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Reconciling food production and biodiversity in farmlands: the role of agricultural intensity and its spatial allocation

Concilier production agricole et biodiversité : le rôle de l'intensité et de son allocation spatiale

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Abstract

During the past several decades, agricultural intensification has been crucial to increase the food supply. Several processes related to intensification are very detrimental to the environment, particularly biodiversity. Today, agriculture is facing the challenge of satisfying its demand for food while improving its environmental sustainability. Knowledge of the shape of the relationship between biodiversity and intensity is necessary to determine both where conservation policies will be most effective and how to allocate intensity to reconcile production and biodiversity. Few empirical studies on this relationship exist, and the influence of the spatial arrangement of intensity on biodiversity remains untested. This Ph.D. thesis determined how to target both agricultural intensity and its spatial allocation for meeting production and conservation objectives of farmlands. To answer this research question, we used a country-scaled approach that combined two France-scaled databases that describe agriculture and farmland birds. We characterized a nationwide gradient of agricultural intensity and studied a farmland bird community along this gradient, using several trait-based descriptors (specialization, trophic level, and species main habitat). Agricultural intensity and bird communities were described at the Small Agricultural Region (SAR; mean width = 22.4 km) level. As a first step, we developed a novel method to estimate an intensity indicator that was based on Input Costs/ha, with SAR resolution. This indicator provides a continuous intensity measure that is relevant across different types of agricultural systems. Secondly, we investigated the effects of a gradient of land uses (grassland to arable land) and its heterogeneity on the bird community. We found habitat specialists suffered from habitat loss, while generalists benefited from heterogeneity. Thirdly, we showed that the community responded significantly to intensity, with winner species replacing loser species along the gradient. The shift between losers and winners was sharper at low intensities. Interestingly, spatial aggregation of intensity had a strengthening effect on the bird community. Finally, the relationships linking intensity to the bird community, food production, and economic performance were integrated into a model aimed at optimizing intensity allocation. Optimal allocations reached win-no-lose solutions with the three criteria. They corresponded to targeted intensity modifications: many small changed, favoring homogeneous, extensive clusters, were optimal within an extensification scenario; while a few large changes, favoring heterogeneity, were optimal within an intensification scenario. We provide one of the first studies demonstrating that spatial aggregation of intensity can influence the biodiversity/intensity relationship. Our results also provide an opportunity to improve the effectiveness of conservation policies, at national scales, with spatial targeting: opposite targeting should be performed either to maximize biodiversity benefits or to increase production, while mitigating biodiversity impacts. Our results highlight the importance of mixed allocation strategies between land sparing/sharing extremes. In order to put these opportunities into effect, further research should address the technical solutions that achieve intensity modification at the farm level and design targeted policies that benefit biodiversity and other environmental criteria.