biodiversa+
European Biodiversity Partnership

Policy brief

Biodiversity Promotes Healthy Agricultural Systems and Benefits Human Health

The diversity of functions that biodiversity provides is crucial to sustain agricultural production. Diversity supports wild bee health . Soil microbial diversity can protect crops from disease and insect pests.

Main findings

- Functional diversity – the variety of roles and traits that species perform within agricultural systems, such as predation on pests, pollination, and nutrient cycling – supports crucial regulatory ecosystem services that ensure safe, nutritious food and contribute to human physical and mental health.
- Functional diversity of ground beetles improves pest control across Europe. Semi-natural habitats can increase beetle diversity.
- Wild bee species have variable and sometimes narrow nutritional needs, requiring a wide range of floral resources with specific nutritional values.
- Reduced floral resources increase the interactions among bee species on flowers, which raises the risk of transferring pathogens between honeybees and wild bees.
- Soil microbial diversity can suppress crop pathogens and insect pests. The addition of manure increases suppression.

Policy recommendations

- Keep strong incentives to protect and restore semi-natural habitats within agricultural landscapes to promote species and functional diversity, which provides regulatory ecosystem services essential to sustain agriculture.
- Plant and protect diverse native flowers while considering plants' nutritional value to meet the variable nutritional needs of wild bee species and support pollination services.
- Implement measures to reduce pesticide use to protect beneficial insects and enhance soil microbial diversity, while minimizing negative effects on human health.
- Control the ectoparasitic *Varroa* mite in managed bees and strengthen biosecurity measures to reduce the spread of pathogens to other pollinators.
- Encourage farming practices of manure addition, crop rotation, and reduced tillage to support soil health and microbial diversity, which helps protect crops from pathogens and insect pests.

Context

Biodiversity within agricultural landscapes provides essential ecosystem services such as **natural pest control, pollination**, and nutrient cycling in healthy soils, underpinning sustainable agricultural production. However, the large-scale intensification of agriculture –including monocropping, excessive use of chemical inputs, and habitat destruction – has dramatically reduced biodiversity, weakening the ecosystem services that agriculture and food production rely on[1,2*]. This loss of diversity also impacts human health, as access to diverse, high-quality food is a key factor in overall well-being[3].

Crops rely on natural enemies to control pests, reducing the dependence on chemical pesticides. Yet, populations of natural enemies, such as ground beetles, have declined alarmingly across European agricultural landscapes[4]. Similarly, **80%** of crops and wild plant species depend on animal pollination. Insect pollinator diversity, primarily wild bees (*Apidae*), guarantees efficient pollination, leading to higher crop quality and yields. However, wild bees have declined sharply over recent decades[5], with at least 10% (~178) of all European wild bee species at risk of extinction[6]. The number of endangered bee species can be as high as **60%** when accounting for species with insufficient population data. Agricultural expansion and intensification are the main drivers threatening bee diversity, along with urban development, fire, disease, and climate change[6].

Soils host more than **25%** of the planet's biodiversity and are the foundation of food production, water filtration and nutrient cycling. Soils significantly contribute to human health by enhancing food nutrition, bioremediating pollution and providing natural antibiotics and medicine. However, **70%** of European soils are degraded due to agricultural intensification and other stressors, reducing their ability to suppress plant diseases and maintain fertility[7].

This brief examines the relationship between biodiversity and the health and functioning of agroecosystems, the health of bee pollinators and other beneficial insects, soils and plants, and the consequences for human health and well-being.

Key results

In 2018, Biodiversa+ launched the BiodivHealth call to support research at the nexus of biodiversity and health. This policy brief highlights findings from four funded research projects: FunProd, NutriB2, VOODOO, and SuppressSoil.

Functional diversity of agricultural systems is essential to human well-being

Functional diversity refers to the variety of biological traits that organisms represent within an ecosystem, such as body size, feeding preference, nutrient cycling, repellent traits, and more[1,2]. de la Riva *et al.* explored how species and functional diversity in agricultural systems are linked to human health[1]. Their framework shows that the functional diversity of soil microbial community, animals and plants supports regulating agroecosystem services like soil formation, nutrient cycling, pollination and biological control of pests and diseases. These services are foundational to agroecosystem health and provisioning services directly linked to food availability and quality, human health, economic development, and recreation. This work highlights that the decline in functional diversity due to agricultural intensification threatens food security and public health, underscoring the urgent need for biodiversity conservation[1].

