

Agriculture and biodiversity

Impacts of different farming systems on biodiversity





Biodiversity is part of the organic farming systems, as promotion of species diversity on farms is integral to organic production. Via practices such as dedicated biodiversity areas, extensively farmed areas and site-adapted management, organic farms provide more space and resources for the diverse needs of a multitude of species.

Farmers benefit from the enhanced ecosystem services provided by greater biodiversity, as this enables them to reduce interventions (e.g. the use of insecticides) in their cropping systems. Functional groups such as pollinators, beneficial insects and decomposers also benefit from organic farming methods.

Species diversity varies between farming systems (organic, conventional, etc.). However, there can also be significant differences between farming types within the same system: for example, annual arable crops, viticulture and orchards or permanent grassland offer different potential for promoting species diversity.

With increased biodiversity, organic farming promotes stability and resilience in production systems, which is becoming increasingly important as disturbance events become more frequent and climatic changes more pronounced. In combination with nature conservation measures, organic agriculture can leverage additional synergies to promote biodiversity.

Content

Biodiversity and farming	3
Species loss and the role of agriculture	4
More biodiversity on organic farms	6
Greater habitat diversity on organic farms	10
Improved ecosystem services with organic management	11
Higher resilience of organic farmland	13
Organic agriculture as part of the solution	13
Risks of conventionalisation in organic agriculture	14

Biodiversity and farming

Biodiversity refers to the diversity of life on Earth. Assessments of biodiversity include not only plants and animals but also bacteria and fungi. The diversity and quality of habitats and the connectivity between them have a significant influence on biological diversity.

Genetic diversity within a population is key to ensuring the continued existence of a particular species in a particular space. Genetic variability enables species to adapt to changes in environmental conditions and the climate. If habitats of a species are located at significant distances from each other, the species' populations in question are at risk of isolation and loss of genetic exchange. It is therefore important for the conservation of biodiversity that habitats are maintained and connected. Therefore, to help conserve biodiversity in farming systems, care must be taken to ensure that biodiversity habitats are optimally distributed in sufficient quantity and quality provide for the long-term biological development opportunities of numerous species. The potential for effective biodiversity promotion rests upon the diversity and abundance of different habitats in the landscape.

Benefit for farming

Biodiversity is a vital prerequisite for the healthy and natural development of all living organisms. Rich biodiversity promotes the optimal functioning of natural processes and supports ecosystem services that are highly significant for agriculture. These include, for example, natural pest regulation, pollination of cultivated and wild plants by insects, and the generation and breakdown of plant biomass.

Agricultural policy and practices are increasingly promoting farming methods that preserve biodiversity and conserve natural resources^[1]. Agroecological measures aim at more robust and efficient farming systems and help minimise the use of external inputs. This can improve natural regulation processes and thus the functionality and sustainability of farming systems.

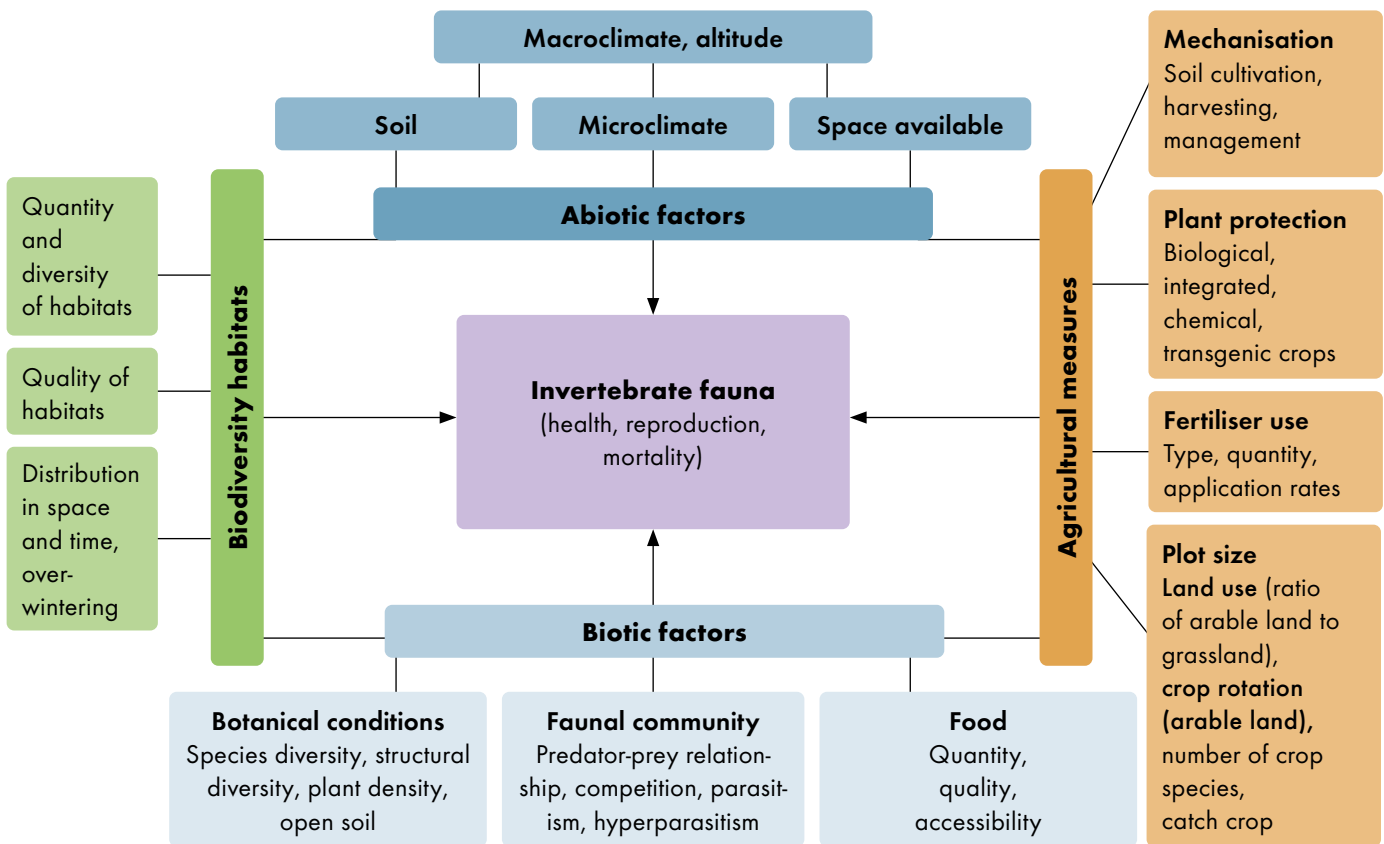
Key factors for biodiversity in agriculture

In general, the diversity of flora and fauna at the local level is influenced by anthropogenic factors such as the type and intensity of agricultural practices and by non-anthropogenic factors as site conditions such as soil characteristics, altitude and microclimate. This is also true for the landscape level, where the quality of landscape infrastructure (e.g. the extent and diversity of habitats) is particularly important. Biotic factors such as food resource availability and structural diversity in cultivated and non-cultivated habitats also have an impact on the diversity and abundance of animal organisms (see Figure 1 on page 4).



