University of Nevada, Reno

Effects of Large-Scale Gold Mining on Habitat Use and Selection by a Resident Population of American Pronghorn

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science in
Natural Resources and Environmental Science

by

Megan J. Osterhout
Dr. Kelley M. Stewart/Thesis Advisor

August 2022

THE GRADUATE SCHOOL

We recommend that the thesis
prepared under our supervision by

Megan J. Osterhout

entitled

Effects of Large-Scale Gold Mining on Habitat Use and Selection by a Resident Population of American Pronghorn

be accepted in partial fulfillment of the
requirements for the degree of

Master of Science

Kelley Stewart
Advisor

Perry Williams
Committee Member

Brian Wakeling
Committee Member

Brad Schultz
Committee Member

Michael Branch
Graduate School Representative

David W. Zeh, Ph.D., Dean
Graduate School

August 2022

Abstract:

Anthropogenic disturbances, including extraction of natural resources, are reducing and fragmenting habitat for wildlife across the western United States. The effects of these disturbances on wildlife populations have been explored by studying populations that migrate through oil and gas fields or wind and solar energy facilities. Our goal was to examine how a resident population of American pronghorn (*Antilocapra americana*) in the Great Basin ecosystem is affected by a large-scale disturbance throughout the year. We investigated how that population selected resources in an area associated with a large open-pit gold mine. We classified levels of disturbance associated with the mine and used a random forest model to select ecological covariates associated with habitat use and selection by pronghorn. We used resource selection functions to examine how the disturbances affected how pronghorn used habitat, both annually and seasonally, in the area around the mine. Pronghorn strongly avoided locations near areas of high disturbance from the mine, which included open pits, heap leach fields, rock disposal areas, and a tram. Pronghorn selected areas near roads although strongest selection was for locations about 2km away from roads. We observed relatively broad variation among individuals both annually and seasonally in the extent to which they selected slope, shrub cover, and roads in this study area and how they responded to the mines. The Great Basin is a mineral rich area that continues to be exploited for natural resources, and sagebrush dependent species, including pronghorn, which rely on this critical habitat are directly affected. Our results provide documentation on how open-pit mining affects a resident population of pronghorn prior to the expansion of the mine and allows us to evaluate the effects of future disturbance on the landscape.

Keywords: anthropogenic disturbance, *Antilocapra americana*, Great Basin, mining, pronghorn antelope, resource selection.

Acknowledgments

I would like to thank my advisor, Dr. Kelley Stewart, who gave me my first opportunity to work as a wildlife technician in the Starkey Experimental Forest as part of an ongoing mule deer research project. While working in Starkey, I gained technical field skills and confirmed my passion for wildlife studies, leading me to continue my education with a master’s degree. I’m thankful for her mentorship over the last three years as I developed my understanding of wildlife ecology. I thank Dr. Kevin Shoemaker, who I had the honor of taking both undergraduate and graduate courses from during my time at UNR. His passion for teaching made every day in the class an absolute joy and his support with analyses for this project were invaluable.

I am thankful for the staff at NDOW, Cody Schroeder, Chris Hampson, Sarah Hale, and Jeremy Lutz. They provided me with data for this project, invited me into the field with them, and shared their knowledge of pronghorn and the Great Basin ecosystem. I enjoyed collaborating with and learning from each of them. I also want to thank Tom Dilts at UNR, who has been a wonderful resource for all things ArcGIS throughout this project.

My coworkers in the Stewart lab have offered me constant support and entertainment during my time at UNR. Dr. Marcus Blum has been an integral part of my undergraduate and graduate work. He gave me volunteer opportunities, shared his knowledge and passion of wildlife, and was always available to talk or problem solve with me about my data. Outside of the office, Marcus has been a true friend and brother, who I’m grateful to have in my life, even if he flicks thumbtacks at me sometimes. Emily Hagler and Heather Reich were my sisters throughout graduate school, surviving classes together and navigating this new world of academia. Their friendship and laughter have helped me through the highs and lows over the last three years. Jason Gundlach, Joshua Vasquez, Jerrod Merrell, and Nathan Jackson are brothers to me in this lab and I thank them for their discussions, support in data analysis, and daily heckling.

Julie Brockman and Madeleine Lohman deserve a special kind of thanks for their willingness to always help with code and talk stats. I don’t know what I would have done without their friendships and our Co-Star and Coffee dates. Haley Moniz has shared a wealth of knowledge, love, and friendship over the last few years and I’m incredibly thankful that herpetology brought her into my life.

My family deserve a huge thanks for their support in my education and letting my passions guide my decisions. My parents have always encouraged me to explore my options and never shut the door on opportunities to continue various forms of education. I appreciate the work ethic and love of learning that they modeled for me growing up and feel lucky to have their love and support.

Lastly, I want to thank my boyfriend, Kellen McCullough, along with the animals in our home: Ralph, Phoebe, Murphy, Ernie, and Daniel. We moved to Reno in 2016 for Kellen to begin his master’s in geophysics at UNR, a decision based on the university also having a wildlife program that I was interested in. This was the first time either of us had moved away from Washington and we’ve had some amazing adventures exploring a new ecosystem and establishing our home. I love you and look forward to what our future has in store!

Table of Contents

List of Tables

List of Figures

Introduction

Human developments are increasing across the western United States causing fragmentation and loss of important habitats for many species of wildlife. Those developments include gas and oil extraction, mining, residential development, fencing, and recreation (Sawyer et al. 2006; Sawyer et al. 2009; Lendrum et al. 2012; Lendrum et al. 2013; Seidler et al. 2014; Blum et al. 2015). The effect of anthropogenic structures on reducing habitat quality and availability for wildlife populations has been increasing over the last several decades, especially because mining for minerals and other natural resources has expanded across the Western United States (Beckmann et al. 2012). Although human developments are increasing, our understanding of the corresponding effects, especially from large-scale mining, on wildlife populations is limited (Blum et al. 2015).

Extraction of natural resources, such as fossil fuels, precious metals, and minerals often occur at large spatial scales causing disturbances that affect entire landscapes. Mining, especially, has increased exponentially over the last decade with increasing price and demand for mineral commodities as well as improved techniques for extracting those resources (Blum et al. 2015). A major impact to natural landscapes worldwide is open-pit mining for precious metals, including gold and silver, and more recently minerals, such as lithium which are important components of electronic devices and batteries (Kaunda 2020). Gold mining is a nearly $9 billion industry in the United States, with large open-pits located throughout the western states and especially in the Great Basin. Open-pit mining causes large-scale disturbances on the landscape because large volumes of earth are removed using drill rigs, explosives, and other heavy machinery (Kaunda 2020).

Landscape disturbances associated with large-scale mining include large pits, heap leaching facilities, rock disposal areas, networks of roads for hauling materials, and exploration sites. Many of these activities operate 24 hours a day (Blum et al. 2015). As developed mines increase in number and size, land that overlaps with critical habitat for wildlife is changed, often permanently, causing shifts in habitat suitability for wildlife. For example, mule deer that migrated through a gold mine in eastern Nevada avoided high levels of disturbance and occupied the few remaining patches of undisturbed habitat within the mine complex (Blum et al. 2015).

Large-scale loss and fragmentation of habitat from disturbances negatively affects wildlife populations, causing declines in population size through reduced survival and recruitment of young (Andrén 1994). These disturbances may affect movement patterns and selection of resources by wildlife populations inhabiting areas near large-scale disruptions to landscapes. Habitat fragmentation is especially concerning for species that require large areas, such as pronghorn. For example, American pronghorn (*Antilocapra americana*) have reported home ranges up to 1,800 km^2 (Reinking et al. 2019). Additionally, Sonoran pronghorn (*Antilocapra americana sonoriensis*) that occupy desserts with widely distributed resources have home ranges up to 2,800 km^2 (Hervert et al. 2005). Habitat loss and fragmentation change how populations and individuals use the landscape. As patches of habitat decrease in size, those species that need large areas of intact habitat tends to decline substantially and the smaller habitat patches may not be suitable to support many wildlife species (Terborgh et al. 2001). Limitations in the size and interspersion of habitat may affect movements, selection of resources, and interactions among and within species (Hagen et al. 2012). Some disturbances result in direct loss of habitat (Sawyer et al. 2006; Sawyer et al. 2009), whereas indirect losses may occur as a result of changes in behavior or movements (Blum et al. 2015; Sawyer et al. 2006; Sawyer et al. 2009), that likely reduce demographic attributes such as birth rate and fawn survival.

American pronghorn are large herbivores that inhabit grassland, shrub steppe, and desert ecosystems across North America (Byers 1997; O'Gara & Yoakum 2004). They are selective foragers adapted to open habitats, which allows large-scale movements and for detection and escape from predators. Historical distribution of pronghorn in North America ranged from South Central Canada to Central Mexico, and from the Mississippi River to the Pacific Ocean (O'Gara & Yoakum 2004). Pronghorn currently occupy fragmented parts of these original ranges since the western expansion and settlement of European humans (O'Gara and Yoakum, 2004).

Pronghorn are sensitive to small-scale anthropogenic features such as fences, roads, and other semi-permeable barriers (Robb et al. 2022; Sawyer et al. 2013; Seidler et al. 2018). Those features, especially highways with fences, can serve as physical barriers to the extent that they reduce gene flow (Dodd et al. 2010 and Sprague 2010). Pronghorn also avoid large-scale disturbances such as gas and oil fields (Beckmann et al. 2012) and wind energy facilities (Milligan et al. 2021). Gold mining operations are typically larger and more difficult to navigate than gas and oil fields. The overall operations often extend beyond the open pits and include features listed above, such as heap leaching and exploration. Each of these features may dramatically affect wildlife populations attempting to navigate through them (Blum et al. 2015). Most of the current research addressing the effects of anthropogenic developments on pronghorn are focused on gas and oil facilities that occur on migratory corridors or winter ranges (Sawyer et al. 2006; Sawyer et al. 2009; Seidler et al. 2015). There is a paucity of information, however, on the effects of landscape-scale disturbance, such as open-pit mining and adjacent exploration sites, on resident populations that are affected by the disturbance year around. Because they require large, open spaces, pronghorn are an ideal species to examine the effects of large-scale disturbances on a resident population throughout the year.

