# ORGANIC FARMING AND BIODIVERSITY

## POLICY OPTIONS

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# EXECUTIVE SUMMARY

This study of the contribution that organic farming to biodiversity and the role of policy had four key objectives:

- To review the evidence on the biodiversity impacts of organic farming in Europe;
- To analyse how organic farming practices, including the avoidance of most agrochemical inputs, contributes to these impacts;
- To review how European policies to support organic farming and the environment have been used;
- To consider and make recommendations on how future CAP and EU policies could be used to expand organic farming and enhance its biodiversity impacts.

**There is now a substantial body of research evidence that demonstrates the positive impacts of organic farming on biodiversity in Europe.**

While most studies have been conducted in the context of temperate, arable systems, there are an increasing number of studies relating to grassland, horticulture and Mediterranean olive and other systems that also support the general conclusions that:

- Organic farming increases both the abundance and species richness of biodiversity across a range of habitats and farming types, when compared with similar, non-organic systems;
- In arable farming, plant species biodiversity is enhanced both within field (in the crops) and in field margins, with 20-95% more species and up to 150% greater abundance recorded in organic systems, with the greatest differences recorded within fields;
- Soil microbial diversity, insects and bird populations are also positively influenced by organic management. In arable contexts, insect species numbers have been reported at 23% higher, and pollinators 30% higher, on average across a number of studies;
- For grassland, studies have shown more limited benefits for plant and soil microbial biodiversity in permanent grassland, where non-organic management tends also to be less intensive;
- Temporary grassland, normally grass/clover leys or lucerne, may be dominated by a limited range of sown species, but will have more unsown species, and the use of flowering legumes can benefit pollinators if managed appropriately – the contribution of organic matter in the rotation also has positive impacts on soil microbial diversity and earthworms;
- In horticulture greater diversity is found within fields as for cultivated arable crops, but also in the understoreys of fruit production systems, with insectivorous bird species also benefitting;
- Relatively few studies have been conducted in Mediterranean olive and vine systems, with some showing benefits, but landscape effects also being important.

**The results generally support the EU Organic Action Plan statement that organic farming delivers 30% more biodiversity on average.**

Given the focus of much of the research on temperate arable systems, there is a need to extend research to cover other land uses and regions, and to focus more on understanding how the benefits recorded are derived and can be enhanced, with the information communicated to farmers in the context of advisory and training programmes.

The biodiversity benefits delivered by organic farming are a consequence both of the practices prohibited under organic regulations, such as the use of synthetic nitrogen fertilisers, herbicides and most pesticides and fungicides, as well as the agroecological practices adopted by organic farmers to solve production issues without them.

The complete avoidance or substantial reduction in the use of agrochemical inputs in organic farming contributes to biodiversity by avoiding or reducing the:

- Direct toxic impacts of herbicides and pesticides on non-target organisms;

- Indirect impacts of herbicide and pesticide use on food sources and habitat for insects, birds and other organisms;
- Impacts of surplus nutrient use on soil ecosystems, including organic matter loss and soil acidification due to nitrogen use and mycorrhizal decline due to phosphate use;
- Impacts on aquatic ecosystems from nitrate leaching and phosphate losses from agricultural land;
- Impacts on sensitive habitats and low nitrogen tolerance species from nitrogen depositions, including ammonia from livestock systems;
- Impacts on insects colonising animal faeces as a result of the use of certain anthelmintics;
- Climate change impacts on biodiversity associated with emissions from agricultural input use and manufacture, as well as loss of soil carbon.

**By completely avoiding the use of most of these inputs, the benefits go significantly beyond those that might be expected from a 10-20% improvement in input use efficiency within conventional systems.**

However, yields are also reduced as a consequence of the input use reductions, so that benefits per unit output may be lower than per unit of land used.

However, the benefits are not only derived from avoided practices and inputs. Key biodiversity-enhancing practices used include the use of:

- Mixed farming systems integrating crops, trees and livestock;
- More diverse and complex rotations and cropping systems;
- Leguminous crops for biological nitrogen fixation, supporting pollinators if managed appropriately;
- Heterogenous genetic materials (variety mixtures, populations, landraces) using genetic diversity to support pest and disease control;
- Sown refuges and other landscape elements for natural predators (passive biological pest control);
- Smaller field sizes, contributing to a more complex landscape mosaic;
- Trees and hedges with complex understoreys for shelter, erosion control and fertility management;
- Alternation of sowing times of crops for weed control, benefiting farmland birds;
- Organic matter, leys and green manures for fertility building, providing energy-rich carbon sources to help maintain soil ecosystems;
- Reduced tillage and soil cultivation depths to protect soils;
- Diverse species mixtures including legumes, herbs and novel forages for grassland;
- Land-based livestock production systems with grazing and reduced stocking rates supporting biodiversity in grassland.

While none of the practices adopted are unique to organic farmers, the combination of many biodiversity-enhancing practices in a systems-based approach allows for synergies to be exploited with the potential for greater impacts.

**Organic farming practices and the related biodiversity benefits illustrate how a land sharing approach can be used constructively, as an alternative to a complete separation of intensive, land sparing but low-biodiversity agricultural production from land prioritised for nature.**

The positive contribution of organic farming to the environment in general and biodiversity in particular has been recognised Europe-wide since the 1990s, when support payments for organic conversion and maintenance were introduced as part of the agri-environmental measures. This is the main source of support for organic farming in the CAP, with an expenditure in 2018 of over 1.8 billion € or 3% of the CAP budget for 8% of the EU's land area. All member states except the Netherlands have implemented conversion and maintenance support, although budgetary and administrative issues have resulted in intermittent availability in some countries. Within and between countries, individual payment rates can be highly variable. These factors impact on the market-focus of organic farming and the need to balance public and private good perspectives.

The potential to combine organic farming support with other agri-environmental support is also highly variable. In some countries, combinations are possible, except where similar requirements are imposed to those specified under organic regulations. In other countries, combinations are not permitted, due to dual funding or budgetary concerns, or are only possible on a very restricted basis. In very few cases have agri-environment options been developed to specifically capitalise on the baseline provided by organic farming standards.

Organic farming has also been recognised as *de facto* qualifying for Greening as part of the Pillar 1 direct payments. This is in recognition of the more diverse cropping systems, the importance of grassland for livestock production and the benefits from non-crop habitats in organic systems. While some of the Greening provisions are not specifically required under organic regulations, they represent good practice that would normally be expected on organic farms.

There is potential for public-private partnerships to support the delivery of environmental benefits by organic farmers. Water agencies or companies in France and Germany have provided specific support to organic farmers to reduce pollution from agrochemicals in water catchment areas, while in Germany retailers are developing schemes to recognised biodiversity actions through improved marketing opportunities.

**The EU has set an ambitious target for the expansion of organic farming to 25% of agricultural land area by 2030 as part of its Farm to Fork and Biodiversity Strategies intended to deliver on the Green Deal. Achieving this will also contribute to the pesticide, fertiliser and antibiotic reduction targets, and to the nature restoration targets.**

As this review has indicated, compliance with organic regulations already delivers biodiversity benefits due to the substantially reduced use of fertilisers and pesticides, as well as the changes in rotations, timing of cultivation and other practices that are used to accommodate this. There are many opportunities to build synergistically on this baseline through initiatives by individual organic farmers and groups of farmers. This is entirely consistent with organic principles, and with the aspirations of most organic farmers. They can be supported in delivering these benefits through well designed Eco-schemes and Agri-environment/Climate options in the new Member States' CAP Strategic Plans.

The new CAP for the period to 2027 places the responsibility on Member States to develop agricultural and agri-environmental policy measures to meet specified objectives. The Commission's expectation is that organic farming will feature strongly in this process – the EU organic action plan envisages that every Member State will set a national target for organic farming and develop a strategic plan to achieve this.

**However, IFOAM Organics Europe suggests that funding for organic farming support through the new Eco-schemes as well as traditional Agri-Environment Climate measures may need to increase 3-5 fold (10 fold in some countries) to deliver the 25% land area target.**

While many policy options to enhance organic farming's biodiversity benefits would have been possible under previous rural development programmes, it is clear that insufficient use has been made of the opportunities and, in some cases, there have been policy constraints imposed that have actively discouraged building more biodiversity benefits on the base that organic farming provides.

To address these issues, Member States (MS) should:

- Explicitly recognise the opportunities for biodiversity conservation and enhancement underpinned by organic farming in their CAP Strategic Plans (CSPs), rural development programmes and national organic action plans. This will require not only recognition by the Commission that organic farming does deliver biodiversity benefits in the context of Eco-schemes, but also a comprehensive assessment by the Commission during CSP adoption of how MS will support biodiversity objectives through organic payments and additional AECM payments.
- Enable combinations of organic farming, Eco-schemes and agri-environmental options wherever possible, ensuring that practice definitions do not unintentionally exclude organic farms, and including options specifically

targeting and building on minimum organic standards, so that opportunities to benefit from synergies and enhanced delivery of biodiversity outcomes can be exploited.

- Encourage natural/ecological focus areas (landscape elements) as part of functioning organic systems, recognising the mutual benefits for biodiversity and agricultural systems such as refuges for beneficial insects. The minimum threshold specified in GAEC 9 should not represent an issue for organic farms, but it could be more ambitious – many organic farms will already exceed the 10% target for nature restoration specified in the EU Biodiversity strategy. The Commission should assess how organic farming can be used to effectively make an active contribution to the EU nature restoration targets under the Biodiversity Strategy.
- Consider whether biodiversity requirements should be more explicit within organic regulations. At present, many of the biodiversity benefits are an indirect consequence of prohibited or restricted practices, and not recognised as biodiversity-focused.
- Support organic and environmental AKIS initiatives to make best use of biodiversity options on organic farms and avoid the risks of unintentional damage. This also requires AKIS delivery agents (agricultural and nature advisors and ecologists) to better understand the contributions that organic farming can make across different farmland types and enterprises.
- Exclude organic premium prices from income foregone calculations, given a) that the environmental benefits are delivered for society as a whole, not just organic consumers, b) organic consumers are motivated to purchase also for other reasons than environmental ones and c) premium prices are normally only available where investment in market development has taken place, which is not normally reflected in income foregone calculations. This would help avoid situations where organic farmers are paid less than other farmers for delivering the same agri-environmental options, creating perverse incentives.
- Consider supplementary payments for conversion to or maintenance of organic farming in sensitive areas such as water catchments, Natura 2000 or other protected areas.
- Give more consideration to public-private partnerships with businesses such as retailers and water companies, as well as to biodiversity offsetting schemes, to provide additional support for organic farmers, as illustrated in Section 4.4 above.

Looking forward, there is a need to reflect on the mechanisms for rewarding the delivery of environmental benefits by farmers. While the income foregone model required under WTO agreements is intended to avoid market distortion by only compensating for income losses and additional costs of agri-environmental measures, this approach provides no additional incentive to adopt more environmental approaches and may overcompensate some farmers while undercompensating others. There is a need to shift the focus from inputs to the actual environmental outputs delivered, and to recognise the biodiversity benefits delivered by those organic farmers who go beyond meeting the minimum requirements needed to be certified organic and qualify for current payments.

If all these issues can be addressed, then the potential for organic farming to deliver even more for biodiversity, and to make a major contribution to the EU's Biodiversity Strategy, is significant and worthwhile.

# INTRODUCTION

## BACKGROUND

IFOAM Organics Europe commissioned this policy review by the Organic Policy, Business and Research Consultancy. It is split into four tasks:

### 1. Overview of studies on the biodiversity impacts of organic farming

A large number of research projects and reviews have been conducted on this topic. The aim of this part of the study is not to undertake another comprehensive review, but to summarise the main outcomes with a focus on primary land use types (arable, grassland, horticulture etc.) and geographical conditions across the EU. It identifies the scope, strengths, and weaknesses of the evidence base where published literature is available. The range of biodiversity impacts, from soil organisms to plants, birds, habitats and landscapes are considered. Recent reviews (Lampkin *et al.*, 2015; Dimambro *et al.*, 2018; Sanders and Hess, 2019) provides a starting point for this review, updated with any significant new evidence from the last two years.

### 2. How do organic management practices contribute to these outcomes?

The aim of this part of the study is to illustrate why it is that organic farming delivers the biodiversity impacts recorded, limitations on this potential, and how organically farmed land could increase biodiversity outcomes (including how any increase in the extent of organic area might best benefit biodiversity). This will separate actions carried out by all organic farmers – e.g., restricted use of fertilisers, pesticides and veterinary inputs and enhanced crop diversity through rotations and use of legumes – from additional activities that can be undertaken by individual organic farmers, building on their baseline organic status – for example, the creation and management of habitats to encourage biological pest control. Land sharing, with biodiversity enhancement and agricultural management designed to be mutually beneficial and synergistic (i.e., the sum of the whole is greater than the sum of the parts), is a key theme.

### 3. Identification of existing policy options to support this process

A review of EU Member State (MS) approaches to combining organic farming and biodiversity-related agri-environment policy is conducted based on existing data. This ranges from restrictions preventing support for organic farming and agri-environmental/climate scheme (AECM) activities on the same land, to specific options for biodiversity specially designed for organic farmers, with multiple combinations in between. This also considers how to overcome some of the eligibility issues that organic land currently faces in accessing AECM funding.

### 4. Options for future policy

This considers the implications of the EU Green Deal, Farm to Fork and Biodiversity Strategies, CAP 2021-2027 proposals including Eco-schemes (including Council and Parliament positions and any agreements reached) and the potential for innovative policy options in this context. The FIBL/IEEP guide prepared for IFOAM Organics Europe (Lampkin *et al.*, 2020) provides an early introduction to the potential of Eco-schemes and the Green Architecture of the new CAP to provide support for the delivery of biodiversity benefits by organic farming.

## CONTEXT

IFOAM defines organic agriculture as *"… a production system that sustains the health of soils, ecosystems, and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic Agriculture combines tradition, innovation, and science to benefit the shared environment and promote fair relationships and good quality of life for all involved"* (IFOAM, 2008). The principles of Health, Ecology, Fairness and Care (IFOAM, 2005) are what underpins organic agriculture. In the EU there are defined production rules that are covered by regulations 834/2007 (EU, 2007) and 889/2008 (EU, 2008). These production rules are designed to promote environmental protection, maintain biodiversity and build consumer trust in organic products. They cover such principles as prohibiting the use of GMOs and limiting the use of artificial fertilisers, herbicides and pesticides but also promoting approaches to the organic system such as crop rotation, cultivation of legumes and green manures to fix nitrogen and improve soil fertility, choice of resistant varieties and breeds to reduce the impacts of weeds, pests and diseases and promoting animal health through not over stocking. A number of these practices such as crop rotations, appropriate and diverse varieties and breeds, and limited use of artificial fertilisers and pesticides, as well the improvement of soil health will have direct impacts on biodiversity in organic farming systems. Table 1.1 illustrates where specific EU production rules contribute to biodiversity. These are considered in more detail in Chapter 3.

Organic farming has been supported as an agri-environmental measure in the European Union since the early 1990s, recognising the beneficial impacts for biodiversity, as well as water, soil, air and climate protection, of the practices covered by organic standards. This recognition was given added weight by the de facto recognition of organic farming for Greening as part of the CAP Pillar 1 Basic Payments from 2014, and the setting of a specific target of 25% of EU land area to be managed organically by 2030 as part of the Biodiversity and Farm to Fork Strategies published by the European Commission in 2020. The achievement of this target has been given additional support with the publication of the third EU action plan for organic farming in March 2021. The policy context is considered in more details in Chapters 4 and 5.

Table 1.1: Production rules and organic objectives and principles that contribute to biodiversity.

| **Production Rules** | **Contribute to biodiversity** |
|---|---|
| Prohibitions [A: 4 (a) iii and (c)] | |
| No mineral nitrogen fertilisers [A: 12.1 (e)] | ✓ |
| No herbicides, only authorised products can be used [A: 12 (h), B: Annex II] | ✓ |
| Strict control of external inputs [A: 4 (b)], minimisation of the use of non-renewable resources [A: 5 (b)] and recycling of wastes and by-products [A: 5 (c)] | |
| Only permitted fertilisers: low-soluble mineral fertiliser [A: 4 (b) iii] and soil conditioners when need proven [B: 3, Annex I] | ✓ |
| Only authorised plant protection products when established threat [A: 12.1 (h), B: Annex II] | ✓ |
| Stocking density and use of livestock manure restricted to maximum of 170 kg N/ha and year [B: 3 &15.1] | ✓ |
| Obligations to use good husbandry practises and prevention [A: 4 (a) iv and 5) | |
| Multiannual crop rotation including legumes and other green manures [A: 12.1 (b)] | ✓ |
| Tillage and cultivation practices that maintains organic matter, and protects soil [A: 12.1 (a)] | ✓ |
| Maintain crop health through prevention (natural enemies, the choice of species and varieties, crop rotation) cultivation techniques and thermal processes [A: 12.1 (g)] | ✓ |
| Number of livestock limited to minimise overgrazing, poaching, soil erosion or pollution [A: 14.1 (b) iv] | ✓ |
| Preference for inputs from organic origin (Art 4b with exceptions (Art 4d)) | |
| Manage entire holding organically (with exceptions) [A: 11] | ✓ |

Article numbers refer to Council Regulation (EC) 834/2007 [A] and Commission Regulation (EC) 889/2008 [B]

Source: After Sanders (2013)

# OVERVIEW OF STUDIES ON THE BIODIVERSITY IMPACTS OF ORGANIC FARMING

## INTRODUCTION

A large number of research projects and reviews have been conducted on this topic. The aim of this part of the study is not to undertake another comprehensive review, but to summarise the main outcomes with a focus on primary land use types (arable, grassland, horticulture etc.) and geographical conditions across the EU. The scope, strengths and weaknesses of the evidence base are identified where published literature is available. The range of biodiversity impacts, from soil organisms to plants, birds, habitats and landscapes will be considered. Recent reports e.g. Lampkin *et al*. (2015); Dimambro *et al*. (2018); Sanders and Hess (2019), will provide a starting point for this review, updated with any significant new evidence from the last two years.

