in organic systems but occurs negligibly on conventional farms.

Undersowing

This is the sowing of a grass or clover ley under a cereal crop so that it exists at low levels while the crop is there and then after harvest, growth takes off. Undersowing increases the level of biodiversity in the cropped area and after harvest supports seed bearing wild plant species throughout the first autumn and winter period of the ley. This technique is used for a high proportion of organic leys, perhaps half. It was once widely used in conventional agriculture but is now used rarely.

Intercropping

This is the growing of two or more different types of crop within the same row or in alternative rows at the same time on a field. It is done for pest and disease or fertility reasons. It is carried out on some organic farms, but uncommonly.

It is never carried out on conventional farms.

6 discussion

6.1 The role of agriculture in conserving the UK's biodiversity

Agriculture has a very important role in the preservation of the UK's biodiversity. Since it arrived about 7000 years ago, it has created or maintained most of the valued "semi-natural" habitats that characterise the UK countryside and support specific communities of wildlife. For example, heathland, flower rich meadows, unimproved pastures, ditches, hedgerows, but also the cropped areas. Farming is also by far the dominant land use in the UK, accounting for 76 per cent of the land area. Furthermore, there is evidence that the UK's traditional farming systems steadily increased the levels of biodiversity: the 1800s were the highest point for biodiversity.

For these reasons, the type of agricultural system that is predominant and that is encouraged by agricultural policies is probably the most important factor in determining the preservation of the country's biodiversity. About 88,000 species (excluding microscopic kingdoms) are thought to exist in the UK. Many will effectively depend on farming to maintain their key habitats (for example 28 species of birds are primarily associated with farmland); others will be more influenced by agriculture than anything else simply because it is the pre-dominant land use, even if other habitats can help maintain numbers.

Many of the UK's habitats have been reduced or degraded in recent years, but there is now a crisis in the biodiversity of our farmland on a scale unmatched in the other 24 per cent of the land. Farmland birds, for example, have shown dramatic declines of on average 40 per cent and several by over 80 per cent. These declines are far greater than in other habitats, such as woodlands, and the situation is ascribed to the profound changes that have taken place in agriculture over the last century. If present trends continue many species will become extinct.

6.2 Approaches to biodiversity conservation

Nature conservation has traditionally consisted of geographically targeted efforts. Since 1949, designated areas have been established across the UK to protect key samples of nationally important habitats or scarce species. For example, nature reserves, Sites of Special Scientific Interest and through agri-environment schemes. While this approach has resulted in a number of successes for rare species or particular locations, worrying declines have been found to have occurred meanwhile right across the country in many different living groups. These have been well documented for birds and wild plants of arable fields, and it is considered that their declines are representative of the situation across the board. Conservation concerns have thus now shifted to include the more common and widespread species.

There is therefore an urgent need to find effective and widely applicable ways of reversing declines in biodiversity throughout the countryside outside designated conservation areas. As a result, many conservation efforts are now focussing on securing beneficial changes in agricultural practices. However, most have been focussed on the non-crop habitat, particularly the field boundary (hedgerows, field margins etc.). This is where most of the biodiversity remains on conventional farms. However, nearly all of the agricultural area, 95 per cent, is actually cropped so the amount of biodiversity supported, or not, by the cropped area is a major consideration.

Another major issue is the consequence of farm specialisation and the loss of mixed farming. This trend has resulted in a stark polarisation in the UK, whereby the east and midlands are now predominantly arable, and the north, the west and Wales predominantly grassland. Even in areas, where mixed farming still exists, the balance has been changed significantly towards specialisation. For wildlife which depend on either arable or grassland habitat, their range will consequently now exclude large parts of the country; for those which depend on a mixture of arable and livestock habitats, the effects will have been even more destructive. Approaches that reverse this trend will need to be favoured.

