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Modeling Farmer's Decision-Making to integrate climate, land use and ecosystem functions

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Land use and climate change are important drivers of environmental change and pose a major threat to ecosystems. Although systemic feedbacks between climate and land use changes are expected to have important impacts, research has rarely focused on the interaction between the two drivers. One reason for this could be that forecasts of land use are hardly available on suitable spatial and thematic scales. Agent-based models (ABMs) represent a potentially powerful tool for creating thematic and spatially fine-grained land use scenarios. In order to derive such scenarios, the complex interaction between land users (e.g. farmers) and the broader socio-economic context in which they operate must be taken into account. On landscape to regional scales, agent-based modelling (ABM) is one way to adequately consider these intricacies. ABMs simulate human decisions, and with individual land owners/users as agents, they can simulate usage paths for individual plots of land in thematically fine resolution. Ideally, these simulations are based on an understanding of how farmers make decisions, including anticipated strategies, adaptive behavior and social interactions. In order to develop such an understanding, participatory approaches are useful because they incorporate stakeholders' perspectives into the model calibration, thereby taking into account culture and traditions that often play an important role in land use decisions. A greater proximity to stakeholder perspectives also increases the political relevance of such land use models. Here we present an example where we developed an ABM (SECLAND) parameterised for 1,329 stakeholders, mostly farmers, in the LTSER region Eisenwurzen (Austria) and simulate the changes in land use patterns resulting from their response to three scenarios of changing socio-economic conditions. Summarized in broad categories, the study region currently consists of 67% deciduous and coniferous forests (including logging), 19% grassland, 9% agricultural land and 6% alpine areas. SECLAND simulated small to moderate changes in these percentages until 2050, with little difference between the scenarios. In general, an increase in forests is predicted at the expense of grasslands. The size of agricultural land remains approximately constant. At the level of the 22 land use classes, the trends between the land use change scenarios differ more strongly. This ABM at the individual or farm level is combined with biodiversity and biogeochemical models that analyse how landowners' decision-making affects various ecosystem parameters. We conclude that agent-based modelling is a powerful tool for integrating land use and climate effects into ecosystem projections, especially at regional level.