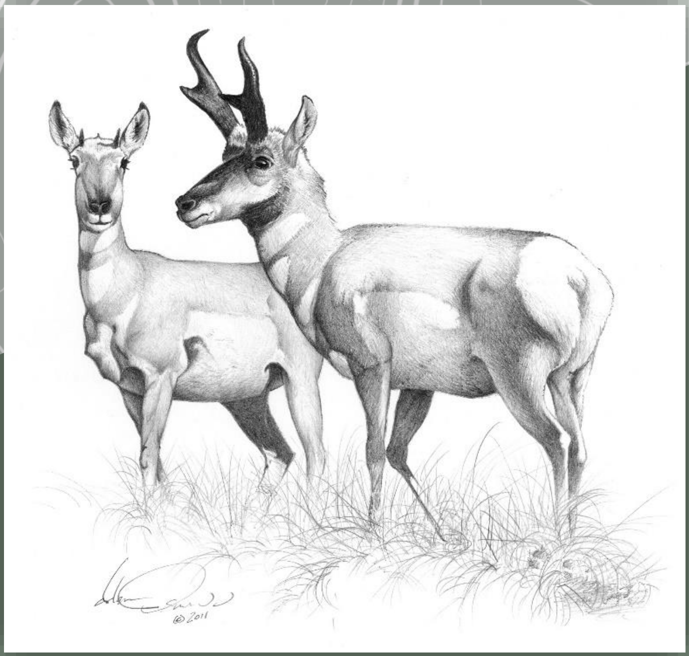
29th Western States and Provinces

Pronghorn Workshop Proceedings



22-25 August 2022

Deadwood, South Dakota

Sanctioned by the Western Association of Fish and Wildlife Agencies

Hosted by the South Dakota Department of Game, Fish and Parks

Proceedings of the Western States and Provinces

Twenty-ninth Biennial Pronghorn Workshop

2022

Editors:
Andy Lindbloom, Lauren Wiechmann, and Andrew Norton

Published by:
South Dakota Game, Fish and Parks

Workshop Planning Committee:

Co-Chairs - Andy Lindbloom and Andrew Norton; SDGFP
Registration and Treasurer - Lauren Wiechmann and Dan Sternhagen; SDGFP. Cathy Campbell and Todd Rich; WAFWA
Sponsors and Vendors - Lauren Wiechmann and Dan Sternhagen; SDGFP
Abstracts and Posters - Nathan Baker and Trenton Haffley; SDGFP
Meals and Social - Steve Griffin; SDGFP
Awards - Chad Switzer (Chair) and Steve Griffin; SDGFP. Rich Guenzel; WGFD (retired)
Program Development - Chad Switzer and Allie Ellingson; SDGFP

Artwork was provided by Adam Oswald.

Suggested Citation:

Lindbloom, A. J., L. M. Wiechmann, and A. S. Norton, editors. 2023. Proceedings of the Western States and Provinces 29th Biennial Pronghorn Workshop, 2022. South Dakota Game, Fish and Parks, Pierre, South Dakota. USA. XXpp.

Gold Sponsors

Silver Sponsors

Bronze Sponsors

T & K Hunting   Cowboy Liquor Store   Jacobs Brewhouse   Scheels

TABLE OF CONTENTS

WORKSHOP AGENDA

MONDAY – 22 AUGUST

4:00 – 7:00 PM	Registration / Social
	Poster Presentations Endangered Peninsular Pronghorn ***Mason Kleist*** *and Melodi Tayles*
	Pronghorn movement and resource selection in Nebraska's agriculturally dominated landscape. ***Katie M. Piecora****, Andrew R. Little, and Dustin H. Ranglack*

TUESDAY – 23 AUGUST

6:30 – 8:00 AM	*Breakfast provided – Mountain Grand Event Center*
7:00 – 8:30	Registration
TUESDAY MORNING SESSION	
8:30 – 8:40 AM	Opening remarks and logistics
8:40 – 9:00	**Welcome to Deadwood, South Dakota** *Kevin Robling, SDGFP Secretary*
	Population Demographics and Evaluation I *Moderator: Andy Lindbloom*
9:00 – 9:20	A comparison of density and detectability of pronghorn in Wyoming from aerial surveys. ***Lee Knox,*** *Jason D. Carlisle and L. Embere Hall*
9:20 – 9:40	Population models aid defensible decision making and guide monitoring of the world's largest pronghorn population. ***Hans W. Martin,*** *L. Embere Hall, Will Shultz, Lee Knox, Paul M. Lukacs and J. Joshua Nowak*
9:40 – 10:00	Can hunters track trends in pronghorn populations? ***Paul F. Jones,*** *Susan H. Peters, Vic Adamowicz and Jay Anderson*
10:00 AM	*Break*
	Movement/Migration I
10:15	*Raffle drawing*

10:20 – 10:40	Migratory strategies and integrated step selection analysis of pronghorn on the Modoc Plateau. ***Colton J. Wise,*** *Clinton W. Epps, Brian R. Hudgens and Robert S. Spaan*
10:40 – 11:00	Wind-energy development alters pronghorn migration at multiple scales. *Megan C. Milligan,* ***Aaron N. Johnston,*** *Jeffrey L. Beck, Kaitlyn L. Taylor, Embere Hall, Lee Knox, Teal Cufaude, Cody Wallace, Geneva Chong and Matthew J. Kauffman*
11:00 – 11:20	Pronghorn exhibit diverse array of seasonal use behaviors on the Modoc Plateau, California. ***Brian Hudgens***
11:20 – 11:40	Seasonal resource selection by pronghorn in central Oregon. ***Andrew J. Walch,*** *Corey Heath, Seth Harju and Donald J. Whittaker*
11:40 – 12:00	Pronghorn resource selection and migration through a high-elevation forest in northern New Mexico. ***Joanna R. Ennis*** *and James W. Cain III*
Noon	*Lunch provided*

TUESDAY AFTERNOON SESSION

Population Demographics and Evaluation II

Moderator: Andrew Norton

1:00 – 1:20 PM	Investigating sources and seasonality of acute, fatal pneumonia in free-ranging pronghorn (*Antilocapra americana*). ***Marguerite Johnson,*** *Madison Blaeser, Erin Schwalbe, Amy K. Wray, Christopher MacGlover, Hank Edwards, Samantha E. Allen, Erika Peckham, Kerry S. Sondgeroth and Jennifer L. Malmberg*
1:20 – 1:40	Assessing genetic susceptibility of pronghorn to prion disease through PRNP gene sequencing. ***Angela M. Grogan,*** *Matthew J. Buchholz, Courtney L. Ramsey, Emily A. Wright, Robert D. Bradley and Warren C. Conway*

1:40 – 2:00	Variation in survival rates across pronghorn northern populations. ***Molly C. McDevitt,*** *Andy Lindbloom, Kelly Proffitt, Joshua Millspaugh and Paul Lukacs*
2:00 – 2:20	Spatiotemporal risk factors predict landscape-scale survivorship for a northern ungulate. *Daniel R. Eacker,* ***Andrew F. Jakes*** *and Paul F. Jones*
2:20 – 2:40	Divergent population parameters signal losses in resilience driven by global change drivers in pronghorn, an iconic rangeland species. *Victoria M. Donovan,* ***Jeffrey L. Beck,*** *Carissa L. Wonkka, Caleb P. Roberts, Craig R. Allen and Dirac Twidwell*
2:40 – 3:00	Pronghorn Range-wide Status Report. ***Andrew Norton*** *and Andy Lindbloom*
3:00 PM	*Break*
	<u>Movement/Migration II</u>
3:15	*Raffle drawing*
3:20 – 3:40	Advancing fence datasets: Comparing approaches to identify fence locations and specifications in southwest MT. ***Simon A. Buzzard,*** *Andrew F. Jakes, Amy J. Pearson and Len Broberg*
3:40 – 4:00	Modeling behavior and space-use: Acclimation of translocated pronghorn on the Edwards Plateau. ***Erin C. O'Connell,*** *Justin T. French, Carlos E. Gonzalez, Louis A. Harveson and Shawn S. Gray*
4:00 – 4:20	Activity dynamics of resident and translocated pronghorn in the Edwards Plateau, Texas. ***Justin T. French,*** *Erin C. O'Connell, L. Cody Webb, Carlos E. Gonzalez, Louis A. Harveson and Shawn S. Gray*
4:20 – 4:40	Using citizen scientists to connect science and road mitigation. *Tracy S. Lee, Paul F. Jones, Andrew F. Jakes, Megan Jensen, Ken Sanderson, Danah Duke and* ***Amanda MacDonald***
6:00 PM	*Awards Banquet – Mountain Grand Event Center*

WEDNESDAY – 24 AUGUST

6:30 – 8:00 AM	*Breakfast provided – Mountain Grand Event Center*

WEDNESDAY MORNING SESSION

8:15 – 10:00	Business Meeting
10:00 AM	*Break*
	Movement/Migration III *Moderator: Chad Switzer*
10:15	*Raffle drawing*
10:20 – 10:40	Deciphering Idaho's pronghorn antelope seasonal movements; modifying migration mapping methods for migration route estimation, seasonal range analysis and conservation. ***Scott Bergen,*** *Jodi Berg, Mark Hurley and Shane Roberts*
10:40 – 11:00	Pronghorn migration in eastern Oregon. ***Jerrod L. Merrell,*** *Kelley M. Stewart and Don Whittaker*
11:00 – 11:20	Migration and management of pronghorn in the Madison Valley, southwest Montana. ***Julie A. Cunningham,*** *Kelly Proffitt and Jesse Devoe*
11:20 – 11:40	Pronghorn demography and movement on the Modoc Plateau, California. ***Brian Hudgens,*** *Colton Wise and David Garcelon*
Noon	*Lunch provided*

WEDNESDAY AFTERNOON SESSION

	History, Management, and Conservation *Moderator: Trenton Haffley*
12:55	*Raffle drawing*
1:00 – 1:20 PM	Habitat and Access priority in South Dakota. ***John Kanta***
1:20 – 1:40	Private lands habitat and landowner tolerance in western South Dakota. ***Bill Eastman***

1:40 – 2:00	Evaluating a landowner-controlled harvest strategy for pronghorn bucks in the northern Texas Panhandle. ***Shawn S. Gray,*** *Calvin L. Richardson, James D. Hoskins and Jonathan C. Malone*
2:00 – 2:20	Collaborative wildlife-snow science: Integrating wildlife and snow expertise to improve research and management. ***Adele K. Reinking,*** *Stine Hojlund Pedersen, Kelly Edler and Glen E. Liston*
2:20 – 2:40	Observations on various pronghorn populations in Mexico and the southwestern United States. ***Raymond M. Lee***
2:40 – 3:00	Ice-Age pronghorn in North America. ***Richard S. White***
3:00 PM	*Break*
3:20 – 3:40	Pronghorn habitat suitability in the flint hills of east-central Kansas. ***Jeff W. Rue*** *and Dustin Ranglack*
3:40 – 4:00	Southeastern Arizona grasslands pronghorn initiative 2010-2019. ***Glen Dickens,*** *John Millican and Rana Murphy*
4:00	***GRAND PRIZE RAFFLE DRAWING***
6:00 PM	*Dinner on the town, on your own*

THURSDAY – 25 AUGUST

Return Travel

CONTRIBUTED PAPERS

PEER-VIEWED SUBMISSIONS (Alphabetical by Lead Author)
(Reviewers – Andy Lindbloom, Andrew Norton, Cody Schroeder)

OBSERVATIONS OF A REMNANT POPULATION OF TRANSLOCATED PRONGHORN NEAR HILLSIDE, ARIZONA

DAVID E. BROWN, *Arizona State University, Tempe, AZ (deceased)*

RAYMOND M. LEE, *Ray Lee LLC, P. O. Box 1448, Cody, WY 82414, (602) 315-0604, rlee@morgensen.com*

MATHEW PEIRCE, *Arizona Game and Fish Department (retired), P. O. Box 1736, Wickenburg, AZ 85356, (928) 684-3774, mcpeirce@gmail.com*

ABSTRACT We monitored the persistence of a remnant population of pronghorn (Antilocapra americana) near Hillside, AZ, over an 11-year period from May 2008 through 21 December 2019. Originally consisting of 3 bucks, 2 does, and 1 female yearling, the last pregnant doe was seen 13 March 2014, and the last fawn was seen 10 November 2014. Only 1 buck was seen after 17 June 2014, and no bucks after 7 July 2018. The last pronghorn were seen on 15 December 2018. Although the possibility exists of animals immigrating or emigrating from the 78 km^2 study area, we did not document such behavior during our study. With no overt attempts at management the population doubled before losing 4 animals following a May 2014 Palmer Drought Severity Index (PDSI) of -4.09. The persistence of this population through 2018 is attributed to low adult mortality and greater recruitment of females than males. The disappearance of this population is attributed to inbreeding depression and low recruitment as a result of genetic bottlenecking. The Hillside population was too small and too isolated to survive without periodic translocations.

KEY WORDS *Arizona, Evolution, Inbreeding Depression, Isolation, Minimum Population Size, Pronghorn.*

INTRODUCTION

It is an accepted belief that small, isolated populations of <50 pronghorn disappear within a few years. Empirical evidence as to how and why this happens is lacking (O'Gara and Yoakum 2004), however reduced fitness due to inbreeding depression is a likely cause (Keller and Waller 2002). To gain insights into this phenomenon and document the effects of inbreeding depression, we monitored a remnant population of introduced pronghorn east of Hillside, AZ (Brown et al. 2015).

BACKGROUND

The Arizona Game and Fish Department (AGFD) translocated 105 pronghorn from Wyoming to vacant historic habitat east of Hillside on 6 February 1984 (51) and 8 February 1993 (54). Difficulties and/or inclement weather accompanied both releases, resulting in poor survival with many animals dispersing widely. To bolster the male population, the AGFD released an additional 5 bucks from Utah on 15 December 1998. The most pronghorn reported seen following translocations after 2000 was 12. On 6 May 2008, Wildlife Manager Matt Peirce observed several individuals thought to be the only survivors of the translocations.

Conventional wisdom states that small pronghorn populations of <50 animals are susceptible to extirpation due to inclement weather, habitat alteration, predation, and negative changes in gene frequency (Ockenfels 1994). Extirpation of populations of <50 desert bighorn sheep (*Ovis canadensis mexicana*) was also predicted by Berger (1990) – a situation refuted by Krausman et al. (1993, 1996). Miller (2014) calculated that a population of <50 pronghorn would face a 10% chance of extinction within 50 years even if the annual adult mortality rate of females was <15%. To test these minimum population hypotheses and the effects of inbreeding depression, we decided to monitor the Hillside pronghorn population for 11 years and document its demise or survival.

STUDY AREA

Pronghorn habitat east of Hillside is limited to about 78 km^2 of malapai mesas of volcanic origin ranging in elevation from 1,175 m to 1,370 m (Figure 1). Habitat quality values (as determined by Ockenfels et al. 1996) were described as 49.2 km^2 of low value, 5.2 km^2 of moderate, 15.0 km^2 of good, and 8.6 km^2 of excellent. The twice daily locations over a 2.5-month period showed the animals to frequent a 23 km^2 area, with an 8.6 km^2 pasture being favored on >90% of the successful visits.

The area is isolated from the closest pronghorn population 80 km to the north by rugged terrain, dense chapparal, or other unsuitable vegetation. Permanent water is lacking, and the pronghorn depend on water provided by 6-8 stock tanks and 3 solar powered wells located in 7 fenced pastures on 2 ranches.

The vegetation is almost entirely semi-desert grassland (Brown 1994) and leased for cattle grazing by the Arizona State Land Department. The primary grass cover is tobosa (*Hilaria mutica*) supplemented by such semi-desert grasses as side-oats grama (*Bouteloua curtipendula*), curly-mesquite grass (*H. berlangeri*), cottontop (*Digitaria arizonica*), and three-awns (*Aristida* spp.). The most prevalent pronghorn forage is the perennial buckwheat (*Eriogonum wrightii*), along with globe mallows (*Sphaeralcea* spp.), wolfberry (*Lycium pallida*), filaree (*Erodium circutarium*), and other annuals. Cacti are common and include the prickly-pears (*Opuntia chloroitica* and *O. phaeacantha*), followed in descending order by *Cylindropuntia acanthaocarpa*, *C. spinosior*, and *Coryphantha* spp. Leaf succulents other than *Yucca baccata* are unusual, and common grassland invaders include snakeweed (*Gutierrezia sarathroe*), burro-weed (*Isocoma tenuisecta*), catclaw (*Acacia greggi*), wait-a-minute (*Mimosa dysocarpa*), and the trees velvet mesquite (*Prosopis velutina*) and crucifixion-thorn (*Canotia holocantha*).

Figure 1. Five pronghorn in favored habitat near Hillside, AZ. Photo by Dawn Langston.

Ungulates include mule deer (*Odocoileus hemionus*) and javelina (*Dicotyles tajacu*), in addition to range cattle. Pronghorn predators encountered included golden eagles (*Aquila chrysaetos*), numerous coyotes (*Canis latrans*), and an occasional mountain lion (*Puma concolor*).

METHODS

Beginning in May 2008, accompanied by 1 to 4 volunteers, we attempted to locate pronghorn at least once each season and as opportunity permitted. Visits to the Hillside area were scheduled during the spring fawning season of April through June, the summer breeding season of July through September, the fall herding season of October through December and the winter months of January through March.

Surveys were conducted by visiting waters and other known use sites and searching for pronghorn with binoculars from 4-wheel drive vehicles and on foot. These searches were greatly facilitated from 21 November 2008 through 29 March 2010 when the AGFD net-gunned an adult buck and a doe and fitted them with "Five Spread Spectrum" GPS collars that transmitted locations twice a day at 1500 and 2300 hours. In addition to helping locate animals, these transmitters provided locations for 455 and 494 days, respectively, thus providing home range and frequent-use data (Figure 2).

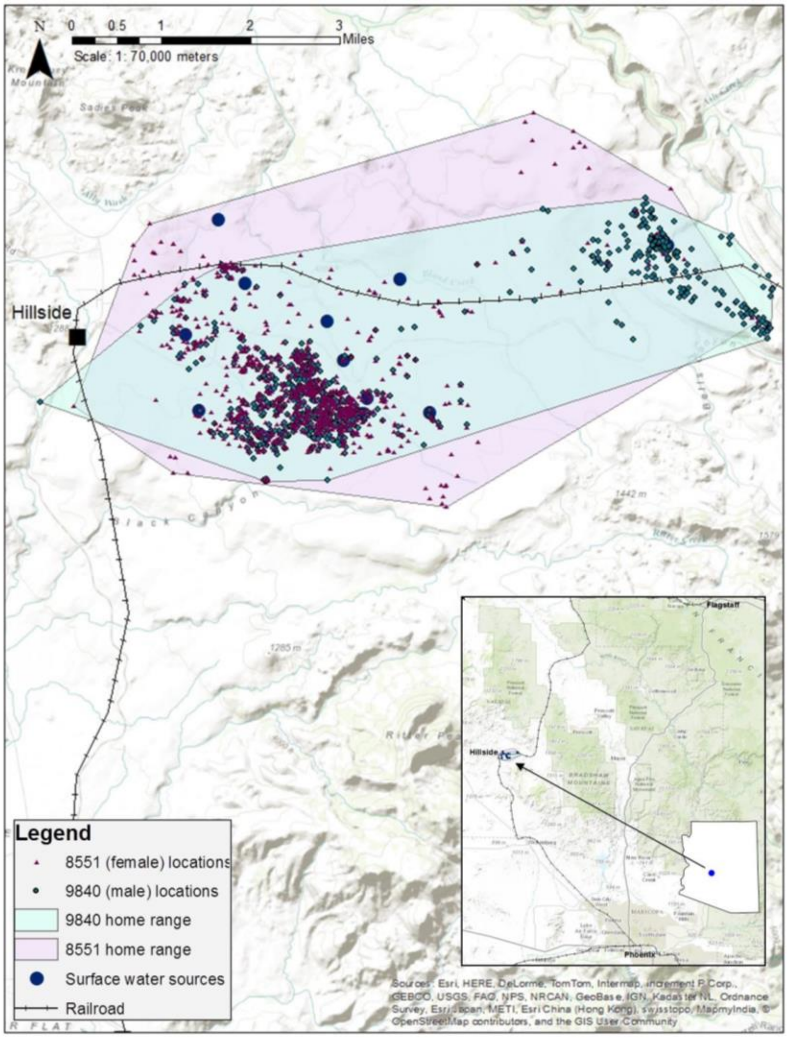


Figure 2. Radio transmitted locations and home ranges of collared male and female pronghorn.

Home ranges were calculated in ArcGIS 10.2.2 using the Minimum Boundary Geometry tool, convex hull. Nonetheless, locating animals after the collars dropped off and getting an accurate classification was sometimes difficult. The pronghorn were exceedingly wary and could rarely be approached within 400 m. Because pronghorn could not always be located from the ground, fixed-wing flights supplemented the ground observations, and motion sensitive cameras were set at 2 water sites to detect individual animals.

Observed animals were classified as adult bucks, adult does, yearling bucks, yearling does, unclassified, male fawns, and female fawns. Pregnant does were recorded when detected and the characteristics of individual animals noted. Although it is possible that some animals immigrated to or emigrated from the study area, only 1 buck from elsewhere was observed during the early years of the study.

Survey data were compared with the National Oceanographic and Atmospheric Administration's Region 3 PDSIs for the month of May. These generated values consider regional precipitation, evaporation, and other weather variables to measure the degree of drought. Minus values indicate drought conditions, with values greater than -4 indicating severe drought. May was chosen as the month to sample as it reflects spring conditions at the time of pronghorn natality in the Hillside area.

RESULTS

Some 107 searches were conducted during the 140-month period from May 2008 to December 2019, during which pronghorn were located on 72 (67%) occasions. The maximum number of animals observed during each May to April period from 2008-2009 to 2018-2019 is shown by age and sex in Table 1. Annual observations ranged from 5 to 9 animals in an area of about 57.5 km^2 with a mean adult buck:doe ratio of 1 male:2.1 females and a mean recruitment rate of 23.6 yearlings:100 does – ratios not atypical of an un-hunted pronghorn population in Arizona. We attributed the stability of the population to a low adult mortality rate and a higher survival of female than male fawns. No more than 2 yearlings were seen in any given year.

Table 1. Maximum numbers of pronghorn observed each year at Hillside, AZ, 2008-2019.

Year[1]	Adult males	Adult females	Male yearlings	Female yearlings	Male fawns	Female fawns	Total	May PDSI[2]	Animals recorded
2008-09	3	2	0	1	0	0	6	-1.6	
2009-10	2	3	0	1	1	0	7	-1.42	
2010-11	2	3	0	1	0	0	6	1.8	
2011-12	2	3	0	2	0	0	7	-1.52	
2012-13	2	3	0	1	0	1	7	-3.49	
2013-14	1	5	1	1	0	0	8	-3.15	Last pregnant female seen 3/13/2014
2014-15	2	4	0	1	1	1	9	-4.09	Last time 2 males seen 6/17/2014
2015-16	1	3	0	1	0	0	5	-1.1	Last fawn seen 11/10/2014
2016-17	1	4	0	0	0	0	5	-2.5	
2017-18	1	4	0	0	0	0	5	0.87	
2018-19	1	4	0	0	0	0	4	-5.07	Last male seen 7/7/2018; 4 does seen 12/15/2018

[1] Years are from May through April 30.
[2] Palmer Drought Severity Index.

Neither the collared male nor the collared female left the study area, and had home ranges of 40.9 km^2 and 57.5 km^2, respectively. A high percentage of locations appeared tied to water sources (Figure 2). We found the pronghorn most often in the 8.6 km^2 East Well pasture. This lightly grazed pasture was relatively open and supported a good buckwheat population. The pasture fences did not appear to restrict pronghorn movement.

Originally consisting of 3 bucks, 2 does, and 1 female yearling, the last pregnant doe was seen on 13 March 2014 and the last fawn was seen on 10 November 2014. Two adult bucks were observed on 17 June 2014, and no bucks after 7 July 2018. Four does were observed on 15 December 2018.

DISCUSSION

That a pronghorn population originally composed of 3 males and 3 females persisted for 11 years is remarkable and attributable to a low adult mortality and recruitment rate biased in favor of females. Although the lack of recruitment seen after 2014 may have resulted from environmental stress and coyote predation, the lack of pregnant females observed after 13 March 2014 suggests the loss of this population was more likely due to inbreeding depression and reduced pre-parturition fitness (Dunn et al. 2011). Male ungulates typically disperse greater distances than females and are usually the sex to pioneer isolated habitats, behavior that is essential to reduce the effects of inbreeding depression in isolated populations (Geist 1971). If so, the Hillside population was too small and too isolated to survive without periodic translocations or immigrations of males from neighboring populations.

SUMMARY

The population stabilized and grew from 6 in 2008 to 9 in 2014. After a PDSI of -4.09 in May 2014, and the subsequent loss of 4 animals, the population declined to 1 male and 4 females in 2017. The male disappeared by the summer of 2018, with only 4 females seen on a 15 December 2018 survey.

ACKNOWLEDGEMENTS

We are especially grateful to David Conrad (AGFD) for equipping the pronghorn with radio collars and to Curtis Herbert (AGFD) for monitoring these animals. Also assisting were Tyler Raspeller who mapped the fences and Steve Jones who identified the plants. Volunteers were essential to the study and included Randy Babb (AGFD, retired), John Carr (AGFD, retired), Richard Ockenfels (AGFD, deceased), Karen Hajeck, Dawn Langston, Melanie Tluczek, M. Robinson, Vicki Preston, Con Ingersoll, and John Stover. Terry and Shelly Blackmore provided access to their ranch through private property.

LITERATURE CITED

Berger, J. 1990. Persistence of different sized populations: an empirical assessment of rapid extinction in bighorn sheep. Conservation Biology 4:91-98.

Brown, D. E. 1994. Semidesert grassland, pp. 123-131 in Biotic communities: southwestern United States and northwestern Mexico. D. E. Brown, ed. University of Utah Press, Salt Lake City.

Brown, D. E., J. N. Carr, D. Conrad, C. Herbert, M. Peirce, M. D. Robinson, M. Tlluczek and P. M. Webb. 2015. Resilience of a small population of translocated pronghorn (*Antilocapra americana*), pp. 18-25 *in* Proceedings of the 26th Biennial Pronghorn Workshop, Texas Parks and Wildlife Department and Borderlands Research Institute, Alpine Texas.

Dunn, S. J., E. Clancy, L. P. Waits, and J. A. Byers. 2011. Inbreeding depression in pronghorn (Antilocapra americana) fawns. Molecular Ecology 20 (23): 4889-4898).

Geist, V. 1971. Mountain sheep: a study in behavior and evolution. University of Chicago Press, Chicago and London. 381p.

Keller, L. F., and D. M. Waller. 2002. Inbreeding effects in wild populations. Trends in Ecology and Evolution 17 (5): 230-241.

Krausman, P., R. Etchberger, and R. Lee. 1993. Mountain sheep persistence in Arizona. Conservation Biology 7:219.

Krausman, P., R. Etchberger, and R. Lee. 1996. Persistence of mountain sheep in Arizona. The Southwestern Naturalist 41:399-402.

Miller, P. S. 2014. Population viability analysis for the Sonoran pronghorn (*Antilocapra americana sonoriensis*) – Revised. U. S. Fish and Wildlife Service, Arizona Ecological Services Tucson, Arizona. 26p.

Ockenfels, R. A. 1994. Factors affecting adult pronghorn mortality rates in central Arizona. Arizona Game and Fish Department Wildlife Digest 16: 1-11.

Ockenfels, R. A., C. L. Ticer, A. Alexander and J. A. Wennerlund. 1996. A landscape-level pronghorn habitat evaluation model for Arizona. Arizona Game and Fish Department Technical Report, Phoenix, 19:1-50.

O'Gara, B. W., and J. D. Yoakum. 2004. Pronghorn: ecology and management. Wildlife Management Institute and University of Colorado Press, Boulder. 948p.

CASE STUDY: EVALUATING A LANDOWNER-CONTROLLED HARVEST STRATEGY OF PRONGHORN BUCKS IN THE NORTHERN TEXAS PANHANDLE

SHAWN S. GRAY, *Texas Parks and Wildlife Department, 109 South Cockrell, Alpine, TX, 432-837-0666, shawn.gray@tpwd.texas.gov*

CALVIN L. RICHARDSON, *Texas Parks and Wildlife Department, 109 South Cockrell, Alpine, TX, 432-837-2051, calvin.richardson@tpwd.texas.gov*

JAMES D. HOSKINS, *Texas Parks and Wildlife Department, P.O. Box 3651, Amarillo, TX, 79116, james.hoskins@tpwd.texas.gov*

JOHNATHAN C. MALONE, *Texas Parks and Wildlife Department, P.O. Box 659, Canyon, TX, 79015, chadd.malone@tpwd.texas.gov*

ABSTRACT Texas Parks and Wildlife Department (TPWD) initiated an experimental buck-only landowner-controlled harvest strategy during the 2013 hunting season in 3 herd units in the northern Texas Panhandle to decrease the administrative burden of issuing pronghorn permits on TPWD staff, and to provide more hunting opportunity and flexibility to hunters and landowners. This new harvest concept relied on landowners to control the harvest of buck pronghorn on their properties as an alternative to TPWD setting quotas through survey-based permit issuance. During the 2017 hunting season 3 more herd units were added to increase the contiguous size of the experimental areas. The resulting experimental sites consisted of 3 herd units located near Dalhart, TX in the northwest Panhandle and 3 herd units near Pampa, TX in the northeast Panhandle. Hunters in the experimental units were required to take their harvested buck to a mandatory check station within 24 hours of harvest. All bucks brought to the check stations were aged using the cementum annuli technique, and basic horn measurements were collected. Annual pre-season fixed-wing surveys were also conducted within the experimental areas. During most years of the experiment, harvest intensity exceeded TPWD's recommended harvest rate. Data suggest that the landowner-controlled harvest strategy did not have negative impacts to pronghorn population sustainability but resulted in a reduced buck age structure and proportion of males. Age structure of harvested bucks during the 2012 hunting season (1 year prior to the experiment) was 4.0 and 4.4 years of age in the Dalhart and Pampa areas, respectively. During the 8 hunting seasons of the experiment the average age of harvested bucks declined to 3.0 years for the Dalhart area and 3.7 years for the Pampa area. The cumulative effects of liberal harvest during the years of the experiment exhibited a more drastic impact by the final year (2020) with average ages of 2.2 in the Dalhart area and 2.7 in the Pampa area. Male sex ratios were also negatively impacted by the landowner-controlled harvest strategy. Prior to the experiment, does per buck ratios were 2.5 in the Dalhart area and 2.7 in the Pampa area. The average sex ratios during the experiment (2013–2020) became more skewed toward does at 2.9 and 4.1 does per buck in the Dalhart and Pampa areas, respectively. Similar to buck age structure, the sex ratios became even more skewed during the last 3 hunting seasons, averaging 3.3 in the Dalhart area and 4.3 in the Pampa area. In addition, hunter and landowner opinion surveys conducted in 2016 and 2020 indicated that support and satisfaction for the landowner-controlled harvest strategy

waned. Therefore, based upon biological data, opinion surveys, and public comments; the landowner-controlled harvest strategy was terminated indefinitely beginning with the 2021 hunting season.

INTRODUCTION

Over the past 10–15 years, pronghorn populations in the northern Texas Panhandle have increased in numbers and expanded in distribution. As a result, demand for pronghorn hunting permits, staff time spent on permit issuance, permit issuance complaints, and population survey intensity rose. To address these issues, TPWD conducted an experimental landowner-controlled season for buck pronghorn in 6 herd units in the northern Panhandle. TPWD staff reasoned because herds in the northern Panhandle were stable to increasing, this new system for buck harvest could work and would eliminate permit issuance conflicts, reduce staff time spent issuing permits, simplify regulations for hunters and landowners, and increase hunter opportunity.

Texas pronghorn populations are almost entirely found on private land; therefore, TPWD issues pronghorn hunting permits directly to landowners or their assigned agents. Issuance of hunting permits is based upon pronghorn population parameters within herd units and the acreage a particular landowner owns within a specific herd unit. For each herd unit, permit issuance rates range from 20–35% of the estimated buck population depending upon population estimates, average fawn production, permit demand and utilization (e.g., average permit utilization for 2021 in the Panhandle was 53%) as well as other factors. To facilitate annual permit issuance, Panhandle TPWD staff spend numerous hours conducting pronghorn surveys and issuing permits. However, a substantial amount of time is spent on other activities associated with permit issuance such as tracking acreage and ownership changes, as well as obtaining and recording changes to landowner/agent contact information. In fiscal year 2012, Panhandle TPWD staff spent 1,688 hours on pronghorn harvest recommendations with about 1,300 hours of that effort attributed to permit issuance. The remainder was spent on pronghorn surveys (~400 hours).

The goal of the experiment was to reduce the administrative workloads of issuing pronghorn permits on TPWD staff, simplify pronghorn hunting regulations, and increase hunting opportunity in areas with stable populations. TPWD considered the landowner-controlled harvest system for bucks would be a viable option for pronghorn management in the northern Panhandle if experimental data suggested minimal or no decline in pronghorn numbers, sex ratios, average buck age structure, and hunter success.

STUDY AREA

TPWD applied the experimental season for buck pronghorn in 3 herd units in the northern Panhandle starting in 2013, and to help mitigate confounding effects of immigration/emigration between herd units expanded the experiment into 3 more adjacent herd units in 2017 (Figure 1). From 2017–2020, 3 herd units were near Dalhart, TX and 3 were near Pampa, TX. Pronghorn densities were highest in the Dalhart area compared to the Pampa area, while sex ratios and fawn crops were similar for both areas prior to initiating the experiment in 2013 (Table 1).

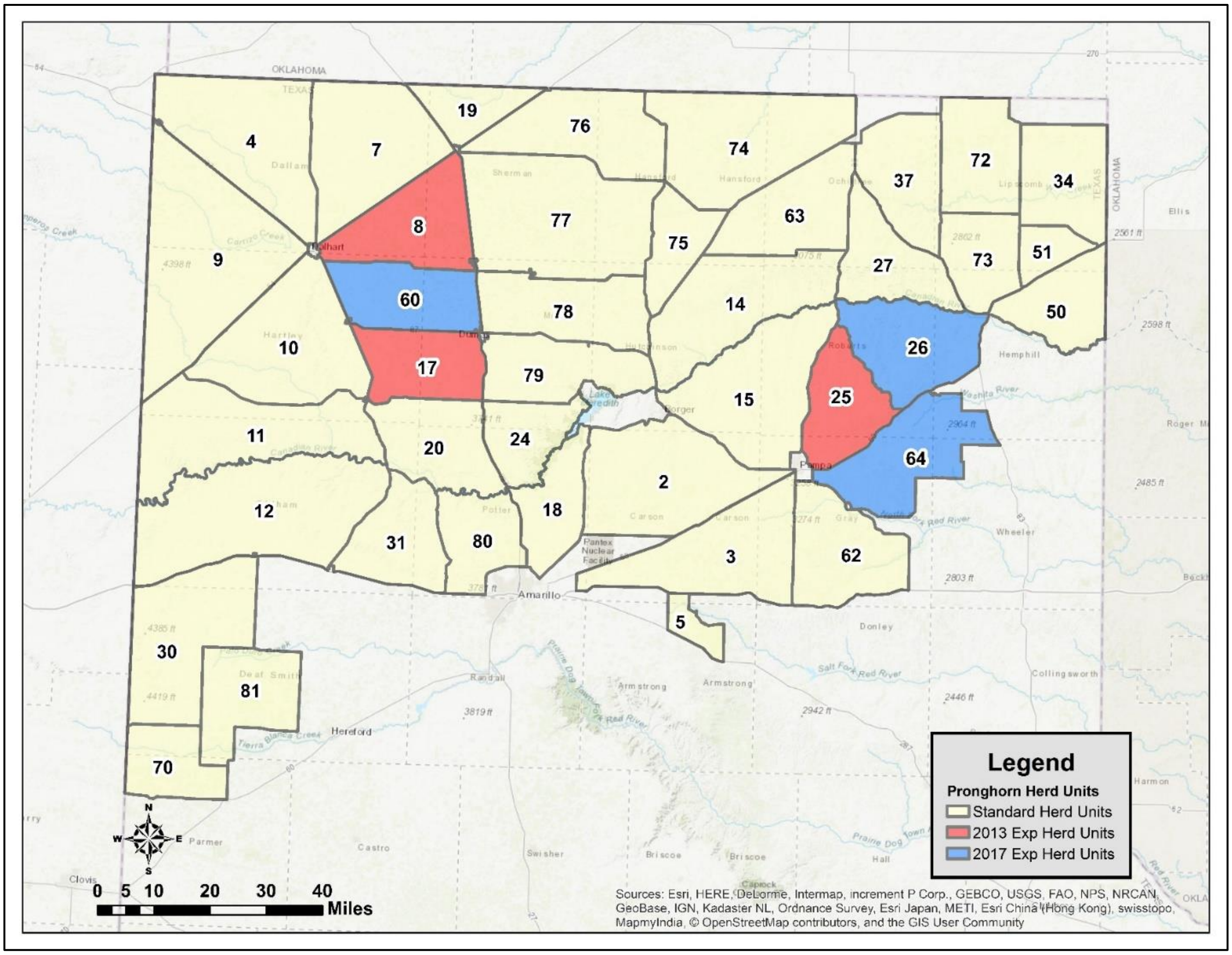


Figure 1. Northern Panhandle pronghorn herd units. Experimental buck-only season applied in herd units colored red (initiated in 2013) and blue (added into the experiment in 2017).

Table 1. Pronghorn population metrics collected by summer fixed-wing surveys from each experimental area prior to starting the experimental season in 2013.

Area	Population	Does:Buck	Fawns:Doe
Dalhart	851	2.5	0.39
Pampa	416	2.0	0.27

The Dalhart herd units were in the High Plains ecoregion (Gould et al. 1960) and consisted of a patchwork of rangeland and farmland, which totaled 563,132 acres. The High Plains rangeland is characterized by large expanses of mixed and shortgrass prairies and playas. Land cover composition of the High Plains is 43% agriculture, 42% prairie, and 10% brushland (Elliot et al. 2014), and agricultural composition is increasing by an average of 6,178 acres/year (USDA 2019).

In contrast, the Pampa herd units comprised 609,510 acres of mostly rangeland with some farmland and the units were in the Rolling Plains ecoregion (Gould et al. 1960). The Rolling Plains consist of shortgrass and tallgrass prairies divided by steep river breaks. Land cover composition of the Rolling Plains is 27% agriculture, 48% prairie, and 11% brushland (Elliot et al. 2014). Agricultural composition of the Pampa site has remained relatively constant during the past 20 years (USDA 2019).

METHODS

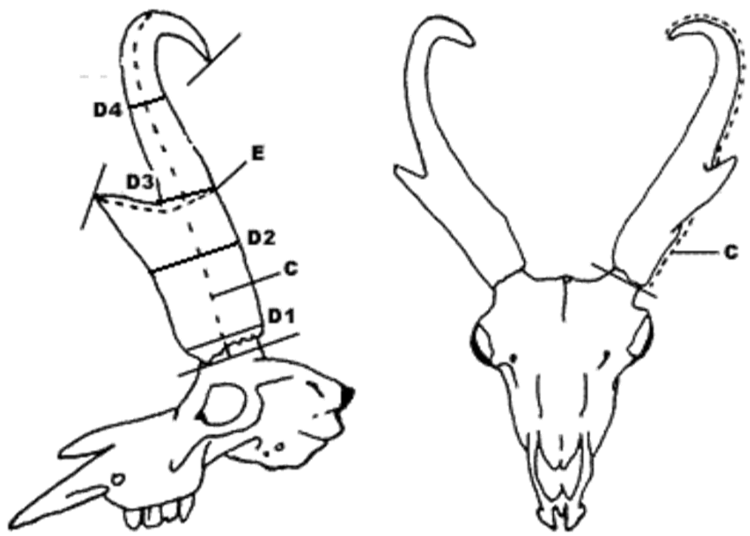
The experimental season allowed landowners to control the number of buck pronghorn harvested on their properties. Herd units included in the experiment were selected based upon pronghorn densities, representative habitat, land use practices, and permit utilization in the northern Panhandle. The experimental season was tested for 8 hunting seasons (2013–2020). The duration of the hunting season during the experiment was 9 consecutive days starting the Saturday closest to October 1. During the experiment, any person with a valid hunting license could obtain an experimental season buck permit at select retail stores or TPWD offices. Hunters needed landowner permission to hunt on any private land even with an experimental season buck permit. In addition, the bag limit of 1 pronghorn still applied in the experimental areas, and hunters were required to present the intact, unfrozen head of a harvested pronghorn at a mandatory check station within 24 hours of harvest. Mandatory check stations were located in Dalhart and Pampa, TX and operated by TPWD staff during the experimental season.