Related to all this is the need to focus effort not simply on reversing declines in species diversity but also on reversing declines in abundance of each species. It is not simply that species will not survive without self sustaining populations of a minimum size. If biodiversity has a real value to humanity, it cannot be acceptable that only samples of each species are preserved in isolated sites around the country, while the general experience of the farmed countryside is one devoid of most wildlife. Instead, biodiversity should be seen as a basic, integral part of a healthy countryside and abundance considered a fundamental indicator of successful countryside management. In this context, biodiversity should be enhanced and conserved to its greatest potential everywhere.

6.3 Evidence for the biodiversity benefits of organic farming

The findings in the studies were that the organic farms delivered measurably and substantially more biodiversity, both at the field margins but also particularly across the field areas. The evidence suggests that organic farming is the most beneficial farming system for biodiversity for the farm types studied.

Do these results really represent the effect of organic farming? Nearly all of the studies were limited to lowland farm areas, so conclusions cannot be made for the uplands from these results. However, the case for the benefits in the lowlands seems very strong. The average differences found were mostly considerable. Where the sample size was large, for example where the largest number of farms were used (Danish bird study) or where the number of individuals being counted was high and significance was calculated for the total results (butterfly study), then many differences were found to be statistically significant and in favour of organic farming. Where the sample size of farms used was smaller and the significance testing was carried out for the individual species or site results separately, then, although the differences found mostly favoured the organic farms, the samples' sizes were such that significance could not be established in many cases. However, where significance was established in these studies, the results were in almost all cases substantially in favour of organic farming. In the three studies where no significance testing was carried out, the differences were always clearly in favour of the organic farms.

Furthermore, and probably more importantly, when all the results are considered together, effectively resulting in a much larger sample size, the results are consistent. It can therefore be presumed that the overall levels of biodiversity on organic farms reflect the individual findings of the studies. From this, general conclusions can be drawn: **that organic farming in the lowlands supports substantially higher levels of abundance and diversity of wildlife. This includes those plant and animal groups that are known to have significantly declined on farmland in recent years.** The Soil Association estimates that the percentage of the England and Wales organic area that is in the lowlands is at least 40 per cent of the total (excluding land under horticulture), with about 19 per cent of the total being arable land.

Is this evidence representative of the total benefits of organic farming in the lowlands? There is actually good reason to think that these results have underestimated the benefits that would be delivered by widespread organic farming:

- In two of the studies, that for arable flora and that for butterflies, the sampling in the field areas was limited to the outer few metres of the crops. As the in-field area accounts for 95 per cent of the agricultural area (19 times the field boundary area) and, in conventional farms, is known to be particularly scarce in wildlife, this would have greatly underestimated the total differences.
- The effort to match or pair the organic and conventional farms meant that in many cases, the selection of the conventional farms would have excluded the very specialised farms now characteristic of much of Britain. Thus, the effects of the structural or cropping changes that organic farming typically brings (for example mixed farming) were often excluded. This is an important deficiency.
- Organic farms tend to be smaller than conventional farms. Again, as most of the studies paired farms, it is likely that the very large, very intensively managed conventional farms (in which direction most farms are still heading) were avoided, so the average differences were probably underestimated.
- In only one case was it clear how long the organic farms had been under organic management. After conversion it takes several years for the soils to fully recover and build up their levels of biological activity and structure. As many farms have only recently converted, it could be that the biodiversity levels of several of those studied had not yet arrived at their capacity.

- Currently, most organic farms are islands in a 'sea' of conventionally farmed land. This could act to dilute and limit the effects, for example for species which range or disperse over large areas. Island biogeography suggests that the benefits would be amplified when organic farming is practised on a large scale.

6.4 Other biodiversity benefits of organic farming

In addition to these findings for lowland ecosystems, it is worth noting other areas where organic farming should provide strong biodiversity benefits. Moreover, conventional agriculture is not in a static state, and organic farming offers an insurance against current developments which will further degrade the situation for the UK's biodiversity.

