



An Integrated Analysis of Scale Effects in Alternative Agricultural Systems (SCALE)

Summary of Research Findings



What is the SCALE project?

The SCALE project brought together multiple scientific disciplines (sociology, geography, economics, ecology and soil science) to evaluate alternative agricultural systems (e.g. organic farming). The SCALE project was initially planned for three years, starting in 2006, but was extended until October, 2010.

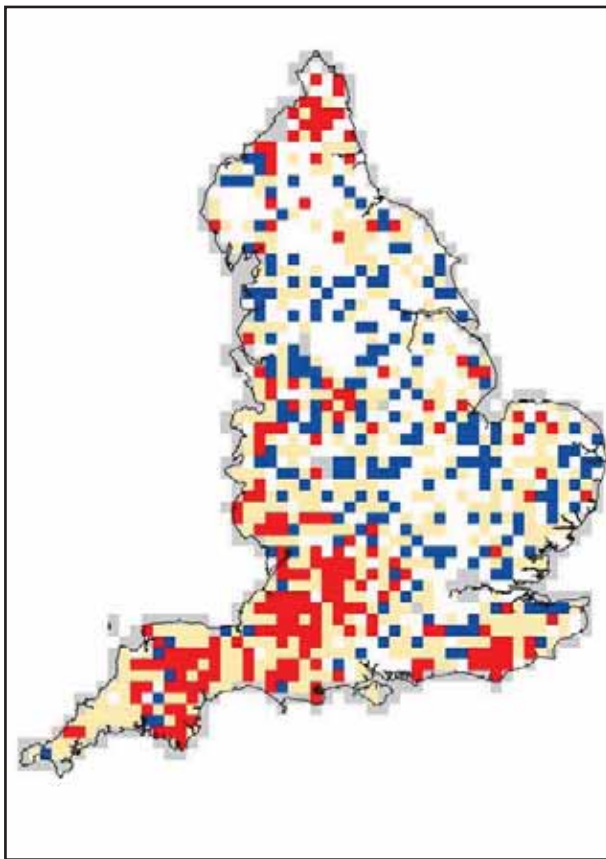
The SCALE project addressed two key questions:

(1) what causes organic farms to be arranged in clusters at local, regional and national scales, rather than spread more evenly throughout the landscape?

(2) how do the ecological, hydrological, socio-economic and cultural impacts of organic farming vary due to neighbourhood effects, at a variety of scales?

In order to address these questions, researchers undertook a comparative study of farms in areas of high and low concentrations of organic farming, to look for differences at field, farm, and local ('neighbourhood') levels.

Patterns of organic farming in the United Kingdom



Concentration of Organic Farms in England

Organic farming in the United Kingdom currently represents 4.3% of agricultural land, and about 4.6% of farmers. This is about average for Europe, where 4.5% of agricultural land is certified as organic, although this ranges from 0.1% in Malta to 18.5% in Austria¹. However, organic farms are not evenly dispersed across the landscape. As part of the SCALE project, the researchers put together a geo-referenced data base of organic farmers in the UK, based on data provided by DEFRA.

Analysis of the variance in organic farming demonstrates that organic farms are more likely to be found on land with lower agricultural potential. These are regions in which production is already low, so loss of production due to conversion will be low; farmers may also have more to gain financially from conversion subsidies in these regions.

Organic farms are also more likely to be found near urban centres, and on small, mixed and dairy farms. There is a clear perception among farmers interviewed in the study that organic farming is best suited to mixed production, as the slurry and "solid" manures from livestock can be used as a substitute for fertiliser.

There was also some evidence that organic farms are more likely to be found in regions dominated by silt and clay soils than on sandy soil.

