Using biophysics and Dynamic Energy Budget theory to investigate how a large mammal responds to varying environmental conditions

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Multiple factors affect where species can survive and persist across the landscape. Climate limits a species’ range and abundance directly – via physiology, activity constraints, and mortality in extreme events – and indirectly, by affecting food availability. We have developed and linked two mechanistic and individual-based models to investigate how populations of red kangaroos (*Macropus rufus*) respond to varying climate and nutritional conditions. Biophysical models are a powerful tool for predicting an animal’s metabolic and water requirements based on how their physiology, behavior, and morphology interact with microclimate conditions. However, biophysical models do not fully capture what energy (and water) is available and how this energy is allocated to different metabolic purposes. Such insight can be granted by metabolic theory, such as the Dynamic Energy Budget (DEB) theory, which considers how animals allocate energy (and mass and nutrients) to maintenance, development, growth, and reproduction throughout the animal’s lifespan. We used the output from a biophysical model (NicheMapper) to calculate maintenance requirements of red kangaroos for a DEB model, and coupled the models with estimated food availability, based on spatial and temporal data on pasture growth. We found that the northern range boundary of the red kangaroo is limited by heat tolerance, which constrains foraging time. We also show how body condition and temporal changes in food availability interact with climate to affect reproductive output. Such a fully mechanistic approach is a novel and powerful tool for investigating how range limits and population vital rates are affected by varying nutritional and climatic environments.