Biodiversity can be considered at the genetic, species and ecosystem level. It is of interest to human populations for both intrinsic (i.e. cultural, social, aesthetic and ethical benefits) and instrumental (i.e. directly used for food, fuel, recreation, or indirectly via ecosystem processes and environmental services) reasons (Decaëns *et al.*, 2006).

While biodiversity is important *per se*, and a major focus of nature conservation and agri-environmental policies as a consequence, it is also of relevance in terms of the support services that it provides to agriculture, not least because agriculture is fundamentally concerned with the provisioning ecosystem services of food and energy production. However, as highlighted elsewhere in this report, biodiversity also contributes to system self-regulation, in particular of pests, parasites and diseases, as well as to pollination, enabling plant reproduction, genetic resources, soil health and water quality. Biodiversity loss as a consequence of agricultural intensification has had a negative impact on these ecosystem services (UK National Ecosystem Assessment, 2011). To an extent they can be replaced by other inputs, but at a cost.

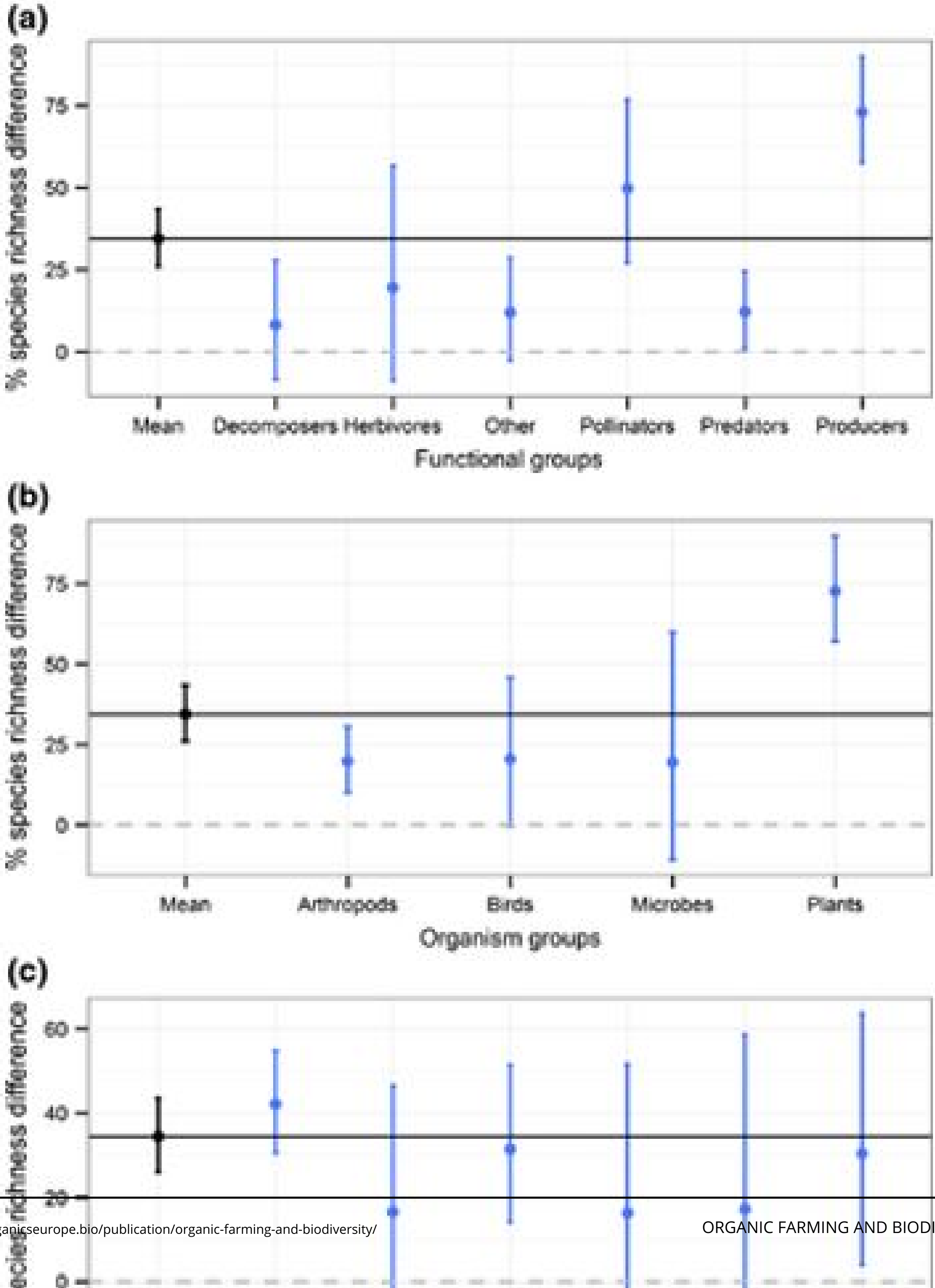
Pollinators in particular are a cause for concern. Approximately 250 crop species are grown in Europe of which 150 are believed to be pollinated by insects and the global value of pollinators in 2005 was estimated to be €120 billion (Gallai *et al.*, 2009). It is therefore a concern what impact the decline in farmland pollinators, particularly honeybees and bumble bees (Biesmeijer *et al.*, 2006; Potts *et al.*, 2010; Hallmann *et al.*, 2017), as a result of agricultural intensification (Goulson, 2003), will have on national and global food production.

Comparisons between organic and conventional systems have historically been difficult to make sense of because of the inherent and implicit differences between the systems and the scale at which comparisons are being made, i.e., plot, field or landscape. This frequently caused bias in site selection and made conclusions on individual studies difficult to draw, which further complicated meta-analysis.

Tuck *et al*. (2014) improved on previous reviews by addressing the hierarchical structure of multiple within-publication effects sizes and including standardised measures of land-use intensity and heterogeneity across all studies. The meta-analysis found that, on average, organic farming increased species richness by about 30% (Figure 2.1). This result was robust over the last 30 years of published studies, lending support to the argument that organic farming is a reliable method for increasing biodiversity on farmland and may help to reverse the declines of formerly common species. This effect was also robust across sampling scales, in contrast to other studies that suggest the benefits of organic farming diminish at larger scales (Gabriel *et al.*, 2010).

The average effect size and response to agricultural management system depended on taxonomic group, functional group and crop type (Figure 2.1). Plants benefitted the most from an organic approach, while arthropods, birds and microbes also showed a positive effect (Tuck *et al*. 2014, op cit.). Among functional groups, pollinators showed the largest effect size, while soil-living decomposers showed little effect. This lack of effect on decomposers is somewhat surprising, given the fact that organic farming has been shown to benefit soil structure and soil conditions but may be due to stronger influences of soil type and structure on soil biodiversity than the farming system itself, although it was noted that soil organisms were in general understudied. There were also varying responses among crop types, with large positive effect sizes in cereals and mixed farming and moderate positive effects for all others (Figure 2.1). Of the three measures of land-use intensity (proportion of arable fields; typical field size; number of habitats), only the proportion of arable fields had any significant overall effect. When there was a greater proportion of arable land in the system, the difference in diversity between organic and conventional farms increased (Tuck *et al*. 2014, op cit.). This suggests that the effect of organic farming on biodiversity is greater in intensively managed landscapes, although again, this was found to vary between groups. For example, predators have a greater response to organic farming in intensively managed landscapes while the effect on pollinators does not increase much with land-use intensity (Tuck *et al*. 2014, op cit.).

Figure 2.1: The difference in species richness (%) on organic farms, relative to conventional, classified by (a) functional group, (b) organism group and (c) crop types (the grand mean is shown in black, accompanied by the black line).



Source: Tuck et al. (2014)

## NOTE OF CAUTION

The studies drawn upon in this report (Lampkin *et al.*, 2015; DEFRA, 2018; Dimambro *et al.*, 2018; Stein-Bachinger, Haub and Gottwald, 2019) themselves drew upon a wide range of publications, and the data held within them. That said the number of papers in any specific area could be small, or of different sample and data sizes, so any one publication can have a greater or lesser impact on the analysis and conclusions by the authors. One particular paper, Gabriel *et al*. (2010), was a large study using novel site matching techniques and drawing on a wealth of data collected during the work of a wider project. The findings are robust for their work in the south of England. However, it is suggested that the sheer size of the data source could possibly bias results when combined with others – in some analysis N=64 with the Gabriel data and N=32 without it. Stein-Bachinger *et al.* (2019) undertook some analysis with and without the data and showed this could be the case in some but not all analyses. This report would not wish to discount the data from Gabriel *et al*. (2010) but where conclusions are being drawn where the data may overwhelm other sources they should be taken with some caution and caveats.

## BIODIVERSITY IMPACTS OF ORGANIC FARMING

This report is based initially on four existing studies. In recent years four reviews have been undertaken on the biodiversity impacts of organic farming. In the German language review edited by (Sanders and Hess, 2019) a chapter on biodiversity (Stein-Bachinger, Haub and Gottwald, 2019) undertakes a meta-analysis of a range of topics including arable weed flora and seed bank, field margin vegetation, birds and insects. Two studies in English (Lampkin *et al.*, 2015; Dimambro *et al.*, 2018) have also been used as the baseline information for this report. The summary of the review by Stein-Bachinger, Haub, and Gottwald (2019) that was in German and primarily focused on central Europe reported

> *"Positive effects of organic farming on biodiversity can be clearly demonstrated for the species groups studied.*

*On average (median values), species numbers on arable land were 95 % higher under organic management as well as 61 % higher for weed seed bankand 21 % higher for field margin vegetation. In the case of the farmland birds, the number of species was 35 % higher and the abundance 24 % higher (median values) for organic farming. At 23 % and 26 %, respectively, these values were higher for flower‐visiting insects. Overall, 86 % (flora) and 49 % (fauna) of the comparison pairs showed distinct advantages through organic farming. Only two out of 75 studies found negative effects from organic management in 12 out of 312 pairs, based on the classification made. It should be noted that landscape structure has a significant impact on biodiversity, especially on fauna, and this can strongly outweigh the effects of land use".*

Lampkin *et al.* (2015) had a wider focus looking at the role of agroecology in sustainable intensification but did look at biodiversity benefits of both organic farming and agroforestry. They concluded "*that agroecological approaches can maintain or increase biodiversity and the output of related ecosystem services – with appropriately designed and managed agroforestry and organic systems offering potentially greater benefits than integrated systems*.

Dimambro *et al.* (2018) suggested equally positive responses and summaries with "*…Studies over the last 30 years have observed that biodiversity generally benefits from organic agriculture, with increases in a range of taxa observed in many cases. However, some studies observe mixed effects with increases, no change or decreases in different taxa or species. The increases in biodiversity in organic systems are often attributed to the more heterogeneous nature of organic holdings (including crop diversity, boundary features and wooded areas) rather than at an individual field level. Organic farms may not always have higher biodiversity than comparable conventional farms, because other factors, especially landscape, do appear to play a large part in influencing biodiversity. …*".

Stein-Bachinger *et al.* (2019) sets out the position in arable systems well for central/northern European systems but there is no reason to believe that the situation in other parts of Europe will be any different. They examined the systemic achievements of organic farming for biodiversity from a large number of scientific studies over the past 30 years. Many comparative studies of organically and conventionally managed arable and grassland areas in the European show that organic management has positive effects on biodiversity (Azeez, 2000; Stolze *et al.*, 2000; Bengtsson, Ahnström and Weibull, 2005; Hole *et al.*, 2005; Mondelaers, Aertsens and van Huylenbroeck, 2009; Rahmann, 2011; Tuck *et al.*, 2014). This applies to soil microbiology and fauna e.g. Niggli and Bensson (1996), Lori *et al.* (2017), the wild weed flora including Frieben (1990), Hald (1999), Rydberg and Milberg (2000), Frieben *et al*. (2012), the above-ground living small animal fauna, e.g., Pfiffner and Niggli (1996), Feber *et al.* (1997), Brown (1999), Pfiffner *et al.* (2001), Lichtenberg *et al.* (2017) as well as the species numbers and densities of birds, among others Lokemoen and Beiser (1997) and Chamberlain *et al.* (1999).

Analysis was undertaken on the available data and comparative pairs from a range of sources. A further analytical check was also undertaken where comparisons in differences between the results of organic and conventional were defined as unambiguous if the difference was at least 20%.

## Table 2.1: Management effects on number of species and/or abundance for different species groups in four reviews

| *Review* <br> *Studies, Period* | *Pfiffner (2001) n=44 <1987-1995* | | | | | | *Bengtsson et al. (2005) n=66 up to 2002* | | | | | | *Hole et al. (2005) n=76, 1982-2005* | | | *Rahmann (2011) n=343, 1991-2011* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Indicator | Abundance | | | No. of species | | | Abundance | | | No. of species | | | Abundance/ No. of species | | | Biodiversity* | | |
| Species group | + | = | - | + | = | - | + | = | - | + | = | - | + | = | - | + | = | - |
| Plants | | | | | | | 7 | | 0 | 22 | | 0 | 13 | 2 | 0 | 93 | 9 | 2 |
| Vertebrates | | | | | | | | | | | | | | | | 26 | 5 | 0 |
| Birds | 5 | 0 | 0 | 2 | 0 | 0 | 12 | | 0 | 3 | | 0 | 7 | 2 | 0 | | | |
| Mammals | | | | | | | | | | | | | 2 | 0 | 0 | | | |
| Invertebrates | | | | | | | | | | | | | | | | 77 | 12 | 7 |
| Arthropods | | | | | | | | | | 21 | | 7 | | | | | | |
| Spider | 6 | 1 | 0 | 0 | 0 | 0 | 4 | | 3 | | | | 7 | 3 | 0 | | | |
| Insects | 15 | 3 | 0 | 7 | 3 | 0 | 29 | | 13 | | | | 21 | 6 | 6 | | | |
| Soil organisms | 23 | 1 | 1 | 6 | 5 | 0 | 44 | | 5 | 7 | | 3 | 16 | 12 | 2 | 38 | 15 | 0 |
| Total | 49 | 5 | 1 | 15 | 8 | 0 | 96 | | 21 | 53 | | 10 | 66 | 25 | 8 | 131 | 24 | 2 |

* term used for diversity and abundance, only the results for the species groups used in this table are shown
+=- Organic greater (+), equal (=) or less (-) compared with conventional management.

Source: Stein-Bachinger et al. (2019)

# ARABLE

## Arable weed flora

Arable weeds are plants that are able to exploit the short-term, open conditions created by ploughing and harvesting within arable systems. Most are annuals that are able to flower and set seed in a short period of time – weeks rather than months. Examples of arable weeds are such plants as Common Corncockle (*Agrostemma githago*), Cornflower (*Centaurea cyanus*), Field Gromwell (*Lithospermum arvense*), Poppy (*Papaver hybridum*) and Cow Cockle (*Vaccaria hispanica*). They are an important part of our agricultural heritage. They were once so common they were considered pests but with the advent of intensive farming systems many are now rare and on the edge of extinction. Organic farming with its avoidance of herbicides can play an important role in protecting this heritage (AHDB, 2017).

Stein-Bachinger *et al*. (2019) make a compelling case that arable flora (weeds) has decreased by 95-99% since the 1950/60s with the decrease particularly seen in conventionally managed fields. The arable weed communities that still exist are impoverished and show a strong decline in specialist arable species and a relative increase in those that are often herbicide tolerant generalists. They based their conclusions on a comparative analysis on 38 studies with 110 comparison pairs. This work showed great variability with a large range of the **mean** number of arable weed species between organic and conventional systems. Comparisons between organic and conventional systems showed at the lowest end that the organic system had 27% fewer **mean** weed species than conventional although when the **median** value was looked at it was 95% higher in organic than conventional systems. As the data was likely to have been variable the median value is likely to be the more meaningful outcome here. For the total number of species, the variation is lower, with a range of 20% to 95% more species in organic systems. All the organic cases had higher total species than conventional with the median being +66%.

Further work (11 comparison pairs) investigated within-field and field margin differences. For the comparison pairs within-field, the median was significantly higher at +304% than at the field margin +94%. The impact of organic farming on the number of species was therefore greater within-field than at the field margin although still considerably greater across the whole field.

A third analysis from the results of 110 comparison pairs can be seen in Figure 2.1. The overall result was that in 86% of cases there was a higher number of floral species in organic land and total number and abundance (mean and total) greater in all studies.

When the 20% filter was applied it did not change the conclusions of the study.

## Table 2.2: Classification of organic farming in terms of number of species and abundance of arable flora compared to conventional agriculture

| | | | No. of studies | Number of comparison pairs + | = | - |
|---|---|---|---|---|---|---|
| Arable flora | Species | Average | 29 | 61 (44) | 9 (0) | 1 (0) |
| | | Total | 11 | 16 (2) | 0 (0) | 0 (0) |
| | Abundance | Average | 5 | 7 (3) | 0 (0) | 0 (0) |
| | | Total | 2 | 4 (0) | 0 (0) | 0 (0) |
| Within fields | Species | Average | 7 | 10 (6) | 1 (0) | 0 (0) |
| | | Total | 1 | 1 (0) | 0 (0) | 0 (0) |
| Field margins | Species | Average | 7 | 10 (5) | 1 (0) | 0 (0) |
| | | Total | 1 | 1 (0) | 0 (0) | 0 (0) |
| Insect pollinated flora | Species | Average | 4 | 8 (8) | 0 (0) | 0 (0) |
| | | Total | 2 | 1 (0) | 3 (0) | 0 (0) |

+ Higher species number and abundance in organic farming (sign. and > +20 %)
= Comparable number of species and abundance in organic farming (not sign. or +/- 20 %)
- Lower species and abundance in organic farming (sign. and < -20 %)
Numbers in parentheses refer to the number of comparison pairs with statistically significant results.
If no significant information was available in the studies, classification was carried out using percentage thresholds.

