Biological Conservation 201 (2016) 78–91

Contents lists available at ScienceDirect

Biological Conservation

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

Shale gas development effects on the songbird community in a central Appalachian forest

Laura S. Farwell [a,*], Petra B. Wood [b], James Sheehan [a], Gregory A. George [a,1]

[a] West Virginia Cooperative Fish and Wildlife Research Unit, Davis College, School of Natural Resources, West Virginia University, P.O. Box 6125, Morgantown, WV, USA
[b] U.S. Geological Survey, West Virginia Cooperative Fish and Wildlife Research Unit, West Virginia University, P.O. Box 6125, Morgantown, WV, USA

ARTICLE INFO

Article history:
Received 1 April 2016
Received in revised form 18 June 2016
Accepted 21 June 2016
Available online xxxx

Keywords:
Energy impacts
Hydraulic fracturing
Marcellus-Utica
Land-use change
Forest fragmentation
Avian guilds

ABSTRACT

In the last decade, unconventional drilling for natural gas from the Marcellus-Utica shale has increased exponentially in the central Appalachians. This heavily forested region contains important breeding habitat for many neotropical migratory songbirds, including several species of conservation concern. Our goal was to examine effects of unconventional gas development on forest habitat and breeding songbirds at a predominantly forested site from 2008 to 2015. Construction of gas well pads and infrastructure (e.g., roads, pipelines) contributed to an overall 4.5% loss in forest cover at the site, a 12.4% loss in core forest, and a 51.7% increase in forest edge density. We evaluated the relationship between land-cover metrics and species richness within three avian guilds: forest-interior, early-successional, and synanthropic, in addition to abundances of 21 focal species. Land-cover impacts were evaluated at two spatial extents: a point-level within 100-m and 500-m buffers of each avian survey station, and a landscape-level across the study area (4326 ha). Although we observed variability in species-specific responses, we found distinct trends in long-term response among the three avian guilds. Forest-interior guild richness declined at all points across the site and at points impacted within 100 m by shale gas but did not change at unimpacted points. Early-successional and synanthropic guild richness increased at all points and at impacted points. Our results suggest that shale gas development has the potential to fragment regional forests and alter avian communities, and that efforts to minimize new development in core forests will reduce negative impacts to forest dependent species.

1. Introduction

The combined use of advanced horizontal drilling techniques and high-volume hydraulic fracturing (i.e., fracking) has increased access to large reserves of unconventional gas trapped in deep shale formations, which were previously considered inaccessible and uneconomical (Johnson et al., 2010). In contrast with conventional drilling for shallow gas deposits, unconventional gas development occurs at a much larger scale both in terms of land use and water consumption (Brittingham et al., 2014). Spurred by technological advances and energy demands, the rapid expansion of drilling for unconventional gas has largely outpaced research on potential environmental and biotic impacts in the United States (Kiviat, 2013; Souther et al., 2014) and in other countries (EIA, 2015).

Over the last decade, unconventional drilling for natural gas from the Marcellus-Utica shale has increased exponentially in the central Appalachian region (EIA, 2012), with 111 wells on the landscape in 2005, and approximately 14,022 wells by the end of 2015 (MCOR, 2016). While drilling in the Marcellus-Utica region has occurred in both forested and agricultural landscapes, the majority of future wells are projected to be drilled on forested lands, many of which lie in large areas of undisturbed forest (Johnson et al., 2010). The rapid expansion of shale gas wells and extensive linear infrastructure (roads and pipelines) has the potential to reduce regional forest cover and to leave remaining forests heavily fragmented (Drohan et al., 2012).

The Marcellus-Utica region is an area also known for its mature forests and diverse flora and fauna (Hinkle et al., 1993). It is considered a key conservation area for forest songbirds, and comprises important breeding habitat for many neotropical migrants, including several species of conservation concern (AMJV, 2015). Forest loss and fragmentation pose serious threats to biodiversity (Pimm and Askins, 1995; Collinge, 1996; Brooks et al., 2002), and are considered major drivers of population declines of forest birds (Robinson et al., 1995; Boulinier et al., 2001). There is growing concern that the rapid expansion of shale gas development will increase impacts of forest loss and fragmentation on breeding birds in the Marcellus-Utica region, particularly in previously intact forests (Kiviat, 2013; Brittingham et al., 2014). In addition to the direct impacts of deforestation, fragmentation, large-scale freshwater consumption (3–5 million gallons per well), increased impervious surfaces, and noise and light pollution, unconventional gas

* Corresponding author.
E-mail address: lsfarwell@mix.wvu.edu (L.S. Farwell).
[1] Current address: Department of Biology, Delaware Valley University, Doylestown, PA, USA.

http://dx.doi.org/10.1016/j.biocon.2016.06.019
0006-3207/

development poses potential secondary impacts on forest ecosystems and wildlife, including soil and water contamination, sedimentation of streams, increased human activity, and altered biotic communities and interactions (Kiviat, 2013; Souther et al., 2014), all of which may have auxiliary effects on avian assemblages.