- Red indicates 'hotspots' of organic farming. (More than 10% of agricultural land within a 10 X 10 km grid is legally certified or in conversion to organic farming).
- Blue indicates 'coldspots' (little or no organic farming).
- Cream indicates agricultural land that was between 'hot' and 'cold' classifications.
- White indicates no organic farms.
- Grey indicates land that was not considered in the analysis

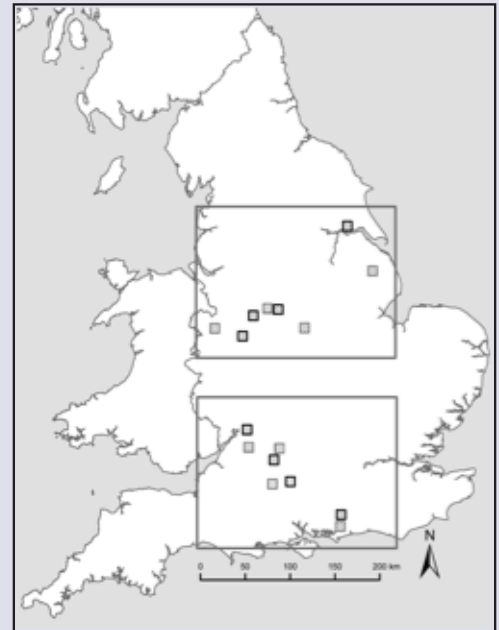
¹ FiBL. 2010. Research Institute of Organic Agriculture FiBL. European Organic Farming Statistics. Organic agricultural land, share of total agricultural land, producers. Sourced from: <http://www.organic-world.net/statistics-europe-land-producers.html>.

Field Research - 'Matched Farms'

The combined research by ecologists, soil scientists, economists and a sociologist addressed how aspects of organic farming vary between areas where organic farming has a 'strong' local concentration ("hotspots") as opposed to areas where there is little organically managed land ("coldspots"). Organic hotspots and coldspots were identified on the basis of the area and the number of organic farms; pairs of hot and coldspot landscapes were matched in agri-environment conditions based on 30 variables describing climate, topography, land use, socio-economy and soil. 'Matched' organic and conventional farms were then selected, based on similarity in terms of:

- dairy or mixed farms, i.e. farms with both arable and livestock farming, with similar livestock, cereal production, farm products and farm size
- soil type (determined from soil survey maps and data)
- proximity (less than 5km between farms)
- on each farm, three winter cereal fields and three permanent pastures were selected.

The result was the selection of 8 clusters of paired hotspot and coldspot landscapes, each containing one organic and one conventional farm (32 in total) in two regions, the Central South West and the Midlands. The organic "hotspots" featured, on average, 17.2% organically managed land within a 10 x 10 km area, while the organic "coldspots" included an average of 1.4% organic land.



Research Sites

Biodiversity Research

The biodiversity surveys comprised flowering plants, farmland birds, spiders, and insects including pollinators, crop pests, and their natural enemies, undertaken in summer 2007 and 2008. Researchers used a variety of methods to sample different species. Earthworms were collected after a mustard powered solution was poured onto the soil, which irritates their skin and makes them come to the surface. Aphids pests and their enemies were counted on wheat plants. Coloured pan-traps attracted pollinators. Insects and spiders were gathered using specifically designed suction machines. Farmland birds were identified by sight and song whilst walking a 1 km transect in the early morning. Plants were identified in the fields within one metre square quadrats.



Researchers found a wide range of farmland species on the farms studied. These include 10 earthworm species and 256 different plant species, such as Scarlet Pimpernel, Stinking Chamomile, Parsley Piert, Thyme-Leaved Sandwort and Shepherd's Purse. Also 23 butterfly species including the rare Duke of Burgundy (pictured), Brimstone, Small White, Green Veined White, Peacock, Marbled White, and Meadow Brown were found. We also found 88 bird species of which 18 were farmland bird species including Skylark, Linnet, Lapwing, Goldfinch and Greenfinch. Others included Swift, Grey Heron, Buzzard, Treecreeper, Great Spotted Woodpecker and Robin.

In terms of biodiversity (the different numbers of species present), organic fields had on average 12.4% higher diversity levels, with plant species' density 58%, butterfly abundance 40%, earthworm abundance 23% and epigeal arthropods 16% higher, but a 33% lower hoverfly abundance and 9% lower bird species density.

