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CHAPTER 1

INTRODUCTION: RESEARCH AND PERSPECTIVES ON THE STUDY OF ANTHROPOGENIC NOISE AND BIRDS

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Welcome to the *Ornithological Monographs* volume focused on how anthropogenic noise affects both birds and the study of birds. Concomitant with the growth of human populations and infrastructure development that has left few landscapes untouched by human activities (Ellis and Ramankutty 2008), there has been an increase in anthropogenic noise that emanates from urban areas, as well as from industrial agriculture, resource extraction activities, and our dendritic transportation networks (Barber et al. 2010). Although the negative effects of anthropogenic noise on humans are fairly well documented (e.g., Alberti 1998, Babisch 2003, Jarup et al. 2008), only recently have biologists recognized that anthropogenic noise represents a serious concern for other species as well. Several recent reviews have highlighted potential and known effects of noise on terrestrial organisms (Patricelli and Blickley 2006, Warren et al. 2006, Slabbekoorn and Ripmeester 2008, Barber et al. 2010, Kight and Swaddle 2011); the present volume is the first compilation specifically focused on this important conservation issue.

Born of a symposium on the effect of anthropogenic noise on birds and bird studies at the 2008 Joint Meeting of the American Ornithologists' Union, Cooper Ornithological Society, and Society of Canadian Ornithologists, this volume represents an effort to bring increased awareness to the issue as well as highlight diverse and interesting research in this area of study. In 2008, organizers at that symposium had difficulty locating enough North American investigators studying the effects of noise on birds to fill all the speaking slots. Now, just a few years later, there would be no such problem; the body of studies involving noise and birds has quickly expanded (Fig. 1) and includes a diversity of species, environments, and noise types. Illustrative of the growing interest in this topic, in 2008 we knew of only four urban-adapted songbirds that have distinctly different singing behavior in noisy areas than in quiet areas (e.g., Slabbekoorn and Peet 2003, Brumm 2004, Fernández-Juricic et al. 2005, Wood and Yezerinac 2006, Fuller et al. 2007). This list has now grown to comprise more than 25 species, including suboscine (suborder Tyranni; Francis et al. 2011b) and nonpasserine species (family Psittacidae; Hu and Cardoso 2010) that are found in both urban and nonurban environments. The individual contributions in the present volume further our knowledge of how noise affects bird communication, and they also address other important issues and consequences associated with noise exposure that have received less attention.

One goal in putting together this *Ornithological Monograph* was to provide an overview of this emerging subfield and present a road map for future research. To this end, the review presented by Ortega (2012) describes the history of studies on the influence of noise on birds, presents a brief primer on how noise is measured, and discusses the many ways in which noise can affect birds. Ortega concludes by presenting several areas in need of future research. This review is a good starting place for people who are unfamiliar with the issues surrounding noise and birds or for those interested in pursuing future studies on this topic.

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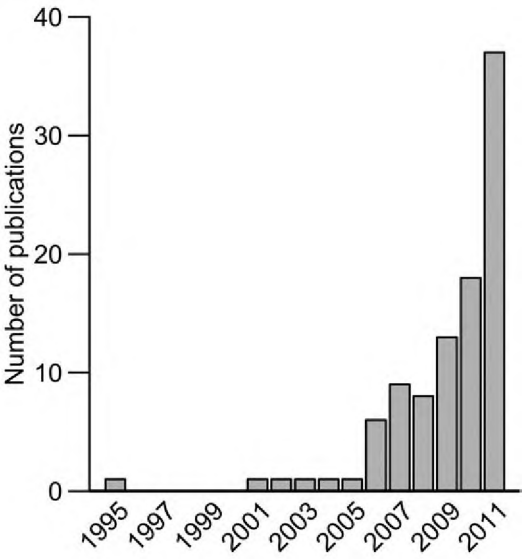

FIG. 1. Results from a Web of Science (Thomson Reuters) search for "bird*noise" and "anthropogenic or urban" conducted on 22 December 2011.

