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Incorporating spatial learning into movement models for naïve animals in a novel environment

One of the principal challenges free-ranging animals face is acquiring information about available resources, which are generally patchily distributed and seasonal in nature. In learning about the environment, animals reduce uncertainty and can make more informed behavioral decisions that ultimately lead to greater fitness benefits. Learning and memory play an important role in how animals exploit their environment. Current models of animal movement rarely account for an individual's past experience when setting out to understand their future behavior, and are often fit without accounting for underlying behaviors (in non-Markovian frameworks) and the inherently autocorrelated nature of movement data. By developing robust methods to incorporate underlying behavior into statistical models, we can gain clearer ecological insights. Further, incorporating past experiences into movement models increases our statistical inference. Here, we used 3 years of GPS locations from naïve bison reintroduced into Banff National Park, Canada to evaluate movement patterns and predict dispersal and space use over time. First, we used a hidden Markov model to delineate traveling from encamped states in the empirical data. Next, we isolated these traveling movements and used a step selection function (SSF) and conditional logistic regression framework to identify how bison used the landscape during their movements. The SSF included landscape and environmental variables (e.g., landcover, snow depth), as well as metrics for past experience (i.e., attraction to previously visited areas). Finally, we simulated 5,000 bison, choosing movements based on the coefficients from the SSF, to predict where bison may move within a 3-year time frame. Our SSF model fit the data very well (Spearman Rank 0.96). Simulated bison used a larger area compared with bison actually on the landscape and were predicted to leave the park boundary in some cases as early as 8.5 months. Our work provides critical information for reintroduction programs by better predicting movements of naïve animals over time. Understanding how animals learn their environment and incorporate that knowledge into movement decisions is particularly important for restorative ecology programs where success is often tied to how populations move and settle in new environments.