Upland biodiversity
Two main conservation problems in the uplands have been the intensification of livestock stocking rates and the loss of mixed farms, leading to widespread overgrazing of the natural level of grassland vegetation, and the loss of traditional small areas of arable habitats for feeding and nesting. For example, in Wales, between 1945 and 1992, sheep numbers rose from 3,980,000 to 11,124,000. Two-thirds of the heather moorland lost between 1947 and 1980 has been attributed to overgrazing. The loss of mixed farming has been a problem in all grassland areas, the lowlands and the uplands. Some wildlife declines have been specifically linked to the loss of arable land in grasslands, for example, the yellowhammer in the north and west of the UK (Gibbons *et al.,* 1993). As organic farming is both more extensive and in nearly all cases based on some mixed farming, these problems would be automatically addressed, suggesting that organic farming is of important benefit to the biodiversity of the uplands.

Soil biodiversity
Soil life is hugely varied in itself and the ecological base for much over-ground life. A number of studies have shown that organic management promotes measurably higher levels of earthworm numbers than conventional soils (eg. Lampkin, 1992). Microbial activity is also thought to be much higher. (In turn, a high level of soil biological activity enhances the nutrient supply to crops, reduces nutrient leaching and helps controls soil pests.)

The trend of agricultural intensification
Although farmers are more aware than ever of the impact of their activities on biodiversity, agriculture is still intensifying. Thus, the individual changes identified as destructive to biodiversity in the UK are on the whole still continuing. Organic farming reverses these trends.

GMOs
Any significant use of genetically modified organisms (GMOs) will pose great risks to the country's biodiversity. These are unquantifiable, but they are also unpredictable, they have all the potential for multiple and large scale environmental disruption, and would be irreversible. There are already indications of the speed and scale of possible effects, with the following findings which have appeared in just a couple of years after commercial planting had started, all of which have implications for biodiversity (see end for references):

- GM pollen has been carried by bees 4.5 km from the crop (in the UK).
- Unintentional cross pollination with non GM plants has occurred and transferred the GM characteristic: with neighbouring crops within two years of planting (GM rape in Canada) such that seeds of a non GM plant variety being marketed and sown in Europe were found to contain GM seeds.
- The modifications are having unpredicted physical side effects, contrary to claims that the technology is precise and thus controllable (examples from the US): GM cotton found to have deformed cotton bolls which dropped off early; more lignin found in GM soya causing stunted, weak stems which tended to split open.

- The modifications are having unpredicted reproductive effects which will greatly speed up the evolutionary response to genetic modifications (examples from the US): the larvae of insects resistant to pesticides produced by GM cotton are taking longer to develop, so will tend to mature and mate exclusively with other resistant larvae; the rate of fertilisation of a GM herbicide resistant plant with wild-type plants is 20 times the rate of non-GM plants which carry the same gene naturally.
- Pest resistant GM (Bt) crops are exuding pesticides at unpredicted levels (examples from the US); producing 10-20 times the amount of toxins of conventional pesticides and leaching toxins into the soil, with negative effects on insect larvae.
- Against predictions, GM crops are resulting in no less, and often greater, use of pesticides and herbicides. In the US, Round-up-ready soya is resulting in the use of two to five times more herbicides and pesticide treatment has not reduced with use of GM pest resistant plants.

These are in addition to the already well known biodiversity problems discovered in the laboratory (effects on lacewings, monarch butterflies) and problems emerging for human health. In contrast, GMOs are not permitted in organic production.

6.5 The whole farm 'package' of organic farming

The benefits of organic farming can be classified under three broad headings: (i) the enterprise mix (mixed livestock and cropping instead of specialisation; crop rotation instead of monoculture etc), (ii) the treatment of the cropped area (avoidance of agro-chemicals; less intensive approach etc) and (iii) the boundary features (field margins, more and larger hedges etc.). But, what is the origin of these?