Biodiversity areas offer habitats and hibernation areas for many species. Connected biodiversity areas and small-scale structures foster biodiversity at a high quality level and provide habitats for rare and endangered species.

Figure 1: Factors influencing biodiversity – the example of invertebrates



Abiotic and biotic site factors strongly shape the conditions for small animal fauna. Anthropogenic activities such as agricultural cultivation measures and the retention and management of biodiversity habitats further influence the invertebrate fauna^[2].

Species loss and the role of agriculture

The intensification of land use associated with the increase in agricultural production over the decades has fundamentally changed the role of agriculture as it relates to biodiversity. In the past, a more diverse system of cultivated land with fields, meadows, field margins, hedgerows, vineyards, copses and traditional orchards provided valuable habitats for many species of flora and fauna as well as soil organisms. These more diverse systems have been largely replaced by intensive agriculture with the onset of the industrial farming revolution, which is causing a massive decline in biodiversity. The main drivers of this decline include high levels of agrochemical use, loss of valuable biodiversity areas such as dry grasslands, hedgerows, floodplains and traditional orchards, the dissection and paving-over of habitats (landscape fragmentation), a large livestock population and the reduction in genetic di-

versity. Climate change, introduced non-native species, light pollution and also the abandonment of meadows and pastures in mountainous areas further exacerbate the problem. As a result, the overall population of insects has declined significantly in recent decades: In Germany, for example, a 75 % decrease in insect biomass within three decades was recorded in 63 protected areas surrounded by agricultural land^[3]. In grassland, too, a decline of 67 % in insect biomass was recorded over a 10-year period as well as a 34 % decrease in insect species^[4]. A decline in insect biomass and species is particularly problematic given that many other species feed on insects, e.g. numerous species of amphibians, birds and bats. Changes in the food chain thus also put at risk many other species and ultimately many important functions in agriculture, such as natural pollination resulting in a cascade effect. Biodiver-

sity loss in various sectors has also been analysed and documented for Switzerland^[5,6]. The Red Lists of endangered species of flora and fauna identify intensive agriculture as one of the main drivers of species loss in the cultural landscape. Many populations are threatened because their size drops to below the minimum viable population size and their habitats are insufficient in size and quality (leading to a lack of genetic exchange). Intensive pesticide use, synthetic nitrogen fertilisers, land consolidation, drainage and the use of heavy machinery have contributed significantly to the drastic decline in biodiversity and to insect decline.

Focus on farming systems

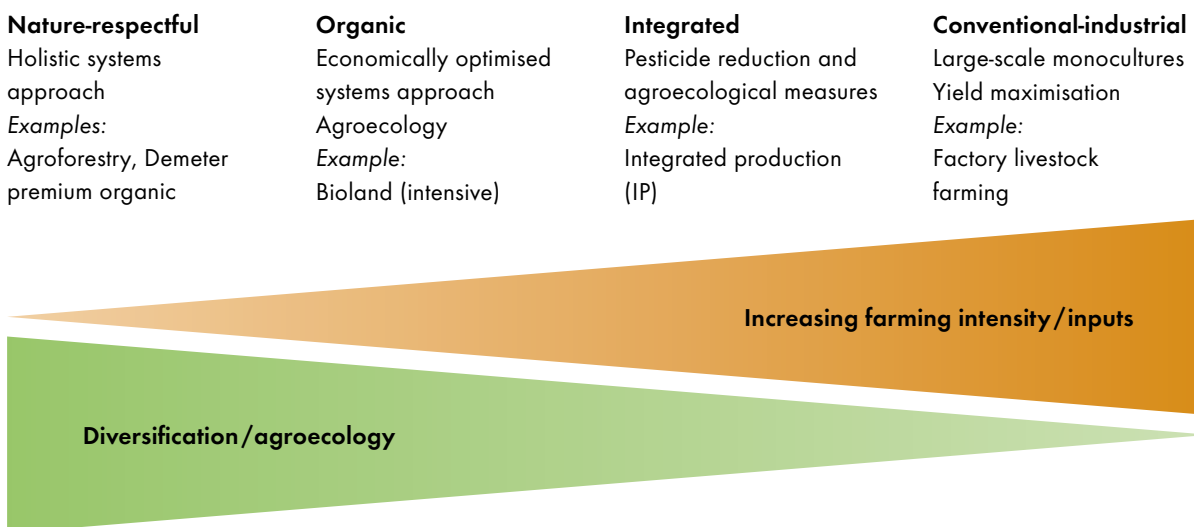
Whether a farming system can be characterised as intensive or extensive depends on the permitted use of inputs on a given farm and on the farm’s structure, mechanisation and land use (crop types, ecological infrastructure, etc.). There is a wide range of different farming systems, from conventional, integrated (IPM with agroecology) or high-input organic farming to low-input systems such as biodynamic or regenerative farming or permaculture principles (Figure 2). Even within the individual farming systems there is great variability of practices, especially in organic farming. This ranges from holistic biodynamic agriculture with diversity in cultivation and diverse biodiversity areas to intensive organic (arable) production in homogeneous landscapes

(e.g. in southern Spain and eastern Europe). Moreover, there is a wide range of different farm types, from specialised farms (arable, vegetable, fruit or viticulture) to diversified mixed farms with significant differences in species diversity between lowlands, hilly areas and mountain regions.



Organically managed fields often harbour a rich flora containing rare and endangered plant species.

Figure 2: Different farming systems and their relationship between productivity and biodiversity promotion



Increasing production intensity tends to go hand in hand with a decrease in the diversification of production and weaker support for and maintenance of diverse, biodiversity habitats.

More biodiversity on organic farms

Numerous comparative studies of the impacts of conventional and organic farming systems have shown that organic agriculture has a more favourable effect on flora and fauna, both in individual plots and at farm level^[7,8]. Global meta-studies show that organically farmed areas have on average 30 % higher species richness and a 50 % higher abundance of organisms^[9]. The differences observed have held steady over the last 30 years^[10]. The effects differ by organism group and also vary with landscape infrastructure, farming systems and farming intensity. The strongest effects of organic practices can be seen in annual arable crops, followed by special crops (viticulture, fruit production). The weakest effects have been observed in grasslands. Important groups such as pollinators, beneficial insects and decomposers are promoted by organic practices in various cropping systems^[9,10,11] (see Table 1 on p. 7). The positive effects are not only evident locally, but also at the landscape level^[12,13,14].

