Preprint (*16 June 2026*) forthcoming in *Advances in Pollinator Research*.

Joint White Paper from Horizon Europe-funded projects Butterfly, VALOR, PollinERA, WildPosh, AGRI4POL, ProPollSoil, RestPoll, and Safeguard

Towards pollinator stewardship in all policies

Policy incoherence in the EU is a major barrier to pollinator restoration

Jeroen P. van der Sluijs, Noa Simon Delso, Johan Axelman, Ignasi Bartomeus, Tom Breeze, Scott Bremer, Florence L.P. Damiens, Michal Filipiak, Nicola Gallai, Georgios Kleftodimos, Alexandra-Maria Klein, Jessica Knapp, Nicolas Langlade, Sara Diana Leonhardt, Julia Leventon, Xiushan Li, Denis Michez, Mirella Miettinen, Henning Nottebrock, May-Brith Ohman Nielsen, Jeff Ollerton, Julia Osterman, Simon Potts, Claus Rasmussen, Sara Reverté, Michael Schloter, Henrik G. Smith, Ingolf Steffan-Dewenter, Martin Thorsoe, Christopher John Topping, Simone Tosi, Kévin Tougeron, Luisa M. Trindade, Zafarani Uwingabire, Adam J. Vanbergen, George Vlontzos, James Williams, Dimitry Wintermantel, Jie Zhang and 96 signatories. (See Appendix 1 for author affiliations and signatories.)

Citation: van der Sluijs, J.P., Simon Delso, N., Axelman, J., Bartomeus, I., Breeze, T., Bremer, S., Damiens, F.L.P., Filipiak, M., Gallai, N., Kleftodimos, G., Klein, A-M., Knapp, J., Langlade, N., Leonhardt, S.D., Leventon, J., Li, X., Michez, D., Miettinen, M., Nottebrock, H., Ohman Nielsen, M-B., Ollerton, J., Osterman, J., Potts, S., Rasmussen, C., Reverté, S., Schloter, M., Smith, H.G., Steffan-Dewenter, I., Thorsoe, M., Topping, C.J., Tosi, S., Tougeron, K., Trindade, L.M., Uwingabire, Z., Vanbergen, A.J., Vlontzos, G., Williams, J., Wintermantel, D., Zhang, J. and 96 signatories (in press) Towards pollinator stewardship in all policies: Policy incoherence in the EU is a major barrier to pollinator restoration. Joint White Paper from Horizon Europe-funded projects Butterfly, VALOR, PollinERA, WildPosh, AGRI4POL, ProPollSoil, RestPoll, and Safeguard. Advances in Pollinator Research.

DOI of pre-print: 10.5281/zenodo.20715670 (all versions: 10.5281/zenodo.20715669)

Funded by the European Union. The eight projects receive(d) funding from the European Union's Horizon Europe and Horizon 2020 research and innovation programmes under grant agreement numbers: Butterfly: 101181930; VALOR: 101181169, PollinERA: 101135005; WildPosh: 101135238, AGRI4POL: 101181146, ProPollSoil: 101219108; RestPoll: 101082102; and Safeguard: 101003476.

Executive summary

Pollinators are critical for Europe's resilience of vital societal functions, competitiveness, and food security. Pollinators are crucial for crop production, wild plant reproduction and evolution, ecosystem resilience, food security, food cultures, terrestrial nature conservation, subsistence, human health and wellbeing, competitiveness, the economy, landscape aesthetics and local identity, sense of belonging and nature connectedness, and ultimately contribute to security and political stability. Europe's dependency on pollinators has increased over the past decades.

Integration of pollinator stewardship across policy areas that affect pollinators is indispensable to achieving the EU's binding targets for restoring pollinator diversity and reversing pollinator decline. Key policy areas that require pollinator stewardship include: agriculture, environment, chemicals, research and innovation, trade, finance, planning, legislation and education.

Europe is rich in wild pollinator species, but these are threatened by multiple pressures. The largest groups of wild pollinators are moths & butterflies, followed by beetles, wasps & bees, and flies. They are all essential to natural ecosystems, and many are crucial for cultivated landscapes, agriculture, and forestry. Many wild pollinator species are in decline, and many are unique to the European continent, placing a particular responsibility on European countries to act. Managed honeybees are considered livestock and are not in decline, but face colony health problems in many European countries.

Multiple complexly interacting drivers and pressures cause pollinator loss. Pressures include: land-use change, unsustainable agricultural and forestry practices, pesticides, climate change, reactive nitrogen, many other chemical pollutants, light pollution, global nutrient dilution, inadequate management of road and railway verges and dikes. These pressures result from historical, cultural, social, political and economic drivers. These drivers take their roots in societal values and worldviews, with instrumental valuations of nature being currently dominant in Europe.

Implementing the EU's binding targets for pollinator restoration calls for an approach that tackles all pressures and drivers simultaneously across many sectors of human activities. Currently, numerous incoherent and sometimes conflicting policies affecting pollinators hinder or counteract pollinator restoration. There is therefore an urgent need to assess, highlight and address this policy incoherence, jeopardising pollinator biodiversity and EU policy goals. Doing so requires addressing the functioning of the EU, including siloed governance structures, limited stakeholder ownership, ongoing conflicts between short-term production goals and the need to maintain pollination services as a public good, fragmented responsibilities across sectors, top-down policy design, weak coordination between administrations, and insufficient adaptation to local context.

A systemic multi-actor approach is essential to achieve the sustainable supply of pollination services for agriculture, forestry, and wild plant communities. Sustainable solutions explicitly integrate agronomic, economic, ecological, and social dimensions. This is hindered by siloed governance structures. Insufficient eco-literacy and educational gaps also contribute to siloed thinking and to the underdevelopment of human and social resources and capacities at many levels. Multi-actor approaches require recognising and addressing power imbalances to ensure that diverse actors can access policymaking, including holders of relational values to pollinators, these being the most marginalised at the EU policy level.

Pollinator decline needs a globally coordinated policy response. Via a complex network of industrial, agri-food and trade links, the effects of pollinator loss in non-EU countries will not only affect countries where they occur but can have far-reaching impacts on many pollinator-dependent supply chains that are critical for the EU.

Failure to halt and reverse wild pollinator declines and threats to managed honeybee colony health poses considerable risks for human food security and nutrition, and linked economic supply chains and sectors that depend on pollination of flowering plants (e.g. medicine, food supplements, biomass energy, biomaterials, textiles, fodder, cosmetics, decoration, art, culture, and tourism).

Unexploited synergies between pollinator restoration and other policy domains are opportunities for policy wins. For instance, pollinators are critical to the achievement of the United Nations Sustainable Development Goals (SDGs), and many of the SDGs are critical to pollinator restoration.

Many policies and regulatory measures currently lack sufficient consideration of pollinator stewardship, but significantly affect pollinators. These include the common agricultural policy (CAP) regulation of pesticides, biocides and other chemicals, the Food and Feed Omnibus, the Environment Omnibus, the regulation on the marketing of seeds, and the regulation on new genomic techniques.

Based on the evidence synthesised in this White Paper, key recommendations are:

1. **Address direct and indirect drivers of pollinator loss, not only pressures**. Recognise that worldviews and values shape governance structures, policies and practices. Encourage cross-sector dialogue and stakeholder engagement, while addressing power imbalances. Embed considerations of pollinators/pollination in policy areas affecting them, including agriculture, environment, chemicals, research and innovation, trade, finance, planning, legislation and education.
2. **Implement and assess enhanced standards for pollinator literacy in general education and for specific and relevant professions.** Local and transnational communities need skilful citizens with basic knowledge of pollinator diversity and the impacts of pollination systems. Professional groups that are, or must be, involved in pollinator stewardship need especially tailored education for their profession or sector.
3. **Make pollinator stewardship explicit, measurable objectives, with clear indicators in EU policies**. In particular, the CAP, the EU Biodiversity Strategy for 2030, and environmental and chemicals legislation because these impact pollinators most. Set measurable targets for floral and non-floral (see 5) resources quality and quantity, pollinator abundance and pollination services.
4. **Establish monitoring frameworks** able to provide evidence of conservation gaps and progress toward defined goals, clarifying the direction of travel, and demonstrating whether actions taken are delivering the intended outcomes. Ensure direct alignment with measurable policy objectives. Co-create and co-implement the EU Pollinator Monitoring Scheme (EU-PoMS) with societal actors, while ensuring that efforts do not divert actors from ongoing activities favourable to pollinators. Ensure the scheme tracks pollinator populations, pesticide exposure and habitat quality. Collect, structure, and store monitoring data using harmonised methodologies, and make it publicly available to support transparent, evidence-informed policy-making. Use the resulting evidence to adjust policies, strengthen accountability and ensure actions contribute effectively to improving pollinator protection and restoration.
5. **Pollinator stewardship must explicitly provide the non-floral resources needed for successful reproduction.** While adult pollinators depend on floral resources, juvenile stages have different food and habitat requirements. For

example, the larvae of moths, butterflies, beetles and flies depend on host plants, dung, and prey, and for some bee species, lack of adequate nesting habitat may be limiting.

6. **Integrate long-term habitat restoration into agri-environmental incentives**. Complement annual, voluntary schemes with multi-year, results-based instruments that reward farmers for maintaining hedgerows, flower-rich grasslands and diverse crop rotations.
7. **Diversify seeds and cropping systems**. Facilitate the marketing of heterogeneous, regionally adapted seed mixes and reward farmers for planting nectar- and pollen-rich plant species. Ensure that any new GMO and NGT-regulated seeds are assessed for their impacts on pollinators and that labelling and traceability are maintained.
8. **Restore and connect habitats within human-modified landscapes** in line with the Nature Restoration Regulation. Ensure that the National Restoration Plans (NRPs) align with the aspirations in the Natural Restoration Plans, including regarding pollinators and grassland butterflies, and that sufficient funding is allocated to their implementation.
9. **Reduce dependence on pesticides, hazardous chemicals, and exposure to microplastics**. Adopt binding reduction targets, implement and advance EFSA Bee Guidance, and implement and promulgate Integrated Pest Management (IPM) and transformative agricultural options (e.g. agroecology). Recognise that pollinators face multiple interacting stressors and assess risks accordingly.
10. **Establish and enforce a post-authorisation monitoring programme** at the EU level for pesticides, biocides, and other chemicals and feed the results into the regulatory system.
11. **Adopt a stepwise systems-based Environmental Risk Assessment (ERA)** for pesticides and other chemicals. Combine prospective authorisation with monitoring, assess cumulative, indirect and landscape-level effects on sensitive species, and develop comparable risk profiles across pesticides and other chemicals. This would improve policy coherence and enable more adaptive management than simple approve/ban decisions.
12. **Ensure that the simplification of EU legislation does not undermine environmental policies and targets that protect pollinators or their habitats.** It is essential that omnibus simplifications will not lead to automatic extensions of pesticide and biocide authorisations without updated risk assessments. Guarantee that the obligation to prevent the deterioration of the status of all bodies of surface water cannot be circumvented or removed.
13. **Integrate EU climate change mitigation regulations and policies within the broader context of the biodiversity crisis.** Climate change is increasingly recognised as a direct threat to pollinator habitats. Future projections indicate these impacts will be severely exacerbated. Policies for a green transition should incorporate nature-based solutions and explicitly value the co-benefits of climate mitigation for pollinator conservation.
14. **Develop cross-sectoral financial incentives and provide access to synthesised and inclusive, actionable knowledge and tools** for the actors involved in implementing the aforementioned recommendations.
15. **Define and assess co-benefits and trade-offs of pollinator-friendly farming across sectors and stakeholder groups.** Recognise that outcomes can be positive or negative depending on landscape context, management combinations, and societal and individual priorities, and use this understanding to guide coherent policy design and implementation.

Introduction

This White Paper is a collaborative work by researchers involved in 8 major EU Horizon research projects on pollinators: Butterfly, VALOR, PollinERA, WildPosh, AGRI4POL, ProPollSoil, RestPoll, and Safeguard (box 1) and synthesises evidence and cross-project expertise to diagnose and address policy incoherence as a major barrier to pollinator protection and restoration. Concepts used in this White Paper that may not be familiar to the reader can be looked up in a glossary in Appendix 2.

Box 1 Overview of the Horizon Europe-funded projects

Butterfly (2025-29): Mainstreaming pollinator stewardship in view of cascading ecological, societal and economic impacts of pollinator decline. Butterfly aims to enhance society's capacity to appraise, foresee, and respond to the threats posed by cascading impacts of pollinator decline with a special focus on the human dimensions.

VALOR (2025-28): VALues and dependence of society on pollinatORs. VALOR is developing a systems-based approach to exploring the impacts of pollinator declines from flower to fork.

PollinERA (2024-27): Understanding pesticide-Pollinator interactions to support EU Environmental Risk Assessment and policy. PollinERA will develop a comprehensive Environmental Risk assessment that integrates a full ecological systems approach.

WildPosh (2024-27): Pan-European assessment, monitoring, and mitigation of chemical stressors on the health of wild pollinators. WildPosh is exploring the impacts of multiple chemical stressors on pollinators with the aim of improving risk management.

AGRI4POL (2025-28): Promoting sustainable agriculture for pollinators. AGRI4POL focuses on developing and improving pollinator-friendly farming practices, including exploring the barriers and incentives to support this.

ProPollSoil (2025-29): Understanding and managing soil health impacts to protect soil-dependent pollinators. ProPollSoil will undertake a comprehensive assessment of the intersection between soil health and pollinators and mutual conservation activities.

RestPoll (2023-27) Restoring Pollinator habitats across European agricultural landscapes based on multi-actor participatory approaches. RestPoll is working with a group of 17 Living Labs across Europe to develop and test practical and effective means to restore pollinator populations.

Safeguard (2021-26) Safeguarding European wild pollinators. Safeguard is undertaking a comprehensive assessment of the status, trends, pressures, values and responses to pollinator declines in Europe.

Pollinator restoration is urgent as their loss undermines Europe's strategic priorities of competitiveness and security, and long-term resilience.

The EU's Preparedness Union Strategy aims at protecting Europe's vital societal functions by building resilience to ensure the supply of critical natural resources. Wild and managed pollinators are one of Europe's most important critical natural resources.

Pollination comprises a system of interactions between flowering plants and animals such as bees, that links earth's vegetation, wildlife and human welfare [1]. There is a high diversity of wild pollinators in Europe: more than 2,100 wild bee species, 900 different species of hoverflies, 500 butterfly species, thousands of moth species and potentially tens of thousands of flower-visiting species of flies, wasps, beetles, other insects, and, in the EU's overseas territories, vertebrate pollinators such as bats and birds. Many moths, beetles and bats are night-active, which makes them less-known but not less important pollinators. A large proportion of the pollinators are unique to European territory, and many of these are on the IUCN Red List, placing a particular responsibility on European countries to act [2,3,4]. Floral resources are essential for the adult life-stage of most pollinators, while for successful reproduction, bees need adequate nesting habitat, and the larvae of moths, butterflies, beetles and flies need resources such as host plants, prey, dead organic matter and dung. Pollinators consequently depend on the habitats providing these resources, sometimes in close proximity. In addition, some pollinators such as honeybees, bumblebees, mason bees and flies [5] are managed by humans for beekeeping products such as honey, and for agricultural pollination [6].

