Global Ecology and Conservation 6 (2016) 36–47

Contents lists available at ScienceDirect

Global Ecology and Conservation

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

Original research article

Sub-lethal effects of energy development on a migratory mammal—The enigma of North American pronghorn

Jon P. Beckmann [a,*], Sarah H. Olson [b], Renee G. Seidler [a], Joel Berger [a,c]

[a] Wildlife Conservation Society, North America Program, 212 South Wallace, Ste. 101, Bozeman, MT 59715, USA
[b] Wildlife Conservation Society, Wildlife Health and Health Policy Program, 2300 Southern Blvd., Bronx, NY, 10460, USA
[c] Fisheries, Wildlife, and Conservation Biology, Colorado State University, Fort Collins, CO 80523, USA

GRAPHICAL ABSTRACT

ARTICLE INFO

Article history:
Received 18 December 2015
Received in revised form 2 February 2016
Accepted 3 February 2016
Available online 19 February 2016

Keywords:
Migration
Natural gas
Pronghorn
Survival
Yellowstone

ABSTRACT

To meet societal demands for energy, ~50,000 gas sites are developed annually in North America, among which many are in western less-developed and wildlife rich areas. To evaluate effects of increasing energy infrastructure requires sufficiently robust study designs, an onerous issue given the vastness of scale, limited funds, and an abject dearth of baseline data. Here we address these issues, first by discussion of the type of approaches needed to develop proper inference about potential effects of energy footprints, and subsequently through an empirical approach by examining the biological performances of more than 370 GPS radio-collared adult female pronghorn (*Antilocapra americana*). A rigorous attempt to examine if industrial development has any impact on pronghorn is based on three assumptions: (i) late-winter body mass reflects a period of inadequate food availability because winter habitat is altered; (ii) variation between population segments reflects spatial differences in food availability, increased energetic costs, or varying survival rates between gas field and non-developed sites; and (iii) reproductive correlates including

* Corresponding author. Tel.: +1 316 992 2927.
E-mail addresses: jbeckmann@wcs.org (J.P. Beckmann), solson@wcs.org (S.H. Olson), rseidler@wcs.org (R.G. Seidler), jberger@wcs.org (J. Berger).

http://dx.doi.org/10.1016/j.gecco.2016.02.001

physiological and immunological markers and adult survival are lower at sites varying in habitat quality. Our study area situated in one of the world's premier wildlife regions – the southern Greater Yellowstone Ecosystem – harbors approximately 100,000 wintering ungulates, some of North America's longest migrations, and two of the continent's largest gas fields. We compared the response of five variables between wild pronghorn in control (not disturbed) and experimental (developed gas fields with well pads, roads, and traffic) sites—pregnancy, chronic stress, immune function, body mass, and adult survival. Despite shifts in animal movements, which included avoidance of energy infrastructure where development is occurring at the highest densities inside two of the largest natural gas fields in North America (Pinedale Anticline Project Area [PAPA] and Jonah fields) and other behavioral or ecological observations of sub-lethal effects, we failed to reject the null hypothesis that development is unrelated to parity in pronghorn biological responses. Studies intent on producing knowledge to assess whether energy development is inimical or not to ungulates will increasingly require appropriate time scales and understanding whether populations are below an expected food ceiling. Further, as with pronghorn in our study region, knowing if individuals are at the limits of their biological range (e.g. altitude) where stressful winter conditions may mask impacts of development is important.

1. Introduction

As the human footprint continues to expand globally, governments will be the final arbiters of strategies implemented on behalf of people and the planet's biodiversity. This is especially true of relatively intact geographies such as the neotropics, Arctic, and savannas where hydrocarbon development presses into wildlife-rich areas (Copeland et al., 2009; Berger and Beckmann, 2010; Naugle, 2010). The establishment of current and future conservation practices is partially dependent on credible science which, in turn requires appropriate study designs to detect if change occurs, and if so the magnitude of change from habitat alteration and other disturbance on population performances. Ideally, such designs would include baseline data on species abundance and distribution, biological attributes, abiotic factors (e.g. temperature and precipitation) and demographic trends (Beckmann et al., 2011). Such information is however rarely available (Northrup and Wittemyer, 2013; Lynch et al., 2015).

The most detailed studies of mammals in petroleum-rich areas have concentrated on four species in North America—caribou (*Rangifer tarandus*), elk (*Cervus elpahus*), mule deer (*Odocoileus hemionus*), and pronghorn (*Antilocapra americana*). While abundant GPS data are available (Hebblewhite and Haydon, 2010; Hebblewhite, 2011) much remains unknown about biological impacts of development at the individual or population level (Sawyer et al., 2009a,b; Lendrum et al., 2012, 2013). Most studies have addressed questions about habitat fragmentation and road avoidance (Beckmann et al., 2011, 2012; Seidler et al., 2015) with responses broadly classified as sub-lethal which may include behavior and ecological components such as movement, density alterations, and habitat shifts (Bayne and Dale, 2011). Since most work has been in areas where baseline data lack, projects have generally been observational and correlative, although at times Before–After-Control-Impact (BACI) approaches have been deployed. Less frequent are studies with replication or comparative design (i.e. control vs. treatment groups). For instance, 66% of 38 studies of the above four ungulates had only a weak observational approach or failed to have control study regions (Hebblewhite, 2011). Such limitations are serious because the power of inference becomes more restricted when null models cannot be tested by randomization of ecological data.

Here, we capitalize on a study design using control and experimental treatments to report the extent to which expanding industrial footprints affect life history parameters, health, and survival in adult female pronghorn. We focus on females because females are the critical element for population growth in all sexually reproducing species. The primary purpose of the study was to examine potential demographic differences between animals wintering in proximity to gas field development and wintering in undeveloped areas. Our goals were to examine pronghorn response (body mass, stress, pregnancy rates, immune-responses (health), and survival) to gas field development. To do this we compare these five parameters between experimental (individuals that winter inside natural gas field boundaries) and control (individuals that winter outside of natural gas field boundaries) subpopulations to understand how varying and increasing densities and scale of development and infrastructure impact pronghorn on their crucial winter range. We pose as a hypothesis that rapid alteration of habitat by energy development negatively affects reproductive correlates of pronghorn. If true, then pronghorn in such areas will be in poorer body condition than at control sites and might similarly be characterized by depressed immune-responses, lower pregnancy rates, higher levels of stress, and poorer survival.

Our study region is within several of North America's largest natural gas fields, both situated within the southern tier of the Greater Yellowstone Ecosystem (Fig. 1; Berger, 2003, Sawyer et al., 2009a, Beckmann et al., 2012, and Seidler et al., 2015). Two large mammals – pronghorn and mule deer – from this site have some of the longest reported migratory movements of any New World terrestrial mammals between Canada and Argentina; each species has also been the subject of regional or