Various groups of flora and fauna are supported in the process. Soil organisms as well as diverse groups of insects, spiders, birds and mammals benefit to varying extents from organic management, depending on the crop produced (see Table 1 on page 7). In contrast, similar levels of animal pest infestation tend to occur in the different farming systems^[15]. A global meta-study on microorganisms confirmed that indicators of microbial biomass activity are on average increased by 32 to 85 % in organic systems^[16].

There is as yet a dearth of comparative studies in mountain areas.

Opportunities for rare and endangered species

A global meta-study has moreover shown that organic farming can support rare insects and spiders (abundance +55 %, diversity +27 % compared to conventional farming)^[17]. Endangered species conservation usually requires tailor-made species protection programmes. The common agri-environmental programmes in cultural landscapes are not sufficient in this regard. Organic farming can however make an important contribution to species protection, especially on farms hosting an abundance of high nature value and biodiversity areas^[18]. The skylark, a characteristic species of the open cultural landscape, which has been strongly

marginalised by the intensification of agriculture, as well as the now rare lapwings and grey partridges, can occur at higher densities under organic management^[19,20]. Rare plant species found on arable land^[21,22] and more specialised species of ground beetle (carabids) have also been found at higher diversities and densities on organic farms^[18].

Promotion of functional groups

Diverse functional groups in high abundance are fundamental for the functioning of many ecological processes in farming systems. Functional groups such as pollinators, beneficial insects, detritivores and producers (diversity of plants) are favoured by organic practices.

Three global review studies have shown that organic agriculture has a positive impact on the diversity and abundance of pollinators, beneficial insects, detritivores (abundance only), herbivores (diversity only) and plants compared to conventional production^[10,11]. In terms of abundance, pollinators (+90 %), beneficial insects (+38 %) and rare arthropods (+55 %) benefit the most (see Table 1 on page 7)^[17].



As several other monolectic wild bee species do, *Hoplitis adunca*, a member of the genus of leafcutter, mason and resin bees, collects pollen from only a single plant species (*Echium vulgare*).

Table 1: Effects of organic farming on the diversity and abundance of different species and functional groups compared to conventional farming ^[9,10,16,23,24,25,26]

Groups	Cropping systems	Abundance	Species diversity
Plants	Arable land	++	++
	Grassland		+ (=)
	Viticulture	+	+
Birds	Various cropping systems	+ (=)	+
Mammals/bats	Various cropping systems	+	+
Earthworms	Arable land	+	=
	Viticulture	+ (=)	=
Spiders	Arable land	+	+
	Viticulture and fruit production	+	+
Beetles	Various cropping systems	= (+)	= (+)
Wild bees	Various cropping systems	+ (=)	+ (=)
Butterflies	Various cropping systems	+	+ (=)
Soil microbes	Various cropping systems	+*	
Mycorrhizal fungi	Arable land	+	+
Pollinators (functional groups)	Various cropping systems	++	++
Beneficial organisms (functional groups)	Various cropping systems	+	+
Decomposers (functional groups)	Various cropping systems	+	+

Positive '+', no difference '='; in some instances '()' compared to conventional farming.

*Microbial biomass

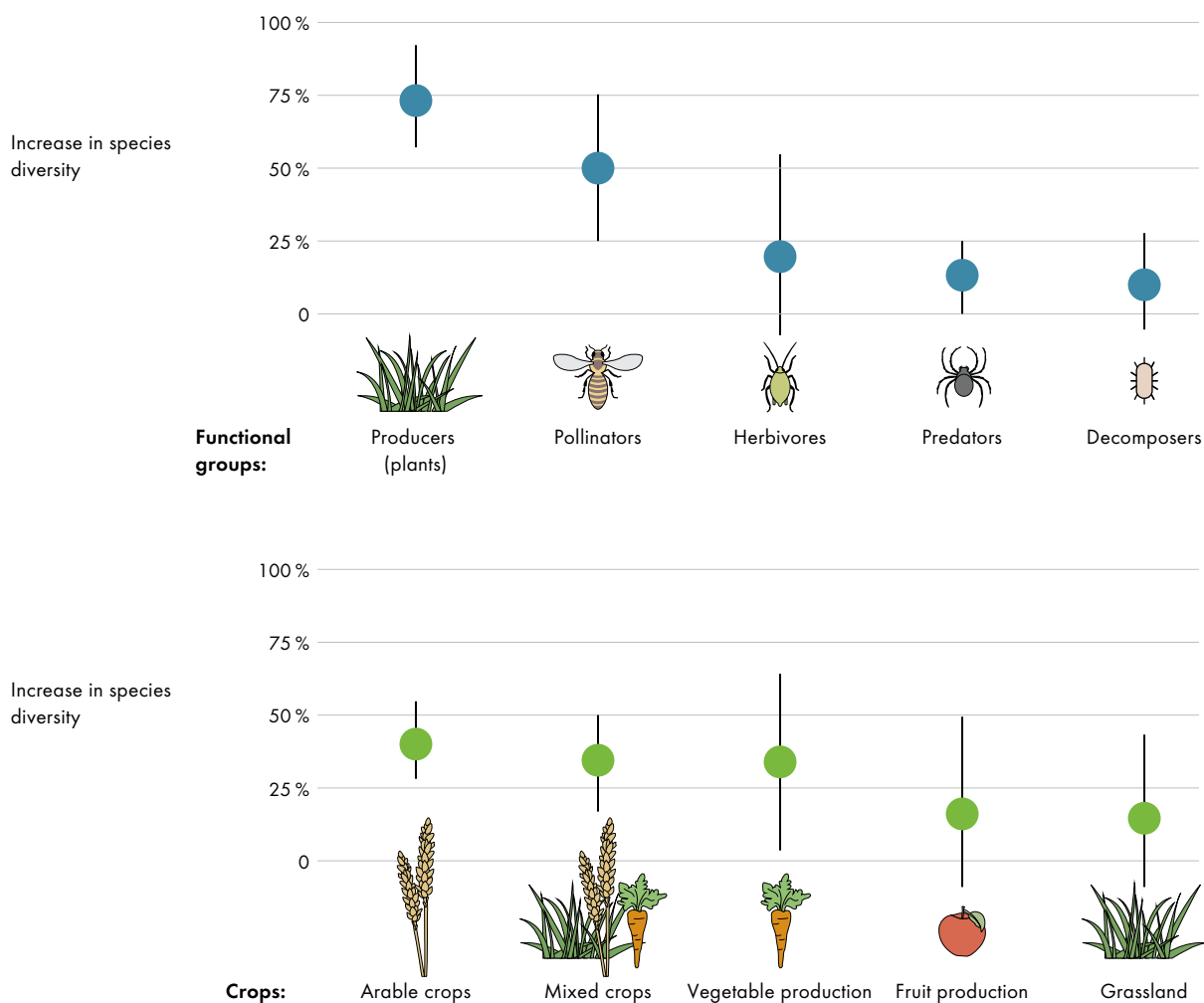


Ground-breeding birds such as the skylark can only survive in areas under extensive management.