TPWD biologists collected harvest data (location of harvest and horn measurements), hunter information, and one or both central incisors for cementum annuli aging by Matson's Laboratory in Manhattan, Montana. Ages estimated by cementum annuli were classified as 0.3, 1.3, 2.3, 3.3, etc. Hunters were also encouraged to bring animals that were harvested outside of the experimental areas to the check stations for comparative analysis.

Annual fixed-wing surveys were conducted during June–July using protocol established by TPWD (Gray 2021) in each herd unit with the experimental season and in other herd units throughout the northern Panhandle. Surveys were conducted within each experimental herd unit from 2013–2020 (7 of the 8 hunting seasons). During surveys, pronghorn were counted and classified into buck, doe, fawn, and unidentified categories. Population and herd composition (sex ratios and fawn crops) estimates were derived from those data collected during aerial surveys.

Mandatory check stations were used to collect horn measurements on all bucks checked during 2013–2020 to document horn development in each age class. Measurements were taken from the right horn and rounded to the nearest 1/8 inch; however, if something was unusually abnormal with the right horn, then the left horn was measured (Figure 2).

To evaluate opinions about the experimental season, TPWD sent out questionnaires to hunters who participated in the experimental season and landowners in northern Panhandle in 2016 and 2020. Hunters selected for the survey were those who obtained experimental permits during the 2015 and 2019 hunting seasons. Landowners selected for the survey were those who had received pronghorn permits from TPWD in the past and had property in the experimental areas.



D1 Circumference	Measured around base of horn at a right angle to long axis. Tape was in contact with the lowest circumference of the horn in which there were no serrations.
D2 Circumference	Measured immediately below the prong.
D3 Circumference	Measured immediately above the prong.
D4 Circumference	Measured at the mid-point distance from the top of prong and horn tip.
Prong Length (E in illustration)	Measured from the tip of the prong along the upper edge of the outer curve to the horn; then continued around the horn to a point at the rear of the horn.
Horn Length (C in illustration)	Measured along the center of the outer curve from tip of horn to a point in line with the lowest edge of base.

Figure 2. Measurements taken at each horn location to the nearest 1/8" and description of each measurement location.

In 2016, all survey recipients were sent a questionnaire by mail. One month later, non-respondents were sent a second survey form. In 2020, all persons who provided an email address were sent an email containing a link to an online survey. After two weeks, non-respondents were sent an email reminder. Two weeks after the reminder, a questionnaire was mailed to all non-respondents, as well as to all that had not provided an email address. Non-respondents were to be sent a second survey form after one month; due to COVID-19, it was delayed to six weeks. Non-respondents were not contacted by any other means.

RESULTS

In most years, buck harvest was higher than what TPWD would have recommended within both experimental areas. Higher harvest rates occurred in the Dalhart area compared to the Pampa area (Figures 3 and 4).

Buck age structure in both experimental areas became younger and was more pronounced in Dalhart than Pampa. The average age of harvested bucks during the 2012 hunting season (1 year prior to the experiment) was 4.0 and 4.4 years of age in the Dalhart (*n* = 7) and Pampa (*n* = 8) areas, respectively. During the 8 hunting seasons of the experiment, the average age of harvested bucks declined to 3.0 years for the Dalhart area (*n* = 561) and 3.7 years for the Pampa area (*n* = 182). The last hunting season (2020) had a more drastic impact with average ages of 2.2 years in the Dalhart area (*n* = 54) and 2.7 years in the Pampa area (*n* = 25). In addition, within the same timeframe the average age of harvested bucks in both experimental areas was younger than in other northern Panhandle herd units. The average age within other northern Panhandle herd units was 4.7 years in 2012 (*n* = 28), 4.2 years from 2013–2020 (*n* = 303), and 3.7 years in 2020 (*n* = 29) (Figure 5).

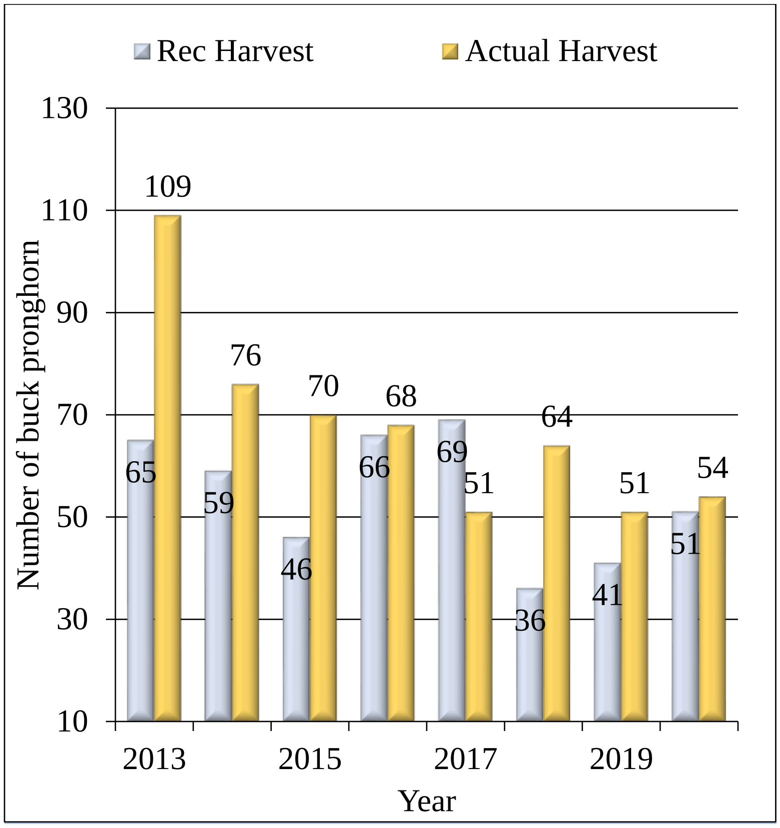


Figure 3. Number of buck pronghorn recommended to be harvested by TPWD compared to actual harvest in the Dalhart experimental area by year.

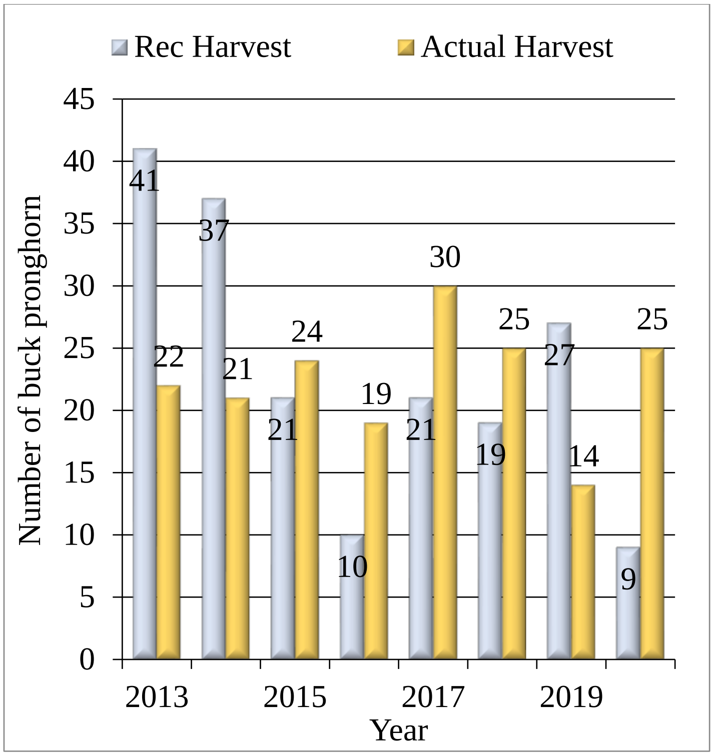


Figure 4. Number of buck pronghorn recommended to be harvested by TPWD compared to actual harvest in the Pampa experimental area by year.

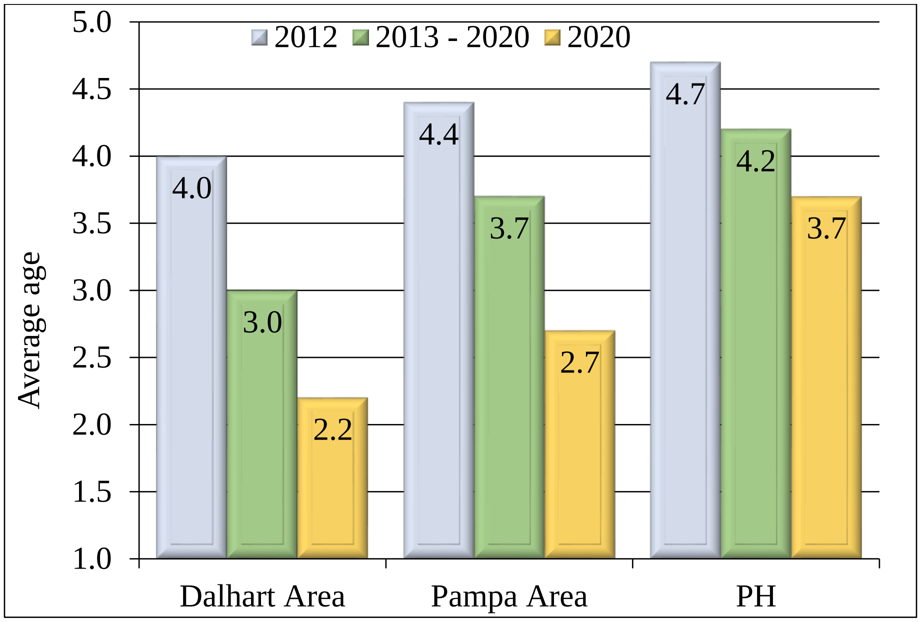


Figure 5. Average age of hunter-harvested pronghorn bucks estimated by cementum annuli during 2012 (prior to experiment), 2013–2020 (8 seasons of the experiment), and 2020 (last season of the experiment). Northern Panhandle herd units not included in the experiment are represented by the PH category.

The 2011 and 2013 average sex ratios were 2.5, 2.7, and 2.2 does per buck for the Dalhart area, Pampa area, and other herd units in the northern Panhandle, respectively. These data were collected as baseline information prior to initiating the experiment in the fall of 2013. The average does per buck from 2014–2020 (7 years of the experiment) in both experimental areas increased with a more severe rise in the Pampa area. In herd units not included in the experiment, sex ratios were more stable compared to the Dalhart and Pampa areas (Figure 6).

The population trends for the Dalhart experimental area and the surrounding herd units in the northwest Panhandle were similar during 2014–2020. However, in the Dalhart experimental area, the population declined by 45% from 2019 to 2020, while the surrounding herd units declined by only 3%. The Pampa experimental area and surrounding herd units in the northeast Panhandle had a slightly different population trend, but both trend lines indicated declining populations. Similar to the Dalhart experimental, the population in the Pampa experimental area exhibited a more pronounced decline from 2019 to 2020 compared to the surrounding herd units (35% decrease in the Pampa experimental area; 5% decrease in the surrounding herd units) (Figures 7 and 8).

Horn measurements were averaged for hunter-harvested bucks brought to the check stations during 2013–2020 and compared by age class. The averages of all horn measurements were greatest within the 5.3-year-old age class. On average, data suggested bucks reached almost 95% of their maximum horn development by 3 years of age. Therefore, bucks ≥ 3.3 years old have the greatest potential for producing trophy quality horns (Figure 9).

Questionnaires were sent to 267 hunters in 2016 and 229 hunters in 2020. In 2016, 672 landowners received the questionnaire with 698 landowners receiving a questionnaire in 2020. Response rates ranged from 42–48% for hunters and 64–66% for landowners.

Hunter success decreased from 53% in 2016 to 37% in 2020. Hunter satisfaction in the experimental areas was high when comparing hunter opinions for both years; however, hunters who were “very satisfied” or “satisfied” decreased from 77% in 2016 to 68% in 2020. Over 80% of hunters responded in both years in support of continuing the experimental season concept in the current areas (Figures 10–12). In contrast to hunters, landowner satisfaction within the experimental areas decreased from 47% in 2016 to 37% in 2020. In addition, more landowners were neutral in 2020 compared to 2016. Landowner support for continuing the experiment within the current areas decreased from 65% in 2016 to 57% in 2020. In 2016, most landowners within the experimental areas believed that they should set harvest quotas, but that number decreased by almost 10 percentage points in the 2020 opinion survey. Only 26% of landowners in the experimental area during the 2016 survey thought pronghorn were an asset. Interestingly, 38% of landowners in the 2020 survey believed pronghorn were an asset (Figures 13–16).

In the 2020 opinion survey, hunters and landowners were asked “if given a choice, would they rather hunt for 9 days under the experimental season concept or go back to TPWD issuing permits to landowners with a 16-day season”, which would extend the current season by one week. Not a majority, but 48% of hunters liked continuing the current 9-day season with the experimental concept; however, 54% of landowners wanted TPWD to issue permits and extend the season to 16 days (Figure 17).

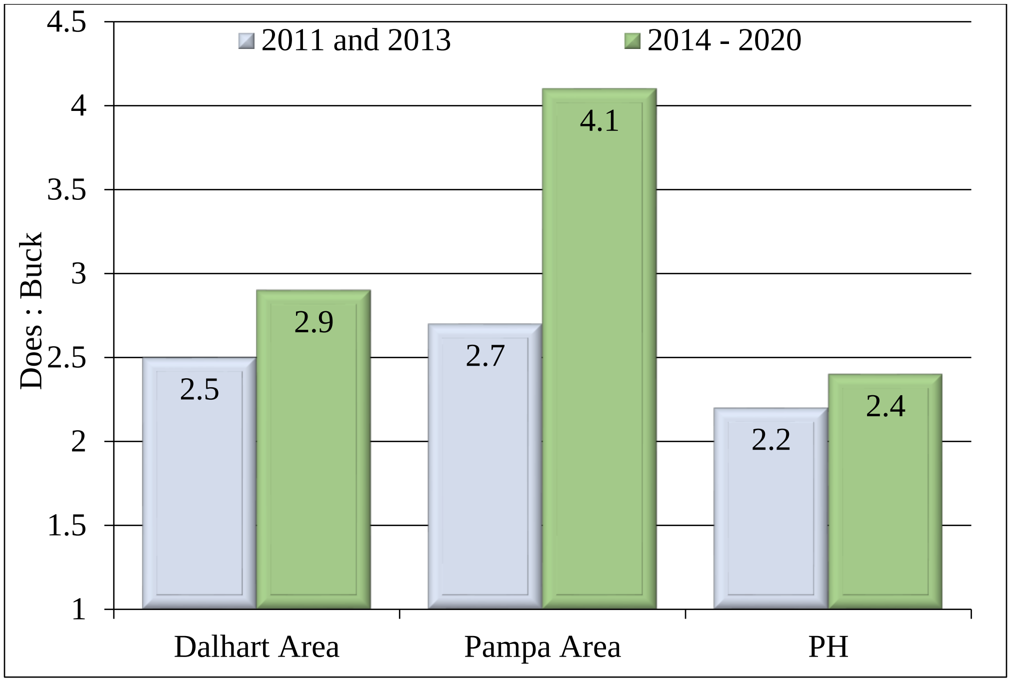


Figure 6. Average sex ratios estimated by June/July fixed-wing surveys during 2011 and 2013 (prior to experiment) and 2014–2020 (7 seasons of the experiment). Northern Panhandle herd units not included in the experiment are represented by the PH category.

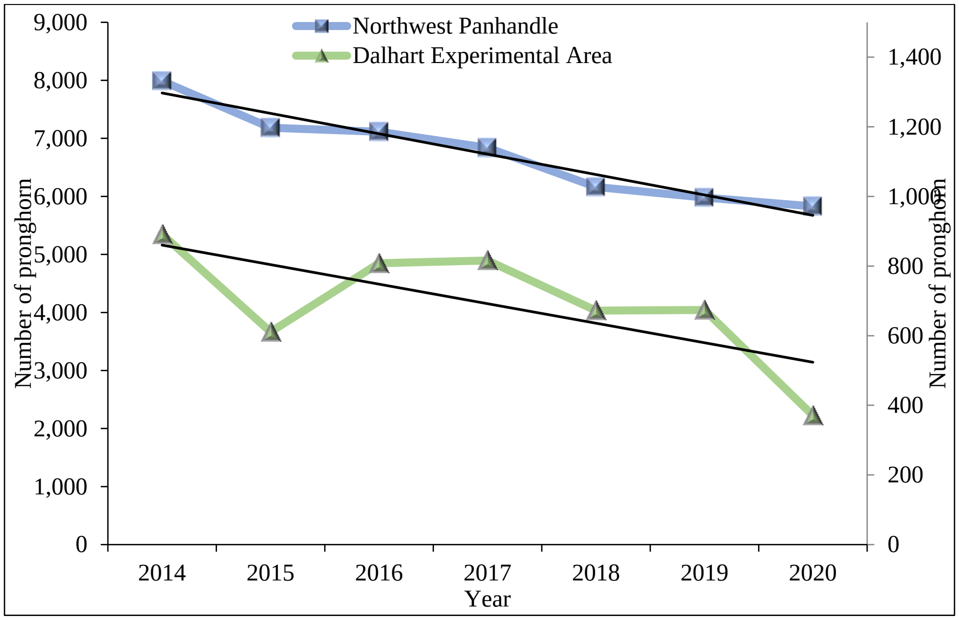


Figure 7. Pronghorn population estimates and trend lines for the Dalhart experimental area and surrounding herd units in the northwest Panhandle from 2014–2020. Left y-axis is for the surrounding herd units in the northwest Panhandle and the right y-axis is for the Dalhart experimental area.

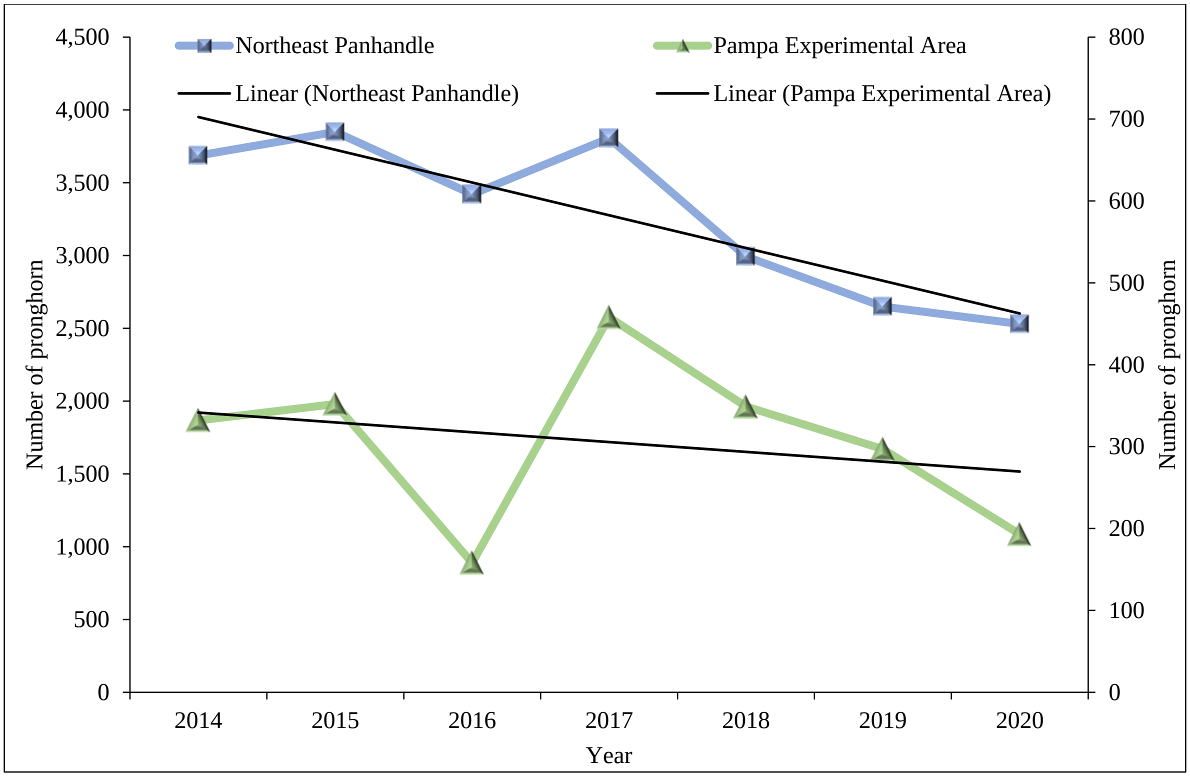


Figure 8. Pronghorn population estimates and trend lines for the Pampa experimental area and surrounding herd units in the northeast Panhandle from 2014–2020. Left y-axis is for the surrounding herd units in the northeast Panhandle and the right y-axis is for the Pampa experimental area.

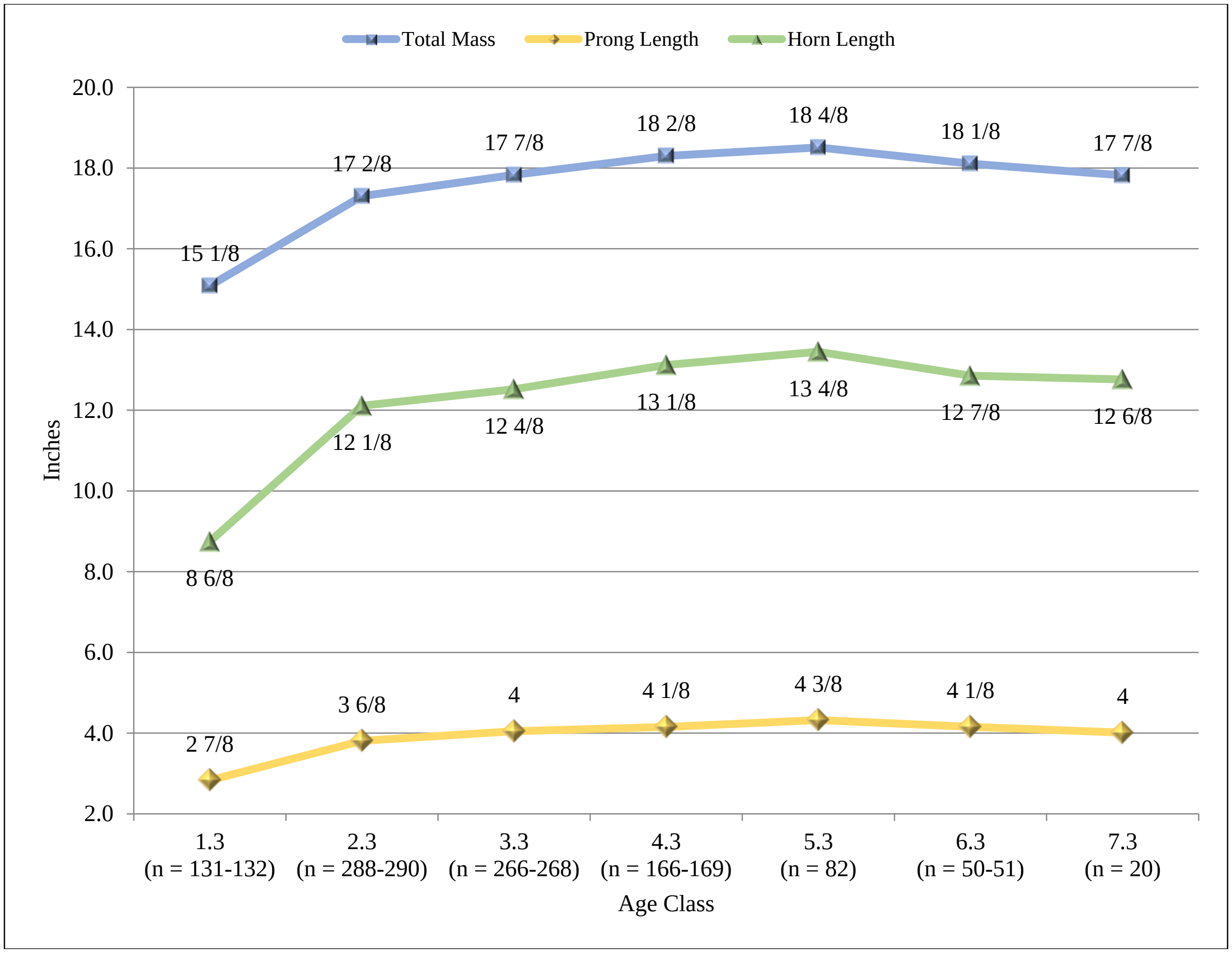


Figure 9. Average horn measurements in inches by age class from bucks checked during the experimental season mandatory check stations, 2013–2020. Total mass was the sum of all 4 circumferences. Sample size within each age class indicated in parenthesis on the x-axis (some measurements not taken for all bucks).

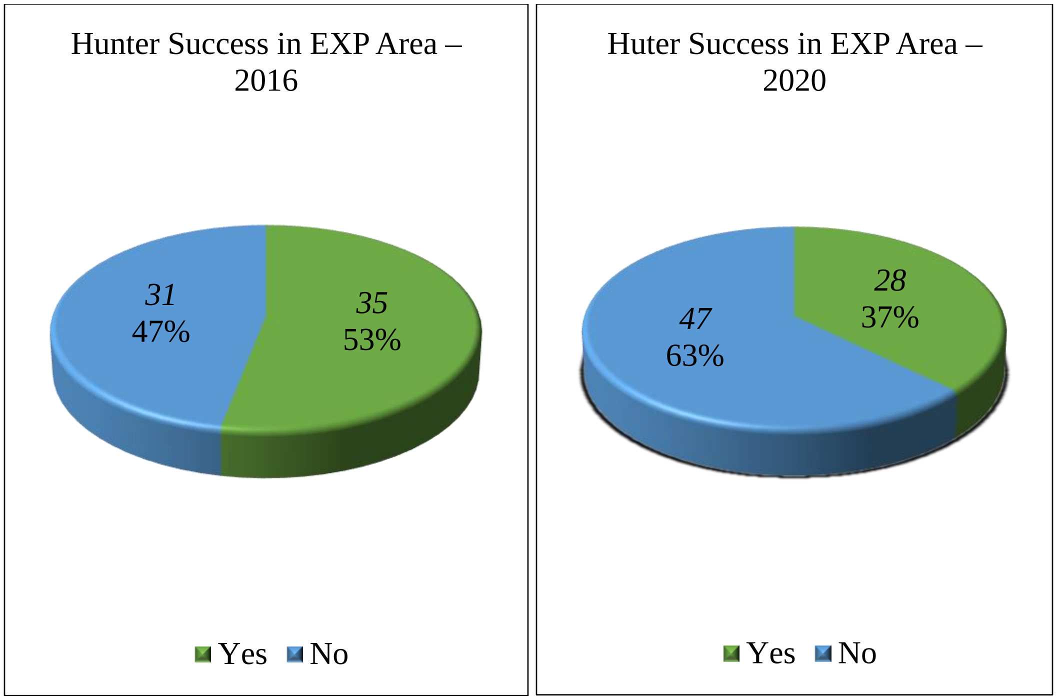


Figure 10. Hunter responses to questionnaires sent in 2016 and 2020 to estimate hunter success within the experimental areas. Sample size above percentage.

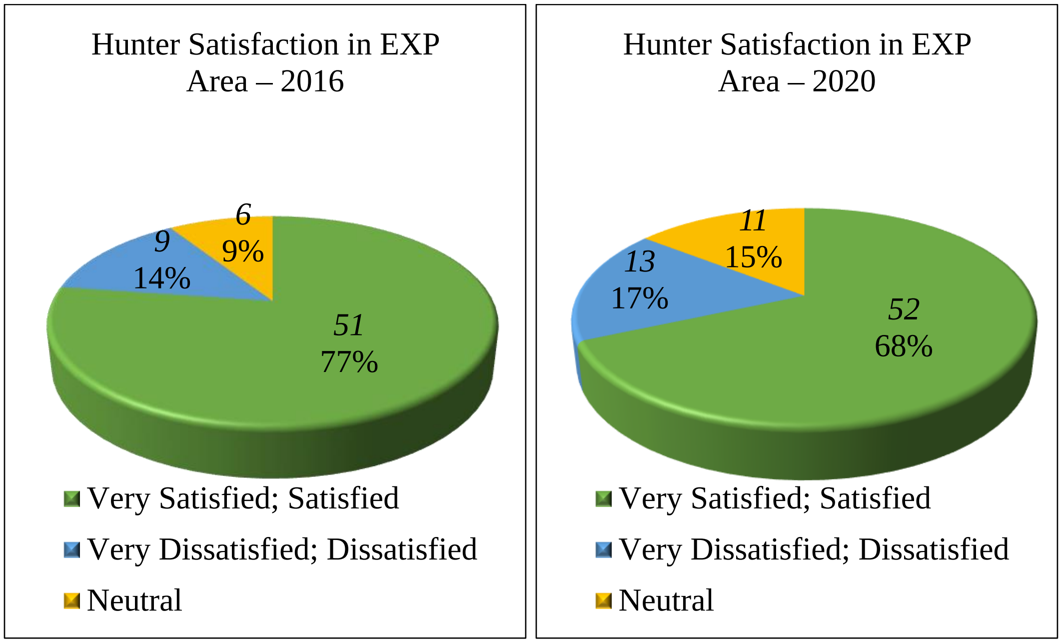


Figure 11. Hunter responses to questionnaires sent in 2016 and 2020 to estimate hunter satisfaction within the experimental areas. Sample size above percentage.

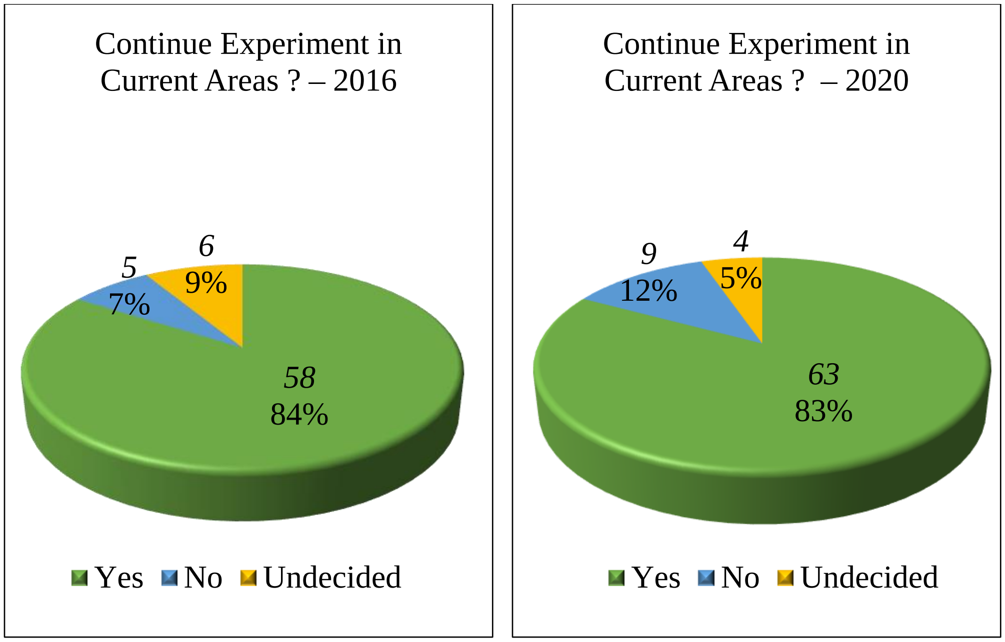


Figure 12. Hunter responses to questionnaires sent in 2016 and 2020. Hunters were asked if they supported continuing the experiment within the current areas. Sample size above percentage.

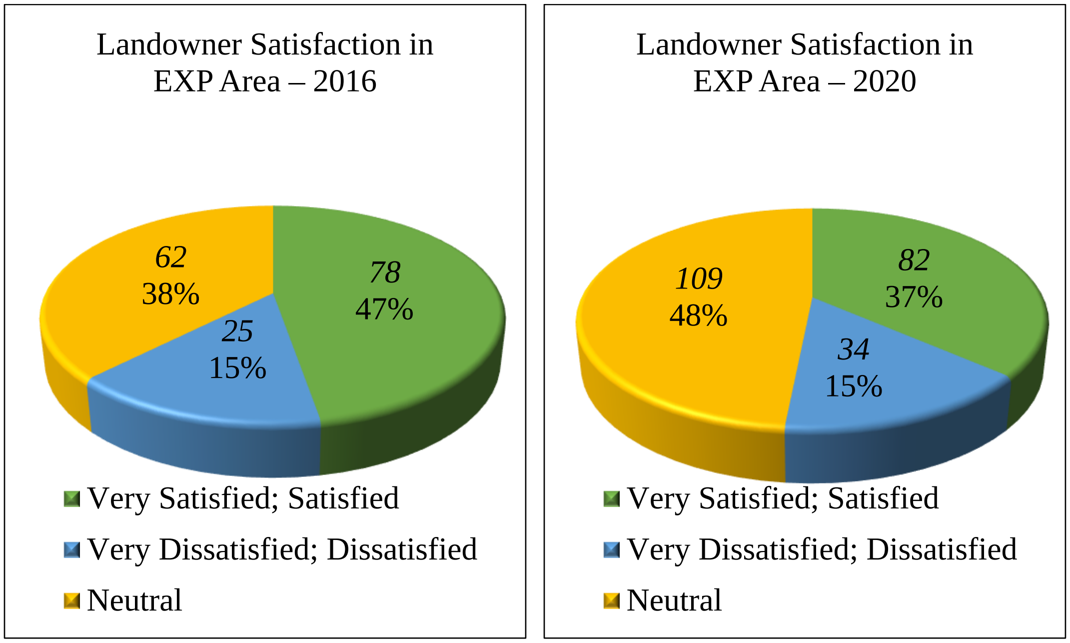


Figure 13. Landowners who responded to questionnaires sent in 2016 and 2020 to estimate landowner satisfaction. Sample size above percentage.

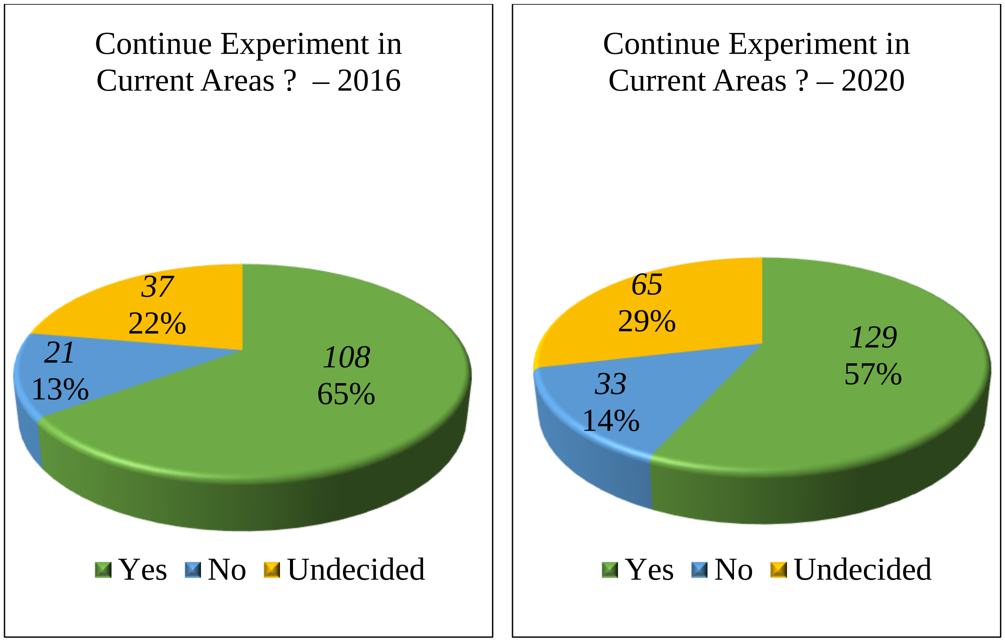


Figure 14. Landowners who responded to questionnaires sent in 2016 and 2020. Landowners were asked if they supported the continuation of the experiment within the current areas. Sample size above percentage.

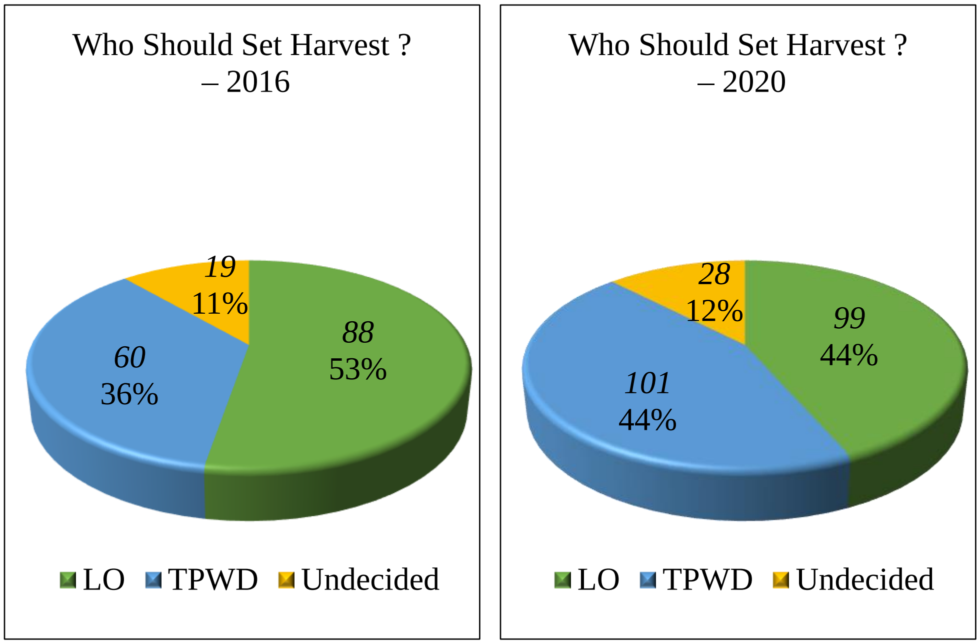


Figure 15. Landowners who responded to questionnaires sent in 2016 and 2020. Landowners were asked who should set pronghorn harvest rates. Sample size above percentage.

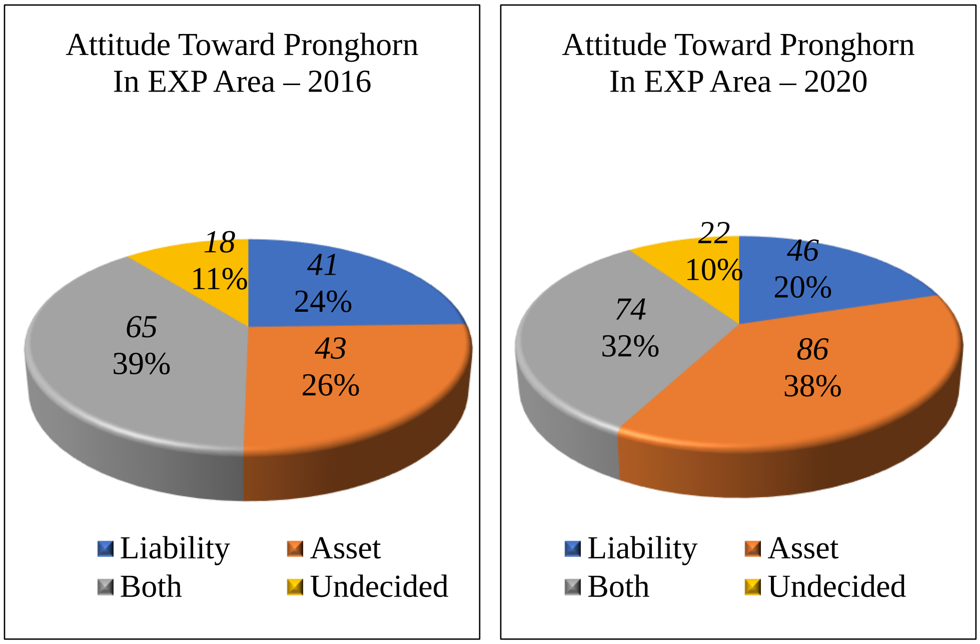


Figure 16. Landowners who responded to questionnaires sent in 2016 and 2020. Landowners were asked about their attitude toward pronghorn. Sample size above percentage.