We examined the effects of an open-pit gold mine on a population of American pronghorn. Our objective was to evaluate how the mine affects placement of home ranges and selection of resources by resident pronghorn inhabiting an area associated with the mine. We hypothesized (H1) that pronghorn avoid areas of high and medium disturbance due to the mine complex. Further, we hypothesized (H2) that roads largely used by vehicles associated with the mine, would be avoided by pronghorn. Finally, we hypothesized (H3) that pronghorn would show seasonal variation in their selection of resources relative to the roads and mine, especially the most highly disturbed areas.

Methods

Study area:

The Great Basin is characterized by basin and range topography, which is alternating mountain ranges and valleys (Grayson 1993; Andreasen et al. 2018). This arid environment is dominated by sagebrush (*Artemisia spp.*) communities at mid and upper elevations. Basins are inhabited by salt desert shrub communities and alpine areas are characterized by conifer forests (Grayson 1993). Pinyon pine (*Pinus monophylla*) and Utah juniper (*Juniperus occidentalis*) occupy mid-elevation area but are infilling and encroaching into lower elevation area (Cottam & Stewart 1940; Romme et al., 2009).

Multiple species of wildlife, including sagebrush dependent species, such as greater sage grouse (*Centrocercus urophasianus*), pygmy rabbits (*Brachylagus idahoensis*), and American pronghorn (Rowland et al. 2006) are widespread.

Our study area encompassed 3,560 km^2 and is within Crescent, Pine, and Grass valleys in Central Nevada (Fig. 1). The three valleys intersect at the western base of the Cortez Mountains with the Simpson Park range bordering Pine and Grass valley. This area is typical of cold desert climate in the Great Basin, with hot dry summers and cold snowy winters (Flaschka et al. 1997). The lowest elevation is 1,435 m and the highest elevation in the Cortez range is Mount Tenabo at 2,887 m. We obtained seasonal weather data from National Centers for Environmental Information (NCEI) and created a climograph of precipitation and temperature to determine seasons (Stewart et al. 2002; McKee et al. 2015). Our seasonal delineations were summer: June-Sept, autumn: October, winter: November-February, and spring: March-May.

The Cortez range is mineral rich and has been mined since 1862. Open-pit and underground mines began operating in the 1930s, and today there are multiple large scale open-pit gold mines located in the Crescent Valley area (Muntean, 2018). The Cortez mine (~23 km^2) is located at the base of Mount Tenabo, where Crescent, Grass, and Pine Valley intersect (Fig. 1). The Pipeline mine (~25 km^2) is located northwest of the Cortez mine and the two are connected via a tram for transporting deposits between them.

Large fires have burned about 182,108 ha of the study area since 1999. Invasive plants such cheatgrass (*Bromus tectorum*) established after the fire in the lower elevations and have outcompeted the native sagebrush species (Grayson 1993). The Bureau of Land Management (BLM) and the Nevada Department of Wildlife (NDOW) seeded the burned areas with a mixture of forage kochia (*Bassia prostrata*) and crested wheatgrass (*Apropyron cristatum*) in 2000 and 2001. Forage kochia is an important resource for pronghorn and is used extensively for habitat improvement across the Great Basin (Cox et al. 2021).

Our study area is inhabited by a resident population of pronghorn that have been steadily increasing over the past 40 years. The Nevada Department of Wildlife estimated the population to be about 100 individuals in the 1980s (Cox et al. 2021). In 2018, the population had increased to approximately 2,700 individuals and in 2021 that had grown to 3,900. This growth is contributed to high recruitment of young; with an average ratio of 41:100 young to adult females between 2016 and 2021 (Cox et al. 2021). Pronghorn populations are generally doing well throughout Nevada, although growth is not currently seen in all pronghorn populations. The statewide population estimate for 2021 was slightly lower than the previous year (Cox et al. 2021).

Animal capture and handling:

Nevada Department of Wildlife captured 10 adult female pronghorn using helicopter-netgun capture in January 2018, and an additional 2 individuals in January 2019 (Krausman et al. 1985). Individuals were fitted with Global Positioning System (GPS) collars (Vectronic Aerospace GmbH, Berlin, Germany). Each pronghorn also received a unique tag in their ear prior to release from the capture location. GPS collars collected five locations per day and were programmed to drop after two years. There were two mortalities during the first spring and summer, therefore sample sizes are 11 for summer and 10 for autumn. All collars had dropped as a result of mortality or programming by June 2021. All capture and handling was approved by the Institutional

Animal Care and Use Committee at the University of Nevada, Reno (Protocol #21-04-1145 exp:4/20/2024) and followed guidelines established by the American Society of Mammalogists for care and use of wild mammals in research (Sikes 2016).

Analyses:

We defined the study area by creating a 100% minimum convex polygon (MCP) of all GPS locations and applied a 1,000 m buffer (ArcMap 10.8.1, Environmental Systems Research Institute [ESRI], Redlands, California, USA) (Fig. 1). All locations with 3-dimensional fixes and less than 3.1 dilution of precision were included in the data to increase accuracy (D’Eon & Delparte 2005). We identified environmental and anthropogenic covariates that have been significant in resource selection functions for pronghorn and other large ungulates (Beckmann et al. 2012; Christie et al. 2017; Milligan et al. 2021). We modeled selection of resources at the population level (2nd order Johnson 1980) using random-forest machine learning techniques to identify important resources to this population. Next, we used resource selection functions (RSFs) with environmental and anthropogenic covariates in a use-available design (Manly et al. 2002; Johnson et al. 2006). We used random locations within the study area to quantify available resources with a ratio of 1 used :1 available location (Fieberg et al. 2021; Northrup et al. 2013).

We created raster layers for elevation (m), slope (°), and aspect (°) from a Digital Elevation Model of the study area from the United States Geological Society (USGS). Because aspect is a circular variable, we applied a transformation by cosine (north-south) and sine (east-west) function (Stewart et al. 2002, Heffelfinger et al. 2020). We obtained information on vegetation cover from the Rangeland Analysis Platform (RAP), which included cover of perennial and annual plants, shrubs, and trees (www.rangelands.app).

The RAP layers are estimated from models using Landsat imagery combined with thousands of vegetation measurements (Allred et al. 2021). We calculated Euclidean distance to water and roads from each used and available location. We downloaded Topologically Integrated Geographic Encoding and Referencing road shapefiles from the Census Bureau (www.census.gov/geographies/mapping-files) and split them into two categories: 1) 4WD roads that are less travelled and travelled at lower speeds and 2) main roads, which include the primary gravel roads and the highway that have higher levels of traffic and speed. The main roads were used for mining traffic as well as travel into and out of town of Crescent Valley.

We obtained layers of all mining activity in the study area from USGS Mineral Resources Data (https://mrdata.usgs.gov/mrds) and supplemented them by digitizing aerial imagery. We classified disturbance resulting from mining (hereafter disturbance) into three levels of intensity (high, medium, and low) like Blum et al. (2015). High disturbance included open-pits, heap leaching pads, rock disposals, and a tram that connected the two open-pit mines. We classified the tram as high disturbance because pronghorn have shown avoidance for semi-permeable barriers (Robb et al. 2022). Medium disturbance included exploratory pads and low disturbance were drilling sites and adits (horizontal passages leading to the mines for purposes of access or drainage). Low disturbance included small exploratory areas, but we excluded the low disturbance from the analysis because of the scarcity of it in our study area. Total area of high disturbance polygons was 59.7 km^2 and medium disturbance polygons totaled 0.68 km^2. We applied a buffer around medium and high disturbance using the average distance traveled by pronghorn between GPS locations, 787 m. This distance accounts for individuals to possibly be within the disturbance when locations were not recorded. We represented mining disturbance with binomial variables. Locations within the buffereddisturbance areas were coded with a 1 and locations outside of the buffer were coded with a 0. We included a third binary variable to represent whether an area was part of the forage kochia seeding treatments to reestablish forage for pronghorn following fires. Seeded areas were largely in the foothills on the southwest side of the Cortez Mountains and the north side of the Simpson Parks Mountains. All rasters for our study were projected to NAD 83 Zone 11N with a spatial resolution of 30 m.

To test our hypotheses, we wanted to evaluate avoidance of disturbances relative to other characteristics on the landscape that affected use by pronghorn. We used random-forest machine learning model to identify variables of importance because boosted regression trees have been shown to have powerful ecological insight through their predictive performance (Breiman 2001; Elith et al. 2008; Shoemaker et al. 2018; Hefffelfinger et al. 2020). Therefore, we fitted a random forest model on a subset of our data using the R package “ranger” (Breiman 2001; Wright & Ziegler 2017). We created the subset of data by randomly thinning all locations by individual and season. Next, we identified variables of predictive importance via recursive feature elimination with the R package “caret” (Kuhn et al. 2022). We performed cross validation for the random forest model with a Receiver Operating Characteristic (ROC) analysis (Boyce et al. 2002) using the R package “ROCR” (Sing et al. 2005). We then used the area under the curve (AUC) from the ROC analysis to assess model performance (Cumming 2000). We cross validated our random forest model by excluding location data for each individual (Shoemaker et al. 2018).

We estimated RSFs by fitting generalized linear mixed-effects models with a binomial error distribution and logit-link function (Bolker et al. 2009; Gillies et al. 2006; Harrison et al. 2018; Long et al. 2014). We included variables of importance from the random forest model and included the disturbance variables to test our hypotheses. Because our random forest model indicated that the shapes of the relationships with elevation, slope, and distance to roads was quadratic, we included quadratic terms on those variables for all of our RSF models using the R package "glmmTMB" (Brooks et al. 2017). The annual model included a random intercept and random slopes on all variables to account for variation of selection among individuals (Gillies et al. 2006; Muff et al. 2020). We did not include random slopes on binomial variables (high and medium disturbance) in the seasonal models because of issues with convergence. Autumn had considerably less data than other seasons because it only represented one month with 10 individuals, therefore we excluded the polynomial term on the random slopes for that season so the model would converge. We performed a DHARMa goodness of fit test on all models to determine if the models appropriately represented the data (Hartig 2022). All plots from our resource selection functions model the intensity of selection for both the population mean and each individual. Intensity of selection in this instance is the probability of a point in the dataset being classified as "used" rather than "available."