Baudry *et al.* showed that organic farming enhances the health of both agricultural systems and humans by supporting landscape heterogeneity and functional diversity of crops, livestock, and wild plants and animals, which, in turn, contribute to a better diet. Organic crops have significantly lower pesticide residues and higher levels of antioxidants, vitamins, and minerals compared to conventional crops. Additionally, diverse farming landscapes contribute to mental health and provide richer cultural services[8].

* Full citations are provided in the attached information sheet for this policy brief.

Functional diversity of natural enemies improves biological control

Bucher *et al.* studied 159 farms across Europe that covered a gradient of land use intensity and found that higher functional diversity (size, mobility, food preference) among ground beetles improves biological control of aphid pests in cereal fields but did not increase crop yield[9]. However, ground beetle communities are already severely diminished on most European farmland due to a long history of intensive land use. Current biodiversity measures within farms are not sufficient to restore their functional diversity[9]. This suggests that in addition to reducing agricultural intensity within farms, it is essential to protect semi-natural habitats (e.g. trees, hedges, or flowering strips) around farms to increase functional diversity at the landscape scale[9].

Wild bees require diverse floral resources with high nutritional value to support their health

Bee species exhibit distinct foraging behaviours and pollinate a broad range of plants, yet bees' specific nutritional needs are hardly known. Ruedenauer *et al.* used innovative genetic methods to identify, for the first time, the exact nutritional amino acids and fatty acids composition of the pollen consumed by different bee species[5]. Each bee species requires a specific nutrient ratio which optimises its growth, development, and fitness[5]. Land use change not only dramatically reduces the diversity but also the nutritional quality of food resources available for bees, compromising their health and survival (Figure 1)[5,10].

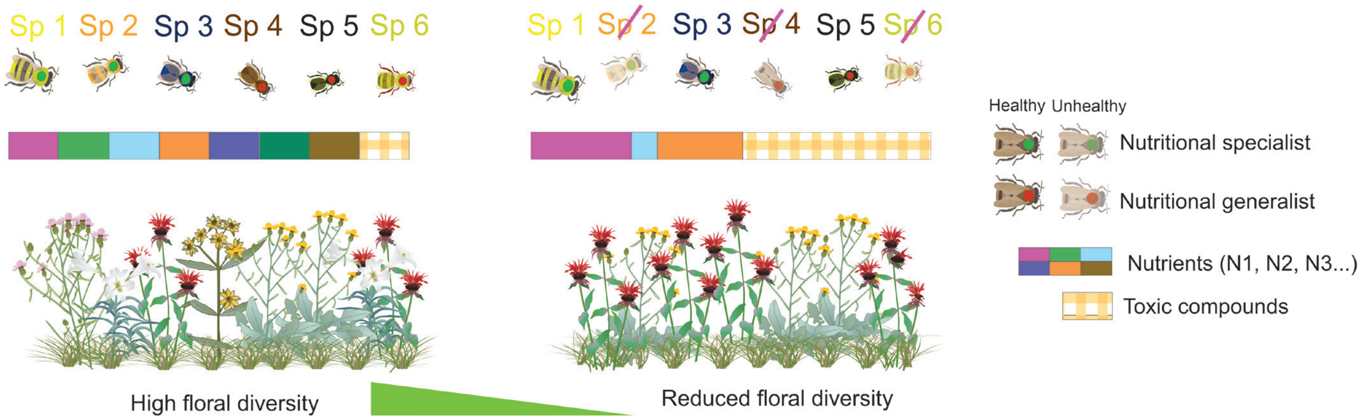

Figure 1: Bee species have specific nutritional requirements that determine their optimal floral resources. Reduction in floral diversity reduces the diversity of bee species that rely on them (source: Parreño *et al.*, 2022).

Filipiak *et al.* investigated the importance of the potassium-to-sodium ratio (K:Na) in bee diets for their health and longevity. Bees choose pollen and nectar with particular nutrient proportions to support their metabolic functions, immune systems, and reproductive success. The required nutrient proportions change across bee life stages. Different groups of flowering species vary in their nutrient composition, highlighting the need for various flowering species to meet wild bees' nutritional needs. These research results call for conservation efforts that prioritise not only floral diversity but also the availability of nutritionally suitable resources for bees[11].

Another nutritional requirement of more than 30% of bee species is plant resin or similar plant materials, which bees use to protect colonies from diseases. Resin from various plant species provides complementary functions in protecting bee health, repelling predators and parasites, and inhibiting microbial and fungal growth[12]. For example, propolis has been shown to combat *Varroa destructor*, a mite that spreads bee viruses such as Deformed Wing Virus[13]. Protecting diverse resin-producing plants in the landscape enhances bee resilience to disease.