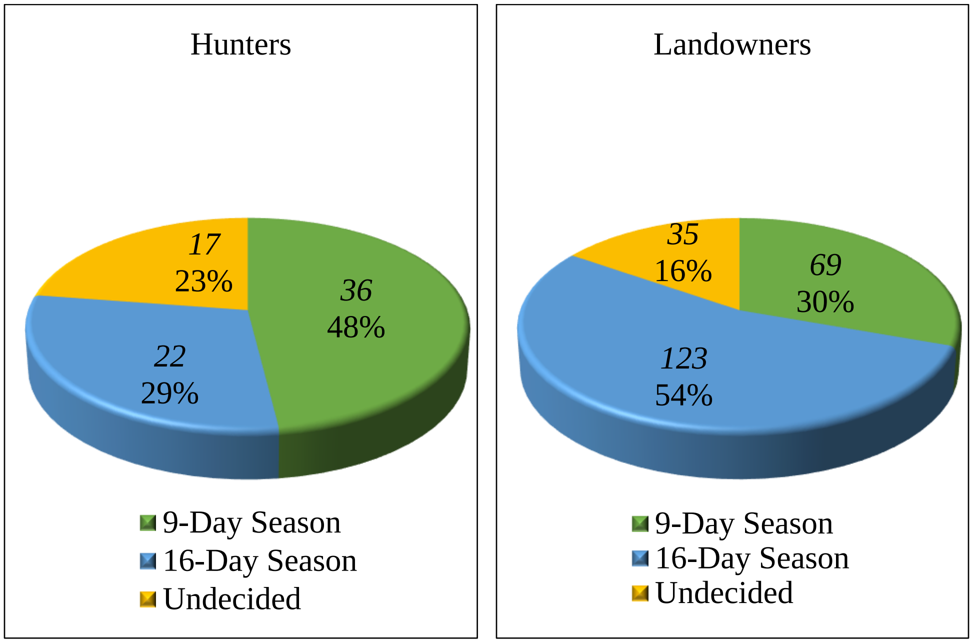


Figure 17. Hunter and landowner responses to the 2020 questionnaire. Both groups were asked if they would rather continue with the experimental concept with the current 9-day season or have TPWD set harvest quotas by issuing permits and extend the current 9-day season to 16 days.

DISCUSSION

Higher harvest rates occurred in the Dalhart experimental area because of more land fragmentation from farming and smaller properties than in the Pampa experimental area. Smaller properties equate to more landowners, thus more opportunities to have more hunters on the landscape. In general, landowners who own farmland have a less favorable opinion of pronghorn because of real or perceived crop damage. The Pampa experimental area, in contrast, consisted of larger properties with fewer landowners and more contiguous rangeland acreage.

The metric that was significantly influenced by the experimental harvest strategy was buck age structure. Harvest data indicated that both experimental areas had fewer mature bucks after several years of the experiment. The Dalhart experimental area had a sharper decline in the average age of harvested bucks than the Pampa experimental area. The other herd units of the northern Panhandle did have a decline in average age of harvested bucks, but it was not as marked as the experimental areas.

Sex ratios also appeared to be altered by the experiment. The Pampa experimental area produced a higher ratio of does per buck than the Dalhart area, which seemed somewhat counter-intuitive when paired with age data from harvested bucks. Several factors impact sex ratios and the number of does and bucks can fluctuate over time. Hunting pressure, fawn production, other sources of mortality, and dispersal all play a role into how many does and bucks are within herd units at a given time. Another factor influencing the ratio can be misclassifications or low detection probabilities from aerial survey observations.

Overall, population trends did not differ much over the course of the experiment. The experimental areas were surveyed every year, while the surrounding herd units were surveyed in a rotation with most being surveyed every other year. This could have mitigated population trend fluctuations for the non-experimental units, making the relative decline in numbers in 2020 within the experimental areas appear more significant than it might have been.

Other studies monitoring horn growth by age class (using cementum annuli) report similar horn growth progression such that maximum horn size occurs from 4–6 years of age with many representatives in younger age classes (2–3) being similar to the peak horn growth age classes (Brown et al 2002, Morton et al 2010, Zornes et al 2010). In fact, our data suggested bucks reached almost 95% of their maximum horn development by 3 years of age on average.

Comparing opinion surveys about the experiment conducted in 2016 and 2020, hunter satisfaction decreased, probably because of impacts to buck age structure and fewer bucks available to harvest. However, hunters still liked the concept of the landowner-controlled harvest system. This was contrasted to landowners whose satisfaction and support for the experimental concept declined from 2016 to 2020. When comparing both opinion surveys, landowner support increased for the management strategy where TPWD sets harvest quotas. Additionally, by 2020 more landowners viewed pronghorn as an asset on their property. Not only did our data demonstrate the negative impacts of the experimental harvest strategy, but landowners also seemed to notice the effects. If given the option, the majority of responding landowners preferred a 16-day season with TPWD setting quotas (through permit issuance) over a 9-day season using the experimental harvest concept.

In 2020, the administrative burden of pronghorn permits on TPWD staff, as well as landowners, was significantly reduced by the development and implementation of an online application that improved the efficiency of permit application, permit issuance, and harvest reporting. TPWD staff now spend substantially less time on the administration of pronghorn permit issuance, and landowners can apply, receive permits, and report harvest with greater ease because of the online system.

This experiment was not intended to meet the scientific rigor of a well-designed research project, but to effectively monitor a management action on Texas' pronghorn resource. In fact, 3 more herd units were added to the experiment after 4 years because data at that point seemed inconclusive. A thorough research project may have provided more definitive proof of the experimental harvest strategy on pronghorn populations; however, using traditional methods of pronghorn population monitoring indicated unfavorable effects on pronghorn buck age structure and sex ratios. Although, the pronghorn population probably could sustain this level of landowner-controlled harvest, effects on long-term hunter opportunity and hunter satisfaction were less tolerable.

MANAGEMENT IMPLICATIONS

Conducting this experiment has provided TPWD with tremendous datasets of new information regarding the upward limits of pronghorn buck harvest. We would have never known these bounds without the experiment. Data suggested pronghorn buck age structure and sex ratios would be adversely impacted by landowner-controlled harvest under current patterns of land use, landowner attitudes toward pronghorn, and landowner knowledge of effects of pronghorn buck harvest. Furthermore, our data indicated annual surveys to establish pronghorn harvest recommendations for permit issuance was a necessary pronghorn management strategy in the Texas Panhandle to meet landowner and hunter expectations (buck age structure and buck availability).

Based upon data from the experiment, opinion surveys, TPWD staff recommendations, and public comments; the Texas Parks and Wildlife Commission adopted pronghorn hunting regulation changes in March 2021 that took effect for the 2021 hunting season. The changes adopted were the elimination of the pronghorn experimental season and extension of the 9-day season to 16 days by closing the season 7 days later statewide.

LITERATURE CITED

Brown, D. E., W. F. Fagan, and R. E. Turner. 2002. Pronghorn horn sheath growth, age, and precipitation on a ranch in southern New Mexico. Proceedings of the Biennial Pronghorn Workshop 20:17–23, Kearney, NE.

Elliott, L. F., A. Treuer-Kuehn, C. F. Blodgett, C. D. True, D. German, and D. D. Diamond.2009-2014. Ecological Systems of Texas: 391 Mapped Types. Phase 1–6, 10 meter resolution Geodatabase, Interpretive Guides, and Technical Type Descriptions. TexasParks & Wildlife Department and Texas Water Development Board, Austin, Texas.Documents and Data Available at: http://www.tpwd.state.tx.us/gis/data/downloads#EMST

Gould, F. W., G. O. Hoffman, and C. A. Rechenthin. 1960. Vegetational areas of Texas. Mapcompiled by the Texas Parks & Wildlife Department, Texas A & M University. TexasAgricultural Experiment Station, Leaflet No. 492.

Gray, S. S. 2021. Pronghorn harvest recommendations performance report. Federal Aid Project No. W-127-R Segment 23. Texas Parks and Wildlife Department, Austin TX, USA.

Morton, K. A., P. F. Jones, and M. G. Grue. 2010. Pronghorn age and horn size in southern Alberta. Proceedings of the Biennial Pronghorn Workshop 24:146, Laramie, WY.

U.S. Department of Agriculture (USDA). 2019. Summary Report: 2017 Census of Agriculture,National Agricultural Statistics Service, Washington D.C.https://www.nass.usda.gov/Publications/AgCensus/2017/Full_Report/Volume_1,_Chapter_1_US/usv1

Zornes, M., P. Burke, B. R. Kroger, T. J., Ryder, and W. J. Rudd. 2010. Horn growth and age in harvested Wyoming pronghorn. Proceedings of the Biennial Pronghorn Workshop 24:144–145, Laramie, WY.

WESTERN STATES AND PROVINCES PRONGHORN STATUS REPORT, 2022

ANDREW NORTON, *South Dakota Game, Fish and Parks, 4130 Adventure Trail, Rapid City, SD 57702, USA, (605) 394-1752, Andrew.Norton@state.sd.us*

ANDY LINDBLOOM, *South Dakota Game, Fish and Parks, 4130 Adventure Trail, Rapid City, SD 57702, USA, (605) 394-1751, Andy.Lindbloom@state.sd.us*

ABSTRACT A range wide pronghorn summary is provided during each biennial western state and province pronghorn workshop. Because of the coronavirus pandemic, the 29th workshop was delayed 2 years. For the 2022 pronghorn workshop, hosted by the South Dakota Game, Fish and Parks, we administered a questionnaire survey to 23 states and provinces spanning pronghorn range from Canada, Mexico, and the United States. The 6-page questionnaire included 91 questions and was designed to standardize information among jurisdictions. We received responses from all 23 jurisdictions providing comprehensive coverage of all pronghorn subspecies from Canada to Mexico. The total 2021 pre-hunting season population estimate was 930,873 across 801,007 square miles of pronghorn range. Of the 8 states or provinces that reported numerical population goals, 5 were below the population objective. Pronghorn population density in Wyoming was nearly 3 times the next highest density reported in Colorado. All pronghorn in Mexico continue to be under objective despite no hunting seasons. Pronghorn densities in Mexico were about 1/6th of the average pronghorn density across the entire range. Adult buck to adult doe ratios averaged 41 bucks to 100 does in 2021, comparable to long-term averages. Except for Arizona Sonoran pronghorn, buck to doe ratios were highest in the northcentral part of the range in Montana and Saskatchewan. Concerningly, fawn to adult doe ratios that averaged 37 fawns per 100 does in 2021 were >5% below long-term averages in 86% of states and provinces. The southwestern region of pronghorn range reported the lowest fawn to doe ratios. Total pronghorn harvest in 2021, excluding Saskatchewan, was 75,400 (11.3 pronghorn harvested per 100 square miles of identified pronghorn range) and accounted for 8% of the range wide estimated population. In addition to the highest population, pronghorn harvest was highest in Wyoming. Across the majority of pronghorn range, below objective populations and/or below average recruitment rates may be cause for concern if the pattern persists.

KEY WORDS *pronghorn, Antilocapra americana, status report, WAFWA.*

INTRODUCTION

Recurrent range wide pronghorn (*Antilocapra americana*) surveys can provide important information to monitor and document demographics, harvest and management strategies, disease, and research for this valuable and unique North American wildlife species. The biennial western state and province pronghorn workshop provides an ideal opportunity to collect comprehensive information about pronghorn. Our objectives were to summarize: (1) demographic information; (2) harvest and harvest management strategies; (3) habitat and predator management and disease information.

We administered a 6-page questionnaire, with 91 questions, to states and provinces from Canada, Mexico, and the United States spanning pronghorn range. All (N = 23) jurisdictions for each subspecies provided responses including: Alberta (CAN), Arizona, Arizona (Sonoran), Baja California (Peninsular; MEX), California, Chihuahua (Mexican; MEX), Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, Saskatchewan (CAN), Sonora (Sonoran; MEX), South Dakota, Texas, Utah, Washington, and Wyoming. Questionnaire responses represented the American (*n* = 19), Sonoran (*n* = 2), Mexican (*n* =1), and Peninsular (*n* =1) subspecies from the United States (*n* = 18), Mexico (*n* = 3), and Canada (*n* = 2). Throughout the report, we reference 4 subspecies classifications (Klimova et al. 2014), although we acknowledge there is debate and subjectivity over pronghorn subspecies differentiation (O'Gara and Yoakum 2004). Sonoran, Mexican (Chihuahua), and Peninsular subspecies and Washington pronghorn were not hunted in 2021. Pronghorn were hunted in the remaining 18 jurisdictions spanning Canada and the United States.

ESTIMATION OF POPULATION PARAMETERS

Observation survey methods used to estimate abundance included fixed-wing aircraft surveys (*n* = 18), ground surveys (*n* = 10), and helicopter surveys (*n* = 7). Fourteen of the 23 jurisdictions estimated detection probability from observed counts using either sightability (*n* = 6), distance (*n* = 4), double-observer (*n* = 3), or mark-resight methods (*n* = 1), and 9 jurisdictions did not estimate detection probability. Among states and provinces, observation surveys are conducted across all months, but the most common survey months are July (*n* = 9), February (*n* = 7) and January (*n* = 6; Figure 1).

The estimated 2021 total pre-hunting season pronghorn population was 930,873 (American subspecies = 929,761; Sonoran subspecies = 977; Peninsular subspecies = 135), and these populations spanned 801,007 square miles of range (1.16 pronghorn/mi^2). No population estimates were available for the Mexican subspecies in Chihuahua. The population density of the American subspecies was 1.17/mi^2, the Sonoran subspecies was 0.19/mi^2, and the Peninsular subspecies was 0.11/mi^2 (Figure 2, Table 1). Eight of 23 jurisdictions had a numerical population objective, and 1 was within 5% of objective (ND), 5 were >5% below objective (AB, AZ and MX Sonoran, SD, WY) and 2 were >5% above objective (CA, SK).

Herd composition survey methods used to estimate Buck:Doe and Fawn:Doe ratios included fixed-wing aircraft (*n* = 15), ground-based (*n* = 12), and helicopter (*n* = 8). Twenty-two jurisdictions that evaluated herd composition used either systematic (*n* = 11), opportunistic (*n* = 11), and/or random (*n* = 3) survey designs. Washington did not provide herd composition survey information. Among states and provinces, composition surveys are conducted across all months, but the most common survey months are July (*n* = 11), and August (*n* = 9; Figure 3).

The average adult bucks per 100 adult does in 2021 from reported values was 41 (*n* = 19), and among the 14 states or provinces that provided long-term averages, 3 were within 5% of their previous 10-year average, 3 were >5% above their previous 10-year average, and 8 were >5% below their previous 10-year average. MT was the highest above (+35%) and NE was the lowest below (-18%) their 10-year Buck:Doe averages. The highest 2021 Buck:Doe ratio was recorded

State or Province	Survey Method FW	Survey Method GRD	Survey Method HELI	*p* method	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Alberta			x								■					
Arizona	x	x	x	do						■	■	■				
AZ Sonoran	x			sght											■	■
Baja California Sur	x			sght	■											
California			x	mr	■	■										
Chihuahua	x	x		sght		■	■	■				■	■	■		
Colorado	x	x	x	dist					■							
Idaho	x	x	x		■	■	■			■	■	■				■
Kansas	x			dist	■	■										
Montana	x	x						■	■		■					
MX Sonoran	x			sght											■	
Nebraska	x			do								■				
Nevada		x	x		■	■							■	■	■	■
New Mexico	x			do							■					
North Dakota	x										■					
Oklahoma	x				■	■										
Oregon		x	x								■					
Saskatchewan		x									■					
South Dakota	x			sght					■							
Texas	x	x		dist						■	■					
Utah	x			sght			■									
Washington	x					■	■									
Wyoming	x	x		dist					■	■						

Figure 1. Pronghorn visual observation survey method (FW = fixed-wing, GRD = ground-based, HELI = helicopter), detection probability (*p*) method (dist = distance, do = double-observer, mr = mark-resight, sght = sightability) and survey timing by month for each state or province in Canada, Mexico and the United States.

in AZ Sonoran pronghorn (70), followed by MT (65), then SK (51). The lowest 2021 Buck:Doe ratio was recorded in OK (27), followed by OR (28), then KS (31; Table 1).

The average fawns per 100 adult does in 2021 from reported values was 37 (*n* = 17), and among the 14 states or provinces that provided long-term averages, 86% were >5% below previous 10-year averages, SK was equal to their average, and KS was 2% above their average. Utah was the lowest (-57%) below their 10-year Fawn:Doe average, followed by NM (-48%), then AZ (-42%). The highest 2021 Fawn:Doe ratio was recorded in MT (55), followed by WY (54), then SK (53). The lowest Fawn:Doe ratio was recorded in TX (13), followed by AZ (14), then NM (16; Figure 4, Table 1).

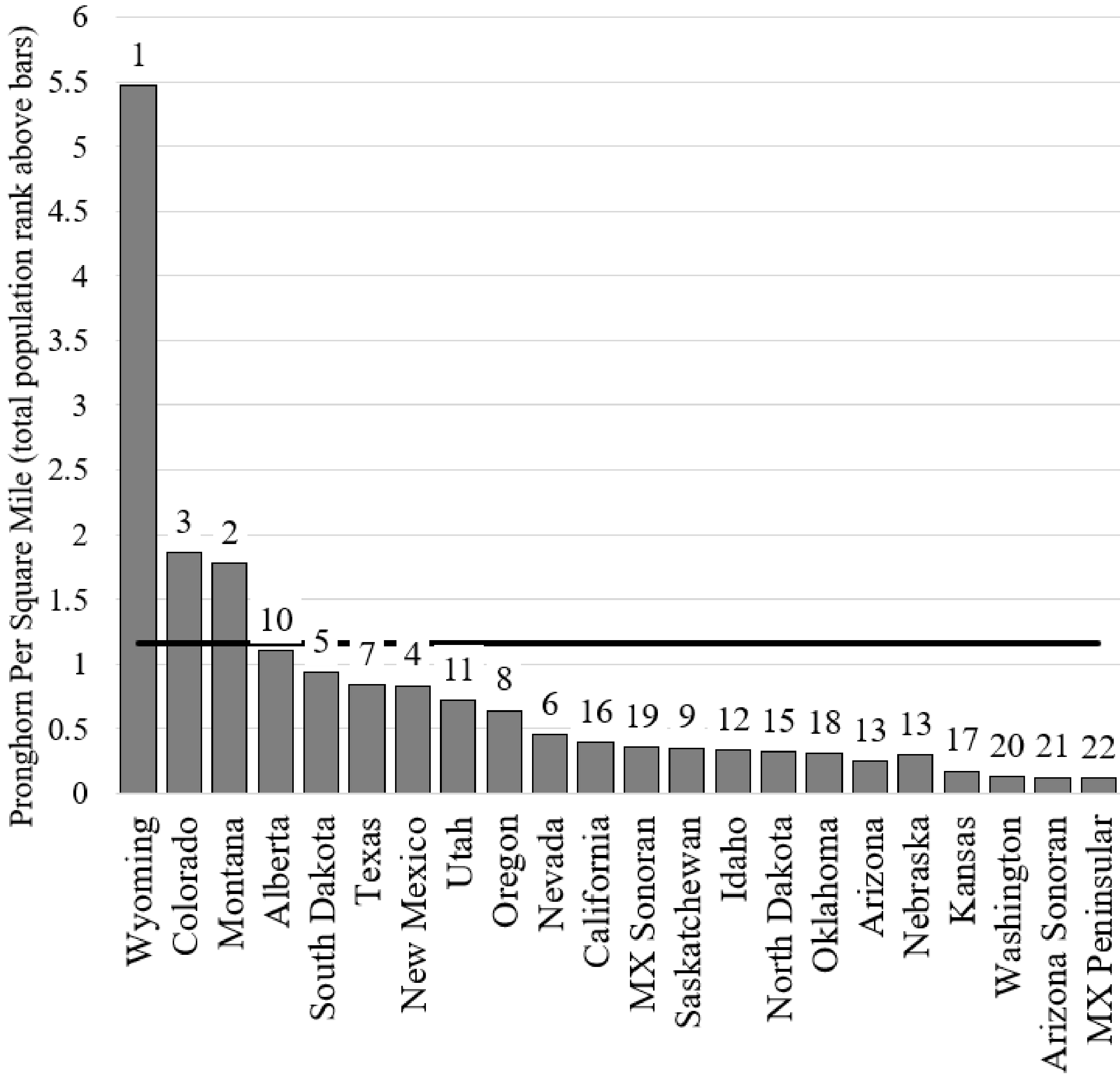


Figure 2. Gray bars indicate 2021 pre-hunting season pronghorn population density estimates, based on primary range, by individual state or province in Canada, Mexico and the United States. The average pronghorn density was 1.16/mi^2 (black horizontal line) and the total population size rank among the 22 jurisdictions is noted above the bars.

Table 1. Total area (mi^2), estimated pronghorn range (mi^2), estimated 2021 pre-hunt population total and population objective, and Adult Buck:100 Adult Doe and Fawn:100 Adult Doe ratios by state or province in Canada, Mexico, or the United States. Parenthetical values after the Buck:Doe and Fawn:Doe ratios are previous 10-year averages.

	Area (sq. mi.)		Population		Ratio Per 100	
State or Province	Total	*Spp.* Range	Estimate	Objective	Buck:Doe	Fawn:Doe
Alberta	255,848	14,495	15,955	20,010	43	45
Arizona	113,998	40,000	10,000		32 (33)	14 (24)
Arizona Sonoran	113,998	3,500	425	525	70	
MX Peninsular	28,500	1,200	135			
California	163,696	9,375	3,694	3,500	32	
MX Chihuahua	964,840	80,000			45	43
Colorado	104,095	48,107	89,700		42 (47)	42 (48)
Idaho	83,544	35,596	12,000			
Kansas	82,278	17,580	3,000		31 (34)	44 (43)
MX Sonoran	69,249	1,566	552	600		
Montana	147,040	95,000	168,821		65 (48)	55 (72)
Nebraska	77,000	34,000	10,000		32 (39)	25 (38)
Nevada	110,567	62,000	28,000		34 (30)	29 (32)
New Mexico	121,697	85,000	70,831		41 (37)	16 (31)
North Dakota	70,704	30,142	9,610	9,500	34 (40)	52 (59)
Oklahoma	69,899	4,100	1,260		27	45
Oregon	96,923	27,324	17,439		28 (32)	31 (35)
Saskatchewan	251,848	45,333	15,958	10,461	51 (50)	53 (53)
South Dakota	77,116	44,516	41,533	69,350	37 (36)	48 (60)
Texas	268,597	24,738	20,810		46 (50)	13 (24)
Utah	84,899	21,717	15,500		41 (44)	19 (44)
Washington	71,300	3,418	450			
Wyoming	97,914	72,300	395,200	460,200	48 (52)	54 (60)

State or Province	Survey Method FW	GRD	HELI	Sampling Design	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Alberta			x	syst							■					
Arizona	x	x	x	syst						■	■	■				
Arizona Sonoran	x			opp	■	■	■	■	■	■	■	■	■	■	■	■
Baja California Sur	x			syst								■				
California			x	opp	■	■										
Chihuahua	x	x		syst		■	■	■				■	■	■		
Colorado	x	x	x	opp, rand								■	■			
Idaho	x	x	x	opp	■	■	■			■	■	■				
Kansas	x			syst							■	■				
Mexico Sonoran	x			opp											■	
Montana	x	x		opp							■					
Nebraska	x			opp								■				
Nevada		x	x	opp	■	■							■	■	■	■
New Mexico	x			opp, rand							■					
North Dakota	x			syst							■					
Oklahoma	x			syst	■	■										
Oregon		x	x	rand, syst							■					
Saskatchewan		x		syst							■					
South Dakota		x		opp									■			
Texas	x	x		syst						■	■					
Utah		x		opp									■			
Wyoming	x	x	x	syst								■				

Figure 3. Pronghorn herd composition observation survey method (FW = fixed-wing, GRD = ground-based, HELI = helicopter), sampling design (opp = opportunistic, rand = random, syst = systematic) and survey timing by month for each state or province in Canada, Mexico and the United States.

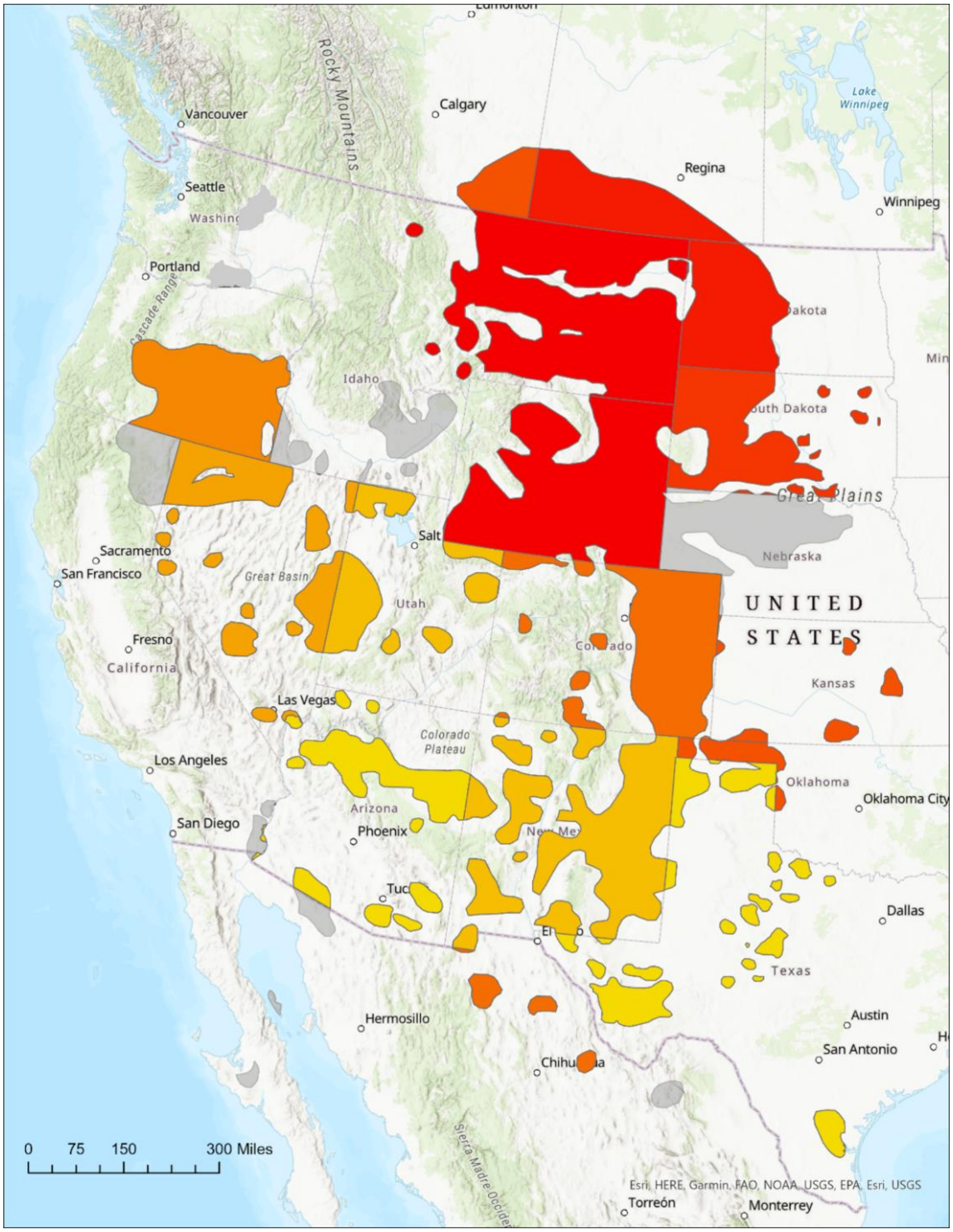


Figure 4. Fawn to 100 adult doe ratios shaded by density (yellow to red = low to high) across Canada, Mexico and the United States. States and provinces without data are shaded with gray. Current pronghorn range was modified from Kauffman et al. (2020) to include Washington range.

HARVEST SUMMARY AND HUNTING SEASON STRUCTURE

Five jurisdictions, Baja California Sur, Chihuahua, Washington, Sonora and AZ (Sonoran subspecies) did not have a hunting season in 2021. Of the 18 jurisdictions that did have a hunting season, all included a firearm season with a limited number of licenses, 12 of which were resident only. Fifteen of 18 jurisdictions provided either a landowner-own-land license or landowner preference for limited draw licenses. The longest firearm season was OK (64 days) and the shortest was KS (4 days). Eleven states had a muzzleloader season with a limited number of licenses, 3 of which were resident only. The longest muzzleloader season was WY (73 days) and the shortest was NM (6 days). Four states prohibited telescopic sights on muzzleloaders (CO, ID, NV, OR) and 2 states (ID, OR) restricted muzzleloaders to black power/flintlock only. Ten jurisdictions had an archery season with a limited number of resident and nonresident licenses and 5 states had unlimited archery resident licenses, 4 of which had unlimited nonresident licenses. The longest archery season was NE (134 days) and the shortest was CA and NM (9 days). One state (NE) allowed the use of crossbows during the archery season. Five states had a youth season for residents and nonresidents, and only 1 (SD), allowed an unlimited number of youth licenses. The longest youth season was ID (146 days) and the shortest was NM (6 days; Figure 5).

The average license rate per population total was 18% (161,191 licenses and 913,353 pronghorn estimated). The highest license rate per population was ID at 40% (4,765 licenses). The lowest license rate per population was CA at 4% (157 licenses).

Seven states required mandatory electronic harvest reporting. Telephone reporting was an alternative option in NE, UT and NM, and NE also had an in-person reporting option. Compliance for mandatory reporting, when estimated (n = 4), ranged 93% (TX) to 99% (CA). Eleven states and 2 provinces administered a harvest survey. Nine states and 1 province conducted an electronic harvest survey, and 8 states also provided a phone and/or mail survey. Two states (ID, MT) administered a phone only survey, but MT is implementing an e-licensing system. Two states (ND, WY) evaluated nonresponse bias. Reporting rate averages (n = 10), when available, ranged from 35% (UT depredation permits) to 85% (OR).
Nine states aged harvested pronghorn using: cementum annuli (n = 4), tooth wear and replacement (n = 3), and horn measurements (n = 2). Seven states managed hunting areas for quality opportunities.

Total pronghorn harvest in 2021, excluding SK, was estimated at 75,400 (bucks = 53,440, does = 21,960) and averaged 11.3 pronghorn per 100 square miles of range (bucks = 8.0/100 sq. mi., does = 3.3/100 sq. mi.). Eight percent of the total pronghorn population estimate was harvested in 2021.

At 44.4 pronghorn harvested per 100 square miles of range, nearly 4 times the average rate, pronghorn harvest was greatest in WY (bucks = 21,844, does = 10,255). Of the states that had a hunting season in 2021, CA had the lowest total harvest (bucks = 119, does = 0; 1.3 per 100 sq. mi.). In addition, AZ, KS, and TX did not harvest any does. The lowest rate of harvest per 100 square miles of range was KS at 0.9. WY clearly had the highest harvest and harvest per square mile, but OK had the highest harvest rate with harvest accounting for 14% of the total population. The highest doe harvest rate was also in OK where doe harvest accounted for 7% of the total population of bucks and does (Figure 6, Table 2).

State or Province	Season	Licenses RES	NR	August	September	October	November	December	January
Alberta	Firearm	lim	lim						
	Archery	lim							
Arizona	Firearm	lim	lim						
	Muzzleloader	lim	lim						
	Archery	lim	lim						
California	Firearm	lim	lim						
	Archery	lim	lim						
	Youth	lim	lim						
Colorado	Firearm	lim	lim						
	Muzzleloader	lim	lim						
	Archery	lim	lim						
Idaho	Firearm	lim	lim						
	Muzzleloader	lim	lim						
	Archery	unlim	unlim						
	Youth	lim	lim						
Kansas	Firearm	lim							
	Muzzleloader	lim							
	Archery	unlim	unlim						
Montana	Firearm	lim	lim						
	Archery	lim	lim						
Nebraska	Firearm	lim							
	Muzzleloader	lim							
	Archery	unlim	lim						
Nevada	Firearm	lim	lim						
	Muzzleloader	lim	lim						
	Archery	lim	lim						
New Mexico	Firearm	lim	lim						
	Muzzleloader	lim	lim						
	Archery	lim	lim						
	Youth	lim	lim						
North Dakota	Firearm	lim							
Oklahoma	Firearm	lim							
	Archery	unlim	unlim						
Oregon	Firearm	lim	lim						
	Muzzleloader	lim	lim						
	Archery	lim	lim						
	Youth	lim	lim						
Saskatchewan	Firearm	lim							
	Muzzleloader	lim							
South Dakota	Firearm	lim	lim						
	Archery	unlim	unlim						
	Youth	unlim	unlim						
Texas	Firearm	lim							
Utah	Firearm	lim	lim						
	Muzzleloader	lim	lim						
	Archery	lim	lim						
Wyoming	Firearm	lim	lim						
	Muzzleloader	lim	lim						
	Archery	lim	lim						

Figure 5. Pronghorn seasons and licenses available (lim = limited quota, unlim = unlimited) by residency (resident = RES, nonresident = NR) and season dates by jurisdiction across Canada, Mexico, and the United States.

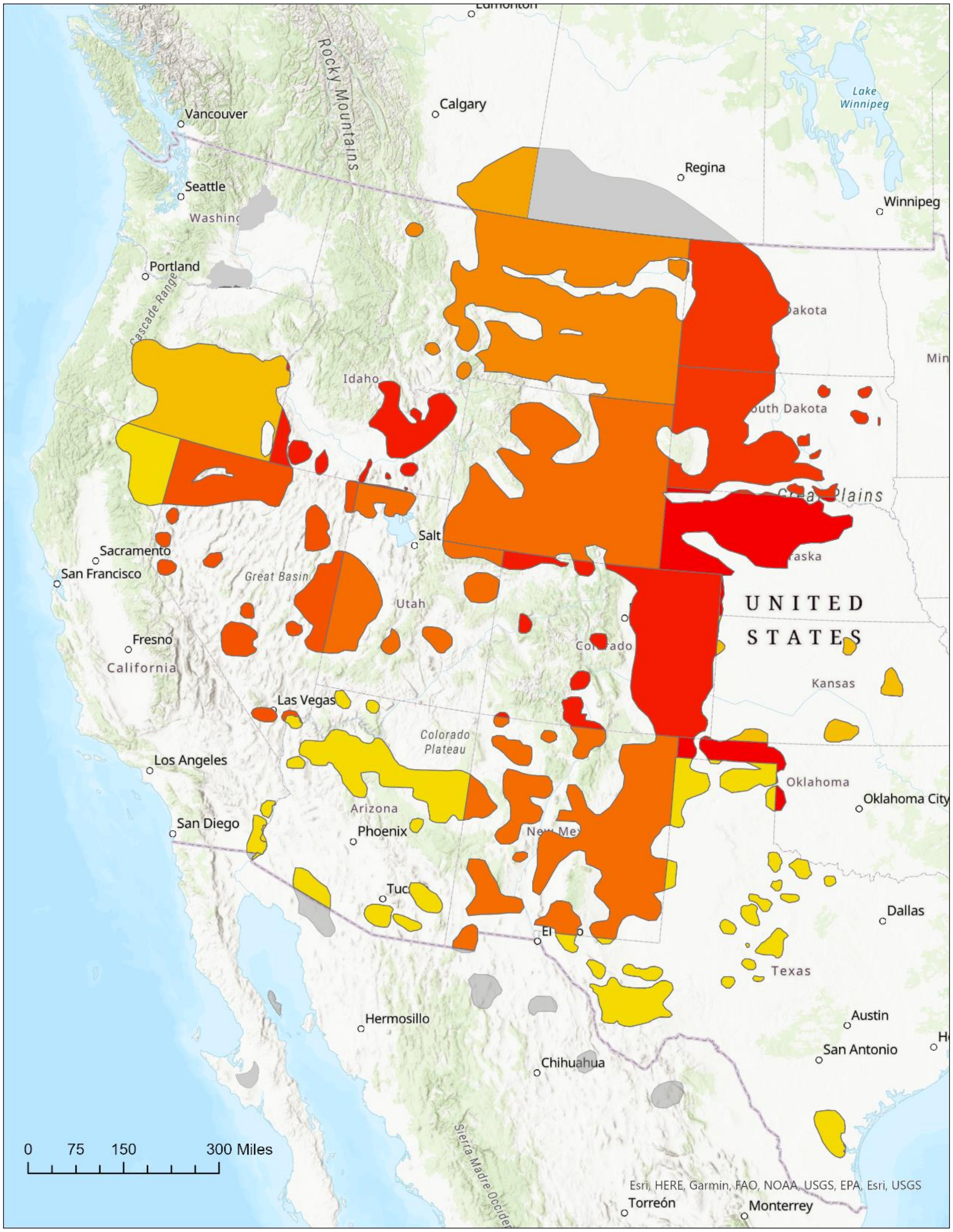


Figure 6. Total pronghorn harvest per total population estimate shaded by density (yellow to red = low to high) across Canada and the United States. States and provinces without data are shaded with gray. Current pronghorn range was modified from Kauffman et al. (2020) to include Washington range.

Table 2. Total pronghorn harvest, harvest per 100 square miles of pronghorn range and harvest rate (i.e., harvest divided by total population) from states and provinces with a hunting season from Canada and the United States. Saskatchewan did not have harvest estimates available.

	Total Harvest			Harvest Per 100 Sq. Mi. Range			Harvest Rate of Tot. Pop.		
State or Province	Buck	Doe	Total	Buck	Doe	Total	Buck	Doe	Total
Alberta	871	144	1,015	6.0	1.0	7.0	0.05	0.01	0.06
Arizona	380	0	380	1.0	0.0	1.0	0.04	0.00	0.04
California	119	0	119	1.3	0.0	1.3	0.03	0.00	0.03
Colorado	5,993	4,263	10,256	12.5	8.9	21.3	0.07	0.05	0.11
Idaho	1,273	185	1,458	3.6	0.5	4.1	0.11	0.02	0.12
Kansas	159	0	159	0.9	0.0	0.9	0.05	0.00	0.05
Montana	8,553	3,678	12,231	9.0	3.9	12.9	0.05	0.02	0.07
Nebraska	799	362	1,161	2.4	1.1	3.4	0.08	0.04	0.12
Nevada	1,823	625	2,448	2.9	1.0	3.9	0.07	0.02	0.09
New Mexico	5,369	288	5,657	6.3	0.3	6.7	0.08	0.00	0.08
North Dakota	776	192	968	2.6	0.6	3.2	0.08	0.02	0.10
Oklahoma	89	84	173	2.2	2.0	4.2	0.07	0.07	0.14
Oregon	915	95	1,010	3.3	0.3	3.7	0.05	0.01	0.06
South Dakota	2,900	1,563	4,463	6.5	3.5	10.0	0.07	0.04	0.11
Texas	578	0	578	2.3	0.0	2.3	0.03	0.00	0.03
Utah	999	226	1,225	4.6	1.0	5.6	0.06	0.01	0.08
Wyoming	21,844	10,255	32,099	30.2	14.2	44.4	0.06	0.03	0.08

Firearm harvest was greatest in WY (31,965, which included archery harvest) among the 17 states and provinces that reported. Firearm harvest was lowest in KS (95; Table 3). CO had the highest muzzleloader harvest (670) and KS was lowest (18; *n* = 10; Table 4). Excluding WY, which doesn't separately estimate archery and firearm harvest, MT had the highest archery harvest (905) and CA was lowest (7; *n* = 14; Table 5). NM had the highest youth harvest (478) and CA was lowest (12; *n* = 5; Table 6). Among all seasons, the highest hunter success rate was estimated during the Utah firearm season (90%) and the lowest was KS archery season (15%). However, UT reported buck only hunter success. The second highest hunter success was reported during the AZ firearm season (89%). The highest harvest rate per license was reported for NM firearm season (91%).

Table 3. Pronghorn firearm hunting season license sales by type (Either-sex, Doe/fawn) and residency (Resident, Nonresident) and harvest by sex, total and harvest success. Utah hunter success is reported for bucks only.