Organic farming is a particular whole farm "systems" approach. It is often discussed as a collection of different practices, but it is actually the whole package of the approach and all the individual practices. Organic farming is based on a set of principles, such as: a holistic approach to farming (instead of addressing problems individually); the creation and maintenance of conditions that positively nurture the health of the crops/livestock (instead of solely treating the symptoms of problems, eg. by applying chemicals); and, the harnessing of natural processes (instead of using artificial inputs). Thus, for example, agro-chemicals are avoided and instead alternative practices based on these principles are used. Many involve the positive use of biodiversity (through the soil, field margins, hedges etc.), thus making the conservation of biodiversity an integral part of the farming activity. For example, the soil is treated as a living entity, not simply as a substrate for crops to grow in.

The standards for organic farming were developed long after organic farming had been established, but are now used as a template and guide for the practice of organic farming. They are legally regulated and their implementation policed by the organic certifying bodies. Some standards are obligatory, others are "recommended". With the latter, many are actually the most practical organic approach and so are also the standard practice. In addition, there are special 'conservation' standards to ensure that specific conservation issues are addressed in more detail.

Some of the biodiversity benefits of organic farming can be directly linked to particular standards (eg. avoiding the use of agro-chemicals, the use of grass leys), others are an indirect result of the standards (eg. mixed crop/livestock farming, mixed spring/autumn sowing), and yet others are the result of the farmers applying the principles and approach of organic farming in a way tailored to their situation and for issues and to a detail not dealt with by the standards.

It is sometimes asked if conventional farming can recreate the advantages of organic farming by adopting its practices. However, as many of the benefits result from the whole system not just the individual practices, and as very fundamental changes are needed to deliver many aspects of organic farming, this is not realistic and many of the benefits will not be achievable. For example, no other system prohibits the use of herbicides and synthetic pesticides in crop production, thus the benefits of this cannot be achieved. Similarly, no other system so completely relies on alternative practices, so these will not be developed to the same degree and some not used at all. Conventional farming methods do not have comprehensive standards, legislation, and regular inspection procedures, thus the benefits of control and accountability would not be delivered. Finally, the individual can always deliver important additional benefits (probably comparatively more important in conventional agriculture) but, other systems do not use the principles of organic farming, thus the commitment and environmentally sensitive approach of the individual farmer is not developed to the same degree by the system.

In conclusion, the total range, degree and quality of the benefits of organic farming is delivered by the whole package of the approach, not simply by the individual practices required by the standards. The adoption of certain organic farming practices by conventional systems will improve conventional farming, but it will not deliver the biodiversity benefits of organic farming.

6.6 Organic farming and specific conservation objectives

Doubt has often been expressed about the suitability of organic farming for delivering specific conservation objectives for particular sites, such as the maintenance of chalk downland or the preservation of particular species that rely on traditional local practices. As a nationally applicable system, it is stated that organic farming will not automatically deliver these objectives in the targeted areas.

This is not, however, a weakness. For, while the above is generally true, no general farming system will automatically deliver such objectives, but this does not mean that organic farming is not the best base from which to deliver these. After all, most semi-natural habitats have been created by extensive, low input agriculture and have been generally degraded by conventional intensive farming practices. While the modern certified system of organic farming will not automatically retain or deliver the desired habitat, standard conventional agriculture will do so even less (individual commitment apart). Furthermore, the pursuit of specific, local conservation objectives should not compromise national biodiversity objectives or those for the wider environment.

Organic farming is likely to be the most environmentally friendly farming system overall and, from the evidence in this report, supports by far the most biodiversity including many of the groups which have suffered the greatest declines on farmland in recent years. In this context, organic farming should be considered simply as the most appropriate starting point on which additional conservation needs, where they exist, can be built.

It is sometimes felt that the organic standards can conflict with particular conservation management requirements. This is rare. The ‘conservation’ standards provide a base level of sensitive management of important habitats and the ‘production’ standards have been drafted to support conservation requirements. For example, although it is normally not allowed as it depletes soil nutrients, the annual removal of hay is allowed under the standards for the management of ancient hay meadows under recognised conservation schemes. In addition, the grazing of non-organic livestock on organic grassland is allowed, and will still be allowed under the new EU organic livestock regulations for a limited period each year.

