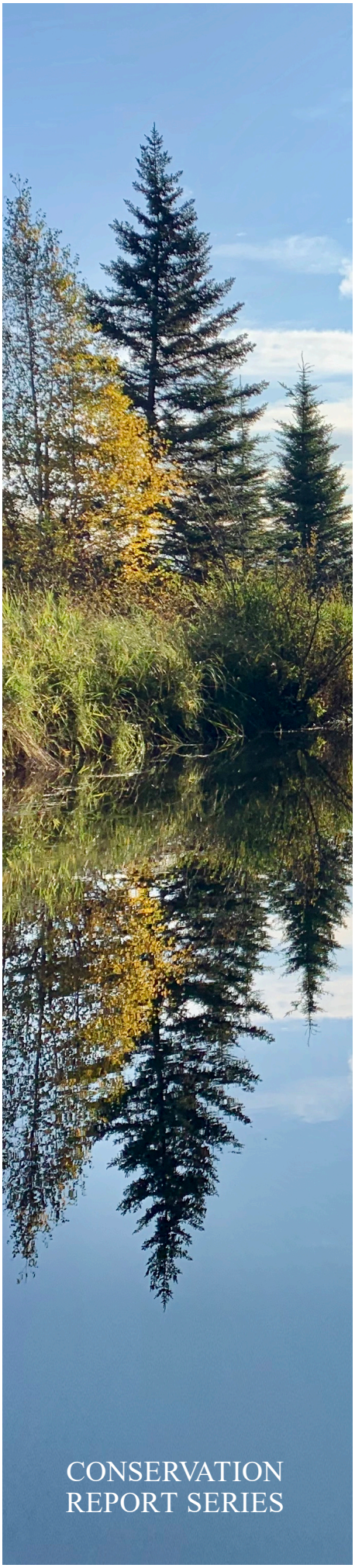

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Can Pronghorn Serve as an Umbrella Species for Other Grassland Obligate Species?

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Can Pronghorn Serve as an Umbrella Species for Other Grassland Obligate Species?

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EXECUTIVE SUMMARY

The Northern Sagebrush Steppe (NSS) is the northern boundary of sagebrush steppe and grassland habitats in North America, and is the periphery of the range for species such as pronghorn (*Antilocapra americana*) and greater sage-grouse (*Centrocercus urophasianus*). The NSS is one of the most threatened ecosystems in the world. Native prairie continues to be converted and fragmented across the region, resulting in increased stress on wildlife populations and overall ecosystem function. Fences are a source of anthropogenic disturbance that is often invisible in terms of its impacts, because fences fragment functional grassland ecosystems by negatively affecting wildlife movement.

To conserve the remaining NSS, we need to create awareness of the impacts of fences on wildlife and assess if one species can serve as an umbrella species to protect the suite of other grassland obligates. The primary objectives for this project were to: 1) develop pronghorn seasonal habitat selection models and assess the effects of fences on the habitat selection pattern; 2) increase awareness of the effects of fences on pronghorn, other wildlife, and their ecosystems by promoting a new discipline called fence ecology; 3) test the efficacy of pronghorn as an umbrella species for greater sage-grouse, grassland songbirds, and waterfowl; and 4) increase the profile of pronghorn and awareness of the need to conserve the NSS through publications in peer-reviewed journals and presentations.

First, we demonstrated that fences have a negative impact on the selection of habitat by pronghorn during the summer and winter seasons. In addition, our modeling demonstrated that by reducing fence density or by modifying fence structure (i.e., pronghorn friendly) we can increase the availability of high-quality habitat on the landscape. Secondly, we published an essay on the impacts of fences on wildlife and ecosystems that advocated for the development of a new discipline called fence ecology. Lastly, we were able to demonstrate overlap in the selection of habitat between pronghorn and greater sage-grouse during migration, but we were not able to validate pronghorn as an ideal umbrella species. In fact, we concluded that the measure of intact native grassland at the 1-km^2 scale functions as the best umbrella "species" (of the species/metrics we included in our model) to represent the conservation needs of grassland obligates such as greater sage-grouse, grassland songbirds, and waterfowl. We believe that our results will help direct conservation efforts for pronghorn and the NSS moving forward.