More than one hundred million years of co-evolution of flowering plants and pollinators has resulted in a resilient network of plant-pollinator relationships, based largely on mutual dependency [7]. Well-functioning plant-pollinator interactions in natural and cultivated systems are essential for crop production, wild plant reproduction and evolution, ecosystem resilience, global food security, terrestrial nature conservation, subsistence, human health and wellbeing, the economy, and landscape aesthetics [8,9]. Ultimately, pollinators contribute to security, resilience and political stability [10]. Between 80% and 90% of all wild flowering plants [11,12] and about three-quarters of globally important crops [13] benefit from animal pollination for seed set, fruit set, reproduction, genetic diversity, plant health, evolution, crop- and fruit quality, crop shelf life and crop commercial value [8]. Essential micronutrients in the human diet, including many vitamins and antioxidants, are almost exclusively found in crops benefitting from animal-mediated pollination [14]. Healthy food consumption is being lost due to insufficient populations of pollinators, and this is resulting in a significant disease burden [15,16]. A recent study found that we are currently losing 3–5% of fruit, vegetable, and nut production per year because of inadequate pollination, leading to a median estimated 427 000 (95% uncertainty interval 86 000–691 000) excess deaths annually from lost healthy food consumption and associated diseases [16]. The volume of production of pollinator-dependent crops has tripled over the last half-century, which has raised the demand for pollination services. In economic terms, globally, hundreds of billions of EUR of crop production and trade rely directly on pollinators [8, 17]. As an extreme example, a total collapse in wild pollinators in Europe by 2030 could result in a global cost of €34 billion per year, including €24 billion in Europe and €12 billion in the EU [18]. Member States that are less supportive of biodiversity-friendly policies would incur the highest costs [18]. This situation would raise the cost of living, drive inflation and fuel political and social mistrust.

As dependency on pollinators has increased over the past century [19], however, human activities have been driving a parallel decline of flowering plants and pollinators [20]. This decline concerns losses of species diversity, genetic diversity, and abundance, along with habitat fragmentation and habitat loss. The decline in many crucial pollinator species has further accelerated over the past few decades [2,3,4,21]. Worldwide, between 2006 and 2015, 25% fewer species of wild bees were seen than was the case before 1990 [22]. In Europe, 10% of bee species [2], 15% of butterfly species [3], and 37% of hoverflies [4] are threatened with extinction. Managed honeybees are not in decline, with numbers depending on beekeeping [23], but their colony health and survival are threatened by pesticides, disease-causing organisms, invasive species, and loss of floral resources [24,25]. If the decline of wild pollinator and the threats to managed honeybee colony health are not adequately stopped and reversed, this poses significant risks for human food security and nutrition, and many other economic supply chains and sectors that depend on pollination of flowering plants (e.g. biomass energy, biomaterials, textiles, fodder, medicine, food supplements, cosmetics, decoration, art, culture, and tourism) [8].

Ultimately, the deterioration of plant-pollinator biodiversity erodes the resilience of the Earth's biosphere.

Pressures and drivers of the parallel declines of pollinators and the resources on which they depend.

Multiple, interlinked drivers and pressures are causing wild pollinator decline and honeybee colony health problems [8,26]. Land-use changes are one of the main pressures, and include the intensification of agriculture, urbanisation, and accompanying losses of natural and semi-natural habitats that provide foraging and nesting resources for pollinators. Related, the large-scale use of agrochemicals (insecticides, fungicides, herbicides, and fertilisers) produces lethal or sublethal impacts on pollinators, directly or indirectly. Juvenile life stages often occupy entirely different niches and environments from adult pollinators and are especially vulnerable [27]. Other pressures include chemical pollutants (biocides, veterinary medicine, heavy metals, phthalates from plastics) [28], air pollutants (ozone, sulphur dioxide, particulate matter, and diesel exhaust) [29,30], and light pollution associated with urbanisation, which negatively affect day-active and night-active pollinator biodiversity and interactions with plants [31]. Nitrogen deposition [32,33] and eutrophication have driven a steep increase in the occurrence of nitrogen-demanding plant species across all main habitat types in Europe [34], which has substantially reduced the diversity and abundance of key floral resources on which adult pollinators rely and of host plants on which many juvenile pollinators (the larvae of moths, butterflies, beetles, flies, etc.) rely. Environmental changes induced by climate change (weather volatility, floods, fires, soil drying, shifting plant-insect populations, changes in the availability of hosts and prey for juvenile pollinators) create problems for pollinators and pollination, in particular at higher latitudes [8,35,36,37,38] as do effects of so called global nutrient dilution [39,40,41,42], invasive species [43,44] and pathogen spread between managed and wild pollinators [45,46,47].

The complexity of the issue, the multiple interactions among pressures, and geographical specificities, make it hard to clearly establish the relative importance of each of the causes in this multi-stressor situation. Metaphors such as "death by a thousand cuts" [48] or a "perfect storm" [49] have been used to express this. Key factors are, however, related to unsustainable agricultural practices, highlighting the urgency of a transition to sustainable agriculture, particularly options such as agroecology and pesticide-free forms of regenerative farming [50,51,52,53].

These pressures are ultimately linked to historical, cultural, social, political and economic drivers [54]. These drivers take their roots in societal values and worldviews and are manifest in deeply entrenched economic growth models that prioritise short-term productivity, siloed governance structures and a general lack of ecoliteracy, recognition of the value of natural capital, and historical agency amongst key actors [55, 56]. Human relations to pollinators run deep in the cultural meanings and practices of societies worldwide, bringing an inertia that slows responses to rapid environmental change [57]. Dominant social and cultural patterns reinforce the view that humans are separate from and superior to nature and that nature is comprised of objects for humans to use as resources [58]. This view reinforces institutional structures that exploit nature for short-term individual and material gain that benefits the privileged and the powerful [58]. Such underlying causes underpin the broader global polycrisis, demonstrating the link between pollinator loss and many other social and environmental challenges [59].

Binding targets for pollinator restoration

Recognising the urgency, the EU Biodiversity Strategy for 2030 and the EU's revised Pollinators Initiative set a commitment to reverse the decline of wild pollinators by 2030. The EU's Nature Restoration Regulation entered into force on 19 August 2024 and establishes a binding target (Art. 10) for Member States to improve pollinator diversity and reverse the decline of pollinator populations by 2030, and thereafter, achieve an increasing trend of pollinator populations, measured at least every six years from 2030.

However, long-term restoration efforts with the aim of recovering past biodiversity require a concerted effort to tackle a multitude of pressures simultaneously across several sectors and policy domains. Indeed, one of the biggest obstacles is the numerous incoherent policies and sometimes conflicting policy goals (e.g. pesticide subsidy schemes) affecting pollinators. This incoherence hinders or counteracts the achievement of the EU's policy objectives regarding pollinators. This is the urgent reason for putting together this White Paper.

Policy coherence is indispensable for the achievement of the EU's binding targets for pollinator diversity and reversal of pollinator decline

The complexity of reversing pollinator decline calls for a systemic policy approach in which pollinator stewardship [60] should be central to all pollinator-relevant policies across sectors. The current situation is very far from that ideal. A recent assessment by the RestPoll project [61] revealed incoherence, policy gaps and conflicts across a wide range of EU and global policies, which limit the effectiveness of measures such as habitat restoration and pesticide reduction.

Pollinator decline reveals a dysfunctional relationship between humans and nature

Scholars from the social sciences and the humanities have diagnosed the current pollinator decline – and more broadly the ecological crisis – as a dysfunctional relationship between modern societies and nature [62]. This manifests in the prioritisation of instrumental valuations of nature, at the expense of intrinsic and relational values [63]. It is also reflected in the worldviews currently dominant at the EU policy level, and the governance structures, policies and practices they shape [54]. This is driving pollinator loss, alongside other indirect drivers, including culture, history, landscape management practices, knowledge gaps, lack of eco-literacy, and reluctance among societal actors to assume agency [62, 54, 56, 64].

Safeguard research identified that the pollinator agenda at the EU policy level can contribute to fostering new relationships between humans and nature [54]. Yet, the EU's ambitions to restore pollinators can only be met if the EU and Member States target the drivers (instead of only the pressures) of pollinator loss, including those related to worldviews, values, institutions and governance [54, 65, 66]. The focus should be on integrating pollinator stewardship across sectors, addressing power imbalances structuring the political agendas affecting pollinators, fostering opportunities for dialogue and stakeholder engagement, and creating conditions for civil society to hold governments accountable. Integrating knowledge and insights from many domains, ranging from conservation biology and ecology to the social sciences, the humanities and the diverse knowledge held by various societal actors and practitioners, and transmitting these to decision makers at all levels is key to improving the situation [54]. This step requires a change in the social organisation of expertise at the science-policy interface to ensure that actionable knowledge reaches decision makers without delay [67]. Further, participatory governance needs to be strengthened while addressing power imbalances [54]. Where farmers, land managers, local authorities and civil society are not meaningfully involved in the design phase, measures may suffer from low legitimacy, weak ownership, reduced compliance and limited participation. Societal actors holding relevant knowledge and relational values in relation to pollinators need to be represented, including those among small-scale beekeepers and farmers, indigenous peoples, local communities, and youth [54, 68].

A multi-stakeholder dialogue in a Safeguard 'Buzzing Table' workshop [54] identified that current decision-making suffers from short-termism, lack of dialogue and coordination, and siloed thinking across different policy sectors. This results in incoherent policies and legislation and fragmented incentives. Both horizontal coherence (consistency across different policy areas) and vertical coherence (coordination across governance levels) are insufficient. Insufficient education standards on pollinators, pollination and related challenges also contribute to siloed thinking and limit the development of the human and social resources and capacities needed to act effectively at many levels [69]. Pollinator restoration is coupled to wider ecological restoration, requiring transformative change [70] and a systemic approach across all sectors, integrating ecological science and socio-political knowledge, targeting values, institutions and governance, and considering the consequences of different decisions. More information and recommendations can be found in the Safeguard policy brief "Towards pollinator-friendly policy and practices: Worldviews, opportunities and barriers", [54, pages 13-14].

Pollinator decline is a global issue and would benefit from a globally coordinated policy response

Pollinator decline is a global phenomenon [8, 71]. Pollinated crops that are not grown in Europe are of key importance to the European food systems (e.g. coffee, cocoa, oil palm) [17]. Given the globalised markets and global supply chains, the effects of pollinator loss in one country can have far-reaching global impacts via a complex network of trade connections [17]. Through the import of crops, many supply chains in Europe critically depend on pollination outside Europe [17]. Large, developed economies such as EU Member States are estimated to suffer the greatest economic losses, even if pollinator losses only affect smaller, less-developed economies in other continents [17]. Pollinator decline, thus, would best be tackled through a globally coordinated response, similar to other global environmental risks such as climate change and atmospheric pollution [60, 71]. This could take the form of an international treaty on global pollinator stewardship [60, 71].

Unexploited synergies between pollinator restoration and other policy domains

Pollinators are critical to the achievement of the United Nations Sustainable Development Goals (SDGs), and the goals of the SDGs themselves are critical to help reverse pollinator decline [72, 57]. Many SDGs cannot be achieved without adequate pollinator restoration and sustainable use of their services. To some extent, all SDGs are dependent on well-functioning plant-pollinator interactions [73, 57]. Pollinators are most clearly linked to 14 of the 17 SDGs and more specifically to 58 of the 169 targets [72]. Pollinators directly contribute to 7 SDGs, notably Zero Hunger (SDG2) and Life on Land (SDG15), and underpin targets on nutrition, income diversification, and resilient agricultural practices. Conversely, progress towards many SDGs – including clean water (SDG6), responsible consumption (SDG12) and poverty reduction (SDG1), Good health and well being (SDG 3)– depends indirectly on contributions from healthy pollinator populations [72]. Restoring pollinator habitats and protecting pollinators is thus synonymous with achieving multiple sustainability objectives.

Pollinator habitat restoration can also have synergies with other policy domains such as climate change adaptation and mitigation, cultural heritage preservation and invasive species management. For instance, one of Butterfly's pollinator Living Labs, Landøy island in southern Norway, concerns coastal heathland restoration through the removal of invasive trees and shrubs, according to traditional heather-burning practices. Restoring the traditional coastal heathland is key to pollinator restoration and culture conservation, and turns the heathlands into carbon storage sites [74]. Another example is choosing native tree species that provide pollen and nectar for pollinators when planting trees in cities to mitigate the impact of heatwaves.

Given that pollinators are essential for human health and well-being [75], pollinator stewardship should be a central pillar of public health policies and One Health approaches. One Health is an integrated, unifying approach to attain optimal health and sustainability for humans, animals, and the environment simultaneously [76]. Four pathways link pollinator health and human health: nutrition (see above), medicine provisioning, mental health and environmental quality. Approximately 28 000 medicinal plants depend on pollinators. Apicultural products such as medical honey, pollen, and propolis are widely used. Pollinators are critical for ecologically functional and aesthetically pleasing green spaces and biocultural landscapes that improve mental health. Initiatives to reduce the use of agrochemicals to protect pollinators have co-benefits for health by contributing to cleaner air, water and food. [75]

Policy incoherence is a livelihood issue for Europe. Farmers and beekeepers are at the frontline of the looming pollinator crisis. Managed and wild pollinators support crop yields, quality, and commercial value, and provide an essential income stream for farmers, beekeepers, and many other actors further on in the many value chains that ultimately depend on pollinators. Incoherent policies also lead to externalised costs. For instance, large-scale pesticide use, monoculture and habitat loss force beekeepers to provide supplemental feeding and to move their beehives more frequently from one location to another, all without compensation [77]. For instance, beekeepers sometimes have to move their hives to nature areas (at high densities creating potential for competition with wild pollinators [78]) so that the colonies can recover from the negative impacts of pesticide exposure during crop pollination. During this recovery period, the hives cannot be rented out for pollination services, resulting in lost income for the beekeeper. Predictable, coherent policy signals are necessary to enable investments in sustainable practices and to secure the livelihoods of farmers, beekeepers and other actors in the many value chains that depend on animal-pollinated plants.

EU policies affecting pollinators – from agriculture, forestry, food and trade to pollution reduction, chemical regulation, and innovation – can either support or hinder the EU's ambitions to restore pollinators. Few of the many potential synergies between pollinator restoration and other policy domains have been translated into EU institutions, and policymakers and lawmakers seem insufficiently aware of their potential and urgency [79]. This limits collective capacity for change. Barriers to mainstreaming pollinator stewardship include a reluctance to change, a lack of ecological knowledge, governance challenges, short-termism, silo thinking, unavailability of affordable alternatives, lack of funding, and a lack of monitoring [54].

To achieve a coherent and holistic approach, a transition to a systems-based environmental risk assessment (ERA) of pesticides [80, 81] needs to be prioritised, and steps toward this goal should be supported through existing and new policies. Instead of assessing pesticides, pollinators, habitats and farming practices in separate silos, a systems-based ERA combines monitoring and modelling, captures multiple stressors and landscape conditions, and enables comparisons across products (pesticides) and management options. For pollinators, this means earlier detection of cumulative and indirect risks and a stronger basis for coordinated action across CAP, biodiversity, chemicals, net-zero pollution (e.g., reactive nitrogen, pesticides), the upcoming Integrated Nutrient Management Plan, and water policies.

Policies that urgently need to assume pollinator stewardship in order to achieve the EU's binding targets for pollinator restoration

The following sections first address the EU Biodiversity Strategy and the Nature Restoration Regulation (NRR), and then briefly review key policy domains that have critical shortcomings in pollinator stewardship that need to be remedied in order to enable the achievement of the EU Nature Restoration Regulation's binding targets for pollinator restoration. These are pesticide and chemical policies, the Food and Feed Omnibus, the Environment Omnibus, seed and reproductive material policies and new genomic techniques. These policies currently either (potentially or actually) counteract pollinator restoration or insufficiently utilise the potential for synergies with pollinator restoration.

