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Using ecological diffusion to inform management of a recovering apex predator

The reintroduction and recovery of predators can be ecologically beneficial as well as socially and economically controversial. However, the growth and expansion of predator populations, and thus their ecological, social, and economic impacts, are not static; they are dynamic in both space and time. We propose a spatiotemporal modeling framework to better inform the ecology and management of recovering predators and demonstrate its utility by applying it to a recovering sea otter (Enhydra lutris) population in southeast Alaska, where sea otters were reintroduced in the late 1960s and have since exhibited unprecedented population growth and range expansion. The framework combines, into a Bayesian hierarchical structure, multiple data sources and a model of ecological diffusion that accounts for density-dependent population growth. The hierarchical ecological diffusion model is continuous in space and time allowing flexibility to make inferences about particular areas of interest (e.g., proposed management units), as well as how those areas can be monitored and incorporated into the model structure. Estimated parameters yield inferences about movement and population ecology and our approach provides multiple derived quantities of interest, such as local current and equilibrium abundance and, of particular utility for management, equilibrium differential. We used our model to learn about how density dependence and equilibrium abundance of sea otters vary spatially across a region, in part driven by spatial variation in the effect of natural resource management on density dependence. Our results also suggest ways in which a dynamic management strategy could be developed and optimized as the population continues to grow and expand its range. While we applied this hierarchical diffusion modeling approach to a recolonizing sea otter population, it could be applied to aid the management of many (re)colonizing predators as well as other taxa.