Key words: fence ecology, migration, native prairie, Northern Sagebrush Steppe, pronghorn, greater sage-grouse, Sprague's pipit, waterfowl

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1.0 INTRODUCTION

The Northern Sagebrush Steppe (NSS) is the northern boundary of sagebrush steppe and grassland habitats in North America and is one of the most threatened ecosystems in the world (Forrest et al. 2004). The NSS is also the northern range limit for a variety of species (e.g., pronghorn [*Antilocapra americana*], greater sage-grouse [*Centrocercus urophasianus*], and grassland songbirds such as Sprague's pipit [*Anthus spragueii*]). Through multiple anthropogenic disturbances, native prairie continues to be converted and fragmented across the region (Lipsey et al. 2015, Smith et al. 2016) resulting in increased stress on wildlife populations and overall ecosystem function. In conservation planning, umbrella species may be selected whose life-history requirements, sensitivity to impacts, spatial range, or position in public perception act as a barometer of ecosystem function (Roberge and Angelstam 2004). Pronghorn are an iconic prairie ungulate whose life-history attributes require them to range over the longest distances of any ungulate in the NSS. In the NSS, 55% of pronghorn migrate between seasonal ranges (Jakes et al. 2018a). For other wildlife species in this system (e.g., greater sage-grouse, Sprague's pipit, mallard [*Anas platyrhynchos*]), maintaining connectivity between seasonal ranges and core habitats is vital in mitigating environmental and anthropogenic disturbances. Because pronghorn are well distributed across the landscape, move and operate at large landscape scales, are sensitive to both environmental and anthropogenic disturbances, and are highly regarded in public perception, we hypothesized that they can serve as an umbrella species for other sagebrush steppe and grassland species at the periphery of their range.

The use of an umbrella species is not a new concept but has been proposed often in the wildlife conservation world. The protection of the designated umbrella species is assumed to also provide protection for other species that use the same general habitat. Therefore, the use of umbrella species for biodiversity protection has been widely applied to allocate limited resources for landscape conservation. We used the umbrella species concept proposed by Roberge and Angelstam (2004): a species whose habitat area and connectivity conservation confers protection to a larger number of species. Although the concept of an umbrella species has been applied worldwide, the results have been mixed in terms of its effectiveness (Caro and O'Doherty 1999, Roberge and Angelstam 2004, Roberge 2006, Johnson et al. 2017).

The primary objectives of this project were to: 1) develop pronghorn seasonal habitat selection models and assess the effects of fences on the habitat selection pattern; 2) increase awareness of the effects of fences on pronghorn, other wildlife, and ecosystems by promoting a new discipline called fence ecology; 3) test the efficacy of pronghorn as an umbrella species for greater sage-grouse, grassland songbirds, and waterfowl; and 4) increase the profile of pronghorn and awareness of the need to conserve the NSS through publications in peer-reviewed journals and presentations. We predicted that if the pronghorn is an acceptable umbrella species for other

grassland obligates, then habitat selected by pronghorn would also encompass those resources important for other species such as greater sage-grouse, Sprague's pipit, and mallards. Alternatively, surrogate "species" (metrics) such as native prairie intactness and connectivity may prove to function in the role of an umbrella species better than pronghorn, at least for conservation of the other grassland species we selected.

2.0 STUDY AREA

Our study occurred within the area known as the Northern Sagebrush Steppe (NSS; Figure 1). The NSS spans three jurisdictional boundaries (Alberta and Saskatchewan, Canada, and northern Montana, USA; centred at 50.0757°N, -108.7526°W) and covers an area of approximately 315,876 km^2. The area is predominately agricultural cropland (approximately 60%) with 34% as native prairie. The native prairie is characterized by flat, open plains and rolling hills created through glacial recession and deposits, with badlands and deep coulees prevalent throughout the region (Mitchell 1980). Elevation ranges from 482 m–910 m (Environment Canada 2010). The study area is considered semi-arid, receiving an annual mean of 39.2 cm of precipitation, with approximately 70% received as rainfall (Environment Canada 2010). Vegetation associated with the native prairie includes a mosaic of shrubs such as big sagebrush (*Artemisia tridentata*), silver sagebrush (*A. cana*), creeping juniper (*Juniperus horizontalis*), and western snowberry (*Symphoricarpos occidentalis*). Native grasses present include blue grama (*Bouteloua gracilis*), June grass (*Koeleria macrantha*), needle and thread grass (*Hesperostipa comata*), and western wheatgrass (*Pascopyrum smithii*). The area also has tame pastures seeded to non-native forages, and both irrigated and dryland agricultural fields. Major cultivated crops include alfalfa hay, canola, mustard, peas, and wheat (Mitchell 1980). Human populations are sparsely distributed with few urban population centres (Figure 1). Cattle grazing is the dominant land use in Alberta and Montana, whereas crop production is generally more prevalent in Saskatchewan. Oil and natural gas wells occur at high densities in Alberta and continue to be developed in Saskatchewan and Montana.

