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EDITORIAL

Effects of agricultural landscapes on biodiversity, ecosystem services, and yield

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Agricultural landscapes as drivers of biodiversity change and ecosystem services

Agricultural areas used for cropping or animal husbandry represent the most extensive land cover globally, covering more than one-third of the terrestrial land surface (FAO 2025). This sheer spatial dominance makes agricultural land a central component of the biosphere and a major driver of global environmental change (Tscharntke & Batáry 2023). Agricultural activities contribute to the transgression of several planetary boundaries that define safe operating space for humanity, particularly those related to biosphere integrity, biogeochemical flows, and climate change (Campbell et al. 2017). Agricultural land-use expansion and intensification, acting primarily through habitat destruction, fragmentation, and degradation, are widely recognized as principal factors in the unprecedented loss of global biodiversity (Tscharntke et al. 2005). Biodiversity loss extends beyond natural ecosystems, since intensification affects agricultural biodiversity by promoting homogenised biota, and decreasing cultivated crop and domesticated breed diversity with the erosion of genetic diversity (IPBES, 2019). Moreover, conventional farming degrades those regulating and supporting ecosystem services provided by natural ecosystems that underpin agricultural production, including pollination, biological pest control and nutrient cycling (Power 2010).

As a result, we find that conventional agriculture puts a tension between maximizing production and maintaining biodiversity and ecosystem services, where we need to avoid trading short-term gains for long-term ecological sustainability (Kotowska et al. 2025). Given their extensive spatial coverage, far-reaching ecological impacts, and persistent ecological assets and processes, agroecosystems should be integrated into biodiversity conservation strategies (Norris, 2008). We need, therefore, more ambitious steps to reach sustainable farming (Báldi et al. 2023).

Transdisciplinary approaches for sustainable agriculture at the landscape scale

Despite the growing body of evidence in the scientific literature, the value of ecosystem services remains largely unquantified and under-recognized for actors in the agricultural sector and society. Ecological research on agroecosystems has largely developed in parallel to agronomic and yield-focused agricultural

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research with limited overlap in aims, concepts, and target audiences (Tancoigne et al. 2014). This disciplinary separation, coupled with weak knowledge transfer to farmers and policymakers, constrains the translation of ecological insights and agronomic reality into management and decision-making (Farah & Amara 2025).

Addressing this challenge requires integrating ecological perspectives with production-oriented considerations through interdisciplinary research (Foley 2005). Overcoming communication barriers between scientists and stakeholders by strengthening transfer pathways is equally important (Sulandjari et al. 2023), as such interactions enable transdisciplinary methods that actively involve farmers, policy makers, and the society to co-produce knowledge and solutions for sustainable agriculture (Barrett 1992). Such approaches are critical under conditions of growing food demand, food security concerns, stringent environmental challenges, and for achieving policy targets such as the UN Sustainable Development Goals 2 Zero Hunger and 15 Life on Land, while preserving the economic viability of farming systems. In the past two decades, research on sustainable agricultural practices has expanded markedly, however, ecological studies explicitly incorporating crop production indicators such as yield along with biodiversity and ecosystem service metrics remain far less common (e.g. Korányi et al. 2025) than those omitting production indicators (Fig. 1).

Sustainability approaches require considerations beyond the field scale as ecological processes and species movements operate across landscape mosaics rather than individual fields (Batáry et al. 2020), while regional scale can be too coarse to capture spatial and management heterogeneity (Barrett 1992). Landscape settings (e.g. composition, and configuration), and cross-scale interactions strongly influence biodiversity and the ecosystem services that underpin sustainable agricultural productivity (Jeanneret et al. 2021). Such a landscape sustainability perspective can help reconcile agricultural production with biodiversity conservation while contributing to broader societal goals such as the Sustainable Development Goals (Wu et al. 2025).