Rare species such as the Scarce Copper butterfly (*Lycaena virgaureae*) benefit from species-rich grassland.

Figure 3: Relative increase in species diversity on organic farms compared to conventional farms



The differences in species diversity on organic farms compared to conventional farms (conv. ref. = 0) vary between functional groups (top) and crop systems (bottom). Plant species diversity is about 75 % higher on organic farms than on conventional farms. A meta-analysis found species richness to be only 20% higher in permanent grasslands such as meadows and pastures under organic management^[10].

Biodiversity in fruit production

Table fruit plantations are intensive production systems. Comparative studies of table fruit plantations in different European countries have shown that both abundance and diversity (+38 %) of a variety of groups of beneficial insects are higher in organically managed orchards than in IPM orchards^[27,28]. Predatory beetles, bugs (*Heteroptera*) and spiders benefit particularly from organic

management, which results in better natural pest control (aphids) in organic apple orchards^[29]. Such indirectly positive aspects can compensate for some of the yield differences. Sown flower strips and other cropland measures enhance the positive effects on beneficial insects and pest control^[30]. In contrast, no differences were found in the natural pollination of fruit trees.



As perennial crops, vineyards offer stable and species-rich ecosystems when no synthetic pesticides and artificial fertilisers are used. High plant species diversity enhances the vineyard and makes the plots attractive for many species of beneficial fauna and other organisms.

Biodiversity in vineyards

Vineyards hold great potential for biodiversity. Their biological diversity is influenced by a variety of agricultural practices (soil cultivation, plant protection, soil management) and agronomic characteristics (soil and climatic conditions, flatter machinery-accessible terrain or terraced vineyard). Due to this significant heterogeneity, differences to other farming systems are diverse. A number of systematic reviews show that organic management in vineyards has a positive effect on plant diversity, soil organisms (microbial biomass, respiration), bacterial diversity, soil fungi (mycorrhiza) and earthworms. Similarly, various arthropod groups such as spiders, ground beetles, wild bees and ants benefit, occurring in greater abundance and diversity^[23,24,25,31]. In addition to species diversity, the composition of faunal communities in vineyards also changes significantly with organic management.

However, intensive soil cultivation can negate some of the positive local effects in organic vineyards. With intensive soil cultivation, earthworm abundance in organically managed vineyards is similar to conventional ones^[24].

Other important beneficial arthropods include predatory mites, as they are important antagonists of spider mites in vineyards.

They also occur in greater diversity and abundance in organic vineyards. Their occurrence is strongly dependent on the intensity of plant protection measures.

At the landscape level, the diversity and abundance of bats^[32] and farmland bird species (more insectivorous species) can be fostered by organic practices in vineyards, even more so in landscapes that are quite devoid of natural features^[33]. In contrast, in structurally rich wine-growing areas (e.g. Tuscany), the occurrence of farmland birds does not differ with organic management, as any losses resulting from agricultural management are compensated for by residual biodiversity habitats in the landscape matrix^[34].

Ultimately, local effects on the various groups of fauna and other organisms are strongly dependent on cultivation intensity. The main causes of reduced biodiversity are intensive pesticide and herbicide use, excessive soil cultivation and lack of (permanent) green cover. Agroecological measures such as permanent green cover/species-rich sowings, careful soil management and the avoidance of herbicides can adjust differences in farming systems for various groups of organisms. Moreover, faunal diversity in vineyards is significantly influenced by the proportion of the surrounding biodiversity habitats.



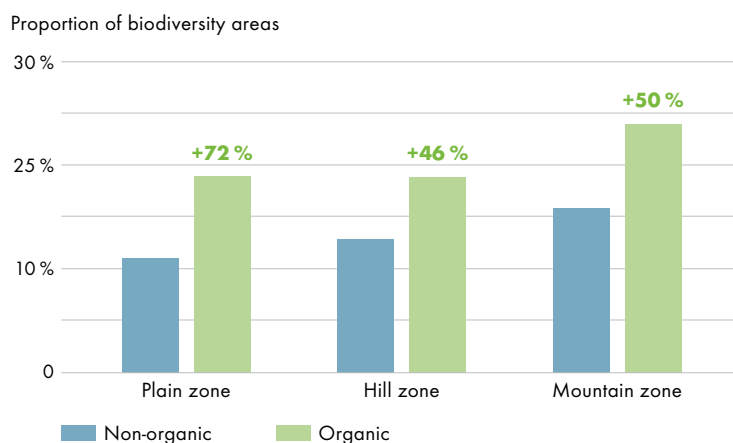
Rich supply of biodiversity areas such as sown wildflower strips is important for the survival of numerous species. Such habitats provide valuable food resources, safe refuges and hibernation sites.

Greater habitat diversity on organic farms

In addition to the intensity of management on agricultural land, the proportion of biodiversity areas on farm holdings is crucial for the preservation of biodiversity. Hedgerows, species-rich and structurally rich meadows and pastures, wildflower strips, fallow land and small-scale structures constitute habitats, refuges and hibernation sites that are essential for the survival of many animal species^[35].

Comparative studies of organic and conventional farms in Switzerland^[36], Denmark^[37] and England^[38] show that the proportion of biodiversity habitats on organic farms is higher than on their conventional counterparts. In many cases, organic farms are characterised by smaller plot sizes, greater plot diversity and more varied land use^[39]. An analysis of all Swiss agricultural farms showed that organic farms hold an average of 22 % and non-organic farms 13 % of their productive land as biodiversity habitats. Organic farms thus implement approximately two thirds more measures. The biggest differences relate to extensively and less intensively used meadows as well as hedgerows and standard fruit trees in the plains and hill zones^[36]. In highly productive favoured regions, however, there is also a significant deficit of valuable biodiversity areas on organic farms.

