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Anthropogenic noise alters bat activity levels and echolocation calls

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ABSTRACT

Negative impacts from anthropogenic noise are well documented for many wildlife taxa. Investigations of the effects of noise on bats however, have not been conducted outside of the laboratory. Bats that hunt arthropods rely on auditory information to forage. Part of this acoustic information can fall within the spectrum of anthropogenic noise, which can potentially interfere with signal reception and processing. Compressor stations associated with natural gas extraction produce broadband noise 24 hours a day, 365 days a year. With over half a million producing gas wells in the U.S. this infrastructure is a major source of noise pollution across the landscape. We conducted a 'natural experiment' in the second largest gas extraction field in the U.S. to investigate the potential effects of gas compressor station noise on the activity levels of the local bat assemblage. We used acoustic monitoring to compare the activity level (number of minutes in a night with a bat call) of the bat assemblage at sites with compressor stations to sites lacking this infrastructure. We found that activity levels for the Brazilian free-tailed bat (*Tadarida brasiliensis*) were 40% lower at loud compressor sites compared to quieter well pads, whereas the activity levels of four other species (*Myotis californicus, M. cillolabrum, M. lucifugus, Parastrellus hesperus*) were not affected by noise. Furthermore, our results reveal that the assemblage of bat species emitting low frequency (<35 kHz) echolocation calls also showed a response, with a 70% reduction in activity levels at loud sites compared to quieter well pad sites whereas the assemblage using high frequency (>35 kHz) echolocation did not exhibit altered activity levels in noise. Lower activity levels of Brazilian free-tailed bats at loud sites indicate a potential reduction in habitat for this species. Additionally, a comparison of echolocation search calls produced by free-tailed bats at sites with and without compressor stations reveal that this species modifies its echolocation search calls in noise—producing longer calls with a narrower bandwidth. Call alterations might affect prey detection. These preliminary findings highlight the important need for further research of how anthropogenic noise affects bats on a landscape scale.

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1. Introduction

Human infrastructure removes wildlife habitat, alters connectivity, causes mortality, and introduces ecological pollutants (Sih et al., 2011). A meta-analytical study found that bird densities decline within 1 km of infrastructure and non-volant mammal densities are reduced within 5 km (Benitez-Lopez et al., 2010). Less is known about bats' response to human alteration of habitat but recent work has shown that bat diversity and activity decline with increasing human development (Jung and Kalko, 2011). For instance, roads cause direct mortality (Medinas et al., 2013) and appear to function as barriers and filters to bat assemblages by restricting movement (Abbott et al., 2012; Bennett and Zurcher, 2012) and changing space use (Bennett et al., 2013). Because the disturbance created by roads and other human infrastructure is comprised of multiple components it is difficult to estimate the strength of any single influence (Forman et al., 2003).

Anthropogenic noise associated with infrastructure is an overlooked stimulus that could affect bat habitat use (Barber et al., 2010; Francis and Barber, 2013). Laboratory experiments have shown that gleaning bats exposed to traffic and gas compressor station noise exhibit reduced foraging efficiency (Siemers and Schaub, 2011; Bunkley and Barber, in preparation) and, when presented with the option, avoid hunting in noise (Schaub et al., 2008). Gleaning bats hunt using prey-generated sounds, which could be masked by anthropogenic noise. The potential effects of noise on these bats as wells on bats that utilize echolocation for prey detection are poorly understood at the landscape scale.

Two approaches have been used to tease apart the independent role of noise from other stimuli associated with anthropogenic disturbance of wildlife. Large-scale playback experiments have shown that traffic noise caused over a one-quarter decline in migrating songbird abundance (McClure et al., 2013) and gas drilling and truck noise reduced male Greater Sage-Grouse (*Centrocercus urophasianus*) lek attendance (Blickley et al., 2012). Other investigators have taken advantage of 'natural experiments' in natural gas extraction fields, comparing quiet sites to loud sites with compressor stations. These studies have found that breeding bird densities decrease by one-third at loud sites (Bayne et al., 2008) and avian communities are substantially altered (Francis et al., 2009), resulting in the disruption of key ecological services such as seed dispersal (Francis et al., 2012). Despite strong evidence illustrating habitat degradation and loss for birds, no study has attempted to identify the effects of noise on habitat use by bats.

Here we present data from our investigation of bat activity levels in the second largest gas extraction field in the U.S., in northwest New Mexico. Compressor stations used for the extraction and transportation of natural gas produce spectrally broadband noise 24 h a day, 365 days a year. We compared bat activity levels and sonar call structure at control well pad sites to nearby sites with compressor stations and predicted that this noise source would influence bat activity levels and shape echolocation characteristics. In this 'natural experiment', control sites lacked a compressor station with its characteristic broadband, high intensity noise, but were otherwise similar to treatment sites with compressors. We quantified the background sound level of sites using continuously deployed Acoustic Recording Units while simultaneously acoustically monitoring bat activity. We hypothesized two potential responses of bat activity level to noise: (1) a continuous response with activity decreasing as background dB levels increased, indicating that bats respond to noise exposure in a dose–response fashion, or (2) a binary response to compressor noise with more activity at well pads than compressor sites and with equal activity between treatment sites, regardless of differences in background dB level, indicating a step-function response to noise exposure.

1.1. Methods

We conducted this work in May and June of 2013 in and near Rattlesnake Canyon Habitat Management Area in the San Juan Basin in northwestern New Mexico (Figs. 1 and 2). The San Juan Basin is the second largest natural gas basin in the United States and the largest coal-bed methane reservoir in the world, producing about one trillion cubic feet of gas per year from more than 150 gas fields (Fassett, 2010).

Piñon pine (*Pinus edulis*) and juniper (*Juniperus osteosperma*) trees are the dominant plants in this arid region (Francis et al., 2012). Rock outcroppings and a nearby canyon and reservoir are also prominent features on the landscape. The San Juan Basin is within the range of 17 bat species (Nowak, 1994), 14 of which were detected during this study. All identified species are in the family Vespertilionidae except for *T. brasiliensis*, which is in the Molossidae family (Nowak, 1994). Piñon–juniper woodlands in New Mexico support an abundant and diverse bat community (Jones, 1965; Chung-MacCoubrey, 1996, 2005). In part this is because piñon–juniper forest is a transition zone between the arid grass/shrubland community at lower elevations and mesic forests at higher elevations, thus, providing habitat for species from both regions (Jones, 1965).

Piñon–juniper habitat in general is considered suitable in terms of food availability, water, and roosts for *E. fuscus*, *M. ciliolabrum*, *M. evotis*, *M. thysanodes*, and *M. volans* (Chung-MacCoubrey, 2005). Large bodies of water, such as the Navajo reservoir, are also important resources for *T. brasiliensis* (Chung-MacCoubrey, 2005). Thus, we consider the piñon–juniper habitat to be generally suitable to the range of bats we sampled at our sites. Treatment and control sites can be considered similar in terms of roost habitat and potential foraging opportunities. We sampled during a time of high bat activity, which coincides closely with pregnancy and parturition of many bat species and thus represents a time of higher energy requirements for females (Altringham, 2011; Fenton, 1997; Kunz et al., 1982). Reproductive females appear to prefer piñon–juniper habitat to the grass/shrubland and mesic forest communities, both for maternity roosts and for rearing young (Chung-MacCoubrey, 2005).