Another goal in compiling this volume was to highlight new, innovative research on the topic. Therefore, the remaining papers present original research on how noise influences avian communication, behavior, habitat selection, and reproductive success and address how noise might hamper investigators' ability to study birds. Although the studies included here represent a fraction of current studies on these topics, they were selected for this volume because they employ a variety of experimental and observational approaches, include a diverse range of species, and address the issue at different scales, from individual behavior to community-level processes.

Birds use acoustic communication for a host of biologically important functions, so it is no surprise that acoustic masking of vocal signals by noise has been cited as a potentially critical problem for a variety of species (Patricelli and Blickley 2006, Francis et al. 2011a). Four contributions to this volume present research related to acoustic communication, each providing a unique and needed perspective. In the first, Blickley and Patricelli (2012) provide an overview of how anthropogenic noise can mask acoustic signals and result in a communication breakdown along three separate stages of the interaction between a signaler and a receiver: detection, discrimination, and recognition. Their analyses demonstrate that low-frequency noise from energy extraction activities masks the acoustic display of lekking male Greater Sage-Grouse (*Centrocercus urophasianus*), greatly reducing the distance at which these signals can be detected. Such masking may impair the ability of female Greater Sage-Grouse to assess potential mates, which is critical to the breeding biology of this species of conservation concern.

In another study focused on the effects from energy-sector noise, Francis et al. (2012a) compare habitat use and singing behavior of the Blue-gray Gnatcatcher (*Polioptila caerulea*) and the Spotted Towhee (*Pipilo maculatus*) in response to chronic noise produced by compressors coupled with natural gas wells. Habitat occupancy of both species is uninfluenced by noise, but the Spotted Towhee sings at a higher frequency in noisy areas, whereas the Blue-gray Gnatcatcher does not. This difference in vocal behavior may be explained by the greater masking potential of this low-frequency noise for the lower-frequency towhee songs than for the gnatcatcher songs and is consistent with recent findings comparing frequency change in several species in Australia (Hu and Cardoso 2010).

Using a study system that spans a gradient of urban development, Kight et al. (2012) present findings from playback experiments that demonstrate how noise, physical habitat features, and signal acoustic properties affect sound propagation. They show that anthropogenic noise and human alterations to natural areas can, respectively, reduce the signal-to-noise ratio (which represents the contrast between the signal and background noise) and degrade signal features. Their findings imply that preserving natural features may be just as important as managing noise levels to maintain conditions suitable for bird communication.

Using the same gradient of urban development, Swaddle et al. (2012) focus on parent–nestling communication. Specifically, they examine whether the begging calls of nestling Eastern Bluebirds (*Sialia sialis*) vary with changes in anthropogenic noise exposure and assess how weather conditions affect call propagation distance. They show that nestlings of this species fail to adjust any aspect of their calling behavior in response to increases in noise levels and that increases in temperature and humidity can greatly reduce the distance at which begging signals can be heard. Collectively, these four studies highlight how masking of acoustic communication by anthropogenic noise can influence birds in a

variety of contexts, from mate selection to habitat use and in both urban and nonurban areas.

Just as noise may impair acoustic communication in several species, noise also interferes with the human observer's ability to detect birds during surveys. Ortega and Francis (2012) show that continuous noise can reduce acoustic detection of birds by ~50%, which can lead to biased estimates of species richness and community diversity. Surprisingly, anthropogenic noise that raises background noise levels by only 5–10 dB(A) above fairly quiet ambient levels can result in severely biased estimates. This finding has important implications for the countless bird surveys that are used worldwide to monitor population trends, and the message is clear: the effects of ambient noise levels, whether human-generated or naturally occurring, must be considered very carefully when conducting standard surveys.

