Extreme Environmental Events and Transient Dynamics Shape Multiple Population Trajectories in Sierra Nevada Bighorn Sheep

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ABSTRACT: We modeled spatio-temporal dynamics of endangered Sierra Nevada bighorn sheep (*Ovis canadensis sierrae*) within the context of hierarchical complexity. A long-standing paradigm is that population dynamics of large mammal herbivores (≥ 10 kg) are characterized by low variation in adult survival and high variation in recruitment. However, some tenets on which this paradigm is based (asymptotic dynamics) may be unrealistic for many species, especially those inhabiting highly variable environments that exist in relatively small subpopulations. Based on modeling of a 22-year dataset of 14 bighorn subpopulations across 5,000 km^2, we have found: (1) extreme events produce transient dynamics in adult survival and recruitment that shape population trajectories for many years; (2) subpopulations can exhibit responses that vary in magnitude and direction to annual environmental conditions; and (3) the taxa is meaningfully characterized by variability in levels and timing of trajectories within subpopulations rather than a mean "trend" or population growth rate across subpopulations. We anticipate that the capability to quantify responses to extreme snow years and years of high predation which this dataset has given us will be broadly applicable to wild sheep with disjunct populations inhabiting highly variable environments. As has been reported elsewhere, we observed a portfolio of migratory behaviors and patterns of habitat selection amongst Sierra bighorn. We observed cascading effects of migratory diversity on demography. We recognize that, once lost, some migratory patterns are more difficult to reestablish than others. Nevertheless, metapopulation persistence may benefit from restoring populations where high-quality seasonal ranges require complex migratory behavior (e.g., longer distances through less preferred habitat). A diverse portfolio of migratory behaviors and occupied landscapes is essential for maximizing the representation, redundancy, and resiliency that are at the core of species restoration. A changing climate presents challenges and opportunities for the restoration of wild sheep populations.

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