Biodiversity Strategy & Nature Restoration Regulation

Pollinator relevance: Pollinators depend on connected, diverse habitats across agricultural, semi-natural and urban landscapes [82]. The EU Biodiversity Strategy for 2030 and the NRR aim to reverse biodiversity loss by restoring degraded ecosystems. The NRR requires Member States to prepare national restoration plans and sets binding targets, including restoring 30% of degraded terrestrial ecosystems by 2030. Article 4 sets the ambitions for the restoration of semi-natural grasslands, a key pollinator habitat. Article 8 is about the restoration of urban systems that have underutilised potential for the creation of quality pollinator habitat (e.g. pollinator-friendly management of public and private green space). Article 10 sets binding targets for pollinator restoration (including monitoring to evaluate the efficiency of the actions). Article 11 deals with the restoration of agricultural systems, including former peat extraction sites. Article 12 addresses restoration of forest ecosystems, which are essential to pollinators, both for forest specialists and in landscapes with mixed land-use [83, 84].

The success of these policies determines whether pollinator habitats expand or continue to shrink. Restoration can increase habitats providing floral resources, breeding, nesting and larval sites for all pollinators (bees, hoverflies, butterflies, moths, etc.) and enhancing landscape connectivity. The implementation, however, requires integration across landscape types, necessitating collaborative working between farmers, landscape managers, beekeepers, local people, indigenous people, and actors along value chains. This collaboration should, in particular, seek to mobilise and utilise indigenous and local knowledge to better inform effective restoration, landscape management, and practices moving towards sustainable use alongside pollinator-sustaining habitats.

The Biodiversity Strategy and NRR have a blind spot for the importance of night-active pollinators such as moths, beetles and bats. Night-active insects and especially moths can make substantial contributions to pollination services. Some studies suggest that nocturnal pollinators may account for a significant share of total pollination, in some cases contributing to a large proportion of flower visits and pollen transport, including in agricultural systems [85,86]. However, this contribution remains poorly quantified and is rarely considered in monitoring schemes, risk assessments, or policy frameworks.

Recommendations:

- Set explicit habitat quality and connectivity targets for pollinators within national restoration plans, strengthening support for Key Pollinator Areas and Buzz Lines. Identify priority landscapes (e.g. species-rich grasslands, hedgerow networks, wetlands) and quantify the area to be restored or managed for pollinator support. Promote higher forest cover in agricultural landscapes as it promotes pollinators in agricultural systems [83,84] and buffers climate extremes [87]. Ensure targets are binding, time-bound and backed by resources. This should include urban and peri-urban habitats, as a significant proportion of food production in the EU occurs near towns and cities, and they can provide good habitat resources for pollinators [88].

- Integrate nature restoration and CAP funding. Use CAP environmental measures (e.g., eco-schemes, Agro-Environmental and Climate Measures (AECM), coupled payments, etc.) to finance restoration of hedgerows, flower-rich margins, fallow lands and agroforestry. Higher payments for old fruit trees and hedgerows with an outstanding value for pollinators would encourage farmers to maintain these structures. Encourage collaboration between farmers, beekeepers, agri-food actors, and conservation organisations to design landscape-scale restoration that benefits both biodiversity and agri-production. When establishing flower-rich spaces, incorporate a diversity of native plants to cater for both adult pollinators and their juveniles [27,89].

- Strengthen the standardised assessments of pollinator diversity and abundance at the member state level through: (1) more intense monitoring of non-arable sites such as semi-natural grasslands in the framework of the EU Pollinator Monitoring Scheme (EU-PoMS) [90], (3) explicitly addressing night-active pollinators, (3) including other taxa in addition to bees, hoverflies, butterflies and moths, (4) coupling of the monitoring of pollinators with the monitoring of pressures or drivers (e.g. pollinator-pesticide co-monitoring), (5) monitoring the delivery of pollination to both crops and wild flowering plant communities and (6) implementation of the monitoring of threatened species.

- Integrate the mandatory monitoring of pollinator diversity and abundance (EU-PoMS, NRR) with ongoing citizen science monitoring initiatives and actively engage beekeepers and the public. Such engagement needs to be additional to existing practices, to ensure that monitoring efforts do not divert actors from ongoing initiatives favourable to pollinators.

- Address socio-economic barriers. Recognise that landowners, farmers and beekeepers may lack incentives to participate in restoration. Provide payments for ecosystem services, secure land tenure and support capacity building. Involve beekeepers and farmers in restoration planning to reduce conflicts and maximise co-benefits.

The Policy Brief “Restoring Pollinators in Europe: Evidence-Based Actions for Nature Restoration Plans” by the RestPoll project addresses this in more detail [61].

Common Agricultural Policy (CAP)

Pollinator relevance: The CAP shapes land cover, land management and the availability of floral resources and pollinator habitat across Europe. Good Agricultural and Environmental Conditions (GAECs) under Pillar I establish baseline requirements for farmers receiving CAP payments, such as maintaining permanent grasslands, protecting wetlands and peatlands, preventing soil erosion, and preserving non-productive features like hedgerows and buffer strips [61]. While GAECs set minimum standards, they generally maintain rather than improve environmental conditions. Because many of these requirements have not changed over a very long period, farmers are not motivated to do better. Eco-schemes introduced in CAP 2023–2027 aim to reward farmers for providing environmental goods, with actions grouped under seven themes (climate adaptation, biodiversity, reduced pesticide use, etc.) [61]. Across 158 eco-schemes, most focus on soil conservation, biodiversity generally, or organic farming; only a few Member States include pollinator-specific measures, such as sowing pollen and nectar forage plants for pollinators or preserving hedgerows [61]. Since eco-schemes are currently voluntary for farmers and designed to support customised national climate and environmental needs, their focus and uptake may vary.

The CAP frequently rewards crop production without valuing pollination services or providing long-term habitats to support pollinators. Under current CAP rules, farmers can decide whether to adopt annual eco-schemes and/or to engage in multi-annual programmes (AECM); they may also choose measures with limited biodiversity benefits. Meanwhile, pollinators depend on the sustained availability of diverse, pesticide-free floral resources across seasons in a local landscape.

In addition, the CAP is aligned with European reactive nitrogen pollution policies that aim to reduce nutrient losses by at least 50% by 2030 and cut fertiliser use by 20%, as part of the EU Green Deal. It is essential to reduce reactive nitrogen pollution of our environment to lessen its impact on pollinators through changing the availability of floral or nesting resources in habitats.

Overall, the majority of CAP spending is used to support farmers' direct income without due consideration to environmental concerns [91]. Besides, the current design of eco-schemes under the CAP gives Member States substantial responsibility for selecting and shaping measures through their national Strategic Plans. While this flexibility allows adaptation to local contexts, eco-schemes are often designed through predominantly administrative or top-down processes, with limited structured involvement of farmers, beekeepers, advisors, territorial actors and civil society. This can reduce ownership, trust, and practical relevance, leading to lower participation rates, weaker compliance, and limited ecological effectiveness. From a governance perspective, pollinator-friendly measures are more likely to succeed when co-designed with stakeholders who understand local farming systems, landscape constraints, implementation barriers and opportunities for collective action. Participatory design can therefore improve legitimacy, uptake, and long-term continuity of measures.

Recommendations:

- Make pollinator stewardship and support of beekeepers explicit objectives of the CAP, recognising wild and managed pollinators and their pollination services as a public good alongside food security and rural livelihoods.

- Use the indicators from the PoMS, such as the farmland pollinator indicator, to measure the performance of the CAP.

- Promote participatory design & individual or collective implementation of eco-schemes with local actors.

- Promote societal and market visibility and societal recognition of farmers' contributions to pollinator restoration.

- Increase incentives for practices that increase the diversity and abundance of pollinators and their floral resources throughout the pollinator foraging season.

- Given the fact that 70% of Europe's wild bee species are ground-nesting, increase incentives rewarding agricultural and landscape management practices such as Conservation Agriculture that better enable ground-nesting bees to nest in agricultural landscapes.

- Allow more flexibility and locally adapted measures, and promote innovation experiments, co-developed by farmers, advisors, scientists and local government.

- Reduce administrative and reporting workload for farmers, while maintaining environmental safeguards through a multiactor approach process towards the next CAP to find acceptable compromises.

- In addition to short-term, voluntary eco-schemes, implement more ambitious, though still voluntary, AECMs and multi-annual results-based instruments that reward farmers for the continuous provision of high-quality habitats (perennial flowering strips, hedgerow networks, agroforestry and low-input grasslands) that offer nectar and pollen throughout the season. Payment rates should reflect habitat quality rather than just area [92].

- Reduce excessive bureaucracy in obtaining subsidies for environmental measures and focus more on allocating resources to local advisory services and controlling the measures implemented, rather than on reporting and mandatory online training. Favour communication among administrations (at the EU, national or regional level) and field practitioners (i.e., field advisors, farmers, etc.) to ensure alignment between promoting pollinator-friendly practices, adapted to local conditions, and administrative requirements.

- Integrate pollinator-friendly practices across GAECs: promote minimum percentages of non-productive features (15 % of arable land) and permanent grasslands rich in wildflowers; maintain buffer strips along water bodies; promote less intensive hedge management; reduce dependence on chemical input, and promote diversification of crop rotations with legume and other pollinator-friendly crop species providing nectar and pollen.

- Link the CAP with the Vision for Agriculture and Food [93]. CAP payments should prioritise farmers who adopt integrated pest management, organic, agroecological, or pesticide-free regenerative practices, and nutrient management plans that collectively benefit pollinators. Ecosystem services beneficial to the environment, water, soil or air quality should be properly rewarded. The EU and national measures should support farmers' sense of agency.

For more information, please see RestPoll's analysis of policy incoherence between promises and performance [61].

Pesticides & Chemicals Policy

Pollinator relevance: Chemical exposure remains one of the most consistent stressors driving pollinator decline. While the EU aims to reduce pesticide use and risk, progress has stalled. Ambitions to reduce pesticide use were hampered when plans to revise the EU's Sustainable Use of Pesticides Directive (SUD) [94] were withdrawn [95]. The SUD is still in force, and Art. 14 requires that Member States ensure that the general principles of Integrated Pest Management (IPM) as set out in Annex III of the SUD are implemented by all professional users by 1 January 2014, but this has still not been achieved. Although IPM approaches have been developed for a wide diversity of crops and contexts, their uptake by farmers and other professional pesticide users remains low across Europe [96]. The European Food Safety Authority's (EFSA) Bee Guidance [97], revised in 2023 to include more realistic exposure routes, has not yet been endorsed by Member

States. Managed and wild pollinators are exposed to a cocktail of pesticides, pathogens and poor nutrition. Interactions between agrochemicals, diseases and nutritional stress can amplify sub-lethal effects, reducing reproduction and survival. [98,99,100,101] Yet risk assessments often consider single substances and single stressors in isolation, ignoring cumulative and synergistic effects.

Recommendations:

- Establish and enforce a post-authorisation monitoring programme at the EU level for pesticides, biocides and other chemicals and feed the results into the regulatory system to further refine predictive models and pesticide risk assessment and management.

- Adopt and implement EFSA's Bee Guidance across all pesticide authorisations, including chronic and sub-lethal endpoints, mixtures of chemicals and extend its scope to include a wider range of pollinators in term of taxonomy and ecological traits, such as sensitive species of solitary bees (at least one ground-nesting species that nests in arable fields), wild bumblebees, hoverflies (at least one species with an aquatic larval stage), non-pest butterflies, and non-pest moths.

- Implement IPM as required by the SUD and reintroduce a binding Sustainable Use of Pesticides Regulation with quantifiable reduction targets in the short term. Align pesticide authorisations among Member States. European citizens requested an EU reduction in the use of 80 % of all synthetic pesticides [102].

- Require pesticide-free buffer zones and low-input areas around key pollinator areas (see also [103]).

- Promote and reward IPM, biopesticides and biocontrol [104], agroecological, and pesticide-free regenerative approaches. Support farmers in adopting pest-prevention measures, such as diversifying crop rotations, creating semi-natural patches to help diversify landscapes, and biological control. Provide advisory services and financial incentives for IPM adoption.

- Consider interactions between stressors in risk assessments and monitoring. Encourage research and regulatory frameworks that evaluate the combined effects of pesticides, pathogens and nutrition in their landscape context. Use field studies and modelling to reflect real agricultural conditions. Include pesticide degradation products (metabolites), their interactions with other stressors, and spill-over to non-target habitats in risk assessments.

- Phase out biocides with the same active ingredients that have been banned in agriculture, in particular imidacloprid (bait spray against flies in cattle stables, ant control). Although not covered in the Omnibuses, this incoherence extends to the Veterinary Medicinal Products Regulation, whose ERA does not include risks for pollinators. Over-the-counter flea treatments for pets contain imidacloprid and fipronil (also banned in agriculture) and should be banned to protect pollinators, especially those with an aquatic larval stage [105]. Complementary legislation should be developed to reduce reliance on harmful biocides, improve ERA for biocides and veterinary medicinal products, and streamline the authorisation of safer alternatives.

For more information, please see the Policy Brief "Reforming EU chemical risk assessment" by the PollinERA project [106].

Relationship with Omnibuses (Food and Feed and Environmental Omnibus)

Pollinator relevance: In 2025, the Commission presented Omnibus packages to simplify regulatory procedures. The Food and Feed Omnibus focuses on regulations related to pesticides, biocides, food additives, bio-control products, and plastics, while the Environmental Omnibus focuses on simplifying procedures for environmental legislation in the areas of industrial emissions, the circular economy, environmental assessments and geospatial data. It includes a weakening of the Water Framework Directive, important here as several pollinators have an aquatic larval stadium [107] (including about 40 European hoverfly species). The WFD has succeeded in preventing the licensing of mining companies and some other major polluters. Mining companies pollute water bodies and destroy large areas of habitat of wild plants and pollinators that were previously in a near-pristine state. These proposals for bulk modification of the regulatory framework aim to simplify regulatory implementation. The Omnibuses propose several measures, such as avoiding re-assessment and re-authorisation for pesticide active ingredients and allowing aerial spraying of pesticides via drones. Current simplification proposals, however, are presenting significant risks to pollinators that are incoherent with EU biodiversity and nature restoration goals.

Recommendations:

- Ensure that the obligation to prevent the deterioration of the status of all bodies of surface water (Art. 4(1) WFD, non-deterioration principle) cannot be circumvented or removed.

- Ensure Omnibus simplifications do not weaken environmental and health standards. Streamlining procedures should not lead to automatic extensions of approvals on active ingredients of pesticides and biocides without updated risk assessments.

- Use simplification to accelerate a systems-based Environmental Risk Assessment (ERA) of pesticides, not to weaken safeguards. Prioritise framing ERA at ecologically relevant levels and fostering interoperable data, shared monitoring linked to clear and measurable policy objectives, and cross-agency cooperation. Simplification should eliminate procedural duplication and focus on information and data that are relevant for decision-making (i.e., post-authorisation monitoring, farming practices, crop selection by farmers, etc.).

- Ensure that the Precautionary Principle [67,108] is enforced and the burden of proof is not shifted away from the agrochemical industry to academia, which is often underfunded and lacks mandate and access to crucial data to comprehensively assess the risks of all pesticides.

- Make regulatory study reports, spatially explicit pesticide-use data, and monitoring data publicly available so independent scientists can verify and update pesticide risk profiles.

