Biological Conservation 184 (2015) 327–334

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Energy development and avian nest survival in Wyoming, USA: A test of a common disturbance index

Matthew G. Hethcoat[a,*], Anna D. Chalfoun[b]

[a] Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology, University of Wyoming, Laramie, WY 82071, USA
[b] U.S. Geological Survey Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology, University of Wyoming, Laramie, WY 82071, USA

ARTICLE INFO

Article history:
Received 15 August 2014
Received in revised form 4 February 2015
Accepted 7 February 2015
Available online 27 February 2015

Keywords:
Brewer's sparrow
Energy development
Fragmentation
Habitat loss
Indices
Natural gas
Nest predation
Sage thrasher
Sagebrush sparrow
Sagebrush steppe

ABSTRACT

Global energy demands continue to result in new and emerging sources of anthropogenic disturbance to populations and systems. Here, we assessed the influence of natural gas development on a critical component of fitness (nest survival) for Brewer's sparrow (*Spizella breweri*), sagebrush sparrow (*Artemisiospiza nevadensis*), and sage thrasher (*Oreoscoptes montanus*), three species of sagebrush-obligate songbirds that are of conservation concern, and assessed the efficacy of a commonly used index of oil and gas development intensity (well density) for estimating habitat transformation and predicting species' responses. During 2008–2009 and 2011–2012 we monitored 926 nests within two natural gas fields in western Wyoming, USA. We calculated landscape metrics (habitat loss, amount of edge, patch shape complexity, and mean patch size) to identify the aspect of landscape transformation most captured by well density. Well density was most positively associated with the amount of sagebrush habitat loss within 1 square kilometer. Nest survival was relatively invariant with respect to well density for all three species. In contrast, nest survival rates of all three species generally decreased with surrounding habitat loss due to energy development. Thus, although well density and habitat loss were strongly correlated, well density resulted in overly conservative estimates of nest survival probability. Our results emphasize the importance of careful evaluation of the appropriateness of particular indices for quantifying the effects of human-induced habitat change. For managers concerned about the effects of natural gas development or similar forms of human land use to co-occurring breeding birds, we recommend minimizing the amount of associated habitat conversion.

1. Introduction

Human modification of ecosystems remains one of the greatest threats to global biodiversity (Tilman et al., 1994; Pimm and Raven, 2000). As such, addressing the impacts of new and emerging sources of anthropogenic disturbance embodies one of the primary challenges in conservation biology. A rapidly growing source of habitat loss, fragmentation, and alteration is from alternative (e.g., solar, wind) and unconventional (e.g., shale gas, oil sands) energy development activities (McDonald et al., 2009; Northrup and Wittemyer, 2013). Global energy demand is forecasted to increase 40% in the next 20 years, with alternative and unconventional energy resources making up an increasingly larger share of the global energy budget (U.S. Energy Information Administration, 2013). Understanding how these activities can affect populations and systems is therefore increasingly important.

North America has been the epicenter of unconventional gas (tight gas, shale gas, and coal-bed methane via hydraulic fracturing), in both the exploitation of current reserves and the development of improved technologies. Accordingly, the number of unconventional gas wells in the United States has nearly doubled since 1990 (U.S. Energy Information Administration, 2013). As a consequence, surrounding habitats have been reduced and fragmented by the associated road networks, pipelines, drill pads, and waste pits. To date, however, quantification of landscape transformation from energy development has been restricted to coarse, regional scale assessments (McDonald et al., 2009; Northrup and Wittemyer, 2013). In addition, many studies examining organismal responses have relied on well density (number of active wells per some defined area) as an index for development intensity (Dale et al., 2008; Doherty et al., 2008, 2010; Carpenter et al., 2010; Harju et al., 2010; Gilbert and Chalfoun, 2011; Hamilton et al., 2011; Taylor et al., 2013). Well locations are

* Corresponding author. Tel.: +1 307 766 5415; fax: +1 307 766 5400.
E-mail addresses: HethcoatMG@gmail.com (M.G. Hethcoat), achalfou@uwyo.edu (A.D. Chalfoun).

http://dx.doi.org/10.1016/j.biocon.2015.02.009
0006-3207/

accurately mapped and readily available for many regions in North America (e.g., Colorado Oil and Gas Conservation Commission, Montana Board of Oil and Gas Conservation, Alberta Energy Regulator), resulting in a convenient gradient of disturbance for comparisons. A potential problem, however, is that the relevance of well density has been presumed and not explicitly investigated. Well pad size and the number of wells on a drill pad can vary substantially (from 1 to >30) depending on drilling approaches, such as the amount of directional drilling employed. The spatial configuration of wells can therefore produce strikingly different landscape-scale habitat patterns (Fig. 1). The resulting landscapes may have similar well densities, but such variation may be decoupled from ecologically relevant parameters such as the degree of habitat loss or the spatial arrangement of remaining patches. Consequently, unanswered questions remain regarding what aspect(s) of habitat change well density most indexes, whether well density is suitable for characterizing landscape transformation, and if well density is an appropriate metric by which to accurately assess species' responses.