And if there is a conflict, it is worth noting that a system of derogations exists precisely for such special needs. Provided that the derogation requested does not conflict with the principles of organic farming (or the basic EU organic regulations) or have negative effects elsewhere, the certifiers are happy to agree these, especially for conservation reasons. For example, a farmer in Cornwall participating in a cirl bunting conservation scheme was granted a derogation to continue growing cereals when converting. The standard normally requires land under cropping to undergo a ‘fertility building phase’ during conversion.

There appear to be only two possible problems which cannot be addressed by derogations:

- The use of herbicides for scrub clearance, stump treatment and bracken control.
- The fact that conservation management is occasionally intensive by design, due to a shortage of biodiversity conservation opportunities in those areas.

Finally, it should be mentioned that the organic standards are continuously reviewed, and that the Soil Association is currently working on guidelines for organic farming on specially managed conservation sites.

Overall then, as well as its capacity for conserving the national level of biodiversity, organic farming should be considered the preferred farming system for targeted conservation objectives that require additional or special management practices.

6.7 Agricultural genetic diversity

Genetic diversity within agriculture is very important. If diversity is encouraged then locally adapted plants and animal breeds which are more appropriate to local ecosystems can be used. But, perhaps more importantly, agricultural genetic diversity is a basic insurance against crop and livestock disease outbreaks becoming national epidemics. The less diversity in the system, the wider and faster new bacterial, viral or other strains can spread throughout the national agricultural base. Crop and animal breeding has now become such a specialised and centralised industry that this essential diversity has been eroded in recent years. This is a huge and increasing risk to the economy of the farm industry and also to national food security, human health and the national economy, as indicated by the cost and ramifications of all major farm health scares. The Irish potato famine of 1846 is an example of a past national crisis which followed low genetic diversity in the crop.

Organic farming reverses this trend as it positively values and encourages genetic diversity. The standards encourage the use of locally adapted, slow growing breeds and the practices of organic farming, as well as the market for organic food, are much more suited than conventional farming to traditional breeds (for example, the emphasis on good animal health instead of relying on veterinary medicines, and the importance of taste in the organic food market). The greater emphasis on local inputs and local markets is also helpful.

6.8 Other benefits of organic farming

There are numerous other benefits of organic farming which cannot be dealt with separately here, but should be borne in mind. Organic farming has many benefits for the wider environment: it is the most sustainable system that is also widely applicable. It reduces pollution incidents, energy use and greenhouse gas emissions. There are numerous apparent health benefits through the avoidance of the use of agro-chemicals: for instance for the water supply, food and farm workers. As the health and vitality of livestock is central to organic systems (routine veterinary medicine use is prohibited), animal health and welfare is a priority delivered by good animal husbandry and avoiding intensive management.

Organic farming also has social benefits: more people are usually employed on organic farms. It has important economic benefits: farming is in crisis and new markets are urgently needed - organic food is a high value and expanding market. Further growth in UK organic production would reduce the UK trade deficit, and widespread organic farming should considerably reduce the enormous costs to the state of the current agricultural system. Finally, organic farming is legally regulated and accountable through the system of standards and inspection.

6.9 The cost efficiency of organic farming in delivering its benefits

For several reasons, organic farming appears to be a very cost effective way of delivering biodiversity and other benefits:

- If the cost of the benefits delivered by the government's Organic Farming Scheme is analysed, then funding organic conversion seems a very efficient government measure. The average payment being made to farmers under the five year scheme is currently about £330/ha. This means that £1million annually yields at least 15,000ha of organically farmed land after five years, which should then remain organically managed thereafter. This compares, for example, with the Countryside Stewardship Scheme where £1million annually funds only 4300ha plus 700 ha of arable field margin and 350km of additional linear features, and where the benefits (apart from new physical features) are maintained only through this level of funding being continued annually (however, the scheme's aims are often more specialised, for example certain habitats Ð these aspects may be more expensive to deliver). (MAFF figures).

