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Building Biodiversity Conservation Plans Robust to Human Land Use Uncertainty

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Abstract : Human development is a threat to biodiversity, and conservation organizations (COs) are purchasing land to protect areas for biodiversity preservation. However, COs have limited budgets and thus face hard prioritization decisions that are confounded by uncertainty in future human land use. This research proposes a data-driven sequential planning model to help COs choose land parcels that minimize the uncertain human impact on biodiversity. The proposed model is robust to uncertain development, and the sequential decision-making process is adaptive, allowing land purchase decisions to adapt to human land use as it unfolds. The cellular automata model is leveraged to simulate land use development based on climate data, land characteristics, and development threat index from NASA Socioeconomic Data and Applications Center. This simulation is used to model uncertainty in the problem. This research leverages state-of-the-art techniques in the robust optimization literature to propose a computationally tractable reformulation of the model, which can be solved routinely by off-the-shelf solvers like Gurobi or CPLEX. Numerical results based on real data from the Jaguar in Central and South America show that the proposed method reduces conservation loss by 19.46% on average compared to standard approaches such as MARXAN used in practice for biodiversity conservation. Our method may better help guide the decision process in land acquisition and thereby allow conservation organizations to maximize the impact of limited resources.

Keywords : data-driven robust optimization, biodiversity conservation, uncertainty simulation, adaptive sequential planning
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