- Ensure efficient integration of independent knowledge and monitoring results in regulatory decision-making. Establish early warning mechanisms that trigger reassessment of pesticide authorisations (e.g., when real-world pesticide residue levels exceed predefined protection thresholds, or when early-warning signs of unforeseen impacts are detected).

- Tackle the root causes of slow, delayed approval processes rather than abandoning mandatory reassessments. Ensure that chemical companies applying for pesticide approval pay fees that cover the whole costs of regulatory evaluations, and that assessments only start when chemical companies have delivered complete dossiers, divide tasks for the evaluation of pesticides among Member States rather than allowing chemical companies to choose the Member State that leads the evaluation of their product and run evaluations for different assessment compartments (e.g. environmental fate, risk to bees, risk to soil organisms, etc.) in parallel where possible and meaningful. Create clear and harmonised decision rules that facilitate regulatory interpretation.

- Complement administrative reforms with substantive measures to reduce chemical use and enhance pollinator protection. The Omnibuses should be accompanied by legislative proposals that advance the EU's goals of reducing pesticide use and protecting biodiversity, e.g., through promoting IPM, organic farming, and agroecology.

- Maintain transparency and stakeholder participation. Policy simplification must not undermine democratic oversight. Engage beekeepers, farmers, academia and civil society in assessing the impacts of regulatory changes on pollinators.

More information can be found in the Scientific Statement on Pesticides in the Omnibus, which we endorse, and in PollinERA's policy brief on chemical risk assessment [106].

Seeds and reproducible material Policies

Pollinator relevance: Regulations governing the marketing of seeds and plant reproductive material affect plant within-species diversity in agricultural landscapes. Associated with a global seed market and the high cost of modern breeding, they favour high-yielding varieties adapted to chemical treatment and restrict the marketing of heterogeneous or locally adapted seeds, thereby reducing floral diversity. For pollinators, monocultures of genetically uniform crops provide short periods of nectar and pollen followed by resource deserts. Moreover, pollen and nectar diversity depend on plant diversity; limited intra- and inter-specific crop diversity can mean less nutritionally balanced food for bees at the species level. As pollinator nutritional needs are probably species specific, some might not find their nutritional requirement in a poorly diverse agro-ecosystem [109,110]. Moreover, current "pollinator-friendly" seed mixes used to supplement pollinator food base often support adult foraging but overlook the nutritionally balanced larval resources needed to secure healthy development, future generations and resilient pollinator populations [89].

Recommendations:

- Seed policies and regulations should aim at intra- and interspecific crop diversity in agrosystems, regional adaptation and pollinator nutrition.

- Promote and facilitate the marketing and uptake of diverse, regionally adapted (native), genetically diverse seed mixtures for cover crops and flowering strips. EU rules should enable farmers and seed producers to market heterogeneous populations and native wildflower mixes without excessive certification costs. Provide financing to help establish new (local) businesses conforming to agreed standards.

- Encourage seed mixes for cover crops and wildflower strips that include nectar- and pollen-rich species spanning early spring to autumn, and seeds for host plants for larvae of hoverflies, butterflies and moths. Mixes should provide a continuous forage, be locally adapted (for instance, to soil conditions) and support a wider range of pollinators.

- Maintain genetic diversity within crop species and wildflower seed mixes to enhance nutritional quality and resilience to pressures that impact plant-pollinator networks. Incentivise farmers to adopt varieties selected for attractiveness to pollinators (e.g. open flowers, high nectar volume, nutrient-rich pollen) and to maintain and use traditional landraces and minor crops where appropriate.

- Ensure that any new crop seed rules include pollinator safeguards, such as prohibitions on seed-coating with neonicotinoids (and other insecticides with the same mode of action) and clear labelling when seeds are treated with systemic pesticides.

- Support community seed banks and farmer-led breeding initiatives that prioritise supporting ecological interactions such as pollination and natural pest control while considering epidemiological risks.

New Genomic Techniques (NGTs)

Pollinator relevance: New Genomic Techniques (NGTs) are a set of methods (e.g., gene editing such as CRISPR) used to modify the genetic material of plants more precisely and more quickly than traditional breeding. A provisional agreement between Parliament and Council (February 2024) proposes that NGT1 plants, whose genetic alterations could occur naturally, will be treated like conventional crops, exempt from most GMO rules, while NGT2 plants will remain subject to lightened GMO requirements [111]. A list of excluded traits prevents NGT1 plants from containing insecticidal or herbicide-tolerant traits; such traits would remain regulated under NGT2. The agreement avoids monitoring the sustainability impacts of NGT plants and the clear labelling and traceability of seeds. It allows patents on NGTs but includes safeguards to ensure farmers can access seeds and avoid prohibitive costs. Organic production remains free of NGTs [111].

Pollinators may be affected by NGT crops in several ways. Traits such as herbicide tolerance encourage increased herbicide use, reducing the floral diversity of wild plants and exposing bees to herbicide drift. Insecticidal traits (e.g. Bt toxins) may affect non-target insects because Bt toxins are inherently toxic for butterflies and other herbivorous pollinators (moths, beetles). However, the scale of the sampling effort needed to reliably detect small but ecologically relevant effects at field-relevant doses is practically unachievable [112]. In such cases, the precautionary principle should apply [67,108,113]. NGT1 and 2 are accelerating modern breeding and therefore exacerbate the existing tension between pollinator-detrimental traits, such as herbicide-resistance or Bt toxin tolerance, and pollinator-friendly traits, such as fungal resistance or greater resource production. Labelling of NGT is essential to manage contamination risks and maintain organic certification. Further, gene-edited crops may alter pollen or nectar composition or flower morphology, affecting bee nutrition. Traceability and labelling are essential for beekeepers to manage contamination risks and maintain organic certification.

Recommendations:

- Maintain a precautionary, science-based risk assessment for all NGT plants, regardless of classification [67,108,113]. Assess impacts on pollinator health, behaviour and nutrition, including potential synergistic effects with pesticides. Excluded traits (insecticidal and herbicide tolerance) must remain strictly regulated.

- Ensure proper labelling and traceability. Farmers and beekeepers should be able to identify NGT-regulated seeds to manage coexistence and avoid unintended gene flow. Traceability must extend to pollen sources, enabling honey producers to meet market requirements.

- Protect farmers' and beekeepers' rights. Intellectual property rules should not lock farmers into purchasing patented NGT seeds or restrict the saving, exchange, and replanting of seeds. Public research on NGTs should prioritise traits that reduce agrochemical use, increase climate resilience, and improve nutritional quality, and the resulting seeds should be open source seeds. Still, clear liability distribution should be defined in the regulatory framework.

- Support traditional and organic breeding. Preserve farmer-led breeding and organic seed systems that enhance genetic diversity in agrosystems. Ensure organic and NGT-free supply chains remain uncontaminated by establishing buffer zones and coexistence rules.

Outlook

This White Paper highlights the interconnections between EU policies and various regulatory measures from the perspective of pollinators, and the policy incoherence and siloed approach that hinders efforts to achieve the goals set for the restoration of pollinator populations and their habitats. This underscores the need for a systemic approach to ensure that pollinator stewardship is integrated into all policies and sectoral practices, and our recommendations aim to support this goal. As an example, a systems-based ERA is no longer only a research concept. The European Food Safety Authority (EFSA)'s MUltiple STressors in Bees project (MUST-B) and the EU Partnership for Environmental Risk Assessment (PERA), together with Horizon Europe projects such as PARC, PollinERA, and WildPosh, are building the monitoring, modelling and interoperable data workflows needed for next-generation pollinator pesticide risk assessment. The near-term benefit for policymakers is not only stronger biodiversity protection, but also more efficient and predictable regulation: better use of monitoring data, fewer blind spots between sectors, and faster identification of lower-risk practices and products.

Climate change is accelerating risks to society and nature and is forecast to become the predominant pressure on biodiversity and its ecosystem functions [114,115]. The interplay and feedback between the climate and biodiversity crises call for integrated national and European policy responses. Systemic policy approaches to pollinator stewardship, therefore provide an example of safeguarding these valued animals, but also highlight the integrated policy approach required to meet the generational challenge of nature restoration and mitigation of and adaptation to drastic climate change.

About the contributing projects

This brief draws upon evidence from multiple EU-funded research and innovation projects that collectively improve understanding of pollinator biology, threats and solutions. Butterfly, VALOR, PollinERA, WildPosh, AGRI4POL, ProPollSoil, RestPoll, and Safeguard (see box 1) provide insights into pollinator ecology, sustainable farming practices, environmental pressures, socio-economic drivers and policy coherence. These projects emphasise that protecting pollinators requires transformative change, aligning scientific knowledge with policies and empowering rural communities.

Contacts

For further information on the science informing this brief, please contact the corresponding author or the consortia of the contributing projects:

Corresponding Author: Jeroen van der Sluijs (jeroen.sluijs@uib.no);

Butterfly: Coordinator: Jeroen van der Sluijs (jeroen.sluijs@uib.no); Project Administrator: Nilgun Kulan (nilgun.kulan@uib.no);

VALOR: Coordinator: Tom Breeze (t.d.breeze@reading.ac.uk); Project Administrator: Elena Carp (e.carp@reading.ac.uk);

PollinERA: Coordinator: Christopher John Topping (cjt@agro.au.dk); Project Administrator: Luna Kondrup Marcussen (lkm@agro.au.dk);

WildPosh: Coordinator: Denis Michez (denis.michez@umons.ac.be); Project Administrator: Sara Reverté Saiz (sara.revertesaiz@umons.ac.be);

AGRI4POL: Coordinator: Adam Vanbergen (adam.vanbergen@inrae.fr); Project Administrator: Luke Lauprete (luke.lauprete@inrae.fr);

ProPollSoil: Coordinator: Sara Diana Leonhardt (sara.leonhardt@tum.de); Project Administrator: Renita Danabalan (r.danabalan@eurice.eu);

RestPoll: Coordinator: Alexandra-Maria Klein (alexandra.klein@nature.uni-freiburg.de); Project Administrator: Amibeth Thompson (amibeth.thompson@nature.uni-freiburg.de);

Safeguard: Coordinator: Ingolf Steffan-Dewenter (ingolf.steffan-dewenter@uni-wuerzburg.de); Project Administrator: Safeguard Secretariat (safeguard@uni-wuerzburg.de).

References

[1] Kevan, P. G., and Menzel, R. (2012) The plight of pollination and the interface of neurobiology, ecology and food security. The Environmentalist. https://doi.org/10.1007/s10669-012-9394-5

[2] Michez, D., Boustani, M., Sentil, A., Benrezkallah, J., de Manincor, N., Wood, T. J., Álvarez Fidalgo, P., Aubert, M., Bellotto, V., Biella, P., Bogusch, P., Bosch, J., Brau, T., Browne, K., Carion, F., Castro, L., Cederberg, B., Clay, J., Debont, T., Bila Dubaić, J., Dall'Olio, R., Dellicour, S., Devalez, J., Devorsine, R., Dufrêne, E., De la Rúa, P., De Tandt, B., Evrard, D., Flaminio, S., Fiordaliso, W., Fontana, P., Gadoum, S., Galbany Casals, M., Gaspar, H., Gekière, A., Gérard, M., Geslin, B., Kasparek, M., Kierat, J., Kohl, P. L., Kuhlmann, M., Kryger, P., Leclercq, N., Le Divelec, R., Lemaire, S., Lescot, S., Lhomme, P., Litman, J., Marshall, L., McCormack, G. P., Moro, A., Mudri Stojnić, S., Ockermueller, E., Oleksa, A., Ortiz-Sánchez, F. J., Patiny, S., Paukkunen, J., Perrard, A., Petanidou, T., Pinto, M. A., Potts, S. G., Praz, C., Put, S. C. L., Radchenko, V. G., Rasmont, P., Requier, F., Reverté, S., Risch, S., Rogenstein, S., Rosa, P., Ruiz, C., Rutschmann, B., Santerre, R., Smit, J., Straka, J., Thulier, J., Tourbez, C., Trottet, A., Vereecken, N. J., Williams, P. H., Winter, E., Zimmermann, D., & Ghisbain, G. (2026) Measuring the pulse of European

biodiversity using the Red List. European Red List of Bees. Brussels, Belgium: European Commission. xi + 176 pp, https://doi.org/10.2779/521877

[3] Van Swaay, C., Warren, M., Ellis, S., Clay, J., Bellotto, V., Allen, D.J. and Trottet, A. (2025) Measuring the pulse of European biodiversity using the Red List. European Red List of Butterflies version 1.1. Brussels, Belgium: European Commission. https://doi.org/10.2779/1280375.

[4] Vujić, A., Gilbert, F., Flinn, G., Englefield, E., Varga, Z., Ferreira, C. C., Eggert, F., Woolcock, S., Böhm, M., Vbra, J., Mergy, R., Ssymank, A., van Steenis, W., Aracil, A., Földesi, R., Grković, A., Mazanek, L., Nedeljković, Z., Pennards, G. W. A., … Veličković, N. (2022) Pollinators on the edge: our European hoverflies. The European Red List of Hoverflies. https://data.europa.eu/doi/10.2779/359875

[5] Davis, A. E., Rowbottom, R., Schmidt, L. A., Preradovic, J., Santos, K. C., Dawson, B. M., ... & Rader, R. (2026) Managed fly pollinators ensure berry crop yields under variable weather conditions. *Agriculture, Ecosystems & Environment*, *400*, 110254. https://doi.org/10.1016/j.agee.2026.110254

[6] Osterman, J., Aizen, M. A., Biesmeijer, J. C., Bosch, J., Howlett, B. G., Inouye, D. W., ... & Paxton, R. J. (2021) Global trends in the number and diversity of managed pollinator species. *Agriculture, Ecosystems & Environment*, *322*, 107653. https://doi.org/10.1016/j.agee.2021.107653

[7] Peña-Kairath, C., Delclòs, X., Álvarez-Parra, S., Peñalver, E., Engel, M.S., Ollerton, J. & Peris, D. (2023) Insect pollination in deep time. Trends in Ecology & Evolution 38: 749-759 https://doi.org/10.1016/j.tree.2023.03.008

[8] IPBES (2016) The Assessment Report on Pollinators, Pollination and Food Production. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. http://doi.org/10.5281/zenodo.3402856.

[9] Uwingabire, Z., Vanbergen, A.J., Damiens, F.L.P., Breeze, T.D., van der Wal, R., and Young, J.C. (2025) Worldviews and values of key societal actors influencing decision-making around nature: The case of wild pollinator conservation in Europe. People and Nature 7:1366-1381. https://doi.org/10.1002/pan3.70035

[10] UK HM Government (2026) Global biodiversity loss, ecosystem collapse and national security: A national security assessment https://assets.publishing.service.gov.uk/media/696e0eae719d837d69afc7de/National_security_assessment_-_global_biodiversity_loss__ecosystem_collapse_and_national_security.pdf

[11] Tong, Z. Y., Wu, L. Y., Feng, H. H., Zhang, M., Armbruster, W. S., Renner, S. S., & Huang, S. Q. (2023) New calculations indicate that 90% of flowering plant species are animal-pollinated. *National Science Review*, *10*(10), nwad219. https://doi.org/10.1093/nsr/nwad219

[12] Ollerton, J., Winfree, R., & Tarrant, S. (2011) How many flowering plants are pollinated by animals?. Oikos, 120(3), 321-326. https://doi.org/10.1111/j.1600-0706.2010.18644.x

[13] Klein, A. M., Vaissière, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. A., Kremen, C., & Tscharntke, T. (2007) Importance of pollinators in changing landscapes for world crops. Proceedings of the royal society B: biological sciences, 274(1608),303-313. https://doi.org/10.1098/rspb.2006.3721

[14] Eilers, E. J., Kremen, C., Smith Greenleaf, S., Garber, A. K., & Klein, A. M. (2011) Contribution of pollinator-mediated crops to nutrients in the human food supply. *PLoS one*, 6(6), e21363. https://doi.org/10.1371/journal.pone.0021363.