Fields in hotspots had on average 9.1% higher diversity levels, and butterflies, solitary bees, epigeal arthropods and hoverflies benefited in particular with 39%, 29% and 12% and 8% higher abundances, respectively.

The strongest contrast in biodiversity levels occurred between conventional fields in coldspot landscapes and organic fields in hotspot landscapes with on average 22.5% higher diversity levels in organic hotspot landscapes, whereas hardly any differences (on average 3.3%) were observed between conventional fields in hotspot landscapes and organic fields in coldspot landscapes.

These results show that organic farming can enhance biodiversity, although the effects are mixed with some species groups responding positively, others negatively. Additional biodiversity benefits are achieved when the area of organically managed land increases, especially for mobile taxa such as flower visiting insects, which experience their environment at larger scales and thus may benefit from the higher floral abundance of aggregated organic farms through better pollen and nectar availability. However, hoverflies and birds were less common on organic farms. Hoverflies are well known to prefer arable landscapes, which are less common on organic farms. The lower number of birds on organic farms could be because of indirect effects: organic farms may be favourable to birds, but an increase in some birds (such as corvids like jays and rooks) can lead to negative effects on the birds on which they may prey.

Soil and Water Research

Research was undertaken on one crop and one grass field per farm in March and April, 2007, when soils were at or near to the field capacity moisture content. Ten samples of soil were taken in a 'W' shaped path in each field, to ensure a representative sample. Water infiltration was recorded, and soil water samples analysed for pesticides, herbicides and nutrient content.



Overall, the analysis of the data shows that with the exception of infiltration rate, no significant differences in the soil physical condition between organic and conventional farming practices. No differences were found between hot and coldspot locations. However, it is possible to detect differences in the effect of soil type and land use (grassland/arable) on a number of the soil properties:

- a. the heavier textured (higher clay content) soils have significantly higher: organic matter, aggregate stability and shear strength; whilst the coarse textured (higher sand content) soils have a significantly lower field capacity moisture content.
- b. grassland has a significantly higher: level of soil organic matter, field capacity moisture content, aggregate stability and soil shear strength.

There were fewer low-level traces of identified pesticide and herbicides in the soil water from the organic fields compared with the conventional fields. However, all the pesticide and herbicide levels recorded were less than the current thresholds given by 'no observed effect concentration (NOEC) level' that are considered detrimental to the environment (PPB Footprint Report, 2009).

As would be expected the conventional arable fields had higher levels of total inorganic nitrogen (30.56 mgkg^{-1}) than the grassland and organic arable ($14.38 - 9.94 \text{ mgkg}^{-1}$). There were no significant differences in total phosphorous and total potassium.

However, whilst there was no significant difference in the infiltration rates between organic and conventional arable soils, there was evidence that infiltration rates were higher on organically managed grassland (7.6 mmhr^{-1}) in comparison with conventional grassland (2.5 mmhr^{-1}). This is likely to reflect lower stocking density on organically managed land, rather than organic management per se. Lower stocking density of livestock can be expected to cause less soil damage and could facilitate better infiltration of water into soil.

Such higher infiltration rates may have a beneficial effect upon reducing runoff from a catchment. Hence, converting land to organic or well managed non-organic grassland (e.g. reduced stocking densities and rotating livestock to prevent poaching) could have the potential to reduce the likelihood of flooding through improved infiltration and lower peak runoff rates.

Economic Research

Economic researchers interviewed farmers on the 32 farms in autumn of 2006, 2007 and 2008. They then averaged the data across the years to reduce the effects of weather or market fluctuations. Data collected included the crop (cereal) yield and revenues, cost and quantities of inputs (e.g. seed, fertilisers, sprays), cultivation and labour. Statistics on subsidies received were collected, although these were not used to evaluate the relative monetary value of the crops produced. However, it was found that on average, conventional farmers had a higher percentage of government subsidies in their turnover than the organic farmers in the study.

As would be expected, conventional farms averaged higher yields than organic farms. This led to higher gross revenues. However, when the production costs and price received for commodities produced was added to the equation, organic farmers averaged higher net margins.

