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A Markov Decision Process model to compare Ecosystem Services Provided by agricultural landscapes

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A Markov Decision Process model to compare Ecosystem Services Provided by agricultural landscapes

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Abstract: One current challenge in managing agricultural landscapes, is to reach a trade-off between provision of food and biodiversity conservation. Two extreme land-use strategies, land sharing and land sparing, are often discussed. The design of decision rules for allocating crops and lands for biodiversity conservation (e.g. grasslands) can be formalized as an optimization problem. However the target to optimize, representing the trade-off between ecosystem services (ES) can be complex to model since ES are usually not defined on comparable scales and may rely on different sides of biodiversity. Here, we will investigate how landscape composition and structure affect the magnitude of ES produced (rape and wheat production, honey production, biodiversity) in farmland as well as the trade-off between provisioning ES and cultural ones. .

We used the Markov Decision Process (MDP) framework for optimizing sequential decision under uncertainty to solve landscape design problems for reaching ES trade-offs using a case study of the relationship between two interacting networks "honey bees – wild bees" and "crops –weeds" in an intensive agricultural landscapes. Since weeds decrease crop production through competition, but may indirectly increase rape production and enhance honey production through the maintenance of honey bees, weed diversity in the agricultural landscape is at the crux of a trade-off between crop production and biodiversity conservation. The MDP model relies on a spatially explicit population dynamic model for weeds as well as reward functions modeling the trade-off of provision between ES. The target to maximize is the sum of rewards over time. We will show that the percentage of grasslands significantly impact the magnitude of ES delivered and that the interaction between this percentage and the degree of aggregation of the grassland can provide non-dominated solutions (in the sense of Pareto) revealing trade-offs between ES.

Keywords: land-sparing, weeds spatio-temporal dynamics, ES trade-off optimization, Pareto optimality..