Figure 4: Proportion of biodiversity habitats on organic and non-organic farms



The proportion of biodiversity habitats is greater on organic farms in all topographic zones. The greatest difference is evident on organic farms in the intensively managed plain zones^[36].

Positive effects at the landscape level

Organic agriculture promotes biodiversity not only locally, but also at the landscape level. This positive landscape effect has been noted in annual crops and permanent crops for the arable weed flora^[40], pollinators^[17, 41] and various groups of beneficial insects^[17,13,42]. In general, the positive effects of organic farming systems are most pronounced in landscapes of moderate complexity^[22,41,43,44,45,46]. In contrast, homogenous featureless landscapes with

few and isolated organic managed areas lack sufficient source and exchange areas of biodiversity. As a result, organic sites are unable to exploit their potential.

The positive effects on species increase with a growing proportion of organic land in the landscape matrix. In the context of agri-environmental programmes, organic agriculture can thus play a

complementary and synergistic role in promoting flora and fauna^[40,42,47].

The effects of large-scale contiguous areas under organic management on the various groups of flora and fauna have not yet been investigated and are the subject of further research.

Improved ecosystem services with organic management

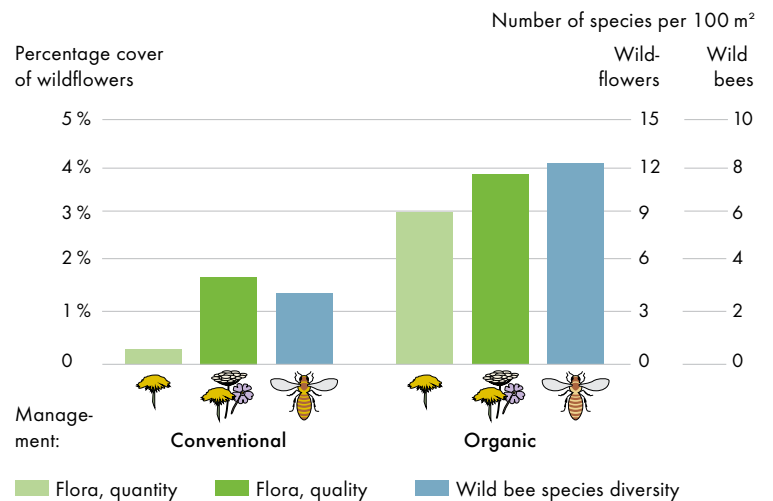
Rich species diversity is fundamental to the functioning of many processes in natural systems. Species-rich habitats are more productive and better able to adapt to environmental changes such as climate change. Species-rich meadows, for example, are less prone to soil erosion, produce more stable yields during periods of drought and have a longer growing season^[48]. The higher species diversity and greater population densities of certain species that have been noted on organic farms impact important ecological processes. Evidence shows that organic farming can improve ecological functions such as:

Natural pollination^[22,41,45,46]

The higher cover and diversity of the accompanying flora in organic cereal plots supports flower-visiting insects such as honeybees and wild bees. There can be a three times higher species diversity and seven times higher abundance of bees in organic fields compared to their conventional counterparts^[46]. With an increasing proportion of organic land in the arable landscape, the populations of wild bees including those of bumblebees in the surrounding biodiversity areas also increase strongly^[41].

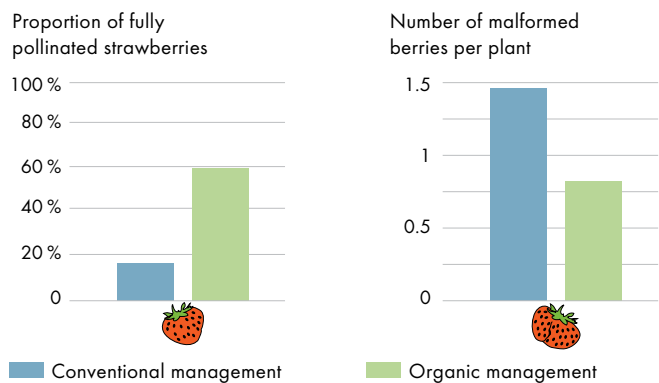
Wild bees play a key role in the pollination of crops and wild plants. Organic arable farming improves pollination of flowering plants even in non-crop habitats due to higher densities of wild bees being supported by organic crops^[22,41]. Organic farming can promote wild bee diversity and abundance not only at farm level but also at the landscape level^[41]. Several studies have shown that organic agriculture promotes species diversity, abundance and reproduction rates of wild bees (Figure 5). Crop pollination, especially of demanding crops such as strawberries and watermelons, can partly better be ensured on organic farms by wild bees. Pollination success is thus less dependent on cost-intensive pollinators such as bumblebees and honeybees^[49,50].

Figure 5: Effects of organic management on biodiversity in arable land



Organic management of arable land fosters wild bee diversity as a result of the greater flower cover and diversity of flowering plants^[46].

Figure 6: Effects of organic management on crop pollination



There are fewer malformations overall on strawberries in organic crops due to higher pollination success^[49].



Nutrient-poor sites host greater botanical diversity, a characteristic that greatly benefits populations of solitary wild bees.

The greater diversity and abundance of pollinators on organic farms gives rise to higher fruit yields and lower losses due to malformed and thus unmarketable berries. This difference is already evident 2 – 4 years after conversion to organic farming (see Figure 6 on p. 11).

Natural pest reduction

The higher diversity of flora and fauna also promotes beneficial arthropods that naturally reduce pests^[15,51]. In many cases, organic farming enhances natural pest control compared to conventional agriculture^[15]. This has been verified for arable crops^[52], vineyards^[13] and fruit crops^[29]. Effect strength is significantly influenced by cultivation measures and landscape features. The strongest natural pest control in organic annual crops was found in heterogeneous landscapes. It decreases with increasing clearance of landscape features and homogenisation of the agricultural landscape and with the intensity of plant protection measures. Insecticide use considerably reduces the potential of natural pest control^[15, 53].

Weed seed predation by specific beetle species can be greater in organic than in conventional fields^[54,55].

Research from Norway shows that, compared to conventional arable soils, soil-borne pests are reduced to a greater extent in organic arable soils as a result of the higher occurrence therein of insect pathogenic fungi^[56].

Dung decomposition in pastures

A richer dung fauna has been found in organic pastures^[57]. Compared to conventional pastures, the dung fauna in organic pastures is impacted to a lesser degree by veterinary drugs toxic to it. Dung beetles play an essential role in the breakdown of the dung and contribute significantly to the faster recycling of plant nutrients contained therein, thus positively impacting on forage quality.