Results

We had a total of 37,409 locations used by 12 individual pronghorn between January 2018 and June 2021. Because of the open landscapes that pronghorn typically inhabit, locations had minimal error and we omitted only 62 from the data. We had 37,347 used locations and 37,347 locations (1:1 ratio) to characterize the resources available in the study area (Table 1). We identified 5 characteristics of the habitat as most important for our population indicated by the recursive feature elimination from the random forest analysis, which were elevation, slope, shrub cover, tree cover, and distance to the gravel road (Fig. 4). Our cross-validation results indicated that the random forest analysis detected real signals versus over fitting the model, with an AUC of 0.84.

Resource selection functions indicated quadratic relationships in selection for elevation, slope, distance to roads, and distance to low and high disturbance (Tables 2 and 3). DHARMa tests were not significant ($p>0.05$) for annual and seasonal models, indicating the model fit was appropriate. Although we observed variation among individuals in selection of resources in our annual model; in general, pronghorn showed the highest intensity of selection for elevations around 2,000 m and slopes about 7° (Figs. 5a, b). Pronghorn showed strongest selection for low cover of shrubs; intensity of selection was variable among individuals and declined slowly with increasing shrub cover to about 40% (Fig. 5c). Intensity of selection for tree cover was strongest close to 0, dropping off rapidly with each 1% increase in tree cover until about 20% tree cover, when use was nonexistent (Fig. 5d).

In general, pronghorn selected for locations near roads with variation among individuals in intensity of selection (Fig. 5e). Nevertheless, all individuals had the highest intensity of selection for locations about 2km from roads. We saw strong avoidance for areas of high disturbance (Fig. 5g). Our model included some selection of medium level of disturbance, but the confidence intervals overlapped zero (Fig. 5f and Table 2).

When we modeled selection of resources by season, we observed variation in the intensity of selection for anthropogenic variables both at the population level and among individuals, especially for roads and disturbances (Figs 6-8). Across seasons, pronghorn maintained the highest intensity of selection for locations about 2km from roads. There was substantial variation in intensity of selection during spring, summer, and autumn, although selection for areas near roads were not significant during summer. Winter had the least variation for intensity of selection among individuals and the highest selection for locations near roads (Fig. 6d).

Pronghorn did not appear to be strongly affected by medium disturbance during spring (Fig 7a). Conversely, pronghorn selected for medium disturbance during summer, but avoided medium disturbance during autumn and winter (Figs 7b, c, d). For high disturbance, the population showed no significant selection or avoidance during spring or autumn (Fig 8a, c), but avoided areas of high disturbance during summer and winter (Figs 8b, d). Like the annual model, we observed substantial variation among individuals in both the medium and high disturbance plots, but those results are driven by random intercepts since random slopes are not included in the seasonal models.

Discussion

Our first hypothesis was somewhat supported because pronghorn in our study avoided areas close to high disturbance at both the annual and seasonal levels, although we observed some selection during summer. Pronghorn had greater selection for high disturbance areas during summer and spring than autumn and winter. This corresponds to a nutritionally demanding time of year associated with parturition. Seasonal nutritional needs may override avoidance of high disturbance during times of year when nutritional demands are highest. Blum et al. (2015) found that during migration, mule deer used habitat patches in relatively undisturbed areas within a mining complex overlapping the route. Krausman et al. (2005) found that Sonoran pronghorn in habitat associated with military activity selected for disturbance areas that had been subjected to fire from explosions. They hypothesized that disturbed areas may support new forage growth in amounts that can sustain higher numbers of pronghorn than undisturbed areas (Krausman et al. 2005). In our study area, there could be patches of high-quality habitat near the open pits that those individuals need for nutritional requirements, such as high protein forage and minerals, although we are unable to test this idea with our current data.

The tram that connects the open pits could be considered to be a semi-permeable barrier (Sawyer et al. 2013), because there are spaces for animals to pass under the tram, although it is lined with fences on both sides. Pronghorn have been seen quickly moving away from a fence once they reach it (Byers 1997; O'Gara & Yoakum 2004; Harrington & Conover 2006), so that behavior may contribute to avoidance of the tram. There is a wildlife crossing bridge constructed in 2008 that goes over the tram, but we did not see any location data that indicated pronghorn crossed over the tram. Seidler et al. (2018) found that pronghorn were gradually able to acclimate to newly constructed wildlife crossings, while still displaying signs of vigilance when approaching up to 20 months post construction. Our GPS locations show no collared individuals used the wildlife bridge during the study period.

Pronghorn did not avoid medium disturbance at the annual level. Additionally, there was some selection for medium disturbance during autumn and winter. While our hypothesis that pronghorn would avoid medium disturbance was not supported at the annual or seasonal levels, high disturbance in our study area was a much larger impact to the landscape, and thus was avoided to a greater extent than was the medium disturbance.

Medium disturbance only occupied a small part of the study area, in the form of multiple small polygons whereas areas of the large disturbance comprised larger and more contiguous area.

Our second hypothesis was not strongly supported by our results, because pronghorn in our study selected locations relatively close to roads. Previous results that show strong avoidance of roads are from studies with highly trafficked roads, such as interstates and freeways (Christie et al. 2017; Robb et al. 2022). Additionally, roads in our study area were not lined with fences, which contrasts with major highways described in other studies that were lined with fences, which contributed to avoidance (Dodd et al. 2010). Nonetheless, most roads in the study area were gravel, and the mining company sprayed roads with water to prevent large dust clouds. Watering can contribute to vegetation growth along roadways and earlier green-up during late winter and spring, which might provide useable forage and thus drive selection for areas near the roadways. Additionally, snow melts faster along roadways because of the thermal conductivity of concrete and rocks (Clauser and Huenges 1995), which can create easier paths of travels. This may contribute to the least amount of individual variation in selection for roads during winter.

The road layer in our model includes a two-lane paved highway (70 MPH speed limit), gravel roads with high mining traffic, and a network of less travelled gravel roads throughout the study area. Berger et al. (1983) found that pronghorn displayed greater vigilance when exposed to heavy traffic associated with mining activities. Levels of traffic likely varied substantially among the roads included in the layer. We were unable to access traffic data in association with the mine, which would have allowed us to compare selection for locations near roads across varying levels of traffic. Our model also does not account for temporal variation in the locations so there may be higher selection at night or during crepuscular hours when traffic was low.

Our third hypothesis was supported by our seasonal models, which indicated variation in selection for anthropogenic features depending on the season. In general, pronghorn showed stronger propensity to select areas relatively close to roads during spring and winter versus summer and autumn. That result is similar to pronghorn in southeastern Alberta, where individuals had higher vigilance levels in association with roads during spring, but not summer (Gavin & Komers 2006). Additionally, pronghorn in south-central Wyoming avoided anthropogenic features (fences, roads, wells) in winter yet selected for areas near them during summer (Reinking et al. 2019). Many populations of pronghorn exhibit seasonal migration (Sawyer et al. 2005; Sawyer et al. 2013). Our study population, however, is resident and remains in Crescent Valley year-round likely because of the relatively mild winters compared to areas with migratory populations of pronghorn. Central Nevada is subjected to drought, but abundant precipitation during three winters prior to the study resulted in improved habitat with flowing springs and seeps (Cox et al. 2021). While our study area has accessible food resources year around, individuals may be forced to use areas close to roads or disturbances from the mine at varying levels across seasons when snow or drought affect available resources.

Forage kochia has been identified as an important part of pronghorn diet in our study area, with biologists reporting frequent use of the areas where seeding occurred. However, kochia seeding variable was not among the important variables selected in the random forest. Cover of shrubs was included as an important characteristic of habitat.

Forge kochia is a half shrub and was included in the shrub cover estimates from the RAP data. The RAP data can account for kochia in the estimate of cover at a finer scale and with more precision than the polygons of seeded areas we used to represent it.

Previous studies showing selection for anthropogenic disturbances demonstrate the ability of populations to persist in areas of disturbance. Beckmann et al. (2012) found that pronghorn selected for areas near gas wells when snow depths were greater than average and hypothesized that the roads leading to those wells were used for easier travel. Christie et al. (2017) observed that pronghorn avoided human development and roads, but not oil and gas wells, likely as a result of placement of these features in high-quality habitat. While our results do not support the hypothesis that pronghorn avoid medium disturbance, individual location data indicated that pronghorn used the land surrounding disturbance, yet no locations were within the actual medium disturbance area.

The concentration of exploration pads in our study area is the proposed location for a future open-pit as part of the expansion of the mine. Many of the home ranges of pronghorn in our study are situated in the area surrounding the medium disturbance, although we observed no locations within those areas. As the area shifts from medium to high disturbance, we predict that level of disturbance will have a strong effect on pronghorn in that portion of the study area. Expansion of the mine into that area of high concentration of use by pronghorn could lead to population declines (Beckmann et al., 2012). As we mentioned previously, NDOW has reported high recruitment and population growth in this population, but the impact of a high-level disturbance in the area occupied by most of the individuals in our study will most likely have negative effects on the population. Demand for precious metals, such as gold and silver, and minerals, such as lithium that is used in electronics and batteries, is leading to an increase in mining in the Great Basin. Expansion of those areas of high disturbance, which was strongly avoided by pronghorn in our study, will result in further fragmentation and loss of habitat. As the Great Basin and across the west continues to be altered by anthropogenic changes, increasing our understanding of how the effects of those impacts on the landscape and on wildlife populations may be mitigated or minimized.