North American sagebrush steppe habitats and the associated wildlife species are ideal and timely foci with which to examine the relationships between energy development, landscape-scale habitat patterns, and ecological processes. Sagebrush steppe is regarded as one of the most altered ecosystems in North America as a result of extensive agricultural conversion, overgrazing, nonnative grass encroachment, and other human activities such as energy development (Braun et al., 1976; Vander Haegen et al., 2000; Knick et al., 2003). Three songbird species closely associated with this system, Brewer's sparrow (*Spizella breweri*), sagebrush sparrow (*Artemisiospiza nevadensis*), and sage thrasher (*Oreoscoptes montanus*) are species of conservation concern for many state and federal agencies and have shown concomitant declines in the majority of their range (Sauer et al., 2012). As an important first step, recent work documented significant declines in abundance of Brewer's sparrows and sagebrush sparrows in areas with higher densities of natural gas wells (Gilbert and Chalfoun, 2011). A critical next step, however, is the identification of potential mechanisms underlying observed declines.

The effects of habitat loss and fragmentation on nesting birds have received considerable attention, particularly patterns of increased nest predation in habitat fragments and near edges (Robinson et al., 1995; Chalfoun et al., 2002). Predation is the primary cause of nest failure in birds and an important factor limiting reproduction and population viability (Martin, 1992). Thus, as an important process that influences a key component of fitness, nest predation may affect patterns of abundance, such as those previously documented for sagebrush songbirds in natural gas areas (Gilbert and Chalfoun, 2011). Therefore, assessing nest predation patterns in relation to ecologically-based metrics offers insight into the development of mitigation strategies for effective conservation and management of songbirds affected by unconventional energy development activities.

The specific objectives of our study were to (1) identify which landscape metric was most closely associated with natural gas well density, (2) determine if well density was a reliable predictor of landscape transformation, and (3) evaluate sagebrush songbird nest survival in relation to natural gas extraction using both well density and the landscape metric most associated with well

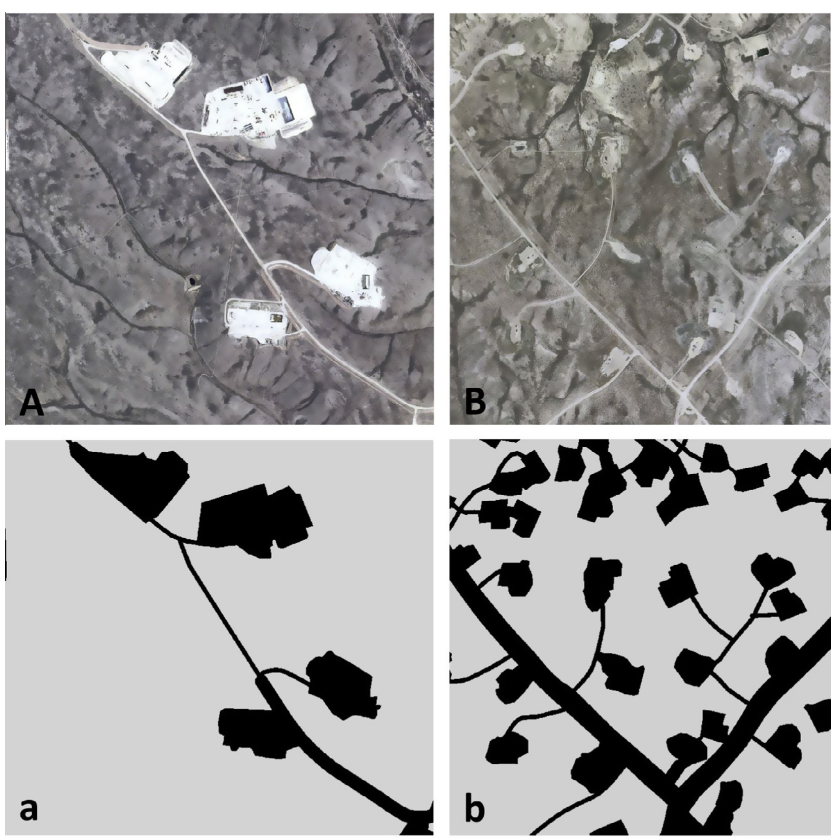

Fig. 1. Aerial imagery of selected study regions inside the (A) Pinedale Anticline and (B) Jonah natural gas fields, Sublette County, Wyoming, USA. Raster images, (a) and (b), of the same locations depict digitized drill pads, road networks, pipelines, reclaimed grass areas (all in black), and sagebrush habitats (grey) as distinct patches. Image (a) contains: 115 active wells, 5 distinct patches, and approximately 12% habitat loss. Image (b) contains: 75 active wells, 21 distinct patches, and approximately 30% habitat loss. Thus, image (a) has 50% more wells than (b) but half the amount of habitat loss, demonstrating the disconnect that can occur with an oft-used index (well density) and associated metrics of habitat alteration.