Source: Stein-Bachinger et al. (2019)

These analyses on arable flora confirm previous reviews and meta-analyses that organic farming has a positive impact on arable flora when compared to conventional farming. They suggest that the reasons for this are the prohibition of herbicides in organic farming, the exclusion of mineral nitrogen fertilizers, and the overall lower nutrient level and lower crop density, and thus better conditions for low-competitive species (Ponce *et al.*, 2011). The control of weeds via mechanical weeding has less effect on the flora than herbicides (Wilhelm, 2016).

Studies by Armengot *et al*. (2013) showed that, in contrast to herbicide application in the conventional variants, biodiversity was not negatively affected by weeding in the organic variants. The only study with a comparative pair in which organic farming had a lower mean number of species according to the 20% classification is by Knudsen *et al*. (2017) and relates to a study of a very extensive and traditionally used cultural landscape in Hungary, where conventional land was also cultivated without pesticides, with little fertiliser and in rotation with grassland. This study is therefore not comparable with studies on modern, conventional farming systems. All other comparisons from the study by Knudsen *et al*. (2017) for other European countries showed clearly positive values for organic farming.

A significant difference in the comparative studies was due to the location of the study areas. This became clear from studies in which species surveys were carried out both in the field interior and at the field margins e.g. Gabriel *et al*. (2010), Batáry *et al*. (2013). In studies by Batáry *et al*. (2012) on the average number of species in winter wheat fields, the difference between the organic and conventional variant in the field interior was around 300% (median), three times higher than at the field margins. These results can be interpreted to mean that the influence of herbicides and fertilisation in conventional farming is less pronounced on the field margins, or that there are "survival niches" on the immediate field margins which are not always or less strongly affected by herbicide treatments (van Elsen, 1989; Kohler, 2015). In organic farming, too, the field margins can be richer in species because mechanical weed control is usually less effective here, the soil can be poorer in nutrients, the stands are lighter and there is no shade from one side of the crop. In addition, fringing species and grasses may migrate more, and specialised species may also occur on particular sites e.g. dry grasslands (Gottwald, 2010). In studies carried out more than 25 years ago, van Elsen (1994) was able to show that in organic farming the difference between field margins and field interiors can level off and that in some cases the inner field margins were even richer in typical Segetal species.

Drawing from the information in Lampkin *et al*. (2015) organic arable fields can support 68-105% more plant species, and 74-153% greater abundance, compared with conventional arable fields (Fuller *et al.*, 2005). Roschewitz *et al*. (2005) concluded that as organic systems are characterised by diverse seed banks, organic fields could be viewed as self-sufficient ecosystems for plants, not relying on immigration from surrounding habitats to maintain species pools. Positive effects of organic farming on plant diversity have been linked to organic management practices including prohibition of herbicide or mineral fertiliser inputs, sympathetic management of non-cropped areas, and more mixed farms (Hole *et al.*, 2005).

## Arable seed bank

The Stein-Bachinger *et al*. (2019) section on the arable seed bank, which show the seed potential in the arable soil, was evaluated using 5 studies with a total of 21 comparison pairs. All organic variants had higher mean species numbers. The median was 61% and the values showed a relatively low range.

In 83% of the comparison pairs, the 20% limit was used to assess a positive effect of organic agriculture to the mean number of species. Two comparison pairs showed no differences in management. The mean abundance showed significant positive effects of organic management for all comparison pairs.

The results on the seed bank correspond to the results of the arable weed flora. In general, when considering flora, it is important to take into account that the absence of certain species is not necessarily related to current management. Factors such as the regional species pool, propagation potentials and impact history e.g. exhaustion of the seed storage due to previous intensive conventional management, can provide a decisive influence on the species spectrum (Rotchés-Ribalta *et al.*, 2015; Lang *et al.*, 2016). This decline in arable weeds has a far-reaching impact up the trophic levels with arable weeds being food and cover for other important biodiversity such as insects, birds and mammals (rabbits, hares etc). The reduction in flowering plants will also impact on pollinators. Many of these declines are driven by conventional production methods such as high fertilisation and dense crop canopies, simplified rotations and effective seed cleaning.

Hawes *et al*. (2010), in research comparing the diversity and abundance of the within-field seedbank and emerged weed flora on conventional, integrated and organic farms across the arable east of Scotland, found significant responses to management intensity, ranging from high agrochemical input use and winter cropping to no inorganic inputs, spring cropping and mixed farming practices. Within fields, species richness was greatest in organic farms, where there were more weeds. However, at a regional and landscape scale, species richness was greater in integrated and conventional farms, due in part to a greater range of crop types and cropping practices between fields, particularly on the integrated farms.

## Arable field margins

In the Stein-Bachinger *et al*. (2019) chapter a total of eight studies were evaluated with 16 comparison pairs. In all cases, the average number of species under organic management was higher and the median value of the number of species in organic variants was 21% higher than in the conventional variant. The classification based on the 20% limit and taking into account the significance information in studies revealed a higher mean number of species in the organic variants in 71% of cases. These were significant in 90% of cases. Organic farming also showed no negative impact on species abundance.

In the studies on field margin vegetation, the differences between management systems were slightly lower than within-field, but significantly positive effects of organic farming still predominated.

## Birds

In Stein-Bachinger *et al*. (2019) the evaluation of birds was carried out on the basis of 18 studies with 57 pairs of comparisons. For the average number of species in birds (n = 16), the range was between 9 and 85%, with a median of 35%. The mean abundance of birds (n = 20) also varied, and the median was 24%. Only 4 comparison pairs had negative deviations, i.e., the values for the number of species and abundance were higher in conventional management. Taking into account the significance information in the studies and the 20% limit, the average number of species and the total number of species in approximately 70% of organically managed cases were higher than in the conventional cases. For mean abundance there was a more mixed picture with half of the comparison pairs studied showing a significant positive effect of organic farming.

Six studies with 10 comparison pairs for Skylark (*Alauda arvensis*) were evaluated separately. A similar picture emerged for the skylark, but the results on overall abundance must be interpreted against the background of the small number of studies and comparison pairs. However, in none of the comparison pairs was a negative effect on ecological management found.

The results on the birds confirm the findings of previous reviews and meta-studies, according to which organic farming has a positive impact on the biodiversity and abundance. However, a larger proportion of the comparison pairs also showed, according to the 20% classification, no differences in the number of species and abundance. One explanation may be that birds are a mobile species group: the wagtail, for example, can search for food up to 1000m from its nest location (Südbeck *et al.*, 2005). Thus, the species can breed in a field and forage in the surrounding area, which reduces the direct influence of intensive management. Mobile biodiversity, with its more flexible spatial use, also creates a methodological problem when comparing land use systems, in contrast to more sedentary types such as the site-constant flora or insects with a smaller radius of action.

Another methodological problem arises from the fact that many wild species of animal in the agricultural landscape use the managed land only as a partial habitat and also use the range of landscape elements e.g., hedges. Some studies take this into account e.g. Gabriel *et al*. (2010), Batáry *et al*. (2010), Winqvist *et al*. (2012) in that landscape structures are recorded and either incorporated into the evaluation on a multifactorial basis or comparable farms are selected in similar landscapes. From the point of view of the specific habitat needs of the individual bird species it is however doubtful that this approach succeeds and leads to "equal" conditions. For example in Gabriel *et al*. (2010), the study areas were selected after analysing 30 different landscape variables. Nevertheless, differences in the landscape structure were cited in the discussion as a probable cause for the different bird colonization of the comparison areas. In the study by Freemark and Kirk (2001), the structure of the landscape ("local habitat" – e.g. hedges, proportion of forest, distribution of winter and summer crops, proportion of grassland) and the management system (organic/conventional) were thought to contribute equally to the variation in bird populations.

For the skylark, subject of a small number of studies, there appears to be a more positive response to organic farming. This open-country species has its main habitat on fields and especially on arable land. It prefers larger fields (Geiger, 2011, quoted in Winqvist *et al*. 2012) and is therefore less influenced than other field birds by landscape structures, but reacts more directly to changes in management (Kragten and de Snoo, 2008; Marja *et al.*, 2014; Joest, 2018). Generally speaking, in connection with the results on arable flora, skylarks and other field bird species are highly prone to also react positively to a well-developed field weed flora (nesting site and food source for insects), which is much better developed in organic farming systems.

The study by Lampkin *et al.*, 2015 found that organic farming has been found in general to have a positive impact on bird biodiversity, but with species-specific variations in responses. To some extent this may be due to the scale of physical weed control on organic farms e.g. Geiger *et al*. (2010) but could also be partly due to the size and mobility of birds together with specialisation of habitats. Gabriel *et al*. (2010) recorded higher overall diversity on conventional farms (particularly of farmland specialists), despite greater food resources (arthropod abundance, weed seeds, and a higher proportion of winter stubble) in the paired organic farms. However, generalist species and members of the crow family were found in higher densities on organic farms. They concluded that landscape characteristics, such as the proportion of arable land and semi-natural grassland, and field margin and hedge lengths, rather than farm management appeared to be the important drivers of bird abundance, although these may in part be a function of management system.

In a study of field-breeding birds, Kragten and de Snoo (2008) found higher abundances of skylark on organic farms, reflecting this species preference for spring cereals which are generally perceived to be more widespread in UK organic systems, due to the need to alternate sowing/planting times for weed control. With a focus on upland farms in England and Wales, Watson *et al*. (2006) found that in winter, there were significantly higher total densities of birds, and in particular insectivores and Farmland Bird Indicator species, on organic farms. In the non-cropped environment, the longer and more varied hedges that tend to characterise organic farms do have some advantages for a range of bird species relative to non-organic farms, especially in simple landscapes (Batáry, Matthiesen and Tscharntke, 2010). Invertebrate-feeding species particularly benefit from the greater habitat diversity found in organic systems, which enhance foraging resources (Smith *et al.*, 2010). In Scottish research, McCracken and Tallowin (2004) highlighted the importance of mixtures of grasses and broad-leaved plants with a range of vegetation heights and structures to provide plant and invertebrate food sources for farmland birds. The diverse ley mixtures including herbs and legumes favoured by some organic producers are likely to support this process, although cutting and grazing needs to be carefully managed to ensure there are food sources over as long a period as possible. Bird populations may also be influenced by the use of untreated seed on organic farms (Roschewitz *et al.*, 2005; Macfadyen, Gibson, Polaszek, *et al.*, 2009; Macfadyen, Gibson, Raso, *et al.*, 2009).

## Insects

A summary of the evidence for organic farming and insects (Lampkin *et al.*, 2015) reported pollinating insects, such as butterflies and bees, particularly seem to benefit from organic practices (Rundlöf and Smith, 2006; Clough *et al.*, 2007; Feber *et al.*, 2007; Holzschuh *et al.*, 2007; Rundlöf, Bengtsson and Smith, 2008; Gabriel *et al.*, 2010; Hodgson *et al.*, 2010), probably reflecting the greater floral resource base available both within the cropped area and semi-natural habitats (see previous section on plants).

Predatory taxa including spiders, wasps and ground beetles also respond positively to organic farming (Schmidt and Tscharntke, 2005; Holzschuh *et al.*, 2007; Diekötter *et al.*, 2010) which has been attributed to greater structural diversity within habitats, increased habitat connectivity, the availability of overwintering habitat and alternative feeding resources in semi-natural habitats.

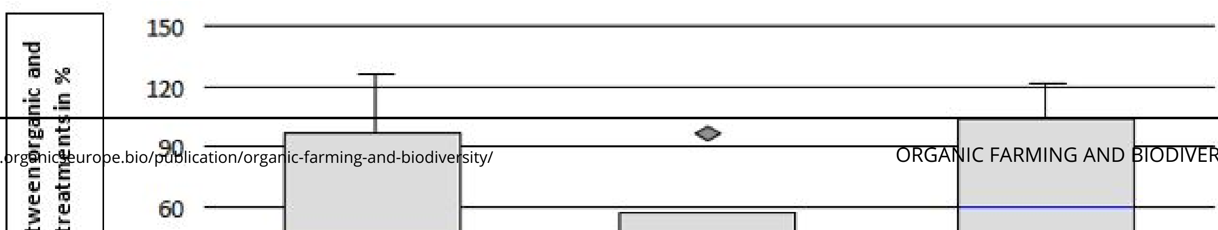
A minority of studies have recorded no significant differences, or a negative response to organic systems, reflecting taxon-specific variation. Ground and rove beetles, pests, and parasitoids have been recorded in lower densities on organic farms in some studies (Bengtsson, Ahnström and Weibull, 2005; Fuller *et al.*, 2005; Clough *et al.*, 2007). Species of ground and rove beetles vary widely in their habitat preferences (Luff, 1996) and some species may prefer conditions found on conventional farms.

Macfadyen *et al*. (2009) found that herbivores in organic fields were attacked by more parasitoid species, while Crowder *et al*. (2010) found that pest control was due to greater evenness of natural enemy populations, independent of species richness. Natural management of pests is, however, variable (Roschewitz *et al.*, 2005; Macfadyen, Gibson, Polaszek, *et al.*, 2009; Macfadyen, Gibson, Raso, *et al.*, 2009), perhaps because of unrecognised interactions in multi-trophic feeding systems and because of the complex interaction between dynamics of their hosts and responses to local and landscape factors (Holzschuh *et al.*, 2007).

In the Stein-Bachinger *et al*. (2019) report a total of 21 studies with 108 comparison pairs were evaluated, comparing the occurrence of selected flower-visiting insect groups (wild bees including bumblebees, honeybees, butterflies, hoverflies and lacewings) on organically and conventionally farmed areas. For insects as a whole, the median number of species was 23% greater on organic areas. The minimum and maximum values were -14 % and 44 % respectively. Separately, the group of bees (wild and honeybees) had a median of 30% higher with a high range of -14% to 592%. For butterflies the median was at 18 % with significantly less variation of all values.

The mean abundance also showed a similar picture as the mean species number for insects with 64 comparison pairs and for only bees (35 comparison pairs). The medians were 26 and 27 % respectively. When only wild and honeybees were considered, the values ranged from -44% to +603%. The median for butterflies (15 reference pairs) was 59% with a variation of -15 up to +122 %. The mean abundance compared to the mean number of species in all species groups showed a higher spread of values.

### Figure 2.2: Relative differences between organic and conventional agriculture with regard to the average abundance of flower-visiting insects, without results by Gabriel et al. (2010)



Positive values show an increased biodiversity in ecologically managed areas (conventional variant = 0%). Mean abundance for flower-visiting insects (n = 32) or separately for bees (wild and honeybees, n = 19) and butterflies (n = 7). Source: Stein-Bachinger et al. (2019)

The study by Gabriel *et al*. (2010) had 32 comparison pairs included in their evaluation which had a significant influence on the overall result. Without these data, the median abundance was 16% higher at 42%. This change mainly affected the group of wild and honeybees, but hardly any effect could be observed in butterflies. Significantly, only two comparison pairs showed negative difference in total, while the mean abundance of the organic variants was greater for all others than for the conventional ones.

The overall findings of the Stein-Bachinger *et al*. (2019) study are that in the case of insects, taking into account the significance data in the studies and the 20% limit, 41% of the comparison pairs showed higher mean species numbers in the organic variant and negative effects of organic management did not occur. In the mean abundance, 42% of the comparison pairs showed a positive effect of organic farming, while the effect was negative in 17% of the comparison pairs. However, it was shown that this negative effect was based on only one study (Gabriel *et al.*, 2010).

In the separate evaluation of wild and honeybees, the values were similar in terms of species numbers and abundance. Without including the data from the study by Gabriel *et al*. (2010), no negative effects resulted (Table 5.6). In the study by Gabriel *et al*. (2010), the values of the organic variants were also higher than in the conventional ones. Overall, a separate analysis of butterflies showed that 73% of the comparison pairs had positive effects of organic management on the mean abundance. This effect was less pronounced with regard to the mean number of species. A total of 4 out of 9 comparison pairs (44%) were assigned to the category Organic +. 5 comparison pairs showed no difference between the management options.

## Table 2.3: Classification of organic farming in terms of number of species and abundance of flower-visiting insects compared to conventional agriculture

| | | | *No. of studies* | *Number of comparison pairs* + | | *=* | | *-* | |
|---|---|---|---|---|---|---|---|---|---|
| Flower visiting insects | Species | Average | 18 | 15 | (11) | 22 | (0) | 0 | (0) |
| | | Total | 5 | 6 | (1) | 1 | (0) | 0 | (0) |
| | Abundance | Average[a] | 16 | 27 | (13) | 26 | (0) | 11 | (0) |
| | | Average[b] | 15 | 16 | (13) | 16 | (0) | 0 | (0) |
| Wild and honeybees | Species | Average | 10 | 9 | (7) | 12 | (0) | 0 | (0) |
| | | Total | 1 | 2 | (0) | 0 | (0) | 0 | (0) |
| | Abundance | Average[a] | 10 | 13 | (7) | 18 | (0) | 4 | (0) |
| | | Average[b] | 9 | 8 | (7) | 11 | (0) | 0 | (0) |
| Butterflies | Species | Average | 6 | 4 | (2) | 5 | (0) | 0 | (0) |
| | | Total | 1 | 0 | (0) | 1 | (0) | 0 | (0) |
| | Abundance | Average[a] | 6 | 11 | (4) | 4 | (0) | | (0) |
| | | Average[b] | 5 | 5 | (4) | 2 | (0) | | (0) |

[a] With data from Gabriel *et al*. (2010)
[b] Excluding data from Gabriel *et al*. (2010)
+ Higher species number and abundance in organic farming (sign. and > +20 %)
= Comparable number of species and abundance in organic farming (not sign. or +/- 20 %)
- Lower species and abundance in organic farming (sign. and < -20 %)
Numbers in parentheses refer to the number of comparison pairs with statistically significant results.
If no significant information was available in the studies, classification was carried out using percentage thresholds.