Acknowledgments

This project was funded by a Hatch grant from the Agriculture and Experiment Station at the University of Nevada, Reno. Barrick Gold Corporation provided funding to Nevada Department of Wildlife for the purchase of collars for this project. We thank S. Hale and J. Lutz of Nevada Department of Wildlife for sharing insight on the study area and population. M. Lohman, and J. Vasquez of the University of Nevada, Reno helped with problem-solving during the analysis stage. We thank T. Dilts for troubleshooting all things ArcGIS. We also thank M. Branch and B. Schultz of the University of Nevada, Reno for their contributions in editing.

Literature cited

Allred, B. W., B. T. Bestelmeyer, C. S. Boyd, C. Brown, K. W. Davies, M. C. Duniway, et al. 2021. Improving Landsat Predictions of Rangeland Fractional Cover with Multitask Learning and Uncertainty. *Methods in Ecology and Evolution* 12(5):841–49.

Andreasen, A.M., K. M. Stewart, J. S. Sedinger, C. W. Lackey, and J.P. Beckmann. 2018. Survival of Cougars caught in non-target foothold traps and snares. *Journal of Wildlife Management* 82(5):906-17.

Andrén, Henrik. 1994. Effects of habitat hragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. *Oikos* 71:355-66.

Beckmann, J. P., K. Murray, R. G. Seidler, and J. Berger. 2012. Human-mediated shifts in animal habitat use: sequential changes in pronghorn use of a natural gas field in greater yellowstone. *Biological Conservation* 147(1):222–33.

Berger, J., D. Daneke, J. Johnson, and S. H. Berwick. 1983. Pronghorn foraging economy and predator avoidance in a desert ecosystem: implications for the conservation of large mammalian herbivores. *Biological Conservation* 25:193-208.

Blum, M. E., K. M. Stewart, and C. Schroeder. 2015. Effects of large-scale gold mining on migratory behavior of a large herbivore. *Ecosphere* 6(5):74.

Bolker, B. M., M. E. Brooks, C. J. Clark, S. W. Geange, J. R. Poulsen, M. H. H. Stevens, et al. 2009. Generalized linear mixed models: a practical guide for ecology and evolution. *Trends in Ecology and Evolution* 24(3):127–35.

Boyce, M. S., P. R. Vernier, S. E. Nielsen, and F. K. A. Schmiegelow. 2002. Evaluating resource selection functions. *Ecological Modelling* 157(2-3):281-300.

Breiman, L. 2001. Random forests. *Machine Learning* 45:5-32.

Brooks, M. E., K. Kristensen, K. J. van Benthem, A. Magnusson, C. W. Berg, A. Nielsen, et al. 2017. Glmmtmb balances speed and flexibility among packages for zero-inflated generalized linear mixed modeling. *R Journal* 9(2):378–400.

Byers, J. A. 1997. American pronghorn: social adaptations and the ghosts of predators past. University of Chicago Press, Chicago, IL.

Christie, K.S., W. F. Jensen, and M. S. Boyce. 2017. Pronghorn resource selection and habitat fragmentation in north dakota. *Journal of Wildlife Management* 81(1):154–62.

Clauser, C. and E. Huenges. 1995. Thermal conductivity of rocks and minerals. *Rock physics and phase relations: a handbook of physical constants* 3:105-126.

Cottam, W. P., and G. Stewart. 1940. Plant succession as a result of grazing and of meadow desiccation by erosion since settlement in 1862. *Journal of Forestry* 389(8):613-26.

Cox, M., P. Jackson, C. McKee, C. Schroeder, M. Scott, C. Munson, et al. 2021. Nevada Department of Wildlife 2020-2021 Big Game Status. Nevada Department of Wildlife. Nevada, USA 117pp.

Cumming, G. S. 2000. Using between-model comparisons to fine-tune linear models of species rangers. *Journal of Biogeography* 27:441-55.

D'Eon, R. G., and D. Delparte. 2005. Effects of radio-collar position and orientation on gps radio-collar performance, and the implications of pdop in data screening. *Journal of Applied Ecology* 42(2):383–88.

Dodd, N. L., J. W. Gagnon, S. Sprague, S. Boe, and R. E. Schweinsburg. 2011. Assesment of pronghorn movements and strategies to promote highway permeability. Arizona Game and Fish Department, Technical Report 619. Phoenix, USA.

Elith, J., J. R. Leathwick, and T. Hastie. 2008. A working guide to boosted regression trees. *Journal of Animal Ecology* 77(4):802–13.

Fieberg, J., J. Signer, B. Smith, and T. Avgar. 2021. A ‘how to’ guide for interpreting parameters in habitat-selection analyses. *Journal of Animal Ecology* 90(5):1027–43.

Flaschka, L., C. W. Stockton, and W. R. Boggess. 1987. Climatic variation and surface water resources in the Great Basin region. *Water Resources Bulletin* 23(1):47-57.

Gavin, S. D., and P. E. Komers. 2006. Do pronghorn (antilocapra americana) perceive roads as a predation risk? *Canadian Journal of Zoology* 84(12):1775–80.

Gillies, C. S., M. Hebblewhite, S. E. Nielsen, M. A. Krawchuk, C. L. Aldridge, J. L. Frair, et al. 2006. Application of random effects to the study of resource selection by animals. *Journal of Animal Ecology* 75(4):887–98.

Grayson, D. K. 1993. The desert’s past: a natural prehistory of the Great Basin. Smithsonian Institution Press, Washington, D.C., USA.

Hagen, M., W. D. Kissling, C. Rasmussen, M. A. M. De Aguiar, L. E. Brown, D. W. Carstensen, et al. 2012. Biodiversity, species interactions and ecological networks in a fragmented world. *Advances in Ecological Research* 46:89-210.

Harrington, J. L. and M. R. Conover. 2006. Characteristics of ungulate behavior and mortality associated with wire fences. *Wildlife Society Bulletin* 34(5):1295-1305.

Harrison, X., A., L. Donaldson, M. E. Correa-Cano, J. Evans, D. N. Fisher, C. E. D. Goodwin, et al. 2018. A brief introduction to mixed effects modelling and multi-model inference in ecology. *PeerJ* 5:e4794.

Hartig F (2022). _DHARMa: Residual Diagnostics for Hierarchical (Multi-Level / Mixed) Regression Models_. R package version 0.4.5, https://CRAN.R-project.org/package=DHARMa

Hervert, J. J., J. L. Bright, R. S. Henry, L. A. Piest, M. T. Brown, J. J. Hervert, et al. 2005. Home-range and habitat-use patterns of Sonoran pronghron in Arizona. *Wildlife Society Bulletin* 33(1):8–15.

Johnson, C. J., S. E. Nielsen, E. H. Merrill, T. L. Mcdonald, and M. S. Boyce. 2006. Resource selection functions based on use–availability data: theoretical motivation and evaluation methods. *Journal of Wildlife Management* 70(2):347–57.

Johnson, D. H. 1980. The comparison of usage and availability measurements for the comparison of usage and availability measurements for evaluating resource preference evaluating resource preference. *Ecology* 61(1):65-71.

Kaunda, R. B. 2020. Potential environmental impacts of lithium mining. *Journal of Energy and Natural Resources Law* 38(3):237–44.

Krausman, P. R., L. K. Harris, S. K. Haas, K. K. G. Koenen, P. Devers, D. Bunting, et al. 2005. Sonoran pronghorn habitat use on landscapes disturbed by military activities. *Wildlife Society Bulletin* 33(1):16-23.

Krausman, P. R., J. J. Hervert, and L. L. Ordway. 1985. Capturing deer and mountain sheep with a net-gun. *Wildlife Society Bulletin* 13:71-73.

Kuhn, M. (2008). Building predictive models in R using the caret package. *Journal of Statistical Software* 28(5):1-26.

Lendrum, P. E., C. R. Anderson Jr., R. A. Long, J. G. Kie, and R. T. Bowyer. 2012. Habitat selection by mule deer during migration: effects of landscape structure and natural-gas development. *Ecosphere.* 3(9):82.

Lendrum, P.E., C.R. Anderson Jr., K. L. Monteith, J.A. Jenks, and R.T. Bowyer. 2013. Migrating mule deer: effects of anthropogenically altered landscapes. *PLoS ONE.* 8(5):e64648.

Long, R. A., R. T. Bowyer, W. P. Porter, P. Mathewson, K. L. Monteith, and J. G. Kie. 2014. Behavior and nutritional condition buffer a large-bodied endotherm against direct and indirect effects of climate. *Ecological Monographs* 84(3):513-32.

Manly, B. F. J., L. L. McDonald, D. L. Thomas, T. L. McDonald and W. P. Erickson. 2002. Resource selection by animals: statistical design and analysis for field studies, 2nd ed. Kluwer Press, Boston MA.

McKee, C. J., K. M. Stewart, J. S. Sedinger, A. P. Bush, N. W. Darby, D. Hughson, et al. 2015. Spatial distributions and resource selection by mule deer in an arid environment: responses to provision of water. *Journal of Arid Environments* 122:76–84.

Milligan, M. C., A. N. Johnston, J. L. Beck, K. T. Smith, K. L. Taylor, E. Hall, et al. 2021. Variable effects of wind-energy development on seasonal habitat selection of pronghorn. *Ecosphere* 12(12):e03850.

Muff, S., J. Signer, and J. Fieberg. 2020. Accounting for individual-specific variation in habitat-selection studies: efficient estimation of mixed-effects models using bayesian or frequentist computation. *Journal of Animal Ecology* 89(1):80–92.

Muntean, J. L. 2019. The Carlin gold system: applications to exploration in Nevada and beyond. *Reviews in Economic Geology* 20:39-88.

Northrup, J. M., M. B. Hooten, C. R. Jr. Anderson, and G. Wittemyer. 2013. Practical guidance on characterizing availability in resource selection functions under a use-availability design. *Ecology* 94(7):1456–63.

O'Gara, B. W. and J. D. Yoakum. 2004. Pronghorn: ecology and management. University Press of Colorado.

Reinking, A. K., K. T. Smith, T. W. Mong, M. J. Read, and J. L. Beck. 2019. Across scales, pronghorn select sagebrush, avoid fences, and show negative responses to anthropogenic features in winter. *Ecosphere* 10(5):e02722.