3.0 MATERIALS AND METHODS

3.1 Pronghorn resource selection models

To assess the pronghorn's suitability as an umbrella species, we first developed a resource selection function (RSF) model for both summer and winter ranges of pronghorn in the NSS using existing data (Jakes et al. 2018a). We used a "use-available" sampling design approach and employed a RSF model to assess a suite of environmental and anthropogenic parameters.

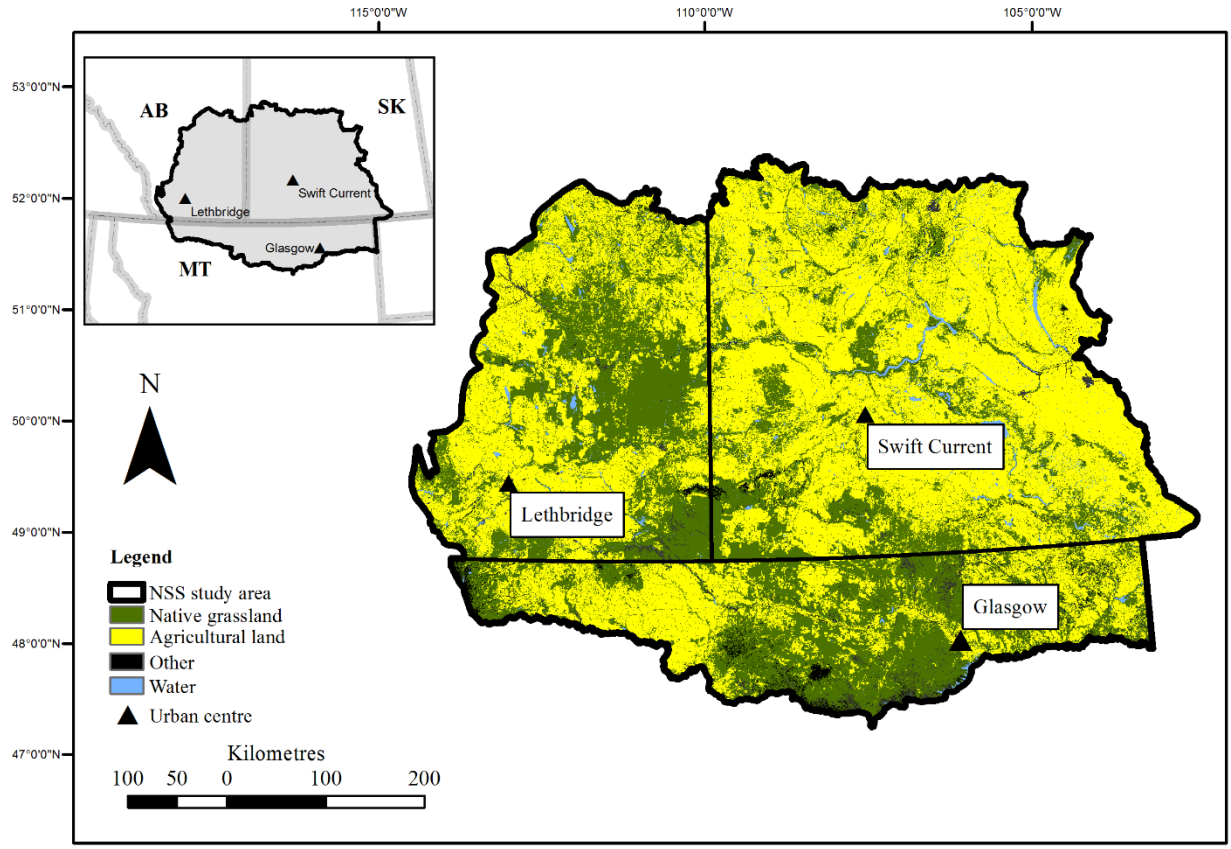

Figure 1. Northern Sagebrush Steppe study area within southeastern Alberta, southwestern Saskatchewan, and northeastern Montana.