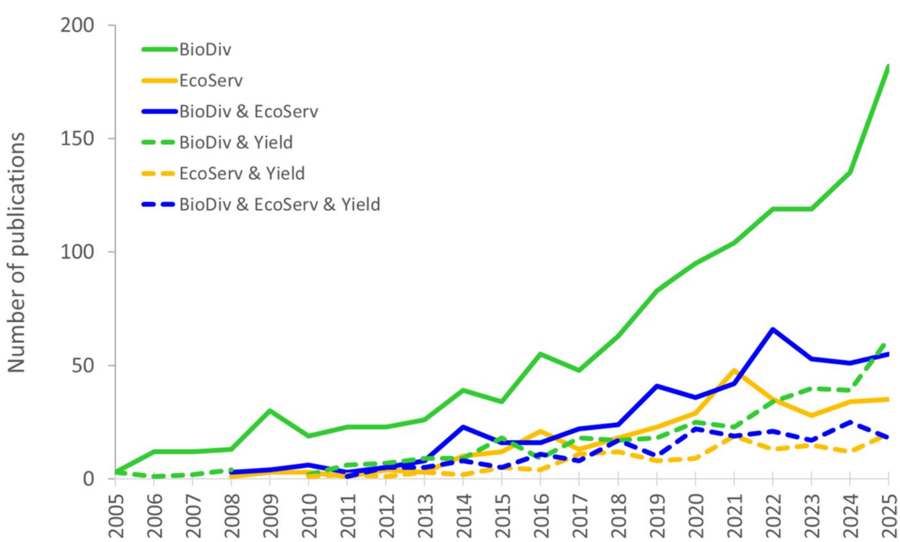

Fig. 1 Temporal trends between 2005 and 2025 in the number of scientific publications assessing different success measures in agroecological research. Source: WoS Core Collection, retrieved on January 25 2026, using combinations of the following search terms in the Topic field: (*agroecolog** OR *agro-ecolog**); (*yield* OR "crop product*"); (*biodivers** OR "species richness" OR "species diversity"); and ("ecosystem service*"). To identify publications focusing on individual or combined indicator types, indicator-specific searches excluded the remaining indicator categories using the *NOT* operator. Yield-only studies were excluded for clarity because of their disproportionately high frequency

Outline of the special collection

With our Special Collection, we aimed to emphasize the importance of comprehensive research on agricultural ecosystems considering a wide range of performance indicators covering biodiversity, ecosystem services, and crop yield at both local and landscape-scales, and to advance the understanding of the causal pathways linking these components. As agricultural systems are deeply integrated into the landscapes, we aimed to gather contributions that capture the complex interactions between local and landscape-scale processes (Batáry et al. 2020). In our Special Collection, altogether 15 articles (12 original research articles and three reviews) were published, covering a wide variety of agricultural systems, geographic regions, and spatial scales. Below, we summarise key topics from the Collection highlighting how individual studies advance our understanding of agricultural systems.

Landscape structure and biodiversity-mediated ecosystem services

A number of studies articulated that the structure of agricultural landscapes significantly affects the assumed ecosystem services through biodiversity patterns. Most studies dealt with functionally important taxonomic groups responsible for specific ecosystem services essential in agricultural systems (i.e. nutrient cycling, pollination, and biocontrol). *Hussain* et al. showed that maintaining heterogeneous landscapes with woodlands, hedgerows, and set-aside lands supports diverse dung beetle communities contributing to nutrient cycling, seed dispersal and pest control. In contrast, *Sõber* et al. found no effects of either landscape composition or configuration on bumblebee richness or abundance, suggesting that Estonian red clover fields may not compromise pollination services by bumblebees when the field is kept at moderate sizes, likely because typical bumblebee foraging distances exceed field radii. Similarly, *Sexton* et al. demonstrated that local-scale characteristics might override landscape context in shaping pollination in urban agroecosystems, suggesting that pollinator support does not require large nearby natural areas, as increasing plant diversity within gardens can provide substantial benefits.