Agricultural landscape heterogeneity supports bee health and functional diversity

Maurer *et al.* sampled semi-natural habitats in agricultural landscapes across Switzerland, including meadows, flower strips, hedgerows, and forest edges. They found diverse semi-natural habitat types support unique wild bee communities during different seasons. Extensively managed meadows support the largest diversity of bee species, including rare and specialised species (Figure 2). A connected network of variable habitat patches that support different bee communities, in addition to flower richness *per se*, is essential for wild bee richness. These results highlight the importance of maintaining diverse, interconnected semi-natural habitats within agricultural landscapes to support resilient bee communities[14].

The NUTRIB2 research project further examined bee diversity along a gradient of land use intensity and demonstrated that landscape heterogeneity is positively correlated with pollen resource diversity, enhancing bee species richness and diversity. Landscape heterogeneity and floral abundance strongly affected the abundance and fitness of both social and solitary bees. Bee species with different body sizes and diet specialisation varied in their responses (i.e. abundance) to landscape heterogeneity[15,16].

Leroy *et al.* observed that grassland management practices such as mowing frequency, grazing intensity, and fertiliser use significantly impact bumblebee nutrition and body condition. The effect of land use intensity and floral diversity on bumblebee species differed based on their functional traits, such as colony size and diet specialisations[17]. They further showed that the reproductive success and body condition of solitary European orchard bees are improved with a higher proportion of semi-natural habitats and hedgerows near orchards, highlighting the critical role of heterogeneous habitats around mass flowering crops to support bee populations[18]. These results suggest that wild bee conservation strategies should consider species-specific nutritional needs and functional traits and protect landscape-level habitat diversity[16,17].

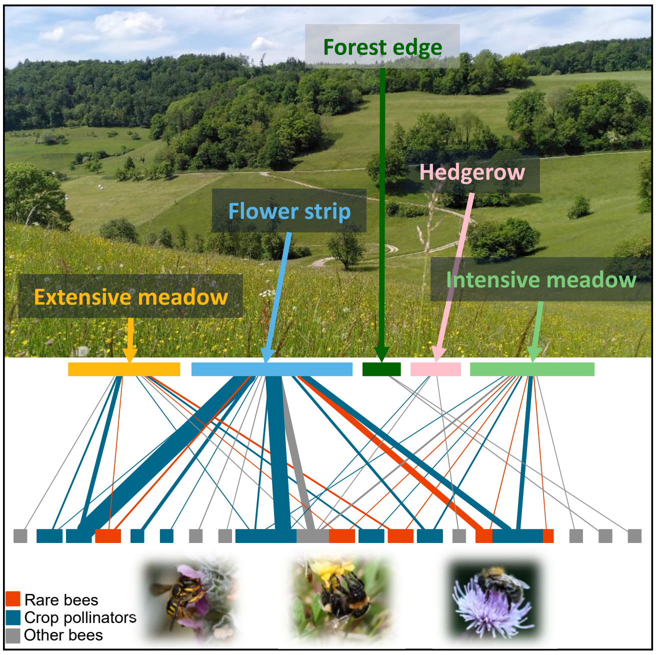

Figure 2: Different semi-natural habitats support variable bee species communities and sustain a bee species-habitat network across agricultural landscapes. The **size** of nodes and links is proportional to the number of links; **upper colours** depict the different studied habitat types; **lower colours** represent bee groups (Source: Maurer, 2022).

Insect pollinator species and plant-pollinator networks

Insect pollinators often prefer specific flower species, creating a network of plant-pollinator interactions. Maurer *et al.* sampled networks of plant-pollinator interactions across three European countries and found that land-use intensification, urbanisation, and an increase in arable crop cover dramatically reduce species diversity and the number of plant-pollinator interactions, resulting in reduced flower visitation frequency, with potentially severe consequences for pollination services[19,20]. Such modifications of plant-pollinator networks may lead to a chain of extinctions of plant and pollinator species that depend on each other. Landscape simplification reduces the resilience of plant and pollinator communities and jeopardises pollination services[20].

Photo: Prof Dr. Sara Leonhardt, NUTRIB2

Reduced floral resources increase pathogen transmission between bee species

Global change, including climate change, invasive species, agricultural intensification, and urbanisation, creates new disease risks for pollinators[21]. Reduced diversity and quality of flowers bring pollinator species to interact more frequently on a limited amount of flowers, increasing the probability of disease transmission[21,22]. Tehel *et al.* demonstrated that Deformed wing virus (DWV), a highly virulent bee pathogen that is transmitted by the mite *Varroa destructor* and can cause bee colony collapse, can spillover from honeybees to other wild bees, with severe consequences for bee survival[23]. In a field experiment, Streicher *et al.* showed that bumblebees exposed to the virus by injection with DWV carry high viral loads that reduce their survival[24].

