

PREFACE

Phenology, or the study of plant and animal life-cycle episodes, is a well-studied and oft-admired science that has been an integral part of human culture for millennia. Polynesians used the reoccurrence of migrating Pacific Golden-Plovers (*Pluvialis fulva*) to discover remote islands, naturalists such as Aldo Leopold remarked at the phenology of plants and animals as the "arteries of the land," and Henry David Thoreau collected budburst and flowering data at Walden Pond that is aiding our understanding of historic and current phenological events. Though phenological observations have been conducted for centuries due to their ease of execution, recently there has been a renewed interest in phenology as an integrative science for monitoring the complex biological response to climate change and extreme weather. Nearly all phenological events are influenced by climate and weather, and it has been suggested that phenological monitoring provides a "yardstick" for documenting environmental change due to these factors (Visser and Both 2005). Yet, while there is strong evidence that timing of flowering and other phenological events are indeed shifting, there remains a limited understanding of how these changes impact the intricate relationships of migratory animals with ephemeral resources throughout the annual cycle. Additionally, it is unclear whether there are individual, population, or ecological consequences if these relationships become decoupled due to climate change. Thus, researchers and practitioners are challenged with

understanding phenological events and relationships, under a variety of climatic conditions, in order to prioritize management and conservation.

Bird migration is arguably one of the most celebrated and well-studied phenological events, and there is evidence (mainly from Europe) that birds are shifting their migration behaviors due to climate change. However, while there has been a surge in phenology research over the past decade, there remains a paucity of studies for avian species and communities throughout North America. Here, we present this volume of *Studies in Avian Biology* to explore the critical linkages between migratory birds, their seasonal resources, and shifts in climate change and weather events. We crafted this volume to bring together recent research focused on bird migration and resource phenology in the United States, with a broader focus on birds that breed and winter throughout North America. While this volume in *Studies in Avian Biology* only scratches the surface of knowledge necessary to understand the effects of climate change on migratory birds properly, we intend for it to act as a compendium for the current state of bird migration and phenology research in North America.

The initial discussions for this project began in 2009. At the time, Jherime and I were Ph.D. students studying bird migration and the phenology of habitat resources in Arizona and Wisconsin, respectively. Upon realizing that we were conducting similar work, we began communicating regularly about similarities and differences we were

observing in our research and that of others across dramatically different ecosystems of the United States. Most of our discussions about the current state of phenological monitoring and research acknowledged the richness of papers studying sub-Saharan migratory birds breeding in Europe. We quickly realized that there was a major gap with bird migration phenology research in North America. One of our colleagues and a fellow phenology researcher, Dr. Joseph J. Fontaine, shared a similar assessment, and he challenged us to fill a small portion of this gap in North America. Based on conversations in 2010 and 2011, we developed a road map of two related tasks to achieve this. The first was a special symposia at the fifth meeting of the North American Ornithological Conference in Vancouver, Canada, during August of 2012, titled "Tracking Migratory Stopover Phenology: Climate Change and the Phenological Synchrony of North American Bird Migration with Seasonal Resources." Here, we brought together 11 speakers, 10 based in North America and the other in Europe, presenting on topics ranging from asynchronous changes in phenology of migrating Broad-tailed Hummingbirds and their early-season nectar resources in Colorado and Arizona (speaker David W. Inouye) to historical migration phenology in Thoreau's Concord over 150 years (speaker Elizabeth R. Ellwood).

From this symposium, we organized this volume of *Studies in Avian Biology*, which was the second task of our road map. With our book, we have brought together over 40 researchers contributing 12 chapters from projects conducted during either spring or fall migration throughout North America. We organized the volume to begin with conservation and management considerations for migratory birds and climate change in both the western and midwestern portions of the United States. We also highlight an exciting new citizen science project—the USA–National Phenology Network Nature's Notebook program—and ways in which these data can be incorporated into conservation research. We then highlight two chapters relating climate on the wintering grounds to spring migration of both short- and long-distance migratory birds. These chapters fall

under the theme of migratory connectivity, which aims to understand the carryover effects of events affecting individuals or populations during one distinct segment of the annual cycle to another. Next, we highlight linkages of birds, their seasonal resources, and climate and weather effects at stopover habitats in both spring and fall migration. The last two sections of this volume, on spring and fall migration, are generally focused on understanding synchronous relationships of migratory birds and their seasonal resources, as well as the nature of these relationships in the face of climate change or extreme weather events. At present, it remains unclear whether the decoupling of these synchronous relationships, often termed "phenological mismatch," has broader population level consequences or other deleterious ecological effects, such as disruption of ecosystem services; these chapters present baseline information for potentially exploring such questions in the future.

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LITERATURE CITED

- Visser, M. E., and C. Both. 2005. Shifts in phenology due to global climate change: the need for a yardstick. *Proceedings of the Royal Society of London B* 272:2561–2569.