	Firearm Licenses				Firearm Harvest			Hunter
State or Province	Either-sex	Doe/Fawn	Resident	Nonres.	Buck	Doe	Total	Success
Alberta	898	219	1,255	50	768	144	912	75%
Arizona	386	0	357	29	291	0	291	89%
California	125	0	124	1	100	0	100	80%
Colorado	8,257	11,868			5,004	4,001	9,005	59%
Idaho	1,095	150	1,169	76	748	112	860	72%
Kansas	126	0	126	0	95	0	95	75%
Montana	30,420	4,265	27,825	2,595	7,772	3,554	11,326	41%
Nebraska	918	880	1,822	73	503	324	827	46%
Nevada	3,415	980	3,075	340	1,618	625	2,243	74%
New Mexico	5,061	241			4,655	188	4,843	75%
North Dakota	1,459	284	1,710	0	776	192	968	68%
Oklahoma	90	225	315	0	69	83	152	
Oregon	1,279	143	1,237	42	786	85	871	74%
Saskatchewan	254	0	254	0				
South Dakota	4,484	1,789	4,643	150	2,239	1,083	3,322	62%
Texas	1,068	0			578	0	578	
Utah	847	396	1,119	124	741	226	967	90%
Wyoming	32,457	24,990	27,353	21,880	21,717	10,248	31,965	84%

Table 4. Pronghorn muzzleloader hunting season license sales by type (Either-sex, Doe/fawn) and residency (Resident, Nonresident) and harvest by sex, total and harvest success.

	Muzzleloader Licenses				Muzzleloader Harvest			Hunter
State or Province	Either-sex	Doe/Fawn	Resident	Nonres.	Buck	Doe	Total	Success
Arizona	60	0	56	4	36	0	36	67%
Colorado	2,473				465	205	670	37%
Idaho	230		210	20	85	5	90	45%
Kansas	45	0	45	0	18	0	18	51%
Nebraska	181		182	2	104	4	108	60%
Nevada	111		112	0	55		55	50%
New Mexico	173	0			93	0	93	54%
Oregon	160	0	155	5	20	6	26	58%
Saskatchewan	106	0	106					
Utah	134		121	13	109		109	85%
Wyoming	133	0	103	30	87	7	94	75%

Table 5. Pronghorn archery hunting season license sales by type (Either-sex, Doe/fawn) and residency (Resident, Nonresident) and harvest by sex, total and harvest success.

	Archery Licenses				Archery Harvest			Hunter
State or Province	Either-sex	Doe/Fawn	Resident	Nonres.	Buck	Doe	Total	Success
Alberta	184	0	223	0	103	0	103	43%
Arizona	228	0	209	19	53	0	53	29%
California	17	0	15	2	7	0	7	41%
Colorado	937				524	57	581	23%
Idaho	3,195		3,023	153	424	53	477	22%
Kansas	377	0	367	10	46	0	46	15%
Montana	5,600				781	124	905	
Nebraska	1,380		1,130	250	192	34	226	16%
Nevada	540		485	55	150		150	25%
New Mexico	740	0			243	0	243	33%
Oklahoma					20	1	21	
Oregon	538	0	523	15	88	4	92	33%
South Dakota	3,019	0	2,142	877	642	94	736	24%
Utah	232		209	23	149		149	67%
Wyoming	53	0	40	13	40	0	40	77%

Table 6. Pronghorn youth hunting season license sales by type (Either-sex, Doe/fawn) and residency (Resident, Nonresident) and harvest by sex, total and harvest success.

	Youth Licenses				Youth Harvest			Hunter
State or Province	Either-sex	Doe/Fawn	Resident	Nonres.	Buck	Doe	Total	Success
California	15	0	15	0	12	0	12	80%
Idaho	95		93	2	16	15	31	42%
New Mexico	474	165			378	100	478	75%
Oregon	40	0	36	4	21	0	21	88%
South Dakota		847	833	14	19	386	405	48%

HABITAT, DEPREDATION AND PREDATION MANAGEMENT AND DISEASE

Fifteen of 23 states or provinces were actively involved in habitat enhancement on state, federal or private lands and 16 states or provinces provided some form of pronghorn depredation assistance. The most common depredation assistance was hazing (9), then landowner tags (8), fencing assistance (7), management hunts (7), financial compensation (5), and food plots (1). Seven states or provinces implemented predator control measures beyond recreational hunting. Seven states or provinces had documented substantial mortality due to disease, mostly hemorrhagic disease (4), but *Mycoplasma bovis* (WY), *Haemonchus spp.* (TX), and hoof rot (CA) were also documented. There was also notable mortality of two to three hundred pronghorn in NM and SD has recently noted above average mortality rates in adult pronghorn with no definitive primary cause.

ACKNOWLEDGMENTS

We kindly thank all respondents to the survey questionnaire including: Dallas Barber (OK), Tom Batter (CA), Stephanie Doerries (Sonora), Kyle Garrison (WA), Shawn Gray (TX), Callie Hartson (AZ), Leanne Heisler (SK), John Hervert (AZ Sonoran), Andy Holland (CO), Kent Hersey (UT), Mason Kleist (Baja CA Sur), Lee Knox (WY), Alberto Lafon (Chihuahua), Raymond Lee (Baja CA Sur), Luke Meduna (NE), Hollie Miyasaki (ID), Kim Morton (AB), Tony Opatz (NM), Matt Peek (KS), Cody Schroeder (NV), Bruce Stillings (ND), Brian Wakeling (MT), Don Whittaker (OR). We also thank Jim Heffelfinger (AZ) and Rich Guenzel (WY) for their assistance providing contacts.

LITERATURE CITED

Kauffman, M, H. Copeland, J. Berg, S. Bergen, E. Cole, M. Cuzzocreo, S. Dewey, J. Fattebert, J. Gagnon, E. Gelzer, and C. Geremia. 2020. Ungulate migrations of the western United States, Volume 1 (No. 2020-5101). US Geological Survey.

Klimova, A., A. Munguia-Vega, J. I. Hoffman, and M. Culver. 2014. Genetic diversity and demography of two endangered captive pronghorn subspecies from Sonoran Desert. Journal of Mammalogy 95:1263-1277.

O'Gara, B. W. and J. D. Yoakum. 2004. Pronghorn ecology and management. Wildlife Management Institute, Washington, District of Columbia.

SEASONAL RESOURCE SELECTION BY PRONGHORN IN CENTRAL OREGON

ANDREW J. WALCH, *Oregon Department of Fish and Wildlife, 61374 Parrell Rd, Bend, OR 97702, USA*

COREY HEATH, *Oregon Department of Fish and Wildlife, 61374 Parrell Rd, Bend, OR 97702, USA*

SETH HARJU, *Heron Ecological, LLC, P.O. Box 235, Kingston, ID 83839, USA*

DONALD G. WHITAKER, *Oregon Department of Fish and Wildlife, 4034 Fairview Industrial Dr. SE Salem, OR 97302, USA*

Correspondence: DONALD G. WHITTAKER, Oregon Department of Fish and Wildlife, 4034 Fairview Industrial Dr. SE Salem, OR 97302, USA. Email: don.whittaker@odfw.oregon.gov

ABSTRACT Animal resource selection is a fundamental aspect of wildlife ecology. Understanding features on the landscape that animals select for is critical information for wildlife managers in order to make population and land management decisions. The Oregon Department of Wildlife (ODFW) collected location data on free-ranging pronghorn (Antilocapra americana) in central Oregon from February of 2018 through March of 2021. Pronghorn were captured and fitted with Global Positioning Satellite (GPS) collars and released, with collars programmed to record locations approximately every 13 hours year-round. We used these GPS data to estimate seasonal range use and delineate migration periods. We generated mixed-model resource selection functions for each season, to better understand how pronghorn used available resources throughout the year. Relationships identified in these models were used to generate predictive maps of spatial patterns in relative resource selection and probability of occurrence across the analysis area in central Oregon.

KEYWORDS *Antilocapra americana, pronghorn, resource selection, Oregon*.

Animal movements, seasonal distributions, and resource selection are fundamental aspects of wildlife ecology. A thorough understanding of what landscape features animals select for seasonally is critical for wildlife managers when making population and land management decisions effecting wildlife. Further, understanding where wildlife occur on the landscape in different seasons is important when designing population monitoring strategies, harvest management strategies and hunting areas, and when reviewing development proposals.

Available data on central Oregon pronghorn (*Antilocapra americana*) populations indicate population surveys are not representative of the pronghorn distribution, population size, and seasonal movements. Pronghorn population trend data shows large, unrealistic swings in population numbers in relatively short time periods suggesting that not all animals are accounted for during surveys. This raises concerns about our understanding of pronghorn distribution and seasonal movements, prompting the need for more detailed information on the species.

Ultimately the goal of this study was to better understand the ecology of pronghorn in central Oregon. Specific objectives for this study included:

1) Determine patterns of seasonal habitat selection and use.
2) Delineate seasonal pronghorn ranges.

Results will better inform pronghorn management in Oregon and throughout their endemic range.

STUDY AREA

This study was conducted in central Oregon east of the town of Bend and generally south of the Blue Mountains (Figure 1). Boundaries of the original 8,300 km2 study area were delineated based primarily on animal distributions observed during annual composition surveys. Elevation ranged from about 1,200-1,950 m with most areas used by pronghorn typified by flat to gently rolling topography. Vegetation was characteristic of northern Great Basin grasslands and included a strong shrub component consisting primarily of sage (*Artemisia spp*.), rabbitbrush (*Chrysothamnus viscidiflorus*), and spiny hopsage (*Atriplex spinosa*). Open juniper (*Juniperus occidentalis*) woodlands occurred in some parts of the study area, primarily on scattered buttes and peaks within the area. Pronghorn populations were naturally occurring in the area with an estimated wintering population of 500–750 animals at the time of capture. Limited buck-only hunting and limited livestock grazing were the primary management activities affecting pronghorn on the study area. High levels of human recreational activities occurred in a number of areas with much of the activity involving off highway vehicles in areas established by the Bureau of Land Management (BLM).

Climate was characteristic of northern Great Basin. Summers were typically warm ($\bar{x}$ monthly temperature = 59˚F) with cool ($\bar{x}$ monthly temperature = 32˚F), generally dry winters (National Oceanic and Atmospheric Administration data (NOAA), Browns Well Oregon station). Also typical of the Great Basin were seasonal extreme temperatures, reaching a low of -10˚F in winter 2021–2022 and a high of 103˚F during summer 2021. The limited precipitation occurs primarily as summer thunderstorms or periodic winter snowstorms.

METHODS

Female pronghorn were captured using a helicopter netgun on winter range during winters 2017-2018 and 2018-2019. During the third year animals were captured on summer ranges in 2019. Animals were restrained, outfitted with either a Lotek Life-Cycle Global Positioning System collar (GPS***, Lotek Wireless Inc. 115 Pony Drive Newmarket, Ontario Canada L3Y 7B5***) or a Vectronic Aerospace (VAS) Lite Track collar (*Vectronic Aerospace Inc., 3292 Ridgeway Drive Suite C, Coralville, IA, USA*), and released at the site of capture. All Lotek collars (41) were programed to collect valid location estimates twice daily at 13 hr intervals throughout the life of the collar. The VAS collars were programmed to collect 4-5 location estimates per day at a 5 hr interval. No biological samples or measurements were collected or recorded at time of capture.

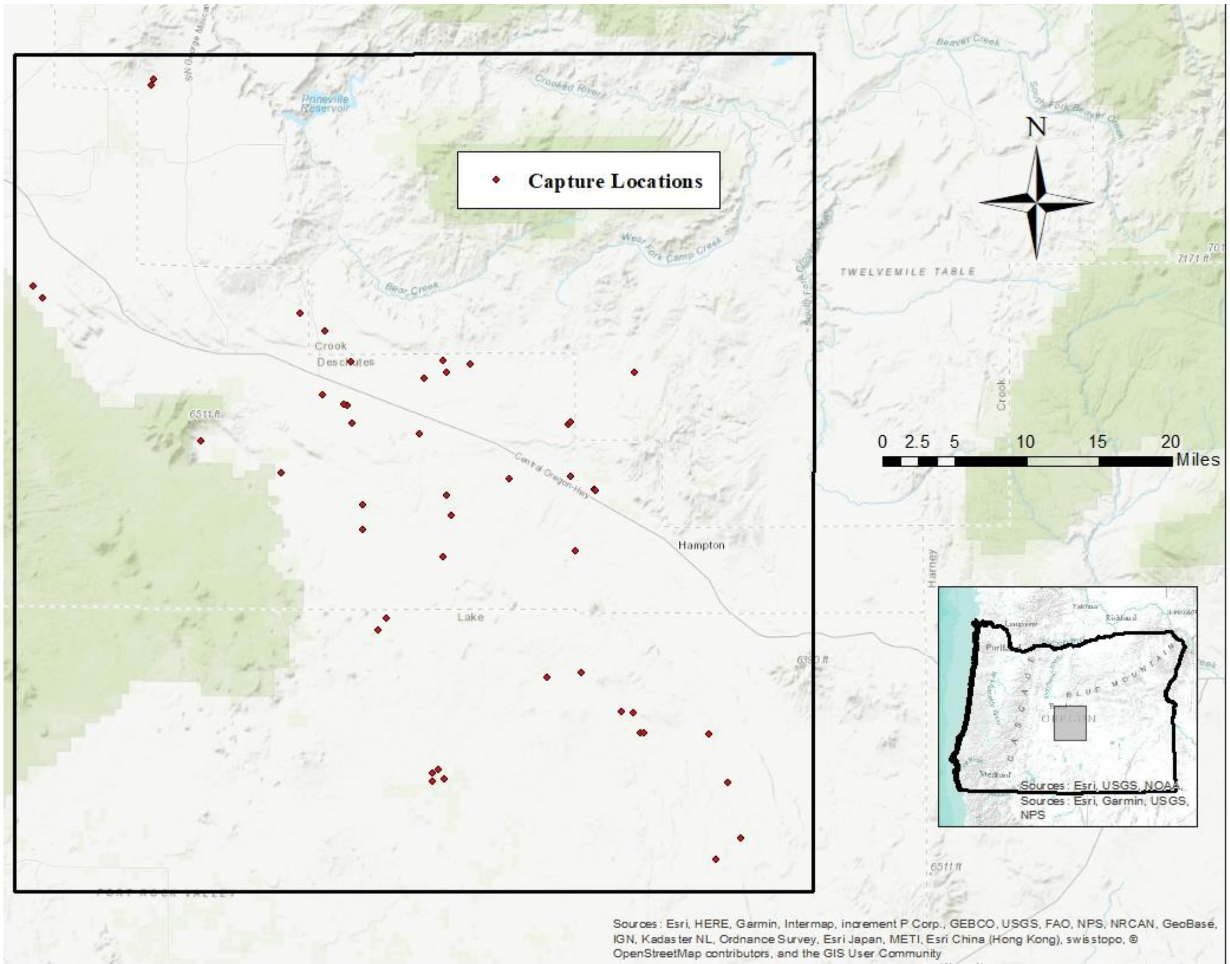


Figure 2. Study area and capture locations for delineation of resource use by pronghorn in central Oregon, USA, 2018-2021.

Collars were monitored remotely by ODFW district personnel. Estimated dates of mortalities were primarily based on email notifications from the manufacturer's monitoring system and by monitoring movement of individual animals. Mortalities were checked as feasible by ODFW staff but due to workload issues cause of death was not determined for most mortalities.

GPS locations were screened to remove erroneous locations (e.g., temporary GPS unit failure) and any locations recorded pre-capture or post-mortality. Net Squared Displacement (NSD) was used as the metric for defining seasons and migrations. NSD is the squared distance between the coordinates for a given location for animal *i* at time *t* from the coordinates of the original location upon release, at time t_0 (Singh et al. 2016). Pronghorn remaining in the release area will have relatively small NSD values. For pronghorn exhibiting migration behaviors that results in distinct seasonal home ranges, sequential plots of NSD values will show one or more plateaus or clusters where the animal spends time in the seasonal range. Based on previous analyses on pronghorn in Oregon, we expected NSD could be used to delineate date boundaries for general habitat 'seasons' for pronghorn in central Oregon, while recognizing that many pronghorn populations are partially migratory (e.g., not all individuals migrate and therefore have year-round home ranges, Barnowe-Meyer et al. 2017, Jakes et al. 2018). Ultimately, we used ocular estimation to identify migratory behaviors based on distributions of Net Squared Displacement (NSD), and to identify general season dates for four seasons: spring, summer, fall, and winter. All points were subsequently assigned to one of the four seasons for each animal.

We modeled resource selection for 12 covariates reflective of vegetative, topographic, and anthropogenic features (Table 1). Spatial covariate data occurred at different spatial resolutions, ranging from 10 m grid cells up to 5 km grid cells. We upscaled low resolution rasters (fence density and distance to fence, 5 km and 1 km, respectively) and the medium resolution rasters (percent *Juniperus occidentalis* and percent *Pinus ponderosa*, both 30 m) to match the resolution of the majority of vegetation and topography rasters (10 m). The caveat to upscaling is that spatial resolution artificially appears higher for the upscaled covariates, and covariates subject to strong selection may 'swamp' predictive resource selection maps. Inference on these covariates with differing resolutions is still coarse, although they were always providing coarse inference on the relationship between selection and fences. The benefit to upscaling is retention of fine-scaled inference on high resolution resources, particularly vegetation and topography. After upscaling to the same resolution, all raster layers were snapped to the same coordinates. All covariates were screened for collinearity with each other prior to analysis. All data were analyzed using the Oregon Lambert coordinate reference system (EPSG:2992) to avoid issues associated with multiple UTM zones within the study area.

Resource selection may occur at multiple levels (e.g., from range wide to patch levels, Johnson 1980). We chose to model resource selection at the individual level (e.g. third order), reflecting a pronghorn's resource selection from locations available within that pronghorn's full home range. To do this we generated minimum convex polygons (MCPs) for all locations from each individual. We buffered each MCP by the average distance between consecutive step lengths across all pronghorn (3 km). We then generated random locations within each buffered MCP at a ratio of 10 available for each 1 used location, calculated separately for each pronghorn. After sub-setting seasonal locations for each pronghorn, the effective ratio of available to used locations was significantly greater than 10:1 and varied depending on the proportion of each pronghorn's locations that fell within a given season.

We used mixed effects logistic regression models for developing seasonal resource selection functions (RSFs). These RSFs provide a statistical comparison of differences between where an animal chose to occur (e.g., used, often denoted as '1') and other available locations where the animal could have occurred (e.g., available, often denoted as '0'). Mixed effect logistic regression allows for inference at both the population and individual levels. Further, it accounts for different numbers of locations within individuals and varying strengths of selection for a given resource between and among individual pronghorn.

The model was hierarchical such that individual locations were nested within individual pronghorn, which were nested within the larger pronghorn population (Gillies et al. 2006). The mixed effect logistic regression model contained a global intercept β_0, a population-level estimate of the selection β_k for each resource k, a random intercept γ_{0i} for each individual pronghorn i (to account for variable sample sizes among individuals), and a random slope γ_{ki} for each individual pronghorn i for each resource k (to account for individual deviation in selection for each resource from the population mean), and associated error terms ε and ε_k, such that:

$$logit(y_{il}) = \beta_0 + \beta_k + \gamma_{0i} + \gamma_{ki} + \varepsilon + \varepsilon_k$$

where y_{il} was a used or available location (l, 1 or 0, respectively) for pronghorn i.

To make inference at population and individual levels, we report variation of resource selection coefficients across individuals and across seasons. We present graphical representations of population-level selection for resources across seasons. To compare strength of selection among covariates occurring on different scales and assess relative magnitude of impacts from changes in covariates, we calculated standardized logistic regression coefficients following Menard (2011) as:

$$Standardized\ coeff_k = \beta_k * Std.Dev._k$$

Finally, we generated predictive RSF maps across the analysis area defined by animal movements for all four seasons using the population level coefficients from the RSF model for each season, following the standard exponential model:

$$RSF_m = \exp\left(\beta_0 + \beta_k * x_{km}\right)$$

for each coefficient β from covariate k and observed values of xk for each grid cell m. These were high resolution (10m), large scale surfaces (i.e., 300 km north-south span, 135 km east-west span, with an irregular shape) reflecting relative probability of pronghorn occurrence as a function of the environmental and anthropogenic covariates. Although both fence density and fence distance were included in the full model, their inclusion in the predictive RSF was problematic. When developing predictive raster maps for the study area, the coarse resolution of the input data combined with strong selection for fence density resulted in some non-sensical predictions. To resolve this, we excluded fence variables and re-created the predictive RSF maps. The resulting maps represent resource selection of the ten vegetation and topographic variables but still account for effects of fence density and fence distance because these variables were part of the model used to estimate the vegetation and topographic coefficients. We then normalized these surfaces to a 0-1 scale to reflect relative probability of selection of a given raster cell by dividing each cell's value by the raster's maximum value.

Extrapolating the RSF outside of raster cells used as input can lead to calculation of extreme values, particularly for covariates that were strongly selected for or against, and whose values were far outside the range of model inputs. To rectify this for display and application, to reflect the relative nature of predictive RSF values (Manly et al. 1993, Morris et al. 2016), and because accuracy of the RSF outside the input cells cannot be validated (Morris et al. 2016), we binned the continuous RSF surfaces into four relative occurrence bins. Cells were grouped into low, medium-low, medium-high, and highest relative probability of use. We validated the binned seasonal predictive RSF maps to ensure that they reflected resource selection decisions of the pronghorn used to build the models. We sampled probability of resource use within relative use bins for each pronghorn, and tested whether increasingly higher probability of use bins were used more frequently by pronghorn using Spearman rank correlation (Boyce et al. 2002).

All statistical analyses were performed using Program R (v4.0.5). The mixed effect logistic regression was performed using package 'lme4'. Spatial generation of MCPs and random available locations performed using package 'raster'. All non-R spatial data management was performed using ArcGIS (v10.4.1).

RESULTS

We captured 62 pronghorn within the study area: 26 during February 2018, 25 during February 2019, and 11 during September 2019. Nine animals were censored from analyses due to capture related injuries. The resulting final pronghorn GPS dataset consisted of 75,416 locations from 53 individual pronghorn, spanning a date range of February 11, 2018 through March 29, 2021. The average number of locations per individual was 1,422.9 (SD 1100.1, range 10-4,577). Movement strategies defined by NSD were highly variable among and within individuals. Most individuals included in analyses showed either year-round range fidelity or sporadic, inconsistent non-seasonal migrations. A few individuals exhibited clear seasonal migrations allowing for delineation of general seasons of spring (1 March – 31 May), summer (1 June – 31 August), fall (1 September – 30 November), and winter (1 December – 28 February).

The twelve modeled covariates were not highly correlated with each other (all Pearson's $r < 0.6$). Population-level estimates for modeled covariates showed consistent and divergent seasonal patterns in selection (Figure 2). Pronghorn avoided areas with higher tree cover, especially in spring (Figure 2a). Pronghorn avoided shrub cover in the spring, but had coefficient estimates close to zero with broadly overlapping confidence intervals in other seasons (Figure 2b). Perennial forbs and grasses were strongly selected for, but only in summer, fall, and winter (Figure 2c). Annual forb and grass cover was selected for only in fall and winter, with no population-level selection in spring or summer (Figure 2d). Percent litter cover was always strongly selected for, particularly in winter (Figure 2e). Percent bare ground was weakly but consistently selected for in summer and fall, but with inconsistent selection in spring and winter (Figure 2f). Pronghorn selected for lower percent *Pinus ponderosa* and *Juniperus occidentalis* cover, but especially so in winter (Figures 2g and 2h, respectively). Pronghorn avoided steep slopes, especially in fall and winter (Figure 2i). West and northwest slope aspects were weakly selected for in winter (Figure 2j). Surprisingly, pronghorn selected for higher fence density than available on the larger landscape, and from spring to winter increased the strength of their selection (Figure 2k). Finally, pronghorn tended to select locations away from fences, but only weakly and only in spring (Figure 2i).

Individual pronghorn often deviated in selection for resources from the general population, either in magnitude of selection/avoidance or in the sign of selection or avoidance itself (Figure 3). In general, even when population-level selection coefficients were statistically significant, some individuals exhibited the opposite type of selection than the general population. For example, the bulk of pronghorn selected for higher percent coverage of perennial forbs and grasses in fall (Figure 3c), three pronghorn had individual coefficients indicating selection for locations with lower perennial forbs and grasses within their home ranges. Other patterns of note include a general unimportance of percent shrub cover (Figure 3b), marked seasonal differences in consistency (i.e., narrow densities) versus generality (i.e., broad densities) in selection for perennial forb and grass cover (Figure 3c), percent bare ground (Figure 3f), ponderosa pine cover

(Figure 3g), western juniper cover (Figure 3h), and avoidance of steep slopes (Figure 3i). For example, while pronghorn always avoided steep slopes (i.e., selected flatter areas), that avoidance was consistently weak during the spring, with some individuals showing increasingly stronger selection for flat areas in the summer and even stronger selection in the fall and winter (Figure 3i).

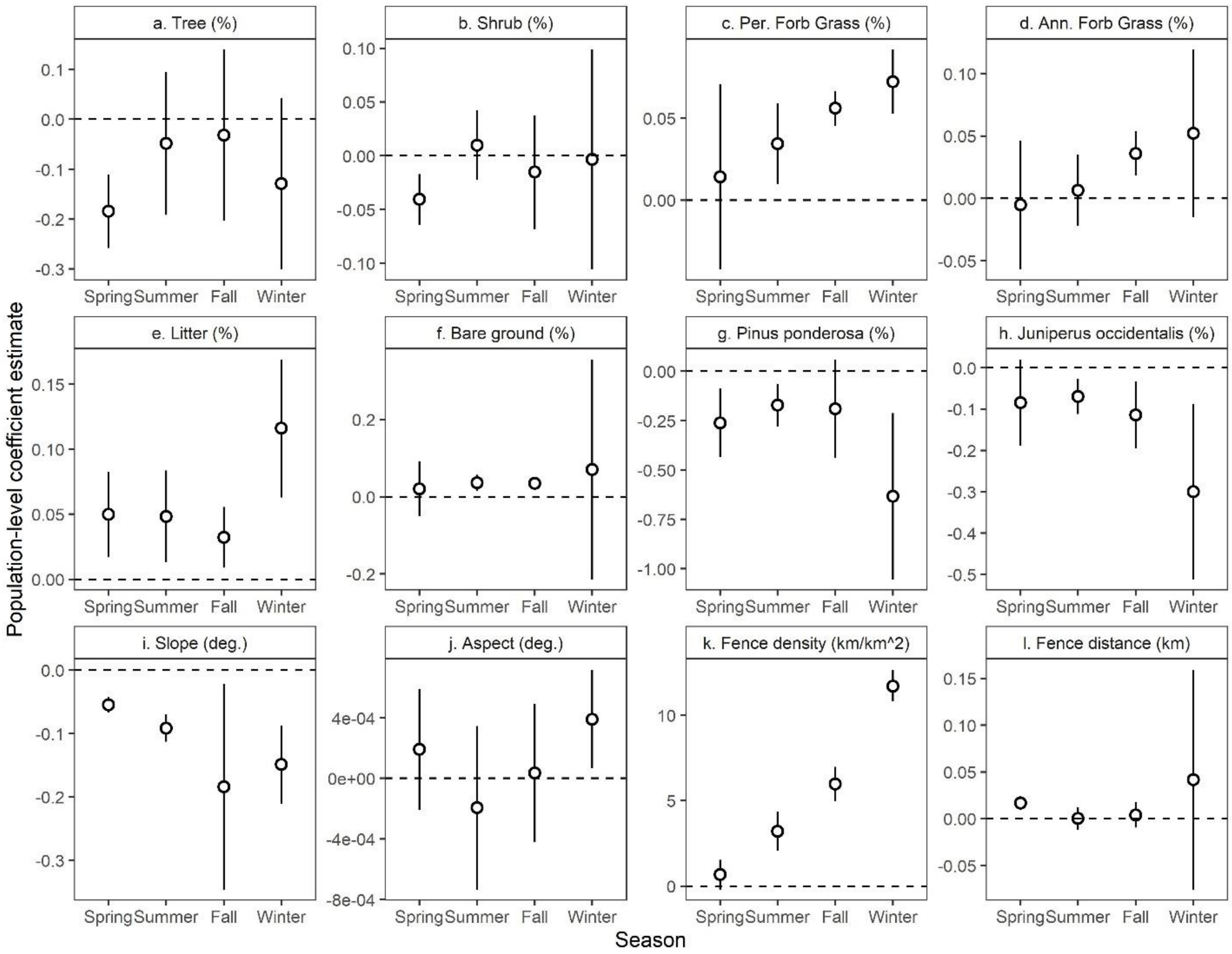


Figure 2. Population-level log-odds coefficient estimates for selection for, selection against, or selection neutral by pronghorn (*Antilocapra americana*) for twelve landscape covariates in central Oregon, USA, 2018-2021. Circles are means and vertical bars are 95% confidence intervals.

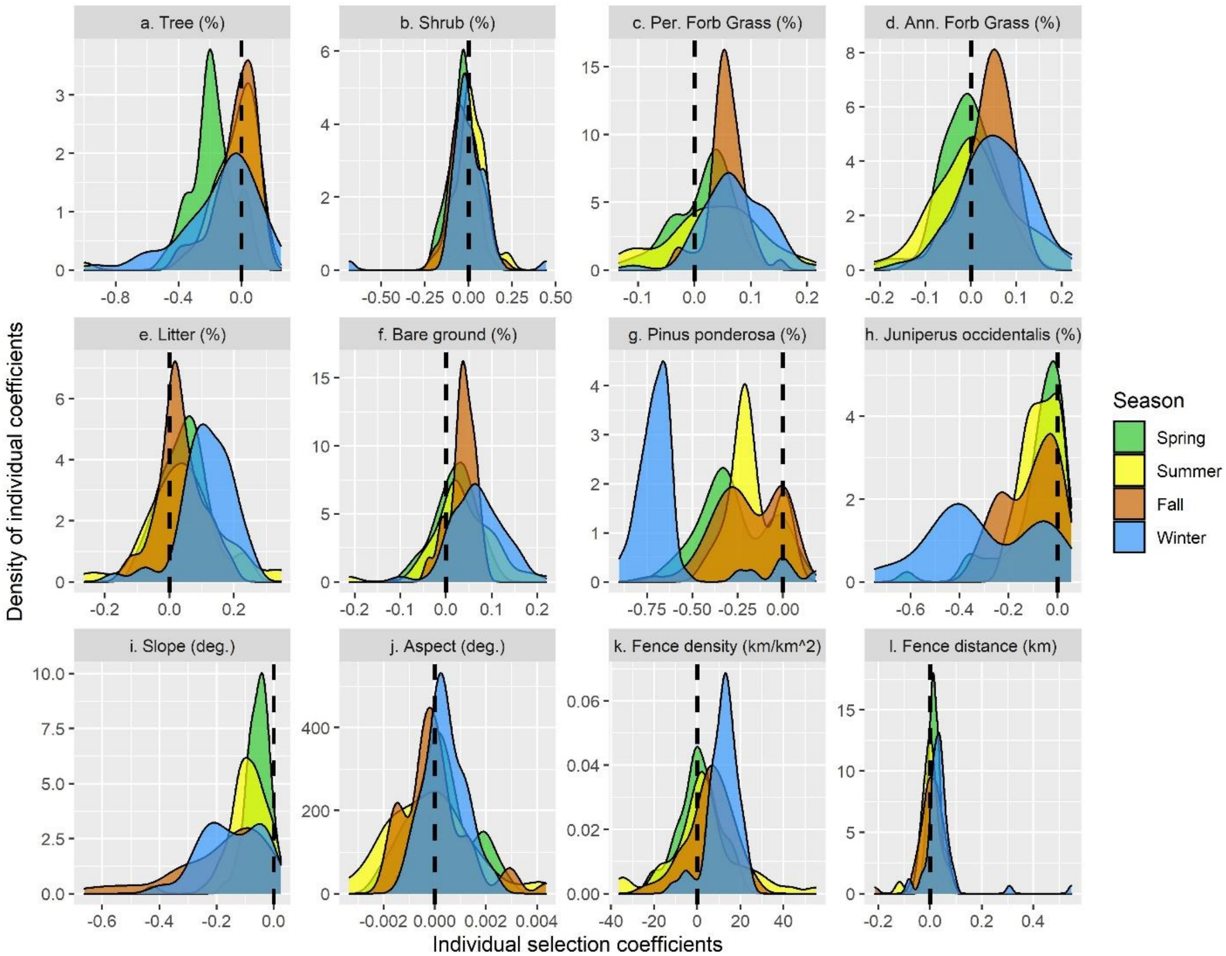


Figure 3. Distributions of individual pronghorn (*Antilocapra americana*) log-odds selection coefficients for twelve covariates during four seasons in central Oregon, USA, 2018-2021. Vertical dashed line represents coefficients of zero (i.e., no selection for or against).

Maps of predicted RSF values elucidated broad spatial patterns in the relative probability of pronghorn selection for and occurrence on the landscape (Figure 4). The northern tier was largely comprised of lowest probability of occurrence, whereas the central and southeastern areas had most of the highest probability of occurrence portions of the landscape. Most strikingly, the seasonal maps, at large scales, were very similar among seasons. This reflected the consistency (or unimportance, i.e., coefficient values near zero), of the seasonal population-level coefficients (Figure 3).

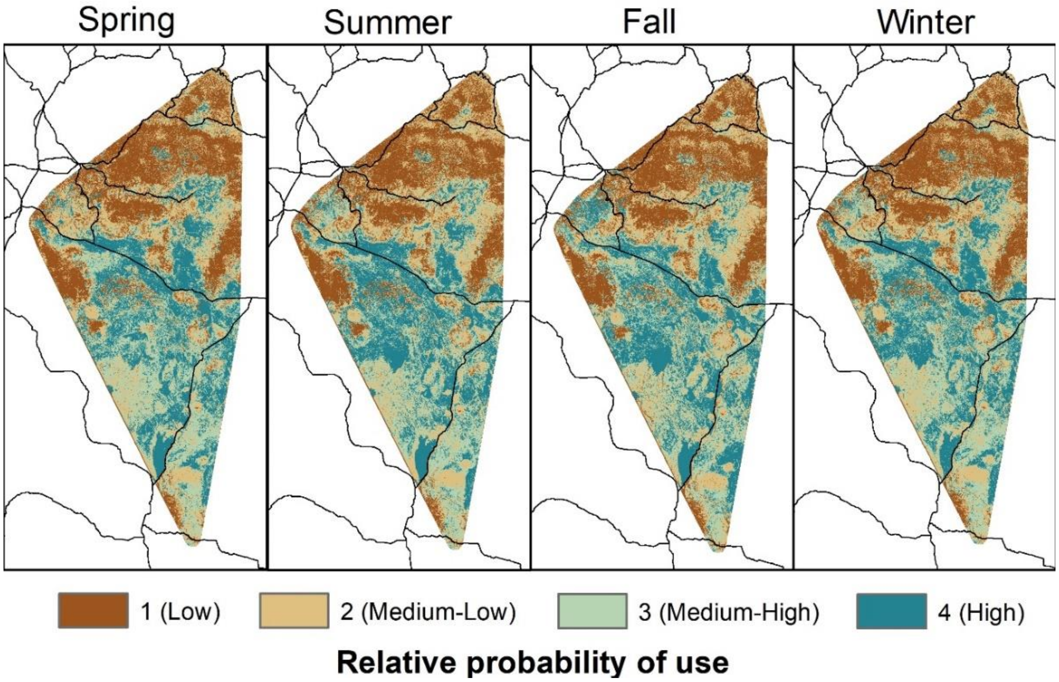


Figure 4. Maps of predicted relative probability of selection of portions of central Oregon, USA, based on seasonal resource selection patterns of 53 GPS-collared pronghorn (*Antilocapra americana*) from 2018-2021.

Despite strong similarities in predicted resource selection across seasons at broad scales, standardized coefficients revealed variation in relative selection strength among variables within across seasons (Table 1). For example, in spring, the dominant variables driving resource selection were avoidance of general tree cover and of *Pinus ponderosa*. In the summer, resource selection was most strongly driven by selection for low slopes and avoidance of *Pinus ponderosa*. During fall, pronghorn resource selection was most strongly driven by selection for low slopes, and during winter, pronghorn strongly avoided *Pinus ponderosa* the most, followed by avoiding steep slopes, *Juniperus occidentalis*, and general tree cover. Looking across seasons within variables, pronghorn selected for higher fence density that increased from spring to winter, with the strongest selection for higher fence densities in winter.

Table 1. Standardized logistic regression coefficients from a hierarchical mixed resource selection function for 53 free-ranging pronghorn (*Antilocapra americana*) in central Oregon, USA, 2018-2021.

	Season			
Covariate	Spring	Summer	Fall	Winter
Tree (%)	-1.45	-0.38	-0.25	-1.01
Shrub (%)	-0.30	0.07	-0.11	-0.03
Per. Forb Grass (%)	0.14	0.33	0.56	0.70
Litter and Duff (%)	0.16	0.15	0.10	0.36
Bare ground (%)	0.24	0.42	0.41	0.82
Ann. Forb Grass (%)	-0.03	0.04	0.22	0.32
Slope (deg.)	-0.65	-1.08	-2.16	-1.75
Fence density (km/km^2)	0.06	0.30	0.56	1.11
Aspect (deg.)	0.02	-0.02	0.00	0.04
Pinus ponderosa (%)	-1.34	-0.89	-0.98	-3.23
Juniperus occidentalis (%)	-0.45	-0.37	-0.61	-1.60
Fence distance (km)	0.19	0.00	0.05	0.46

Our validation of relative probably of use maps (e.g. RSF maps) was highly correlated, indicating their accuracy at predicting occurrence and resource use of the 53 GPS-collared pronghorn (Figure 5) was good. As relative probability of use increased (i.e., from 1 to 4), an increasingly higher proportion of GPS locations occurred within bins of high use (Spearman $\rho = 0.92$, $p < 0.001$).

DISCUSSION

Previous work to identify pronghorn migration timing and behaviors in southern Oregon have found that while the population may be partially migratory, migratory individuals showed clear seasonal migration behavior and distinct seasonal ranges (Collins 2016, Larkins et al. 2018). Here, the majority of pronghorn were non-migratory or showed short-term long distance movements, often returning to the capture area. This may be due to greater behavioral plasticity in resource selection and habitat use by pronghorn in the sampled population, with no need to establish distinct seasonal ranges for most individuals. On the other hand, anthropogenic development, particularly fences, may constrain pronghorn migratory behaviors constraining

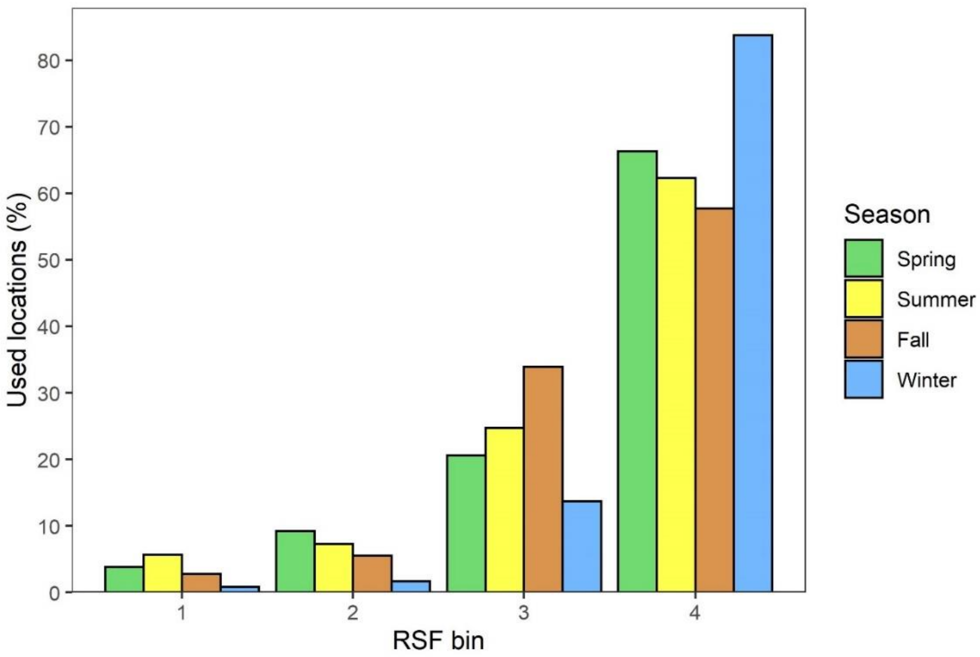


Figure 5. Observed use of each predicted relative resource selection function (RSF) bin by pronghorn (*Antilocapra americana*) in central Oregon, USA, 2018-2021. RSF bin '1' is lowest probability of occurrence and bin '4' is the highest probability of occurrence.

pronghorn to settling for a non-migratory annual cycle (Jakes et al. 2020). Surprisingly, pronghorn selected locations with higher fence density and did not avoid the fences themselves. This may be due to challenges with the input fence datasets, which may have been too coarse to allow for detection of fine scale relationships. Previous work has found that pronghorn avoid fences, but only at broad spatial scales and not once they have chosen a landscape within which to move (Jones et al. 2019, Jakes et al. 2020). Alternatively, central Oregon pronghorn may have been selecting for higher fence density because fence density is reflective of other landscape features. Fences tended to occur in flat, treeless locations. Finally, pronghorn can be facultative migrators (Collins 2016), choosing to move only in response to prevailing environmental condition. The span of this dataset may not have covered sufficient variation in winter severity to observe facultative migration.

