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What attracts elk onto cattle pasture? Implications for inter-species disease transmission

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ABSTRACT

In Southwest Alberta, beef cattle and wild elk (*Cervus elaphus*) have similar habitat preferences. Understanding their inter-species contact structure is important for assessing the risk of pathogen transmission between them. These spatio-temporal patterns of interactions are shaped, in part, by range management and environmental factors affecting elk distribution. In this study, resource selection modeling was used to identify factors influencing elk presence on cattle pasture and elk selection of foraging patches; furthermore, consequences for inter-species disease transmission were discussed.

Data on pasture management practices and observations of elk were collected from 15 ranchers during interviews. Pasture use by elk was defined based on telemetry data (from GPS collars deployed on 168 elk in 7 herds) and rancher observations. At the patch scale, foraging patches used by elk were identified by spatio-temporal cluster analysis of telemetry data, whereas available patches were randomly generated outside the area delimited by used patches. For pastures and patches, landscape and human-managed features were characterized using remote sensing data and interviews, respectively. Attributes of available and used pastures (or patches) were compared using resource selection functions, on annual and seasonal (or annual and monthly) time scales. Additionally, intensity of pasture use was modeled using negative binomial regression.

Cultivated hay land and mineral supplements were associated with elk presence on cattle pastures, whereas pastures with manure fertilization and higher traffic-weighted road densities were less likely to be used by elk. The effects of landscape (elevation, aspect, water access) and vegetation (forest cover, Normalized Difference Vegetation Index) characteristics on patch selection were consistent with typical elk habitat requirements. The presence of cattle and the traffic-weighted road density were negatively associated with patch selection. The apparent avoidance of cattle by elk reduced the risk of direct transmission of pathogens, except during winter months. However, human-managed features attracting elk to cattle pastures (e.g. hay land and mineral supplements) may increase inter-species pathogen transmission through indirect contacts.

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1. Introduction

Interfaces between wildlife, livestock and humans are increasingly recognized to be of critical importance in the emergence or re-emergence of pathogens (Woolhouse et al., 2005; Jones et al., 2011). Human activities have important consequences on the dynamics of infectious diseases in wildlife and livestock species (Murray and Daszak, 2013; Patz et al., 2004), in particular by altering host species distributions and their contact structure (Daszak et al., 2001). In agricultural landscapes, spatio-temporal patterns of interactions between species are influenced by various habitat, behavioral, ecological, and management factors (Van Campen and Rhyan, 2010). Thus, understanding how human alterations of ecosystems and land-management practices induce changes in these interactions is an essential step in assessing the risk of inter-species pathogen transmission (Kilpatrick et al., 2009; Morgan et al., 2004; zu Dohna et al., 2014).

In southwestern Alberta, the overlap of cattle pastures and elk (*Cervus elaphus*) home range provides opportunities for inter-species interactions, which could result in pathogen transmission (Pruvot et al., 2014). Cattle have similarities of diet and habitat preferences with elk (Hosten et al., 2007; Torstenson et al., 2009), and their overlap is higher than with any other sympatric wild ungulate (zu Dohna et al., 2014), particularly during late summer and winter (Coe et al., 2001; Hosten et al., 2007). Land management for cattle production can alter interaction patterns between cattle and elk by modifying resource availability (Hosten et al., 2007; Van Campen and Rhyan, 2010; Muhly et al., 2013). However, studies on the contact structure of cattle and wild cervids have included small-scale pasture management practices in only a few instances (Brook and McLachlan, 2009; Berentsen et al., 2013; Kukielka et al., 2013). Among important practices, rotational grazing is a strategy used by 88% of Alberta cow-calf producers (Rothwell, 2005) to ensure that the nutritional needs of livestock are met, to avoid over-grazing, and to provide shelter in winter (Alberta Agriculture Food and Rural Development, 2006). Additionally, ranchers provide supplemental feed during winter, mineral supplements, and ensure water availability to cattle. Assessing the consequences of these management practices on the distribution of wild elk is essential to better characterize interactions between cattle and elk and thereby, inform further risk assessment of inter-species disease transmission.

Similar multi-host systems have been described over the past decade in Manitoba, Canada (Brook et al., 2013) with tuberculosis transmitted between elk and cattle, or in the Greater Yellowstone Area, USA, where brucellosis is maintained at the interface between bison, elk and cattle (Rhyan et al., 2013; Schumaker, 2013). Various other pathogens have the potential to be shared between cattle and elk, through direct contact (e.g. Bovine Viral Diarrhea Virus, herpesviruses such as Bovine Herpesvirus 1 or Malignant Catarrhal Fever viruses, and respiratory pathogens such as Parainfluenza-3 virus, *Pasteurella multocida*, or *Mycoplasma pneumonia*), indirect contact through environmental contamination (e.g. *Clostridium* sp., *Leptospira* sp., *Mycobacterium avium* subsp. *paratuberculosis*, *Cryptosporidium* sp., and various gastro-intestinal parasites), indirect transmission through complex life cycles (e.g. *Neospora caninum*, *Toxoplasma gondii*, *Dicrocoelium lanceolatum*, *Fascioloides magna*, *Echinococcus granulosus*), or vector-borne transmission (Bluetongue virus, Epizootic Hemorrhagic Disease virus, *Anaplasma marginale*, *Babesia* sp.) (Smits, 1991; Aguirre et al., 1995; Frölich, 2000; Corn and Nettles, 2001; Conner et al., 2008; Corn et al., 2010; Miller et al., 2013). The response of elk to cattle presence and to pasture management practices likely affects inter-species interactions, and the risk of transmission of various types of pathogens between cattle and elk.

In this paper, we used elk telemetry data, ranchers' observations of elk pasture use, information on pasture management, and landscape attributes to identify environmental and ranch management factors associated with elk use of cattle pastures and foraging patch selection. We expected ranch management to exert an important influence on pasture use by elk, while having a lesser effect on habitat selection at a finer spatio-temporal scale (patch selection). However, we anticipated that the presence of cattle might be an important factor affecting resource selection at this finer scale. Finally, we used these findings to identify the influence of specific pasture management practices on the risk of inter-species pathogen transmission between cattle and elk.

2. Materials and methods

This study was done with permission from the University of Calgary Animal Care Committee (protocol M09123) and the University of Calgary Conjoint Faculties Research Ethics Board (file 6598). Animal capture protocols were approved by the University of Alberta, University of Calgary, and the Government of Alberta (permits BI-2008-19, RC-06SW-001 and 23181CN).

2.1. Study area

The study area was in the foothills of the Canadian Rocky Mountains, in southwestern Alberta, Canada. The landscape is part of the montane ecotype characterized by rolling hills and a mosaic of grass and mixed forest, supporting an elk population with 7 main herds ranging in size from 150 to 1300 animals (Table 1). The area covers the municipal districts of Pincher Creek, Crowsnest Pass, Willow Creek, and Ranchland, with the western and southern sides defined by borders with British Columbia and the United States, respectively (Fig. 1). This area supports a variety of human activities including logging, oil and gas extraction, recreation and livestock production (Arc Wildlife Services Ltd, 2004), including approximately 84,300 cows in ~700 cow-calf operations (Statistics Canada, 2011). The study area and these elk herds were extensively described elsewhere (Muhly et al., 2011; Ciuti et al., 2012a, 2012b; Muhly et al., 2013).