We used pronghorn Global Position system (GPS) relocation data (i.e., training data) to predict seasonal (i.e., summer and winter) range at the second and third order (Johnson 1980, Burnham and Anderson 2002). Second order selection is defined as the selection of a home range, whereas third order selection is defined as the selection of habitat within a home range (Johnson 1980). We generated five available points for every used point at both scales. We examined a suite of covariates that represented vegetation and topography (i.e., normalized difference vegetation index [NDVI] to represent greenness [summer only], maximum NDVI [winter only], cosine of aspect, terrain ruggedness, density of hydrology) as well as anthropogenic landscape features (i.e., all road density, paved road density, oil and gas well pad density) to determine if they influenced the selection patterns of pronghorn. To evaluate the influence of fences on pronghorn habitat selection, we examined two specific covariates based on the scale of analysis. At the second order, we examined the density of fences within a 100 m buffer around each used and available point. At the third order, we tallied how many fences were crossed between consecutive used points and between a used point and five randomly drawn available steps. We conducted our seasonal range selection for migratory and resident pronghorn separately (Jakes et

al. 2018a). We validated each model's predictive performance by withholding 20% of the animals at random from both the migratory and resident pronghorn groups (i.e., testing data) to estimate Spearman rank correlation coefficients between the predicted probability of use and the observed frequency of validation across map outputs (Johnson et al. 2006). We used five bins in the Spearman rank correlation, where bin 1 represented low use and bin 5 represented high use.

Lastly, we evaluated the extent of habitat affected by fragmentation from fencing by estimating the zone of influence (i.e., indirect habitat loss) associated with fencing on the landscape (Polfus et al. 2011). We used a previously developed fence spatial location map for southeastern Alberta (Seward et al. 2012) and a fence density map for northern Montana (Poor et al. 2014) to assess indirect habitat loss under varying fence density scenarios (i.e., reduced, current, increased) on seasonal range. First, we predicted the relative probability of selection across the reduced study area and divided the predictions into five equal bins, where a prediction value of 1 represented low use and a bin of 5 represented high use. We then measured the change in habitat quality by comparing the percent change in predicted relative probability of selection bin between the original model and the model with a decreased or increased fence density. Change in high quality habitat was measured as the percent change in bins 4 and 5, while change in low quality habitat was the percent change in bin 1. Detailed methods can be found in Jones et al. (2019).

3.2 Fence ecology

Fences are ubiquitous, so their impact on wildlife and ecosystems is difficult to grasp. Working with an international team of biologists, we aimed to increase awareness on the effects of fences on wildlife and ecosystems by developing an essay that: 1) illustrates the prevalence of fencing on the landscape; 2) reviews the effects (positive and negative) of fencing as it relates to wildlife conservation; and 3) identifies knowledge gaps and suggests research opportunities as it relates to fences, wildlife, and ecosystems. Through this essay we promote the formation of a new discipline called fence ecology that would be equivalent to road ecology.

3.3 Pronghorn and greater sage-grouse migratory route overlap

We used data from 18 collared greater sage-grouse captured from 2010–2011 and 40 pronghorn captured from 2009–2010 to measure the extent of current greater sage-grouse conservation and policy in maintaining the migratory pathways of both species. We fit Brownian bridge movement models (Horne et al. 2007) to GPS data to identify individual migratory pathways and then used the pathways to assess the temporal and spatial overlap between the two species. Because greater sage-grouse are a federally listed species in the USA, we then assessed the protection measures in place for sage-grouse to see if they would also conserve pronghorn pathways. Lastly, we combined our results of pathway overlap with a risk conversion model to assess the potential of losing the pathways if private native prairie were cultivated to agricultural crops (Smith et al.