Interestingly, the net margins for organic farms in hotspot areas was about the same as that of conventional farms in coldspot areas, whereas the highest net margin was found on the organic farms in coldspot areas, and the lowest was found in conventional farms in hotspot locations.

In the productive (also called technical) efficiency analysis the focus is broadened to include outputs beyond the physical yield and revenue from cereal production. The farms were considered as multi-output systems in which farmers use a combination of inputs to produce both cereals and biodiversity. Four technical efficiency (TE) indexes were used, combining measures of cereals production and biodiversity production in different ways. There is strong evidence (all 4 TE indices) of higher efficiency on hotspot, as opposed to coldspot, organic farms, while there is evidence that the reverse is true in the conventional sample, albeit for only 1 of the 4 TE indices (the other three not showing a statistically significant difference).

Next the efficiency analysis was conducted using the financial value of inputs and cereal yield in addition to on-farm biodiversity levels measured in physical terms. The results indicate that while the conventional farms still outperform the organic farms in coldspots this is no longer the case among the hotspot farms, where there is no significant difference between the organic and conventional farms. As before, the organic farms in the hotspots outperform those in the coldspots, for three out of four TE indices. For conventional agriculture the reverse holds as in the physical analysis; however, comparing to organic farms the evidence is slightly weaker since it holds for 2 of the 4 TE indices. This implies that organic farmers are associated with greater technical efficiency in landscapes where there is a greater concentration of organically managed land.

	Organic	Conventional
Grain yield (tonne/ha)		
Hot	3.3	8.2
Cold	3.8	8.5
All	3.5	8.3
Grain price (£/tonne)		
Hot	249	124
Cold	245	140
All	247	132
Revenue (£/ha)		
Hot	900	1124
Cold	1060	1255
All	960	1190
Costs (£/ha)		
Hot	333	679
Cold	342	638
All	336	657
Net Margin (£/ha)		
Hot	608	432
Cold	743	603
All	660	516

Sociocultural Research

Farmers in two of the 'neighbourhoods' surrounding matched pairs of organic and conventional farmers were interviewed in winter of 2007 and 2008. Organic farmers were located through membership lists provided by the Soil Association and Organic Farmers and Growers; non-organic farmers were identified through yell.com. 48 farmers in total were interviewed. The focus of the interview was on farm history and future plans, perceptions and experience of organic farming, definitions of 'good farming', and social networks. From these interviews, two major themes emerged – 'effectively organic' farming, and the importance of 'good farming' to social acceptance.

'Effectively organic' farming

One unexpected finding of the interviews was the number of farmers (12 of 27 non-organic farmers) who identified themselves as 'nearly' or 'effectively organic', due to the limited amount of chemical fertilisers, pesticides and medicines they use on their farms. This led to a review of statistics on fertiliser and pesticide use in the UK, which found that there has been clear decline in the use of chemical fertilisers in recent decades, with 2008 dem-

onstrating the lowest level of nitrogen use across the UK since 1983. Nitrogen use on grassland in England has reduced even further, to levels similar to those of 1969. Similarly, by 2008 levels of phosphate and potash used on arable and grassland crops in England had declined to 1960s levels. Use of pesticides tells a different story, complicated by the reducing weights of active products (achieved through technological advances), the increasing average number of applications on the fields in which pesticides are applied (from four in 1998 to six in 2008) and the limited availability of statistics prior to 1992². The general picture, however, is of increased area over which pesticides are used (on both arable crops and grassland), but reduced use rates. Ninety-nine percent of rough grazing, 93% of permanent pasture and 86% of grass (2-5 years old) remained untreated with pesticides in 2005³. The reason farmers in this study gave for this trend was reducing inputs in order to produce commodities more efficiently, rather than aiming for the highest possible outputs.

A number of organic farmers also described using low levels of inputs prior to formal conversion (9 of 21 organic farmers). For the farmers that converted, conversion was not considered a big step, because they felt they were already 'halfway there'. Therefore, if it made sense economically, it was an easy step to take. As one farmer put it

"We didn't have to fundamentally change the way we were farming. Ok we got rid of the fertiliser spreader and sprayer, but we were still growing pretty much the same crops. We still had pretty much the same size flock of sheep and we increased the beef a bit". (Farmer 12)

These farmers also considered other aspects of organic conversion, such as the ability to employ more people on-farm.