Source: Stein-Bachinger et al., 2019

The positive influence of organic farming on the biodiversity and abundance of the selected insect groups was demonstrated in the Stein-Bachinger *et al*. (2019) study in line with the conclusions of previous reviews and meta-studies. It is important to note that in only one study with 32 comparison pairs were negative effects of organic farming seen on the basis of the selected 20% deviation (cf. abundance mean a and mean b). In the case of insects, the group of wild and honeybees had a significant influence on the greater spread of values. Wild bees (including bumblebees) should on the one hand react to the better floral supply in organic farming, but on the other hand are highly dependent on suitable nesting substrates in open landscapes e.g. Happe *et al*. (2017). Many species need specific landscape features and nearly natural features. If these features are not available in the landscape, no major effects are to be expected from the cultivation system, especially with the mean abundance. Otherwise, the importance of organic farming can be very high locally. Holzschuh *et al*. (2008) found an increase in the abundance of 60% in solitary bees and of 150% in bumblebees on fallow strips that were surrounded by a high proportion of organically farmed fields. The study investigates further a number of other studies which showed differing outcomes for insect biodiversity. Power and Stout (2011) showed negative values for organic farming for wild bees but the sample size was very small (8). Krauss *et al*. (2011) although had large samples focused their studies on the within field areas but positive outcomes in the organic variant.

In summary, for the insect groups selected in the study, it can be stated that the weaker reaction to organic farming or the greater variation in effects compared to the flora may be due in large part to the dependence of many insects on the landscape structure or on accompanying biotopes, especially during reproduction and hibernation. This dependence can strongly overlay the effects of land use (Pfiffner *et al.*, 2001; Tscharntke *et al.*, 2005; Holzschuh *et al.*, 2007; Holzschuh, Steffan-Dewenter and Tscharntke, 2010; Winqvist, Ahnström and Bengtsson, 2012). The generally high variability in insect abundance can also contribute to the high variance in the results on insect abundance, which makes standardised comparative studies difficult. In addition, asynchronous fluctuations in different study areas can strongly influence the results.

## GRASSLAND

### Unimproved grassland

Studies on the impact of organic farming on grassland biodiversity are not as common as those for arable. Dimambro *et al*. (2018) suggested that results were also less clear than when considering the whole farm. For example, a review paper by Hole *et al*. (2005) observed that within grassland systems differences in vegetation composition between organic and conventional sown pastures tended to be less marked than for arable fields, and that the natural colonization of grassland to form a diverse sward is a slow and unreliable process, regardless of farming regime, especially where rarer species are largely absent from the seedbank. Indeed, a meta-data analysis of literature found 19 studies on grassland observing an increase in floral biodiversity on organic farms with five studies showing no change when compared to conventional farms (Rahmann, 2011).

In a lowland permanent grassland study (not ploughed or reseeded for at least seven years) in the Republic of Ireland, ten matched pairs of organic and conventional dairy farms were investigated (Power and Stout, 2011). Total plant richness was significantly higher on organic farms than conventional and also higher in field margins than the centre of fields.

In a Bavarian permanent grassland comparison study the number of plant species in organic grassland was only slightly higher than extensive grassland, which was in turn slightly higher than intensive grassland of the eight organic grassland farms, the one that converted three years prior to the study had a lower number of plant species than the average for intensive farms (Haas, Wetterich and Köpke, 2001).

Batáry *et al*. (2013) investigated insect-pollinated and non-insect pollinated forbs in meadows and found that both diversity and cover of forbs were positively affected by organic management in meadows (and wheat fields) and showed that organic management supports a higher species richness and cover of insect-pollinated plants.

Studies of soil biodiversity within grassland systems have shown mixed effects. A study of Welsh grassland soils (Yeates *et al.*, 1997) showed inconsistent effects of organic or conventional management practices. Bacterial and fungal phospholipid fatty acids (PLFA) were about a third of extractable PLFA. Bacterial PLFA predominated and were largely unaffected by management (except in silt where there were more in organic). Fungal PLFA were greater under organic management in all soils. Tardigrada and Acari were more abundant under organic management, as were nematode populations. Lumbricid earthworm populations were smaller under organic managements at all sites.

In a large-scale comparison of mycorrhizal fungal communities, Verbruggen *et al*. (2010) assessed arbuscular mycorrhiza (AMF) community composition in 13 pairs of organic and conventional arable fields and five semi-natural grasslands. Highest AMF richness was recorded in grasslands, and organic systems had significantly higher numbers than conventional fields. AMF richness increased significantly with time since conversion from conventional to organic management. AMF communities in organic fields were more similar to grasslands than conventional fields and were less uniform with higher between-site diversity.

### Improved grassland

Studies on the impact of organic improved grassland/leys on biodiversity are not very common but a small number do give an indication of the impact of organic management. Haas *et al*. (2001) looked at grassland systems in Germany and noted that biodiversity in all systems is lower than 30-40 years ago but did find plant species numbers in organic and extensive conventional systems to be slightly higher than in intensively managed permanent grassland. 29.0 species were found in organic systems and 26.8 in extensive conventional on average, with 24.6 species in intensive conventional.

### Leys

A ley is defined as a piece of land put down to grass, clover, etc., for a single season or a limited number of years, in contrast to permanent pasture. Although leys do not currently play a significant role in conventional farming systems, they are an important part of organic systems. This makes direct comparisons between organic and conventional systems difficult and there is limited published information. However, their benefits are thought to be many including fertility building and weed management as well as increasing the biodiversity within the farming system. Studies on the impact of weeds within leys by Döring *et al*. (2017) showed that organic leys constitute an important element of farm biodiversity. This study showed that organic leys add to the diversity on farms by including a range of crop species that are otherwise not cultivated and harbour a range of wild plant species that further contribute to species richness on the farm.

The review by Hole *et al*. (2005) stated that the presence of grass-clover leys in the organic rotation was the principal reason for significantly higher numbers of non-pest butterfly abundance reported by Feber *et al*. (1997).

## HORTICULTURE

There are also fewer studies looking at biodiversity in horticultural systems. The review by Dimambro *et al*. (2018) summarises some of the impacts.

### Vegetable production

The review reported on Nafferton Factorial Systems Experiments which consisted of 128 plots (24 × 12m), half organic and half conventional, with a range of fertiliser and pesticide treatments (Eyre, Shotton and Leifert, 2008). Beneficial invertebrate activity was assessed in five crop types which contained arable, horticultural (vegetable and legume) and grass/clover. Crop type was an indicator of the activity of different groups and fertility management had more significant effects than crop protection, with some groups more active on conventional plots and others on organic plots. A study in the Netherlands of 20 organic and 20 conventional paired vegetable farms (Kragten *et al.*, 2011) showed that at a crop level there was no evidence that organic management led to greater invertebrate abundance, but different taxonomic groups were found to be more abundant in certain organic crops: Carabidae (cereals and potatoes), Araneae (cereals), Staphylinidae (potatoes), Formicidae (carrots) and 'other invertebrates' (carrots). A study in New Zealand comparing fields of organic and conventional carrots (Berry *et al.*, 1996) showed that organic fields had significantly higher numbers of parasitic hymenoptera, rove beetles (Staphylinidae), and lacewings (Neuroptera). However, other taxa such as hover flies (Syrphidae) showed no differences. Spiders (Araneae) and centipedes (Chilopoda) also had similar numbers in both organic and conventional carrot fields.

### Fruit production

Dimambro *et al*. (2018) summarised the literature on the effects on biodiversity when comparing organic and conventional fruit production (Table 2.4). Cerutti *et al.* (2011) reported in Dimambro *et al*. (2018) state "*Although many aspects of environmental accounting methodologies in food production have already been investigated, the application of environmental indicators in the fruit sector is still rare and no consensus can be found on the preferred method. On the contrary, widely diverging approaches have been taken to several aspects of the analyses, such as data collection, handling of scaling issues, and goal and scope definition*". Less literature was available for Dimambro *et al*. (2018) literature review from the fruit sector, with a meta-analysis only finding a total of 13 studies on perennial crop land (orchards, vineyards and agroforestry). This found an increase in flora biodiversity under organic management in twelve instances, one finding no change and two observing less biodiversity as compared to conventional systems (Rahmann, 2011), with multiple citations of some studies due to different conclusions for different species groups.

The orchard understorey is an important part of the orchard system and a range of approaches to managing it exist: whole area as grass, grass strips with bare areas, grazed or mown. A study of apple and cherry orchards in Poland found biodiversity of weeds in organic orchards was greater than in conventional orchards. This was attributed to the repeated shallow cultivation of the understory soil, and no herbicide treatments, which resulted in the increase of perennial weeds. The composition of these weed species was modified by the method of soil cultivation and environmental conditions (Lisek and Sas-Paszt, 2015). It was also found that understorey species richness and the species pool were significantly higher in organic apple orchards than in the conventional and integrated managed orchards in the Czech Republic (Lososová *et al.*, 2011).

## Table 2.4: Fruit biodiversity summary, comparing the effect of organic farming against conventional.

| | | Effect | | | | | |
|---|---|---|---|---|---|---|---|
| **Study Parameter** | **Farming System** | **Long term study/ years** | **Increase** | **Mixed** | **No effect** | **Decrease** | **Reference** |
| Weed cover | Orchards (apple) | 3 | | | | - | (Meng *et al.*, 2016) |
| Weed biodiversity | Orchard (apple & pear) | 4 | + | | | | (Lisek and Sas-Paszt, 2015) |
| Species richness | Orchard (apple) | + | | | | | (Lososová *et al.*, 2011) |
| Biodiversity | Vineyards | No | | +/- | | | (Puig-Montserrat *et al.*, 2017) |
| Spider community abundance, species richness, species diversity | Orchard (apples) | No | | +/- | | | (Im *et al.*, 2015) |
| Ant abundance, species richness, and predation on moth larva | Orchard (apples) | No | + | | | | (Schurr, 2017) |
| Ground insect indicator taxa diversity and density | Orchard (apples) | No | + | | | | (Popov *et al.*, 2018) |
| Pollinator richness and abundance | Orchard (apples) | No | | | x | | (Alins *et al.*, 2016) |
| Spider and carabid biodiversity and profusion | Vineyards | No | | +/- | | | (Caprio *et al.*, 2015) |
| Ant abundance & number | Vineyards | No | + | | | | (Masoni *et al.*, 2017) |
| Grasshopper, spider and plant abundance, species richness, community composition | Vineyards | No | | +/- | | | (Bruggisser, Schmidt-Entling and Bacher, 2010) |
| Great tit young produced per ha | Orchards (apple) | 3 | + | | | | (Bouvier *et al.*, 2005) |
| Breeding bird abundance, species richness, diversity | Orchards (apple) | 3 | + | | | | (Bouvier *et al.*, 2011) |
| Bird diversity | Orchards (apple, plum etc) | No | + | | | | (Genghini, Gellini and Gustin, 2006) |
| Bird species richness and abundance | Orchard (apple) | No | | +/- | | | (Katayama, 2016) |

Source: Dimambro et al. (2018)

Studies of invertebrate biodiversity in orchard systems show a mixed impact of organic production. Miñarro *et al*. (2009) looked at the impact of organic and conventional apple production systems with three row management systems (straw mulching, tillage and herbicide) on activity-density and biodiversity of epigeic predators by monthly sampling of pit-fall traps. Tree row management had a greater effect than production system. Mulching produced lower total predator catches, reduced carabid abundance but increased staphylinid catches. Species richness did not significantly differ among row management systems for ants, spiders or the total catches, but was higher on herbicide-treated plots for carabids. The fertilizer application treatment only influenced the species richness of rove beetles, being greater in the chemically-treated plots. Im *et al*. (2015) found the abundance of spider communities (total number of individuals) was higher in organic apple orchards than in conventional orchards, with no significant difference in species richness and species diversity between orchard type. A Spanish apple orchard pollinator study found there were no significant interactions between the type of management (organic vs. conventional) and the proportion of cultivated area in the number of flower visits by pollinators, fruit set and number of seeds per fruit (Alins *et al.*, 2016).

The type of management (organic vs. conventional) did not affect the community of pollinators. They suggested that the lack of influence of organic management in the abundance of insect pollinators may be due to the relatively small size of the apple orchards compared to the surrounding conventional agriculture.

Dimambro *et al*. (2018) identified and summarised work on birds in apple orchards. An apple orchard trial in the Netherlands observed greater numbers of caterpillars on organic orchards as compared to Integrated Pest Management (IPM) orchards, even in areas where great tit density was enhanced via the installation of nest boxes (Mols and Visser, 2007): great tits are suggested to be a factor in caterpillar control. In a French study the mean number of blue tit young produced per ha (orchard productivity) was significantly higher in organic orchards than in conventional and IPM orchards (Bouvier *et al.*, 2005). It was suggested that pesticide use in the non-organic orchards reduced the amount of insect prey for the blue tits to feed on. Further French work found bird abundance, species richness, and diversity were all highest in organic orchards and lowest in conventional orchards and the pest control strategy affected insectivorous birds more than granivores (Bouvier *et al.*, 2011) which again would suggest that depletion of prey is a factor. A similar picture was found in a Japanese study with species richness being greater in organic apple orchards than in conventional orchards (Katayama, 2016), but only insectivorous species were more abundant in organic orchards, when compared to granivores and omnivores. A study in northern Italy (Genghini, Gellini and Gustin, 2006) of a range of orchard types (peach, vineyards, kiwi, pear, apricot, cherry, apple, persimmon and plum) and farming systems (conventional, organic and IPM) showed that granivores were the most abundant across all farm systems. Insectivores were less abundant in general, but more abundant on organic and integrated farms. Bird diversity was greater in organic and integrated farms than conventional. It was suggested that the approach to pest control within the different farming systems were the major driver of these differences, but the type of farm and structure of the orchard could also play a part.

## MEDITERRANEAN SYSTEMS

The majority of research on organic farming has concentrated on arable and grassland systems in Central and Northern Europe. Relatively fewer studies have been carried out in Mediterranean systems, with particular focus on vine and olive systems. A brief summary of the outcomes of these studies follows.

### Vineyards

A study of organic and conventional vineyards in an intensively cultivated area of northern Italy by Nascimbene *et al*. (2012) showed that organic farming promoted local plant species richness in the vineyards and grassland strips though it had no effect on linear hedgerows. These differences in richness were not associated with species composition suggesting similar plant communities in the vineyards regardless of management.

A study in Catalonia,  north-eastern Spain by Puig-Montserrat *et al*. (2017) into organic and non-organic vineyards studied the vine plots (vascular plants, butterflies, moths and bird) and grass strips between crop lines (only butterflies and vascular plants). Crop treatment was found to have an important effect that was stronger on the more immobile organisms. Organic farms had consistently richer communities of both vascular plants and butterflies and to a lesser extent moths (with the weaker response probably due to insufficient sampling). Birds, the most mobile of the surveyed taxa, showed no significant response to farming system. The grass strips acted as reservoirs of biodiversity. Puig-Montserrat *et al*. (2017) suggest that organic farming may contribute to halting the widespread decrease of butterflies and other insects in the region.

A study by Katayama *et al*. (2019) conducted a series of meta-analyses to compare taxon richness, abundance, and community similarity in (semi-)natural habitats and conventional, integrated, organic, and abandoned orchards/vineyards. It also compared fruit/nut yield among the three farming systems. Compared to conventional farming, both integrated and organic farming were similarly effective in increasing taxon richness. This was attributed to the great reduction in pesticide use in these systems (it was suggested that in organic and integrated fruit systems similar levels of pesticides were used) along with the more frequent use of cover crops and mulches. However, organic farming showed greater richness and abundance (+16% and +51%, respectively) but a significantly lower yield (−18%).

A French study (Froidevaux, Louboutin and Jones, 2017) using matched organic and conventional vineyard plots looked at arachnids and bats (model taxa with different functional traits in respect to mobility, dispersal ability and home range size). They found arachnid abundance was higher in organic vineyards, although arachnid species richness was positively associated with the amount of ground vegetation cover. For bat activity and species richness organic farming was ineffective on its own. Their results suggested that landscape features were more important for bats than vineyard management, with significantly higher bat activity recorded on vineyard plots located at close proximity to hedgerows and rivers.

### Olives

Biodiversity in organic olives is again an understudied area with very limited evidence published. Álvarez *et al*. (2019) looked at habitat complexity in organic olive groves. They show that natural enemies are more common in areas with more complex semi-natural habitats. Landscape studies (Martínez-Núñez *et al.*, 2020) on pollinators (in this case solitary bees) in olive orchards showed that organic fields had higher (+53%) bee colonisation rates than non-organic fields regardless of what landscape the orchards were in. A study by Villa *et al*. (2020) looked at landscape composition on the abundance of olive moth (*Prays oleae*) in both integrated and organic olive orchards. They concluded that crop management type had no impact on *P. oleae* abundance which was heavily influenced by landscape composition and complexity. Work by Álvarez *et al*. (2019) in organic olive orchards supported this: it showed the importance of the presence of ground cover and adjacent vegetation, and overall the benefits of complex adjacent landscapes.

## CONCLUSIONS

There is now a substantial body of research evidence that demonstrates the positive impacts of organic farming on biodiversity in Europe. While most studies have been conducted in the context of temperate, arable systems, there are an increasing number of studies relating to grassland, horticulture and Mediterranean olive and other systems that also support the general conclusions that:

- Organic farming increases both the abundance and species richness of biodiversity across a range of habitats and farming types, when compared with similar, non-organic systems;
- In arable farming, plant species biodiversity is enhanced both within field (in the crops) and in field margins, with 20-95% more species and 75-150% greater abundance recorded in organic systems, with the greatest differences recorded within fields;
- Soil microbial diversity, insects and bird populations are also positively influenced by organic management. In arable contexts, insect species numbers have been reported at 23% higher, and pollinators 30% higher, on average across a number of studies;
- For grassland, studies have shown more limited benefits for plant and soil microbial biodiversity in permanent grassland, where non-organic management tends also to be less intensive;
- Temporary grassland, normally grass/clover leys or lucerne, may be dominated by a limited range of sown species, but will have more unsown species, and the use of flowering legumes can benefit pollinators if managed appropriately – the contribution of organic matter in the rotation also has positive impacts on soil microbial diversity and earthworms;
- In horticulture greater diversity is found within fields as for cultivated arable crops, but also in the understoreys of fruit production systems, with insectivorous bird species also benefitting;

- Relatively few studies have been conducted in Mediterranean olive and vine systems, with some showing benefits, but landscape effects also being important.