Two studies focused on bats, a taxonomic group with an important role in biological pest control, experiencing dramatic declines in agricultural landscapes in recent decades. *Hiller* et al. highlighted that linear landscape elements such as hedgerows and high crop diversity create favourable landscape settings for bat activity. *Szabadi* et al. assessed bat activity with a focus on livestock farms, showing that both landscape composition and farm-level characteristics emerge as significant drivers of bat activity. They found that several bat species are most active in livestock farms in the landscapes, suggesting that bats may also contribute to livestock pest control.

Biodiversity, ecosystem service and yield under agricultural intensification

Several contributions in this Collection examined how agricultural intensification operates across local and landscape scales. *Molina-Venegas* et al. showed that agricultural intensification simplified arable weed assemblages, degrading their taxonomic and phylogenetic diversity to tolerant species. They used crop yield as a field-level indicator of intensification and showed that this measure was more important than other landscape-scale indicators. *Meyer* et al. investigated land-use intensity effects on plant diversity and biomass using upscaled prediction maps. They found that in semi-natural grasslands, intensive land-use decreases species richness and its variability. However, it has a positive effect on biomass production and its variability across various spatial scales.

In their meta-analysis, *Bucher* et al. addressed the full pathway linking biodiversity, ecosystem services, and crop yield, quantifying the effects of local and landscape-scale land-use intensity. They found that high local land-use intensity harmed pollinator communities and pollination services, whereas pollination services supported crop yield. In contrast, relationships involving biological pest control were more context-dependent. Complementing their results, *Alarcón-Segura* et al. highlighted in their systematic review that although semi-natural habitats in agricultural landscapes consistently enhanced both pollination and biological pest control, biological pest control does not always translate into increased crop productivity.

Crop diversification and restoration for multifunctional agricultural landscapes

Crop diversity was shown as an important management option at the landscape-scale for supporting biodiversity, ecosystem service provision, and crop yield in our Collection. For example, in tropical agricultural landscapes, *George & Santos* found that crop diversity combined with tree cover fosters both higher biodiversity and crop yields, highlighting agroforestry as a potential viable pathway for aligning biodiversity conservation with economic performance. *Camba Sans* et al. investigated whether landscape heterogeneity enhances ecosystem services in a Brazilian grassland region, finding that cropland functional diversity and the spatial segregation of grasslands supported several regulating ecosystem service provision. In their synthesis, *Fijen* et al. demonstrated that crop diversification benefits pollinator diversity, and discussed a number of ways in which diversification could take place without taking land out of production.

A number of contributions gave valuable insights into how landscape-scale planning and restoration can help create multifunctional agricultural landscapes. *He* et al. developed a landscape classification framework and identified the plain-mountainous transition zone for land sharing where agricultural production and ecological diversity can be balanced. *Destrempes* et al. studied how forest restoration on old-fields supports both ecosystem services and crop production. With their scenario-based modelling approach, they found that the amount of restoration enhanced ecosystem service provision, particularly when restoration targeted marginal agricultural lands. Similarly, wildflower strip addition to cropland field margins was found to help several regulating and supporting ecosystem services according to the modelling study of *Li* et al., with landscape composition indicators mediating its benefits.

Concluding remarks

By targeting researchers, practitioners, and policymakers, the collection aimed to advance the understanding of agricultural landscapes and their implications for biodiversity, ecosystem services, and yield. Most contributions focused on specific components of the broader causal pathways rather than addressing the entire framework envisioned by the Collection. This underscores that studies adopting a full system perspective in agricultural landscapes are relatively rare (de la Riva et al. 2023).

Taken together, our Collection demonstrates that multifunctional and sustainable agricultural landscapes cannot be achieved by addressing biodiversity, ecosystem services, and agricultural production in isolation. Instead, their integrated assessment along with land-use and management drivers across various spatial scales, is necessary to leverage synergies, to manage trade-offs, and to inform decision makers.

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Declarations

Competing interests The authors have not disclosed any competing interests.

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