As expected based on pronghorn ecology, pronghorn in central Oregon consistently avoided forested areas and selected for flat locations with higher perennial forb and grass cover. Although the importance of individual variables sometimes shifted among seasons, the consistent strong avoidance of tree coverage in general, and *Pinus ponderosa* specifically, meant that the seasonal predictive RSF maps were highly similar among seasons. This is coupled with a low rate of strict seasonal migratory behavior among individual pronghorn, meaning that for pronghorn in central Oregon, the population may be largely non-migratory and simultaneously are selecting locations based on the same general types of pronghorn habitat – flat grasslands with minimal trees. The caveat to this is that the RSF maps reflect the resource selection choices of the collared pronghorn within the observed timespan. Different pronghorn or different time periods may result in different resource selection behaviors, and thus different predictive maps.

There are likely other environmental and anthropogenic covariates that pronghorn respond to when selecting locations on the landscape. For example, from visual inspection several GPS locations were clearly making use of agricultural land, and thus these and other features may be important drivers of seasonal land use in portions of central Oregon.

We also found the frequency with which individual pronghorn deviated from population means in selection to be high, especially during winter. For example, the bulk of pronghorn clearly showed positive selection for % annual forbs and grasses, % litter, % bare ground, and distance from fences (Figure 1) in winter. However, population level confidence intervals for these selection coefficients were extremely wide. We found a similar pattern for avoidance for % tree cover, % shrub cover, % ponderosa pine, and % juniper (Figure 2). This may be due to plasticity in resource selection among individuals. It may also reflect functional resource selection, such that the amount of litter cover influenced the strength or direction of selection. In this case, it could be that if landscape litter cover is high, measured selection becomes weaker as pronghorn began selecting for other resources that are important but more limiting than what is reflected by high litter cover.

Future analyses could explore several findings from this analysis, including additional focus on functional resource selection and a finer-scale focus on the effects of anthropogenic features (e.g., fences, roads, irrigated agriculture) on resource selection and movement to gain a more detailed picture of how variation in resource availability underlies the direction and magnitude of resource seasonal habitat selection.

MANAGEMENT IMPLICATIONS

The majority of pronghorn ranges in southeastern Oregon are currently subject to a number of issues potentially impacting available resources for the species including but not limited to energy exploration and development, increasing recreational activities, catastrophic wildland fires, invasive species, and effects of climate change on habitats. Resource use patterns by pronghorn have not been previously studied in Oregon. This study describes and predicts the resources that are important to pronghorn in central Oregon. Importantly, results of this study will better inform managers when directing response to these factors affecting the species like habitat treatments and energy development. Further, information on seasonal distributions of animals will be useful for designing population surveys. Further work will be required to adequately address issues of movement strategies (migratory, and nonmigratory animals) relative to distributions of habitats and the potential barrier represented by US Highway 20 bissecting the study area.

ETHICS STATEMENT

All pronghorn were captured and marked following the Guidelines of the American Society of Mammologists for the Use of Wild Mammals in Research (Gannon et al. 2007).

LITERATURE CITED

Barnowe-Meyer, K.K., P.J. White, T.L. Davis, J.J. Treanor, and J.A. Byers. 2017. Seasonal foraging strategies of migrant and non-migrant pronghorn in Yellowstone National Park.

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

Bunnefeld, N., L. Börger, B. van Moorter, C. M. Rolandsen, H. Dettki, E. J. Solberg, G. Ericsson. 2011. A model-driven approach to quantify migration patterns: individual, regional and yearly differences. Journal of Animal Ecology, 80(2), 466-476.

Collins, G.H. 2016. Seasonal distribution and routes of pronghorn in the northern Great Basin. Western North American Naturalist 76:101-112.

Gannon, W. L., R. S. Sikes, and the Animal Care and Use Committee of the American Society of Mammalogists. 2007. Guidelines of the American Society of Mammalogists for the use of wild mammals in research. Journal of Mammalogy 88:809–823.

Gillies, C.S., M. Hebblewhite, S.E. Nielsen, M.A. Krawchuk, C.L. Aldridge, J.L. Frair, D.J. Saher, C.E. Stevens, and C.L. Jerde. 2006. Application of random effects to the study of resource selection by animals. Journal of Animal Ecology 75:887-898.

Jakes, A.F., C.C. Gates, N.J. DeCesare, P.F. Jones, J.F. Goldberg, K.E Kunkel, and M. Hebblewhite. 2018. Classifying the migration behaviors of pronghorn on their northern range. Journal of Wildlife Management 82:1229-1242.

Jakes, A.F., N.J. DeCesare, P.F. Jones, C.C. Gates, S.J. Story, S.K. Olimb, K.E. Kunkel, and M. Hebblewhite. 2020. Multi-scale habitat assessment of pronghorn migration routes. PLoS ONE 15:e0241042.

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

Jones, P.F., A.F. Jakes, A.C. Telander, H. Sawyer, B.H. Martin, and M. Hebblewhite. 2019. Fences reduce habitat for a partially migratory ungulate in the Northern Sagebrush Steppe. Ecosphere 10:e02782.

Larkins, A., S. Harju, and D.G. Whittaker. 2018. Pronghorn migration and survival: a statistical analysis of a southeastern Oregon population. 2018 Proceedings of the Western States and Provinces Pronghorn Workshop: Volume 28.

Manly, B.F.J., L.L. McDonald, and D.L. Thomas. 1993. Resource Selection by Animals: Statistical Design and Analysis for Field Studies, Chapman & Hall.

Menard, S. 2011. Standards for standardized logistic regression coefficients. Social Forces 89:1409-1428.

Morris, L.R., K.M. Proffitt, and J.K. Blackburn. 2016. Mapping resource selection functions in wildlife studies: concerns and recommendations. Applied Geography 76:173-183.

Singh, N.J., A.M. Allen, and G. Ericsson. 2016. Quantifying migration behavior using net squared displacement approach: clarifications and caveats. PLoSOne 11: e0149594

ICE AGE PRONGHORN OF NORTH AMERICA

RICHARD S. WHITE, *The Mammoth Site, 1800 US Highway 18 Bypass, Hot Springs, SD 57747*, rswhite@mammothsite.org

GARY S. MORGAN, *New Mexico Museum of Natural History and Science, 1801 Mountain Road N.W., Albuquerque, NM 87104*

ABSTRACT Four genera (with a total of 9 species) of pronghorn are known from the Ice Age or Pleistocene (Late Blancan to Rancholabrean) of North America: Capromeryx, Stockoceros, Tetrameryx, and Antilocapra. Ironically, the living pronghorn, Antilocapra americana, has a meager record in the Pleistocene, despite its abundance and wide distribution in recent times. Only 7 records of Antilocapra in the Pleistocene are recognized as valid; most of the remaining 85 records in the literature are based on non-diagnostic fragments. Antilocapra overlaps in size with Stockoceros and Tetrameryx; Stockoceros being mainly smaller, and Tetrameryx being mainly larger than the modern species. Identification of Antilocapra in the Pleistocene has been based primarily on size; Tetrameryx being ignored in most such considerations. To complicate comparisons further, there is no known occurrence of a Tetrameryx skull being directly associated with a skeleton, so we have no known reference for its postcranial remains, and no idea of potential variation in size. We examine the distribution of Ice Age pronghorn in time and space, discussing the occurrence of these animals in cave and karst deposits versus open sites. Finally, we highlight the interesting problem of why three genera, two of them roughly the same size as the modern species and one a dwarfed form, should have become extinct by the end of the Pleistocene. We review and contrast previous explanations of why the extant American pronghorn survived and flourished, concluding that dietary plasticity was likely the determining factor.

KEY WORDS *Antilocapra, Capromeryx, Stockoceros, Tetrameryx, Ice Age, Dietary Plasticity*.

INTRODUCTION

The living pronghorn, an iconic symbol of the North American prairie, is the sole living member of its family, Antilocapridae. First appearing in North America some 27 or 28 million years ago (Beaty and Martin, 2009) in the late Oligocene (Early Arikareean North American Land Mammal Age NALMA) they were likely descended from Early Oligocene ancestors in Asia. Once they appeared in North America, they radiated and diversified into 21 genera (Janis and Manning, 1998) with several dozen species. The phylogeny is certainly over split at the species level, and perhaps also at the genus level, particularly the primitive forms, the merycodontines. Pronghorn evolved an amazing variety of horn forms, some with multiple tines on each side (2 or 3), others with branched, twisted and even spiraled horns. These were described and illustrated in the Proceedings of the 20th Biennial Pronghorn Workshop (Heffelfinger et al. 2002). This paper concentrates on the more recent diversification of pronghorns in Antilocaprinae, and those in particular that lived during the Pleistocene (Ice Age) beginning about 2.6 million years ago.

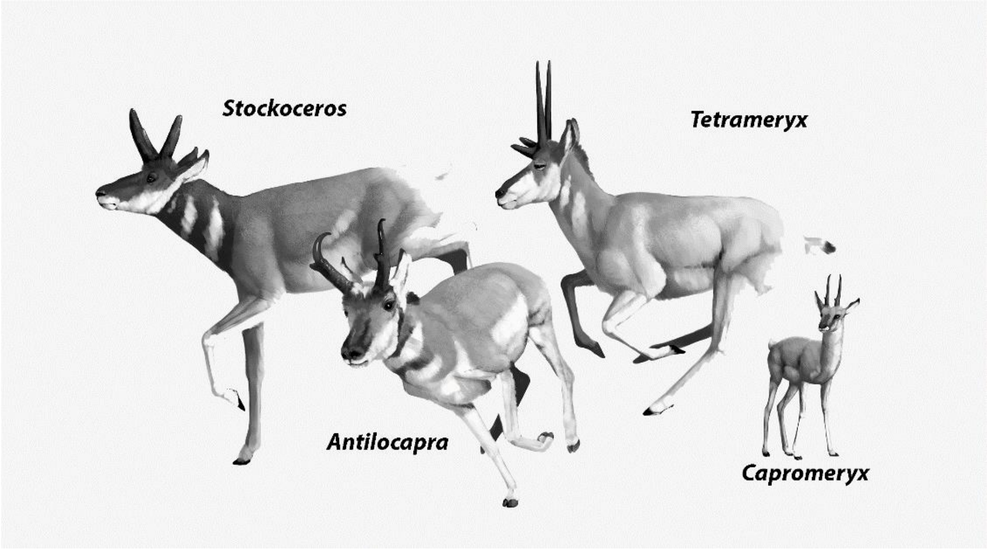
MATERIALS AND METHODS

We compiled a database of all occurrences of pronghorn fossils in North America based on an extensive literature search. For many of these, the authors examined the collections and verified the identifications. Where we were not able to verify the identification, we judged the validity of the identifications made by others based the nature of the material described – that is, what elements of the skeleton were present, whether they were complete or fragmented, and the distinctiveness of that element among the 4 genera being considered. We then mapped those occurrences for each of 4 time periods: Early Blancan, Late Blancan, Irvingtonian and Rancholabrean to understand the geographic distribution of each genus through time. We combined this data with information on isotopic data on food preferences, as well as micro- and meso-wear patterns on teeth to understand potential dietary differentiation. This information was then utilized to evaluate the various explanations provided by previous authors for the survival of *Antilocapra americana*, and to suggest the most likely available explanation.

SPECIES ACCOUNTS

Four genera of pronghorns are known as fossils from the Pleistocene (Figure 1). *Capromeryx* (with three species), *Stockoceros* (with two specie plus one undescribed), *Tetrameryx* (with two species) and *Antilocapra* (one species), which survived into the Holocene and is widespread today (see Kurtén and Anderson, 1980 for a summary of the Pleistocene forms). A brief discussion of each genus is presented here.

Figure 1. The four genera of Ice Age pronghorns. Artist: Benji Paynose, Arizona Museum of Natural History.



Capromeryx
The earliest of the Ice Age pronghorn to appear in the fossil record is *Capromeryx*, which appeared prior to the onset of the Ice Age, in the Early Blancan, some 3 million years ago. Known from Washington, New Mexico and from Mexico, *Capromeryx tautonensis* was the largest species in the genus, nearly the size of modern pronghorn. Each horn core had two prongs of nearly equal size, which stood straight up from above the eye socket and were parallel to each other (Figure 1), not diverging as in *Stockoceros* and *Tetrameryx*. By the early Pleistocene (late Blancan), *C. tauntonensis* had evolved into *C. arizonensis*, slightly smaller in body size than its predecessor, and with the anterior (front) prong of each horn smaller than the posterior (back) prong. The latest individuals of *C. arizonensis* had anterior prongs only half the length of the posterior prong. *C. arizonensis* gave rise to the dwarfed terminal species, *Capromeryx furcifer*, in which the anterior prong was less than 50% the length of the posterior prong (White and Morgan 2011). *C. furcifer* was tiny, weighing perhaps 10 – 13 kilograms ($\leq$ 28 lbs., Saysette, 1999). *Capromeryx* fossils are known from at least 140 locations in North America. The last species of *Capromeryx* was a dwarfed form adapted to an open woodland habitat in which its predator avoidance mechanism was hiding rather than fleeing, as suggested by White and Morgan (2011, based on comparing antilocaprids with the African bovids as described by Jarman (1974).

Stockoceros
Stockoceros is known from two named species, *S. conklingi* and *S. onusrosagris* (Kurtén and Anderson, 1980). More recent authors have synonymized the two, with *S. conklingi*. Slight differences in the way the samples from Papago Springs Cave (Arizona) and San Josecito Cave (Mexico) were measured are responsible for the claimed size difference between the two species. There is also an undescribed species from the early Pleistocene of El Golfo, Sonora, Mexico, which may belong to *Stockoceros*, or may warrant a new genus name (R.S. White unpublished data). *Stockoceros* is on the average slightly smaller than *Antilocapra*, but the largest *Stockoceros* overlap in size with the smallest *Antilocapra*. The anterior and posterior prongs on each horncore are sub-equal in length (Figure 1). *Stockoceros* is known from 43 localities in North America.

Tetrameryx
The largest of the four antilocaprid genera is *Tetrameryx*, with two species, *T. irvingtonensis* and *T. shuleri*. *Tetrameryx* is on average slightly larger than *Antilocapra*, but the two species overlap in size. *Tetrameryx* is represented mostly by horn cores; there are no known postcranial remains directly associated with a skull, so we have little idea of the range in variation of limb measurements. *Tetrameryx* has two prongs on each horn core; the posterior one is greatly elongated and is as much as 3 to 4 times the length of the anterior tine (Figure 1).

Antilocapra
The living American pronghorn is represented by one species, *Antilocapra americana*. *Antilocapra* has a single, upright large horn with an anterior hook, or prong, underlain by a blade shaped core with a slight bulge where the anterior hook, (or prong), is located in the horn sheath. *Antilocapra* averages slightly larger than *Stockoceros* and slightly smaller than *Tetrameryx* but overlaps with both. There are 92 records in the literature of *Antilocapra* from the Rancholabrean NALMA; however, we consider only seven of those records as valid in this study. The remaining 85 records consist of isolated bones or fragments of bones which cannot be reliably distinguished from large *Stockoceros* or small *Tetrameryx*. It is likely that at least some of those

records do pertain to *Antilocapra*, but that cannot be determined with any degree of certainty. The record of *Antilocapra* in the Holocene is more reliable, simply because the other two genera became extinct at the end of the Pleistocene. We provisionally accept the record for *Antilocapra* in the Holocene as enumerated by McCabe et al. (2004), consisting of 366 records, primarily from archaeological sites. It should be noted that some of those records may have confused pronghorn with mule or white-tailed deer (*Odocoileus* spp.), as they are roughly of similar size. Lawrence (1951) provides reliable osteological characters separating *Antilocapra* from *Odocoileus*. *Antilocapra* was apparently rare in the Rancholabrean, but abundant in the Holocene. Estimates of pronghorn population size during their peak in the Holocene just prior to the arrival of European settlers to as much as 30 – 40 million animals (O'Gara and Yoakum, 2004).

DISTRIBUTION THROUGH THE ICE AGE

Figures 2 – 5, (Maps 1-13) depict the distribution of the four genera of pronghorn through the Ice Age (Pleistocene Epoch: Late Blancan, Irvingtonian and Rancholabrean NALMA). The sites where each has been found have been plotted at a coarse scale on the maps, with each state in which specimens of that genus have been recovered shaded in. A shaded state may represent only one site, or it may represent dozens. At the scale of these maps, the distribution is adequately represented; the only exception to this is in the Canadian Provinces, where pronghorn are known only from the southernmost portions of Saskatchewan, Manitoba and Alberta. However, the entire Province has been shaded on the maps to keep the method consistent.

Capromeryx has perhaps the most interesting distribution through time (Figure 2, Maps 1-4). First appearing before the Ice Age in the early Blancan in Washington, New Mexico and Hidalgo, Mexico, by the Late Blancan it had spread eastward into what is now the Great Plains (Kansas and Nebraska), and there are also records from the Intermountain West (Arizona, New Mexico, Texas). Most strikingly, it is abundant in the Late Blancan of Florida with large samples at several sites, including Inglis 1A and the Santa Fe River. *Capromeryx* occurs in the Inglis 1A site, together with reptiles (alligator lizard, western hognose snake), birds (condor, burrowing owl, scrub jay), and small mammals (jackrabbit, pallid bat) indicative of savanna/grassland or arid habitats in western North America (Morgan and Emslie, 2010), as well as a similar number of species of South American origin that were participants in the Great American Biotic Interchange (glyptodonts, armadillos, pampatheres, three genera of ground sloths, capybara, porcupine, giant flightless bird). Morgan and Emslie (2010) proposed that two savanna or grassland corridors existed in the southeastern US in the early Pleistocene, one connecting Florida to western North American and a second, the Gulf Coast savanna corridor, connecting Florida with more tropical habitats in Mexico along the Gulf of Mexico coastal plain. These early Pleistocene savanna corridors appear to coincide with glacial intervals characterized by lower sea level and a drier climate in Florida. The late Blancan records of *Capromeryx* in Florida are the only occurrences of this genus east of the Mississippi River; at the end of the Blancan they disappear from Florida.

In the Rancholabrean, near the end of the Ice Age, *Capromeryx* is abundant in the west, with 74 records from California, Nevada, Arizona, New Mexico, Texas, Kansas, and Nebraska. Records in Mexico include Baja California Norte, Sonora, Chihuahua, Coahuila, San Luis Potosi, Guadalajara, Michoacan, Guerrero, Aguascalientes, Hidalgo, Veracruz, Puebla, and Mexico. *Capromeryx* is found about equally in cave and karst features as in open sites (32 versus 42 sites); in most cases the number of identified specimens per site is low, with fewer than 10 specimens. The exceptions are the sites in Florida mentioned above, and at Rancho La Brea in California. In the Florida localities, adult animals predominate; in the sample from Rancho La Brea, juveniles and near neonates predominate, suggesting a very different mode of accumulation. It is likely that *Capromeryx* was a favored prey of the many large raptorial birds known from Rancho La Brea, while the Florida sites were likely pitfall or carnivore den accumulations.

At the beginning of the Ice Age, *Capromeryx* shifted from a mixed feeding strategy (grazing and browsing) to a primarily browsing diet, based on meso-wear and micro wear analyses of the teeth (Semprebon and Rivals, 2007). This is interpreted to reflect its dwarfing and probably a change from a herd animal to one living a more solitary life in the open woodland environments which dominated western North America, as proposed by White and Morgan (2011) based on the guild comparison with African bovids by Jarman (1974).

Stockoceros is known from a few sites (Figure 3) at the beginning of the Ice Age in the Irvingtonian from California, Colorado, Nebraska, Texas and in Sonora, Mexico. In the Rancholabrean, it is more widely spread, occurring in California, Arizona, New Mexico, Texas, and Nebraska in the US and in Aguascalientes, Baja California Sur, Hidalgo, Mexico, Nuevo Leon, Puebla, San Luis Potosi, Sonora, and Veracruz in Mexico. Two large samples of *Stockoceros* are known, one from Papago Springs Cave in Arizona, with a minimum number of individuals of 76, and another from San Josecito Cave, in Nuevo Leon, Mexico, with at least 176 individuals. Previously thought to have been inhabited by those pronghorns (Skinner 1942), both sites were pitfall accumulations (Czaplewski et al., 1999; White and Morgan, 2022). *Stockoceros* occurs in cave and karst features slightly more frequently than does *Capromeryx* (21 versus 23 sites); the two occur together in 10 sites. *Stockoceros* had a mixed diet, feeding on graze and browse, perhaps regionally or seasonally (Semprebon and Rivals, 2007). *Stockoceros* also has a higher index of hypsodonty (a measure of how high-crowned the teeth are) than does modern *Antilocapra* (Sembrebon, et al., 2019).

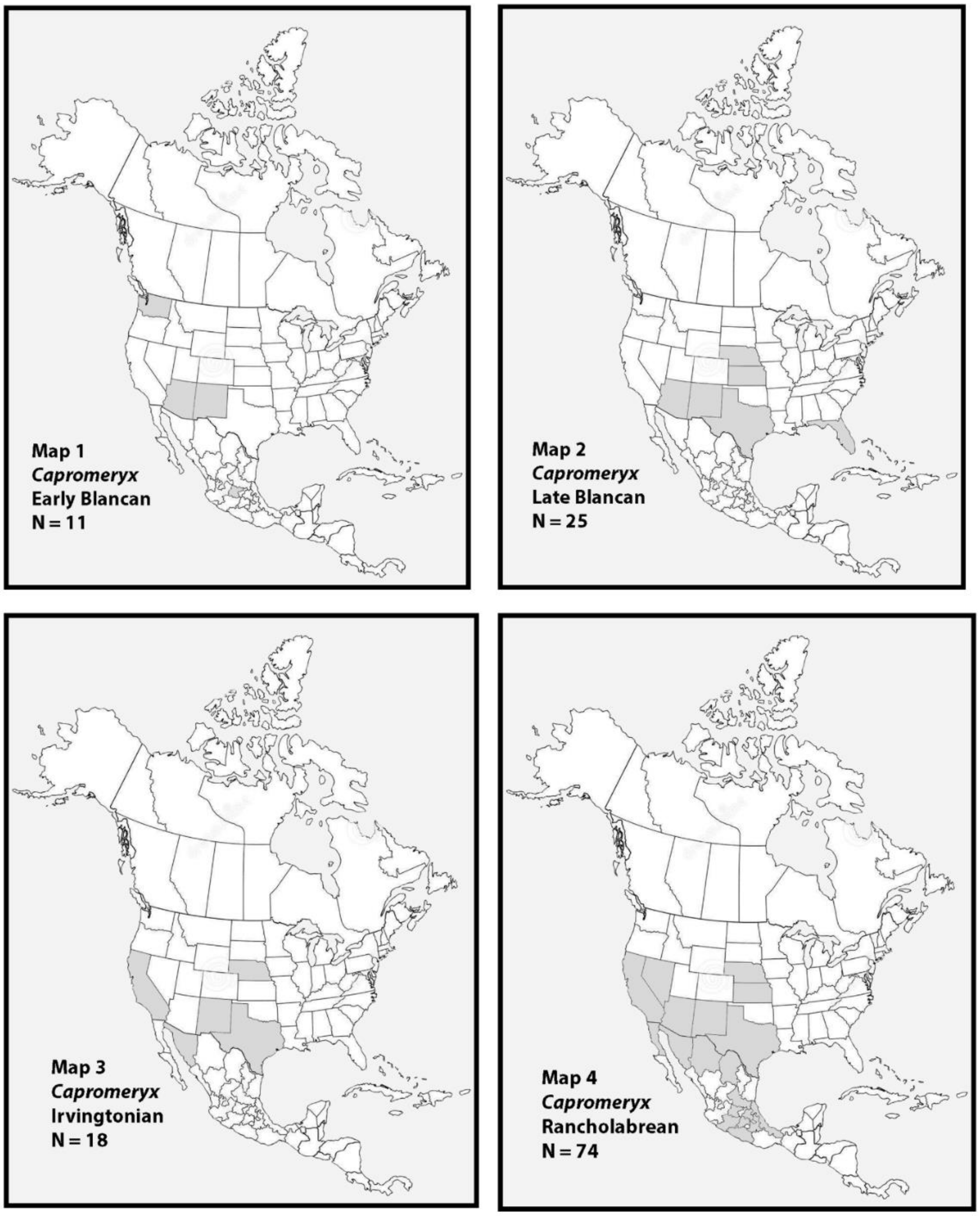


Figure 2. Maps 1 – 4. Distribution through time of Capromeryx.

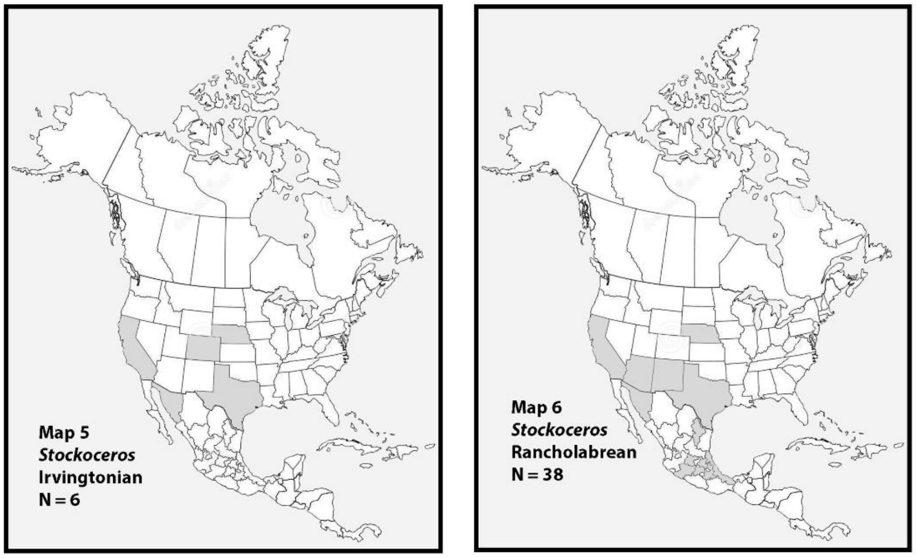


Figure 3. Maps 5 and 6. Distribution through time of *Stockoceros*.

Tetrameryx is the rarest of the 4 genera overall (Figure 4), with only 3 occurrences in the Blancan from Arizona and California, 7 in the Irvingtonian from California, Sonora and Texas, and 21 in the Rancholabrean from California, Nevada, Utah, and Texas in the US, as well as Sonora, Aguascalientes, Jalisco, Michoacan, Guanajuato, Puebla, Veracruz and Zacatecas in Mexico. They are known only from open sites; *Tetrameryx* has not been found in any cave or karst feature. We know very little about *Tetrameryx* other than its skull. Postcranial remains are rare and questionably referred to T*etrameryx* based only on its slightly larger average size relative to *Antilocapra*. There are no skeletons associated with a skull.

Antilocapra presents several difficulties in determining its past distribution. Not known before the Rancholabrean, it has been reported in the literature as occurring at 92 localities (Figure 5). However, nearly all these records are based on a single specimen, sometimes just a fragment of a bone. Because *Antilocapra* overlaps in size with both *Stockoceros* and *Tetrameryx*, it is impossible to allocate such fragmented material to one of the three genera. Of the 92 records, we consider just 7 of them to be referrable to *Antilocapra*. It is likely, of course, that at least some of those indeterminate records are, in fact, *Antilocapr*a.

Figure 4. Maps 7 – 9. Distribution through time of *Tetrameryx*.

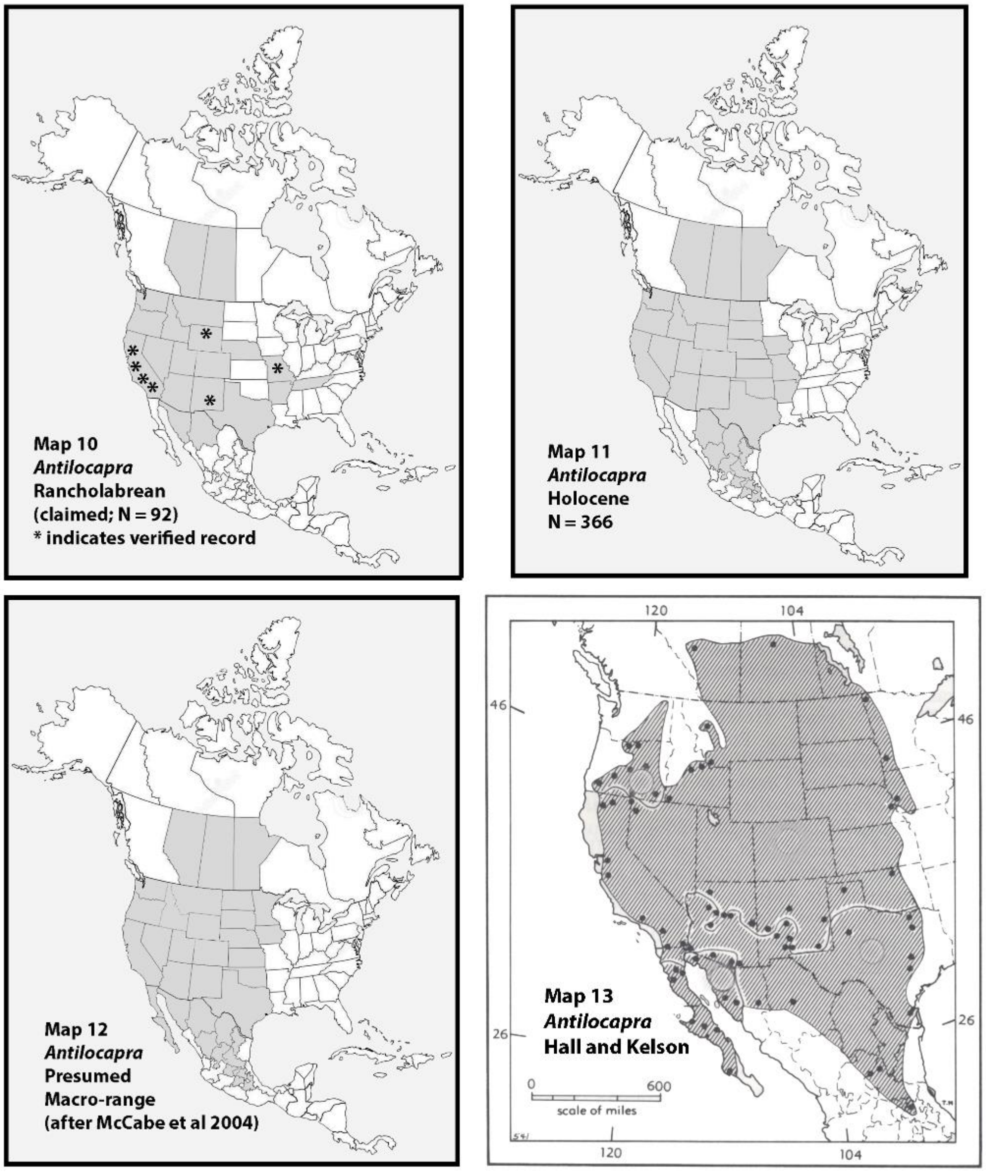


Figure 5. Maps 10 – 13. Distribution through time of Antilocapra. Maps 11, 12 and 13 all refer to the post-Pleistocene, 11K to the present; 11 is based on the distribution of recovered bone remains; Map 12 is based on a combination of historical records and vegetation types, while Map 13, modified from Hall and Kelson (1959) is based on museum specimens, with only specimens which determine the boundary plotted as dots.

We have much more confidence in the Holocene record, since by then *Stockoceros* and *Tetrameryx* were extinct. The distribution of *Antilocapra* in the Holocene matches its distribution in modern times (Figure 5). *Antilocapra* has less high-crowned teeth than did *Stockoceros* (Sembrebon et al., 2019), also indicative of *Antilocapra* pursuing a more varied feeding strategy with less reliance on grasses. *Antilocapra* and the extinct antilocaprids have often been portrayed as quintessential grasslands grazers, with hypsodont teeth throughout their evolution; but studies of modern pronghorn show that despite their hypsodont teeth, their diet is a widely variable mixed feeding strategy with grasses comprising less than 12% of the diet on a yearly basis (O'Gara and Yoakum, 2004). The hypsodont teeth of modern pronghorn are a heritage from their antilocaprid ancestors, and not a response to their present-day habitat and diet. The retention of hypsodont teeth is part of their dietary plasticity, enabling them to feed on grasses, forbs and small browse (so-called "dirty browse") at certain times of the year, or in specific locations, where leafy plants are not available.

EXPLAINING THE SURVIVAL OF ANTILOCAPRA

Our review of the distribution of Ice Age pronghorns in time and space poses an obvious question. Why did Antilocapra americana survive the extinction at the end of the Ice Age, while three closely related pronghorn, Capromeryx, Stockoceros and Tetrameryx all became extinct? What was different about Antilocapra which gave it an advantage over the others? Potential explanations for the survival and flourishing of Antilocapra americana after the end of the Ice Age are available. They can be roughly grouped into three categories: 1) morphological, physiological, and behavioral; 2) the end-Pleistocene extinctions themselves; and 3) climate change and shifting vegetation zones.

Morphology, physiology, and behavior

Several authors have appealed to distinctive features of the physiology, behavior, and morphology of the living pronghorn as an explanation for their success. Physiological mechanisms to regulate body temperature and prevent desiccation are mentioned by O'Gara and Brown (2004) and by McCabe et al. (2004). Brown and Ockenfels (2007) cited its large body size and its speed, combined with behavioral adaptations to cold and drought, as the key to its success. Such appeals are unsatisfying because we know little information on these traits in the extinct pronghorn.

In terms of skeletal morphology, *Antilocapra* is nearly the same size as *Stockoceros* and *Tetrameryx*, but *Capromeryx* is far smaller. The body mass of *Capromeryx* was estimated as 10-13 kilograms by Saysette (1999), while the body mass of the living pronghorn ranges from 40 to 60 kilograms (88 to 132 lbs.), depending on sex, time of year and forage conditions (O'Gara and Yoakum, 2004). *Stockoceros* averaged slightly smaller and T*etrameryx* slightly larger than *Antilocapra*. In terms of cursorial ability, limb measurements and relative size of limb segments in *Stockocreros* and *Tetrameryx* are broadly similar to *Antilocapra*, so there is little evidence supporting any significant difference in speed.

Turning to behavioral characteristics, we do have the ability to evaluate feeding strategy for the extinct pronghorns. Meso-wear and micro-wear analyses of the occlusal surfaces of the teeth can provide information on the nature of the plant food being consumed, and carbon and oxygen isotope analyses can indicate preferential feeding on C3 or C4 plants. Semprebon and Rivals (2007) analyzed micro-wear and meso-wear patterns for a wide variety of antilocaprids, including all 4 of the Ice Age genera. Their analyses (Figure 6) show clear niche partitioning among the pronghorns, with *Capromeryx* a browser, *Stockoceros* a mixed feeder and *Tetrameryx* a grazer; *Antilocapra* occupies a position close to all three strategies, indicating dietary plasticity with the ability to shift into either browsing, grazing or a mixed strategy as environmental conditions changed. Connin et al. (1998) analyzed a wide variety of Ice Age herbivores from the southwestern United States in order to understand the distribution of C4 and C3 grasses in the Late Pleistocene. Their data show (Figure 7) that antilocaprids had the lowest reliance on C4 grasses among the large herbivores (*Mammuthus*, *Bison*, *Equus* and *Camelops*) indicating that despite their habitat being dominated by C4 grasses, they relied heavily on C3 plants (grasses, forbs, shrubs and foliage). Retaining a significant degree of hypsodonty gave them the plasticity to shift towards a mixed or grazing feeding strategy when their preferred browse plants were not available.

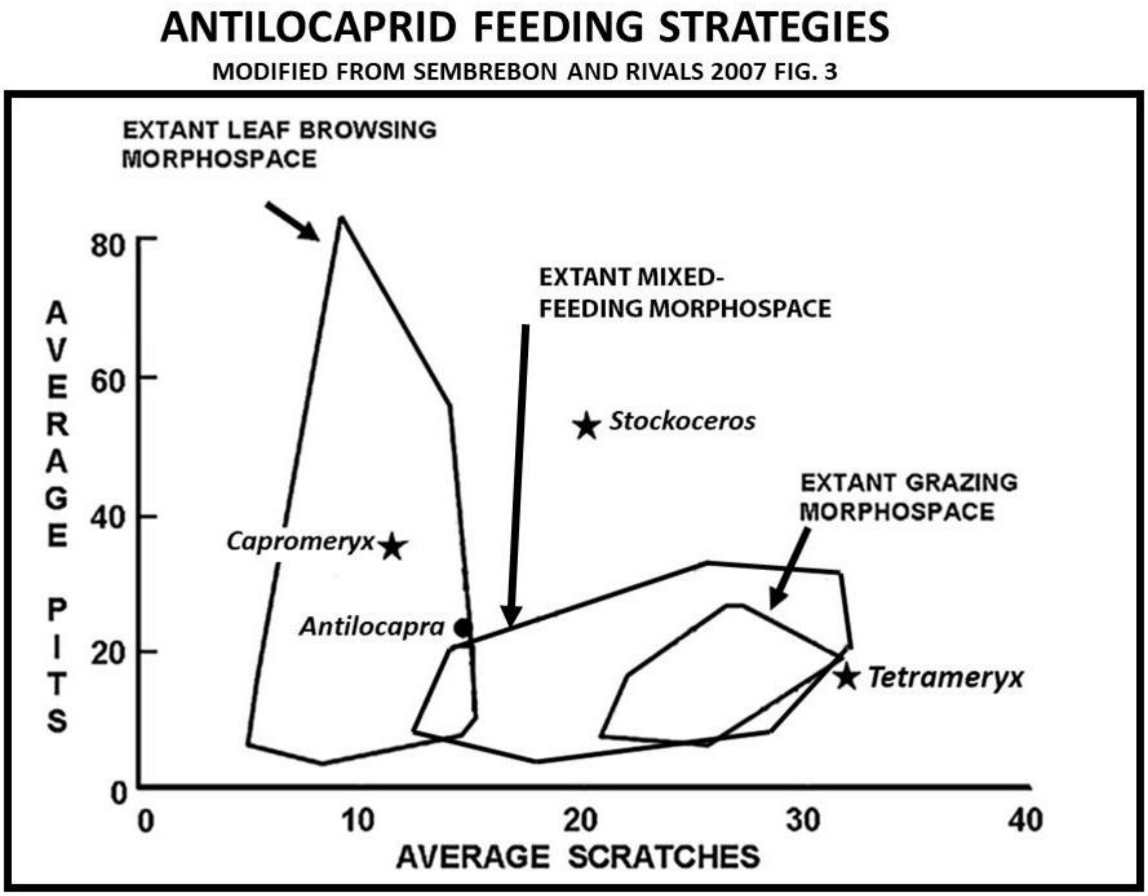


Figure 6. Meso-wear and micro-wear data, modified from Semprebon and Rivals (2007, Fig. 3). Capromeryx plots well within the morphospace occupied by extant browsers; Stockoceros is intermediate indicating a mixed feeding strategy but with more reliance on browsing than other mixed feeders; and Tetrameryx shows a grazing strategy with occasional reliance on browsing. Antilocapra occupies a position just withing the browsing morphospace but positioned so it could easily move into the mixed feeding or grazing spaces.