The results generally support the EU Organic Action Plan statement that organic farming delivers 30% more biodiversity on average. Given the focus of much of the research on temperate arable systems, there is a need to extend research to cover other land uses and regions, and to focus more on understanding how the benefits recorded are derived and can be enhanced, with the information communicated to farmers in the context of advisory and training programmes.

## HOW DO ORGANIC MANAGEMENT PRACTICES CONTRIBUTE TO THESE OUTCOMES?

A study by the team led by the Organic Research Centre for Defra (DEFRA, 2018) reviewed a range of practices mentioned in organic standards and their impact on a variety of environmental outcomes. Results from the work highlighted the substantial benefits that can accrue from organic management techniques in terms of environmental performance. In particular, this applies for the impact categories of soil quality, non-renewable resource-use efficiency and biodiversity. As some management practice(s) can lead to lower yields compared to high-input-output approaches, this can lead to reduced positive/more negative environmental impacts when comparisons are made per unit of product. Conversely, systems applying such management practices will generally perform better when comparisons are made on a unit of land-area basis.

The ORC team reviewed organic standards and worked with experts to identify a range of techniques and management practices and scored them against their environmental impact including biodiversity. The outcomes for biodiversity can be found in Table 3.1. Their overall assessment was that organic management practices have considerable potential to improve a range of environmental performances including biodiversity.

Table 3.1: Biodiversity impact assessment for organic management techniques

| *Practice* | *Biodiversity impact* | *Key assumptions* |
|---|---|---|
| Mixed farming | ↑↑ | Collaboration between crop and livestock enterprises leading to reduced use of manufactured fertiliser through use of manure on holding and enhanced system diversity (Watson *et al.*, 2005; Rodrigues *et al.*, 2006; Wilkins, 2008; Scialabba and Müller-Lindenlauf, 2010; Knox *et al.*, 2011; Lemaire *et al.*, 2014; Soussana and Lemaire, 2014; Lampkin *et al.*, 2015; Smith, Williams and Pearce, 2015; Altieri and Nicholls, 2017) |
| Use of diverse rotations | ↑↑↑ | A range of crop types used to promote soil health by improving the diversity of root architecture and reduce disease/pest burdens (Marcroft *et al.*, 2004; Ball *et al.*, 2005; Beckie, 2006; Smith *et al.*, 2008; Stobart, 2011; McDaniel, Tiemann and Grandy, 2014; Gaudin *et al.*, 2015; Lynch and Wojciechowski, 2015; Maltais-Landry and Frossard, 2015; Preissel *et al.*, 2015; Venter, Jacobs and Hawkins, 2016; Altieri and Nicholls, 2017) |
| Manure and compost as fertiliser | ↑ | Home-produced manure and compost replacing manufactured NPK fertiliser (Smith *et al.*, 1998; Gunapala and Scow, 1998; Chambers, Smith and Pain, 2000; Sharpley and Moyer, 2000; Fließbach and Mäder, 2000; Blair *et al.*, 2006; Flavel and Murphy, 2006; Rigolot *et al.*, 2010; MacLeod *et al.*, 2010; Hjorth *et al.*, 2011; Hartmann *et al.*, 2015a; Neher, Weicht and Dunseith, 2015; Hijbeek *et al.*, 2018) |
| Ruminants predominantly forage fed | ↑↑ | Assumes forage-based diet for ruminants (e.g. grass and clover), i.e. feeding less/minimal amounts of grain or compound feed (Bailey *et al.*, 2003; Lee, Isenhart and Schultz, 2003; Nevens and Reheul, 2003; Hancock and Wilson, 2003; Parish and Sotherton, 2004; Berry, Ogilvy and Gardener, 2004; Ros, Klammer, *et al.*, 2006; Ros, Pascual, *et al.*, 2006; Carvell *et al.*, 2007; Tejada *et al.*, 2008; Wilkins, 2008; Smith, 2009; Tejada, Hernandez and Garcia, 2009; Dougherty *et al.*, 2009; Borin *et al.*, 2010; Dalal *et al.*, 2010; Smith *et al.*, 2011; Diacono and Montemurro, 2011; Tuomisto *et al.*, 2012a, 2012b; Soussana and Lemaire, 2014; Van Zanten *et al.*, 2014; Smith, Williams and Pearce, 2015; Benton *et al.*, 2017; Salou, Le Mouël and van der Werf, 2017; DEFRA, 2017) |
| Mechanical weed control | ↑↑ | Removing weeds by soil surface cultivation, including spring-tine harrowing, inter-row cultivation, finger weeding (Dawson, Huggins and Jones, 2008; Bajgai *et al.*, 2015; Crittenden *et al.*, 2015; Smith, Williams and Pearce, 2015; Melander *et al.*, 2017; Pesticide Action Network, 2017) |
| The use of leys in arable rotations | ↑↑ | The inclusion of a 1-3 year legume or grass ley in the arable rotation to build soil fertility and biological activity. (Watson *et al.*, 2005; Wilkins, 2008; Knox *et al.*, 2011; Döring *et al.*, 2012; Moss and Lutman, 2013; IBERS, 2014; Loaiza Puerta *et al.*, 2018; Sanders and Hess, 2019) |
| Encouraging natural predators (outdoors) | ↑↑↑ | Devotion of farm area(s) to conservation for promotion of natural predators, including planting/maintaining wildlife areas (e.g. beetle banks, species-rich field margins) to encourage natural predators for pest control (Carlsson and Huss-Danell, 2003; Hovi, Sundrum and Thamsborg, 2003; Doyle and Topp, 2004; Edwards, 2005; Eriksson *et al.*, 2005; Halberg *et al.*, 2010; Dekker *et al.*, 2012; Tuomisto *et al.*, 2012b; Lampkin *et al.*, 2015; Steenfeldt and Hammershøj, 2015; Vogeler, Vibart and Cichota, 2017) |
| Use of green waste compost | ↑ | Compost produced from landscaping and garden green waste applied to fields as a valuable soil amendment, reducing fertiliser use and improving soil health, whilst also reducing landfill (Leighty, 1938; Power, 1990; Latif *et al.*, 1992; Liebman and Dyck, 1993; Nemecek *et al.*, 2008; Lassaletta *et al.*, 2014) |
| Animals provided with maximum possible outdoor access year-round | * | Outdoor access year round for livestock, including loafing yards and sacrifice fields (Savory and Butterfield, 1998; Smith, Williams and Pearce, 2015; Garnett *et al.*, 2017; Muller *et al.*, 2017) |
| Diverse/herbal sward | ↑↑↑ | Use of diverse species mixes in grassland, which could include clovers, lucerne, sainfoin, legumes, ryegrass, timothy, cocksfoot, fescue and chicory, among others (Storkey *et al.*, 2011; Döring *et al.*, 2012; Lampkin *et al.*, 2015) |
| Increasing use of legumes in crop rotations | ~ | There are two main types of legumes: seed/grain legumes and perennial forages as green manure. The impacts within this assessment are focussed on the former category, i.e. the use of grain/seed legumes in crop rotations. (Lassaletta *et al.*, 2014; Voisin *et al.*, 2014; PGRO, 2017; Stagnari *et al.*, 2017) |
| Novel forages (e.g.' chicory) | ↑↑ | Inclusion of forage crops such as lucerne, sainfoin and chicory within pasture areas on livestock farms. (Marley *et al.*, 2006; Dawson, Huggins and Jones, 2008) |
| Undersowing of leys in crops | ↑↑↑ | Sowing a ley sward during or after the sowing of a crop, usually cereal, allowing the ley to establish while the main crop is still in the ground (Watson *et al.*, 2005; Wilkins, 2008) |

**Note:** Scale/rate approach used to assess the impact of the management technique: None ~; Low ↑; Moderate ↑↑; High ↑↑↑; Context/system boundary specific *.

Source DEFRA (2018)

A report by FiBL (Pfiffner and Balmer, 2011) identified the main causes of higher biodiversity in organic systems as:

- Forgo use of herbicides;
- Forgo use of chemically-synthesized pesticides;
- Less and purer organic fertilizer;
- Fewer cattle per square meter;
- More diversified crop rotation with higher clover-grass percentage;
- Conservation tillage;
- Higher percentage of semi-natural areas;
- Higher percentage of arable and ecological areas;
- More diversified farm structure.

In addition, the reductions in nitrogen and phosphorus fertiliser result in reduced eutrophication impacts on aquatic ecosystems, and reduced impacts on nitrogen-sensitive species from atmospheric depositions.

## SYSTEM DIVERSITY/MIXED FARMING

The ORC literature review (DEFRA, 2018) highlighted the substantial benefits that can be achieved through a closer integration of crops and livestock within mixed farming systems. In particular, benefits can accrue where the inclusion of livestock prompts the utilisation of nitrogen-fixing-legume-containing leys, which can contribute to soil fertility-building, biodiversity and pest, disease and weed control, whilst reducing dependence on manufactured N fertiliser (Knox *et al.*, 2011; Lemaire *et al.*, 2014).

An observation by Ulber *et al*. (2009) was that the increased plant diversity on organic farms arose from multiple aspects of the system, such as longer crop rotations and the absence of herbicides and synthetic fertilisers. This was emphasised by the observation that, under non-organic conditions, a change of only a single factor, in this case the introduction of crop rotation, did not affect plant diversity.

Organic farms tend to have more favourable habitats such as hedgerows, grass margins, grassy ditches, small fields etc. than conventional farms. Norton *et al*. (2009) studying farms in England that had some arable crops found that the organic farms were located in more diverse landscape types; had smaller field sizes; higher, wider and less gappy hedgerows subjected to less frequent cutting; use rotations that include grass; and are more likely to be mixed. Even within diverse landscapes, organic systems had greater field and farm complexity than non-organic systems. This has prompted considerable discussion about whether benefits are derived from the farming system or from the habitat that is independent of the farming system. Some researchers e.g. Chamberlain *et al*. (2010) argue that the benefits of organic farming – in this case for farmland bird populations – come “primarily through greater habitat heterogeneity” and not from organic farming practice, but as discussed below, even in diverse landscapes, organic farms are more complex.

Several studies covering the range of taxa found that the biodiversity benefits of organic systems are of particular value in simple agricultural landscapes where organic farms are both spatially and temporally more diverse than their conventional counterparts e.g. Clough *et al*. (2007b), Boutin *et al*. (2008). Batáry *et al*. (2010). However, Norton *et al*. (2009) found that even within diverse landscapes, organic systems had greater field and farm complexity than non-organic systems. Some studies have also shown that organic farms can influence biodiversity in the surrounding landscapes with higher diversity recorded on conventional farms in organic ‘hotspots’ e.g. Rundlöf *et al*. (2008), Gabriel *et al*. (2010), Hodgson *et al*. (2010) suggesting that species are ranging across neighbouring conventional farms.

The increased systems diversity and complexity will impact positively on biodiversity by producing an increased number of potentially interconnected habitats that benefit both flora and fauna above and below ground. The spatial separation of different habitats on a farm at the same time i.e., leys with floriferous plants, species rich grassland, headlands and hedgerows plus cropped areas provides sites for pollinators, arable weeds, grassland fauna etc at any one moment in time. They also provide habitats and refuges for crop pest predators allowing reduced applications of pesticides. System diversity also allows for a wider range of habitats for a wider range of fauna including birds, mammals, and a range of insects i.e., pollinators.

## ROTATIONS

Crop rotations are an essential part of an organic system and organic standards require certain principles to be observed within the rotation. These include a balance between fertility and exploitative phases of the rotation, the inclusion of a leguminous crop to provide nitrogen for following crops, the inclusion of crops with different root systems, and that plants with similar pest and disease susceptibilities must be separated by a suitable time period. They may also include a more diverse range of sowing (winter/spring) for weed control purposes.

A systematic comparison of organic and conventional crop rotations at the global scale based on a meta-analysis of the scientific literature by Barbieri *et al*. (2017), summarised in Dimambro *et al*. (2018), found that organic farming has differences in land-use compared to conventional, with increased complexity of organic crop rotations considered likely to enhance ecosystem service provisioning to agroecosystems. Some key findings when comparing organic with conventional farming were:

- Catch crops and undersown cover crops in cereal fields are more frequent in organic systems;
- Lower proportion of cereals;
- Higher frequency of cereal intercropping with legumes;
- More nitrogen fixing crops, including mixed legume-grass temporary leys;
- More diverse crop rotations;
- Longer crop rotations.

Organic mixed farming practices and the rotations they rely on can play an important role in enhancing biodiversity in farming systems. The association during different parts of the rotation between cropping and livestock enterprises through transfer of manure, feed and/or through the use of grazing livestock on grass/clover leys is an important component that delivers many environmental services including improved soil quality, water quality and biodiversity. Increased landscape mosaic diversity created by rotations can encourage populations for a large range of taxa (plants, insects, small animals and birds), in particular by providing permanent vegetation within undisturbed fields (i.e. forage and grasslands Lemaire *et al*. (2014)).

Introducing crops and varieties that increase the diversity and distribution of crop architecture and biomass above and below ground is also important in delivering environmental services. The number of crops in a sequence, combined with the frequency of return of those crops, can alter the ecosystem services provided by a rotation. The inclusion of species mixtures or intercrops may enhance effects also. Venter *et al*. (2016) showed the soils under more diverse crop rotations had higher microbial richness (+15.11%) and diversity (+3.36%) scores, possibly resulting from different organic matter inputs, as well as soil structure and habitat changes. Above-ground biodiversity can be enhanced by the crop species selected, which provide a range of habitats. Differences in flowering times can attract a wider variety of pollinators.

Similarly, the use of diverse or herbal species in ley swards, for permanent or temporary pasture and either grazed or ungrazed, can improve biodiversity with the farming system. It is shown to improve soil structure, N availability, biodiversity, weed cover and drought resistance. This approach reduces monocultures in swards (Wilkinson, 2017). Diverse mixtures support more pollinators throughout the season and provide a larger food range for birds. Mixtures with higher diversity do not compromise wild plant diversity (Zaralis *et al.*, 2016). The inclusion of forage crops such as lucerne, sainfoin and chicory within pasture areas on livestock farms is a common technique employed by organic farmers. Novel forages can be grown as a pure stand but are usually grown in a grazing mix (e.g., with clover to help supply N through biological fixation) to improve productivity, biodiversity, resource use efficiency and soil health. Lucerne hay fields can encourage on-farm biodiversity by providing a habitat for microorganisms and invertebrates (Veronesi, Huyghe and Delgado, 2006). Increased floral abundance and longer flowering periods can also improve the availability of nectar and pollen, driving bumblebee community composition and pollinator populations (Knight *et al.*, 2009; Potts *et al.*, 2009; Stanley, Knight and Stout, 2013).

Leys can also be established by sowing during or after the sowing of a crop. This is usually done with a cereal and allows the ley to establish while the main crop is still in the ground; this can be before or after the main crop is harvested and reduces the need for tillage in preparation for sowing the ley. Undersown leys can provide an uncultivated overwinter bridge, which allows many insects to pupate in the soil and emerge as adults in spring. These adults lay eggs all through the neighbouring cereal crops and, by the time game chicks hatch in mid-summer, there are lots of small sawfly caterpillars around for them to eat (GWCT, 2018). Arthropod abundance, density and species richness was higher in undersown spring barley and undersown grass fields compared to mono-cropped fields (Huusela-Veistola and Hyvönen, 2006). A study in Finland found that fallow plots established by undersowing spring barley with grass or grass and red clover had more spiders and fewer pest insects than a control plot of spring barley, but similar numbers of ground beetles (Fletcher, 2018).

Rotations and the inclusion of both crops and livestock systems within them allows ruminants to be predominantly forage fed. This allows the production of meat/milk from forage, through grass-based diets with lower concentrate feed rates, and reduces the need for manufactured inputs, especially fertiliser and purchased compound feed. The use of forage/grassland areas can conserve and encourage on-farm functional biodiversity (Wilkins, 2008) although the wider adoption of such methods may result in less land available for conservation or forestry (Basset-Mens and Van Der Werf, 2005; Fischer *et al.*, 2014). Although outdoor grazing systems can promote greater species diversity in grassland compared to cutting for silage and mulching (Lampkin *et al.*, 2015), the use of extensive grazing practices can result in greater agricultural land use, limiting the amount of land available for conservation and other purposes (Green *et al.*, 2005).

Rotations add a temporal aspect to the spatial diversity produced by mixed farming systems. Rotational systems generally have a wider range of crops, livestock and leys/grassland. The increase in range of crops and grassland will promote increased diversity of flora and fauna within the crops and swards as well as in the soil. The use of multispecies leys within rotations increases the range of plant species in themselves but also reduces the amount of synthetic fertilisers needed and promotes biological activity in the soil. The lower fertility levels within the cropping systems also promotes arable weeds that can be rare in intensive systems. The temporal features of a rotation mean that within a given farm or landscape there will be a range of habitats that can promote more mobile types of biodiversity such as birds, mammals and a range of mobile insects.

## AVOIDANCE OF AGROCHEMICALS

### Soil fertility

The use of synthetic nitrogen and phosphate fertilisers has direct impacts on biodiversity, which organic farming avoids. These impacts include:

- Suppression of nitrogen sensitive species, in part through competition from more nitrogen-responsive species;
- Eutrophication of aquatic habitats and algal blooms as a result of nitrate leaching and phosphate loss through soil erosion and run-off from manure and slurry applications;
- Nutrient accumulation, acidification, and organic matter reduction in soils (affecting in particular earthworms and mycorrhizae).