Effects of enhanced ecosystem services at local and landscape level

A higher diversity of a variety of functional groups (beneficials, saprophages, mycophages, phytophages) has also been found in organic vineyards^[58], where the natural regulation of certain pest species (grape moths) can be stronger than in conventional viticulture, both at the local and landscape levels^[13]. Moreover, an increasing proportion of organic vineyard acreage in a landscape dominated by viticulture (Bordeaux) has been shown to be a stronger driver of natural enemies than the proportion of biodiversity habitats^[47].

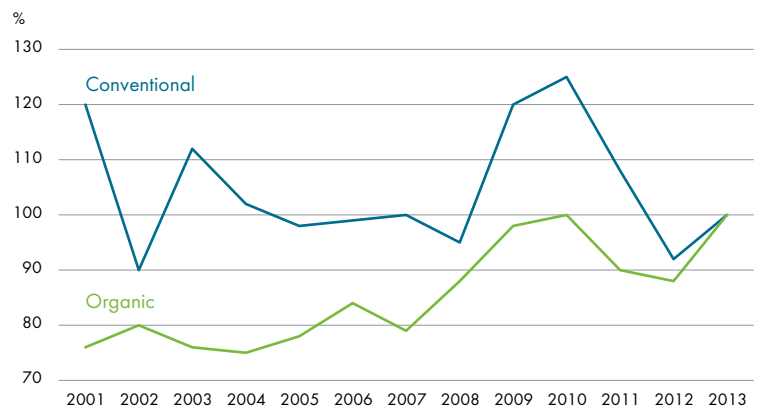
Higher resilience of organic farmland

Species and habitat diversity make an important contribution to the resilience and adaptability of agricultural crops to environmental impacts. Structurally rich and heterogeneous landscapes promote the mobility and migration of fauna to new sites and thus favour the important exchange of genetic material. Beneficial insects also benefit from structural diversity, thereby strengthening system stability and resilience. In turn, the reduced dependence on external farm inputs, sustainable resource use, the diversification of farming systems and the self-organisation and innovation of organic holdings all contribute to the socio-economic resilience of organic agriculture.

Crops in organically managed systems tend to produce higher yields under arid conditions than their conventional counterparts. For example, organic maize yields have been found to be 37 % and soybean yields 96 % higher than under conventional management in such conditions^[59]. Another example are species-rich meadows, which produce more stable yields during periods of drought and have a longer growing season^[48].

On average, organic yields per hectare are 20 % lower than conventional yields^[60, 61]. However, this difference in yields varies greatly between crops and cultivation practices. Crop diversification and agroecologically optimised crop rotations in organically managed systems reduce the yield gap to around 10 % or less (Fig. 7)^[60]. An additional factor capable of reducing the yield gap is the resilience of organically managed systems, for example to

Figure 7: Development of yield differences between conventionally and organically farmed arable lands



Average relative yield in conventional (blue) and organic (green) cropping, measured in a 6-year crop rotation over a period of 13 years. Relative yield: 100 % = longer-term average yield per crop. Yields for all crops are aggregated per year^[62]. In this long-term field trial from the Netherlands, organic yields converge with those of conventional farming over time.

drought. The yield gap between organic and conventional farming will become smaller as a result of technical advances, especially in the areas of breeding, plant protection and cultivation techniques. Due to their higher biodiversity, organic systems may result in greater spatial stability of soil biotic and abiotic properties and soil processes, which are essential requirement to long-term yield security^[62].

Organic agriculture as part of the solution

The biodiversity and climate crises are very much related to land use. In this respect, organic farming has gained a lot of experience with whole-farm approaches in recent decades. Such agroecologically oriented approaches can then be integrated into a variety of farming systems. In order to alleviate current environmental issues and strengthen agroecology, organic farming is increasingly being given greater consideration in agricultural policy. The EU Biodiversity Strategy 2030 aims for at least 25 % of agricultural land to be farmed organically by 2030 (EU 2020: Biodiversity Strategy for 2030; Farm to Fork Strategy). From an agroecological perspective, the development of entire organic regions (e.g. in

arable-grassland landscapes) would be beneficial. This would likely yield considerable positive economies of scale for biodiversity and with respect to other environmental aspects (e.g. drinking water and the protection of environmental waters from pollution). These positive effects can reasonably be expected as a result of generally lower cultivation intensity (reduced use of auxiliary inputs), smaller plot sizes in crop production, more biodiversity and species-rich habitats, as well as potential changes in accompanying habitats.

Risks of conventionalisation in organic agriculture

Organic farms, too, can find themselves facing trade-offs between agricultural land use and the conservation of natural habitats. Growing economic pressure and the high demand for organic products can push organic farmers to intensify and specialise their production. However, excessive intensification of organic production and specialisation on a limited number of crops put at risk the many benefits of organic management (risk of conventionalisation).

Cultivation with a focus purely on yield leads to a higher use of auxiliary inputs such as organic fertilisers and biological pesticides, simplified crop rotations, increased plot sizes, a reduction in biodiversity areas and intensive soil cultivation/management and weed control.

Diversified organic farming with a focus on optimal agroecological conditions and incorporating high-quality biodiversity areas has a sustained impact on biodiversity and enables numerous synergies between nature and production.

Whole farm advisory plays an important role in this regard. It increases the proportion and fosters the quality of biodiversity areas and improves knowledge transfer for agroecological production^[63]. Ecological and economic performance can be further improved through whole-farm advisory with respect to agroecology and nature conservation, and through the refinement of organic standards regarding biodiversity and landscape design.

Greater species diversity through an agroecological systems approach

In organic farming, a variety of cultivation and landscape design measures are implemented that have a demonstrably positive impact on biodiversity. In particular, the following characteristic measures promote biodiversity:

- Refraining from herbicide use
- Refraining from the use of chemically-synthesized pesticides
- Implementing measures aimed at supporting beneficials (functional biodiversity, preventive plant protection)
- Reduced fertiliser inputs (especially nitrogen) and refraining from the use of mineral nitrogen fertiliser
- Diverse crop rotations incorporating a high proportion of grass-clover leys and including catch crops
- Careful soil management (humus management)
- Limited livestock density and feed purchases
- Considerable proportion of biodiversity areas
- Diversity of farmland (mixed farms)
- Diverse farm structure and low level of specialisation in cropping

These factors not only foster biodiversity, but also strengthen natural cycles and thus increase the sustainability of organic farms. Ultimately, the effects of organic farming are highly dependent on the farm and landscape context^[61]. They vary with the needs and mobility of different groups of organisms as well as with landscape characteristics and cultivation intensity.