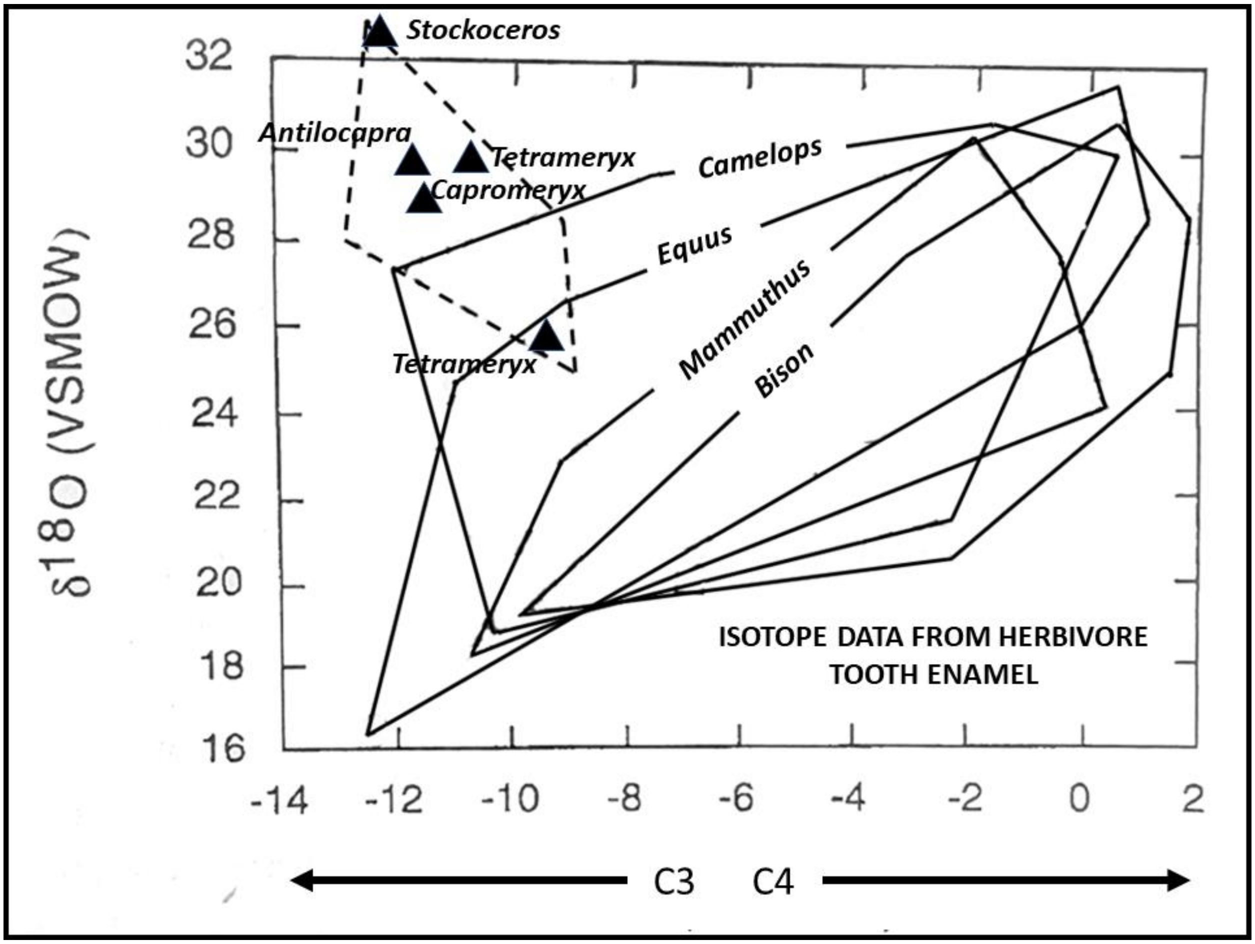


Figure 7. Carbon and Oxygen isotope data from mega-herbivores from the Late Pleistocene of the Southwestern US. Modified from Connin et al. (1998). Dashed line indicates morphospace of antilocaprids. Antilocapra, Stockoceros and Capromeryx fed primarily of leafy C3 plants, while Tetrameryx occasionally consumed slightly more C4 grasses and shrubs.

Pleistocene Extinctions

At the end of the Ice Age, a major extinction event occurred about which much has been written. Several different scenarios have been proposed to explain those extinctions, but for the purpose of this paper the cause is not relevant. The question is why *Antilocapra* survived, and the other three pronghorns do not survive. It is clear that the extinctions did take place. The extinctions have three implications which are considered here: 1) reduction of competition, 2) emptying of ecological niches, and 3) the reduction of predators. Figure 8 illustrates the severity of the end-Pleistocene extinctions, showing the reduction of mega-herbivores and the reduction of mega-carnivores. Large mammals were more severely affected than were medium or small bodied mammals in both the mega-herbivore and mega-carnivore guilds. Thirty-five genera of large mammals (Fig. 8) became extinct in North America at the end of the Pleistocene (Faith and Surovell, 2009).

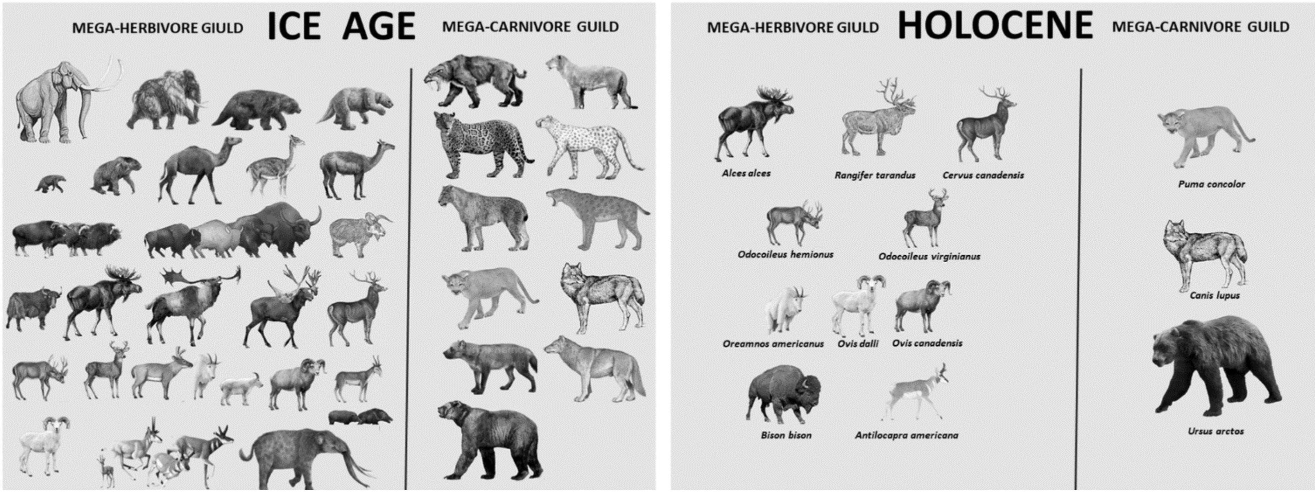


Figure 8. Graphic illustration of the reduction of the mega-herbivore and mega-carnivore guilds from the Ice Age fauna to the Holocene post-extinction fauna. (Original chart; individual animals modified from numerous sources.)

Significant reduction in the number of species in each guild took place with the extinctions; decreased competition for resources within the prey populations would have resulted, allowing their populations to increase. This increase is a pattern seen in several of the Ice Age survivors. Bison were relatively uncommon in the Pleistocene; immediately after the Ice Age they increased in population until, at their peak, they numbered an estimated 30-60 million bison (Meager, 1978). Pronghorn, also seemingly uncommon in the Ice Age, increased their numbers to 20-40 million (Seton, 1909; O'Gara and Yoakum, 2004). Mule deer and black-tailed deer may also have increased in number and range at the same time, although the evidence for this is equivocal. Other large game animals in the western US were incredibly abundant when Europeans began pushing westward, having also spread throughout the same area inhabited by pronghorn (see Maps 11 – 13). This, of course does not explain why *Antilocapra* was the one species out of the 4 genera which did survive; it merely describes that survival and subsequent proliferation. The paucity of predators also would have facilitated the survival and spread but again does not explain why *Antilocapra* was benefited over the other species of pronghorn..

Climate change and shifting vegetation zones

One of the characteristics of the Ice Age was the alternation of periods of cooling and warming. With these changes came the concomitant shifting north and south of vegetation zones in the areas south of the margin of continental glaciation. Figure 9 shows the biotic zones of North America at full glacial, immediately post glacial and in modern times.

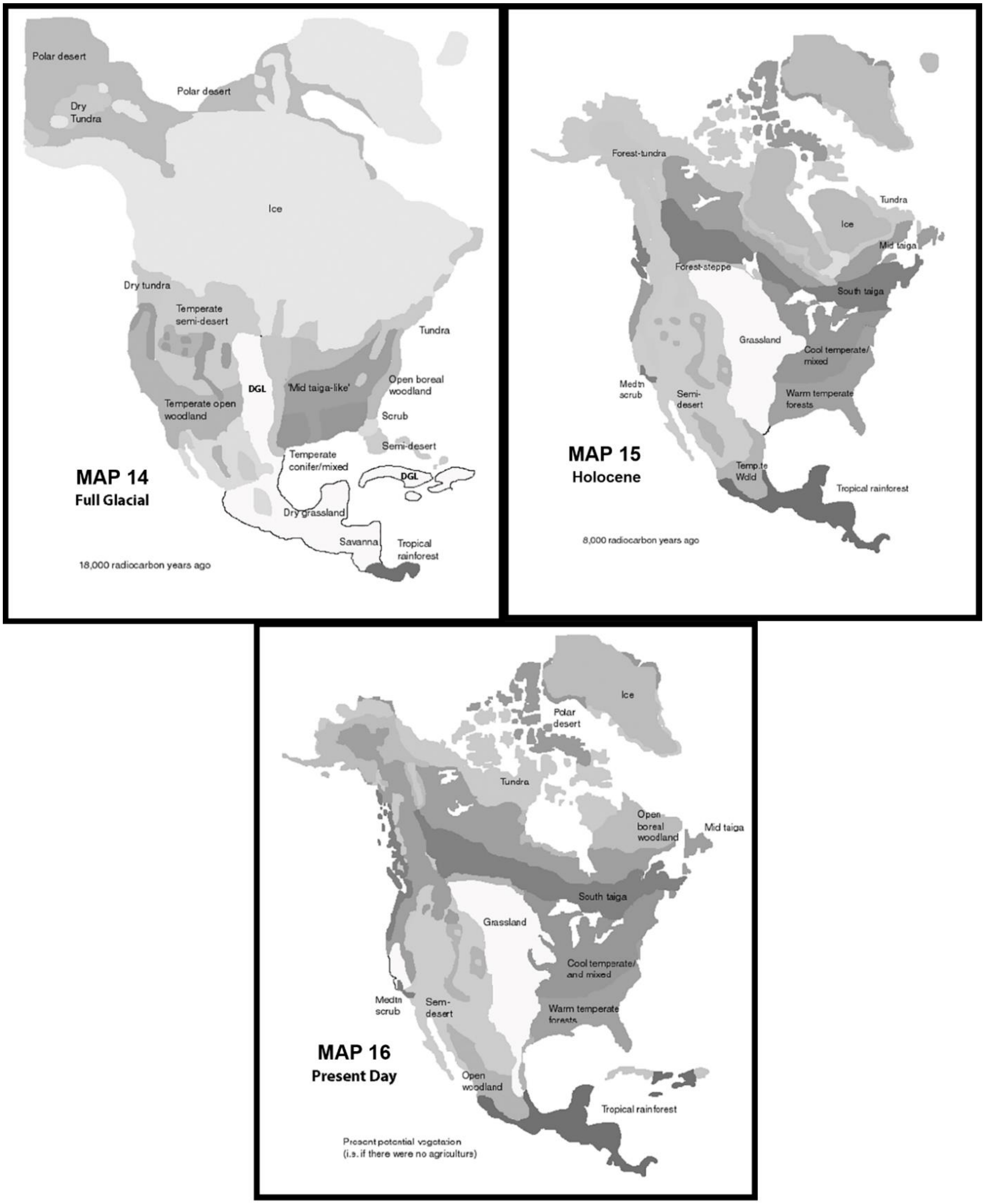


Figure 9. Maps 14-16. The shifting of vegetation zones after the Ice Age. Map 14 (upper left) shows biotic zones at Full Glacial times, about 18,000 years before present; Map 15 (upper right) depicts the biotic zones well after the end of the Ice Age, about 8,000 years before the present; Map 16 (bottom) shows modern distribution similar to that of the Holocene. Modified from Adams J.M. & Faure H. (1997).

The shifting of vegetation zones after the Ice Age are shown on Maps 14 – 16. Map 14 shows biotic zones at Full Glacial times, about 18,000 years before present. Note the reduced northern limit of dry grasslands, and their southern extension well into Mexico and Central America. Map 15 depicts the biotic zones well after the end of the Ice Age, about 8,000 years before the present. Grasslands have moved well northward into Canada and spread significantly east and west. The semi-desert biome has expanded north as well as south; also extending further east and west. The two biomes together covered most of western North America. In modern times (discounting agriculture) the distribution is similar to that in the Holocene, with some retraction of the grasslands westward, but significant extension back into Mexico along the Atlantic corridor. Climate change and shifting biotic zones describes factors allowing the success of *Antilocapra americana*, but do not explain why, of the 4 genera, it alone survived.

SUMMARY

WHY ANTILOCAPRA? If many of the potential explanations as outlined above are unsatisfactory, what then is the reason that *Antilocapra* survived the mass extinction event that occurred at the end of the Ice Age? The only explanation which considers the characteristics of the three extinct pronghorns *Capromeryx*, *Stockoceros*, and *Tetrameryx* is behavioral, and perhaps indirectly physiological. Dietary plasticity seems likely to have allowed Antilocapra to shift its diet into browsing, grazing or a mixed feeding strategy depending on variations of habitat and the availability and abundance of preferred plant foods. *Antilocapra* alone appears to have been able to shift with the changes in climate and vegetation, preferring browse high in C3 plant foods. It retained a high degree of hypsodonty enabling it to graze seasonally, by geographic location or in times of changing climate. *Capromeryx* was a dwarfed form adapted to an open woodland habitat feeding on leafy browse. *Stockoceros* was a mixed feeder, though with a high reliance on leafy browse, apparently avoiding grazing altogether (Semprebon and Rivals 2007). We have less data for *Tetrameryx*, but it appears to have placed greater reliance on C4 grasses, and hence grazing, than the other Ice Age pronghorn.

Of all previously suggested explanations for the success of *Antilocapra*, perhaps the one closest to the mark was offered by Brown and Okenfels (2007):

"The only prongbuck remaining to be hunted by newly arrived humans was the animal we now know as the pronghorn…. Having emerged from its intermountain refugia, physiologically and behaviorally adapted to both cold and drought, this singular prongbuck was able to successfully occupy the continent's semiarid grasslands and advancing deserts… Perhaps the secret of the pronghorn's success was its retention of body size, which, coupled with its cursorial abilities, allowed the animal to range widely, abandoning deteriorating habitats and colonizing newly available areas." We suggest dietary plasticity as underling much of that success.

ACKNOWLEDGEMENTS

We thank Jim Mead and Jim Heffelfinger for their comments on the manuscript which helped improve the manuscript. R.S. White would like to thank Earl Manning for decades of discussions about pronghorn which helped inform my ideas. Jim Heffelfinger (AZGFD) shares my interest (obsession) with pronghorn biology, and it was he who suggested that I participate in this workshop. Jim Mead has provided a supportive intellectual environment at The Mammoth Site and encouraged my research. Carolyn Torrey White aided and encouraged me in many ways, not the least of which was making me promise to continue my research and writing shortly before her death in August 2020 – Q.E.P.D.

LITERATURE CITED

Adams, J.M. and H. Fauvre, 1997. QEN Members. Review and atlas of palaeovegetation: Preliminary land ecosystem maps of the world since the Last Glacial Maximum. Oak Ridge National Laboratory, TN, USA . http://www.esd.ornl.gov/projects/qen/adams1.html. Accessed 23 April 2023.

Beaty, B.L. and L.D. Martin., 2009. The earliest North American record of the Antilocapridae (Artiodactyla, Mammalia). PaleoBios 29(1): 29-35.

Brown, D.E. and R.A. Ockenfels. 2007. Arizona’s Pronghorn Antelope, A Conservation Legacy. Arizona Antelope Foundation, 190 pp.

Byers, J. A. 2003. Built for Speed: A Year in the Life of Pronghorn. Harvard University Press, Cambridge Mass 230 pp.

Connin, S.L., J. Betacourt, and J. Quade. 1998. Late Pleistocene C4 plant dominance and summer rainfall in the southwestern United States from isotopic study of herbivore teeth, Quaternary Research 50: 179-193.

Czaplewski, N.J., W.D. Peachy, J.I. Mead, T-L.Ku., and C.J. Bell. 1999. Papago Springs Cave revisited, Part 1: Geological setting, cave deposits and radiometric dates, Occasional Papers of the Oklahoma Museum of Natural History 3: 1-25.

Faith, J.T., and T.A. Surovell. 2009. Synchronous extinction of North America’s Pleistocene mammals, PNAS 108(49):20641-20645.

Hall, E.R. and K.R. Kelson. 1959. The Mammals of North America, Vol 1 and 2. 1083 pp.

Heffelfinger, J.R., B.W. O’gara, C.M. Janis, and R. Babb. 2002. A bestiary of ancestral antilocaprids, Proceedings of the Pronghorn Workshop 29: 87-111.

Janis, C. M. and E. Manning. 1998. Antilocapridae; *in* Janis, C. M., Scott, K.M., and Jacobs, L. L., eds., Evolution of Tertiary mammals of North America, Volume 1:Terrestrial carnivores, ungulates, and ungulate-like mammals: Cambridge UniversityPress, Cambridge, p. 491–507.

Jarman, P.J. 1974. The social organization of antelope in relation to their ecology. Behaviour.48: 215-267.

Kurtén, B. and E. Anderson. 1980. Pleistocene Mammals of North America. Columbia University Press, New York:442 pp.

Lawrence, B. 1951. Post-cranial skeletal characters of deer, pronghorn, and sheep-goat with notes on *Bison* and *Bos*, Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard University 35(3): 41 pp.

McCabe, R. E, O’Gara, B.W. O’Gara, and H.M. Reeves. 2004. Prairie Ghost: Pronghorn and Human Interaction in Early America, University Press of Colorado, 175 pp.

Meager, M.M. 1978. Bison, pages 122-133 in J.L. Schmidt and D.L. Gilbert, eds. Big Game of North America. Stackpole Books, Harrisburg, Pennsylvania, 494 pp.

Morgan, G. S. And S. D. Emslie. 2010. Tropical and western influences in vertebrate faunas from the Pliocene and Pleistocene of Florida: Quaternary International 217: 143–158.

O'Gara, B.W. and J.D. Yoakum. 2004. Pronghorn: Ecology and Management. University Press of Colorado, 903 pp.

Saysette, J.E. 1999. Postcranial Estimation of Body Mass in Pronghorns with Emphasis on *Capromeryx* (Mammalia:Artiodactyla), Unpublished Ph.D. Dissertation, Colorado State University, Fort Collins, Colorado; 192 pp.

Semprebon, G.M. and F. Rivals. 2007. Was grass more prevalent in the pronghorn past? An assessment of the dietary adaptations of Miocene to Recent Antilocapridae (Mammalia:Artiodactyla), Palaeogeography, Palaeoclimatology, Palaeoecology 253: 332-347.

Semprebon, G.M., F. Rivals, and Janis, C.M. Janis. 2019. The role of grass vs. exogenous abrasives in the paleodietary patterns of North American ungulates, Frontiers in Ecology and Evolution 7(65): 1-23.

White, R. S. and G. S. Morgan. 2011. *Capromeryx* (Artiodactyla: Antilocapridae) from the Rancholabrean Tramperos Creek Fauna, Union County, New Mexico, with a review of the occurrence and paleobiology of *Capromeryx* in the Rancholabrean of New Mexico: New Mexico Museum of Natural History and Science, Bulletin 53: 641–651.

White, R. S. and G. S. Morgan. 2022. Pronghorn in cave and karst deposits: Cave dwellers, accidental deaths or carnivore dens? Paper presented at the National Speleological Society Convention, Cave Paleontology Session, 15 June 2022 (and in press).

CONTRIBUTED ABSTRACTS

ABSTRACTS OF PRESENTED PAPERS AND POSTERS
(Alphabetical by Lead Author)

DECIPHERING IDAHO'S PRONGHORN ANTELOPE SEASONAL MOVEMENTS; MODIFYING MIGRATION MAPPING METHODS FOR MIGRATION ROUTE ESTIMATION, SEASONAL RANGE ANALYSIS AND CONSERVATION

Presenting Author: SCOTT BERGEN, *Idaho Dept. of Fish and Game, 1345 Barton Road, Pocatello, ID 83201, USA, (208) 236-1263, scott.bergen@idfg.idaho.gov*

JODI BERG, *Alta Science and Engineering Inc., 220 E 5th St Suite 325, Moscow, ID 83843, USA, (208) 882-7858, jodi.berg@alta-se.com*

MARK HURLEY, *Idaho Dept. of Fish and Game, 2885 W. Kathleen Ave. Coeur d'Alene, ID 83815, USA, (208) 769-1414, mark.hurley@idfg.idaho.gov*

SHANE ROBERTS, *Idaho Dept. of Fish and Game, 600 South Walnut St., Boise, ID 83712, USA, (208)334-3700, shane.roberts@idfg.idaho.gov*

ABSTRACT It is recognized that ungulate seasonal migrations are amongst the most endangered phenomena globally. Subsequent and current US DOI initiatives have recognized that seasonal migrations are worth conserving in the western continental US and provide mechanisms and methodologies for estimating these migration routes and two other cervids. Unfortunately, methodologies used to delineate migration routes and migration stopover locations have not worked for some populations in the continental US. In Idaho, we have found that winter range variability is a major factor that can obscure determining when and where pronghorn seasonal migrations begin using net-squared displacement protocols. When we modified 'anchor' locations to peak fawning date provides for a more accurate and easier NSD graph to interpret. Further, when using this 'anchor' location, we are able to identify winter movement corridors that are recognized as being critical for pronghorn herds where winter conditions can influence and change population trajectories (aka, winter kill). We have found that estimates of stopover locations based on population level utilized distributions are not consistent with results based on parsimonious methods based on rate and duration. These methodological adaptations have allowed IDFG to estimate six migration routes for winter herds occurring in Idaho. In this talk, I talk about the management implications of these results for the identification of migration routes, migration stopover locations, and range analysis and how Idaho has incorporated these findings into its statewide pronghorn management.

OBSERVATIONS OF A REMNANT POPULATION OF TRANSLOCATED PRONGHORN NEAR HILLSIDE, ARIZONA

DAVID E. BROWN (Deceased), *Arizona State University, P.O. Box 35141, Tempe, AZ 85069, (602) 471-2872, debrown@asu.edu*

Presenting Author: *RAYMOND M. LEE, *P.O. Box 130, Cody, WY 82414, (602) 315-0604, rlee@morgenson.com*

MATTHEW PEIRCE, *P.O. Box 1736, Wickenburg, AZ 85356, (928) 684-3774, mcpeirce@gmail.com*

ABSTRACT We monitored the persistence of a remnant population of 4 to 9 pronghorn near Hillside, AZ over a 10-year period from May 2008 through February 23, 2019. Originally consisting of 3 bucks, 2 does and 1 female yearling, the last pregnant doe was seen 3/13/2014 and the last fawn was seen on 11/10/2014. Only 1 buck was seen after 6/17/2014 and no males after 7/7/2018. The last pronghorn was seen on 12/15/2018. Although the possibility exists of animals immigrating or emigrating from the 78 km² study area, we did not document such behavior during our study. With no overt management the population doubled before losing 4 animals following a May 2014 Palmer Drought Severity Index of -4.09. The persistence of this population through 2018 is attributed to low adult mortality and a greater recruitment of females than males. The disappearance of this population is attributed to inbreeding depression and low recruitment as a result of genetic bottle-necking. The Hillside population was too small and too isolated to survive without periodic translocations and predator control would not have helped.

* No presentation for this abstract. Raymond M. Lee will be presenting some of this material in abstract titled Observations on various pronghorn populations in Mexico and the southwestern United States.

ADVANCING FENCE DATASETS: COMPARING APPROACHES TO IDENTIFY FENCE LOCATIONS AND SPECIFICAITONS IN SOUTHWEST MONTANA

Presenting Author: SIMON A. BUZZARD, [1]*National Wildlife Federation, 240 North Higgins Ave., Suite 2, Missoula, MT 59802, USA, (406) 529-2409, BuzzardS@nwf.org; Environmental Studies Program, University of Montana, Jeannette Rankin Hall 106A, Missoula, MT 59812, USA.*

ANDREW F. JAKES, [1]*Smithsonian Conservation Biology Institute, 1500 Remount Road, Front Royal, VA 22630, USA, (406) 439-7583 JakesAF@si.edu*; *National Wildlife Federation, 240 North Higgins Ave., Suite 2; Missoula, MT 59802, USA*

AMY J. PEARSON, *The Nature Conservancy, 32 South Ewing St, Helena, MT 59601, USA, (406) 443-0303, APearson@tnc.org*

LEN BROBERG, *Environmental Studies Program, University of Montana, Jeannette Rankin Hall 106A, Missoula, MT 59812, USA, (406) 243-6273, Len.Broberg@mso.umt.edu*

[1]Current address, phone number and email
ABSTRACT Fencing is a major anthropogenic feature but its ecological impacts are difficult to quantify due to a widespread lack of spatial data. We created a fence model and compared outputs to a fence mapping approach using satellite imagery in two counties in southwest Montana, USA to advance fence data development for use in research and management. The model incorporated road, land cover, ownership, and grazing boundary spatial layers to predict fence locations. The model predicted 34,706.4 km of fences with a mean fence density of 0.93 km/km^2 and a maximum density of 14.9 km/km^2. We also digitized fences using Google Earth Pro in random 93.2 km^2 areas (n = 50). We validated both approaches using fence data collected on random road transects (n = 330). The Google Earth approach showed greater agreement (K = 0.76) with known samples than the fence model (K = 0.56) yet was unable to map fences in forests and was significantly more time intensive. We overlaid GPS vector data from collared female pronghorn (*Antilocapra americana*) (n = 45) from January 30th – August 16th, 2022 to visually assess where turn angles increased near mapped fences, potentially indicating reduced fence permeability. We also evaluated fence attributes more broadly and found that private lands were more likely to have fences with lower bottom wires ($t(366.4) = -4.73$, $p = 0.001$) and higher top wires ($t(367.76) = 5.22$, $p < 0.0001$) than those on public lands with sample means at 22 cm and 26.4 cm, and 115.2 cm and 110.97, respectively. Both bottom wire means were well below recommended heights for ungulates navigating underneath fencing (≥ 46 cm), while top wire means were closer to the 107 cm maximum fence height recommendation. Our novel fence type data can help inform policy while our tools for estimating fence locations can help identify potential areas for conservation actions when paired with wildlife movement data.

MIGRATION AND MANAGEMENT OF PRONGHORN IN THE MADISON VALLEY, SOUTHWEST MONTANA

Presenting Author: JULIE A CUNNINGHAM, *Montana Fish, Wildlife and Parks. 1400 S. 19th Ave, Bozeman MT 59718, USA. (406) 577-7865, juliecunningham@mt.gov*

KELLY PROFFITT, *Montana Fish, Wildlife and Parks. 1400 S. 19th Ave, Bozeman MT 59718, USA. (406) 577-7884, kproffitt@mt.gov*

JESSE DEVOE, *Montana Fish, Wildlife and Parks. 1400 S. 19th Ave, Bozeman MT 59718, USA. jesse.devoe@mt.gov*

ABSTRACT The Madison Valley is a high-elevation grassland valley surrounded by the Gravelly and Madison mountain ranges north and west of Yellowstone National Park. The study area is bisected east to west by the Madison River and US Route 287. Pronghorn were native to this valley but were thought to have been extirpated by the 1920s. A series of transplants 1951-1952 restored pronghorn to the Valley and their population expanded to more than 2,000 individuals, but little was known about their movement habits or herd structure. Secretarial

Order 3362, designed/implemented to improve habitat quality, winter range, and migration corridors for western big game, provided an opportunity to study Madison Valley pronghorn as part of the statewide Montana Migration Initiative. Montana Fish, Wildlife and Parks captured and fitted with GPS collars 82 adult female pronghorn over three years (2019-2021) to evaluate seasonal ranges, herd structures, migratory routes, as well as identify problematic and non-problematic natural and human-made barriers. We found a clear herd structure, with two nonmigratory herds on the west side of the Valley and one partially migratory herd on the east side. Individuals on the east side had a variety of movement strategies including residency, short-distance migrations, and long-distance migrations as far as 100km. Migratory pathways followed a narrow route between forested hills, highways, rivers, and human development. Pronghorn crossed the Continental Divide at a low-elevation saddle and continued south to Island Park, Idaho. These research findings have been used to develop partnerships between other agencies, NGOs, and private landowners and collaboratively improve fences and protect pronghorn pathways.

DIVERGENT POPULATION PARAMETERS SIGNAL LOSSES IN RESILIENCE DRIVEN BY GLOBAL CHANGE DRIVERS IN PRONGHORN, AN ICONIC RANGELAND SPECIES

VICTORIA M. DONOVAN, *Department of Agronomy & Horticulture, University of Nebraska, 512 North 12th Street, Lincoln, NE 68583, USA. (402) 540-0678; vdonovan2@unl.edu*

Presenting Author: JEFFREY L. BECK, *Department of Ecosystem Science and Management, University of Wyoming, Dept 3354, 1000 East University Avenue, Laramie, WY 82071, USA. (307) 766-6683; jlbeck@uwyo.edu*

CARISSA L. WONKKA, *United States Department of Agriculture–Agricultural Research Service, Northern Plains Agricultural Research Laboratory, 1500 N Central Avenue, Sidney, MT, 59270, USA. (406) 433-9416; carissa.wonkka@usda.gov*

CALEB P. ROBERTS, *United States Department of the Interior–U.S. Geological Survey, Arkansas Fish and Wildlife Cooperative Research Unit, University of Arkansas, SCEN 522, Fayetteville, AR, 72701, USA. (479) 575-6709; cr065@uark.edu*

CRAIG R. ALLEN, *Center for Resilience in Agricultural Working Landscapes, University of Nebraska-Lincoln, 203K Keim Hall 1825 North 38th Street, Lincoln, NE, 68583, USA. (402) 472-0421; callen3@unl.edu*

DIRAC TWIDWELL, *Department of Agronomy & Horticulture, University of Nebraska, 512 North 12th Street, Lincoln, NE 68583, USA. (402) 580-8832; dirac.twidwell@unl.edu*

ABSTRACT Conservation is increasingly focused on preventing species' population losses before they occur. This requires understanding changes in the resilience (the amount of disturbance a population can endure while continuing to persist within its current state) of

populations in response to global change drivers before drastic population declines occur. We used population productivity (late summer juveniles per 100 females) as an indicator of population resilience to global change drivers in 40 pronghorn (*Antilocapra americana*) populations across sagebrush (*Artemisia* spp.) steppe in Wyoming, which includes one of the globe's most intact rangeland ecosystems. Pronghorn are an iconic rangeland species that have been exposed to increasing levels of anthropogenic, climatic, and land-use change. Using data collected across the state of Wyoming, we (1) assessed long-term signals of population resilience and compared these to changes in population size, (2) identified patterns in large-scale global change drivers (i.e., climate, land cover change) across pronghorn habitat, and (3) determined the relationship between global change drivers and population resilience over a 35-year (1984–2019) period. We found that while Wyoming hosts some of the most abundant populations of pronghorn in North America, many herds are experiencing long-term declines in productivity, signaling losses in population resilience. These declines were not limited to smaller populations, but rather occurred in some of the largest and most productive populations in the region. Long-term declines in productivity were associated with increases in oil and gas development and woody encroachment. Although increasing across almost all herds, woody vegetation cover remains at low levels, suggesting that pre-emptive management may help to prevent drastic losses in pronghorn populations. Our findings highlight the value of utilizing trends in population demographics as an indicator of changing population resilience to support preventative conservation efforts in the face of rapid global change.

Donovan, V. M., J. L. Beck, C. L. Wonkka, C. P. Roberts, C. R. Allen, and D. Twidwell. In review. Divergent population parameters signal losses in resilience driven by global change drivers in pronghorn, an iconic rangeland species. Global Change Biology.

ARIZONA ANTELOPE FOUNDATION-ARIZONA GAME & FISH DEPARTMENT & NATIONAL FISH & WILDLIFE FOUNDATION'S "SOUTHEASTERN ARIZONA GRASSLANDS PRONGHORN INITIATIVE" 2010-2019

Presenting Author: GLEN DICKENS-CWB, *Vice President/Projects/Grants Manager Arizona Antelope Foundation, P.O. Box 1191, Mesa, Arizona 85211. (520-247-4907), gbdickens@comcast.net*

JOHN MILLICAN, *Southeastern Arizona Field Manager Arizona Antelope Foundation, P.O. Box 1191, Mesa , Arizona 85211. (520-508-4272), j2dbmill@msn.com*

RANA MURPHY, *Terrestrial Wildlife Specialist Region V Arizona Game & Fish Department, 555 North Greasewood Road Tucson, Arizona 85745. (520-388-4448), rmurphy@azgfd.gov*

ABSTRACT A "Southeast Arizona Collaborative Grassland Workgroup" was created in February 2010 by the Tucson office of the Arizona Game and Fish Department and collaboratively drafted a southeastern Arizona Regional Pronghorn Strategy to increase pronghorn population numbers, distribution and connectiveness. Partners in this working group included: AAF, AGFD, BLM, USFS, ASLD, USDA, USFWS, NRCS, TNC, Altar Valley

Conservation Alliance, Pima County, Arizona Wildlife Federation, AZ Land Trust, Audubon Society, Tombstone High school, Range Riders, Southern Arizona Conservation Corps and local ranchers/landowners. Long-term goals for this 9-year grant period 2011-19 were to; 1) establish a region-wide dynamic geodatabase with integrated multi-species layers to prioritize grasslands restoration/maintenance activities for pronghorn and other sensitive grassland species, 2) permanently record pronghorn travel corridors and remove or modify barriers, including fences, shrubs and trees, 3) target/plan grassland treatments/burns in priority habitat locations on an annual and long-term basis to benefit the highest number of keystone grassland species, 4) supplement at least one pronghorn population and increase numbers in two subpopulations and 5) improve grassland habitat in five pronghorn subpopulation zones. In 2011, 2013 and 2014 the Arizona Antelope Foundation (AAF) was awarded 3 different grants through the National Fish and Wildlife Foundation's (NFWF) Sky Islands Initiative totaling $510,000 to support the Arizona Game and Fish Department (AGFD) and AAF's 10-year Southeastern Arizona Grasslands Pronghorn Initiative initiated in April 2010. These funds were matched in-kind by 1) $245K - Rancher/landowner labor, equipment, and materials. 2) $337K - AAF labor, travel, food, equipment, and materials. 3) $569K - Habitat Partnership Funds and other project cash match and 4) $80K - Pima County Open Space Conservation land-acquisition funds for a total of $1.231M In-kind match. Final combined project financial total was $1.741M. AAF and partners accomplished the following results between 2012 and 2019: Pronghorn connectivity was improved on 191,800 acres in 6 herd zones through 27 fence projects, modifying 105 miles of fencing. The majority of that work was accomplished by 769 volunteers who drove 185,517 miles and donated 13,270 hours of labor. University and high school students, as well as Boy Scouts participated in 14 of the 27 fence modification projects. Eleven grasslands projects completed in 4 herd zones restored 7,874 acres of grasslands through burning, mesquite grubbing, and spot treatments with herbicides. Thirteen water projects were completed to provide year-around water distribution and security in 4 herd zones. Ninety-five (95) pronghorn were transplanted to supplement 6 subpopulations. The pronghorn population was increased in those subpopulations by a minimum of 548 animals as of August 2019, meeting the minimum viable population objective of 125 animals in 3 of the 6 subpopulations. A long-term GIS data base, including 658 total layers for each of the 6 herd zones, was established to monitor the pronghorn and habitat changes. Long-term landowner/rancher relations were improved on 21 separate properties. The projects efforts continue today with operating funds provided by the AAF and miscellaneous available AGFD habitat partnership, grant and federal funds.

SPATIOTEMPORAL RISK FACTORS PREDICT LANDSCAPE-SCALE SURVIVORSHIP FOR A NORTHERN UNGULATE

DANIEL R. EACKER, *Taurus Wildlife Consulting, 1017 Edwin Pl, Juneau, AK 99801, USA, 406-291-9169 daniel.eacker@tauruswildlifeconsulting.com*

Presenting Author: ANDREW F. JAKES, [1]*Smithsonian Conservation Biology Institute, 1500 Remount Road, Front Royal, VA 22630, USA, 406-439-7583 JakesAF@si.edu*; *National Wildlife Federation, 240 North Higgins Ave., Suite 2; Missoula, MT 59802, USA*

PAUL F. JONES, *Alberta Conservation Association, #400 817 4th Ave South, Lethbridge, AB T1J 0P6, Canada, 403-382-4357 Paul.Jones@ab-conservation.com*

[1]Current address, phone number and email

ABSTRACT Effective wildlife conservation and habitat restoration necessitates unraveling the drivers of population dynamics for species affected by anthropogenic habitat alterations. Pronghorn (*Antilocapra americana*) can serve as a focus for management actions to restore habitat and maintain connectivity as they are known to annually move long distances and are sensitive to landscape disturbances. We used Bayesian proportional hazards models to assess anthropogenic risk factors that could potentially predict landscape-scale survivorship for pronghorn in the Northern Sagebrush Steppe ecosystem, where extensive habitat loss and fragmentation has occurred from the conversion of native sagebrush grasslands to agricultural lands, natural resource extraction and transportation infrastructure. We used relocations from 170 GPS-collared adult female pronghorn from 2003–2011 to test the importance of linear features (road and fence densities) and forage productivity (maximum decadal NDVI) for spatiotemporal pronghorn mortality risk, while accounting for seasonally fluctuating snow depth. As predicted, we found considerable support for the effects of average snow water equivalent (SWE), within pronghorn seasonal ranges, with mortality risk increasing by 45.7% with every 10 kg/m^2 increase in SWE (range = 0–53.7 kg/m^2). We also found support that greater densities of linear features increased mortality risk. Our models predicted that survivorship would decline by 27.1% over the observed range of road densities (range = 0–1.4 km/km^2) and 11.8% over the range of fence densities (0–6.1 km/km^2) encountered by pronghorn. Our results also suggested that agricultural areas could act as ecological traps for pronghorn based on mortality risk increasing by a factor of 14.3% with every 0.1 increase in maximum decadal NDVI (range = 0.38–0.73) on summer range. Using these results, we developed the first broad-scale, spatially explicit map of predicted annual pronghorn survivorship, which included both anthropogenic features and environmental gradients, to identify areas for conservation and habitat restoration efforts. Our efforts to highlight anthropogenic risk factors across the Northern Sagebrush Steppe can support conservation and habitat restoration for pronghorn populations at the northern periphery of their range.

PRONGHORN RESOURCE SELECTION AND MIGRATION THROUGH HIGH-ELEVATION FORESTS IN NORTHERN NEW MEXICO

Presenting Author: JOANNA R. ENNIS, *Department of Fish, Wildlife and Conservation Ecology, New Mexico State University, Box 30003, MSC 4901, Las Cruces, New Mexico 88003, 850-982-1281, jennis@nmsu.edu*

JAMES W. CAIN III, *U.S. Geological Survey, New Mexico Cooperative Fish and Wildlife Research Unit, Box 30003, MSC 4901, Las Cruces, New Mexico 88003, 575-646-3382, jwcain@nmsu.edu*

ABSTRACT Few studies have documented pronghorn (*Antilocapra americana*) herds that migrate to higher elevations through forested landscapes. New Mexico's North Central pronghorn herd migrates from winter ranges on the Taos Plateau to high elevation (2255 to 3292 m) montane grasslands in the San Juan Mountains. We examined how forested landscapes influenced habitat selection during spring migration and when tree or woody encroachment could influence migrations in the future. Using a hypothesis-driven approach we selected landscape variables that could influence pronghorn migration and habitat selection during spring migration. We developed integrated step-selection functions (iSSF) with models parameterized based on landscape variables calculated at the end of each step. Patterns of selection during spring migration showed avoidance of high tree canopy cover and unpaved roads, while selecting for higher elevations and south facing slopes. Pronghorn avoided forests over herbaceous, shrubland, and riparian habitats. Our results demonstrate that pronghorn selectively moved to open patches through this forested landscape to reach summer range. We showed that unpaved roads reduce pronghorn habitat use. Management implications include finding a threshold density where pronghorn can migrate through this forested landscape. Mitigating the effects of roads on pronghorn could be considered for future land-use plans.