Organic farming has a unique approach to the development and management of soil fertility that is not seen in other non-organic farming systems with the prohibition of synthetic nitrogen fertilisers and the use of more complex rotations (see above), primarily based on legume/grass leys supplemented by the application of manures. The inclusion of a legume or grass ley in the arable rotation is to build soil fertility and biological activity, increase soil organic matter, prevent disease, control weeds, increase farm biodiversity and promote crop and animal health. Ley species richness increases the diversity of insects, small animals and birds (Weibull, Östman and Granqvist, 2003).

The application of home produced or imported manures and composts are also an important approach to improving soil fertility. Litterick *et al*. (2004) define compost as "solid particulate organic material that is the result of composting, that has been sanitised and stabilised, and that confers beneficial effects when added to soil and/or used in conjunction with plants". This is already a well-used practice in non-organic farming, but it is important in such systems to carefully account for the nutrients available and balance fertiliser application accordingly.

Using manures and composts replaces the macro- and micro-nutrients removed in crop and livestock produce, as well as increasing soil organic matter content. A major benefit is provision of micronutrients that are not present in pure chemical fertilisers. In a long-term field trial comparing rotations using manure or compost with artificial fertiliser-based systems, distinct communities of microbes were found in the treatments with organic materials. Organic manure application increased the richness and decreased the evenness of the soil microbiota (Hartmann *et al.*, 2015b).

The use of fertility building legume-based leys, green manures, animal manures and composts replaces the need for synthetic fertilizers. These increase the biological activity of the soil, through the supply of energy as well as nutrients, and allow a wider range of weed and other flora that do not grow in more high fertility intensive systems. The use of leys with a range of floriferous legumes provides feed sources for pollinators: if managed carefully they can do so from spring to autumn.

## Weed management

The use of herbicides in intensive conventional farming systems can largely eradicate non-crop plants (not only weeds) from the system, which reduces the seed rain – a food source for birds and mammals but also threatening the survival of rare plants themselves.

Organic systems are prohibited from using chemical herbicides and must rely on rotations (see above) or physical approaches to weed management such as the use of tined, brush-based implements and/or comb harrows for weed removal in field crops. Weeds are rarely if ever eradicated within a crop and so provide both seed for diverse and rare weeds to persevere within the system, and as a feed source for birds and mammals. The use of mechanical weeding is likely to encourage improved diversity of flora and fauna compared to chemical methods, as the method(s) applied are unlikely to remove weeds entirely. Some remaining flora diversity is likely to remain in the field, providing biological diversity, offering habitats for beneficial/biocontrol insects, as well as insects as a food source for birds, and helping to keep the soil covered and supporting mycorrhizal fungi populations (Melander *et al.*, 2017; Pesticide Action Network, 2017).

## Pest, disease and parasite control

That the use of pesticides for insect control has a significant impact on non-target as well as target organisms is widely documented over many decades. The impact may be direct, due to lack of selectivity of a specific product, or it may be indirect, by removing a host or food source for the non-target organisms, including beneficial insects and birds. Conversely, the use of sown refuges such as field margins and beetle banks, and other landscape elements including trees and hedges, can support a more diverse and abundant range of natural predators, providing opportunities for passive biological control of pests.

The use of fungicides for disease control is also severely restricted in organic farming, although a number of fungicides are permitted, including copper compounds which do have negative environmental impacts. Copper is used primarily as a fungicide on top fruit, vines and potatoes, but although permitted, its use is restricted in organic farming.  Processes are in place to reduce and eventually ban copper use in organic farming completely (IFOAM EG, 2018). Significant research is being undertaken to find alternative controls for fungal diseases in the relatively few crops that still rely on these products.

The reduced use of anthelmintics for parasite control in livestock can have a positive impact on dung beetle species richness and diversity (Hutton and Giller, 2003; Tonelli, Verdú and Zunino, 2017). The use of anthelmintic and the prophylactic use of veterinary medicines is permitted under limited conditions in organic farming.  Parasites are managed through the rotation with a strong reliance on grazing management and clean grazing systems.  There is some evidence that alternative forages such as *Lotus corniculatus and Chichorium intybus* can help with management of parasites (Marley *et al.*, 2003).

# LANDSCAPE

Conservation/wildlife promotion areas (e.g., beetle banks, hedges, field margins, agroforestry) in farmed landscapes encourage natural predators, reducing the need for imported pesticides and providing a range of ecosystem services such as soil protection, reduced run-off and nutrient retention. Ecological infrastructure manipulation considerably enhances biodiversity and species richness, providing a habitat and food supply for a range of invertebrates, birdlife and mammals whilst encouraging increased numbers of natural predators (Smith *et al.*, 2011). Margins sown with wild bird seed mixes could be considered a valuable offset to the low-biodiversity arable field centres treated with herbicides. Such areas also provide vital forage opportunities for farmland birds during the winter period, when other food availability is limited (Williams, Audsley and Sandars, 2006). Crops grown for game cover, for example, have been shown to support up to 100 times more farmland birds and significantly more species than surrounding arable habitats (Parish and Sotherton, 2004). The use of pollen and nectar mixes sown into field margins can also significantly increase the number of bumblebees (Carvell *et al.*, 2007).

The benefit of landscape within organic farming systems is important. Organic farms tend to have smaller fields resulting in increased field boundaries – headlands, hedges etc. This provides habitat for a wide range of biodiversity. Many species need specific landscapes features and near natural features. If these features are not available in the landscape, no major effects are to be expected from the cultivation system. Otherwise, the importance of organic farming can be very high locally. The work by Gabriel *et al*. (2010) showed not only are the more mobile elements of biodiversity (birds, mammals, insects) affected by landscape but that plants can also be affected at both a farm and landscape level.

The practices considered in the chapter, including the integration of landscape elements to benefit agricultural systems, illustrate the potential of a land-sharing approach to contribute to resolving the tensions between agriculture and biodiversity (Tscharntke *et al.*, 2012; Fischer *et al.*, 2014; Finch *et al.*, 2020). While it is clear that many species prefer and would benefit from undisturbed natural habitat and nature restoration, there are a number of key species, including farmland birds and arable wildflowers, that have adapted to agricultural systems, and which would be negatively impacted by a land sparing approach built on agricultural intensification. Lower intensity, land-sharing approaches such as organic farming have a key role to play in the mix of approaches, including nature restoration, that might be needed to deliver on biodiversity conservation goals.

## CONCLUSIONS

The biodiversity benefits delivered by organic farming are a consequence both of the practices prohibited under organic regulations, such as the use of synthetic nitrogen fertilisers, herbicides and most pesticides and fungicides, as well as the agroecological practices adopted by organic farmer to solve production issues without them.

The complete avoidance or substantial reduction in the use of agrochemical inputs in organic farming contributes to biodiversity by avoiding or reducing the:

- Direct toxic impacts of herbicides and pesticides on non-target organisms;
- Indirect impacts of herbicide and pesticide use on food sources and habitat for insects, birds and other organisms;
- Impacts of surplus nutrient use on soil ecosystems, including organic matter loss and soil acidification due to nitrogen use and mycorrhizal decline due to phosphate use;
- Impacts on aquatic ecosystems from nitrate leaching and phosphate losses from agricultural land;
- Impacts on sensitive habitats and low nitrogen tolerance species from nitrogen depositions, including ammonia from livestock systems;
- Impacts on insects colonising animal faeces as a result of the use of certain anthelmintics;
- Climate change impacts on biodiversity associated with emissions from agricultural input use and manufacture, as well as loss of soil carbon.

By completely avoiding the use of most of these inputs, the benefits go significantly beyond those that might be expected from a 10-20% improvement in input use efficiency within conventional systems. However, yields are also reduced as a consequence of the input use reductions, so that benefits per unit output may be lower than per unit of land used.

However, the benefits are not only derived from avoided practices and inputs. Key biodiversity-enhancing practices used include the use of:

- Mixed farming systems integrating crops, trees and livestock;
- More diverse and complex rotations and cropping systems;
- Leguminous crops for biological nitrogen fixation, supporting pollinators if managed appropriately;
- Heterogenous genetic materials (variety mixtures, populations, landraces) using genetic diversity to support pest and disease control;
- Sown refuges and other landscape elements for natural predators (passive biological pest control);
- Smaller field sizes, contributing to a more complex landscape mosaic;
- Trees and hedges with complex understoreys for shelter, erosion control and fertility management;
- Alternation of sowing times of crops for weed control, benefiting farmland birds;
- Organic matter, leys and green manures for fertility building, providing energy-rich carbon sources to help maintain soil ecosystems;
- Reduced tillage and soil cultivation depths to protect soils;
- Diverse species mixtures including legumes, herbs and novel forages for grassland;
- Land-based livestock production systems with grazing and reduced stocking rates supporting biodiversity in grassland.

While none of the practices adopted are unique to organic farmers, the combination of many biodiversity-enhancing practices in a systems-based approach allows for synergies to be exploited with the potential for greater impacts. Organic farming practices and the related biodiversity benefits illustrate how a land sharing approach can be used constructively, as an alternative to a complete separation of intensive, land sparing but low-biodiversity agricultural production from land prioritised for nature.

# CURRENT POLICIES SUPPORTING ORGANIC FARMING AND BIODIVERSITY

## FINANCIAL SUPPORT FOR CONVERSION TO AND MAINTENANCE OF ORGANIC FARMING

Since 1994 (EC Reg.2078/92), support for conversion to and maintenance of organic farming has been an agri-environmental policy measure implemented in almost all EU member states, recognising the environmental benefits of the approach, including biodiversity.

As the land area under organic management in the European Union has grown, from a little over 100 thousand hectares (kha) in 1987 to 13.8 million hectares (Mha) in 2018 (7.5% of EU agricultural area), so too has the expenditure on policy support. By 1997, almost 2.5 Mha were certified and 260 MECU spent annually on support (Lampkin *et al*., 1999). In 2007, nearly 7.5 Mha were certified and expenditure increased to more than 800 MEUR (Sanders *et al*., 2011).

A recent review of organic farming policy in the EU by the Thünen Institute (Lampkin and Sanders, 2021) has identified that, in 2018, 8.8 Mha of organic land (64% of the certified organic area) were supported with these payments, at a total cost of over 1.8 billion €, representing about 3% of the CAP budget (Table 4.1). Under the 2014-2020 Rural Development Programme, organic farming support was separated from other agri-environment support, but the expenditure on organic farming amounted to 47% of the amount spent on EU agri-environment support. According to the available data, Denmark, Greece, Croatia, Lithuania and Latvia spent more on organic farming support than on other agri-environment measures, while the UK, Ireland and Malta spent less than 5% on organic, and the Netherlands provided no direct support at all for organic farming.

With the setting of a target for 25% of EU agricultural land area to be organic by 2030, a further trebling of land area, and potentially expenditure, is anticipated in the next decade.

While conversion and maintenance support were combined with agri-environment support in the policy periods 1994-1999, 2000-2006 and 2007-2013, from 2014 the situation changed with organic farming support covered by a separate Article 29 (Measure 11) in the overarching Rural Development Regulation 1305/2013. The guidance on implementation of this Article is provided in a separate Measure Fiche. The key features of the support were that:

- Farmers or groups of farmers would be eligible provided that they met the active farmer criterion (this was different to other agri-environmental support (Article 28/Measure 10) which was open to other land managers).
- Payments are usually made on a per hectare basis, differentiated by land use, but may also be made on a per animal or per beehive basis.
- Double funding of organic farming support should be avoided. This was particularly relevant in the context of organic farmers being considered to meet de facto the Greening requirements of the Pillar 1 Basic payment support (see below). It was also relevant to combinations with other agri-environmental support.
- The calculation of payments should be based on income foregone, additional costs and transaction costs. The calculations should take account of changes in land use, yields and livestock numbers, as well as input use and premium prices for organic products.
- Payments are normally subject to the following limits (also applicable where different payments are combined on the same area of land) although higher payments may be made if justified by MS as happened in parts of Germany, Spain and Italy as well as Hungary, Luxemburg, Malta and Wales.

    — 600 €/ha per year for annual crops

— 900 €/ha per year for specialised perennial crops

— 450 €/ha per year for other land uses

- The control system for organic farming defined by Regs. 834/2007 and 889/2008 was envisaged as the primary means of verifying compliance with the Article 29 requirements. To this extent, the costs of certification could be considered as a transaction cost for scheme implementation, with up to 20% of support allocatable for this. However, some countries used an alternative RDP Measure for Quality standards to support certification costs.

## Table 4.1: Organic farming support payments in EU Member States, 2018

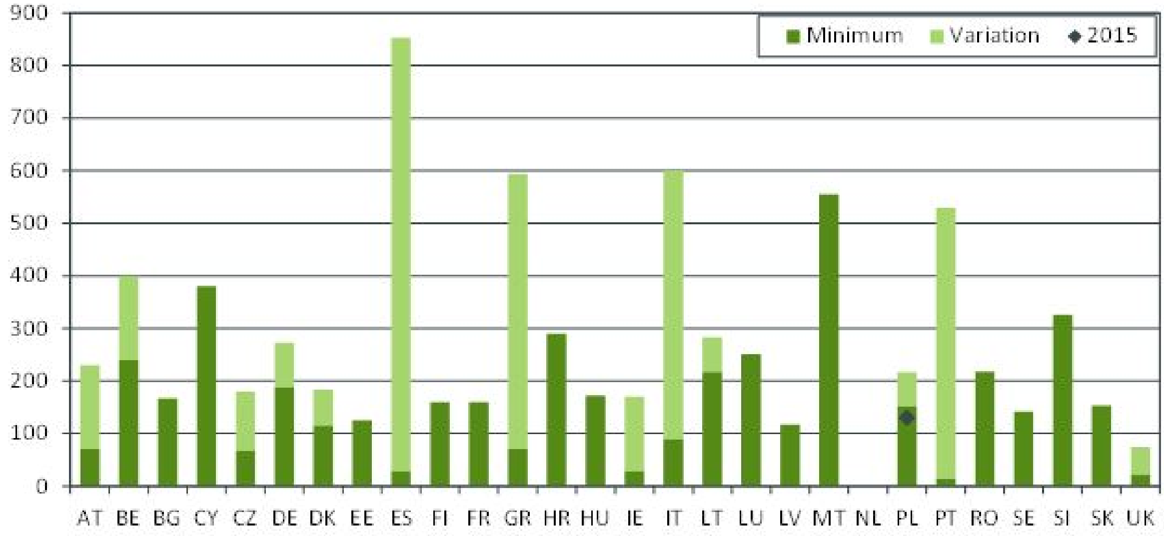
| | Total support payments (M€) | Total number of agree-ments | Average support (€/agree-ment) | Total land area supported (kha) | % of 2018 national UAA supported | Land area per agreement (ha) | Average support (€/ha) | Total land area (kha) certified | % certified area supported | % of 2018 national UAA certified | Total AECM payments (M€) | Organic exp. relative to AECM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AT | 121 | 23422 | 5157 | 515 | 19.4% | 22.0 | 234 | 639 | 81% | 24.1% | 286.7 | 42.1% |
| BE | 19 | 2000 | 9650 | 80 | 5.9% | 39.8 | 243 | 89 | 89% | 6.6% | 34.6 | 55.8% |
| BG | 24 | 4230 | 5727 | 68 | 1.4% | 16.2 | 354 | 129 | 53% | 2.6% | 31.7 | 76.4% |
| CY | 4 | n/a | n/a | 5 | 3.5% | n/a | 805 | 6 | 76% | 4.5% | 10.2 | 36.2% |
| CZ | 53 | 8976 | 5903 | 506 | 14.4% | 56.4 | 105 | 520 | 97% | 14.8% | 123.6 | 42.9% |
| DE | 300 | 25260 | 11884 | 1150 | 6.9% | 45.5 | 261 | 1521 | 76% | 9.1% | 435.1 | 69.0% |
| DK | 41 | n/a | n/a | 223 | 8.5% | n/a | 184 | 257 | 87% | 9.8% | 25.5 | 160.7% |
| EE | 18 | 1754 | 10474 | 186 | 18.9% | 105.9 | 99 | 207 | 90% | 21.0% | 29.7 | 61.9% |
| ES | 159 | n/a | n/a | 1045 | 4.3% | n/a | 152 | 2246 | 47% | 9.3% | 227.5 | 69.7% |
| FI | 56 | 4632 | 12137 | 274 | 12.1% | 59.2 | 205 | 297 | 92% | 13.1% | 240.9 | 23.3% |
| FR | 180 | 31000 | 5806 | 1040 | 3.6% | 33.6 | 173 | 2035 | 51% | 7.0% | 442.6 | 40.7% |
| GR | 97 | n/a | n/a | 248 | 4.7% | n/a | 390 | 493 | 50% | 9.3% | 66.4 | 146.1% |
| HR | 33 | 7759 | 4255 | 94 | 6.4% | 12.2 | 350 | 103 | 91% | 6.9% | 8.3 | 397.7% |
| HU | 21 | 2173 | 9877 | 115 | 2.2% | 53.1 | 186 | 209 | 55% | 3.9% | 153 | 14.0% |
| IE | 8 | 1523 | 5253 | 72 | 1.6% | 47.3 | 111 | 74 | 97% | 1.6% | 260.8 | 3.1% |
| IT | 386 | n/a | n/a | 1098 | 8.5% | n/a | 352 | 1958 | 56% | 15.2% | 421.5 | 91.6% |
| LT | 36 | n/a | n/a | 184 | 6.2% | n/a | 197 | 240 | 77% | 8.1% | 12.3 | 294.5% |
| LU | 1 | 77 | 16541 | 5 | 3.8% | 64.1 | 258 | 6 | 85% | 4.4% | 21.3 | 6.0% |
| LV | 28 | 4012 | 6948 | 261 | 13.5% | 65.1 | 107 | 280 | 93% | 14.5% | 13.6 | 205.0% |
| MT | 0.002 | 6 | 393 | 0.01 | 0.1% | 1.1 | 374 | 0.05 | 13% | 0.4% | 0.6 | 0.4% |
| NL | 0 | 0 | 0 | 0 | 0.0% | 0.0 | 0 | 64 | 0% | 3.5% | 66 | 0.0% |
| PL | 47 | 14321 | 3296 | 342 | 2.4% | 23.9 | 138 | 485 | 71% | 3.3% | 175.5 | 26.9% |
| PT | 25 | n/a | n/a | 206 | 5.7% | n/a | 124 | 213 | 96% | 5.9% | 138.4 | 18.4% |
| RO | 42 | 7169 | 5919 | 183 | 1.4% | 25.5 | 232 | 326 | 56% | 2.4% | 119.3 | 35.6% |
| SE | 75 | 5635 | 13297 | 355 | 11.8% | 63.0 | 211 | 609 | 58% | 20.3% | 127.3 | 58.9% |
| SI | 10 | 6951 | 1386 | 46 | 9.6% | 6.6 | 210 | 48 | 96% | 10.0% | 30.7 | 31.4% |
| SK | 17 | n/a | n/a | 158 | 8.2% | n/a | 108 | 189 | 84% | 9.8% | 20.5 | 83.5% |
| UK | 18 | 2876 | 6229 | 338 | 1.9% | 117.5 | 53 | 457 | 74% | 2.6% | 369.4 | 4.8% |
| EU28 | 1821 | n/a | n/a | 8798 | 4.9% | n/a | 207 | 13700 | 64% | 7.6% | 3893.1 | 46.8% |

Source: Thünen Institute (Lampkin and Sanders, 2021)

- This support was subject to a co-financing rate of 75% EU (85% in less developed and peripheral regions) and 25% (15%) national funding.
- Member States were encouraged to consider this support in the context of the market situation for organic food, and to adopt a strategic approach to policy integration in the context of organic action plans. Linkages with other RDP measures such as training and advice, investment in physical assets and EIP operational groups should also be considered.