[15] Smith, M. R., Singh, G. M., Mozaffarian, D., & Myers, S. S. (2015) Effects of decreases of animal pollinators on human nutrition and global health: a modelling analysis. The Lancet, 386(10007), 1964-1972. https://doi.org/10.1016/S0140-6736(15)61085-6

[16] Smith, M.R., Mueller, N.D., Springmann, M., Sulser, T.B., Garibaldi, L.A., Gerber, J., Wiebe, K., and Myers, S.S.(2022) Pollinator deficits, food consumption, and consequences for human health: a modeling study. Environmental Health Perspectives, 130(12), 127003. https://pmc.ncbi.nlm.nih.gov/articles/PMC9749483/

[17] Murphy, J. T., Breeze, T. D., Willcox, B., Kavanagh, S., & Stout, J. C. (2022) Globalisation and pollinators: Pollinator declines are an economic threat to global food systems. *People and Nature*, *4*(3), 773-785. https://doi.org/10.1002/pan3.10314

[18] Feuerbacher, A., Kempen, M., Steidle, J. L., & Wieck, C. (2025) The economic, agricultural, and food security repercussions of a wild pollinator collapse in Europe. *Nature Communications*, *16*(1), 9892. https://doi.org/10.1038/s41467-025-65414-7

[19] Aizen, M.A., Garibaldi, L.A., Cunningham, S.A., Klein, A.M. (2009) How much does agriculture depend on pollinators? Lessons from long-term trends in crop production. Annals of Botany 103:1579-1588. https://doi.org/10.1093/aob/mcp076

[20] Biesmeijer, J. C., Roberts, S. P., Reemer, M., Ohlemuller, R., Edwards, M., Peeters, T., ... & Kunin, W. E. (2006) Parallel declines in pollinators and insect-pollinated plants in Britain and the Netherlands. *Science*, *313*(5785), 351-354. https://doi.org/10.1126/science.1127863

[21] European Environment Agency (2025) Protecting and restoring Europe's wild pollinators and their habitats. Briefing. https://www.eea.europa.eu/en/analysis/publications/protecting-and-restoring-europes-wild-pollinators-and-their-habitats

[22] Zattara EE, Aizen MA (2020) Worldwide occurrence records reflect a global decline in bee species richness. One Earth, 4:114- 123 http://dx.doi.org/10.1016/j.oneear.2020.12.005

[23] Wood T., Michez D., Paxton R., Drossart M., Neumann P., Gérard M., Vanderplanck M., Barraud A., Martinet B., Leclercq N., Vereecken N.J. (2020) Managed honey bees as a radar for wild bee decline? Apidologie, 51(6): 1100-1116. https://dx.doi.org/10.1007/s13592-020-00788-9

[24] Mainardi G., Sponsler D., Minaud E., Vardakas F., Charistos L., Requier F., Hatjina F., Steffan-Dewenter I. (2025) Floral diversity enhances winter survival of honeybee colonies across climatic regions. Journal of Applied Ecology 62: 1487-1497. https://doi.org/10.1111/1365-2664.70054

[25] Rutschmann B, Kohl PL, Steffan-Dewenter I (2023) Foraging distances, habitat preferences and seasonal colony performance of honeybees in Central European forest landscapes. Journal of Applied Ecology 60: 1056-1066. https://doi.org/10.1111/1365-2664.14389

[26] Howard, C., Buchori, D., Carvalheiro, L. G., Hogendoorn, K., Jha, S., Lattorff, H.M.G., Ngo, H.T., Seymour C. L., Senapathi D., & Potts, S.G. (2025) Emerging threats and opportunities for conservation of global pollinators A rapid assessment for Bee:wild https://www.beewild.org/uploads/2025/10/Emerging-Threats-Full-Report.pdf

[27] Filipiak, M., & Filipiak, Z.M. (2022) Application of ionomics and ecological stoichiometry in conservation biology: Nutrient demand and supply in a changing environment. *Biological Conservation*, *272*, 109622. https://doi.org/10.1016/j.biocon.2022.109622

[28] Dewaele J., Javal M., Pinchon A., Evrard D., Hautekèete N., Michez D., Cuvillier V. (2025) Acute exposure to environmental doses of di-n-butyl phthalate but not di-2-ethylhexyl phthalate induces mortality in isolated and cold-stressed workers of Bombus terrestris L. (Hymenoptera: Apidae). Environmental Research, 286: 122836 https://doi.org/10.1016/j.envres.2025.122836

[29] Ryalls, J.M., Langford, B., Mullinger, N.J., Bromfield, L.M., Nemitz, E., Pfrang, C. and Girling, R.D., (2022) Anthropogenic air pollutants reduce insect-mediated pollination services. Environmental Pollution, 297, p.118847. https://doi.org/10.1016/j.envpol.2022.118847

[30] Duque, L., Steffan-Dewenter, I. (2024) Air pollution: a threat to insect pollination. Frontiers in Ecology and the Environment 22: e2701. https://doi.org/10.1002/fee.2701

[31] Dicks, L.V., Breeze, T.D., Ngo, H.T., Senapathi, D., An, J., Aizen, M.A., Basu, P., Buchori, D., Galetto, L., Garibaldi, L.A., Gemmill-Herren, B., Howlett, B.G., Imperatriz-Fonseca, V.L., Johnson, S.D., Kovács-Hostyánszki, A., Kwon, Y.J., Lattorff, H.M.G., Lungharwo, T., Seymour, C.L., Vanbergen, A.J. and Potts, S.G. (2021) A global-scale expert assessment of drivers and risks associated with pollinator decline. Nature Ecology & Evolution. https://doi.org/10.1038/s41559-021-01534-9

[32] David, T. I., Storkey, J., & Stevens, C. J. (2019) Understanding how changing soil nitrogen affects plant–pollinator interactions. Arthropod-Plant Interactions, 13(5), 671-684 https://doi.org/10.1007/s11829-019-09714-y

[33] Klop, E., Omon, B., & WallisDeVries, M. F. (2015) Impact of nitrogen deposition on larval habitats: the case of the Wall Brown butterfly Lasiommata megera. *Journal of Insect Conservation*, *19*(2), 393-402. https://doi.org/10.1007/s10841-014-9748-z

[34] Midolo, G., Clark, A. T., Chytrý, M., Essl, F., Dullinger, S., Jandt, U., ... & Keil, P. (2026) Sixty years of plant community change in Europe indicate a shift toward nutrient-richer and denser vegetation. *Science Advances*, *12*(15), eaeb2493. https://doi.org/10.1126/sciadv.aeb2493

[35] Soroye, P., Newbold, T. and Kerr, J. (2020) Climate change contributes to widespread declines among bumble bees across continents. Science 367:685-688. https://doi.org/10.1126/science.aax8591

[36] Antão, L.H., Weigel, B., Strona, G., Hällfors, M., Kaarlejärvi, E., Dallas, T., ... & Laine, A.L. (2022) Climate change reshuffles northern species within their niches. Nature Climate Change 12:587-592. https://doi.org/10.1038/s41558-022-01381-x

[37] Hamilton CW et al (2024) Predicting the suitable habitat distribution of berry plants under climate change. Landsc. Ecol. 39:18. https://doi.org/10.1007/s10980-024-01839-7

[38] Korten H, Steffan-Dewenter I (2026) Drought events reduce reproductive success of a long-tongued bumblebee species. Proceedings of the Royal Society B: Biological Sciences 293. https://doi.org/10.1098/rspb.2025.3056

[39] Ziska, L.H., Pettis, J.S., Edwards, J., Hancock, J.E., Tomecek, M.B., Clark, A., Dukees, J.S., Loladze, I, and Polley, H.W. (2016) Rising atmospheric CO_2 is reducing the protein concentration of a floral pollen source essential for North American bees. Proceedings of the Royal Society B: Biological Sciences, 283(1828). https://doi.org/10.1098/rspb.2016.0414

[40] Kaspari, M., & Welti, E.A. (2024) Nutrient dilution and the future of herbivore populations. Trends in Ecology & Evolution, 39(9), 809-820. https://doi.org/10.1016/j.tree.2024.05.001

[41] Filipiak, Z. M., Mayoral, C., Mills, S. A., Hayward, S. A., & Ullah, S. (2024) Elevated atmospheric CO_2 alters the multi-element stoichiometry of pollen-bearing oak flowers, with possible negative effects on bees. *Oecologia*, *206*(1), 101-114. https://doi.org/10.1007/s00442-024-05610-2

[42] Welti, E.A., & Kaspari, M. (2024) Elevated CO_2, nutrition dilution, and shifts in Earth's insect abundance. Current Opinion in Insect Science, 65, 101255. https://doi.org/10.1016/j.cois.2024.101255

[43] Vanbergen, A. J., A. Espíndola, and M. A. Aizen (2018) Risks to pollinators and pollination from invasive alien species. Nature Ecology & Evolution 2:16-25.

[44] Tourbez C. de Manincor N., Ghisbain G., Michez D. (2025) Attractiveness of exotic invasive plants can disconnect native plants from their floral visitors. Oikos, 2025: e11482

[45] Proesmans, W., C. Alaux, M. Albrecht, K. Bassit, N. Cyrille, A. Dalmon, V. Diévart, C. Dominik, E. Felten, A. Gajda, J. M. Heuschele, E. Laurent, C. Maurer, P. Neumann, M. Pioz, A. Schauer, O. Schweiger, J. Settele, E. Stolle, H. Szentgyörgyi, O. Yañez, Y. Liu, A. Żmuda, R. J. Paxton, and A. J. Vanbergen (2026) Drivers of Viral Prevalence in Landscape-Scale Pollinator Networks Across Europe: Honey Bee Viral Density, Niche Overlap With This Reservoir Host and Network Architecture. Ecology Letters 29:e70309. https://doi.org/10.1111/ele.70309

[46] Maurer, C., Yañez, O., Schauer, A. Neumann, P., Vanbergen, A.J., Schweiger, O., Paxton, R.J., Szentgyörgyi, H., Pellissier, L., and Albrecht, M.. (2026) Resident viruses, but not honeybee-associated viruses, impair solitary bee fitness in the field. Proceedings of the Royal Society B: Biological Sciences 293. https://doi.org/10.1098/rspb.2025.1940

[47] Maurer, C., Schauer, A., Yañez, O., Neumann, P., Gajda, A., Paxton, R.J., Pellissier, L., Schweiger, O., Szentgyörgyi, H., Vanbergen, A.J., and Albrecht, M. (2024) Species traits, landscape quality and floral resource overlap with honeybees determine virus transmission in plant-pollinator networks. Nature Ecology & Evolution 8:2239-2251. https://doi.org/10.1038/s41559-024-02555-w

[48] Wagner, D. L., Grames, E. M., Forister, M. L., Berenbaum, M. R., & Stopak, D. (2021) Insect decline in the Anthropocene: Death by a thousand cuts. *Proceedings of the National Academy of Sciences*, *118*(2), e2023989118 https://doi.org/10.1073/pnas.2023989118

[49] Jablonski, D., & Edie, S. M. (2023) Perfect storms shape biodiversity in time and space. *Evolutionary Journal of the Linnean Society*, *2*(1), kzad003. https://doi.org/10.1093/evolinnean/kzad003

[50] Gliessman, S. (2018) Defining agroecology. Agroecology and sustainable food systems, 42(6), 599-600. https://doi.org/10.1080/21683565.2018.1432329

[51] Vanbergen, A.J., Aizen, M.A., Cordeau, S., Garibaldi, L.A., Garratt, M.P.D., Kovács-Hostyánszki, A., Lecuyer, L., Ngo, H.T., Potts, S.G., Settele, J., Skrimizea, E., and Young, J.C. (2020) Transformation of agricultural landscapes in the Anthropocene: Nature's contributions to people, agriculture and food security. Advances in Ecological Research 63 (I):193-253. https://doi.org/10.1016/bs.aecr.2020.08.002

[52] Kovács-Hostyánszki, A., A. Espíndola, A. J. Vanbergen, J. Settele, C. Kremen, and L. V. Dicks. (2017) Ecological intensification to mitigate impacts of conventional intensive land

use on pollinators and pollination. Ecology Letters 20:673-689. https://doi.org/10.1111/ele.12762

[53] Martin, E.A., Dainese, M., Clough, Y., Báldi, A., Bommarco, R., Gagic, V., Garratt, M.P., Holzschuh, A., Kleijn, D., Kovács-Hostyánszki, A., Marini, L., Potts, S.G., Smith, H.G., Al Hassan, D., Albrecht, M., Andersson, G.K., Asís, J.D., Aviron, S., Balzan, M.V., Baños-Picón, L., Bartomeus, I., Batáry, P., Burel, F., Caballero-López, B., Concepción, E.D., Coudrain, V., Dänhardt, J., Diaz, M., Diekötter, T., Dormann, C.F., Duflot, R., Entling, M.H., Farwig, N., Fischer, C., Frank, T., Garibaldi, L.A., Hermann, J., Herzog, F., Inclán, D., Jacot, K., Jauker, F., Jeanneret, P., Kaiser, M., Krauss, J., Le Féon, V., Marshall, J., Moonen, A., Moreno, G., Riedinger, V., Rundlöf, M., Rusch, A., Scheper, J., Schneider, G., Schüepp, C., Stutz, S., Sutter, L., Tamburini, G., Thies, C., Tormos, J., Tscharntke, T., Tschumi, M., Uzman, D., Wagner, C., Zubair-Anjum, M., Steffan-Dewenter, I. (2019) The interplay of landscape composition and configuration: new pathways to manage functional biodiversity and agroecosystem services across Europe. Ecology Letters 22: 1083-1094. https://doi.org/10.1111/ele.13265

[54] Gionfra, S., Cividino, R., Damiens, F., Van der Wal, R. (2024) Towards pollinator-friendly policy and practices: worldviews, opportunities and barriers. Policy brief written by IUCN and SLU for Safeguard (H2020 project No. 101003476). Zenodo. https://doi.org/10.5281/zenodo.14904853

[55] Dasgupta, P. (2025) On Natural Capital. Penguin: London.

