TEMPLE UNIVERSITY
Department of Mathematics

Applied Mathematics and Scientific Computing Seminar

Room 617 Wachman Hall

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Metabolic Approaches to Predicting Ecological Impacts of Climate Change: Parasites, Polar Bears and Other Arctic Critters

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Abstract.

Climate change is affecting ecosystems worldwide. Predictive models for future impacts are needed but often remain elusive due to ecosystem complexity and a lack of data to parameterize models. Here, I argue that most impacts can be understood using bioenergetic approaches. Two major frameworks – the Metabolic Theory of Ecology (MTE) and Dynamic Energy Budget Theory (DEB) – have emerged in recent years, and I will discuss how these can be used to predict climate change impacts. For illustration, I focus on arctic ecosystems, which – due to a strong climate signal and relatively low complexity – are particularly suitable to develop and test predictive models. First, I link MTE with host-macroparasite models, an approach that allows addressing some of the central questions concerning climatic impacts on host-parasite systems, such as which systems are the most sensitive to change, or at which locations climate change will have the greatest impact. The framework allows integrating multiple nonlinear environmental effects to predict parasite fitness under novel conditions, and can, for example, be used to determine whether climate change will lead to range contractions, shifts, or expansions. Applying the models to seasonal environments, I show that climate warming can split previously continuous spring-to-fall transmission seasons into two separate transmission seasons with altered timings. Further, I show that parasites with an indirect life cycle may adapt more easily to warmer climates than parasites with a direct life cycle, in contrast to commonly prevailing assumptions. Model predictions conform closely with empirical data for several helminth parasites, indicating broad model applicability. Second, I discuss DEB-models for polar bears, which capture the functional dependence between energy availability and physiological processes to predict survival and reproduction under future environmental conditions. Finally, I highlight potential alleys to link MTE- and DEB-approaches to develop a unifying mechanistic, bioenergetic framework for understanding climatic impacts on ecosystems. Throughout, I will place particular emphasis on the usefulness of bioenergetic approaches for estimating model parameters a priori, even in data-poor systems. This ability could help resolve prevailing problems of data scarcity and thus provide a framework for understanding and predicting climate change impacts worldwide.