Despite the common guidance on the setting of payments, the rates for organic farming support were highly variable within and between MS (Figs. 4.1 and 4.2), with some countries using a small number of land use categories (e.g., arable, improved grassland), and others highly differentiated rates for individual plant and animal species. This can be challenging as organic farming is closely linked to the market for organic food, and there is the potential for support payments to have a distorting impact on the market.

## Figure 4.1: Organic farming maintenance payments (€/ha) for arable crops in EU Member States, 2019

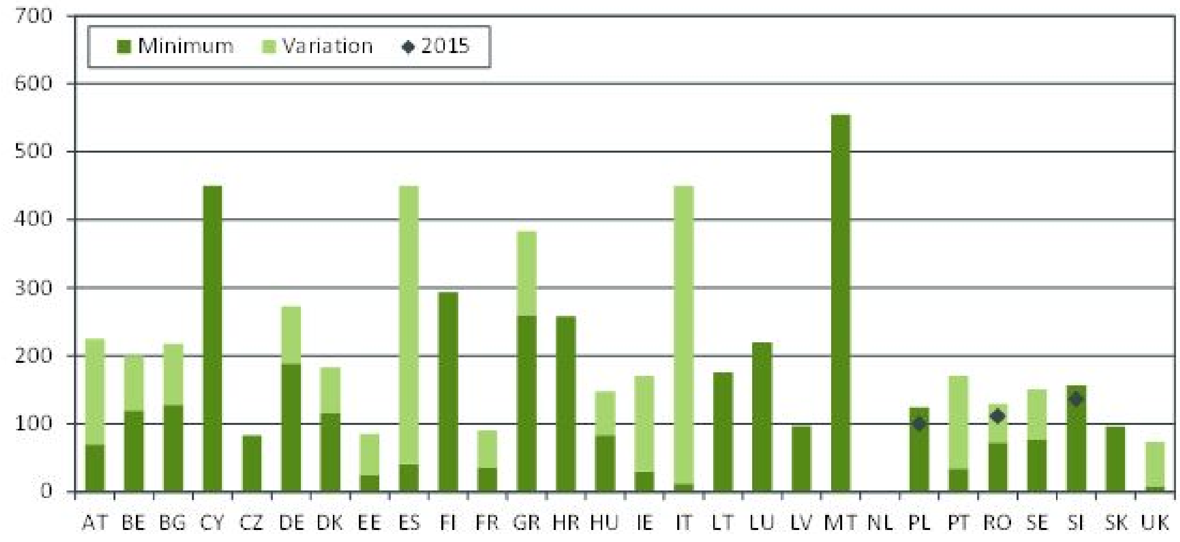



Euro conversions: 2019 average rates used for DK, PL, SE, UK. Other non-Euro countries' payment rates set in Euros

FR no maintenance payments in 2019; GR and UK-NIE no maintenance payments in 2015

Source: Thünen Institute (Lampkin and Sanders, 2021)

Figure 4.2: Organic farming maintenance payments (€/ha) for grassland in EU Member States, 2019




Euro conversions: 2019 average rates used for DK, PL, SE, UK. Other non-Euro countries' payment rates set in Euros

FR no maintenance payments in 2019; GR and UK-NIE no maintenance payments in 2015

Source: Thünen Institute (Lampkin and Sanders, 2021)

While the basis for the calculation of payment rates – income foregone, additional costs incurred, and transaction costs (including organic certification as a cost of verifying compliance with scheme requirements) – was clearly set out in EU regulations and guidance fiches, the methods applied, and costs included, varied in different countries. Typically for example the income foregone during conversion is higher than once full organic status has been achieved, in part because crops and livestock produced are not eligible for organic premium prices. If a crop of wheat yield 5t/ha attracts a premium of €100/t, then the conversion payment should be €500/ha higher than maintenance for this reason alone. But in very few MS was this the case. In some countries, such as the UK, the percentage of costs compensated was reduced, so as not to create an undue incentive to conversion. In others, such as Spain and Italy, a fixed percentage of 10% or 20% was added to the maintenance payment to create a conversion rate – clearly not taking account of specific costs and income factors during the conversion period. In others, there was no difference at all in support for conversion and for maintenance. The differential between maintenance and conversion payments in all EU countries is also illustrated in IFOAM Organics Europe (2021).

There is also a high degree of variability in eligibility conditions. While in almost all cases management of land and livestock to the standards set out by the EU organic regulation was required, in a few the utilisation of organic land by non-organic livestock appears to be permitted (in a couple of cases with higher payments if organic livestock involved). In Greece, only full-time farmers were eligible for support, excluding a significant number of commercial (active) part-time farmers.

Budgetary constraints also impacted on scheme availability, leading to implementation delays, irregular calls for applications (at 2-3 year intervals) as in Ireland and Bulgaria or the withdrawal of support for maintenance in France and of access to new entrants in other regions such as Wales. In some cases, e.g. Denmark, support for conversion was only available to new entrants – existing organic farmers converting additional land were not eligible. Such administrative constraints can have significant impacts on organic market development, and the ability of the market to support the delivery of environmental benefits by farmers.

## COMBINATIONS OF ORGANIC AND OTHER AGRI-ENVIRONMENT SUPPORT

In most countries, combinations with other agri-environmental options are possible, reflecting the tradition of organic farming support integrated with agri-environmental support in previous policy periods. Examples of support that could be combined (usually a limited selection in each country) are:

- Agri-environmental, nutrient budgeting and similar management plans;
- Rare animal breeds and crop varieties (endangered indigenous varieties);
- Use of beneficial insects in greenhouses;
- Use of biological and other alternative pest controls, especially in horticulture;
- Green manures and cover crops on arable land;
- Spring cultivations for crops to reduce nitrate leaching;
- Reduced or minimum tillage systems;
- Intercropping and extended rotations;
- Ecological refuges on arable land for farmland bird species;
- Uncultivated/multi-functional field margins around arable crops;
- Low intensity fertiliser use (including organic manures);
- Increasing soil organic matter;
- Maintenance of winter stubbles;
- Conservation strips within fields;
- Use of environmentally-friendly horticultural methods;
- Maintaining habitats of protected species in arable land;
- Biodiversity conservation and enhancement;
- Improved manure/slurry management and spreading techniques, slurry incorporation;
- Management of grassland for biodiversity/wildlife – restricted mowing and grazing dates;
- Traditional practices for seasonal grazing (pastoralism);
- Pasture grazing for animal welfare;
- Growing flowering plants for pollinators;
- Butterfly protection measures;
- Hamster friendly follow-on crops;
- Grass strips for erosion control and improved management of inter-row spaces in perennial crops;
- Restoration and maintenance of high nature value (HNV) grassland;
- Restrictions on use of grassland for silage;
- Wetland creation and management;
- Conversion or arable to grassland;
- Preservation of hedges and dry stone walls;
- Hedgerow planting, coppicing and laying;
- Maintenance of traditional/extensive hay meadows, orchards and olive groves;
- Planting groves of native trees;
- Bat, bird and bee boxes;
- Wildlife species specific options (Corncrake (Crex crex), cranes, geese, swans);
- Cultivation of papilionaceous flowers;
- Cultivation of fibre flax and fibre hemp using less fertilizing substances;

- Conservation of landscape and archaeological features;
- Water protection, e.g. buffer strips and reduced nitrate leaching;
- Reduction of surface water run-off from land;
- Welfare friendly housing for male breeding animals;

In almost all cases, these combinable options are open to all farmers, not only organic farmers, and some countries report higher participation in AEC options by organic farmers, but it has not been possible to secure reliable data on this.

In Ireland, the measures for individual bird species (Chough, Breeding waders, Geese, Swans, Hen Harriers, Grey Partridge, Twite) can be implemented on organic farms, but only if the organic payment is not claimed on the land involved. The same is true for the environmental management of fallow land, wild bird cover, riparian margins, protection of archaeological monuments on tillage land and low input permanent pasture options. In other countries, such as Poland, Hungary, Estonia and parts of Italy (Bolzano, Trento, Veneto, Puglia, Friuli, Liguria and Sicilia) combinations of any agri-environment measures on the same land are not possible, although in a few of the Italian regions rare breed options can be combined. While the risk of double funding or exceeding maximum payment thresholds in the EU RD regulations were cited as reasons, this meant that opportunities to encourage organic farmers to undertake additional actions to support biodiversity, and to benefit from synergies with the underlying organic management, could be missed.

In other cases, permanent grassland (e.g., in Sweden) was not eligible for organic support, but could access agri-environmental support for grassland biodiversity. In Romania, participating in grassland biodiversity options (such as management of grassland for HNV value or for species of birds such as small eagles, bustards, *Crex crex*, *Lanius minor* and *Falco vespertinus* and butterflies (*Maculinea* sp.)) was compulsory for grassland receiving organic support. In Czechia, a number of additional measures going beyond organic minimum standards have been directly integrated into the organic farming support scheme, including grassland mowing frequencies and latest cutting dates and the inclusion of green manures with legumes after arable crops. Very few examples of combinations focused on the use of organic farming methods in sensitive areas (e.g. national parks, Natura 2000) were found, although some specific cases exist, for example the Rhön Biosphere Reserve where organic farming is encouraged in the context of a nature protection region.

Given that organic farming was originally supported (for 21 years) as an agri-environment measure and ongoing support is justified on this basis, combinations with other agri-environment options might be considered normal. There may be valid reasons where combinations of specific options are excluded, for example where:

- Requirements for an option are very similar to organic management, such as restrictions on nitrogen fertiliser or pesticide inputs, and double funding might be involved;
- Agri-environment options target land on farms that is not actively farmed, for example specific wildlife habitats, and therefore would not be eligible for organic farming support payments;
- Agri-environment options requires practices, such as the use of herbicides to control invasive weeds, that are incompatible with organic management – although in these cases there may be opportunities to identify alternative management practices that could be acceptable and deliver similar outcomes.

There may also be a case to include options that are specifically focused on organic farms and the opportunities and challenges that organic management creates. In England, five options were available for this purpose in the 2014-2020 RDP. As an example, the wild bird seed mixture option permitted organic farmers to use cleanings (weed seeds) from grain as part of the seed mixture, whereas non-organic farms could only use harvested grains. Schleswig-Holstein in Germany also implemented a specific biodiversity measure for organic farmers, focusing on small elements in arable production including reduced field sizes and wildflower strips on a proportion of the land.

A source of conflict, or at least frustration, in this context is the setting of payment rates for organic farmers undertaking similar measures to non-organic farmers. This relates in particular to the inclusion of premium prices to offset the income foregone, which is not required for any other schemes than organic. This can result in payments to organic farmers for undertaking the same options being lower than for non-organic farmers, the argument being that the organic market partly compensates for the action, and non-organic farmers do not have access to this market. While it is true that, for some consumers at least, the environmental benefits associated with organic farming are a reason for their willingness to pay more, for many there are other, more personal reasons such as quality, taste or the desire to avoid pesticide residues, so that the whole of the price premium paid cannot be attributed to the biodiversity or other environmental benefits. Organic farmers may not even access any premium price and may for legitimate reasons sell products on conventional markets, while still generating the environmental benefits from their organic land management. Indeed, there is a case that any price premium obtained is more a reflection of the marketing activities undertaken by the farmer, which also incur costs that are not usually included in the income foregone calculations. At the same time, if an agri-environment option involves taking land out of production, then the full value of the organic crop or livestock no longer produced does become a relevant factor.

**Organic farming has demonstrated the potential for beneficial combinations with other agri-environment measures in order to build on what is already delivered by organic methods, and to go further than the minimum requirements of organic regulations, in particular with respect to specific habitat and species related measures.**

Administrative constraints that prevent combinations being adopted are clearly counter-productive but are still found in many countries. Solutions can be found for double-funding issues where this is a concern. Even better would be the development of nature-focused AEC measures that specifically take account of organic practices.

## GREENING

RDP support for conversion and maintenance is not the only support available for organic land management. Organic farming also qualified *de facto* for Greening, representing 30% of Pillar 1 basic funding, which meant that organic farmers were not obliged to meet the same conditions as other farmers concerning crop diversification, protection of permanent grassland and maintenance of 5% ecological focus areas. This was on the basis that organic cropping systems are more diverse per se, with a higher proportion of grassland (temporary leys in the case of arable and horticultural systems) and increased wildlife within crops as well as in field margins. It has been suggested that this provision meant that organic farmers were free to plough up permanent grassland, but other administrative constraints would have inhibited this and there is insufficient evidence to show this was the case in practice.

While organic farmers are not required specifically to provide non-cropped habitat (ecological focus areas), such practices can benefit the farming system by providing refuges for beneficial insects and are therefore considered good practice. Some of the practices that were approved for ecological focus areas, including the production of legumes and catch crops without the use of pesticides, and the maintenance of existing landscape elements such as hedges, would also be considered normal practice on organic farms.

Considering these factors, the *de facto* recognition of organic land for Greening was appropriate, provided that double funding issues with rural development regulation support could be resolved satisfactorily. This should not normally be a problem, as there are many other practices and prohibitions (e.g. no synthetic nitrogen, herbicides, land-based livestock production) covered by organic regulations that were not requirements for Greening, and that together would have had much greater impact on income foregone calculations.

## CORPORATE SUPPORT FOR ECOSYSTEM SERVICES

Although not widely the case, in some countries, corporate bodies like water companies or agencies have been involved in supporting organic farming in recognition of the value to them of the environmental benefits derived. With less fertiliser and pesticide use, the costs for cleaning up water supplies in catchment areas can be reduced.

The primary example for this type of intervention is in France, albeit focused more on water protection than biodiversity, where some water agencies individually initiated support measures. For the 2014-2020 RDP, all water agencies became contributors to the French co-financing of Pillar 2 organic support, almost matching the contribution made by the French government. (In the previous RDP, organic farming support had been fully EU financed as a Pillar 1 Article 68 measure.) Some water agencies, such as Eau de Paris, have recently introduced new payments for organic farming, in part as a response to the government withdrawing maintenance support for organic farming in 2018.

In Germany, the Munich water company has also provided support over many years. Also relevant in some German *Länder* is the use of offsetting schemes, where monies paid by companies undertaking developments to offset the biodiversity and other impacts of their developments can be used to 'buy' biodiversity back from specific nature restoration initiatives as well as from organic farms. Retailers are also supporting groups of organic farmers to adopt additional biodiversity conservation measures through supply contracts and higher prices, for example Edeka Nord in partnership with WWF, the organic organisation Biopark and the ZALF research centre.

In such situations, care needs to be taken to ensure that the support provided does not result in double funding or impact negatively on the support available from other sources. In situations where governments are not funding, or only partly funding, the costs of organic conversion and maintenance, then there may not be an issue with double funding, even if an area-based payment is made by a third party. Indeed, in such situations the third party funding can represent a valuable additional source of support for the viability of organic farms and the continuing delivery of public goods.

There are also potential problems with such payments as they may be considered state aid under EU competition law, particularly where public bodies are involved. To comply with this law, support should either meet the *de minimis* rule that the payment does not exceed €20,000 per farm over a three year period, or be registered and approved by the EU-Commission to make sure that it does not create market distortion, which can be a lengthy and complex process.

## CONCLUSIONS

The positive contribution of organic farming to the environment in general and biodiversity in particular has been recognised Europe-wide since the 1990s, when support payments for organic conversion and maintenance were introduced as part of the agri-environmental measures. This is the main source of support for organic farming in the CAP, with an expenditure in 2018 of over 1.8 billion € or 3% of the CAP budget for 8% of the EU's land area. All member states except the Netherlands have implemented conversion and maintenance support, although budgetary and administrative issues have resulted in intermittent availability in some countries. Within and between countries, individual payment rates can be highly variable. These factors impact on the market-focus of organic farming and the need to balance public and private good perspectives.

The potential to combine organic farming support with other agri-environmental support is also highly variable. In some countries, combinations are possible, except where similar requirements are imposed to those specified under organic regulations. In other countries, combinations are not permitted, due to dual funding or budgetary concerns, or are only possible on a very restricted basis. In very few cases have agri-environment options been developed to specifically capitalise on the baseline provided by organic farming standards.