2016). Using this assessment, we developed a tool to conserve large-scale, multi-species migratory pathways to ensure species persistence at the periphery of their ranges.

3.4 Pronghorn as an umbrella species

We tested the pronghorn's potential as an umbrella species by using pronghorn seasonal range (Jones et al. 2019) and migration pathway maps (Jakes et al. 2020) and overlayed them with pre-existing data for a suite of species. The other species included greater sage-grouse seasonal range (Doherty et al. 2010) and migration pathways (Newton et al. 2017), as well as core habitats for Sprague's pipit (Lipsey et al. 2015), and a suite of five waterfowl species. The five waterfowl species included northern pintail (*Anas acuta*), gadwall (*A. strepera*), mallard, blue-winged teal (*A. discors*), and northern shoveler (*A. clypeata*); all of these species depend on a matrix of wetland and grassland habitats for breeding and rearing young (Doherty et al. 2015). Collectively, these grassland inhabitants encompass game species with high societal and economic value, species of conservation concern (i.e., federally listed), species iconic of the systems they inhabit, and species that migrate across jurisdictional and international boundaries, which have made them each focal species for conservation among government and non-governmental organizations. We used distribution models for species commonly used in prioritizing conservation across the NSS and evaluated each species' effectiveness as an umbrella species by measuring their ability to confer conservation to the other species. In addition to assessing individual species, we included a null model based on the relative intactness of the grassland and sagebrush habitat, as well as a model representing connectivity of the patches. Intactness of grassland and sagebrush habitat is a common currency used by all species. Lastly, we used a systematic conservation planning approach to develop an optimal multi-species conservation design for prioritization using both equal weighting of multiple species and empirical values of focal species effectiveness.

3.5 Pronghorn conservation awareness

The last objective of this project was to increase the profile of pronghorn and awareness of the need to conserve the NSS through publications in peer-reviewed journals and presentations. Over the three years of the project our aim was to publish one peer-reviewed paper and present one paper at a scientific conference per year. These publications and presentations were to be given by Alberta Conservation Association staff as well as our colleagues who are participating in the project. Lastly, we aimed to create awareness with the general public through popular news articles and presentations.

4.0 RESULTS

4.1 Pronghorn resource selection model

We published our pronghorn resource selection and fence modeling results in the peer-reviewed journal Ecosphere (see Jones et al. 2019). Here we provide a synopsis of our results on habitat selection and impacts of fencing on pronghorn contained within the published paper. At the second and third orders during summer, both migrant and resident selection was driven by road density. During winter at both orders, migrant selection was driven by terrain ruggedness, while for resident pronghorn selection was driven by road density. When we added in fence density at the second order and fence crossing at the third order to our models during both seasons, each covariate representing fences was one of the strongest covariates in determining selection by both migrant and resident animals. Our models predicted an increase of 16%–38% in high-quality habitat if fences were completely removed from the landscape, mimicking pre-European natural conditions. On the other hand, if we doubled the amount of fencing currently on the landscape there was an increase of 13%–21% in low-quality habitat and a reduction of 1%–11% in high-quality habitat.

4.2 Fence ecology

We published our essay on the need for a new discipline called fence ecology in the peer-reviewed journal Biological Conservation (see Jakes et al. 2019b). In that essay, we defined fence ecology as the empirical investigation of the interactions between fences, wildlife, ecosystems, and societal needs. We demonstrated that fences are more prevalent on the landscape than roads yet receive far less attention in comparison to road ecology. We concluded our paper with a call for scientists and conservationists to "see" and study fences as a broad-scale anthropogenic disturbance that has widespread impacts on wildlife and ecosystems. The eventual outcome of a better understanding of fences and their cumulative effects can lead to solutions for sustaining wildlife and ecosystems in balance with societal needs.