ACTIVITY DYNAMICS OF RESIDENT AND TRANSLOCATED PRONGHORN IN THE EDWARDS PLATEAU, TEXAS

Presenting Author: JUSTIN T. FRENCH, *Borderlands Research Institute – Sul Ross State University, 400 N. Harrison St., Alpine, TX 79830, USA, (432) 837-8505, Justin.French@sulross.edu*

ERIN C. O'CONNELL, *Borderlands Research Institute – Sul Ross State University, 400 N. Harrison St., Alpine, TX 79830, USA, (432) 837-8505, eco20il@sulross.edu*

L. CODY WEBB, *Rocker b Ranch, 10151 Cr. 401 Barnhart, TX 76930, USA, (325) 835-2025, Landon.Webb@tsrh.org*

CARLOS E. GONZALEZ, *Borderlands Research Institute – Sul Ross State University, 400 N. Harrison St., Alpine, TX 79830, USA, (432) 837-8505, Carlos.Gonzalez-Gonzalez@sulross.edu*

LOUIS A. HARVESON, *Borderlands Research Institute – Sul Ross State University, 400 N. Harrison St., Alpine, TX 79830, USA, (432) 837-8505, Harveson@sulross.edu*

SHAWN S. GRAY, *Texas Parks & Wildlife Department, 109 S. Cockrell St., Alpine, TX 79830, USA (432) 837-3251, Shawn.Gray@tpwd.tx.gov*

ABSTRACT Diel activity cycles are partly driven by their behavioral response to predation risk. Prey species can adjust diel activity, as well as space use, to maximize foraging and breeding opportunities while minimizing predation risk, leading to the idea of a dynamic Landscape of Fear (LoF). While predation is often cited as a partial cause of pronghorn decline, little is understood about how their diel activity, much less how that influences their response to a LoF

or, ultimately, their demography. This could impact the outcomes of translocation efforts, as relocated animals may be behaviorally adapted to different predators than they encounter in their new environment. As an exploratory step, we compared the activity dynamics of 6 resident and 23 translocated pronghorn following a large-scale restoration using autocorrelation surfaces. Diel activity cycles were, in fact, cyclic; pronghorn alternated between diurnal activity in the winter and crepuscular activity in spring and summer. While we found some evidence of distinct groups in diel activity dynamics, we found little evidence of differences between resident and translocated pronghorn. However, we found differences in the degree of crepuscular activity by pronghorn between the fawning seasons of 2020 and 2021. These years also differed in fawn recruitment, suggesting doe diel activity during this period and fawn success could be related. Additional data and analyses with more specificity are needed to evaluate this hypothesis. Importantly, the translocation process did not appear to disrupt pronghorn circadian rhythm. Finally, cyclic patterns were strong across all pronghorn, suggesting diel movement cycles should be considered in movement-based habitat selection models, such as integrated Step Selection Analysis.

CASE STUDY: EVALUATING A LANDOWNER-CONTROLLED HARVEST STRATEGY FOR PRONGHORN BUCKS IN THE NORTHERN TEXAS PANHANDLE

Presenting Author: SHAWN S. GRAY, *Texas Parks and Wildlife Department, 109 South Cockrell, Alpine, TX, 432-837-0666, shawn.gray@tpwd.texas.gov*

CALVIN L. RICHARDSON, *Texas Parks and Wildlife Department, 109 South Cockrell, Alpine, TX, 432-837-2051, calvin.richardson@tpwd.texas.gov*

JAMES D. HOSKINS, *Texas Parks and Wildlife Department, P.O. Box 3651, Amarillo, TX, 79116, james.hoskins@tpwd.texas.gov*

JOHNATHAN C. MALONE, *Texas Parks and Wildlife Department, P.O. Box 1404, Pampa, TX, 79066, chadd.malone@tpwd.texas.gov*

ABSTRACT Texas Parks and Wildlife Department (TPWD) initiated an experimental buck-only landowner-controlled harvest strategy during the 2013 hunting season in 3 herd units in the northern Texas Panhandle in an attempt to decrease the administrative burden of issuing pronghorn permits on TPWD staff and to provide more hunting opportunity and flexibility to hunters and landowners. This new harvest concept relied on landowners to control the harvest of buck pronghorn on their properties as an alternative to TPWD setting quotas through survey-based permit issuance. During the 2017 hunting season 3 more herd units were added to increase the contiguous size of the experimental areas. The resulting experimental sites consisted of 3 herd units located near Dalhart, TX in the northwest Panhandle and 3 herd units near Pampa, TX in the northeast Panhandle. Hunters in the experimental units were required to take their harvested buck to a mandatory check station within 24 hours of harvest. All bucks brought to the check stations were aged using the cementum annuli technique, and basic horn measurements were collected. Annual pre-season fixed-wing surveys were also conducted within the

experimental areas. During most years of the experiment, harvest intensity exceeded TPWD's recommended harvest rate (permit issuance rate of 35% of the estimated buck population). Data suggest that the landowner-controlled harvest strategy did not have negative impacts to pronghorn population sustainability, but showed undesirable effects on buck age structure and sex ratios. Age structure of harvested bucks during the 2012 hunting season (1 year prior to the experiment) was 4.0 and 4.4 years of age in the Dalhart and Pampa areas, respectively. During the 8 hunting seasons of the experiment the average age of harvested bucks declined to 3.0 years for the Dalhart area and 3.7 years for the Pampa area. The last 3 hunting seasons (2018–2020) showed a more drastic change with average ages of 2.5 in the Dalhart area and 3.4 in the Pampa area. Sex ratios were also negatively impacted by the landowner-controlled harvest strategy. Prior to the experiment, does per buck ratios were 2.5 in the Dalhart area and 2.7 in the Pampa area. The average sex ratios during the experiment (2013–2020) became more skewed toward does at 2.9 and 4.1 does per buck in the Dalhart and Pampa areas, respectively. Similar to buck age structure, the sex ratios became even more skewed during the last 3 hunting seasons, averaging 3.3 in the Dalhart area and 4.3 in the Pampa area. In addition, hunter and landowner opinion surveys conducted in 2016 and 2020 indicated that support and satisfaction for the landowner-controlled harvest strategy waned. Therefore, based upon biological data, opinion surveys, and public comments; the landowner-controlled harvest strategy was terminated indefinitely beginning with the 2021 hunting season.

ASSESSING GENETIC SUSCEPTIBILITY OF PRONGHORN (ANTILOCAPRA AMERICANA) TO PRION DISEASES THROUGH PRNP GENE SEQUENCING

Presenting Author: ANGELA M. GROGAN, *Department of Natural Resources Management, Goddard Building, Box 42125, Texas Tech University, Lubbock, TX, 79409, USA, (970)759-6832, angela.grogan@ttu.edu*

MATTHEW J. BUCHHOLZ, *Department of Natural Resources Management, Goddard Building, Box 42125, Texas Tech University, Lubbock, TX, 79409, USA, (715)204-8680, matthew.buchholz@ttu.edu*

COURTNEY L. RAMSEY, *Department of Natural Resources Management, Goddard Building, Box 42125, Texas Tech University, Lubbock, TX, 79409, USA, (806)834-7105, Courtney.Ramsey@ttu.edu*

EMILY A. WRIGHT, *Department of Biological Sciences, Texas Tech University, Box 43131, Texas Tech University, Lubbock, TX, 79409, USA, (214)991-2397, Emily.A.Wright@ttu.edu*

ROBERT D. BRADLEY, *Department of Biological Sciences, Texas Tech University, Box 4313, Lubbock, TX, 79409, USA; and the Natural Science Research Laboratory, Museum of Texas Tech University, Box 43191, (806)834-1303, robert.bradley@ttu.edu*

WARREN C. CONWAY, *Department of Natural Resources Management, Goddard Building, Box 42125, Texas Tech University, Lubbock, TX, 79409, (806)834-6579, warren.conway@ttu.edu*

ABSTRACT Chronic wasting disease (CWD) affects both native and non-native North American Cervids and has become a major conservation issue for wildlife managers worldwide. As CWD expands geographically, concerns about management and species susceptibility continue to be part of a larger narrative of wildlife management, conservation, and human health. Given how CWD is transmitted, and the history of spontaneous generation of novel prion diseases, the possibility of interfamilial transmission also raises concerns. Historically, pronghorn (*Antilocapra americana)* have utilized much of the same habitat as susceptible cervids and occur within the endemic CWD area of Colorado and Wyoming. However, to date, there has been no research on pronghorn susceptibility to prion diseases like CWD, as they have been assumed to be resistant and not susceptible. In Texas, pronghorn occur in portions of both the Texas Panhandle and the Trans-Pecos, where currently both regions contain Texas Parks and Wildlife Department CWD containment and surveillance zones. Our goal is to sequence the prion protein gene, *PRNP*, exon 3 (the coding region of the prion protein, PrP^{C}) in pronghorn from Texas and New Mexico to compare to amino acid sequences of known susceptible Cervids and assess if pronghorn may be susceptible to prion diseases. Currently, we are amplifying and sequencing *PRNP* from individuals from Texas (including translocated individuals) and New Mexico. Preliminary results indicated that pronghorn have one additional octapeptide repeat, for a total of 6 repeats, rather than the 5 octapeptide repeats seen in Cervids. Additionally, pronghorn seem to align with Cervids for codons 95,96,116,132, and 225, which might confer susceptibility to CWD. This research will be useful for evaluating the potential risks associated with sympatric coexistence of pronghorn with Cervids in CWD containment zones in Texas, and to assess if pronghorn are susceptible to prion diseases.

PRONGHORN EXHIBIT DIVERSE ARRAY OF SEASONAL USE BEHAVIORS ON THE MODOC PLATEAU, CALIFORNIA

Presenting Author: BRIAN HUDGENS, *Institute for Wildlife Studies, 140 H Street, Blue Lake, CA 95525, (707) 496-4725, hudgens@iws.org*

ABSTRACT Considerable attention has been given in recent years to the variety of migratory behaviors that ungulates employ. However, the focus on migration ignores many other of seasonal use behaviors animals may exhibit to cope with seasonal changes in resource availability and mortality risk. We document that pronghorn inhabiting the Modoc Plateau exhibit a varied repertoire of seasonal use behaviors. Animals responded to changing seasonal conditions by expanding, shrinking, or shifting their home ranges, migrating up to 61 km, or not changing their home ranges at all. Individuals mix strategies throughout the year and exhibit different annual patterns across years, while neighboring individuals may exhibit different behavioral strategies in the same year. This variety of behaviors implicates a large number of

interacting environmental and internal cues influencing the size, shape, and location of seasonal home ranges.

PRONGHORN DEMOGRAPHY AND MOVEMENT ON THE MODOC PLATEAU, CALIFORNIA

Presenting Author: BRIAN HUDGENS, *Institute for Wildlife Studies, 140 H Street, Blue Lake, CA 95525, (707) 496-4725, hudgens@iws.org*

COLTON WISE, *Institute for Wildlife Studies, 140 H Street, Blue Lake, CA 95525, (832) 244-8271, wise@iws.org, colton.wise@oregonstate.edu*

DAVID GARCELON, *Institute for Wildlife Studies, 140 H Street, Blue Lake, CA 95525, (707) 844-3516, garcelon@iws.org*

ABSTRACT Pronghorn (*Antilocapra americana*) residing in northeastern California and southern Oregon make up the western-most populations connected to the Great Basin ecoregion. Relatively little work has been conducted on the California population, but aerial surveys indicate that the population has declined by over 85% since 1992. We studied pronghorn movements and survival of adults and fawns to better understand factors that might be contributing to the population decline. We placed satellite GPS collars on 100 adults (99 females, 1 male) and tracked their movements for up to 7 years. Annual adult survival from 2014-2022 was 0.78 (+/- 0.032 SE). Causes of mortality varied from year to year, with mountain lions (*Puma concolor*) being an important predator in some years and coyotes (*Canis latrans*) in others. We found evidence that increased cover is associated with mortality risk. We tracked 114 radio-collared fawns for up to 200 days. Fawn survival through 200 days was higher during the first three years of the study 2015-2018 (s=0.45 +/- 0.071 SE) than during the last three years (s=0.17 +/- 0.058 SE). We used adult movement data to identify fences with the greatest impact on pronghorn movement. We found that modification of these fences can increase their permeability. Landscape level changes leading to greater cover for predators, such as woodlands expanding into sage steppe areas, and fences that are not wildlife friendly may be increasing mortality risk and reducing access to quality habitat.

INVESTIGATING SOURCE AND SEASONALITY OF ACUTE, FATAL PNEUMONIA IN FREE-RANGING PRONGHORN (ANTILOCAPRA AMERICANA) IN WYOMING

Presenting Author**:** MARGUERITE JOHNSON, *University of Wyoming, Department of Veterinary Sciences, Wyoming Game and Fish Department, Wildlife Health Laboratory, 1174 Snowy Range Road, Laramie, WY 82070, USA, (307)339-7171, Maggie.johnson@wyo.gov*

MADISON BLAESER, *University of Wyoming, Department of Veterinary Sciences, 1174 Snowy Range Road, Laramie, WY 82070, USA*

ERIN SCHWALBE, *University of Wyoming, Department of Veterinary Sciences, 1174 Snowy Range Road, Laramie, WY 82070, USA*

AMY K. WRAY, *University of Wyoming, Department of Veterinary Sciences, 1174 Snowy Range Road, Laramie, WY 82070, USA*

CHRISTOPHER MACGLOVER, *University of Wyoming, Department of Veterinary Sciences, 1174 Snowy Range Road, Laramie, WY 82070, USA*

HANK EDWARDS, *Wyoming Game and Fish Department, 1174 Snowy Range Road, Laramie, WY 82070, USA*

SAMANTHA E. ALLEN, *Wyoming Game and Fish Department, 1212 S. Adams St, Laramie, WY 82070, USA*

ERIKA PECKHAM, *Wyoming Game and Fish Department, 815 Rockwood, Gillette, WY 82717, USA*

KERRY S. SONDGEROTH, *University of Wyoming, Department of Veterinary Sciences, Wyoming State Veterinary Laboratory, 1174 Snowy Range Road, Laramie, WY 82070, USA*

JENNIFER L. MALMBERG, *University of Wyoming, Department of Veterinary Sciences, Wyoming State Veterinary Laboratory, 1174 Snowy Range Road, Laramie, WY 82070, USA, 307-766-997, Jennifer.malmberg@uwyo.edu*

ABSTRACT The bacterium *Mycoplasma bovis* (*M. bovis)* is a globally distributed, economically important bacterial pathogen of cattle (*Bos taurus*) and American bison (*Bison bison*). Pneumonia, polyarthritis and mastitis are among the most common clinical signs. Reports of *M. bovis* in free-ranging wildlife are rare, consisting of a few isolated cases in mule deer (*Odocoileus hemionus*) and white-tailed deer (*Odocoileus virginianus*). In early 2019 near Gillette, Wyoming, we documented *M. bovis* as the cause of acute, fatal pneumonia in free-ranging pronghorn antelope (*Antilocapra americana*), a previously unreported finding. Here we report on additional pronghorn mortalities due to *M. bovis* occurring in the same geographic region one year later. Mortalities occurred between February and April in 2019 and 2020 with over 500 documented mortalities in total. To evaluate whether pronghorn develop chronic, subclinical infections and begin assessing *M. bovis* status in other sympatric species, we used PCR testing of nasal swabs to opportunistically survey select free-ranging ungulates. We found no evidence of subclinical infections in 230 pronghorn sampled from nine counties in Wyoming and ten in Montana, USA. All mule deer (*Odocoileus hemionus*) (n=231) sampled from 11 counties in Wyoming also were PCR negative. To estimate the potential for environmental transmission, we examined persistence of *M. bovis* in various substrates and conditions. Controlled experiments revealed that *M.* bovis can remain viable for 6 hours following inoculation of shaded water, and up to 3 hours in shaded hay and topsoil. Our results indicate transmission of *M. bovis* from livestock to pronghorn through the environment is possible, and that seasonality of infection could be due to shared resources during late winter. Further

investigations to better understand transmission dynamics, to assess population level impacts to pronghorn, and to determine disease risks among pronghorn and other ungulate taxa appear warranted.

Johnson, M., C. MacGlover, J. L. Malmberg, K. S. Sondgeroth, T. K. Bragg, A. K. Wray, E. Schwalbe, M. K. Davison, M. Blaeser, W. H. Edwards, T. Creekmore, S. E. Allen, H. Killion, and E. Peckham. 2022. Source and Seasonality of Epizootic Mycoplasmosis in Free-Ranging Pronghorn (Antilocapra americana). Journal of Wildlife Diseases 58.

CAN HUNTERS HELP TRACK TRENDS IN PRONGHORN POPULATIONS?

Presenting Author: PAUL F. JONES, *Alberta Conservation Association, #400 817 4th Ave South, Lethbridge, AB T1J 0P6, Canada, paul.jones@ab-conservation.com*

SUSAN H. PETERS, *#101, 9 Chippewa Road, Sherwood Park, Alberta, T8A 6J7, Canada, sue.peters@ab-conservation.com*

VIC ADAMOWICZ, *Department of Resource Economics and Environmental Sociology, University of Alberta, 5-15 General Services Building, Edmonton, AB, T6G 2H1, Canada, vic.adamowicz@ualberta.ca*

JAY ANDERSON, *Department of Resource Economics and Environmental Sociology, University of Alberta, 5-15 General Services Building, Edmonton, AB, T6G 2H1, Canada,* jaya@ualberta.ca

ABSTRACT Data used to manage wildlife populations effectively require survey methods that provide accurate and precise population estimates that are also efficient and economical. In Alberta, aerial surveys have historically been the primary method used to estimate population size, trend, distribution, and herd composition for ungulates, including pronghorn. As such, aerial surveys have been an important source of data for setting hunting allocations; however, these surveys are intermittent and are prohibitively expensive, prompting the need for additional strategies for monitoring populations. Hunter observations of moose in Scandinavia have proven to be a valuable data source for monitoring population trends. Using hunter observations of pronghorn and other harvestable species could provide an alternative cost-effective method of collecting large-scale data on population trends and demographics. In 2021, Alberta Conservation Association partnered with the University of Alberta and Inside Outside Studios to launch ABHuntLog; a mobile phone survey that uses the iHunter smartphone app as a platform to allow hunters to voluntarily report species observations and harvest records at a Wildlife Management Unit level. The survey also allows for the tracking of hunter activity to evaluate the economic importance of hunting to Alberta's economy. Here we demonstrate the utility of the data collected from a conservation and hunter's perspective using pronghorn (and where needed, other ungulates) as the case study.

ENDANGERED PENINSULAR PRONGHORN

Presenting Author: MASON KLEIST, *El Paso Zoo, 4001 E. Paisano, El Paso, Texas 79905, (239) 450-9804, masonkleist@icloud.com*
MELODI TAYLES, *San Diego Zoo Safari Park, 15500 San Pasqual Valley Road, Escondido, California 92027-7017, mtayles@sdzwa.org*

ABSTRACT Peninsular pronghorn (*Antilocapra americana peninsularis*) are an endangered subspecies of pronghorn in Baja California, Mexico. Zoological institutions are actively working to recovery the peninsular pronghorn. There are five zoos in America that breed peninsular pronghorn and they work together to keep the gene pool strong. Some zoos are strictly holding facilities for males if there are ever a surplus of males in the captive populations. The Peninsular Pronghorn Recovery Project is a conservation program that works specifically on maintaining sustainable populations of peninsular pronghorn in Baja California and in captivity.

A COMPARISON OF DENSITY AND DETECTABILITY OF PRONGHORN IN WYOMING FROM AERIAL SURVEYS

Presenting Author: LEE KNOX, *Wyoming Game and Fish Department, 1212 S Adams St, Laramie, WY 82070, USA, (307) 745-4046, lee.knox@wyo.gov*

JASON D. CARLISLE, *Wyoming Game and Fish Department, 1212 S Adams St, Laramie, WY 82070, USA, (307) 745-4046, jason.carlisle@wyo.gov*

L. EMBERE HALL, *Wyoming Game and Fish Department, 1212 S Adams St, Laramie, WY 82070, USA, (307) 745-4046, embere.hall@wyo.gov*

ABSTRACT Accurate estimates of population size are foundational to appropriate management and conservation of wildlife species. Estimating the abundance of free-ranging wildlife over large areas and through time poses a significant challenge to wildlife managers. Wyoming is home to approximately 50% of pronghorn (*Antilocapra americana*) rangewide, and pronghorn are a species of particular interest to wildlife stakeholders. Wyoming uses an aerial line transect survey following a distance-sampling protocol to estimate the population size in distinct herd units. A 200-m wide strip along line transects is surveyed by one observer on one side of the plane, with the strip beginning 65 m from the transect to omit the unviewable area directly below the plane. Surveys are conducted from fixed-wing aircraft at a nominal 91 m (300 ft) above ground level and speeds of 80 to 120mph, and observers use strut markers to assign pronghorn detections to one of five distance ranges. Data are analyzed using distance-sampling statistical models, and abundance estimates feed into integrated population models and inform subsequent management decisions. Herd-specific analyses sometimes suffer from relatively small sample sizes and often have less precision than desired. In an effort to improve the precision of estimates and draw comparisons of density and detectability among herd units, we undertook a comprehensive analysis of data from multiple surveys. Preliminary herd-level estimates of probability of detection ranged from approximately 40 – 80%, and estimates of pronghorn

density ranged from approximately 2 – 10 pronghorn/km^2 (5 – 25 pronghorn/mile^2). Preliminary results suggest that pooling data can produce estimates with higher precision, and that accounting for herd-level differences in pronghorn density and detectability remains important to accurate population monitoring.

OBSERVATIONS ON VARIOUS PRONGHORN POPULATIONS IN MEXICO AND THE SOUTHWESTERN UNITED STATES

Presenting Author: RAYMOND M. LEE, *Ray Lee LLC, P. O. Box 1448, Cody, Wyoming, 602-315-0604, rlee@morgensen.com*

ABSTRACT Various pronghorn populations in Baja California Sur, Chihuahua, Sonora, Arizona, and New Mexico have been surveyed to determine demographics, population estimates, and sustainability. Aerial surveys in some areas have occurred annually since 1994. These surveys, designed in accordance with the Pronghorn Management Guides, have been conducted to help identify appropriate management opportunities and to evaluate the success of prior and ongoing management actions. Some populations have been reduced by adverse climatic conditions, limited genetic variability, small initial population size, lack of community support, habitat interference caused by human made structures, and inter-specific competition. Other populations have increased due to aggressive management actions. Examples of both results are discussed.

USING CITIZEN SCIENTISTS TO CONNECT SCIENCE AND ROAD MITIGATION

TRACY S. LEE, *Miistakis Institute, Mount Royal University, EB 3013 Mount Royal University, Calgary, AB T3E 6K6, Canada, tracy@rockies.ca*

PAUL F. JONES, *Alberta Conservation Association, #400 817 4th Ave South, Lethbridge, AB T1J 0P6, Canada, paul.jones@ab-conservation.com*

ANDREW F. JAKES, *Smithsonian's National Zoo and Conservation Biology Institute,1500 Remount Road, Front Royal, VA 22630, USA, JakesAF@si.edu*

MEGAN JENSEN, *Nature Conservancy of Canada*

KEN SANDERSON, *Miistakis Institute, Mount Royal University, EB 3013 Mount Royal University, Calgary, AB T3E 6K6, Canada, ken@rockies.ca*

DANAH DUKE, *Miistakis Institute, Mount Royal University, EB 3013 Mount Royal University, Calgary, AB T3E 6K6, Canada, danah@rockies.ca*

Presenting Author: AMANDA MACDONALD, *Alberta Conservation Association, #400 817 4th Ave South, Lethbridge, AB T1J 0P6, Canada,* *amanda.macdonald@ab-conservation.com*

ABSTRACT Roads, their infrastructure, and associated traffic have significant impacts on wildlife, from direct mortality caused by collisions with vehicles to more indirect effects when wildlife avoid a road reducing access to important resources. Historically, transportation departments identified road mitigation sites based on hotspots of wildlife vehicle collisions (WVC) to ensure human safety. Often wildlife crossing needs are not accounted for in determining road mitigation sites. As an alternative, wildlife professionals have used landscape connectivity models derived from GPS collar data to identify linkage areas along roads that allow animal movement. However, these landscape models can be coarse and only provide general areas of where animals will likely traverse roads. We aimed to identify finer-scale locales to inform where road mitigation would best benefit pronghorn connectivity across the TransCanada Highway (TCH) in Alberta and Saskatchewan, Canada using three data sources: 1) pronghorn observations reported by citizen scientists via a smartphone application (Pronghorn Xing), 2) a pre-existing spring and fall pronghorn connectivity model, and 3) WVC data reported to RCMP or provincial government transportation agencies. Using these three data sets, we documented 16 potential crossing areas where pronghorn are more expected to cross the highway and therefore are candidate sites for mitigation. We then refined the potential mitigation sites using expert opinion from a steering committee. We also determined that WVC clusters derived from government agencies road carcass data do not align well with potential pronghorn crossing areas. To effectively reduce the impact of roads on wildlife, transportation planners need to consider multiple species, collision and crossing areas, and the type of mitigation required to facilitate safe movement. Additionally, by harnessing the competency of citizen scientist to fill in data gaps, planners will increase local awareness and support for mitigation plans and projects.

POPULATION MODELS AID DEFENSIBLE DECISION MAKING AND GUIDE MONITORING OF THE WORLD'S LARGEST PRONGHORN POPULATION

Presenting Author: HANS W. MARTIN, *Speedgoat Wildlife Solutions, Missoula, MT, USA, (406) 499-1202, hans.martin@speedgoat.io*

L. EMBERE HALL, *Wyoming Game and Fish Department, Laramie, WY, USA, (307) 413-2253, embere.hall@wyo.gov*

WILL SHULTZ, *Wyoming Game and Fish Department, Cheyenne, WY, USA, (307) 777-4584, will.shultz@wyo.gov*

LEE KNOX, *Wyoming Game and Fish Department, Laramie, WY, USA, (307) 745-4046, lee.knox@wyo.gov*

PAUL M. LUKACS, *University of Montana/ Speedgoat Wildlife Solutions, Missoula MT, USA, (406) 243-5675, paul.lukacs@umontana.edu*

J. JOSHUA NOWAK, *Speedgoat Wildlife Solutions, Missoula MT, USA, (406) 214-7666, josh.nowak@speedgoat.io*

ABSTRACT Agencies across western North America are faced with the unique challenge of monitoring and managing pronghorn (*Antilocapra americana*), a species with a unique life history, a penchant for migration, and a limited range. In collaboration with Wyoming Game and Fish, we developed an integrated population model (IPM) to help inform and defend pronghorn management in the state. The WDGF monitoring program provides a useful test-case for the application of IPMs to a species with a life history strategy that varies significantly from mule deer and elk. We used harvest surveys, abundance estimates, and composition surveys to inform an integrated population model which incorporates statistical population reconstruction within the typical IPM framework. We found the IPM worked well to describe Wyoming pronghorn populations while providing defensible inputs to management decisions. However, we also discovered some key takeaways that need to be considered when implementing these models for pronghorn. These include the incorporation of effort covariates that track changes in harvest rates, population definitions that respect spatial closure assumptions necessary for any population model, and structuring models to reflect the relatively fast life history strategy of pronghorn.

VARIATION IN SURVIVAL RATES ACROSS PRONGHORN NORTHERN POPULATIONS

Presenting Author: MOLLY C. MCDEVITT, *Wildlife Biology Program, Department of Ecosystem and Conservation Sciences, W.A. Franke College of Forestry and Conservation, University of Montana, Missoula, Montana 59812 USA, (505) 250-6139, molly1.mcdevitt@umontana.edu*

ANDY LINDBLOOM, *South Dakota Game, Fish and Parks, 4130 Adventure Trail, Rapid City, South Dakota 57702 USA. Andy.Lindbloom@state.sd.us*

KELLY PROFFITT, *Montana Fish, Wildlife and Parks, 1400 19th Avenue, Bozeman, MT 59718 USA, kproffitt@mt.gov*

JOSHUA MILLSPAUGH, *Wildlife Biology Program, Department of Ecosystem and Conservation Sciences, W.A. Franke College of Forestry and Conservation, University of Montana, Missoula, Montana 59812 USA, Joshua.millspaugh@umontana.edu*

PAUL LUKACS, *Wildlife Biology Program, Department of Ecosystem and Conservation Sciences, W.A. Franke College of Forestry and Conservation, University of Montana, Missoula, Montana 59812 US, Paul.lukacs@umontana.edu*

ABSTRACT Estimating demographic parameters (i.e., survival and recruitment) is critical for tracking and predicting trends in wildlife populations. Identifying how demographic parameters change in response to dynamic landscape and climatic conditions can provide insight into how wildlife populations will respond under future environmental changes. Further, in understanding

demographic responses across spatiotemporal factors, ecologists can better guide management actions aimed to maximize conservation efforts in wildlife populations. In this project, we study how pronghorn population survival rates vary across space and time. Leveraging GPS location and survival data from nearly 1,000 GPS collared pronghorn across Montana and South Dakota, we estimate annual survival from over 10 pronghorn populations. With over 500 juvenile and adult pronghorn collared in northwestern and central South Dakota and an additional 500 adult pronghorn collared in eastern, central, and southwestern Montana we can compare survival rates from mountain valley populations to mixed grass prairie ecosystems. To analyze these GPS collar data, we used a hierarchical Bayesian survival model to estimate annual survival rates across 2 years. Our results found that survival greatly varies across populations. Mean parameter estimates ranged from 0.66 (CRI 0.55 - 0.77) to 0.90 (CRI 0.85 – 0.94). Such variation offers insight into mechanisms driving survival across space and time and brings ecologists a step closer to effectively adapting conservation actions that best meet management objectives in a changing landscape.

PRONGHORN MIGRATION IN EASTERN OREGON

Presenting Author: JERROD L. MERRELL, *University of Nevada, Reno, 1664 N. Virginia St. Mail Stop 186 Reno, Nevada 89557, 775-225-1857, jmerrell@unr.edu*

KELLEY M. STEWART, *University of Nevada, Reno, 1664 N. Virginia St. Mail Stop 186 Reno, Nevada 89557, kelleys@unr.edu*

DON G. WHITTAKER, *Oregon Department of Fish and Wildlife, 4034 Fairview Industrial Dr. SE Salem, OR 97302, don.whittaker@odfw.oregon.gov*

ABSTRACT Migration maximizes accessibility of high-quality forage in variable ecosystems. This ubiquitous behavior is found in taxa worldwide. Large herbivores use long distance migrations to obtain seasonally productive forage. Mule deer (*Odocoileus hemiones*) and elk (*Cervus canadensis*) of the western US migrate to lower elevations when snow makes forage at high elevation inaccessible. Pronghorn (*Antilocapra americana*) in the western US also move between distinct seasonal ranges to obtain higher quality forage. Our objectives were to identify migration corridors and stopover locations used by a population of pronghorn in southeast Oregon. We deployed 154 GPS collars on adult female pronghorn between 2019 and 2021 by means of helicopter capture. We used a Brownian Bridge Movement Model to identify movement corridors, seasonal home ranges, and stopover locations using location data from 107 different pronghorn. Additionally, we identified individual movements between home ranges as well as migration corridors. Additionally, we identified substantial variation among individuals in timing of movements and locations of seasonal ranges. Our observations indicate that pronghorn movement southeast Oregon is influenced by shifting forage quality and not predicted by calendar dates.

WIND-ENERGY DEVELOPMENT ALTERS PRONGHORN MIGRATION AT MULTIPLE SCALES

MEGAN C. MILLIGAN, *U.S. Geological Survey, Northern Rocky Mountain Science Center, 2324 University Way, Suite 2, Bozeman, Montana 59715 USA, (575) 571-3518, mmilligan@usgs.gov*

Presenting Author: AARON N. JOHNSTON, *U.S. Geological Survey, Northern Rocky Mountain Science Center, 2324 University Way, Suite 2, Bozeman, Montana 59715 USA, (406) 994-7158, ajohnston@usgs.gov*

JEFFREY L. BECK, *Department of Ecosystem Science and Management, University of Wyoming, Laramie, Wyoming 82071, USA, (307) 766-6683, jlbeck@uwyo.edu*

KAITLYN L. TAYLOR, *Grouse Mountain Environmental Consultants, 760 West Fetterman Street, Buffalo, Wyoming 82834 USA, (307) 684-2112, ktaylor@gmecwy.com*

EMBERE HALL, *Wyoming Game and Fish Department, 1212 S. Adams Street, Laramie, Wyoming 82070, USA, (307) 745-4046, embere.hall@wyo.gov*

LEE KNOX, *Wyoming Game and Fish Department, 1212 S. Adams Street, Laramie, Wyoming 82070, USA, (307) 745-4046, lee.knox@wyo.gov*

TEAL CUFAUDE, *Wyoming Game and Fish Department, 1212 S. Adams Street, Laramie, Wyoming 82070, USA, (307) 321-7087, Teal.Cufaude@wyo.gov*

CODY WALLACE, *Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology, University of Wyoming, Laramie, Wyoming 82701, USA, cwalla21@uwyo.edu*

GENEVA CHONG, *U.S. Geological Survey, Northern Rocky Mountain Science Center, 2324 University Way, Suite 2, Bozeman, Montana 59715 USA, (307) 231-1534, geneva_chong@usgs.gov*

MATTHEW J. KAUFFMAN, *U.S. Geological Survey, Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology, University of Wyoming, Laramie, Wyoming 82071, USA, (307) 766-6404, mkauffm1@uwyo.edu*

ABSTRACT Migration is a widespread behavioral strategy that facilitates population persistence and ecosystem functioning, but migration routes have been increasingly disrupted by anthropogenic activities, including energy development. Wind energy is the world's fastest growing source of electricity and represents an important alternative to hydrocarbon extraction, but its effects on migratory species beyond birds and bats are not well understood. We evaluated the effects of wind-energy development on pronghorn migration, including behavior and habitat selection, to assess potential effects on connectivity and other functional benefits including stopovers. We monitored GPS-collared female pronghorn from 2010–2012 and 2018–2020 in

south-central Wyoming, USA, an area with multiple wind-energy facilities in various stages of development and operation, and collected 286 migration sequences from 117 individuals, including 121 spring migrations, 123 fall migrations, and 42 facultative winter migrations. While individuals continued to migrate through wind-energy facilities, pronghorn made important behavioral adjustments relative to turbines during migration. These included avoiding turbines when selecting stopover sites, selecting areas farther from turbines at a small scale, moving more quickly near turbines in spring, and reducing fidelity to migration routes relative to wind turbines under construction. While much remains to be learned, the behavioral adjustments pronghorn made relative to wind turbines could affect the functional benefits of migration, such as foraging success or the availability of specific routes, over the long-term.

WESTERN STATE AND PROVINCE PRONGHORN STATUS REPORT, 2022

Presenting Author: ANDREW NORTON, *South Dakota Game, Fish and Parks, 4130 Adventure Trail, Rapid City, SD 57702, USA, (605) 394-1752, Andrew.Norton@state.sd.us*

ANDY LINDBLOOM, *South Dakota Game, Fish and Parks, 4130 Adventure Trail, Rapid City, SD 57702, USA, (605) 394-1751, Andy.Lindbloom@state.sd.us*

ABSTRACT A range wide pronghorn summary is provided during each biennial western state and province pronghorn workshop. Because of the coronavirus pandemic, the 29th workshop was delayed 2 years. For the 2022 pronghorn workshop, hosted by the South Dakota Game, Fish and Parks, we administered a questionnaire survey to 23 states and provinces spanning pronghorn range from Canada, Mexico, and the United States. The 6-page questionnaire included 91 questions and was designed to standardize information among jurisdictions. We received responses from all 23 jurisdictions providing comprehensive coverage of all pronghorn subspecies from Canada to Mexico. The total 2021 pre-hunting season population estimate was 929,016 across 801,007 square miles of pronghorn range. Of the 8 states or provinces that reported numerical population goals, 5 were below the population objective. Pronghorn population density in Wyoming was nearly 3 times the next highest density reported in Colorado. All pronghorn in Mexico continue to be under objective despite no hunting seasons. Pronghorn densities in Mexico were about 1/6th of the average pronghorn density across the entire range. Adult buck to adult doe ratios averaged 41 bucks to 100 does in 2021, comparable to long-term averages. Except for Arizona Sonoran pronghorn, buck to doe ratios were highest in the northcentral part of the range in Montana and Saskatchewan. Concerningly, fawn to adult doe ratios that averaged 38 fawns per 100 does in 2021 were >5% below long-term averages in 85% of states and provinces. The southwestern region of pronghorn range reported the lowest fawn to doe ratios. Total pronghorn harvest in 2021, excluding Saskatchewan, was 75,400 (11.3 pronghorn harvested per 100 square miles of identified pronghorn range) and accounted for 8% of the range wide estimated population. In addition to the highest population, pronghorn harvest was highest in Wyoming. Below objective populations and below average recruitment rates may be cause for concern if the pattern persists.

MODELING PRONGHORN BEHAVIOR AND SPACE-USE: ACCLIMATION OF TRANSLOCATED PRONGHORN IN THE EDWARDS PLATEAU

Presenting Author: ERIN C. O'CONNELL, *Borderlands Research Institute, Department of Natural Resource Management, Sul Ross State University, Alpine, TX 79830, USA, eco20il@sulross.edu*

JUSTIN T. FRENCH, *Borderlands Research Institute, Department of Natural Resource Management, Sul Ross State University, Alpine, TX 79830, USA*

CARLOS E. GONZALEZ, *Borderlands Research Institute, Department of Natural Resource Management, Sul Ross State University, Alpine, TX 79830, USA*

LOUIS A. HARVESON, *Borderlands Research Institute, Department of Natural Resource Management, Sul Ross State University, Alpine, TX 79830, USA*

SHAWN S. GRAY, *Texas Parks and Wildlife Department, Alpine, TX 79830, USA*

ABSTRACT Translocation is the most widely used tool to combat megafauna population declines to prevent extinction. However, despite widespread use, there are no explicit measures for translocation success. To alleviate this challenge, it is first essential to define appropriate timescales to assess translocation success. To address this, we estimated the post-translocation acclimation period for translocated pronghorn (*Antilocapra americana*) based on patterns of animal space use. The acclimation period is a critical time scale indicative of translocated individuals changing their space use and becoming familiar with their novel environment. Familiarity with the environment is associated with a lower mortality risk. We postulated that residents would maintain a static range size over time, whereas translocated pronghorn would initially have large range sizes that declined as they acclimated. In February 2019, Texas Parks and Wildlife Department (TPWD) collared 20 resident pronghorn on Rocker b Ranch, near Big Lake, Texas. In January 2020, TPWD translocated 115 pronghorn from Pampa, Texas, to the Rocker b Ranch, 45 of which were fitted with Global Positioning Systems collars. We fit weekly utilization distributions (UD) using a kernel density estimator for each resident and translocated pronghorn, following the translocation event. We took the area of the 75% isopleth of each UD to collate a time series of each individual's weekly range size. We then fit generalized linear mixed models to quantify differences between resident and translocated pronghorn behavior through time. We found that the acclimation period for translocated pronghorn is approximately 6 months post-release, much longer than previously thought ($R^2 = 0.30$). In addition, translocated pronghorn settled into smaller ranges than residents ($\beta = 5.87$ km^2, 95% CI = ± 1.05), supporting the notion memory is a primary factor in pronghorn space use, and suggesting translocated may have fitness advantages over residents. These results also suggest the success of both fence modification efforts and translocations should be evaluated over longer time scales than previously thought. Further, translocation may expedite the colonization of reconnected habitat following fence modification, conferring a previously unrecognized advantage of this practice.