  Because inspection and control of organic farming, both at conversion and subsequently, is largely overseen by the industry and not government, the administration costs are low compared to other agri-environment schemes.

- Many of the practices of organic farming make positive use of biodiversity (through the soil, field margins, hedges etc.). Thus biodiversity is given an economic value which means that conservation is not at odds with the economic pressures on the farmer and therefore much more secure. (This contrasts with the traditionally adversarial approach of intensive farming, where conserving biodiversity is largely a peripheral and costly activity. In these circumstances, individuals apart, biodiversity conservation is mainly dependent on the continuance of external payments and limited to the rules of the contracts involved, as well as by the limits of conventional farming.)
- It is sometimes considered that organic farming could not be an option for most of the UKÕs farmland simply because of the small amount (three per cent) that is currently organically managed and its dependence on a premium price. However, widespread organic farming is actually much more within reach than is often realised.

  For a start, farm conversion is proceeding at high rate, over one per cent of UK agricultural land each year, and demand for conversion is even greater. Then, the UK market that can pay for these benefits is much larger than the current level of domestic supply (70 per cent of organic produce is being imported) and the market is undersupplied and also rapidly growing (at about 40 per cent a year). Beyond this, the level of organic farming probably would be limited were the area completely dependent on the market opportunities. But the market should be considered a bonus. A market means that the government, or conservation interests, do not have to fund the total cost of the system as they would with non market measures. Both the value and relative low cost of widespread organic farming should mean that support beyond the market can be viewed as an attractive option.

  For example, at current conversion rates, a very simple calculation indicates that conversion of the whole of the UK agricultural area (18,600,000 ha) would cost about £1.2 billion a year over five years. Then, as organic farmers receive lower CAP subsidies than conventional farmers, about £40/ha less, 'maintenance' payments thereafter of, say, £40/ha could be made at no extra cost. In comparison, £3 billion is already being spent each year on directly supporting the current agricultural system together with £2.3 billion or £208/ha (Pretty *et al.*, in press) that has been calculated as being spent each year on the indirect costs of conventional agriculture (the financial costs to the environment, health etc.). In addition, there are significant 'costs', such as the loss of national biodiversity, that cannot be quantified in this way.

Thus, widespread organic farming should be a cost-effective and achievable means of reducing the total cost of agriculture to the government while at the same time delivering on key government objectives such as for biodiversity.

6.10 Areas of further research

From these findings, it seems that further research would be beneficial in the following areas:

- Quantification of the total biodiversity benefits of widespread organic farming (for example totalling the contribution of the in-field and field boundary biodiversity benefits).
- Assessment in different parts of the country of the biodiversity benefits of organic farms compared to the conventional farming regimes that are typical of the region (ie. not using paired farms).
- The biodiversity benefits of organic farming in the uplands.
- The biodiversity benefits of organic farming for the soil.
- The impact of organic farming on aquatic ecosystems.
- The diversity and biodiversity benefits of trees on organic farms.
- The evolution of biodiversity levels on organic farms over time.
- Organic farming and the management requirements of designated conservation areas.
- The cost efficiency in delivering biodiversity of different conservation measures.
- The state and importance of agricultural genetic diversity.

7 conclusions

There is now a large body of evidence that in lowland areas, organic farming supports much greater levels of both wildlife abundance and diversity than conventional farming systems. This includes those plant and animal groups that are known to have significantly declined on farmland in recent years.

The total in-field benefits are greater than the field boundary differences, indicating that the total biodiversity supported by organically farmed areas is substantial. Organic farming also reintroduces the benefits of mixed farming to predominantly arable or grassland areas, addressing a fundamental problem in the current agricultural situation that cannot easily be addressed. This and the extensive nature of organic farming indicate important benefits for the uplands. The biodiversity benefits are delivered by the whole system of organic farming, not simply by the collection of practices required by the organic standards.