Organic farming has also been recognised as *de facto* qualifying for Greening as part of the Pillar 1 direct payments. This is in recognition of the more diverse cropping systems, the importance of grassland for livestock production and the benefits from non-crop habitats in organic systems. While some of the Greening provisions are not specifically required under organic regulations, they represent good practice that would normally be expected on organic farms.

There is potential for public-private partnerships to support the delivery of environmental benefits by organic farmers. Water companies in France and Germany have provided specific support to organic farmers to reduce pollution from agrochemicals in water catchment areas, while in Germany retailers are developing schemes to recognised biodiversity actions through improved marketing opportunities.

# OPTIONS FOR FUTURE POLICY

## EUROPEAN STRATEGIES

The EU Green Deal, together with the Farm to Fork and Biodiversity Strategies, have placed significant emphasis on securing European biodiversity and climate goals. The contribution of organic farming to these aims has been recognised by the 25% target for organic land area in Europe by 2030. An expansion of organic farming would not only contribute to this specific target, but also to others, including the reduction in pesticide, fertiliser and antibiotic use specified in the Farm to Fork Strategy, as well as to nature restoration, pollinator and other targets in the Biodiversity Strategy.

The EU's Biodiversity Strategy 2030, published in May 2020, aims to protect and enhance biodiversity in agricultural and non-agricultural contexts, with a focus on:

- 30% of land, some of which will be farmland, in protected areas;
- Increasing organic farming and biodiversity-rich landscape features on agricultural land;
- Halting and reversing the decline of pollinators;
- Restoring at least 25,000 km of EU rivers to a free-flowing state;
- Reducing the use and risk of pesticides by 50% by 2030;
- Planting 3 billion trees by 2030.

The Biodiversity Strategy recognises that while some biodiversity goals may be best met by nature restoration excluding agriculture, farming has a key role to play in a European context where agriculture and biodiversity are closely integrated. The debate over land sparing or land sharing approaches continues, but while it is clear that some species require no or very limited agricultural activity for their survival, others have thrived in the context of co-existence with agricultural activities. A land sparing model, with further intensification of agricultural activity on some land, is likely to cause further damage to these farming-adapted species. A land-sharing approach, including the use of lower-intensity systems such as organic farming, may be better able to continue support the farmland biodiversity that has evolved over centuries of co-existence. The inclusion of organic farming as a target in the Strategy reflects this, but while organic farming is targeted specifically, it can also contribute to reducing nutrient losses to water courses, reducing pesticide use, and encouraging the planting of trees in the context of agroforestry.

## EU ORGANIC ACTION PLAN

The third EU organic action plan, published at the end of March 2021, highlights the contribution to biodiversity that organic farming can make, and the 25% organic area target that is part of the 2030 Biodiversity Strategy. However, although the Plan recognises that organic farming delivers biodiversity benefits, stating that organic farms deliver 30% more biodiversity benefits, there are no actions specifically focused on organic farming and wildlife biodiversity, for example with respect to the forthcoming, legally binding EU nature restoration targets and the potential for increasing biodiversity performance on organic farms through improved information and advice to producers.

There is an action relating to genetic biodiversity and the role of specialist seed breeding and yield enhancement in organic production. There is also an important commitment to 30% of future EU agricultural research funding being focused on topics directly related to or relevant to organic farming, which could potentially include questions relating to biodiversity enhancement.

The EU action plan calls for all member states to develop national action plans with area targets. This should be linked to agri-environmental and information actions with a specific biodiversity focus as part of the CAP Strategic Plans and Rural Development Programmes.

## ECO-SCHEMES

In addition to the nearly 30-year-old agri-environment measures, the new CAP foresees the introduction of Eco-schemes in Pillar 1, which have significant potential to support organic farming and other environmentally friendly farming systems (see Lampkin *et al*., 2020). The EU Commission is also enthusiastic about the potential for organic farming to be supported via Eco-schemes, but in its guidance to Member States on the implementation of Eco-schemes it failed to recognise the contribution of organic farming to biodiversity, potentially inhibiting MS engagement, despite the extensive research and practical evidence outlined in this report, and the inclusion of organic farming in the Biodiversity Strategy. At the same time, individual agroecological practices such as mechanical weed control, mixed cropping, cover crops between perennial crop rows and mixed species grassland, which are also part of organic farming, were credited with biodiversity benefits.

**As this review has indicated, compliance with organic regulations already delivers biodiversity benefits due to the substantially reduced use of fertilisers and pesticides, as well as the changes in rotations, timing of cultivation and other practices that are used to accommodate this.**

There are many opportunities to build synergistically on this baseline through initiatives by individual organic farmers and groups of farmers. This is entirely consistent with organic principles, and with the aspirations of most organic farmers. They can be supported in delivering these benefits through well designed Eco-schemes and Agri-environment/Climate options in the new MS CAP Strategic Plans.

Eco-schemes offer some Member States the possibility to shift funding for organic farming from Pillar 2 to Pillar 1, which is 100% EU funded. This can help address budgetary problems where organic farming is taking up a high and increasing share of rural development funding, with the associated co-financing commitments. Compared with other Eco-scheme options, the likely demand, at least for maintenance payments, is known.

Other Member States may prefer to retain organic support in Pillar 2 in order to maintain close links with other agri-environment options, or because they have a history of supporting organic farming through a combination of EU and national funding. Concerns have been raised that the annual agreement basis for Eco-schemes is too short term for organic farming. This may be true for the conversion process, which involves system restructuring and learning processes over several years, where the longer term agreements (5-7 years) typically available under Pillar 2 may be relevant. However, maintenance agreements could be managed on an annual basis in line with support for farming in general, which is also a long-term business commitment. For some farmers concerned about future market prospects and the need to repay rural development support if they are forced to quit organic farming early, an annual agreement approach could actually help build confidence.

In some cases, Member States may opt for Eco-schemes that are more generally defined so that both organic and non-organic farmers are eligible. Organic farmers may have prioritised access, or be able to qualify more easily because they have already adopted relevant practices. Organic Denmark has proposed a Sustainability Eco-scheme, focused on Climate and Biodiversity, which would be open to all farms on this basis. For Biodiversity, this would include a field eco-space index reflecting the initial structure and type of farm, including crop diversity on arable land and minimum areas of permanent grassland and landscape features, with additional points relating to cropping, tillage and input use.

This generic Eco-scheme approach has the advantage that the direct payments previously received continue to be available to all farmers, rather than one group of farmers benefiting at the expense of another, and permitting a continued focus on specific agri-environmental enhancement of organic farming in Pillar 2. Conversely, proposals such as in Germany for Eco-schemes that organic farmers would not be eligible to access would mean reduced direct payment support for the organic sector, offsetting the benefit of any Pillar 2 payments that may be available.

## CONDITIONALITY

Conditionality replaces elements of Greening and Cross-compliance in the new CAP. The key elements from the original Commission proposal are summarised in Lampkin *et al*. (2020) and cover Statutory Management Requirements (SMR) and Good and Agricultural and Environmental Condition (GAEC). Although overall agreement on the new CAP was reached in June

2021, the Conditionality clauses were still under negotiation at the time of publication of this report. The requirements most relevant to biodiversity include:

- SMR 3: Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds: Article 3(1), Article 3(2)(b), Article 4(1), (2) and (4).
- SMR 4: Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild flora and fauna: Article 6(1) and (2).
- GAEC 1: Maintenance of permanent grassland based on a ratio of permanent grassland in relation to agricultural area (at national, regional, sub-regional, group-of-holdings or holding level. The variation of this ratio shall be maximum 5% compared to reference year 2015 or 2018). Even if, as in Greening, organic farmers are not specifically required to maintain permanent grassland, the integration of livestock in most organic systems provides an incentive to maintain grassland. Care is however needed to avoid loss of grassland for the establishment of horticultural enterprises, but this may be addressed through other regulatory mechanisms.
- GAEC 2: Appropriate protection of wetland and peatland including appropriate management, e.g. paludiculture, but only from 2025. This has not been a specific focus for organic regulations, but greater attention could be given to organic paludiculture in future.
- GAEC 3: Ban on burning arable stubble, except for plant health reasons.
- GAEC 4: Establishment of buffer strips along water courses, normally minimum width of 3m without using pesticides and fertilizers, but with significant scope for exceptions to this. Organic management would ensure non-use of pesticides and fertilisers in all cases.
- GAEC 7: Minimum soil cover to avoid bare soil in periods that are most sensitive, taking account of length and severity of winter periods. This is an important organic farming principle and should not represent a problem to organic farmers.
- GAEC 8: Crop rotation in arable land. Rotation is defined as a change of crop at least once a year at land parcel level (except in case of multiannual crops, grasses and other herbaceous forage, and land lying fallow), including the appropriately managed secondary crops. This is not required for farms with less than 10ha arable land or more than 75% permanent grassland or underwater crops, although larger farms could still have significant areas of arable land. Farms with more than 75% of arable area growing herbage or leguminous crops, or is fallow, are also exempted. Organic farms are considered de facto to meet this requirement. MS may limit the area under a single crop to avoid monocultures, or require enhanced rotational practices including leguminous crops, catch crops or crop diversification, consistent with soil protection aims.
- GAEC 9: Minimum share of agricultural area devoted to non-productive areas or features including fallow land. At least 4% of arable land at farm level should be allocated to this, potentially reduced to 3% where 7% covered by a relevant Eco-scheme. A 7% minimum applies if the area includes catch crops (weighting factor 0.3) or nitrogen-fixing crops cultivated without the use of plant protection products, but at least 3% should still be fallow or non-productive features in this case. Existing landscape features should be retained, with a ban on cutting hedges and trees during the bird breeding and rearing season; with optional measures for avoiding invasive plant species. Similar exemptions apply as for GAEC 8 for farms with less than 10 ha arable, or more than 75% grassland, or 75% of arable land growing herbage or leguminous crops or fallow. Exemptions may also imply in countries with very high forest cover. While a case may be made for organic farming also to be exempt here, it would be desirable for organic farming to demonstrate that it can at least meet the 7% target, and even better the 10% nature restoration target specified in the EU Biodiversity Strategy.
- GAEC 10: Ban on converting or ploughing permanent grassland (designated as environmentally-sensitive permanent grasslands) in Natura 2000 sites. This should not represent an issue for organic farmers for reasons outlined previously.

In general, organic farming is well placed to meet the new Conditionality requirements, but individual farms need to take care that they do not just rely on being organic but are also meeting the minimum standards required for all farmers. Continuing exemptions for organic farmers from the Greening requirements now incorporated in Conditionality could be interpreted negatively by some, because these requirements – e.g., GAEC 9 – are not specified directly in organic regulations, even if organic farmers are normally delivering much more than the basic requirement in practice.

## CONCLUSIONS AND RECOMMENDATIONS

The EU has set an ambitious target for the expansion of organic farming to 25% of agricultural land area by 2030 as part of its Farm to Fork and Biodiversity Strategies intended to deliver on the Green Deal. Achieving this will also contribute to the pesticide, fertiliser and antibiotic reduction targets, and to the nature restoration target.

**The new CAP for the period to 2027 places the responsibility on Member States to develop agricultural and agri-environmental policy measures to meet specified objectives.**

The Commission's expectation is that organic farming will feature strongly in this process – the EU organic action plan envisages that every MS will set a national target for organic farming and develop a strategic plan to achieve this. However, IFOAM Organic Europe (2021) suggests that funding for organic farming support through the new Eco-schemes as well as traditional Agri-Environment Climate measures may need to increase 3-5 fold (10 fold in some countries) to deliver the 25% land area target.

While many policy options to enhance organic farming's biodiversity benefits would have been possible under previous rural development programmes, it is clear that insufficient use has been made of the opportunities and, in some cases, there have been policy constraints imposed that have actively discouraged building more biodiversity benefits on the base that organic farming provides.

To address these issues, Member States should:

- Explicitly recognise the opportunities for biodiversity conservation and enhancement underpinned by organic farming in their CAP Strategic Plans (CSPs), rural development programmes and national organic action plans. This will require not only recognition by the Commission that organic farming does deliver biodiversity benefits in the context of Eco-schemes, but also a comprehensive assessment by the Commission during CSP adoption of how MS will support biodiversity objectives through organic payments and additional AECM payments.
- Enable combinations of organic farming, Eco-schemes and agri-environmental options wherever possible, ensuring that practice definitions do not unintentionally exclude organic farms, and including options specifically targeting and building on minimum organic standards, so that opportunities to benefit from synergies and enhanced delivery of biodiversity outcomes can be exploited.
- Encourage natural/ecological focus areas (landscape elements) as part of functioning organic systems, recognising the mutual benefits for biodiversity and agricultural systems such as refuges for beneficial insects (Tscharntke *et al*., 2012). The minimum threshold specified in GAEC 9 should not represent an issue for organic farms, but it could be more ambitious – many organic farms will already exceed the 10% target for nature restoration specified in the EU Biodiversity strategy. The Commission should assess how organic farming can be used to effectively make an active contribution to the EU nature restoration targets under the Biodiversity Strategy.
- Consider whether biodiversity requirements should be more explicit within organic regulations (Sanders, 2013). At present, many of the biodiversity benefits are an indirect consequence of prohibited or restricted practices, and not recognised as biodiversity-focused.
- Support organic and environmental AKIS initiatives to make best use of biodiversity options on organic farms and avoid the risks of unintentional damage. This also requires AKIS delivery agents (agricultural and nature advisors and ecologists) to better understand the contributions that organic farming can make across different farmland types and enterprises.
- Exclude organic premium prices from income foregone calculations, given a) that the environmental benefits are delivered for society as a whole, not just organic consumers, b) organic consumers are motivated to purchase also for other reasons than environmental ones and c) premium prices are normally only available where investment in market development has taken place, which is not normally reflected in income foregone calculations. This would help avoid situations where organic farmers are paid less than other farmers for delivering the same agri-environmental options, creating perverse incentives.
- Consider supplementary payments for conversion to or maintenance of organic farming in sensitive areas such as water catchments, Natura 2000 or other protected areas.
- Give more consideration to public-private partnerships with businesses such as retailers and water companies, as well as to biodiversity offsetting schemes, to provide additional support for organic farmers, as illustrated in Section 4.4 above.

Looking forward, there is a need to reflect on the mechanisms for rewarding the delivery of environmental benefits by farmers. While the income foregone model required under WTO agreements is intended to avoid market distortion by only compensating for income losses and additional costs of agri-environmental measures, this approach provides no additional incentive to adopt more environmental approaches and may overcompensate some farmers while undercompensating others. The focus of this approach is more on inputs and practices than on actual environmental outputs delivered, which is understandable from an auditing and control perspective. For organic farming, in most cases, the payments are constant per hectare at least on a regional basis, so that individual farmers who do more for the environment may only get the same support as those who do the absolute minimum. The public money for public goods principle, with a stronger emphasis on actual results, appears to be highly relevant, although the challenges of implementing such schemes with acceptable administrative burdens and transaction costs should not be underestimated. Research is currently in progress at the Thünen Institute in Germany to develop an approach for remunerating the additional environmental services provided by individual organic farmers, so that those who do more can be recognised for this. The intention is that pilot schemes using this approach might be implemented in some German *Länder* from 2023/2024.

If all these issues can be addressed, then the potential for organic farming to deliver even more for biodiversity, and to make a major contribution to the EU's Biodiversity Strategy, is significant and worthwhile.

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# LIST OF ACRONYMS

| | |
|---|---|
| **AEC** | Agri-Environment Climate |
| **AECM** | Agri-Environment Climate Measures |
| **AHDB** | Agriculture and Horticulture Development Board |
| **AKIS** | Agricultural Knowledge and Innovation Systems |
| **AMF** | Arbuscular Mycorrhiza |
| **CAP** | Common Agricultural Policy |
| **Commission** | European Commission |
| **CSPs** | CAP Strategic Plans |
| **DEFRA** | Department for Environment, Food and Rural Affairs (UK) |
| **EC** | Council Regulation |
| **EIP** | European Innovation Partnership |
| **EU** | European Union |
| **FiBL** | Research Institute of Organic Agriculture |
| **GAEC** | Good Agricultural and Environmental Condition of land |
| **GMOs** | Genetically Modified Organisms |
| **Green Deal** | European Green Deal |
| **GWCT** | Game and Wildlife Conservation Trust |
| **IFOAM** | International Federation of Organic Agriculture Movements |
| **IFOAM Organics Europe** | International Federation of Organic Agriculture Movements - Europe |
| **IPM** | Integrated Pest Management |
| **MECU** | Million European Currency Units |
| **MEUR** | Million Euros |
| **MS** | Member States |
| **ORC** | Organic Research Centre |
| **Plan** | Organic Action Plan |
| **PLFA** | Phospholipid Fatty Acids |
| **RD** | Rural Development |
| **RDP** | Rural Development Programme |
| **SMR** | Statutory Management Requirements |
| **UK** | United Kingdom |
| **WTO** | World Trade Organization |
| **WWF** | World Wide Fund for Nature |
| **ZALF** | Leibniz Centre for Agricultural Landscape Research |

# COLOPHON


## COMMISSIONED AND PUBLISHED BY IFOAM ORGANICS EUROPE, 2020

### GREEN ORGANICS

### EXECUTIVE AGENCY FOR SMALL AND MEDIUM-SIZED ENTERPRISES (EASME)

**PUBLISHED BY:**
IFOAM Organics Europe
Rue du Commerce 124, BE-1000 Brussels
+32 2 280 12 23
[email protected]
www.organicseurope.bio & www.euorganic2030.bio
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**WITH THE SUPPORT OF:** This publication is co-financed by the European Union, under the Executive Agency for Small and Medium-sized Enterprises (EASME). The sole responsibility for this communication lies with IFOAM Organics Europe. The EASME is not responsible for any use that may be made of the information provided.



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