Robb, B. S., J. A. Merkle, H. Sawyer, J. L. Beck, and M. J. Kauffman. 2022. Nowhere to run: semi-permeable barriers affect pronghorn space use. *Journal of Wildlife Management* 86(4):e22212.

Romme, W. H., C. D. Allen, J. D. Bailey, W. L. Baker, B. T. Bestelmeyer, P. M. Brown, et al. 2009. Historical and modern disturbance regimes, stand structures, and landscape dynamics in piñon-juniper vegetation of the western United States. *Rangeland Ecology & Management* 62(3):203-22.

Rowland, M. M., M. J. Wisdom, L. H. Suring, and C. W. Meinke. 2006. Greater sage-grouse as an umbrella species for sagebrush-associated vertebrates. *Biological Conservation* 129(3):323–35.

Sawyer, H., M. J. Kauffman, A. D. Middleton, T. A. Morrison, R. M. Nielson, and T. B. Wyckoff. 2013. A framework for understanding semi-permeable barrier effects on migratory ungulates. *Journal of Applied Ecology* 50(1):68–78.

Sawyer, H., M.J. Kauffman, and R. M. Nielson. 2009. Influence of well pad activity on winter habitat selection patterns of mule deer. *Journal of Wildlife Management* 73(7):1052–61.

Sawyer, H., F. Lindzey, and D. McWhirter. 2005. Mule deer and pronghorn migration in western wyoming. *Wildlife Society Bulletin* 33(4):1266–73.

Sawyer, H., R. M. Nielson, F. Lindzey and L. L. Mcdonald. 2006. Winter habitat selection of mule deer before and during development of a natural gas field. *Journal of Wildlife Management* 70(2): 396-403.

Seidler, R. G., D. S. Green, and J. P. Beckmann. 2018. Highways, crossing structures and risk: behaviors of greater yellowstone pronghorn elucidate efficacy of road mitigation. *Global Ecology and Conservation* 15:e00416.

Seidler, R. G., R. A. Long, J. Berger, S.Bergen, and J. P. Beckmann. 2014. “Identifying Impediments to Long-Distance Mammal Migrations.” *Conservation Biology* 29(1):99–109.

Shoemaker, K. T., L. J. Heffelfinger, N. J. Jackson, M. E. Blum, T. Wasley, and K. M. Stewart. 2018. A machine-learning approach for extending classical wildlife resource selection analyses. *Ecology and Evolution* 8(6):3556–69.

Sikes, R. S. 2016. 2016 Guidelines of the American society of mammalogists for the use of wild mammals in research and education. *Journal of Mammalogy* 97(3):663–88.

Sing, T., O. Sander, N. Beerenwinkel, and T. Lengauer. 2005. ROCR: Visualizing classifier performance in R. *Bioinformatics* 21(20):3940–41.

Sprague, S. C. 2010. Highways and pronghorn population genetics in northern Arizona pronghorn. Thesis, Northern Arizona University, Flagstaff, Arizona, USA.

Stewart, K. M., R. T. Bowyer, J. G. Kie, N. J. Cimon and B. K. Johnson. 2002. Temporospatial distributions of elk, mule deer, and cattle: resource partitioning and competetive displacement. *Journal of Mammalogy* 83(1):229-44.

Terborgh, J., L. Lopez, P. V. Nuñez, M. Rao, G. Shahabuddin, G. Orihuela, et al. 2001. Ecological meltdown in predator-free forest fragments. *Science* 294(5548):1923–26.

Wright, M. N., and A. Ziegler. 2017. Ranger: a fast implementation of random forests for high dimensional data in C++ and R. *Journal of Statistical Software* 77(1):1-17.

Table 1. Descriptive statistics of all used (*n*=37,347) and available locations (*n*=37,347) for adult female pronghorn (*n*=12) associated with the Cortez gold mining operations in central Nevada, USA, 2018- 2021. Note: For binomial variables, we reported the number of locations that fall within (1) or outside of (0) the area of that characteristic.

Habitat characteristics	**Used locations**		**Available locations**	
	Mean	*SD*	*Mean*	*SD*
Continuous variables				
Elevation (m)	1883	162	1794	237
Slope (°)	6.88	4.97	6.49	7.72
Aspect (°) sine transformation	0.90	0.74	0.97	0.74
Aspect (°) cosine transformation	1.09	0.66	1.07	0.67
Perennial forbs and grasses (% cover)	23	10.62	16.79	12.56
Annual forbs and grasses (% cover)	21.30	14.06	14.56	16.01
Shrub (% cover)	13.37	6.66	18.15	10.35
Tree (% cover)	0.89	0.74	3.59	9.36
Distance to water (km)	2.84	1.81	3.79	2.44
Distance to 4WD roads (km)	1.19	1.07	1.78	1.97
Distance to main roads/hwy (km)	2.39	1.45	2.28	1.96
Binomial variables				
Seeded areas	16,119	96	4,793	65
Medium disturbance	1,615	39	472	22
High disturbance	585	24	1,520	38

Table 2. Parameter estimates, confidence intervals, and *p*-values for annual model of resource selection using non-linear mixed effects models for 12 adult female pronghorn associated with the Cortez gold mining operations in central Nevada, USA, January 2018 to June 2021. *N*=37,347

Parameter	**Estimate**	**CI**	***p*-value**
Intercept	0.89	0.59	0.003
Elevation	1.47	0.86	< 0.001
$(\text{Elevation})^2$	-1.13	0.57	< 0.001
Slope	0.21	0.45	0.350
$(\text{Slope})^2$	-0.62	0.16	< 0.001
Shrub	-0.77	0.10	< 0.001
Tree	-1.81	0.51	< 0.001
Distance to road	-0.35	0.31	0.035
$(\text{Distance to road})^2$	-0.62	0.33	< 0.001
Medium disturbance	-1.36	.81	0.090
High disturbance	-6.79	2.92	0.020

Table 3. Parameters estimates, confidence intervals, and *p*-values from resource selection functions using non-linear mixed effects models for 12 adult female pronghorn associated with the Cortez gold mining operations in central Nevada, USA, January 2018 to June 2021. Spring is March-May (*n*=7,580), summer is June-September (*n*=11,500), autumn is October (*n*=2,512), and winter is November-February (*n*=15,755).

Season	**Parameter**	**Estimate**	**CI**	***p*-value**
Spring				
	Intercept	0.62	0.74	0.104
	Elevation	1.17	1.45	0.113
	$(\text{Elevation})^2$	-1.46	0.69	< 0.001
	Slope	0.52	0.59	0.084
	$(\text{Slope})^2$	-0.76	0.18	< 0.001
	Shrub	-0.82	0.24	< 0.001
	Tree	-1.87	0.55	< 0.001
	Distance to road	-0.57	0.35	0.002
	$(\text{Distance to road})^2$	-0.88	0.51	< 0.001
	Medium disturbance	-0.28	0.35	0.129
	High disturbance	-0.03	0.29	0.848
Summer				
	Intercept	-0.05	0.51	0.849
	Elevation	1.97	1.63	0.018
	$(\text{Elevation})^2$	-1.19	0.71	0.001
	Slope	0.50	0.76	0.203
	$(\text{Slope})^2$	-0.90	0.27	< 0.001
	Shrub	-0.84	0.18	< 0.001
	Tree	-2.58	1.33	< 0.001
	Distance to road	-0.22	0.49	0.390
	$(\text{Distance to road})^2$	-0.50	0.29	0.001
	Medium disturbance	0.43	0.29	0.005
	High disturbance	-0.54	0.31	0.001

Table 3. Continued

Season	**Parameter**	**Estimate**	**SE**	***p*-value**
Autumn				
	Intercept	-0.07	0.53	0.793
	Elevation	5.40	1.72	< 0.001
	(Elevation)^2	-2.36	0.31	< 0.001
	Slope	0.02	0.53	0.938
	(Slope)^2	-0.72	0.16	< 0.001
	Shrub	-1.37	0.24	< 0.001
	Tree	-2.74	0.80	< 0.001
	Distance to road	-0.55	0.53	0.040
	(Distance to road)^2	-1.02	0.18	< 0.001
	Medium disturbance	-0.83	0.61	0.007
	High disturbance	20.04	6305	0.995
Winter				
	Intercept	1.30	0.59	< 0.001
	Elevation	1.69	0.82	< 0.001
	(Elevation)^2	-1.53	0.69	< 0.001
	Slope	-0.19	0.27	0.159
	(Slope)^2	-0.58	0.16	< 0.001
	Shrub	-0.83	0.18	< 0.001
	Tree	-1.68	0.14	< 0.001
	Distance to road	-0.41	0.35	0.021
	(Distance to road)^2	-0.81	0.27	< 0.001
	Medium Disturbance	-0.55	0.27	< 0.001
	High Disturbance	-3.75	0.69	< 0.001