[56] Altmire, G.R., and York, R. (2026) The Anthophilic rift: advancing a sociology of biodiversity loss through the pollination crisis. *Environmental Sociology*, 1-14. https://doi.org/10.1080/23251042.2026.2626279

[57] Patel, V., Pauli, N., Biggs, E., Barbour, L., & Boruff, B. (2025). Why bees are critical for achieving sustainable development 1. In The Routledge Handbook of Global Sustainability Education and Thinking for the 21st Century (pp. 37-51). Routledge India

[58] O'Brien, K., Garibaldi, L. A., Agrawal, A., Bennett, E., Biggs, R., Calderón Contreras, R., Carr, E. R., Frantzeskaki, N., Gosnell, H., Gurung, J., Lambertucci, S. A., Leventon, J., Chuan, L., Reyes García, V., Shannon, L., Villasante, S., Wickson, F., Zinngrebe, Y., & Périanin, L. (2025) IPBES Transformative Change Assessment: Summary for Policymakers. Zenodo. https://doi.org/10.5281/zenodo.17099400

[59] Gurung, J., Leventon, J., Wickson, F., Dabezies, J., Olemako, T., Penca, J., Rajvanshi, A., Roseline, R., Turnhout, E., Yoshida, Y., Kahrić, A., Naggea, J., & Renaud, A. (2025) IPBES Transformative Change Assessment: Chapter 1. Transformative change and a sustainable world. Zenodo. https://doi.org/10.5281/zenodo.19820195

[60] Van der Sluijs, J.P. and Vaage, N.S. (2016) Pollinators and global food security: the need for holistic global stewardship. Food ethics, 1(1), 75-91. https://doi.org/10.1007/s41055-016-0003-z

[61] Thorsøe, M.H.; Ādamsone-Fiskoviča, A.; Rasmussen, C.; Kanonarchi, F.; Kleftodimos, G.; Bach, J.L.; Dicks, L.; Fedoriak, M.; Gallai, N.; Angelstam, P.K.; Stone, T.F. & Breeze, T.D. (2024) Inconsistencies between promise and performance of policy designs for pollinator restoration. Deliverable D4.2 EU Horizon RestPoll Project, Grant agreement No. 101082102 https://restpoll.eu/wp-content/uploads/2025/04/D4.2_Policy_coherence_analysis_RestPoll_WP4.2_AU_v1.pdf

[62] Kureethadam, J. I. (2018) *The philosophical roots of the ecological crisis: Descartes and the modern worldview*. Cambridge Scholars Publishing.

[63] IPBES (2022) Methodological Assessment Report on the Diverse Values and Valuation of Nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Balvanera P., Pascual U., Christie M., Baptiste B., González-Jiménez D.(eds.). IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.6522522

[64] van der Sluijs, J. P., Foucart, S. & Casas, J. (2021) Editorial overview: Halting the pollinator crisis requires entomologists to step up and assume their societal responsibilities. Current Opinion in Insect Science 46, vi-xiii. https://doi.org/10.1016/j.cois.2021.08.004

[65] Razzaque, J., Visseren-Hamakers, I. J., McElwee, P., Rusch, G. M., Kelemen, E., Turnhout, E., ... Muradian, R. (2019) Options for decision-makers. In E. S. Brondízio, J. Settele, S. Díaz, & H. Ngo (Eds.), Global assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany: IPBES. https://doi.org/10.5281/zenodo.3832108

[66] IPBES (2024). Thematic Assessment Report on the Underlying Causes of Biodiversity Loss and the Determinants of Transformative Change and Options for Achieving the 2050 Vision for Biodiversity of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (Transformative Change Assessment). O'Brien, K., Garibaldi, L., and Agrawal, A. (eds.). IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.11382215

[67] RECIPES (2022) Guidance on the application of the precautionary principle in the EU. https://recipes-project.eu/results/guidance-future-application-precautionary-principle.html

[68] Hill, R., Nates-Parra, G., Quezada-Euán, J.J.G. et al. Biocultural approaches to pollinator conservation. Nat Sustain 2, 214–222 (2019). https://doi.org/10.1038/s41893-019-0244-z

[69] McBride, B. B., Brewer, C. A., Berkowitz, A. R., & Borrie, W. T. (2013) Environmental literacy, ecological literacy, ecoliteracy: What do we mean and how did we get here?. Ecosphere, 4(5), 1-20. https://doi.org/10.1890/ES13-00075.1

[70] Díaz, S., Settele, J., Brondízio, E. S., Ngo, H.T., Agard, J., Arneth, A., ... & Zayas, C.N. (2019) Pervasive human-driven decline of life on Earth points to the need for transformative change. *Science*, *366*(6471), eaax3100. https://doi.org/10.1126/science.aax3100

[71] Van der Sluijs, J. P. (2020) Insect decline, an emerging global environmental risk. *Current opinion in environmental sustainability*, *46*, 39-42. https://doi.org/10.1016/j.cosust.2020.08.012

[72] Kinneen, L, Metodiev, T, Ngo, H. and Thijssen, M, Senapathi, D. and Potts, S.G. (2022) Pollinators are critical for the SDGs and vice versa. Policy Brief for CBD COP15. https://www.safeguard.biozentrum.uni-wuerzburg.de/Project/PublicFileSystem/media/others/SAFEGUARD_COP15_PolicyBrief.pdf

[73] Ollerton, J. (2021) Pollinators & Pollination: Nature and Society. Pelagic Publishing, Exeter, UK

[74] Dekker, A., Hage, A., Leendertse P. Ohman Nielsen, M-B, Frøyen, A.J., Løvlund Bach, J., Craig, S.B.B, Rasmussen, C., Thorsøe, Olsen, M.C.A., Maxim, L., Requier, F., Biella, P., Brambilla, G., Galassini, A.A.R., Labra, M., De la Rúa, P., López, V.M., Vlontzos, G. and van der Sluijs, J.P. (2026) Territorial diagnosis and Living Lab formulation. Deliverable 7.1 of Butterfly. https://butterfly-europe.eu/deliverable-7-1-territorial-diagnosis-and-living-lab-formulation/

[75] Garibaldi, L. A., Gomez Carella, D. S., Nabaes Jodar, D. N., Smith, M. R., Timberlake, T. P., & Myers, S. S. (2022) Exploring connections between pollinator health and human health. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *377*(1853). https://doi.org/10.1098/rstb.2021.0158

[76] Prata, J.C.; Ribeiro, A.I.; Rocha-Santos, T. (2022) An Introduction to the Concept of One Health. In: One Health, pp. 1–31. Elsevier: Amsterdam.

[77] Bremer, S., Meisch, S., Hempel, M., & Dunn-Sigouin, E. (2026) Adapting seasonal beekeeping patterns in western Norway. Time & Society, 35(1), 45-72. https://doi.org/10.1177/0961463X241275003

[78] Geldmann, J., & González-Varo, J.P. (2018) Conserving honey bees does not help wildlife. *Science*, *359*(6374), 392-393. https://doi.org/10.1126/science.aar2269

[79] Lithgow, D., Martínez, M. L., Silva, R., Geneletti, D., Gallego-Fernández, J. B., Cerdán, C. R., Mendoza, E., & Jermain, A. (2017) Ecosystem Services to Enhance Coastal Resilience in Mexico: The Gap between the Perceptions of Decision-Makers and Academics. Journal of Coastal Research, 116–126. https://doi.org/10.2112/SI77-012.1

[80] Topping, C.J., Norton, M., Wogram, J., & Axelman, J. (2025) Escaping the Reductionistic Trap: A Systems-Based Approach to Environmental Risk Assessment. *Environmental Science & Technology*, *60*(1), 3-6. https://doi.org/10.1021/acs.est.5c16333

[81] Axelman, J., Aldrich, A., Duquesne, S., Backhaus, T., Brendel, S., Focks, A., ... & Sousa, J. P. (2024) A systems-based analysis to rethink the European environmental risk assessment of regulated chemicals using pesticides as a pilot case. *Science of The Total Environment*, *948*, 174526. https://doi.org/10.1016/j.scitotenv.2024.174526

[82] Knapp, J., Dicks, L., Kranke, N., Morgan, W., Potts, S., Smith, H.G., Stout, J., Thijssen, M., Thompson, A., Klein, A.M. (2026) Restoring pollinators in Europe: Evidence-based actions for Nature Restoration Plans. Policy brief written by RestPoll (EU Horizon project No. 101082102) Zenodo. https://doi.org/10.5281/zenodo.18655302

[83] Ulyshen, M., Urban-Mead, K.R., Dorey, J.B., and Rivers, J.W.. (2023) Forests are critically important to global pollinator diversity and enhance pollination in adjacent crops. Biological Reviews 98:1118–1141. https://doi.org/10.1111/brv.12947

[84] Vujanovic, D., Losapio, G., Mészáros, M., Popov, S., Markov Ristic, Z., Mudri Stojnic, S., Jovic, J, and Vujic, A. (2023) Forest and grassland habitats support pollinator diversity more than wildflowers and sunflower monoculture. Ecological Entomology, 48(4), 421-432. https://doi.org/10.1111/een.13234

[85] Walton, R. E., Sayer, C.D., Bennion, H., & Axmacher, J.C. (2020) Nocturnal pollinators strongly contribute to pollen transport of wild flowers in an agricultural landscape. Biology letters, 16(5). https://doi.org/10.1098/rsbl.2019.0877

[86] Buxton, M.N., Gaskett, A.C., Lord, J.M., & Pattemore, D.E. (2022) A global review demonstrating the importance of nocturnal pollinators for crop plants. Journal of Applied Ecology, 59(12), 2890-2901. https://doi.org/10.1111/1365-2664.14284

[87] Ganuza C, Redlich S, Uhler J, Tobisch C, Rojas-Botero S, Peters MK, Zhang J, Benjamin CS, Englmeier J, Ewald J, Fricke U, Haensel M, Kollmann J, Riebl R, Uphus L, Müller J, Steffan-Dewenter I (2022) Interactive effects of climate and land use on pollinator diversity differ among taxa and scales. Science Advances 8: eabm9359. https://doi.org/10.1126/sciadv.abm9359

[88] Schulze S, Maihoff F, Zhang J, Kessner-Beierlein D, Bender A, Schöninger A, Holzschuh A, Steffan-Dewenter I (2026) More than flowers: Habitat type, floral resources, and landscape context shape pollinator communities in villages. Ecological Applications 36: e70190. https://doi.org/10.1002/eap.70190

[89] Filipiak, Z. M., Denisow, B., Stawiarz, E., & Filipiak, M. (2022) Unravelling the dependence of a wild bee on floral diversity and composition using a feeding experiment. *Science of the Total Environment*, *820*, 153326. https://doi.org/10.1016/j.scitotenv.2022.153326

[90] European Commission (2025) Supplementing Regulation (EU) 2024/1991 of the European Parliament and of the Council by establishing a science-based method for monitoring pollinator diversity and pollinator populations. Commission delegated regulation (EU) 2025/2188. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202502188

[91] Thorsøe, M.H., Munkholm, L.J., Berg, T. R., Graversgaard, M., Witt, N., Krabbe, K., ... & Noe, E.B. (2026) The Farmer and Soil Health: Understanding the Foundation for Sustainable Soil Management. *European Journal of Soil Science*, *77*(2), e70294. https://doi.org/10.1111/ejss.70294

[92] Bishop, G.A., Kleijn, D., Albrecht, M., Bartomeus, I., Isaacs, R., Kremen, C., ... & Fijen, T. P. (2025) Critical habitat thresholds for effective pollinator conservation in agricultural landscapes. *Science*, *389*(6767), 1314-1319. https://doi.org/10.1126/science.adr2146

[93] EC (2025) A Vision for Agriculture and Food: Shaping together an attractive farming and agri-food sector for future generations https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52025DC0075

[94] EC (2009) Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02009L0128-20190726

[95] European Parliament (2024) Legislative train 08.2024, 1a European Green Deal, Proposal for a regulation on the sustainable use of plant protection products. https://www.europarl.europa.eu/legislative-train/carriage/sustainable-use-of-pesticides-%E2%80%93-revision-of-the-eu-rules/report?sid=8301

[96] Deguine, J.P., Aubertot, J.N., Flor, R.J., Lescourret, F., Wyckhuys, K.A., & Ratnadass, A. (2021) Integrated pest management: good intentions, hard realities. A review. *Agronomy for Sustainable Development*, *41*(3), 38. https://doi.org//10.1007/S13593-021-00689-W

[97] European Food Safety Authority (EFSA), Adriaanse, P., Arce, A., Focks, A., Ingels, B., Jölli, D., ... & Auteri, D. (2023) Revised guidance on the risk assessment of plant protection products on bees (Apis mellifera, Bombus spp. and solitary bees). *EFSA Journal*, *21*(5), e07989. https://doi.org/10.2903/j.efsa.2023.7989

[98] Barraud A., Askri D., Barascou L., Schwartz J.M., Toktas Y., Nicodème L., Alaux C., Albrecht M., Arafah K., Bulet P., Vanderplanck M., Michez D. (2025) Facing multiple threats: diet–pesticide interactions in bumblebees. Science of the Total Environment, 1004: 180716. https://doi.org/10.1016/j.scitotenv.2025.180716

[99] Nicholson, C. C., Knapp, J., Kiljanek, T., Albrecht, M., Chauzat, M. P., Costa, C., de la Rúa, P., Klein, A. M., Mänd, M., Potts, S. G., Schweiger, O., Bottero, I., Cini, E., de Miranda, J. R., di Prisco, G., Dominik, C., Hodge, S., Kaunath, V., Knauer, A., ... Rundlöf, M. (2024) Pesticide use negatively affects bumble bees across European landscapes. Nature, 628(8007), 355–358. https://doi.org/10.1038/s41586-023-06773-3

[100] Baron, G.L., Raine, N.E., Brown, M.J.F. (2014) Impact of chronic exposure to a pyrethroid pesticide on bumblebees and interactions with a trypanosome parasite. J. Appl. Ecol. 51 (2), 460–469. https://doi.org/10.1111/1365-2664.12205

[101] Johnson, R.M., Dahlgren, L., Siegfried, B.D., Ellis, M.D. (2013) Acaricide, fungicide and drug interactions in honey bees (Apis mellifera). PloS One 8 (1). https://doi.org/10.1371/journal.pone.0054092

[102] European Commission (2023) Save bees and farmers ! Towards a bee-friendly agriculture for a healthy environment. https://europa.eu/citizens-initiative/initiatives/details/2019/000016_en

[103] Reverté, S., Ghisbain, G., Albrecht, M., Bartomeus, I., Bellotto, V., Bogusch, P., Boustani, M., Fiordaliso, W., Flaminio, S., Fornoff, F., Gaspar, H., Gekière, A., Geslin, B., Ješovnik, A., Ortiz-Sánchez, F.J., Petanidou, T., Potts, S.G., Radchenko, V., Ruiz, C., Soares, A., Soon, V., Stavrinides, M., Straka, J., Tourbez, C., Trottet, A., Underwood, E., Wood, T.J., Zimmerman, D., Lees, C., Garn, A.-K. and Michez, D. (2026) European Wild Bees: Moving from assessment to conservation planning, 2025. A report to the European Commission by the IUCN SSC Wild Bee Specialist Group and the IUCN SSC Brussels, Belgium: European Commission. https://doi.org/10.2779/5662020

[104] Health Council of the Netherlands (2025) Health gains through the use of biocontrol for plant protection. https://www.healthcouncil.nl/latest/news/2025/11/12/improve-authorisation-and-application-of-natural-plant-protection

[105] Perkins, R., Glauser, G., & Goulson, D. (2025) Swimming emissions from dogs treated with spot-on fipronil or imidacloprid: Assessing the environmental risk. *Veterinary Record*, *196*(11), e5560.

