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The dynamical interactions of Amazon deforestation, intensification of cattle ranching and technology adoption: insights from a socio-ecological model

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Deforestation in the tropics - with vast consequences for the ecosystem and climate - is mainly driven by subsequent land use, which is not only determined by environmental and economic constraints but also influenced by the use of different production technologies. Inefficient production technologies can lead to excessive use of land, especially in areas where land is easily available and accessible. Here, the adoption of new technologies could help to use already converted land more intensively and ease pressures on ecologically valuable areas. In this study, we take the Brazilian Amazon as a prominent example region to explore the interplay of land-use decisions with environmental and economic dynamics in the process of land-use intensification and frontier expansion.

Expansion of pasture land for cattle ranching to satisfy increasing domestic and international demands is one of the important drivers for deforestation in the Brazilian Amazon. Pasture run-down and following land abandonment further drive the expansion of deforestation frontiers into pristine forests. Therefore, intensification of livestock production, especially better pasture management, could potentially reduce deforestation. However, a number of reasons including the large spatial extent of the region make the process of comparing the effectiveness of different management techniques, technologies and policies in the region difficult. Therefore, the effectiveness and possible outcomes of policies to foster intensification are highly debated in the literature. Some authors deny that intensification policies are a viable option to spare forests as long as they are not a scarce resource [1] while others insist that intensification has an effect if only supported by the right policies [2].

In this presentation, we introduce a concise agent-based model to study conditions under which intensification can reduce deforestation and explore the trade-offs between intensified and extensive land uses. While most agent-based models in land science are developed for small study regions, our approach is scalable also to regional levels and for this purpose abstracts from many local specificities. In the proposed model, a collection of cattle ranchers interacts with the local environment via decisions to convert forest into pasture land and manage this pasture. Deforestation and land abandonment is traced by simple land-cover succession equations and ecological dynamics consider the evolution of pasture productivity depending on pasture management, deforestation and tree regrowth. Agent decisions are captured by heuristic strategies depending on economic and ecological constraints. Agents can follow either an extensive strategy, corresponding to traditional cattle ranching with fallow periods and slash-and-burn fertilization, or an intensive strategy, i.e. cattle ranching with high inputs such as machinery and industrial fertilizers. The choice of the production strategy is modeled as a social learning process: Agents are located on a geometric network representing neighborhood and acquaintance relations and imitate the successful strategies of their neighbors.

We will present a comprehensive analysis of the model and discuss conditions that foster sustainable land use. Finally, we will give an outlook at possible extensions of the model and applications to issues such as compliance with Brazil's Forest Code and feedbacks from changes in climate.

References:
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