For other low input farmers, conversion to organic farming was not a serious consideration – there are many other options for increasing farm economic viability, such as contracting machinery, conversion of farm buildings, and developing leisure centres or activities. Some commodities – such as rare breed livestock – already receive premium prices, and therefore would not benefit from organic certification.

There were also concerns that the difference in profitability between organic and conventional farming would not make it worthwhile long-term. Recent studies^{4,5} demonstrate that organic farming is typically more profitable, but that the advantages over conventional production are increasingly marginal. Conversion to organic farming was viewed by respondents as a long-term investment – and therefore not an option for those for whom the future of the farm was uncertain (e.g. through inheritance or retirement) although one farmer did identify conversion as a retirement strategy – fitting with his existing semi-retirement plan of decreasing stocking density and converting his farm to grass.

For farmers who were not low input, conversion to organic farming was usually not a serious consideration, due to the number of changes that would need to be made to convert (e.g. adding livestock to an arable farm, loss of investment in machinery etc). In responding to decreasing profit margins, most farmers believed they had the choice of either "getting bigger or concentrating on something else". For most farmers, converting to organic farming was only a consideration if they had already decided against intensification.

'Good Farming'

There have been several studies that have demonstrated that farmers have relatively uniform definitions of what it means to be a 'good farmer' in their region. These definitions are important, because they impact on how farmers choose to run their farms. In this study, we were interested in seeing whether organic farmers defined 'good farming' differently than non-organic farmers, and whether this was different between hotspots and coldspots.

The cultural symbols identified by both organic and non-organic farmers centered around tidiness, getting farm tasks done on time, 'doing the job right', hard work, weed-free fields, livestock condition and quality, maintenance of wildlife habitats such as hedges, preservation of soil fertility, making good use of resources, and being progressive. The difference between organic farmers and non-organic farmers was that organic farmers tended to put more emphasis on maintaining the environment, and making good use of resources, and less on clean fields. This reflects both the 'organic farming ideals' and the pragmatic realities of organic farming production.

² Garthwaite, D.G., Thomas, M.R., Parrish, G., Smith, L., Barker, I. 2009. Pesticide Usage Survey Report 224. Arable Crops in Great Britain 2008 (Including Aerial Applications 2007-2008). Food & Environment Research Agency, Sand Hutton, York UK, YO41 1LZ <http://www.fera.defra.gov.uk/plants/pesticideUsage/fullReports.cfm>

³ Garthwaite, D.G., Thomas, M.R., Anderson, H.M., Battersby, A. 2006. Pesticide Usage Survey Report 210. Grassland and Fodder Crops in Great Britain 2005. (including aerial applications 2003-2005). Department for Environment, Food & Rural Affairs & Scottish Executive Environment & Rural Affairs Department. Available at: <http://www.fera.defra.gov.uk/plants/pesticideUsage/grassland2005.pdf>.

For both non-organic and organic farmers, it was important to maintain a financially viable farm, although there was recognition that this has become increasingly difficult.

Organic farmers identified the financial difficulties of farming in recent years as a major reason for the growing acceptance of organic farming in farming communities. Organic converts in the study expressed a belief that there had been a “massive change in attitude” (Farmer 22) towards organic farmers:

“in the old days it was, we [organic farmers] were a joke you know, we were treated as a joke... [it] is increasingly becoming oh it doesn't look a mess, and he is still making money and he is still employing Andrew, whereas I made Fred redundant and all the rest of it.” (Farmer 4).

Longevity and financial viability have helped to gain credibility for organic farmers. Although there were a few farmers for whom the other approach was not acceptable (e.g. who believed that their own approach – be it organic or non-organic - was the only way to approach farming), most expressed respect for a number of other farmers, including those who had adopted a different approach. Distinctions were made on the basis of which farmers were perceived as ‘doing a good job’, rather than whether they were organic or not. However, it was clear that not all farmers are considered ‘good farmers’ and that trust between neighbours can be a problem as a result.