4.3 Pronghorn and greater sage-grouse migratory route overlap

We published our assessment of the overlap in migratory pathways of pronghorn and greater sage-grouse in the NSS in the peer-reviewed journal Biological Conservation (see Tack et al. 2019). Here we provide a synopsis of the paper published in Biological Conservation. The timing and duration of migration, as well as the use of stopover sites along the migratory pathway were similar between pronghorn and greater sage-grouse. For both species, the migratory pathways tended to be through large and intact public and private working lands, with an additional 5% of the migratory pathways through protected areas. Within private lands, both species largely

migrated through intact grazing lands, of which most of the land within the Montana component of the pathway was under protection through conservation easements.

4.4 Pronghorn as an umbrella species

This objective is underway, and a draft of the paper has been developed and reviewed by all coauthors. However, the paper has not been submitted to a peer-reviewed journal at the time of writing. Work on the paper continues under the Alberta Conservation Association's project "Pronghorn Movement and Enhancement (Fence Trials)", with the intent to submit and publish in 2021. In the meantime, this is a synopsis of the results to date. Spatial data layers were collected from all species and used in a systematic conservation planning algorithm. Various scenarios were run to identify critical landscapes that meet a minimum set of needs for each species independently, as well as across all species. In addition, scenarios were run to examine if any one species would adequately represent the conservation needs of other grassland obligates. It was determined that no single species served adequately as an umbrella for the rest. Indeed, rather than a species, habitat in the form of intact native prairie (measured at a 1-km scale) functions as the most useful umbrella "species" to represent the needs of the grassland obligates considered. Following intact native prairie, our models suggested that Sprague's pipit ranked ahead of pronghorn or sage grouse as an effective umbrella species.

4.5 Pronghorn conservation awareness

We published two papers in Biological Conservation: *A fence runs through it: a call for greater attention to the influence of fences on wildlife and ecosystems* (Jakes et al. 2018), and *Beyond protected areas: private lands and public policy anchor intact pathways for multi-species wildlife migration* (Tack et al. 2019). A third paper was published in Ecosphere: *Fences reduce habitat for a partially migratory ungulate in the Northern Sagebrush Steppe* (Jones et al. 2019). We completed eleven news articles in papers/online across the USA and Canada, one live radio interview for a radio station in Saskatchewan, Canada, and an interview for a podcast in the USA (Appendix A). We presented results from the migration corridor overlap between pronghorn and sage-grouse, the effects of fencing on pronghorn seasonal range selection, and on pronghorn movement and anthropogenic features that impede these movements (fences and roads) at various conferences and meeting across Canada and the USA (Appendix A). Through these outreach activities we have reached a broad, international audience of over one million people.

5.0 DISCUSSION

The two overarching goals of this project were to assess the effects fences have on wildlife (and in particular, pronghorn) and ecosystems, and to assess if pronghorn are an effective umbrella species for a suite of grassland obligate species. Associated with these two goals was to create awareness of the need to conserve pronghorn and the NSS. While we have successfully demonstrated and created awareness of the negative effects of fences on pronghorn and the need for a discipline called fence ecology, our hypothesis related to the appropriateness of pronghorn as an umbrella species was not supported with our data. Since our work on pronghorn and fences was published in peer-reviewed journals there has been an increase in papers associated with fences and wildlife (Laskin et al. 2020, Mcinturff et al. 2020, Robb 2020, Segar and Keane 2020, Xu et al. 2020).

Our results clearly demonstrate the impact fences have on pronghorn and the need to reduce fence densities or modify existing fences to improve the quality of habitat available for pronghorn across the NSS. Modifications to existing fences to allow passage by pronghorn, as well as mule deer (*Odocoileus hemionus*) and white-tailed deer (*O. virginianus*), can be achieved using a number of methods that have been scientifically proven to be effective (Burkholder et al. 2018, Jones et al. 2018; 2020a). These fence modifications can reduce the potential for their direct and indirect impacts on pronghorn (Harrington and Conover 2006, Jones 2014, Reinking et al. 2019, Jones et al. 2020b). Even though it is expensive to install and maintain fences for a landholder (Knight et al. 2011), these costs can be offset through available landholder programs throughout the world (Frank and Ekilund 2017). In Alberta, Alberta Fish and Game Association assists landholders with the purchase of double-stranded smooth wire and installs the wire to pronghorn-friendly standards (Paige 2020) free of charge.