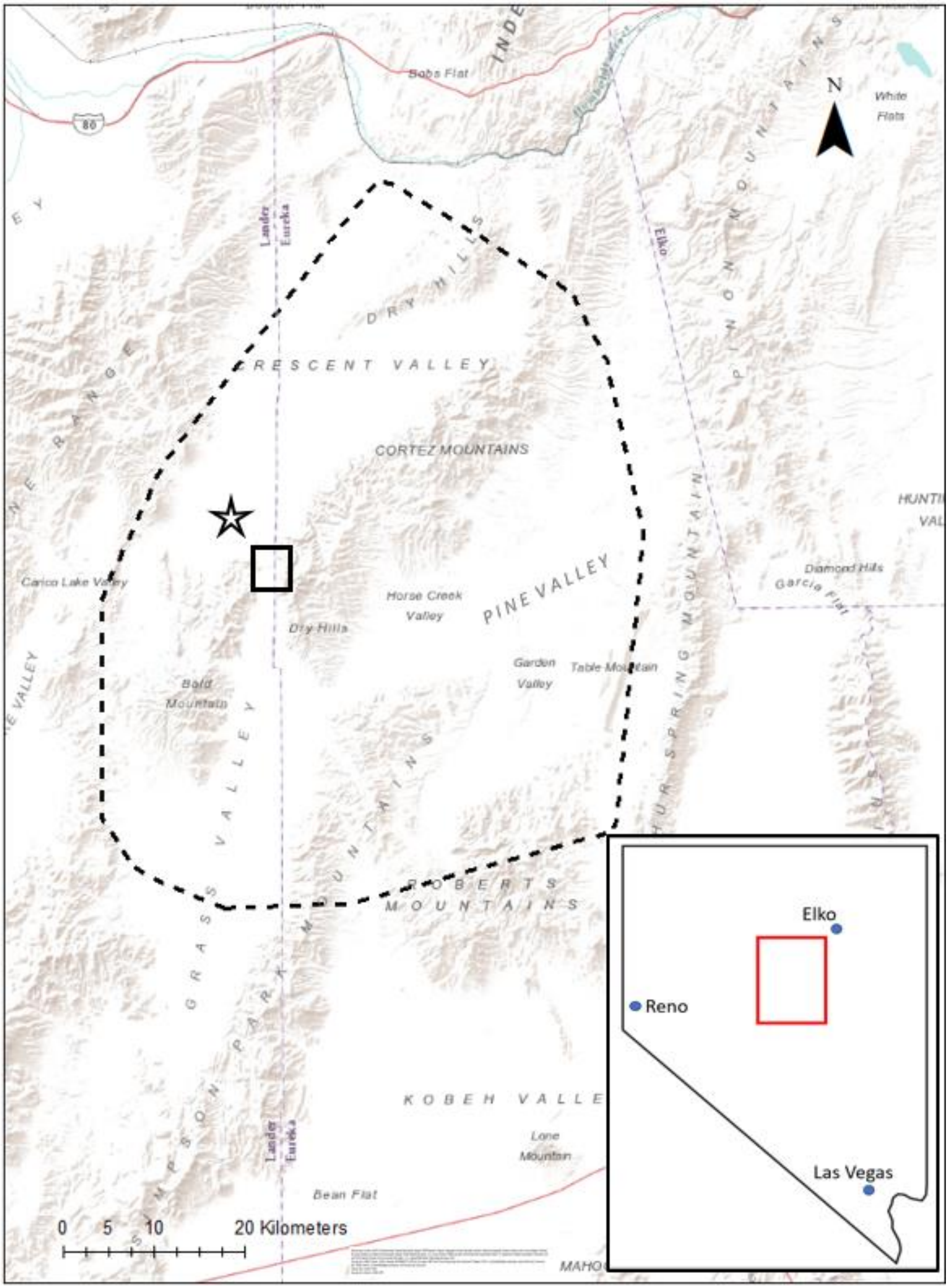

Figure 1. Map of the study area in central Nevada. Dashed line represents the minimum convex polygon of all used locations of adult female pronghorn from January 2018 to June 2021. The square at the base of the Cortez Mountains depicts the Cortez mine and the star in Crescent Valley depicts the Pipeline mine.

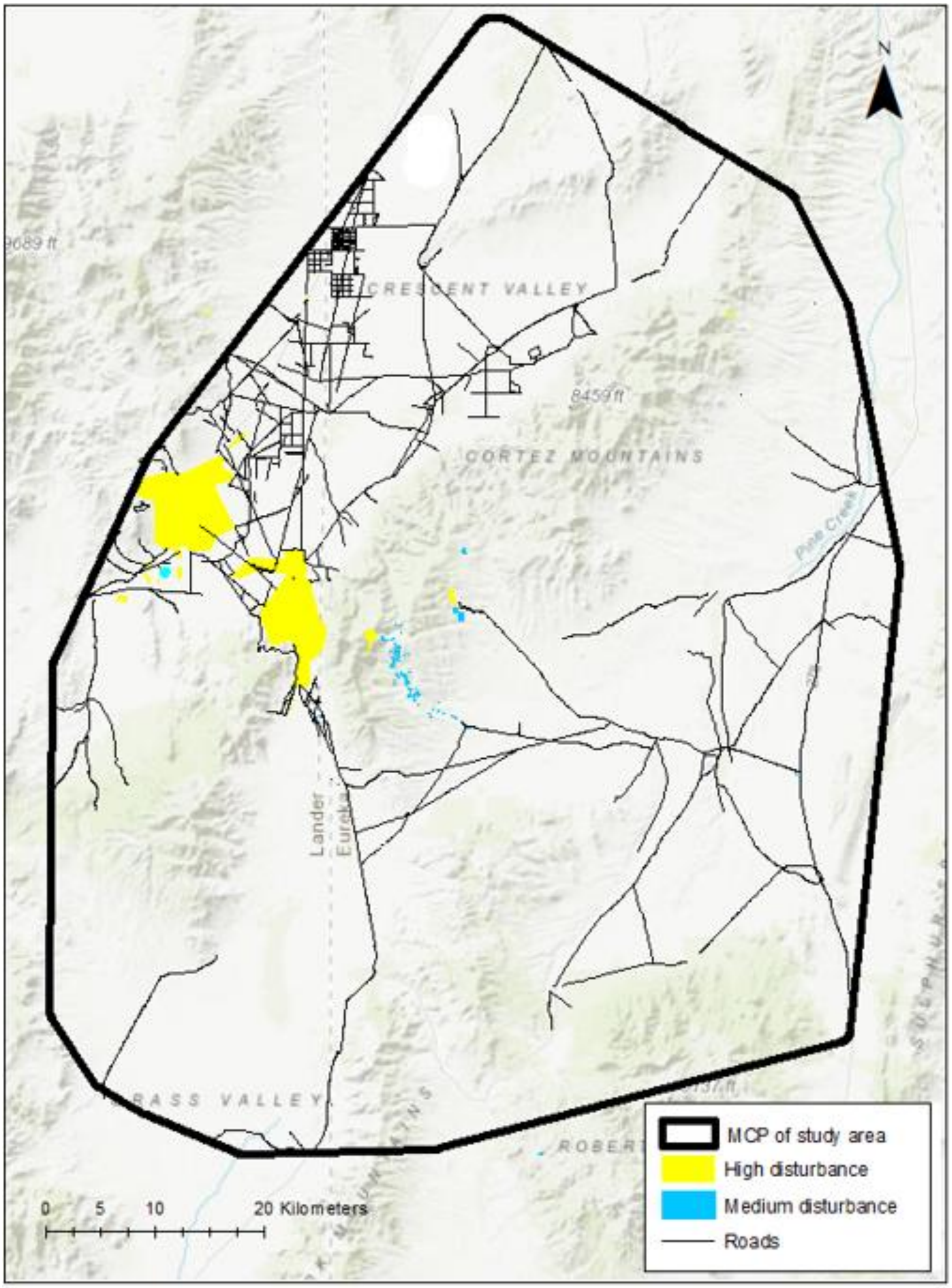

Figure 2. Roads and disturbance areas of mining activities in the study area for habitat selection by adult female pronghorn near the Cortez and Pipeline mines 2018-2021. Roads are depicted with black lines, high disturbance with yellow polygons, and medium disturbance with blue polygons.

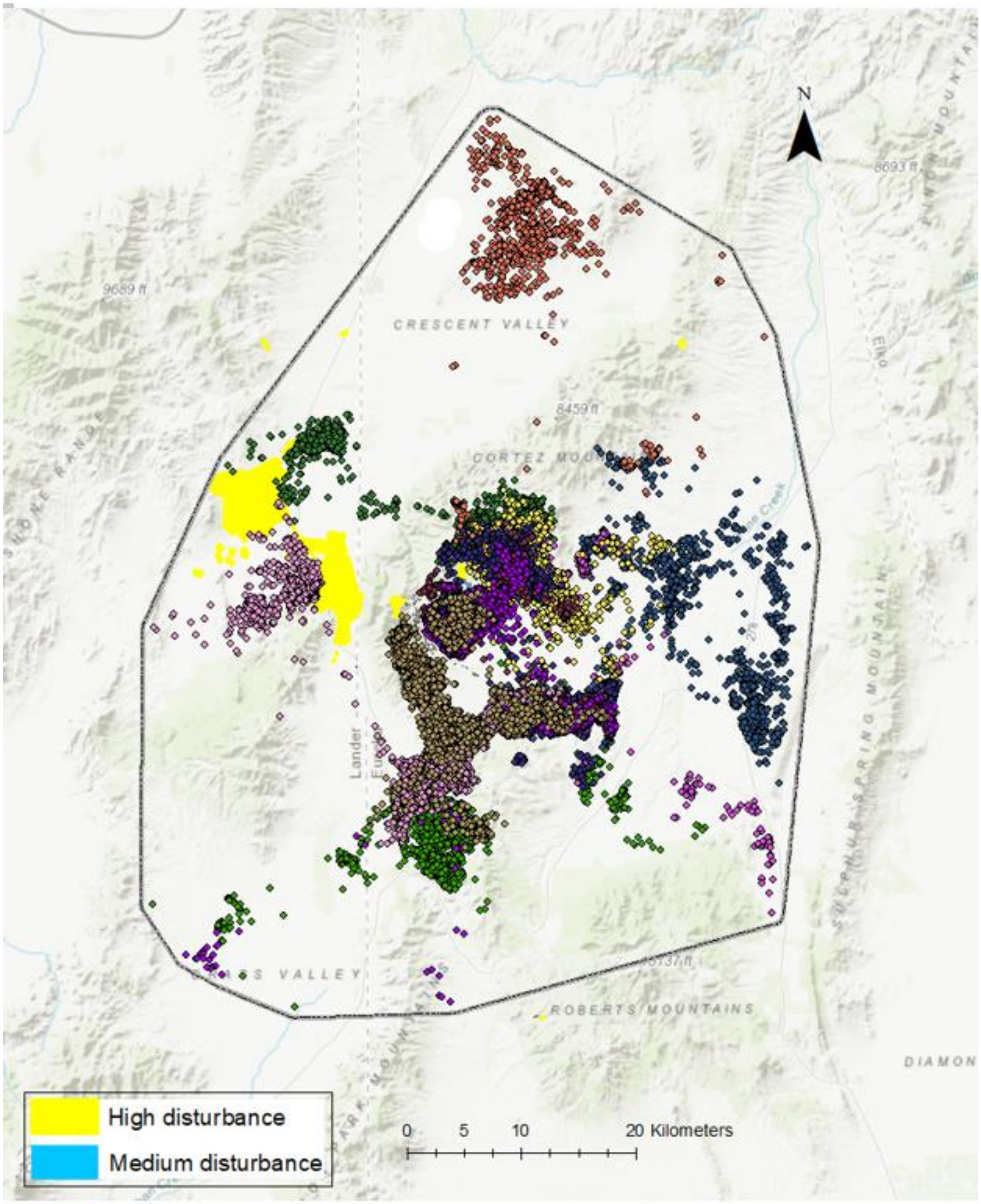

Figure 3. All used locations of adult female pronghorn (*n*=12) in the study from January 2018 to June 2021. Each colored point represents the GPS location of one individual, yellow polygons represent high disturbance and blue polygons represent medium disturbance.