Strengthening ecosystem functions and conserving resources

In order to maintain important ecosystem functions and reduce biodiversity loss, more resource-conserving crop cultivation (reductions in the use of pesticides and fertilisers) and a significantly higher proportion of biodiversity areas and organically managed areas in the landscape are needed^[9,10,11]. Organic agriculture leverages synergies of existing ecosystems and exerts a complementary effect on biodiversity in the context of agri-environmental programmes. In addition to whole-farm expert advice, fair payments for ecological services and effective economic incentive systems for the targeted promotion of (functional) biodiversity are essential for the successful implementation of biodiversity measures on farms and in the wider agricultural landscape.

For more information on services delivered by organic farming (only in german), please refer to:

www.argumente.fibl.org

www.agrinatur.ch

References

- 1 Reganold J. P. and J. M. Wachter, 2016. Organic agriculture in the twenty-first century. *Nature Plants* 2,1-8
- 2 Pfiffner L. and L. Armengot, 2019. Biodiversity as a prerequisite of sustainable organic farming. In: *Improving organic crop cultivation* Köpke (ed.), Chapter 16: 401-433. Burleigh Dodds Science Publishing, Cambridge, UK. ISBN: 978-1-78676-184-2
- 3 Hallmann C. A. et al., 2017. More than 75 percent decline over 27 years in total flying insect biomass in protected areas. *PLoS ONE* 12(10): e0185809
- 4 Seibold S. et al., 2019. Arthropod decline in grasslands and forests is associated with landscape-level drivers. *Nature*, 574(7780), pp.671-674
- 5 Fischer M. et al., 2015. Zustand der Biodiversität in der Schweiz 2014. Forum Biodiversität Schweiz, Bern
- 6 Lachat T. et al., 2010. Wandel der Biodiversität in der Schweiz seit 1900. Ist die Talsohle erreicht? Bristol-Stiftung; Haupt, Zürich
- 7 Mäder P. et al., 2002. Soil fertility and biodiversity in organic farming. *Science* 296: 1694-1697
- 8 Hole D. G. et al., 2005. Does organic farming benefit biodiversity? *Biological Conservation* 122: 113-130
- 9 Bengtsson J. et al., 2005. The effects of organic agriculture on biodiversity and abundance: a meta-analysis. *Journal of Applied Ecology* 42: 261-269
- 10 Tuck S. L. et al., 2014. Land-use intensity and the effects of organic farming on biodiversity: a hierarchical meta-analysis. *Journal of Applied Ecology*, 51, 746-755
- 11 Smith O. M. et al., 2019. Organic farming provides reliable environmental benefits but increases variability in crop yields: a global meta-analysis. *Frontiers in Sustainable Food Systems*, 3, p.82
- 12 Henckel L. et al., 2015. Organic fields sustain weed metacommunity dynamics in farmland landscapes. *Proceedings of the Royal Society B Biological Science*, 282, 1808
- 13 Muneret L. et al., 2019a. Organic farming at local and landscape scales fosters biological pest control in vineyards. *Ecological applications*, 29(1), p.e01818
- 14 Inclan D. J. et al., 2015. Organic farming enhances parasitoid diversity at the local and landscape scales. *Journal of Applied Ecology*, 52(4), pp.1102-1109
- 15 Muneret L. et al., 2018a. Evidence that organic farming promotes pest control. *Nature sustainability*, 1(7), pp.361-368
- 16 Lori M. et al., 2017. Organic farming enhances soil microbial abundance and activity - A meta-analysis and meta-regression. *PLoS one*, 12(7), p.e0180442.19
- 17 Lichtenberg E. M. et al., 2017. A global synthesis of the effects of diversified farming systems on arthropod diversity within fields and across agricultural landscapes. *Global Change Biology*, 23, 4946-4957
- 18 Pfiffner L. and H. Luka, 2003. Effects of low-input farming systems on carabids and epigeal spiders - a paired farm approach. *Basic and Applied Ecology* 4: 117-127
- 19 NABU 2004. Vögel der Agrarlandschaft - Bestand, Gefährdung, Schutz. Naturschutzbund Deutschland e.V., Berlin, p 44
- 20 Neumann H., R. Loges and F. Taube, 2007. Fördert der ökologische Landbau die Vielfalt und Häufigkeit von Brutvögeln auf Ackerflächen? *Berichte über Landwirtschaft* 85, 272-299
- 21 Gabriel D. et al., 2006. Beta diversity at different spatial scales: plant communities in organic and conventional agriculture. *Ecological Applications* 16: 2011-2021
- 22 Gabriel D. and T. Scharntke, 2007. Insect pollinated plants benefit from organic farming. *Agric. Ecosystems and Environment* 118: 43-48
- 23 Döring J. et al., 2019. Organic and biodynamic viticulture affect biodiversity and properties of vine and wine: a systematic quantitative review. *American Journal of Enology and Viticulture*, 70(3), pp.221-242.
- 24 Karimi B. et al., 2020. A meta-analysis of the ecotoxicological impact of viticultural practices on soil biodiversity. *Environmental Chemistry Letters*, pp.1-20
- 25 Stein-Bachinger K. et al., 2021. To what extent does organic farming promote species richness and abundance in temperate climates? A review. *Organic Agriculture*, 11(1), pp.1-12
- 26 Paiola A. et al., 2020. Exploring the potential of vineyards for biodiversity conservation and delivery of biodiversity-mediated ecosystem services: A global-scale systematic review. *Science of the total environment*, 706, p.135839
- 27 Happe A. K. et al., 2019. Predatory arthropods in apple orchards across Europe: responses to agricultural management, adjacent habitat, landscape composition and country. *Agriculture, Ecosystems & Environment*, 273, pp.141-150.
- 28 Samnegård U. et al., 2019. Management trade offs on ecosystem services in apple orchards across Europe: Direct and indirect effects of organic production. *J. of Applied Ecology*, 56(4), pp.802-811
- 29 Porcel M. et al., 2018. Organic management in apple orchards: higher impacts on biological control than on pollination. *Journal of Applied Ecology*, 55(6), pp.2779-2789.
- 30 Cahenzli F. et al., 2019. Perennial flower strips for pest control in organic apple orchards-A pan-European study. *Agriculture, Ecosystems & Environment*, 278, 43-53
- 31 Katayama N. et al., 2019. Biodiversity and yield under different land-use types in orchard/vineyard landscapes: a meta-analysis. *Biological Conservation*, 229, pp.125-133
- 32 Rodríguez-San Pedro A. et al., 2018. Influence of agricultural management on bat activity and species richness in vineyards of central Chile. *Journal of Mammalogy*, 99(6), pp.1495-1502
- 33 Rollan A., A. Hernández-Matías and J. Real, 2019. Organic farming favours bird communities and their resilience to climate change in Mediterranean vineyards. *Agriculture, ecosystems & environment*, 269, pp.107-115
- 34 Assandri G. et al., 2016. Diversity in the monotony? Habitat traits and management practices shape avian communities in intensive vineyards. *Agriculture, Ecosystems & Environment*, 223, pp.250-260
- 35 Pfiffner L. and H. Luka, 2000. Overwintering of arthropods in soils of arable fields and adjacent semi-natural habitats. *Agriculture, Ecosystems and Environment* 78, 215-222
- 36 Schader C. et al., 2008. Umsetzung von Ökomassnahmen auf Bio- und ÖLN-Betrieben. *Agrarforschung* 15: 506-511
- 37 Aude E., K. Tybirk and M. Bruus Pedersen, 2003. Vegetation diversity of conventional and organic hedgerows in Denmark. *Agriculture, Ecosystems and Environment* 99, 135-147
- 38 Gibson R. H. et al., 2007. Plant diversity and land use under organic and conventional agriculture: a whole-farm approach. *Journal of Applied Ecology* 44: 792-803
- 39 Norton L. et al., 2009. Consequences of organic and non-organic farming practices for field, farm and landscape complexity. *Ecosystems and Environment*, 129, 221-227
- 40 Henckel L. et al., 2015. Organic fields sustain weed metacommunity dynamics in farmland landscapes. *Proceedings of the Royal Society B Biological Science*, 282, 1808
- 41 Holzschuh A. et al., 2008. Agricultural landscapes with organic crops support higher pollinator diversity. *Oikos* 117: 354-361
- 42 Inclan D. J. et al., 2015. Organic farming enhances parasitoid diversity at the local and landscape scales. *Journal of Applied Ecology*, 52(4), pp.1102-1109
- 43 Tscharnke T. et al., 2005. Landscape perspectives on agricultural intensification and biodiversity - ecosystem service management. *Ecology Letters* 8 (8): 857-874
- 44 Rundlof M. and H. G. Smith, 2006. The effect of organic farming on butterfly diversity depends on landscape context. *Journal of Applied Ecology* 43 (6):1121-1127

