Carnivorans in a changing world: Trait-environment relationships under ecological disruption

Organisms interact with their environments through functional traits that shape how they acquire resources, move through landscapes, and respond to ecological constraints. Traits related to diet and feeding, such as cranial morphology, often show strong associations with environmental conditions, reflecting long-term ecological filtering. These trait-environment relationships can promote functional complementarity among species and contribute to ecosystem stability. However, as ecosystems become increasingly altered by anthropogenic forces, fundamental questions arise about when these relationships remain intact and when they begin to degrade. I explore how ecological disruption reshapes trait signals and how these changes can be used to understand species responses by evaluating: the standing trait variation in relatively intact systems, the ways anthropogenic pressure can scramble trait-environment relationships, and how trait-based patterns can be used to quantify when ecological signals remain predictive. Using carnivoran mammals as a focal system, I show that even in minimally disturbed environments, trait signals can be subtle and context dependent. Under stronger disruption, such as urbanization and captivity, traits tend to shift in consistent ways, altering morphology, behavior, and functional performance, including traits related to feeding efficiency, brain size, and locomotion. These changes have consequences across biological scales. At an organismal level, altered environments can reshape traits in ways that influence functionality. At an ecosystem level, trait shifts and species losses can disrupt community structure and ecosystem functioning. By modeling trait-environment relationships, we can identify where these signals are stable, where they have broken down, and where disruption is most likely to occur spatially. Finally, these approaches can be extended to fossil communities, allowing trait-based models to inform paleoenvironmental reconstructions. Together, this work advances a framework for interpreting traits in disrupted ecosystems, linking modern ecological change with deep-time perspectives and improving our ability to diagnose and predict ecological responses to environmental disruption.