[106] Topping, C.J., Simon Delso, N, Williams, J.H. and Axelman, J. (2025) Reforming EU chemical risk assessment: from regulatory bottlenecks to systems solutions. PollinERA policy brief. https://doi.org/10.3897/arphapreprints.e180508

[107] Stewart, R., et al., 2017, 'Ecosystem services across the aquatic–terrestrial boundary: Linking ponds to pollination', *Basic and Applied Ecology* 18, pp. 13-20 https://doi.org/10.1016/j.baae.2016.09.006

[108] Drivdal L., Camorani, S., De Smedt, K, Dreyer, M., Edelenbosch R, Lemus, D., Sikma, T., Vos, E. and van der Sluijs, J.P. (2022) Sector specific briefs on the application of the precautionary principle (sectors chemicals and gene technology) RECIPES Deliverable 3.3. https://recipes-project.eu/sites/default/files/2022-07/D.3.3%20Sector%20Briefs-Final.pdf

[109] Vaudo A., Tooker J., Patch H., Biddinger D., Coccia M., Crone M., Fiely M., Francis J., Hines H., Hodges M., Jackson S., Michez D., Mu J., Russo L., Safari M., Treanore E., Vanderplanck M., Yip E., Leonard A., Grozinger C. (2020) Pollen Protein: Lipid macronutrient ratios may guide broad patterns of bee species floral preferences. Insects, 11(2): 132. https://doi.org/10.3390/insects11020132

[110] Barraud A., Barascou L., Lefebvre V., Sene D., Le Conte Y., Alaux C., Grillenzoni F.-V., Corvucci F., Serra G., Costa C., Vanderplanck M., Michez D. (2022) Variations in Nutritional Requirements Across Bee Species. Frontiers in Sustainable Food Systems, 6: 824750. https://doi.org/10.3389/fsufs.2022.824750

[111] New genomic techniques: deal to support the green transition in farming | News | European Parliament https://www.europarl.europa.eu/news/en/press-room/20251201IPR31710/new-genomic-techniques-deal-to-support-the-green-transition-in-farming

[112] Aviron, S., Sanvido, O., Romeis, J., Herzog, F., & Bigler, F. (2009) Case-specific monitoring of butterflies to determine potential effects of transgenic Bt-maize in Switzerland. Agriculture, Ecosystems & Environment, 131(3-4), 137-144. https://doi.org/10.1016/j.agee.2009.01.007

[113] Drivdal, L. and van der Sluijs, J.P. (2021) Pollinator conservation requires a stronger and broader application of the precautionary principle. *Current Opinion in Insect Science*, *46*, 95-105. https://doi.org/10.1016/j.cois.2021.04.005

[114] IPBES (2019) Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. S. Díaz, J. Settele, E. S. Brondízio E.S., H. T. Ngo, M. Guèze, J. Agard, A. Arneth, P. Balvanera, K. A. Brauman, S. H. M. Butchart, K. M. A. Chan, L. A. Garibaldi, K. Ichii, J. Liu, S. M. Subramanian, G. F. Midgley, P. Miloslavich, Z. Molnár, D. Obura, A. Pfaff, S. Polasky, A. Purvis, J. Razzaque, B. Reyers, R. Roy Chowdhury, Y. J. Shin, I. J. Visseren-Hamakers, K. J. Willis, and C. N. Zayas (eds.). IPBES secretariat, Bonn, Germany. https://files.ipbes.net/ipbes-web-prod-public-files/inline/files/ipbes_global_assessment_report_summary_for_policymakers.pdf

[115] Pereira, H.M., Martins, I.S., Rosa, I.M., Kim, H., Leadley, P., Popp, A., ... & Alkemade, R. (2024) Global trends and scenarios for terrestrial biodiversity and ecosystem services from 1900 to 2050. Science, 384(6694), 458-465. https://doi.org/10.1126/science.adn3441

[116] Maxim, L., Spangenberg, J. H., & O'Connor, M. (2009) An analysis of risks for biodiversity under the DPSIR framework. Ecological economics, 69(1), 12-23. https://doi.org/10.1016/j.ecolecon.2009.03.017

[117] McLeod, L.J., Kitson, J.C., Dorner, Z., Tassell-Matamua, N.A., Stahlmann-Brown, P., Milfont, T.L., & Hine, D.W. (2024) Environmental stewardship: A systematic scoping review. PLoS One, 19(5), e0284255. https://doi.org/10.1371/journal.pone.0284255

[118] US EPA. (2005) Everyday choices: opportunities for environmental stewardship. https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P1004DHB.txt

Appendix 1

Authors and Signatories

Authors:

1. **Jeroen P. van der Sluijs** (convening lead-author / corresponding author jeroen.sluijs@uib.no) (Butterfly). Coordinator of Butterfly. Centre for the Study of the Sciences and the Humanities, University of Bergen, Bergen, Norway.
2. **Noa Simon Delso** (convening lead-author) (Butterfly, PollinERA). Policy leader in both projects. BeeLife European Beekeeping Coordination, Brussels, Belgium.
3. **Johan Axelman** (PollinERA). Social-Ecological Systems Simulation Centre (SESS), Section for Agricultural Biodiversity, Department of Agroecology, Aarhus University.
4. **Ignasi Bartomeus** (VALOR, AGRI4POL, Safeguard). Estación Biológica de Doñana (EBD-CSIC). Seville, Spain.
5. **Tom Breeze** (VALOR, WildPosh, AGRI4POL, RestPoll, Safeguard). Co-ordinator of VALOR, Work Package leader of Agri4POL WP5 (Social & economic opportunities and obstacles towards pollinator-friendly food systems). University of Reading. UK.
6. **Scott Bremer** (Butterfly). Centre for the Study of the Sciences and the Humanities, University of Bergen, Bergen, Norway; NORCE Norwegian Research Centre, Bergen, Norway.
7. **Florence L.P. Damiens** (VALOR, Safeguard). Department of Ecology, Swedish University of Agricultural Sciences.
8. **Michal Filipiak** (Butterfly, ProPollSoil). Jagiellonian University in Kraków, Faculty of Biology, Institute of Environmental Sciences; Kraków, Poland.
9. **Nicola Gallai** (Butterfly, RestPoll). Université de Toulouse, ENSFEA, UT2J, UTTOP, LEREPS, Toulouse, France.
10. **Georgios Kleftodimos** (Butterfly, ProPollSoil, RestPoll). CIHEAM-IAMM (Institut Agronomique Méditerranéen de Montpellier), Montpellier, 34090, France; MoISA, Univ Montpellier, CIHEAM-IAMM, CIRAD, INRAE, Institut Agro, IRD, Montpellier, France.
11. **Alexandra-Maria Klein** (RestPoll). Coordinator of RestPoll. Nature Conservation and Landscape Ecology, University of Freiburg, Germany.
12. **Jessica Knapp** (PollinERA, RestPoll). Department of Earth and Environmental Sciences, Lund University, Lund, Sweden.
13. **Nicolas Langlade** (AGRI4POL). WP leader of Agri4POL of WP Genetics of crop floral traits governing pollinator attraction: future pollinator-smart crops. Coordinator of HelEx consortium. Univ Toulouse, INRAE, CNRS, LIPME, Castanet-Tolosan, France.
14. **Sara Diana Leonhardt** (Butterfly, ProPollSoil, RestPoll). Coordinator of ProPollSoil. Plant-Insect Interactions, Technical University of Munich, Freising, Germany.
15. **Julia Leventon** (AGRI4POL). Global Change Research Institute of the Czech Academy of Sciences, CzechGlobe.
16. **Xiushan Li** (VALOR, Safeguard). Coordinator of Safeguard China. College of Life Science, China West Normal University, China.
17. **Denis Michez** (WildPosh). Coordinator of WildPosh. Safeguard Work-package leader on pollinator status and trends. University of Mons, Research Institute for Biosciences, Laboratory of Zoology. Belgium.
18. **Mirella Miettinen** (Butterfly). Mirella Miettinen, UEF Law School, University of Eastern Finland. P.O. Box 111, FI-80101 Joensuu, Finland.
19. **Henning Nottebrock** (AGRI4POL, RestPoll). WP1 lead in AGRI4POL: Multi-Actor-Approach and responsible for the SPHERE Master course (projects involved RestPoll, AGRI4POL, ProPollSoil, VALOR, Butterfly). Nature Conservation and Landscape Ecology, University of Freiburg. Germany.
20. **May-Brith Ohman Nielsen** (Butterfly). Leader Butterfly WP&: Human dimensions. University of Agder. Norway.

21. **Jeff Ollerton** (Butterfly, ProPollSoil). School of Life & Environmental Sciences, University of Northampton, Waterside Campus, Northampton, UK and Germplasm Bank of Wild Species & Key Laboratory for Plant Diversity and Biogeography of East Asia, Kunming Institute of Botany, Chinese Academy of Sciences, 132 Lanhei Road, Kunming 650201, China
22. **Julia Osterman** (WildPosh, RestPoll). Department of Biological and Environmental Sciences, University of Gothenburg; Gothenburg, 41390, Sweden, and Centre for Future Chemical Risk Assessment and Management (FRAM), University of Gothenburg, Sweden. Julia Osterman was supported by the Svenska Forkingsrådet Formas (2024-00298).
23. **Simon Potts** (VALOR, WildPosh, AGRI4POL, RestPoll, Safeguard). University of Reading. UK.
24. **Claus Rasmussen** (Butterfly, ProPollSoil, RestPoll). Department of Agroecology, Aarhus University, Denmark.
25. **Sara Reverté** (WildPosh). Project manager of Wildposh. Laboratory of Zoology, University of Mons, Belgium.
26. **Michael Schloter** (ProPollSoil). Technical University of Munich, School of Life Science, Professorship for Env. Microbiol. Munich, Germany.
27. **Henrik Smith** (RestPoll). Lund University, Department of Earth and Environmental Sciences (MGeo), Sweden.
28. **Ingolf Steffan-Dewenter** (Safeguard). Safeguard coordinator. Department of Animal Ecology and Tropical Biology Biocenter, University of Würzburg, Am Hubland, 97074 Würzburg. Germany.
29. **Christopher John Topping** (PollinERA). Social-Ecological Systems Simulation (SESS) centre, Department of Agroecology, Aarhus University, Denmark.
30. **Martin Thorsoe** (Butterfly, ProPollSoil). Department of Agroecology, Aarhus University. Denmark.
31. **Simone Tosi** (WildPosh). Università di Torino. Italy.
32. **Kévin Tougeron** (WildPosh). Ecology of Interactions and Global Change, Research Institute for Biosciences, University of Mons, Av. du champ de Mars 6, 7000 Mons, Belgium.
33. **Luisa M. Trindade** (AGRI4POL). Laboratory of Plant Breeding, Wageningen University & Research, Wageningen, The Netherlands.
34. **Zafarani Uwingabire** (Safeguard). Université de Bourgogne Europe, Institut Agro Dijon, INRAE, UMR Agroécologie, Dijon, France.
35. **Adam J. Vanbergen** (AGRI4POL, Safeguard). AGRI4POL Coordinator & Safeguard Work-package 5 co-leader Integrated Assessment Framework: socio-ecological concepts, tools and solutions. Université de Bourgogne Europe, Institut Agro Dijon, INRAE, UMR Agroécologie, Dijon, France.
36. **George Vlontzos** (Butterfly, ProPollSoil, RestPoll). University of Thessaly, Dep. of Agriculture Crop Production and Rural Development, Volos, Greece.
37. **James Williams** (PollinERA). Department of Agroecology, Aarhus University, Aarhus, Denmark.
38. **Dimitry Wintermantel** (WildPosh, RestPoll). Chair of Nature Conservation and Landscape Ecology, University of Freiburg; Freiburg, Germany.
39. **Jie Zhang** (Safeguard). Data manager of Safeguard. Julius-maximilians-University of Würzburg, Germany

Signatories:

40. **Didier Alard** (Safeguard). University of Bordeaux, France.
41. **Matthias Albrecht** (AGRI4POL, RestPoll, Safeguard). Agroscope, Agroecology and Environment, Zurich, Switzerland.
42. **Enkhzaya Amarjargal** (ProPollSoil). Chair of Soil Biophysics, Technical University of Munich, Germany.
43. **Andrijana Andric** (WildPosh, Safeguard). BioSense Institute, University of Novi Sad, Serbia

44. **Emilie Andrieu** (RestPoll). Emilie Andrieu 1 DYNAFOR, University of Toulouse, INRAE, Castanet-Tolosan, France. 2 LTSER Zone Atelier PYRÉNÉES GARONNE, Auzeville-Tolosane, France."
45. **Ildikó Arany** (RestPoll). Bükk National Park Directorate
46. **András Báldi** (Safeguard). HUN-REN Centre for Ecological Research, Hungary.
47. **Paolo Biella** (Butterfly, ProPollSoil). University of Milano - Bicocca, Department of Biotechnology and Biosciences, Milan, Italy
48. **Mark Brady** (VALOR). Department of Earth and Environmental Sciences (MGeo), Lund University, Sweden. AgriFood Economics Centre, Swedish University of Agricultural Sciences & Lund University, Sweden.
49. **Mark Brown** (WildPosh, Safeguard). Department of Zoology, University of Cambridge, UK.
50. **Tatiana Cardenas** (WildPosh). Anses, Sophia Antipolis Laboratory, Unit of Honeybee Pathology, Sophia Antipolis, France
51. **Maria Clara Castellanos** (Butterfly). Department of Ecology & Evolution, University of Sussex, UK
52. **Marie-Pierre Chauzat** (WildPosh). In WildPosh, I am the co-leader of the WP6 Assessing the effectiveness and feasibility of mitigation measures. Anses, Laboratory for Animal Health, Maisons-Alfort, France Anses, Sophia Antipolis Laboratory, Unit of Honeybee Pathology, Sophia Antipolis, France"
53. **Mattis Cherdon** (RestPoll). LEREPS, ENSFEA, Université de Toulouse, Toulouse, France
54. **Joseph Chipperfield** (Butterfly, ProPollSoil). Norwegian Institute for Nature Research (NINA)
55. **Richard Comont** (WildPosh, ProPollSoil, RestPoll, Safeguard). Bumblebee Conservation Trust
56. **Finn Corus** (Butterfly). Centre for the Study of the Sciences and the Humanities, University of Bergen, Bergen, Norway.
57. **Nicky Creux** (AGRI4POL). LIPME, INRAE, France.
58. **Pilar De la Rúa** (Butterfly, WildPosh, ProPollSoil). I have a special role in WildPosh as work-package co-leader (WP3): Omics of pesticide responses in pollinators. Department of Zoology and Physical Anthropology, University of Murcia, 30100 Murcia, Spain
59. **Annemarie Dekker** (Butterfly). Ecological researches and advisor, Centre for agriculture and the environment, the Netherlands
60. **Justine Dewaele** (ProPollSoil). Department of Food Environmental and Nutritional Sciences, University of Milan, Milan, Italy.
61. **Natali Dobreva** (WildPosh). Pensoft Publishers.
62. **Virginia Domínguez-García** (Safeguard). Estacíon Biológica de Doñana (CSIC), Seville, Spain.
63. **Christophe Dominik** (WildPosh, AGRI4POL, Safeguard). Department of Community Ecology, UFZ—Helmholtz Centre for Environmental Research, Halle (Saale), Germany iDiv—German Centre for Integrative Biodiversity Research Halle-Jena-Leipzig, Leipzig, Germany.
64. **Maxime Eeraerts** (AGRI4POL). Estación Biológica de Doñana, CSIC, Sevilla, Spain.
65. **Monika Egerer** (ProPollSoil). Urban Productive Ecosystems, Technical University of Munich, Germany.
66. **Lotta Fabricius Kristiansen** (RestPoll). Department of People and Society, National Competence Centre for Advisory Services, Swedish University of Agricultural Sciences, Skara, Sweden.
67. **Thijs Fijen** (AGRI4POL). Plant Ecology and Nature Conservation group, Wageningen University & Research, Wageningen, The Netherlands.
68. **Zuzanna Filipiak** (Butterfly, ProPollSoil). ProPollSoil; Work-Package Co-Leader in WP4 “Filling knowledge gaps on the biology, ecology and threats for soil–pollinators interactions”. Institute of Environmental Sciences, Faculty of Biology, Jagiellonian University, Krakow, Poland
69. **Tsenka Garova** (VALOR, WildPosh, Safeguard). Pensoft Publishers..