- 45 Moradin L. A. and M. L. Winston, 2005. Wild bee abundance and seed production in conventional, organic, and genetically modified canola. *Ecological Applications* 15: 871-881
- 46 Holzschuh A. et al., 2007. Diversity of flower-visiting bees in cereal fields: effects of farming system, landscape composition and regional context. *Journal of Applied Ecology* 44: 41-49
- 47 Muneret L. et al., 2019b. Organic farming expansion drives natural enemy abundance but not diversity in vineyard dominated landscapes. *Ecology and evolution*, 9(23), pp.13532-13542
- 48 Oehri J. et al., 2017. Biodiversity promotes primary productivity and growing season lengthening at the landscape scale. *PNAS* 114. 10160-10165
- 49 Andersson G. K., M. Rundlöf and H. G. Smith, 2012. Organic farming improves pollination success in strawberries. *PloS one*, 7(2), p.e31599
- 50 Williams N. M. and C. Kremen, 2007. Resource distributions among habitats determine solitary bee offspring production in a mosaic landscape. *Ecological applications*: 17, 910-921
- 51 Zehnder G. et al., 2007. Arthropod pest management in organic crops. *Annual Review of Entomology*, 52: 57-80
- 52 Birkhofer K. et al., 2016. Organic farming affects the biological control of hemipteran pests and yields in spring barley independent of landscape complexity. *Landscape ecology*, 31(3), 567-579
- 53 Geiger F. et al., 2010a. Persistent negative effects of pesticides on biodiversity and biological control potential on European farmland. *Basic and Applied Ecology*, 11, 97-105
- 54 Navntoft S. et al., 2009. Weed seed predation in organic and conventional fields. *Biological Control* 49: 11-16
- 55 Diekötter T. et al., 2016. Organic farming affects the potential of a granivorous carabid beetle to control arable weeds at local and landscape scales. *Agricultural and Forest Entomology* 18,167-173
- 56 Klingen I., J. Eilenberg and R. Meadow, 2002. Effects of farming system, field margins and bait insect on the occurrence of insect pathogenic fungi in soils. *Agriculture, Ecosystems and Environment* 91: 191-198
- 57 Hutton S. A. and P. S. Giller, 2003. The effects of the intensification of agriculture on northern temperate dung beetle communities. *Journal of Applied Ecology* 40: 994-1007
- 58 Miguel-Aristu J. et al., 2019. Efectos del manejo del viñedo sobre la biodiversidad de artrópodos epiedáficos en Andalucía oriental (España). *Revista Ecosistemas* 28, no. 3: 115-125
- 59 Gomiero et al., 2011. Environmental Impact of Different Agricultural Management Practices: Conventional vs. Organic Agriculture. *Critical Reviews in Plant Sciences* 30: 95-124
- 60 Ponisio L. C. et al., 2015. Diversification practices reduce organic to conventional yield gap. *Proc. R. Soc. B.*, 282, 20141396
- 61 Seufert V. and N. Ramankutty, 2017. Many shades of gray – The context-dependent performance of organic agriculture. *Science advances*, 3(3), p.e1602638
- 62 Schrama J. J. et al., 2018. Crop yield gap and stability in organic and conventional farming systems. *Agriculture, Ecosystems and Environment*. 256: 123-130
- 63 Chevillat V. et al., 2017. Mehr und qualitativ wertvollere Biodiversitätsförderflächen dank Beratung. *Agrarforschung Schweiz* 8 (6): 232-239

Imprint

Published by

Research Institute of Organic Agriculture FiBL
Ackerstrasse 113, Postfach 219, 5070 Frick, Switzerland
Tel. +41 (0)62 865 72 72, info.suisse@fibl.org
www.fibl.org

Authors: Lukas Pfiffner and Sibylle Stöckli (FiBL Switzerland)

Editors: Vanessa Gabel, Jeremias Lütold, Gilles Weidmann (FiBL)

Graphic design: Sandra Walti and Brigitta Maurer (FiBL Switzerland)

Photos: Thomas Alföldi (FiBL): p. 1; Lukas Pfiffner (FiBL): pp. 2, 5, 7 (1), 10, 12, 13; Andy Ducry (BirdLife Switzerland): p. 3; Markus Jenny (Vogelwarte Sempach): p. 7 (2); Maya Frommelt (Bio Suisse): p. 9

FiBL article no.: 1548

DOI: 10.5281/zenodo.7743951

The factsheet is available as a free download at shop.fibl.org or can be ordered at a charge.

2nd edition 2023 © FiBL