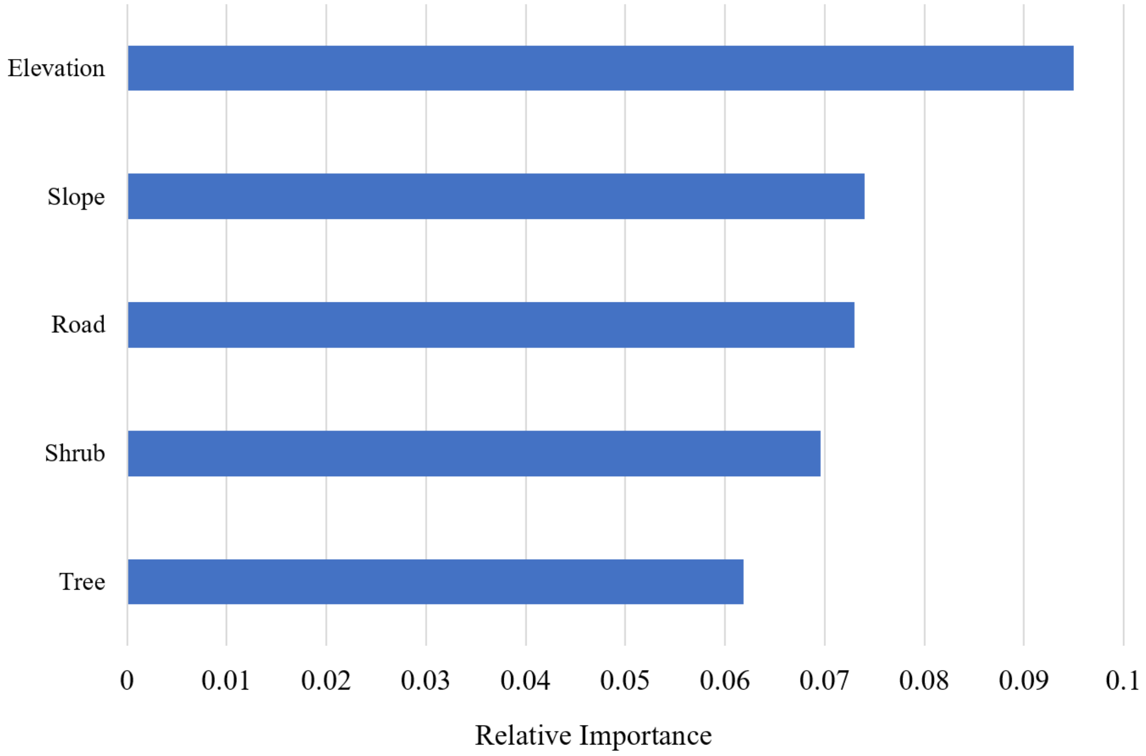

Figure 4. Relative importance rankings derived from random forest models for variables explaining selection of resources for 12 female pronghorn associated with the Cortez gold mine in central Nevada from 2018-2021.

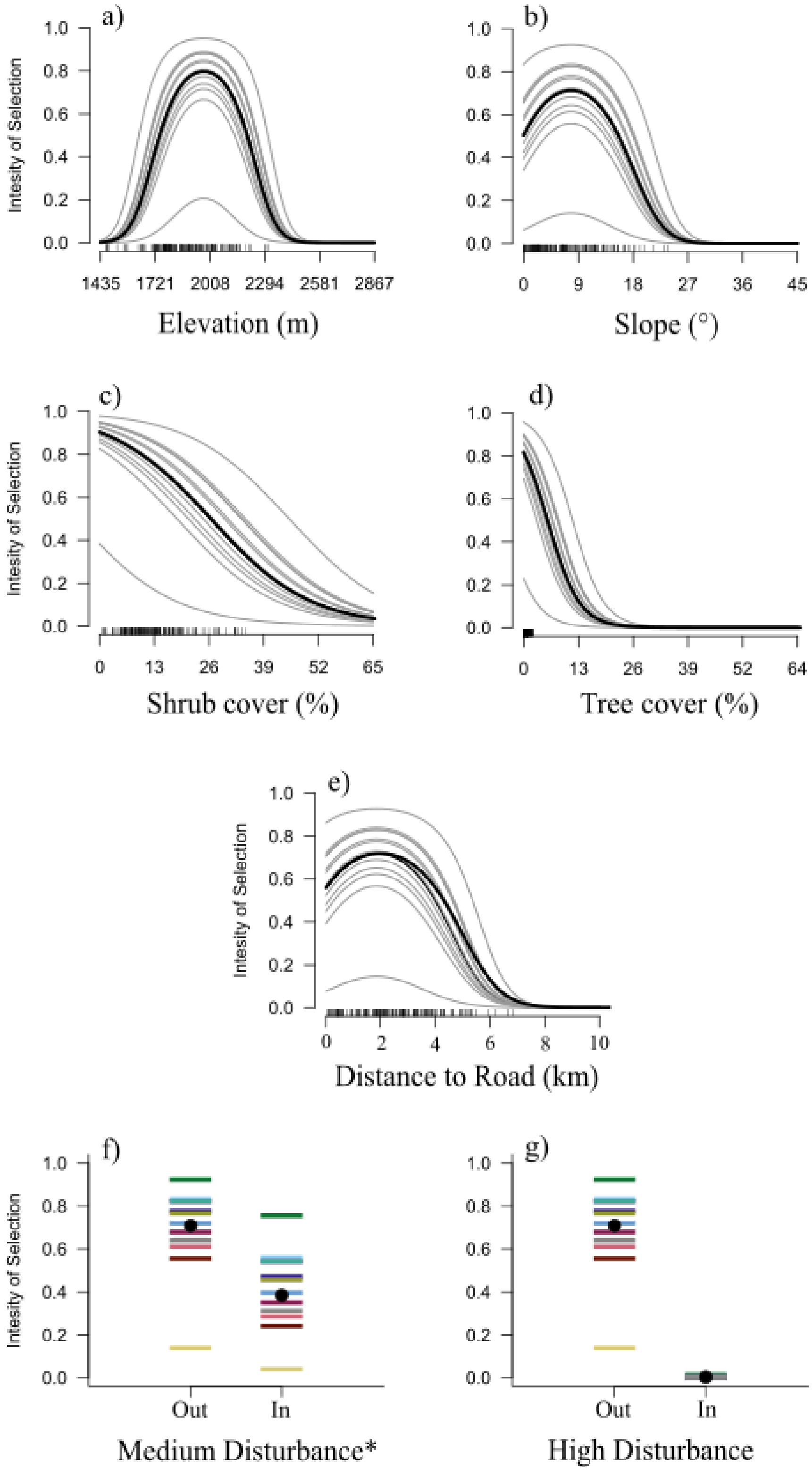
a)
Intesity of Selection
1.0
0.8
0.6
0.4
0.2
0.0
1435
1721
2008
2294
2581
2867
Elevation (m)
b)
1.0
0.8
0.6
0.4
0.2
0.0
0
9
18
27
36
45
Slope (°)
c)
Intesity of Selection
1.0
0.8
0.6
0.4
0.2
0.0
0
13
26
39
52
65
Shrub cover (%)
d)
1.0
0.8
0.6
0.4
0.2
0.0
0
13
26
39
52
64
Tree cover (%)
e)
Intesity of Selection
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
6
8
10
Distance to Road (km)
f)
Intesity of Selection
1.0
0.8
0.6
0.4
0.2
0.0
Out
In
Medium Disturbance*
g)
1.0
0.8
0.6
0.4
0.2
0.0
Out
In
High Disturbance

Figure 5. Annual plots of resource selection by adult female pronghorn (*n*=12) associated with the Cortez gold mine in central Nevada, 2018-2021. Visualizations were derived from the annual non-linear mixed effects model with random intercepts and slopes on each variable. In each plot, solid black line represents the population mean and individuals are shown as the grey lines. Tick marks at the bottom of the plot represent every 200th used location. The x-axes for our disturbance variables represent locations inside or outside the disturbance areas with a solid black circle to represent the population mean and individuals represented by each color line (f and g). Note that the asterisk on Medium Disturbance indicates a non-significant relationship.