Terrestrial birds are often used to assess how complex communities respond to human-modified landscapes, and are effective biological indicators of environmental degradation (Bradford et al., 1999; O'Connell et al., 2000). Birds also exhibit a wide range of habitat associations and space-use behaviors, and can reveal a diversity of responses to land use change (Leonard et al., 2008). To date, few studies have directly quantified impacts of unconventional oil and gas development on birds, and even fewer have focused on effects of forest disturbance associated with unconventional gas development on birds. In the boreal forests of Alberta, Canada, ovenbirds exhibited a threshold response to seismic line density and their territories did not cross seismic lines (Bayne et al., 2005; see Table 1 for scientific names of all species), and abundance of forest songbirds decreased near active compressor stations (Bayne et al., 2008). Other studies of unconventional oil and gas impacts on birds have primarily occurred in the western U.S., with a focus on sagebrush obligate species (Gilbert and Chalfoun, 2011; Blickley and Patricelli, 2012; Mutter et al., 2015), grassland birds (Thompson et al., 2015), and noise impacts of compressor stations in northwestern New Mexico (Francis et al., 2009, 2011). While there has been an increase in interest and research on the effects of unconventional oil and gas development on birds and other wildlife in the eastern U.S., this method of extraction is still relatively new in the region and much is still unknown about region-specific effects on forest ecosystems (Kiviat, 2013; Souther et al., 2014).

We monitored annual breeding bird abundances and changes in land cover associated with shale gas development at a long-term study site in northern West Virginia, to evaluate potential biological impacts. The specific objectives of our study were to (1) quantify the effects of shale gas development on forest cover at the site, both in terms of forest loss and fragmentation, and (2) determine if changes in species richness and relative abundance of songbirds reflect sensitivity to forest disturbance associated with unconventional gas development. Quantifying how breeding songbirds respond to this changing landscape is a valuable first step in developing spatially explicit management strategies to mitigate potential negative effects of ongoing unconventional gas development in forested landscapes.

2. Methods

2.1. Study area

Lewis Wetzel Wildlife Management Area (LWWMA) overlays the Marcellus and Utica shale gas basins in northwestern West Virginia

Table 1
Passerines and near-passerines surveyed at Lewis Wetzel Wildlife Management Area, West Virginia, from 2008–2015. Species were categorized into three guilds impacted by anthropogenic disturbance: forest interior, early successional, and synanthropic species. Birds with no assigned guild were excluded from analyses. Priority conservation species are shown in bold.

Forest interior	Early successional	Synanthropic	No assigned guild
Acadian flycatcher[1]	**Brown thrasher**[1]	American goldfinch	Black-billed cuckoo
Empidonax virescens	*Toxostoma rufum*	*Spinus tristis*	*Coccyzus erythropthalmus*
American redstart	**Blue-winged warbler**[1,2]	American robin	Blue-gray gnatcatcher
Setophaga ruticilla	*Vermivora cyanoptera*	*Turdus migratorius*	*Polioptila caerulea*
Black-and-white warbler[1]	Common yellowthroat	Baltimore oriole	Carolina chickadee
Mniotilta varia	*Geothlypis trichas*	*Icterus galbula*	*Poecile carolinensis*
Black-throated green warbler	Eastern bluebird	Blue jay	Cedar waxwing
Setophaga virens	*Sialia sialis*	*Cyanocitta cristata*	*Bombycilla cedrorum*
Blue-headed vireo	**Eastern towhee**[1]	Brown-headed cowbird	Downy woodpecker
Vireo solitarius	*Pipilo erythrophthalmus*	*Molothrus ater*	*Picoides pubescens*
Brown creeper	**Field sparrow**[1]	Carolina wren	Great-crested flycatcher
Certhia americana	*Spizella pusilla*	*Thryothorus ludovicianus*	*Myiarchus crinitus*
Cerulean warbler[1,2,3]	**Golden-winged warbler**[1,2,3]	Chipping sparrow	Northern flicker
Setophaga cerulea	*Vermivora chrysoptera*	*Spizella passerina*	*Colaptes auratus*
Eastern wood peewee[1]	Gray catbird	Eastern phoebe	Northern parula
Contopus virens	*Dumetella carolinensis*	*Sayornis phoebe*	*Setophaga americana*
Hairy woodpecker	**Indigo bunting**[1]	European starling	Red-bellied woodpecker
Picoides villosus	*Passerina cyanea*	*Sturnus vulgaris*	*Melanerpes carolinus*
Hooded warbler[1]	Orchard oriole	Mourning dove	Ruby-throated hummingbird
Setophaga citrina	*Icterus spurius*	*Zenaida macroura*	*Archilochus colubris*
Kentucky warbler[1,2]	**Prairie warbler**[1,2]	Northern cardinal	Summer tanager
Geothlypis formosa	*Setophaga discolor*	*Cardinalis cardinalis*	*Piranga rubra*
Louisiana waterthrush[1]	White-eyed vireo	Song sparrow	Tufted titmouse
Parkesia motacilla	*Vireo griseus*	*Melospiza melodia*	*Baeolophus bicolor*
Ovenbird	Willow flycatcher		White-breasted nuthatch
Seiurus aurocapilla	*Empidonax traillii*		*Sitta carolinensis*
Pileated woodpecker	**Yellow-breasted chat**[1]		Yellow warbler
Dryocopus pileatus	*Icteria virens*		*Setophaga petechia*
Red-eyed vireo			Yellow-billed cuckoo
Vireo olivaceus			*Coccyzus americanus*
Rose-breasted grosbeak			Yellow-throated vireo
Pheucticus ludovicianus			*Vireo flavifrons*
Scarlet tanager[1]			
Piranga olivacea			
Wood thrush[1,2]			
Hylocichla mustelina			
Worm-eating warbler[1,2]			
Helmitheros vermivorum			
Yellow-throated warbler[1]			
Setophaga dominica			

[1] Appalachian Mountains Joint Venture Conservation Priority Species (AMJV, 2015).
[2] USFWS Birds of Conservation Concern, National List (USFWS, 2008).
[3] IUCN Red List Species (IUCN, 2015).