PRONGHORN MOVEMENT AND RESOURCE SELECTION IN NEBRASKA'S AGRICULTURALLY DOMINATED LANDSCAPE

Presenting Author: KATIE M. PIECORA, *University of Nebraska – Lincoln, School of Natural Resources, 101 Hardin Hall, 3310 Holdrege St., Lincoln, NE 68583, USA, (813) 495-2565, kpiecora2@unl.edu*

ANDREW R. LITTLE, *University of Nebraska – Lincoln, School of Natural Resources, 306 South Hardin Hall, 3310 Holdrege St., Lincoln, NE 68583, USA, (402) 219-1913, alittle6@unl.edu*

DUSTIN H. RANGLACK, *University of Nebraska – Kearney, Department of Biology, BHS 343, 2401 11th Ave, Kearney, NE 68849, USA, (308) 865-8545, ranglackdh@unk.edu*

ABSTRACT Grasslands are globally recognized as one of the most ecologically and economically valuable biomes on earth, yet 50% of North America's temperate grasslands have been converted to crop production and rangeland for livestock. Pronghorn (*Antilocapra americana)* are an endemic species to these imperiled temperate grasslands and are capable of some of the longest migrations of all North American ungulates. With the conversion of these critically important temperate grasslands, landscape fragmentation may pose significant challenges to movements and resource selection of pronghorn and may significantly alter their use compared to historical populations. Currently, a knowledge gap exists in our understanding of pronghorn resource selection in Nebraska. We seek to understand how landscape structure influences pronghorn movement and resource selection across a fragmented agricultural system in the panhandle of western Nebraska and the Sandhills. We captured and fit 110 adult pronghorn in western Nebraska with GPS collars and collected locations every 2.5 hours. Using step selection functions, we will compare habitat features and environmental conditions at used versus available locations to identify selection preferences. We hypothesize that large-scale crop production artificially increases access to forage, improving fitness of year-round residents and lessening the need for long-distance seasonal movement. This analysis is in progress and results will be finalized by July 2022. With pressure mounting on farmers to feed an ever-growing human population, results from this study will build a foundation to guide management for long-term persistence of pronghorn in a human-dominated landscape.

COLLABORATIVE WILDLIFE-SNOW SCIENCE: INTEGRATING WILDLIFE AND SNOW EXPERTISE TO IMPROVE RESEARCH AND MANAGEMENT

Presenting author: ADELE K. REINKING, *Cooperative Institute for Research in the Atmosphere, Colorado State University, Fort Collins, CO 80523-1375, USA, adele.reinking@colostate.edu*

STINE HØJLUND PEDERSEN, *Cooperative Institute for Research in the Atmosphere, Colorado State University, Fort Collins, CO 80523-1375, USA, and Department of Biological*

Sciences, University of Alaska Anchorage, Anchorage, AK 99508, USA, stine.pedersen@colostate.edu

KELLY ELDER, *US Forest Service, Rocky Mountain Research Station, Fort Collins, CO 80526, USA, kevin.elder@usda.gov*

GLEN E. LISTON, *Cooperative Institute for Research in the Atmosphere, Colorado State University, Fort Collins, CO 80523-1375, USA, glen.liston@colostate.edu*

ABSTRACT Snow and other winter features or processes affect many aspects of wildlife ecology, ranging from movement behaviors, to forage accessibility, to community dynamics. Moreover, the relationships between wildlife and the snow properties they experience, such as snow onset date, depth, and distribution, can ultimately influence individual fitness and alter population dynamics. Therefore, researchers and managers in regions experiencing snow often seek to understand these interactions and their consequences. However, studying and monitoring wildlife-snow relationships remain challenging, because properly characterizing snow and identifying, accessing, and applying relevant snow information at appropriate spatial and temporal scales often require a detailed understanding of physical snow science and technologies that typically lie outside the expertise of wildlife professionals. To overcome these difficulties and achieve novel, more nuanced understandings of wildlife-snow relationships, we advocate for substantive, cross-disciplinary collaboration between the wildlife and snow sciences. We propose a five-step procedure to facilitate this collaboration, and we present the different types of snow information that can be used within this interdisciplinary framework. These data types and methods include field observations, remote-sensing datasets, and examples of modeling tools that simulate spatiotemporal snow property distributions and evolutions. Our procedure details how to identify relevant snow information at appropriate spatiotemporal scales, produce validated and tailored snow datasets, and apply the resulting snow information in wildlife analyses through direct collaboration between wildlife and snow professionals. We present these concepts through the lens of several real-world examples of wildlife-snow studies and focus on how this work is relevant to the ungulate ecology community, with particular emphasis on pronghorn research and management.

Reinking, A. K., S. H. Pedersen, K. Elder, N. T. Boelman, B. A. Oates, S. Bergen, M. B. Coughenour, T. W. Glass, J. A. Feltner, K. J. Barker, L. R. Prugh, T. J. Brinkman, T. W. Bentzen, Å. Ø. Pedersen, N. M. Schmidt, and G. E. Liston. In press. Collaborative wildlife-snow science: Integrating wildlife and snow expertise to improve research and management. Ecosphere: Innovative Viewpoints. DOI: : 10.1002/ecs2.4094.

PRONGHORN HABITAT SUITABILITY IN THE FLINT HILLS OF EAST-CENTRAL KANSAS

Presenting Author: JEFF W. RUE, *University of Nebraska at Kearney and Kansas Department of Wildlife and Parks 2613 N. Jade Road. Hillsboro, KS 67063, USA, (316) 772-2706, jeff.rue@ks.gov*

DUSTIN RANGLACK, *University of Nebraska at Kearney, 2401 11th Ave. Kearney, NE 68849, USA, (308) 865-8545, ranglackdh@unk.edu*

ABSTRACT Pronghorn (*Antilocapra americana*) were translocated into the Flint Hills region of Chase County, Kansas during the late 1970s through the early 1990s as a part of statewide reintroduction efforts into portions of their historical range. Since the last translocation in 1992, the Chase County pronghorn population has stabilized at approximately 30 individuals. Several research projects conducted in the 1990s provided important information on the Chase County population and local habitat conditions during initial translocations. However, land ownership and land management have changed which may impact pronghorn habitat suitability. Habitat conditions were inventoried in 2021 to determine the current status of pronghorn habitat and potential limiting factors including bottom wire fence heights, fence density, pasture size, vegetation composition, vegetation height, and coyote occupancy. Maximum bottom wire fence height was estimated at an average of 41 cm and minimum of 30.7 cm which are below the recommended minimum bottom wire height of 46 cm. Additionally, only 27.3% of the total number of fences sampled were ≥ 46 cm which suggests a low percentage of adequate bottom wire height for pronghorn passage. Fence density and pasture size was estimated at 1.9 km/km^2 and 2.6 km^2 respectively. Vegetation height averaged 8.6, 10.0, and 11.1 cm for June, July, and August 2021, which falls below fawn habitat height recommendations (> 25 cm). Coyote naïve occupancy was determined to be 100% among nine camera trap sites while individual site estimated occupancies was lower (psi = 50%). Management recommendations that may be acceptable to local landowners is a minimum average bottom wire height of 46 cm to improve pronghorn passage and movement across the landscape and maintain an average vegetation height >25 cm during the months of June, July, and August to increase potential fawning habitat.

SEASONAL RESOURCE SELECTION BY PRONGHORN IN CENTRAL OREGON

Presenting Author: ANDREW J. WALCH, *Oregon Department of Fish and Wildlife, 61374 Parrell Rd, Bend, OR 97702, 541-388-6229, Andrew.j.walch@odfw.oregon.gov*

COREY HEATH, *Oregon Department of Fish and Wildlife, 61374 Parrell Rd, Bend, OR 97702, corey.heath@odfw.oregon.gov*

SETH HARJU, *Heron Ecological, LLC, P.O. Box 235, Kingston, ID 83839, seth@heronecological.com*

DONALD G. WHITTAKER, *Oregon Department of Fish and Wildlife, 4034 Fairview Industrial Dr. SE Salem, OR 97302, don.whittaker@odfw.oregon.gov*

ABSTRACT Understanding features on the landscape that animals select for is critical information for wildlife managers in order to make population and land management decision to manage wildlife, and is important for predicting where wildlife are expected to occur across the landscape. The Oregon Department of Wildlife (ODFW) collected location data on free-ranging pronghorn (*Antilocapra americana*) in central Oregon from February of 2018 through March of 2021. Pronghorn were captured and fitted with Global Positioning Satellite (GPS) collars and released, with collars programmed to record locations approximately every 13 hours year-round. We used net squared displacement to estimate seasonal range migration periods and estimated mixed-model resource selection functions to understand resource selection by pronghorn. We found that this is a mixed migratory population, but that most individuals showed year-round range fidelity or sporadic non-seasonal migrations. Pronghorn avoided *Pinus ponderosa* and *Juniperus occidentalis* cover, especially during winter. Pronghorn also selected for areas with higher annual forb and grass cover, but only in fall and winter. Surprisingly, pronghorn selected for locations with higher surrounding fence density than was available within their home ranges, and from spring to winter increased the strength of their selection. Variation in selection for specific resources among individual pronghorn was highly resource and season dependent. Maps of the predicted relative probability of occurrence validated well (Spearman rho = 0.92, $p < 0.001$) and are now available for pronghorn managers across a large portion of central Oregon.

ICE-AGE PRONGHORN IN NORTH AMERICA

Presenting Author: RICHARD S. WHITE, *The Mammoth Site*, *1800 us Highway 18 Bypass Hot Springs, SD 57747*, *rswhite@mammothsite.org*

ABSTRACT Four genera (with a total of 6 species) of pronghorn are known from North America: *Capromeryx*, *Stockoceros*, *Tetrameyx*, and *Antilocapra*. Ironically, the living pronghorn, *Antilocapra americana*, has a meager record in the Pleistocene, despite its abundance and wide distribution in recent times. Only 7 records of *Antilocapra* in the Pleistocene are recognized as valid; most of the nearly 100 other records in the literature are based on non-diagnostic fragments. *Antilocapra* overlaps in size with *Stockoceros* and *Tetrameryx*; *Stockoceros* being mainly smaller, and *Tetrameryx* being mainly larger than the modern species. Identification of *Antilocapra* in the Pleistocene has been based primarily on size; *Tetrameryx* being ignored in most such consideration. To complicate comparisons further, there is no known occurrence of a *Tetrameryx* skull being directly associated with a skeleton, so we have no known reference for its postcranial remains, and no idea of potential variation in size. I examine the distribution of Ice-Age pronghorn in time and space, discussing the occurrence of these animals in cave and karst deposits versus open sites. Finally, I highlight the interesting problem of why three genera, two of them roughly the same size as the modern species and one a dwarfed form, should have become extinct by the end of the Pleistocene, while the extant American pronghorn survived and flourished.

MIGRATORY STRATEGIES AND INTEGRATED STEP SELECTION ANALYSIS OF PRONGHORN (ANTILOCAPRA AMERICANA) ON THE MODOC PLATEAU

Presenting Author: COLTON J. WISE, Oregon State University, colton.wise@oregonstate.edu

CLINTON W. EPPS, Oregon State University, Clinton.epps@oregonstate.edu

BRIAN R. HUDGENS, Institute for Wildlife Studies, Hudgens@iws.org

ROBERT S. SPAAN, Oregon State University, Rob.Spaan@oregonstate.edu

ABSTRACT Anthropological effects have influenced habitat and organisms' ability to move across landscapes freely. For pronghorn (Antilocapra americana), barriers such as fences and roads inhibit movement. Understanding migratory strategies and how pronghorn interact with the environment during range shifts would improve management. To distinguish migratory strategies, we used location data from 173 GPS-collared pronghorn in California, Nevada, and Oregon, collected over six years. Using a mechanistic range shift analysis, we identified movements between ranges and migration strategies. We then used an integrated Step-Selection Analysis (iSSA) to determine how landscape characteristics influence these movements. We determined that 114 of 173 (65.9%) of pronghorn shifted ranges at least once. Range shifts lasted an average of 4.57 days, with individuals traveling an average distance of 22.04 km (range = 1.05–78.30 km). Migration strategy varied, with some individuals remaining as residents and others shifting up to ten times/year. Our iSSA indicated that terrain roughness, fence density, and distance to fence influenced pronghorn movements. The next step is using our iSSA to simulate pronghorn movements under different environmental conditions. We were able to identify individuals with varying strategies of migration and identified landscape features that affected these movements. This study demonstrates how migratory behavior can vary within and amongst populations and will help inform how habitat modification efforts can alter landscape connectivity.

BUSINESS MEETING

DRAFT Business Meeting Minutes

29th Biennial Western States and Provinces Pronghorn Workshop
22-25 August 2022
Deadwood, South Dakota

1. Call to order
    - *Meeting called to order at 8:24 AM (MST), by Andy Lindbloom (SDGFP)*

2. Roll call of states, provinces, universities, and federal agencies
    - *Alberta – Kim Morton*
    - *Saskatchewan – Leanne Heisler*
    - *Idaho – Andy Holland*
    - *Kansas – Matt Peek*
    - *Montana – Brian Wakeling*
    - *Nebraska – Luke Meduna*
    - *Nevada – Cody Schroeder*
    - *New Mexico – Anthony Opatz*
    - *Oregon – Don Whittaker*
    - *South Dakota – Andy Lindbloom*
    - *Texas – Shawn Gray*
    - *Utah – Kent Hersey*
    - *Wyoming – Lee Knox*

3. Review agenda
    - Handouts
    - Agenda additions
    - Approval
        - *Don Whittaker Motioned to approve; Seconded by Holly Miyasaki*

4. Review 2018 minutes
    - Handouts
    - Edits
    - Approval
        - *Shawn Gray Motioned to approve; Cody Schroeder Seconded*

5. Progress on action items

- WAFWA registrations and workshop budget/expenses
  - *104 Registrations (approx. $30,000) plus 3 attended that did not need to register (Dept secretary, daughter of award recipient, invited speaker that only attended to present)*
  - *Venue approx. $21,000 but will depend on final tally as some items are charged based on amount used (e.g., water bottles, coffee)*
  - *Sponsors ($3,000)*
  - *Vendors ($1,500)*
  - *SWAG Items*
  - *Did not need to use $2500 transfer funds from Nevada*
  - *16 States and Provinces represented*
  - *40 agencies, organizations, and companies attended*

- Workshop frequency
  - *Previous discussions at prior meetings revolved around the ability to fill an agenda. South Dakota was able to fill two days of meeting with presentations. All agreed to stay on a two-year biennial schedule.*

- Bylaws and Awards updates
  - Handouts
  - Designate committee
  - *Brian Wakeling suggested that a group or committee get together work on revision of bylaws.*
  - *Don Whittaker didn't think that we have much for changes that are needed in the bylaws.*
  - *Discussion on Federal Agencies attending. Attendance has declined over the past two meetings.*
  - *Chad Switzer mentioned the need for a document that summarizes the history of meeting, e.g., awards information.*
  - *Bylaw changes – Discussion on how changes are made. Member/Rep. voting primarily and then it goes through WAFWA. This group is not a Working Group, so no Director Liaison has been appointed. It was suggested the Director from the host state would possibly be the one submitting any action items to WAFWA.*
  - *Review Committee – volunteers from Nevada (Cody Schroeder), South Dakota (Andy Lindbloom), and Montana (Brian Wakeling) agreed to participate in a review committee of all bylaws and guidelines pertinent to this workshop. The host state of Oregon (Don Whittaker) would assist and coordinate the activities of this committee.*

6. Determine next location and host
    - *2024 – Oregon*
    - *2026 – Colorado*
    - *2028 - Utah*

7. Award information
    - *Steve Griffin mentioned it was difficult to meet all of the committee member criteria listed in the awards bylaws. Suggested that this needs reviewed/revised. Group agreed this will be part of the bylaws review previously discussed.*

8. Adjourn
    - *Meeting adjourned at 8:58 AM (MST)*

AWARDS

THE BERRENDO AWARD

The Berrendo Award is the most prestigious recognition offered through the Pronghorn Workshop. Berrendo is derived from the Spanish word for pronghorn—North America's prairie speedster— that epitomizes the difficulty of being a remaining Pleistocene native in a modern world. The award will be bestowed on an individual or a group of collaborators/team that made major contributions to pronghorn ecology and management.

<u>Award criteria include:</u>

- First choice will be given to a nominee that is either retired or deceased. Additional outstanding and exceptional candidates will also be considered.
- Contribution(s) by nominees can be a lifetime (>10 years) career directly involved in pronghorn research or management.
- Contribution(s) can be a major publication(s), including books, chapters of books, special reports, monographs, or other publications that have regional or range-wide significance.
- Contribution(s) needs to have afforded significant scientific advancement in the management or research of pronghorn.
- The contribution can represent either a single event or a long-term commitment to pronghorn.

<u>Previous Winners of the Berrendo Award:</u>

2002: Jim Yoakum (retired BLM), Verdi, Nevada
2004: Bart O'Gara (deceased, Univ. of Montana Fish & Wildlife Coop. Unit), Lolo, MT
2006: Tom Pojar (retired Colorado Division of Wildlife), Kremmling, Colorado
2008: Richard Ockenfels (deceased, Arizona Game and Fish Department), Mayer, Arizona
2010: Rich Guenzel (retired Wyoming Game and Fish Department), Laramie, Wyoming
2012: None
2014: Tommy Hailey (retired Texas Parks and Wildlife Department), Alpine, Texas
2016: Jorge Cancino (Centro de Investigaciones Biologicas del Nosoeste, Baja California Sur, Mexico
2018: John A Byers (University of Idaho), Moscow, Idaho

<u>2022 Recipient of the Berrendo Award</u>

David E. Brown (Arizona Game and Fish Department, Deceased 2021)

Accepting the Berrendo award on behalf of David Brown is J. Elaine Brown (daughter; center). Presented by Chad Switzer (SDGFP, Awards Chair; left) and Steve Griffin (SDGFP; Awards committee; right).

David E. Brown was posthumously awarded the 2022 Berrendo Award after receiving 3 strongly compelling nominations. These nominations each spoke to his dedication to pronghorn research, management, ecology, and conservation. His advancement of pronghorn research and management while working for the Arizona Game and Fish Department, the time he spent as an adjunct professor at Arizona State University, his initiation and longstanding involvement with the Arizona Antelope Foundation, and his consistent contributions to the Biennial Pronghorn Workshops from 1982-2016, all demonstrate the amount of passion and drive that Dave had for pronghorn throughout his lifetime. With 23 books, 250 articles, 120 scientific papers, and 12 presentations at the Biennial Pronghorn Workshops, Dave has shown true dedication to informing and educating everyone in the pronghorn field. Most notable is the book "Arizona's pronghorn Antelope. A Conservation Legacy" which he co-authored with Richard Ockenfels in 2007. He has been honored with several awards including: Wildlife Conservationist of the Year and the Thomas E. McCCullough Award for career achievement by the Arizona Wildlife Federation, inducted to the Arizona Outdoor Hall of Fame, and received the first Lifetime Achievement Award by the Arizona Chapter of the Wildlife Society (which was named in his honor). Dave was a passionate biologist, natural historian, and an extraordinary advocate for pronghorn and the habitat that supports them. He has influenced the careers of many individuals, inspired future generations, and encouraged everyone to be skeptical and questioning when searching for answers to your next pronghorn question. Quoted from Jim Heffelfinger's nomination: "Pronghorn, and everyone who loves them, are better off because Dave was their champion."

Nominations were submitted by: Rich Guenzel, Carl D. Mitchell, and Jim Heffelfinger

SPECIAL RECOGNITION AWARD

The Special Recognition Award was created to honor the many people, teams or organizations that have made worthy contributions that aid in the conservation of pronghorn. These can include projects that are oriented to pronghorn management, research or appreciation.

Award criteria include:

- Nominee should be living and currently/recently active and involved in pronghorn conservation.
- Contribution(s) should be an important event or accumulation of important contributions to pronghorn management, research, or appreciation.
- Contribution(s) can be a new field or analytical technique that has regional or range -wide application.

Previous Special Recognition Award Recipients:

2002: Karl Menzel (NE), Jorge Cancino (BCS, MX), Bill Rudd (WY), Richard Ockenfels (AZ)
2004: Rich Guenzel (WY), Alice Koch (CA), John Hervert (AZ), Arizona Antelope Foundation (AZ)
2006: Rick Danvir (UT), Fred Lindzey (WY), Rick Miller (AZ)
2008: Morley Barrett (Alb, Canada), David Brown (AZ)
2014: Joe Riis (SD), Hall Sawyer (WY), and Emilene Ostlind (WY)
2016: Jorge Cancino (Mexico), Paul Jones (AB)
2018: Bill Rudd (WY), Matt Kauffman (WY), Ken Gray (NV), Tom Warren (NV), Charlie Clements (NV), Jim Young (NV)

2022 Recipients of the Special Recognition Award

The National Fish and Wildlife Foundation, Arizona Game and Fish Department, Arizona Antelope Foundation, and Dr. Andrew Jakes (MT)

Accepting the Special Recognition Award from left to right on behalf of the Arizona Antelope Foundation (Glen Dickens) and the Arizona Game and Fish Department (Brandon Foley and Callie Cavalcant).

The partnership between Arizona Antelope Foundation, Arizona Game and Fish Department, and National Fish and Wildlife Foundation on the Southeast Arizona Grasslands Pronghorn Initiative has been a tremendous success for conservation and management of pronghorn, as well as many other grassland species. Their strategic and well planned approach to improving habitat connectivity, ultimately restored pronghorn populations to previous desired levels. They achieved this result through the cooperation and coordination of funding sources, landowner support, volunteers and youth engagement over a multi-year project (2010-2019). The effects of this initiative improved water availablity in 13 sites, removed or altered fencing affecting 191,800 acres, enhanced grasslands with the use of prescribed fire, misquite removal and herbicide treatments across 7,874 acres, translocated 95 animals, and reduced the impact of predators on fawning areas. A quote from the nomination submitted by Brian Wakeling: “This is the type of public-private partnership that we often seek but rarely find. This collaborative group pulled it off.”

Nominations were submitted by: Amber Munig, Brian Wakeling, and Raul Vega

Dr. Andrew Jakes accepting the Special Recognition Award in 2022.

Dr. Andrew Jakes has built his career around the enhancement of pronghorn migration across inter-state and international boundaries. His innovative approaches to documenting migration corridors, and scientific findings to maintain connectivity for pronghorn, have had a direct impact on populations in Montana, Idaho, Alberta and Saskatchewan. But his findings and methods have been applied to a much broader portion of pronghorn range.

He earned his PhD in 2012 at the University of Calgary identifying critical migration pathways and linkage areas in Montana, Alberta and Saskatchewan. His post-doctoral work at the University of Montana involved coordination with the Alberta Conservation Association and The Nature Conservancy to evaluate fence modifications to enhance pronghorn fence crossings. The 18 inch bottom wire fence construction that this project identified as beneficial, has now become a standard for many jurisdictions. Dr. Jakes has 13 peer-reviewed papers related to pronghorn, 2 additional papers currently under review, and contributed to the Biennial Pronghorn Workshop with 7 presentations. His cooperative, engaging and humble personality have allowed everyone around him to become engaged and inspired, ultimately creating a sense of community in the pronghorn field. Although he has a deep knowledge of pronghorn behavior, he has always expressed a sense of curiosity for new and innovative ways to enhance pronghorn migration corridors, and ultimately population sustainability. A quote from Rich Guenzel's nomination letter reads "He is one of the leading proponents for conserving pronghorn migrations at landscape scales."

Nominations were submitted by: Paul F. Jones, Rich Guenzel, and Adele K. Reinking

PRONGHORN HALL OF FAME

The Hall of Fame was created to honor historic individuals or groups/teams that accomplished outstanding services for pronghorn conservation prior to the establishment of the Berrendo Award (pre-2002). Those involved in pronghorn conservation today owe much to the efforts of pronghorn biologists, managers, researchers, and other conservationists that produced worthy efforts prior to the establishments of any awards. The Pronghorn Hall of Fame awards are an ongoing effort to formally recognize the careers and long-term contributions of our predecessors.

<u>Criteria for presenting this award include:</u>

- The nominee must be retired or deceased (criteria accepted at 2006 Pronghorn Workshop).
- *An inductee* may be a pronghorn advocate, a land manager, an agency biologist, an academic, an artist, or various combinations thereof.
- Nominee's career should have contributed to increases in pronghorn numbers, distribution, knowledge of, or appreciation.
- Pronghorn conservation must have been a paramount part of nominee's career (criteria accepted at 2006 Pronghorn Workshop).
- Contributions must be of historic significance to the management, research, or conservation of pronghorn.
- Contributions should have regional, national, or international value or application.
- Contributions can be scientific or popular books, chapters of major books, a monograph, agency/organization special reports, or a number of articles (>5) in scientific or popular journals.
- Contribution(s) can be an important scientific advancement in either a field or analytical technique.
- All Berrendo Award winners will automatically be inducted into the Pronghorn Hall of Fame, either upon retirement or passing.

<u>Previous Hall of Fame Inductees:</u>

- Jim D. Yoakum and Bart W. O'Gara (2002 and 2004 Berrendo Award recipients) automatically inducted.
- Tom M. Pojar (2006 Berrendo Award recipient)
- Arthur S. Einarsen (OR), Helmut K. Buechner (TX), and T. Paul Russell (NM) (2008 elected as members).
- Richard A. Ockenfels (2008 Berrendo Award recipient).
- Rich Guenzel (2010 Berrendo Award recipient).
- Tommy Hailey (2014 Berrendo Award recipient)
- Jorge Cancino (2016 Berrendo Award recipient)
- William Hepworth (2016 selected member)
- John A. Byers (2018 Berrendo Award recipient)

<u>2022 Inductees of the Pronghorn Hall of Fame</u>

David E. Brown (deceased, 2022 Berrendo Award recipient)

Edson Fichter (Idaho State University, deceased 1994)

Acceptance of the Pronghorn Hall of Fame Award on September 8, 2022 on behalf of Edson Fichter at the Edson Fichter Nature Area in Pocatello, Idaho is from left to right: **Sarah Fichter Carter** (daughter), **Robert Autenrieth** (Dr. Fichter's first MS graduate student for pronghorn antelope behavior research at Idaho State University), **Nancy Fichter Dillon** (daughter)

Dr. Edson Fichter has made significant impacts to early pronghorn management and research and should have been inducted to the Pronghorn Hall of Fame in 1994, but the awards were not initiated until 2002. Over the course of Dr. Fichter's lifetime (1910-1994) he contributed to the science, management, research, and beauty of pronghorn. He spent his early years in Iowa, gaining his PhD. at the University of Nebraska. From there he moved his family to Idaho to become a professor at Idaho State College (later Idaho State University), where he taught biology, zoology and wildlife management for 26 years. During this time, he mentored dozens of student and published over 20 scientific papers on reproduction, seasonal herd sizes, fawn behavior, and the relationship of pronghorn behavior to management. Every summer from1956-1942 he trekked out to Pahsimeroi Valley to observe and record pronghorn behavior. His journal entries of meticulously recorded notes, photos, color motion film and published papers played a significant roll in informing Idaho Fish and Game's pronghorn management decisions at the time and for years to come. He retired from Idaho State University in 1975, but that was by no means the end of his impact on pronghorn management or his ability to share his knowledge and passion with others.

Dr. Fichter was also an accomplished artist, his drawings and scientific illustrations portrayed many different species, but it is believed that pronghorn where his favorite subject. His artwork graced the cover of the 1976 and 1978 Biennial Pronghorn Workshop proceedings and the first edition of the Workshop's Management Guidelines in 1978. Dr. Fichter was active in the Biennial Pronghorn Workshop from 1972-1980, contributing 6 presentations in that time. Not only was Dr. Fichter a research biologist and professor, but he was also a naturalist, artist, photographer, poet, author, mentor, curator and philosopher. His scientific writings will remain a cornerstone of biological knowledge and his artwork will continue to show the beauty and wonder of our natural world.

Nominations were submitted by: Jennifer Jackson and Rich Guenzel

SUMMARY OF PRONGHORN WORKSHOPS HOSTS

Year	Workshop	Location
1965	1st	New Mexico
1966	2nd	Colorado
1968	3rd	Wyoming
1970	4th	Nebraska
1972	5th	Montana
1974	6th	Utah
1976	7th	Idaho
1978	8th	Alberta
1980	9th	Arizona
1982	10th	North Dakota
1984	11th	Texas
1986	12th	Nevada
1988	13th	Oregon
1990	14th	Colorado
1992	15th	Wyoming
1994	16th	Kansas
1996	17th	California
1998	18th	Arizona
2000	19th	Baja California Sur
2002	20th	Nebraska
2004	21st	North Dakota
2006	22nd	Idaho
2008	23rd	Alberta
2010	24th	Wyoming
2012	25th	New Mexico
2014	26th	Texas
2016	27th	Montana
2018	28th	Nevada
2022	29th	South Dakota

2022 WORKSHOP ATTENDEES

Full Name	Company Name
Allen, Travis	Nevada Department of Wildlife
Andersen, Sonja	Montana Fish, Wildlife & Parks
Atwood, Steve	Montana Fish, Wildlife and Parks
Baillie, Hunter	Nebraska Game and Parks
Baker, Nathan	South Dakota Game, Fish and Parks
Bantus, Oana	Lotek Wireless Inc.
Barber, Dallas	Oklahoma Department of Wildlife Conservation
Beck, Jeff	University of Wyoming
Beckmann, Jon	KDWP
Buzzard, Simon	National Wildlife Federation
Chitwood, Colter	Oklahoma State University
Crane, Madison	University of Montana
Cunningham, Julie	Montana Fish, Wildlife and Parks
Dart, Marlin	Caesar Kleberg Wildlife Research Institute
DeVore, Ryan	Montana Fish, Wildlife & Parks
Dickens, Glen	Arizona Antelope Foundation
Dilley, Josh	Colorado Parks and Wildlife
DiMarco, Emma	Telonics Inc.
Doggett, Jake	Montana Fish, Wildlife and Parks
Dorak, Brett	Montana Fish, Wildlife and Parks
Ennis, Joanna	New Mexico State University
Etchart, Jose	Texas Parks and Wildlife
Fairbanks, Sue	Oklahoma State University
Foley, Brandon	Arizona Game & Fish Department
Foster, Melissa	Montana Fish, Wildlife & Parks
French, Justin	Borderlands Research Institute
Garrison, Kyle	WDFW
Gray, Shawn	Texas Parks & Wildlife
Griffin, Steve	South Dakota Game, Fish, and Parks
Grogan, Angela	Department of NRM, Texas Tech University

Guenzel, Rich	Wyoming Game & Fish Dept.
Haffley, Trenton	South Dakota Game, Fish and Parks
Hahn, Derek	Oklahoma State University
Harper, Erin	Lotek Wireless Inc.
Harryman, Samuel	Texas Parks & Wildlife Department
Hartson, Callie	Arizona Game and Fish Department
Heffelfinger, Levi	Caesar Kleberg Wildlife Research Institute
Heisler, Leanne	Saskatchewan Ministry of Environment
Henderson, Charles	Idaho Dept. of Fish and Game
Hersey, Kent	Utah Division of Wildlife Resources
Holland, Andy	Colorado Parks and Wildlife
Hoskins, James	Texas Parks & Wildlife Department
Hudgens, Brian	Institute for Wildlife Studies
Jackle, Greg	Oregon Department of Fish & Wildlife
Jakes, Andrew	Smithsonian's National Zoo and Conservation Biology Institute
Jaster, Levi	Kansas Department of Wildlife and Parks
Johnson, Marguerite	Wyoming Game and Fish Department
Johnston, Aaron	US Geological Survey
Jones, Paul	Alberta Conservation Association
Kanta, John	SD Game, Fish and Parks
Kirk, Josh	Nevada Department of Wildlife
Knox, Lee	Wyoming Game and Fish
Koch, Alice	Ca. Dept. of Fish and Wildlife (retired)
Kraft, Jordan	Wyoming Game and Fish Department
Krohner, Jessica	University of Montana
Lee, Raymond	Ray Lee LLC
Lindbloom, Andrew	South Dakota Game, Fish, and Parks
Little, Andrew	University of Nebraska-Lincoln
MacDonald, Amanda	Alberta Conservation Association
Markl, Nick	South Dakota Game Fish and Parks
Martin, Hans	SpeedGoat
McDevitt, Molly	University of Montana, Wildlife Biology
McGuire, Aaron	South Dakota Game, Fish and Parks
Meduna, Luke	Nebraska Game and Parks Commission
Menghini, Kody	Nevada Department of Wildlife

Merrell, Jerrod	University of Nevada, Reno
Mitchell, Emily	Montana Fish, Wildlife & Parks
Miyasaki, Hollie	Idaho Department of Fish and Game
Morton, Kim	Alberta Environment and Parks - Fish and Wildlife Stewardship
Nordeen, Todd	Nebraska Game and Parks Commission
Norton, Andrew	SD Game, Fish & Parks
Nowak, Josh	SpeedGoat
O'Connell, Erin	Borderlands Research Institute
Opatz, Anthony	New Mexico Department of Game and Fish
OReilly, Megan	Montana Fish Wildlife and Parks
Partee, Ed	Nevada Department of Wildlife
Paugh, Justin	Montana Fish, Wildlife and Parks
Peckham, Erika	Wyoming Game and Fish
Peek, Matt	Kansas Department of Wildlife and Parks
Piecora, Katie	University of Nebraska - Lincoln
Ramsey, Courtney	Department of NRM, Texas Tech University
Ranglack, Dustin	University of Nebraska at Kearney
Reinking, Adele	Colorado State University
Rue, Jeff	Kansas Department of Wildlife and Parks
Savage, Hayden	Oklahoma Department of Wildlife Conservation
Schmitz, Brad	MT FWP
Schroeder, Cody	Nevada Department of Wildlife
Sinclair, Kylie	Nebraska Game and Parks Commission
Sternhagen, Dan	SD Game Fish & Parks
Stewart, Kelley	University of Nevada, Reno
Sutton, Thomas	Montana Fish, Wildlife, and Parks
Switzer, Chad	South Dakota Department of Game, Fish and Parks
Taylor, Ashley	Montana Fish, Wildlife and Parks
Turnley, Matt	Oklahoma State University
Vitt, Allen	Colorado Parks and Wildlife
Wakeling, Brian	Montana Fish, Wildlife and Parks
Walch, Andrew	Oregon Department of Fish & Wildlife
Weaver, James	Texas Parks & Wildlife Department
Werner, Brandon	Wyoming Game and Fish
White, Richard	The Mammoth Site

Whittaker, Don	Oregon Department of Fish & Wildlife
Wiechmann, Lauren	SD Game, Fish and Parks
Wise, Colton	Oregon State University
Yarnall, Michael	MT Fish, Wildlife, and Parks

IN MEMORIAM

Caroline Lewis Ward, 1989-2021

On July 8, 2021 Caroline Lewis Ward passed away peacefully at a hospital in Austin, Texas with friends and family holding her. Caroline would tell you she did not "lose" her fight, she just crossed the finish line free from pain, doctor visits and recurring issues. She loved life, her family and friends and we will continue that love forevermore. Her laugh was infectious, her smile was brilliant, her spirit and fight were unmatched. The zest she embodied cannot be put into words. Caroline possessed an unparalleled love for wildlife and nature that lead to her completing her master's degree at Texas A&M – Kingsville evaluating survey techniques and sightability for pronghorn in 2016. While her pronghorn research may have ended, she never lost her love and amazement for the species, and her contributions to survey methods will help pronghorn populations for years to come. Her love, life partner, best friend and husband Ben were a couple that could not have been matched any better. Without a doubt Caroline kicked cancers butt and never let it steal her joy. She touched countless lives with her energy, wit, and a beautiful smile - all things that many will cherish for the rest of their own lives.

Richard Allen Ockenfels, 1952-2022

Richard Allen Ockenfels was born on March 4, 1952 at the Murray County Memorial Hospital in Slayton, Minnesota and passed away at Banner University Hospital in Phoenix, Arizona on January 5, 2022. He was born to Francis and Gracella Ockenfels of Currie, Minnesota. Richard passed with his sisters Kathy and Linda and brother Steve by his side.

Richard graduated from Glendale Community College in 1974 after attending part time while working. He graduated from Arizona State University with a BS in 1977. He went on to graduate with an MS in wildlife biology from Oklahoma State University in 1980. He started his dream job in 1981 with the Arizona Game and Fish Department. He retired in 2008 after 27 years with the Arizona Game and Fish Department. In 1998, he successfully organized and chaired the 19th Pronghorn Workshop in Arizona. He contributed to three editions of the "Pronghorn Management Guide". In addition, he was a leader in developing and implementing the Pronghorn Workshop Awards Program for six years. Because of his long-term expertise in research and management, he has cooperated in pronghorn programs with provincial, state and federal agencies. Also, he provided professional technical support to wildlife managers in Mexico. He developed new GIS inventory procedures for pronghorn habitat that are a model for current management. In addition, he has provided pronghorn management counseling to the Arizona Wildlife Federation and the Arizona Antelope Foundation. One of the recipient's major contributions to pronghorn management has been conducting field research investigations, and then making the findings available to the wildlife society through scientific literature. Consequently, he has authored more than 37 reports on pronghorn of which 15 were printed in the Pronghorn Workshop Proceedings or Pronghorn Management Guides. Topping all this, he also coauthored the first and only book on pronghorn in Arizona.

In 2002, Richard received the Special Recognition Award at the 20th Biennial Pronghorn Workshop in Kearney, Nebraska. Richard also received the 2008 Berrendo Award at the 23rd Pronghorn Workshop held in Canmore, Alberta. This award is the most prestigious award offered through the Pronghorn Workshop. Receiving this award automatically qualified Richard into the Pronghorn Hall of Fame.

David Earl Brown, 1938-2021

David Earl Brown, Phoenix - Died September 9th, 2021 as he lived his life-on his own terms. Born January 26th, 1938 in Neenah, WI his family moved to Santa Clara, CA when he was 12 years old, where he later graduated from San Jose University. He took a job with the Arizona Game & Fish Department in Tucson- where he was promoted and moved to Phoenix in 1968. Retiring from the AZGFD in 1988, he then began another career at ASU in the Biology Department as an adjunct professor. David E. Brown authored 23 books, 250+ articles, and 120+ published scientific papers. His work creating the Biotic Communities Map with Charles Lowe in 1982 is used as the standard of the Southwest to this day. Well known as an avid outdoorsman, wildlife photographer, biologist, public speaker, educator, and writer, he never hesitated to share his vast knowledge and was humble when it came to using his talents to conserve wildlife. Wildlife politics were as contentious then as they are now, but David bridged political gaps through his exemplary performance as a Wildlife Manager and his keen insights into wildlife and their habitats. His broad interests and insatiable curiosity led him all over the world, including more than half the states in the U.S., 30 Mexican states, Central America, Cuba, Africa, Europe, and the Caribbean. David mentored hundreds of college students, often collaborating with them on research projects in an effort to give them a leg up on their careers.

David was a past president and co-founder of the Arizona Antelope Foundation and an elected fellow of the Arizona-Nevada Academy of Sciences. In addition to being selected as Educator of the Year, he was chosen as the Wildlife Conservationist of the Year by the Arizona Wildlife Federation and awarded a Maytag Professorship by ASU, the Thomas E. McCullough Award for a career of professional wildlife conservation achievement by the Arizona Wildlife Federation, and the W. Frank Blair Eminent Naturalist Award in 2000 by the Southwestern Association of Naturalists. David was the first recipient of the Arizona Chapter of the Wildlife Society's David E. Brown Lifetime Achievement Award, named in his honor. David was a familiar face at Pronghorn Workshops since 1982. He attended and presented papers at numerous meetings, served on the Awards Committee in recent years, and most notably authored the criteria for the Pronghorn Workshop “Hall of Fame Award” to recognize significant figures from the past. In 2002, Brown was inducted into the Arizona Outdoor Hall of Fame. In 2008, David received a Special Recognition award at the 23rd pronghorn workshop in Canmore, Alberta. Additionally, in 2022, David Brown was posthumously awarded the Berrendo Award at the 29th Biennial Pronghorn Workshop that was held in Deadwood, South Dakota. This award is the most prestigious award offered through the Pronghorn Workshop. Receiving this award automatically qualified David into the Pronghorn Hall of Fame.

29th Biennial

PRONGHORN

workshop 2022