Interestingly, organic farming was viewed more positively by farmers in the southern ‘hotspot’ than in the Midlands ‘hotspot’. This appeared to be because the southern ‘hotspot’ developed over the past 20 years, as well-respected, long term farmers and their successors converted to organic farming, and continued to run viable farm businesses. In the Midlands site, most of the organic farmers were new to the area, due in part to the active recruitment of organic farmers by a local estate. These ‘newer’ farmers were viewed with more scepticism by other local farmers.

Implications: What happens to the research now?

Study findings are communicated to government and other researchers in several forms. A report on project findings goes directly to the research councils and Defra. Government and industry representatives attended the final project workshop, where the findings and their implications were discussed directly. Papers are also written in journal articles for other researchers. All of the data is archived (in anonymous form) so that other researchers can use it in the future.

In this study we have several key findings:

- *Higher concentrations of organic farms leads to higher average levels of biodiversity. This means it would be beneficial to many species for groups of farmers to co-operate to produce habitats for these species. However, some species would actually be worse off if this was the case, and would need alternative arrangements.*
- *Higher average biodiversity can be produced at no cost to farmers, where adoption of actions are widespread (e.g. on organic farms in hotspot locations). This also supports the case for farmer collaboration to produce biodiversity.*
- *Organic management of grasslands results in higher soil water infiltration rates. This could lead to land management measures to reduce flooding in vulnerable areas, through encouragement of conversion to grassland from arable, and reduced stocking density. This can apply not only to organic farms but also to more sensitive management of conventional grassland.*
- *Less productive agricultural areas are most likely to respond first if increased conversion rates step up the government's agenda. However, many of the farmers in these areas may be ‘effectively organic’ already, so environmental benefits of conversion may be less than would be the case for the conversion of intensively managed farms.*

Some researchers are also calling for ‘payment by results’ environmental schemes – meaning that farmers would get paid for the amount of biodiversity (or other objectives) they produce, which would encourage them to learn how to support specific species, rather than having to follow generic guidelines which may not suit their farm, or the plants and animals living there. Our research shows that while this might motivate farmers to be more creative in some of their environmental activities, because a lot of species travel between farms, accurate measurement of what an individual farmer achieves would be very difficult.

⁴ Jackson, Andrew and Nicolas Lampkin. Organic Farm Incomes in England and Wales 2005/2006. Institute of Rural Studies, Aberystwyth, the University of Wales.

⁵ Soil Association 2010. Organic Market Report 2010. Available at: <http://www.soilassociation.org/LinkClick.aspx?fileticket=bTXno01MTtM=&tabid=116>.



Who are the SCALE researchers?

The SCALE project was led by a team of researchers from across the UK. The project co-ordinator was Dr Sigrid Stagl, University of Sussex (now at the University of Vienna). Other team members are:

Prof. Tim G. Benton, Institute of Integrative & Comparative Biology, University of Leeds

Dr. Ben Davies, Business School, University of Aberdeen

Dr. Doreen Gabriel, Institute of Integrative & Comparative Biology, University of Leeds

Prof. Richard Godwin, National Soils Resources Institute, Cranfield University

Miss. Laura Hathaway-Jenkins, National Soils Resources Institute, Cranfield University

Prof. William E. Kunin, Institute of Integrative & Comparative Biology, University of Leeds

Dr. Bruce Pearce, The Organic Research Centre, Elm Farm

Dr. Dan Rigby, School of Economic Studies, University of Manchester

Dr. Ulrich Schmutz, Henry Doubleday Research Association

Dr. Unai Pascual, Department of Land Economy, University of Cambridge,

Dr. Steve M. Sait, Institute of Integrative & Comparative Biology, University of Leeds

Dr. Ruben Sakrabani, National Soils Resources Institute, Cranfield University

Dr. Lee-Ann Sutherland, Macaulay Land Use Research Institute, Aberdeen

We also recruited over 20 field assistants and MSc students who undertook the ecology work in the field over the 12 week summer season.

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