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Analyzing behavioral-state dependent habitat selection using Hidden Markov Models in combination with Integrated Step Selection Analysis

Space-use behaviors emerge from the interplay of internal state and external factors. An animal's internal state changes through time and, in turn, space-use behaviors – including habitat selection – should change depending on internal motivations. Behavioral state dependence in habitat selection is rarely acknowledged, but ignoring it can confound the inference we make on habitat selection processes and mislead our estimates of habitat suitability. We investigated the effect of behavioral state on habitat selection of female greater sage-grouse translocated from Wyoming to North Dakota. Translocated animals undergo post-release behavioral modification after release, initially focusing on exploring their new environment before eventually settling. We expected sage-grouse habitat selection to differ between the initial exploration phase and after settling. We used Hidden-Markov Models combined with Integrated Step Selection Analysis to, first, segment individual trajectories into behavioral states (exploratory and restricted) and, second, quantify habitat selection in each state while accounting for seasonality and individual reproductive status. In the exploratory state, sage-grouse selected for high sagebrush cover in all seasons; during winter, they also selected for gentle slopes and avoided roads. In the restricted state, females with broods selected for high herbaceous cover and roads. When they did not have a brood, sage-grouse in restricted state selected for gentle slopes year-round and otherwise used resources in proportion to their availability. Features selected in restricted state, not in exploratory state, are likely to be indicative of suitable settlement habitat; thus, accounting for underlying behavioral states is important when habitat selection estimates are used to inform selection of future release sites. Our results demonstrate that sage-grouse adjust their habitat selection to their current internal state and exemplify the need to account for behavior in habitat selection studies. We discuss the statistical limitations of our approach, namely the lack of uncertainty propagation between the behavioral state assignment and the habitat selection estimation, and we suggest possible future avenues to improve on our approach.