70. **Michael Garratt** (VALOR, AGRI4POL, RestPoll, Safeguard). School of Agriculture, Policy and Development, University of Reading, Reading, UK.
71. **Elena Gazzea** (Safeguard). University of Padova, Padova, Italy.
72. **Costanza Geppert** (AGRI4POL, Safeguard). Department of Agronomy, Food, Natural Resources, Animals and Environment (DAFNAE), University of Padova, Viale dell'Università 16, 35020, Legnaro, PD, Italy.
73. **Simon Hodge** (ProPollSoil). University College Dublin, Ireland.
74. **Andrea Holzschuh** (Safeguard). Department of Animal Ecology and Tropical Biology, University of Würzburg, Biocenter, Würzburg, Germany.
75. **Hanna Honchar** (AGRI4POL, RestPoll). Department of Community Ecology, Helmholtz Centre for Environmental Research—UFZ, Halle, Germany, and Department of ecological monitoring, Institute for evolutionary ecology NAS Ukraine, Kyiv, Ukraine.
76. **Seyed-Ali Hosseini-Yekani** (Butterfly). Leibniz Centre for Agricultural Landscape Research (ZALF), 15374 Müncheberg, Germany.
77. **Elif Kardas** (WildPosh, AGRI4POL). University of Mons, Belgium.
78. **Alexander Keller** (ProPollSoil). Cellular and Organismic Networks, Faculty of Biology, Ludwig-Maximilian-Universität, Faculty of Biology, Munich, Germany.
79. **David Kleijn** (VALOR, AGRI4POL, RestPoll, Safeguard). Plant Ecology and Nature Conservation Group, Wageningen University, Wageningen, The Netherlands.
80. **Jochen Krauss** (Safeguard). Department of Animal Ecology and Tropical Biology, Biocenter, University of Würzburg.
81. **Rebecca Magdalena Kropp** (VALOR). Department of Animal Biology, Edaphology and Geology, Universidad de La Laguna (ULL), Spain.
82. **Nilgun Kulan** (Butterfly). Project manager of Butterfly. University of Bergen, Bergen, Norway.
83. **Leonidas Sotirios Kyrgiakos** (Butterfly, ProPollSoil, RestPoll). Department of Agriculture Crop Production and Rural Environment, University of Thessaly, Volos, Greece.
84. **Shimrit Laor Leib** (ProPollSoil). Comparative Microbiome Analysis, Helmholtz Center for Environment and Health, Oberschleissheim, Germany.
85. **Marion Laurent** (WildPosh). 6Anses, Sophia Antipolis Laboratory, Unit of Honeybee Pathology, Sophia Antipolis, France
86. **Peter Leendertse** (Butterfly). Centre for agriculture and the environment, the Netherlands.
87. **Matti Leponiemi** (WildPosh). Department of Zoology, University of Cambridge, UK.
88. **Lorenzo Marini** (AGRI4POL, Safeguard). DAFNAE, University of Padova, Viale dell'Università 16, Legnaro, Padova, Italy
89. **Guillem Mas Cornet** (AGRI4POL). Associació Paisatges Vius.
90. **Laura Maxim** (Butterfly). Laboratoire Interdisciplinaire Sciences Innovations Sociétés (LISIS), UMR 1326/9003 Université Gustave Eiffel, ESIEE Paris, CNRS, INRAE, 3 All. Jean Renoir, 93160 Noisy-le-Grand, France.
91. **Ivan Meeus** (Butterfly, ProPollSoil). Department of Plants and Crops, Faculty of Bioscience Engineering, Ghent University, Belgium.
92. **Jelena Meinilä** (VALOR). Taskleader on human nutrition and health implications of pollinator decline (in WP5 Dependence of value chain actors). Department of Food and Nutrition, University of Helsinki, Finland.
93. **Teodor Metodiev** (VALOR, PollinERA, WildPosh, AGRI4POL, Safeguard). Pensoft Publishers.
94. **Marija Milicic** (WildPosh, Safeguard). BioSense Institute – Research Institute for Information Technologies in Biosystems, University of Novi Sad, Novi Sad, Serbia.
95. **Edward A. D. Mitchell** (ProPollSoil). Laboratory of Soil Biodiversity, University of Neuchâtel, Switzerland.
96. **Neda Modova** (AGRI4POL). Pensoft.
97. **Nerea Montes-Perez** (Safeguard). Estación Biológica de Doñana - CSIC, Spain.
98. **Adele Muscolo** (ProPollSoil). WP co-leader. Mediterranea University of Reggio Calabria, Italy.

99. **Carmen Nebauer** (ProPollSoil). Part of the coordination team for ProPollSoil. Technical University of Munich, Germany.
100. **Astrid E. Neumann** (ProPollSoil). Scientific Project Manager of ProPollSoil. Plant-Insect Interactions, Technical University of Munich, Freising, Germany.
101. **Nhien Nguyen** (Butterfly, RestPoll). CIHEAM-IAMM (Institut Agronomique Méditerranéen de Montpellier), Montpellier, France.
102. **Pierre Noiset** (ProPollSoil). Cellular and Organismic Networks, Faculty of Biology, Ludwig- Maximilians- Universität München, Munich, Germany.
103. **Francisco Orozco-Meléndez** (Butterfly). Centre for the Study of the Sciences and the Humanities, University of Bergen, Bergen, Norway.
104. **Erik Öckinger** (Safeguard). Department of Ecology, Swedish University of Agricultural Sciences, Uppsala, Sweden.
105. **Alejandra Parreno** (ProPollSoil). Technical University of Munich, Germany.
106. **Robert Paxton** (WildPosh). Martin Luther University Halle-Wittenberg, Germany.
107. **Snežana Popov** (Safeguard). University of Novi Sad, Faculty of Sciences & University of Ljubljana, Faculty of Education, Ljubljana, Slovenia.
108. **Lauréna Porcel** (WildPosh). Anses, Sophia Antipolis Laboratory, Unit of Honeybee Pathology, Sophia Antipolis, France
109. **Tereza Prášilová** (AGRI4POL). Department of Social Processes and Sustainability, Global Change Research Institute of the Czech Academy of Sciences CzechGlobe, Czech Republic.
110. **Nigel Raine** (ProPollSoil). Nigel E. Raine, School of Environmental Sciences, University of Guelph, Guelph, Ontario, Canada.
111. **Fabrice Requier** (Butterfly, ProPollSoil). Université Paris-Saclay, CNRS, IRD, UMR Évolution, Génomes, Comportement et Écologie, 91198, Gif-sur-Yvette, France
112. **Laura Roquer-Beni** (RestPoll). 1- Centre de Recerca Ecològica i Aplicacions Forestals (CREAF) 2- Universitat Autònoma de Barcelona,Barcelona, Spain.
113. **Carlos Ruiz** (VALOR). University of La Laguna, Spain.
114. **Maj Rundlöf** (VALOR, PollinERA, AGRI4POL, RestPoll). Lead RestPoll WP2 on context dependency, scalability, and synergies across pollinator restoration measures and PollinERA WP4 on monitoring and risk indicators. Department of Biology, Lund University, Sweden.
115. **Jeroen Scheper** (VALOR, RestPoll, Safeguard). Plant Ecology and Nature Conservation Group, Wageningen University & Research, Wageningen, The Netherlands.
116. **Katharina Schwarz** (Butterfly). Université du Luxembourg.
117. **Oliver Schweiger** (Butterfly, WildPosh, AGRI4POL, RestPoll, Safeguard). Helmholtz Centre for Environmental Research - UFZ, Germany.
118. **Deepa Senapathi** (VALOR, WildPosh, AGRI4POL, RestPoll, Safeguard). School of Agriculture, Policy & Development, University of Reading, Reading, UK.
119. **Josef Settele** (Butterfly, AGRI4POL, RestPoll, Safeguard). Department of Conservation-Biology and Social-Ecological Systems, UFZ—Helmholtz Centre for Environmental Research, Halle (Saale), Germany; iDiv—German Centre for Integrative Biodiversity Research Halle-Jena-Leipzig, Leipzig, Germany; Martin Luther University Halle-Wittenberg, Halle, Germany.
120. **Aleksandra Splitt** (ProPollSoil). ProPollSoil, WP2 co-leader "Consolidating existing knowledge on biology, ecology and threats for soil-dependent pollinators below and above-ground". The National Institute of Horticultural Research, Skierniewice, Poland.
121. **Carla Stoyanova** (VALOR, PollinERA, WildPosh, AGRI4POL, Safeguard). Leader of VALOR WP7: "Co-developed tools for expanded engagement and interaction" and leader of PollinERA WP6: "Communication, Dissemination and Exploitation". Pensoft Publishers.
122. **Gabriella Süle** (Safeguard). Lendület Ecosystem Services Research Group, Institute of Ecology and Botany, HUN-REN Centre for Ecological Research, Vácrátót, Hungary.

123. **Tanja Šumrada** (AGRI4POL). University of Ljubljana, Biotechnical faculty, Jamnikarjeva ulica 101, Ljubljana, Slovenia
124. **Martijn Thijssen** (WildPosh, AGRI4POL, RestPoll, Safeguard). Policy expert on environmental and sustainability. Senior advisor at ORG-ID.
125. **Amibeth Thompson** (RestPoll). RestPoll project manager. University of Freiburg, Chair of Nature Conservation and Landscape Ecology. Freiburg, Germany.
126. **Sophie Thoyer** (AGRI4POL). WP co-leader "Social & Economic Opportunities and Obstacles towards Pollinator-Friendly Food Systems". Center for Environmental Economics- Montpellier, INRAE, France.
127. **Joanna Tusznio** (VALOR). Jagiellonian University in Kraków, Poland.
128. **Dušanka Vujanovic** (Safeguard). BioSense Institute, University of Novi Sad, Serbia.
129. **Richard Walters** (VALOR, AGRI4POL, RestPoll). Department of Earth and Environmental Sciences, Lund University.
130. **Dehui Wang** (Butterfly). MSc student in Sustainability, University of Bergen, Bergen, Norway.
131. **Agata Warchalska-Troll** (VALOR). Institute of Environmental Sciences, Faculty of Biology, Jagiellonian University in Krakow, Krakow, Poland.
132. **Mohsen Zarebanadkouki** (ProPollSoil). Technical University of Munich, School of Life Sciences, Professorship for Soil Biophysics and Environmental Systems, Munich, Germany.
133. **Yujie Zhang** (VALOR). Wageningen University and Research, Wageningen, The Netherlands.
134. **Ying Zhang** (VALOR). Beijing Forestry University.
135. **Corinne Zurbruegg** (AGRI4POL). Agridea, Switzerland.

Reviewers:

Lorenzo Benini. Team coordinator – Methods and tools for Integrated Assessment & Sustainability transitions expert, European Environment Agency, Denmark.

Appendix 2

Glossary

AECM Agro-Environmental and Climate Measures

Agroecology: farming with nature – not against it – to produce healthy food while protecting biodiversity, ecosystems and human well-being, supporting farmers, and connecting producers and consumers. It is based on 13 principles that seek to improve resource efficiency, strengthen resilience, and secure social equity/responsibility: Recycling, input reduction, soil health, animal health, biodiversity, synergy, economic diversification, co-creation of knowledge, social values and diets, fairness, connectivity, land and natural resource governance and participation. (CFS HLPE report 14).

CAP: Common Agricultural Policy of the European Union

CRISPR: (Short for CRISPR Cas9) Clustered Regularly Interspaced Short Palindromic Repeats - CRISPR-associated protein 9 (cas9). A genome-editing technology that can be used to create varieties of crops with changed specific genetic properties such as drought-resistence.

Drivers: Socio-economic, socio-cultural, institutional, historical and political forces and factors driving human activities, which increase or mitigate pressures on the environment. [116]

EFSA: European Food Safety Authority

ERA: Environmental Risk Assessment

EU-PoMS: EU Pollinator Monitoring Scheme

GAECs: Good Agricultural and Environmental Conditions. A set of standards under the EU Common Agricultural Policy that farmers must meet to receive certain agricultural subsidies, aimed at protecting soils, water, biodiversity, and landscape features.

Global nutrient dilution: Rising atmospheric CO_2 impacts plants in a way that makes plant tissues and products more calorific, less nutritious and more unhealthy as food for insect pollinators and their larvae. This phenomenon is called "global nutrient dilution" and threatens pollinators by reducing the quality of the food they depend on, weakening their development, health and survival, and increasing the risk of broader population declines.

IPM: Integrated Pest Management. An ecosystems-based approach to managing pests. It emphasises reducing the negative impacts of pest management on agro-ecosystems, through using natural pest control, improving crop resilience, and minimising the use of pesticides.

Multi-Actor Approach: An approach to the co-creation of actionable knowledge and solutions in collaborative research and innovation projects that includes a wide range of societal actors. It acknowledges that many societal actors are knowledge holders and it seeks to be interactive, transdisciplinary and responsible.

MUST-B: MUltiple STressors in Bees project. An initiative by the European Food Safety Authority (EFSA) to develop a holistic, integrated risk assessment framework for managed honeybees. It addresses how combined stressors (e.g., pesticides, diseases, climate, malnutrition) affect colony health at the landscape level.

NGT: New Genomic Techniques

Nitrogen: Short for reactive nitrogen (see below)

NRR: Nature Restoration Regulation of the European Union

Omnibus: EU Omnibus packages are legislative packages introduced by the European Commission to simplify and amend multiple EU laws simultaneously, mainly to reduce administrative burdens and streamline regulation.

PERA: EU: Partnership for Environmental Risk Assessment (EU partnership initiative)

Pollinator stewardship: the responsibility and mindset to care for pollinators, their habitats, and the sustainable use of their services in all we do. It is shared by all those whose actions can affect pollinators and their habitat. This sense of responsibility is a transformative concept and value that can be reflected through the choices of governments, policy makers, companies, farmers, landscape managers, gardeners, NGO's, communities, individuals, etc. It is also a behaviour, one demonstrates through continuous improvement of the pollinator friendliness of one's practices and policies. (Compare to environmental stewardship [117, 118])

PoMS: Pollinator Monitoring Scheme

Pressures: Stresses that human activities place on the environment. Pressures are consequences of human activities (i.e. release of chemicals, physical and biological agents, extraction and use of resources, patterns of land use, creation of invasion corridors) which have the potential to cause or contribute to adverse effects (Impacts). [116]

Reactive nitrogen: all chemical forms of nitrogen present in the environment except for molecular nitrogen gas (N_2). In particular, the air pollutants nitrogen oxides (NO_x), ammonia (NH_3), nitrous oxide (N_2O), and the water pollutant nitrate (NO_3^-).

Regenerative agriculture: A holistic farming approach that rehabilitates ecosystems by focusing on soil health, biodiversity, and water quality. It also seeks to actively restore degraded soil, sequester carbon to mitigate climate change, and improve water retention, rather than just extracting resources. Key practices include no-till farming, cover cropping, and rotating livestock.

Resilience: the capacity of a system to tolerate disturbances without collapsing. Resilience in ecology refers to the ability of an ecosystem to absorb disturbances and still maintain its essential structures, functions, and feedbacks.

SDG: Sustainable Development Goal. 17 global goals adopted by the United Nations as part of the 2030 Agenda for Sustainable Development.

SUD: EU's Sustainable Use of Pesticides Directive