The effect of landscape configuration on pest-predator dynamics and the implications for biological control - a spatiotemporal model

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Abstract

Intensive agriculture has induced agricultural landscape simplification. It negatively impacts biodiversity, such as natural enemies, leading to a potential decrease in the ecosystem service of pest regulation. Biological pest regulation in agroecosystems is an important and complex process, affected by landscape configuration and farming practices. These factors influence the dynamics of both pests and natural enemies, but also the way the latter deliver regulation. The dynamics depend on how life cycles are completed which requires a diversity of resources in the landscape, such as food, or hibernation sites. The success of pest regulation also depends on aspects of the spatiotemporal dynamics, e.g. how the natural enemies are able to find and control pests on crops. However, the relations between landscape features, biodiversity dynamics and service provision are still poorly understood.
In this work we develop a mechanistic model that simulates the spatiotemporal dynamic of a pest-predator interaction, through various scenarios for landscape configuration. In particular, we study the effect of the proportion of semi-natural habitats, and their spatial arrangement on biological control for different pest pressures.

Our model predicts potential relations between landscape structure, biodiversity dynamics and effective regulation. We find that both landscape structure and pest dynamics influence predator dynamics and the effectiveness of pest control. We show that the optimal proportion of semi-natural habitat in the landscape for pest regulation depends on pest abundance. These findings imply that landscape structure will influence the efficiency of biological control, which requires spatial and temporal co-occurrence of pests and natural enemies. Furthermore, one of the originalities of our work is to simulate gain in crop loss due to biological control, which allows quantifying directly the ecosystem service.
Our model could be a tool to design pest management strategies that consider landscape configuration as a lever for a more sustainable agriculture.

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