Because of its applicability to all farmland in the UK, organic farming offers great potential to reverse the decline of the UK's biodiversity, and in particular many of today's dramatically declining farmland species. The contribution of organic farming to UK biodiversity objectives is currently constrained by the limited percentage of the agricultural area that is managed organically (three per cent). However, this is rapidly increasing and the many other positive aspects of organic farming (the whole 'package' of the system, verifiable standards, market demand, other benefits etc.) suggest its widespread expansion would be a cost efficient, secure and straightforward policy option for biodiversity, as well as being highly beneficial.

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Soil Association

The Soil Association is a membership charity which was founded in 1946 by a group of farmers, scientists and nutritionists, who were concerned about the way food was produced. It is at the centre of the campaign for safe, healthy food, an unpolluted countryside and a sustainable farming policy in Britain and world wide.
The organisation has now grown in scope and complexity but the core is essentially simple; there are direct links between the health of the soil, plants, animals and humans, and organic agriculture is a sustainable system of food production which is based on these interconnections: Healthy soil. Healthy food. Healthy people.

To achieve this end, the Soil Association is working in many different areas:

- Policy; working to achieve change in food and farming systems through lobbying and policy work.
- Campaigns; joining forces with members, supporters and other like minded groups to campaign for the elimination of GMOs from the food chain; promoting the responsible use of antibiotics in farming; working in partnership with conservation agencies to protect wildlife and biodiversity.
- Setting organic standards to ensure the integrity of organic food and other products. Soil Association Certification Ltd, a subsidiary company, which awards the Soil Association organic symbol to 80 per cent of the organic food sold in the UK.
- Providing professional, technical support to farmers and growers with the aim of increasing the amount of land farmed organically and providing more jobs in the countryside.
- Promoting organic food so that people everywhere will have the opportunity to buy and eat organic food, be it from a local market, a box scheme, a corner shop or a supermarket.

The Soil Association provides modern, practical solutions to the challenges facing society today.

Organic farming

The main components of an organic farming system are the avoidance of artificial fertilisers and pesticides, and the use of crop rotations and other forms of husbandry to maintain fertility and control weeds, pests and diseases.

Rotations

A correctly designed and implemented crop rotation is at the core of organic crop production. A rotation contains the following key elements:

- Provides sufficient crop nutrients and minimises their losses.
- Provides nitrogen through leguminous crops.
- Aims to minimise and control weed, pest and disease problems.
- Maintains the soil organic matter and structure.
- Provides a profitable output of organic cash crops and/or livestock.

Crop

Fertility is generally provided by animal manures and leguminous nitrogen. The aim of the organic system is to be self sustaining, although in some instances it is permitted to bring in organic fertilisers or naturally occurring mineral products such as rock phosphate.

Crop protection

No synthetic products can be used in organic crop production systems. Where direct intervention is required, non-synthetic substances like sulphur may be used occasionally. Pest, weed and disease control are achieved through rotation, choice of varieties, timing of cultivations and habitat management to encourage natural predators.

Livestock

Animal welfare is of the highest standard and all livestock are managed in ways that allow their natural behaviour patterns to be expressed. There is no routine use of antibiotics, growth promoters or other drugs.

Standards

The Soil Association's Standards for Organic Food and Farming is a comprehensive guide to the production or processing of organic food in order to qualify for the Soil Association organic symbol.
All standards for organic farming, horticulture and food processing are subject to EU regulation. In the UK they are regulated by a government supported organisation, the United Kingdom Register of Organic Food Standards (UKROFS). Inspection and certification are carried out by accredited organisations such as the Soil Association.

Similar schemes now operate in many other countries throughout the world. Only certified produce may legally be sold as 'organic' within the EU.

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