These findings underscore the urgent need for improved biosecurity measures and habitat restoration to reduce the spread of bee pathogens.

Soil biodiversity supports the suppression of crop disease and insect damage

Soils Soils with high microbial diversity promote crop health and suppress pathogens by competing for resources, inhibiting pathogen growth by triggering the plant's defence responses, producing antifungal compounds, or directly parasitising pathogens like *Fusarium* fungi[25].

Harmsen *et al.* discovered that the microbiome of soils with an innate ability to suppress plant fungal pathogens can also protect plants from insect pests[26].

Agricultural practices such as crop rotation, organic amendments, and reduced tillage enhance microbial diversity and activity, significantly increasing soils' ability to suppress pathogens[25]. For example, Todorović *et al.* found that manure-treated soils have higher levels of organic matter and potassium, which enhance microbial activity and suppress *Fusarium* fungal infection in wheat[27]. Manure amendments in farming practices can reduce reliance on chemical fungicides, promoting soil health and sustainable management of crop fungal diseases and insect pests[27].

Policy recommendations

The findings from the BiodivHealth projects highlight the critical role of biodiversity in sustainable food production, ecosystem health, and human well-being. Although the research projects did not conduct specific studies on the effectiveness and cohesion of current policies, nor were they assessed during the production of this policy brief, the results suggest that the following recommendations and measures can help achieve the EU's ambition of sustainable, resilient, and inclusive food systems, contributing to the broader objectives of the European Green Deal and the EU Biodiversity Strategy for 2030.

- **Keep strong incentives for farmers to preserve and restore semi-natural habitats** such as meadows, flower strips, hedgerows, and forest patches to enhance landscape heterogeneity. The results presented in this brief indicate the critical importance of improving connectivity between farms and semi-natural habitats to enhance functional and species diversity and support the health of wild bees and natural enemies. Diverse agricultural landscapes also support human mental health and cultural benefits. National authorities can consider this recommendation in the implementation of the EU's Common Agricultural Policy (CAP) 2023-27, especially in the eco-schemes that direct payments for voluntary climate-and environment-friendly farming practices..

- **Ensure the implementation of pesticide use reduction and promote organic farming practices** like crop rotation, cover cropping, and reduced tillage. Results presented demonstrate that these practices enhance the functional diversity of beneficial insects and improve the health and survival of pollinators. Lower chemical use may also support soil microbial diversity, essential to protect crops from fungal and insect pests. This recommendation is aligned with the goal of the EU Farm to Fork strategy to **reduce pesticide use by 50%** by 2030 and Integrated Pest Management (IPM). Expanding legislation on Plant Protection Products (PPPs) under Regulation 1107/2009 to include wild pollinators, in addition to honeybees, could further protect beneficial species.

- **Protect and plant native wildflowers with high nutritional value** to support the diverse nutritional needs of wild bees and reduce disease transmission risks. Incentives under the CAP's eco-schemes and reduced administrative hurdles can support these efforts.

- **Improve biosecurity measures in beekeeping by controlling ectoparasitic mites** (*Varroa destructor*), a prominent vector of several bee viruses[28], monitoring and controlling pathogen levels in honeybees, and reducing density of managed apiaries to reduce disease spillover to wild bee populations. These actions can be supported under the EU Nature Restoration Law, as part of the EU Pollinators Initiative, or under the EU Pollinator Monitoring Scheme (EU PoMS).

- **Encourage organic manure amendments and promote other farming practices such as crop rotation and reduced tillage** to support soil health and enhance soil microbial diversity, protecting crops from considerable losses by *Fusarium* fungi and pest insects. Align these practices as part of the EU Soil Strategy for 2030 and the proposed directive on Soil Monitoring and Resilience (Soil Monitoring Law), which promotes sustainable soil management and restoration of degraded soils.

Link to sources

FunProd
NutriB2
SuppressSoil
VOODOO

The scientific publications used in this policy brief can be found in the Information Sheet of this briefing, downloadable from: www.biodiversa.eu/policy-briefs/

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About this Policy Brief

This Policy Brief is part of a series aiming to inform policymakers on the key results of the biodiversity research projects funded by Biodiversa+ and provide recommendations to policymakers based on research results.

The series of Biodiversa+ Policy Briefs can be found at https://www.biodiversa.eu/policy-briefs/.

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