Although we had hoped to demonstrate that pronghorn would be an excellent umbrella species for a suite of grassland obligates, our analysis did not confirm this. Instead, native prairie intactness proved to be a better umbrella "species" (metric) than any of the actual species we evaluated. This result is not too disconcerting nor particularly surprising. Modern technology associated with GPS collars and remote sensing data allows us to develop intricate, species-specific models. While these intricate models may precisely predict the selection patterns of the species they were developed for, expanding them to predict the habitat requirements of other species is likely not achievable. That is, each species has its own fine-scale selection pattern that allows it to coexist with other species in the NSS. Therefore, the real common denominator for the suite of species we assessed as potential umbrella species is intact native prairie, the surrogate metric that rose to the top of our modelling effort. Retaining and expanding large, intact blocks of native prairie is important, along with ensuring functional connectivity pathways are maintained across the landscape. Together, intact native prairie and functional connectivity will ensure species are able to move between habitat blocks to adjust their distribution in

response to changing environmental conditions and to meet daily and seasonal resource requirements. In the longer term, the ability to move freely will be critical in the face of global warming.

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7.0 APPENDICES

Appendix 1. List of publications, presentations, news articles, and radio interviews completed between April 2017 and March 2020 related to pronghorn movement, fences as barriers, and potential solutions.

Description	Date
Article in Great Falls Tribune titled "Study finds best fence for safe pronghorn passage."	May 4, 2017
Live radio interview on The Prairie Naturalist out of Regina, Saskatchewan on pronghorn and fences.	May 11, 2017
Article in Billings Gazette titled "What's the best way for pronghorns to squeeze under fences?"	June 15, 2017
Article in Casper Star Tribune titled "What's the best way for pronghorns to squeeze under fences?"	June 16, 2017
Article in US Today titled "Study finds best fence for safe pronghorn passage."	June 19, 2017
Article in The Montana Conservationist titled "What's the best way for pronghorns to squeeze under fences?"	June 21, 2017
Article in Cool Green Science titled "How can the pronghorn cross the fence?"	June 26, 2017
Article in Earth Touch news network titled "Buck's run-in with barbed wire is why we need pronghorn-friendly fences."	July 19, 2017
Right to Roam Podcast interview with Dr. Jakes on pronghorn and fences.	September 2, 2017
Article titled "Pronghorn and fences" distributed in Great Places Data Goodness November webmail out to 1.37 million subscribers	December 2017
Article in Sierra titled "Don't fence me in."	December 20, 2017
Article in Medicine Hat News titled "Fish and Game partners with others in program to protect pronghorns"	January 18, 2018

Appendix 1 continued:

Presentation by Dr. Jakes at the Transboundary Grasslands Conservation Conference titled "Identification, challenges and opportunities in wildlife connectivity across the Northern Great Plains region."	February 2018
Article on The Wildlife Society website titled "WSB: which wildlife-friendly fences work for pronghorn?	May 9, 2018
Presentation by Dr. Jakes at the 8th Annual Matador Science and Land Management Symposium titled "Beyond protected areas: private lands and public policy anchor intact pathways to multispecies wildlife migration."	June 2018
Presentation by Dr. Jakes at the 8th Annual Matador Science and Land Management Symposium titled "Beyond protected areas: private lands and public policy anchor intact pathways to multispecies wildlife migration. "	June 2018
Presentation at the 28th Biennial Pronghorn Workshop titled "Modeling the response of pronghorn to varying degrees of fencing on the landscape."	August 14, 2018
Presentation at the 28th Biennial Pronghorn Workshop titled "Beyond protected areas: private lands and public policy anchor intact pathways to multispecies wildlife migration."	August 15, 2018
Presentation to the Lethbridge Naturalists titled "Pronghorn: nomads of the prairies."	February 13, 2019
Journal article in Biological Conservation titled "Beyond protected areas: private lands and public policy anchor intact pathways for multi-species wildlife migration."	March 18, 2019
Presentation by Dr. Jakes at the University of Montana titled "Connectivity in wildlife conservation management – using pronghorn and fencing as a case study."	March 21, 2019
Journal article in Ecosphere titled "Fences reduce habitat for a partially migratory ungulate in the Northern Sagebrush Steppe."	July 2019

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