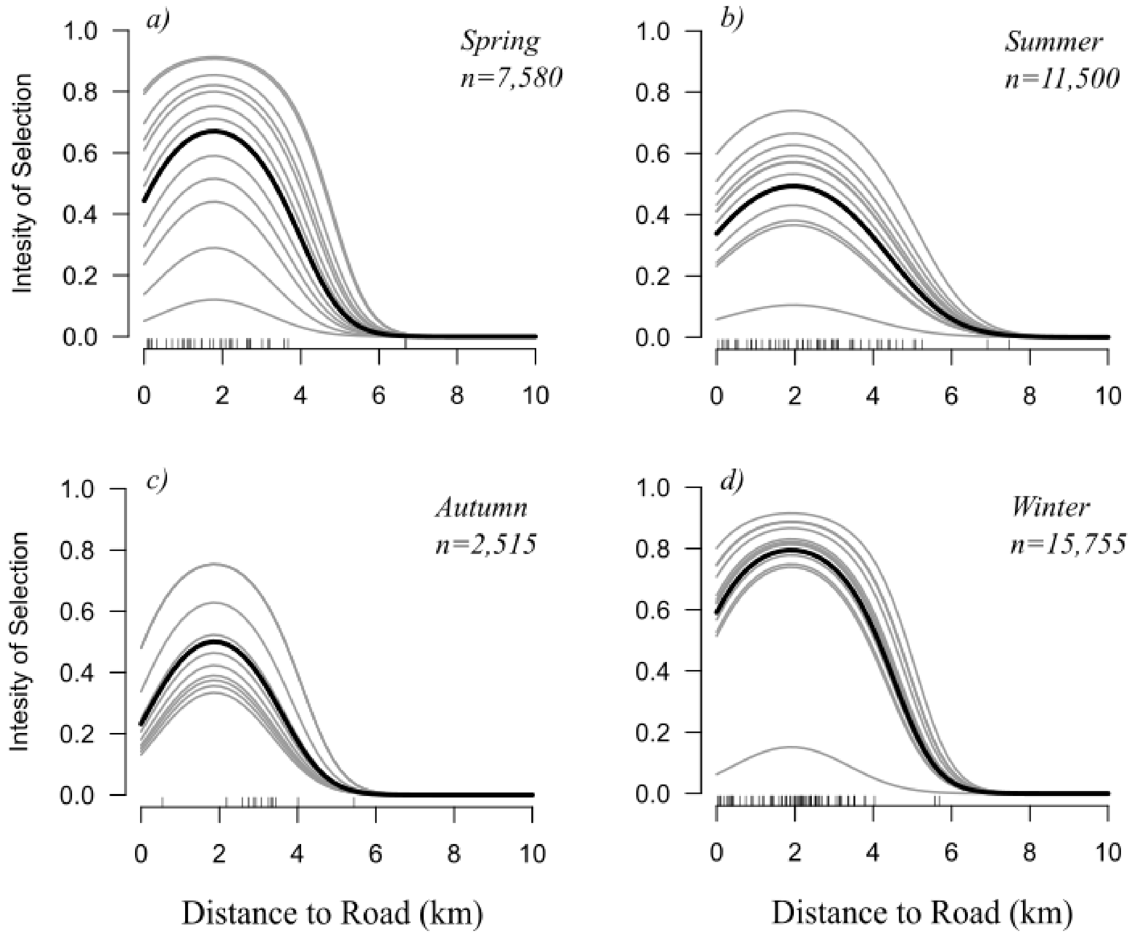

Figure 6. Intensity of selection plots for distance to roads by season for pronghorn (winter *n*=12, spring *n*=12, summer *n*=11, autumn *n*=10) associated with the Cortez gold mine in central Nevada 2018-2021. Visualizations were derived from the annual non-linear mixed effects model with random intercepts and slopes. Covariates and intensity of selection (0 to 1) are on the axes. Solid black line represents the population mean and individuals are shown as the grey lines. Tick marks at the bottom of the plot represent every 200th used location. Sample sizes on the figures represent number of locations for that season.

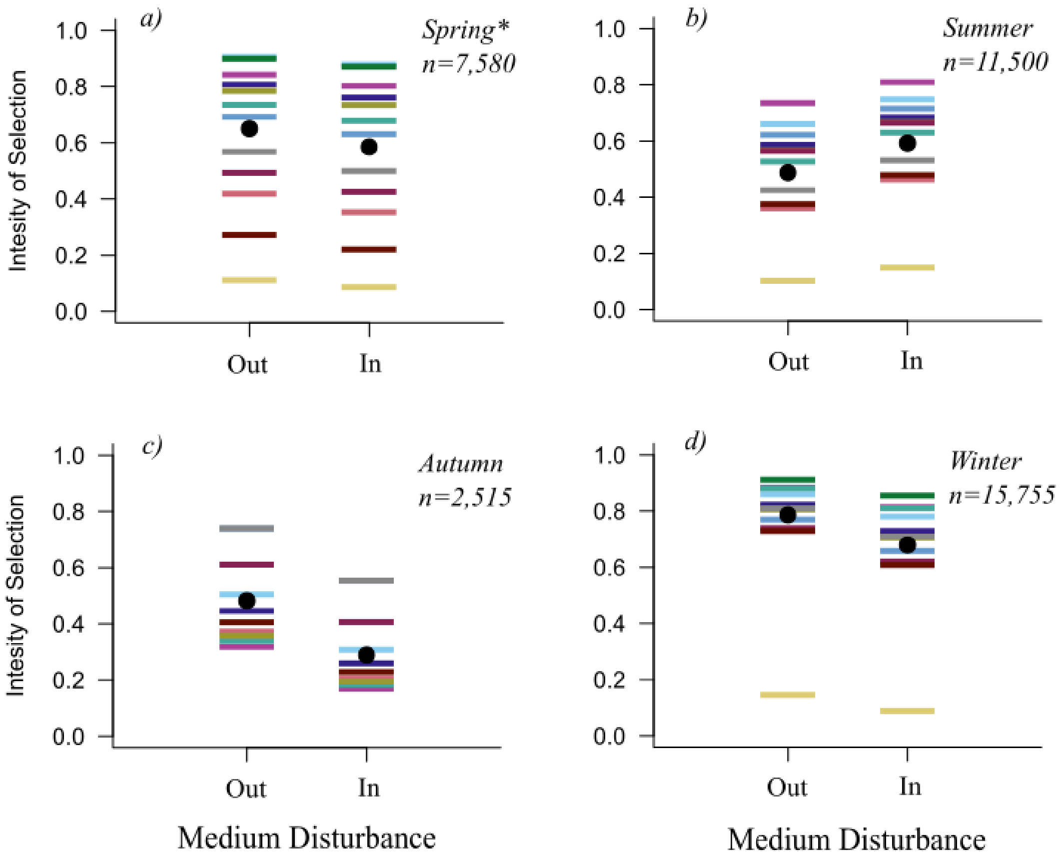

Figure 7. Intensity of selection plots for medium disturbance by season for pronghorn (winter *n*=12, spring *n*=12, summer *n*=11, autumn *n*=10) associated with the Cortez gold mine in central Nevada 2018-2021. Visualizations were derived from the annual non-linear mixed effects model with random intercepts. X-axes represent locations inside or outside the disturbance areas and y-axes represent intensity of selection (0 to 1). A solid black circle represents the population mean and individuals are represented by each color line. Sample sizes on the figures represent number of locations for that season. Note that an asterisk indicates a non-significant relationship for that season.

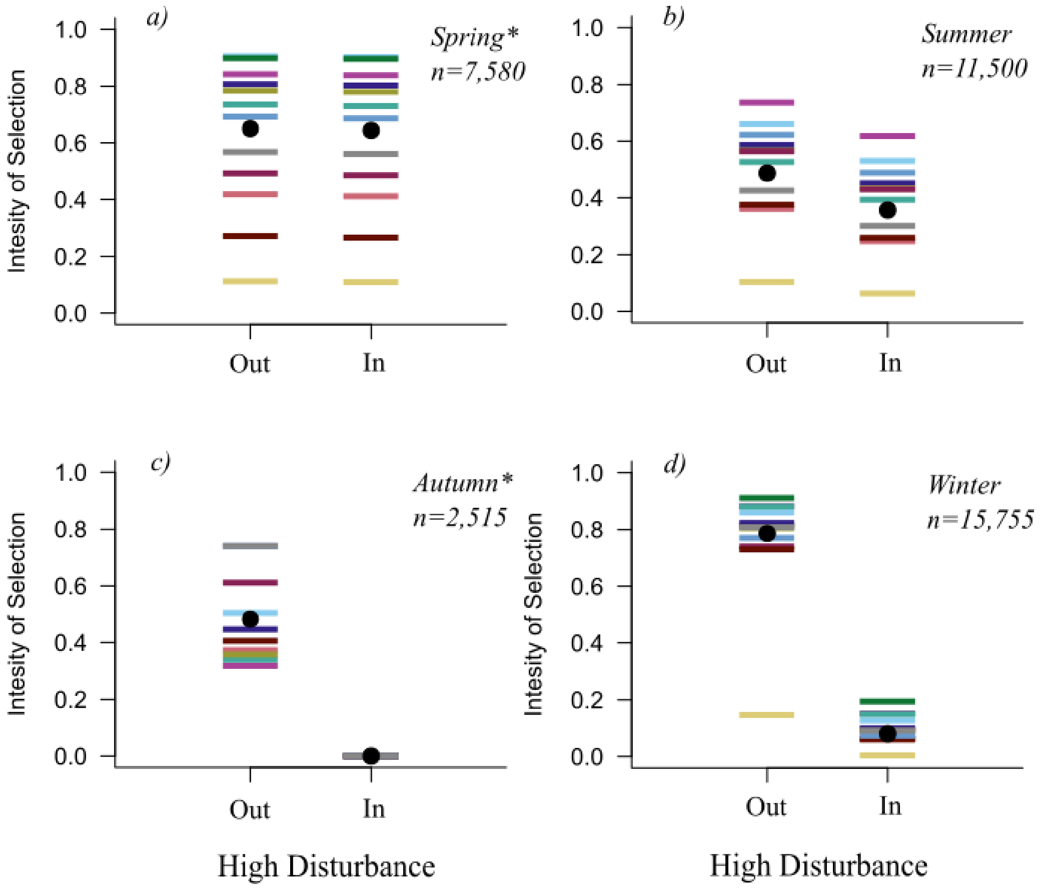

Figure 8. Intensity of selection plots for distance to high disturbance by season for pronghorn (winter *n*=12, spring *n*=12, summer *n*=11, autumn *n*=10) associated with the Cortez gold mine in central Nevada 2018-2021. Visualizations were derived from the annual non-linear mixed effects model with random intercepts. X-axes represent locations inside or outside the disturbance areas and y-axes represent intensity of selection (0 to 1). A solid black circle represents the population mean and individuals are represented by each color line. Sample sizes on the figures represent number of locations for that season. Note that an asterisk indicates a non-significant relationship for that season.