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Land sparing or sharing or something in between? Multi-objective land use optimization based on scenario analysis.

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Abstract: As the UN Sustainable Development Goals on energy, food security, water and ecosystems are closely interlinked, integrated modelling approaches are required to support the dialogue about impacts, priorities and choices of future land use. Our study builds upon the land sparing vs. land sharing debate addressing both agriculture and conservation goals in response to land use intensity, composition and configuration. We used the process-based Soil and Water Assessment Tool (SWAT) to simulate agricultural yield, stream flow and water quality for the 140 km² Lossa catchment in Central Germany. To capture biodiversity, we developed statistical (random forest) models predicting the breeding habitat of 13 bird species. SWAT and the bird habitat models were applied to stakeholder-defined land use scenarios referring to either land sparing or land sharing or business-as-usual for the year 2030. The scenarios differ in terms of land use and agricultural management, e.g. crop composition, fertilizer application and tillage practices, as well as in the amount of linear elements such as tree rows, hedges and filter strips. Among the scenarios, land sharing has been evaluated best for providing bird habitats and water in good quality. However, this came at the cost of a significantly decreasing gross agricultural margin. Furthermore, we coupled our models with a genetic algorithm (NSGA-2) to explore pareto-optimal land use strategies where the different scenarios can be spatially combined. Preliminary results indicate numerous solutions which might improve the provisioning of ecosystem services (agricultural yield, water quality) and biodiversity (bird habitat) at the same time.

Keywords: land use scenarios; ecosystem services; biodiversity; integrated modelling; multi-objective optimization