The influence of climate on songbird survival, behavior, and distributions

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Marquette University, 2025

Understanding how abiotic and biotic factors interact to shape species distributions and population dynamics is essential in a rapidly changing world. Ecological research has traditionally focused on either regional or local scale processes that determine distributions and abundances. For example, some environmental factors such as climate can influence both large-scale population dynamics (i.e., macroclimate effects) and local-scale interactions and individual performance (i.e., microclimate effects), while other factors such as biotic interactions among individuals mostly influence local interactions in a way that might scale up to influence larger-scale population dynamics. However, we lack a comprehensive understanding of how broad-scale and local-scale environmental factors combine and potentially interact to impact species distributions and abundances. The goal of this dissertation is to advance our understanding of the effect that climate and local-scale biotic interactions have on the spatial distributions and local population dynamics of species. To achieve this goal, this dissertation is divided into three chapters that examine: 1) the broad-scale effects of global climate cycles on annual survival rates of birds; 2) broad- and local-scale effects of climate and local-scale effects of interactions with competitors on bird stress physiology; and 3) how local microclimate interacts with species traits to determine aggressiveness in species interactions. In this dissertation, I use songbirds as a study system to examine the role of climatic variation, species interactions, and habitat quality in structuring populations across spatial and ecological gradients. This dissertation will advance our current ecological understanding of how broad and local scale environmental factors combine and interact to influence the distributions and population dynamics of species. Below I provide more information about each chapter.

In the first chapter, I used mark-recapture data from over 350,000 individuals across North America to test the mechanisms of how broad-scale climatic variation correlate to fluctuation in population sizes. I test how global climate cycles, like the El Niño Southern Oscillation and North Atlantic Oscillation, affect annual apparent adult survival probability for 49 species across North America. I found that global climate cycles have synchronized effects on survival and could provide mechanistic support for the broad-scale climate hypothesis, which posits that population dynamics of organisms are largely synchronized at regional scales. Climate impacts on survival were largely synchronized within broad regions, but effects varied by migratory strategy, region, and species traits. These findings suggest that global climate cycle effects on nonbreeding areas of birds' ranges might be responsible for this spatial synchrony in survival rates.

In the second chapter, I evaluated predictions from habitat selection theory by investigating how fine-scale variation in habitat structure, climate, and conspecific density influence individual markers of stress in a high elevation forest specialist songbird, the hermit

warbler (*Setophaga occidentalis*). Telomeres are a biomarker of physiological stress where increased telomere shortening correlates with increased accumulated oxidative stress. Understanding how measures of stress vary across habitat gradients can help answer questions on habitat selection processes. I found that telomere length increased with elevation and decreased with conspecific density. This suggests that songbirds in this system are following an ideal despotic compared to an ideal free distribution, as stress was lowest in higher-quality breeding habitat with fewer conspecific competitors.

In my third chapter, I conducted a playback experiment along a microclimatic gradient to test how microclimate and other environmental factors affect the strength of intra- and interspecific aggression for two closely-related species pairs. I found that aggressive interactions shift with environmental context, suggesting that aggression levels are not fixed but vary across ecological gradients like forest structure.

Together, these studies demonstrate that population and community processes in birds are jointly shaped by interactions among broad- and local-scale climatic variability, local-scale habitat structure, and local-scale species interactions. This work advances our understanding of how abiotic and biotic factors jointly influence avian ecology and underscores the need for a multi-scalar approach to studying population and community dynamics in changing environments.