Species differ in their response to introduced noise, and understanding the impact of anthropogenic noise in relation to other threats is critical for developing effective management plans for sensitive species. Lackey et al. (2012) examine behavioral responses, territory placement, and reproductive success in the federally endangered Golden-cheeked Warbler (*Setophaga chrysoparia*) in a field experiment that used playback of construction noise. Their results suggest that this species alters neither its territory placement nor its behavior in response to noise playback. Reproductive success also appears to be unaffected by construction noise. These findings suggest that intermittent construction noise may not be among the major threats to Golden-cheeked Warblers. This study also highlights the challenges associated with experimentally introducing noise stimuli. Although it is often difficult to accurately reproduce a real noise disturbance in the field, noise playback is certain to serve as an important tool for identifying and quantifying the effects of noise on wildlife in future noise-related research.

In a final contribution, Francis et al. (2012b) focus on community-level processes by examining nest predation patterns in response to noise generated from gas well compressors. They use motion-triggered cameras paired with artificial nests baited with Japanese Quail (*Coturnix japonica*) eggs to determine which predator species prey upon nests in noisy and quiet areas. Their results confirm patterns of higher nest success for real nests in noisy areas (Francis et al. 2009) but also suggest that lower predation in noisy areas may be due primarily to lower densities of main nest predators, rather than to predators being present but impaired by noise in their ability to locate nests. This study underscores the need to examine the effect of noise on species interactions in order to understand individual species' responses to noise as well as cumulative community-level consequences.

Collectively, these papers provide a snapshot of a topic of major current interest in diverse fields, including conservation biology, behavioral ecology, population biology, and community ecology. In the opening review, Ortega (2012) outlines many areas in need of research, but a few issues stand out as especially important in guiding research questions and study designs aimed to reveal how anthropogenic noise affects birds and other wildlife.

It is often difficult to compare noise impacts across studies because of the many ways in which noise is measured and the sparse descriptions of noise that are frequently published. It is critical that we begin to standardize noise-measurement methodologies so that comparisons across studies can be more meaningful. Until standards are established, investigators must strive to fully describe how the noise stimulus varies temporally, report any amplitude-weighting scale that was applied to measurements, and provide power spectra and spectrograms of noise to illustrate the spectral distribution of acoustic energy. To do so, we biologists need to become more familiar with the variety of measurement devices and metrics available; a recent review by Pater et al. (2009) provides a good starting place for researchers who are new to these tools and techniques.

To develop a broader understanding of noise effects on birds and to predict future impacts, studies must include a more taxonomically diverse collection of species, including both those that thrive in urban settings and others that are known to be sensitive to anthropogenic disturbance. We also currently lack an understanding of how species' responses to noise differ with changes in the frequency, power, and timing of noise-exposure events. For example, some types of noise may compromise acoustic communication, but others may increase stress levels (Kight and Swaddle 2011) or trigger no response at all (e.g., Lackey et al. 2012). Determining which sources of noise are most and least problematic will be key to developing effective conservation measures.

We must also develop an understanding of the mechanisms that underlie responses to noise. Are the observed changes in reproductive success and habitat occupancy due primarily to acoustic masking of vocalizations, as has been frequently hypothesized, or are they associated with other mechanisms such as physiological stress? Are individuals responding directly to noise or indirectly via other social and environmental factors that are also influenced by noise? Answering these questions will require more comprehensive and integrated studies that examine the effects of noise on a range of physiological and behavioral parameters.

Problems associated with anthropogenic noise will only grow as Earth is increasingly dominated by human-altered landscapes (Ellis and Ramankutty 2008, Ellis 2011) and because sources of noise are growing faster than the human population (Barber et al. 2010). We have a lot to learn about how and why birds and other wildlife respond to anthropogenic noise, how responses to noise interact with other types of human disturbances to affect populations, and to what extent effects of noise have cumulative consequences for community-level processes. Disentangling these influences will be a challenge, but we hope that this volume will inspire others to begin their own research efforts aimed at understanding this emerging conservation issue. Ultimately, our ability to comprehend and mitigate the effects of noise on birds may be critical to their ability to survive and prosper in an increasingly human-dominated world.

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