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The Western State and Provinces Pronghorn Workshop is a biennial event sanctioned by the Western Association of Fish and Wildlife Agencies.





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# **Table of Contents**

Dedication—James D. Yoakum, 1926–20125
<u>Technical Session</u> Arizona Antelope Foundation Southeastern Arizona Grasslands Pronghorn Initiative
Pronghorn (Antilocapra americana) Habitat Modeling in the Big Chino Valley, Arizona
Seasonal Effects of Forage Quality and Dietary Composition on Pronghorn ( <i>Antilocapra americana</i> ) in a Desert Environment
Evaluation of Pronghorn Habitat in Southeastern California10 Kevin B. Clark, David E. Brown, and Grant Harris
Seasonal Composition and Nutritional Quality of Pronghorn Diet in the Southern High Plains of Texas
Pronghorn Response to Wind Energy Development on Winter Range in South-central Wyoming
Pronghorn Offspring Survival in a Low Density Translocated Population: Is Birth Synchrony a Mechanism for the Allee Effect?
Post-release Movements of Tranlocated Pronghorn in the Trans-Pecos of Texas
Post-release Survival of Translocated Pronghorn in the Trans-Pecos of Texas
Pronghorn Permeability Associated with Fence Characteristics in Northern Arizona
Opening Up the Prairies: Evaluating the Use of Goat-bars by Pronghorn
Evaluation of Distance Sampling as a Technique to Monitor Pronghorn in Kansas59 Jared Oyster, Elmer Finck, and Matt Peek

Pronghorn Use of Prescribed Burn Areas in the Southern High Plains of Texas
Identifying Impediments to Long-distance Pronghorn Migration to Facilitate Conservation
Renee G. Seidler, Scott Bergen, Joel Berger, and Jon P. Beckmann
An Investigation into the Recent Pronghorn Decline in the Trans-Pecos Region of Texas70 James H. Weaver, Louis A. Harveson, Ken Waldrup, Shawn Gray, and Billy Tarrant
Costs and Benefits of Intense Coyote Removal to Increase Pronghorn Fawn Recruitment in Northern Arizona
Brian Wakeling, Ronald L. Day, Jr., and Amber Munig
Pronghorn State and Provincial Status Reports and Long-term Trends72 Ryan N. Walker
Posters A Mismatch Between Management and Conservation Actions for Taxa In and Outside the Red-lists: The Case of the Pronghorn and a Proposal
Genetic Diversity in Two Critically Endangered Captive Breeding Subspecies of Antilocapra americana
Habitat Use by American Pronghorn ( <i>Antilocapra americana americana</i> ) on Anderson Mesa, Northern Arizona
Where Are All the Fences: Mapping Fences From Satellite Imagery
Artificial Water Utilization by Translocated Pronghorn in Trans-Pecos, Texas
Summary of Pronghorn Workshops Held to Date

# **Dedication**

# James D. Yoakum 1926–2012

by Tom Pojar

Few organizations are fortunate enough to have a member that is a bonding agent and ambassador for its activities since its inception. The Pronghorn Workshop is one such fortunate organization. Jim Yoakum has been an active and contributing member of the Workshop since its early days. When by-laws or procedures need fine tuning, we could always count on Jim's input; he provided stability and direction for our organization.

Jim's interest, fascination, respect, and, finally, his full blown love affair with "prongs". ("Prongs" was one of his favorite pet names for this little hot rod of the prairie; berrendos is another of his pet names. Both of these names, I believe, originated with our colleague, Jorge.)

Jim was born in 1926 in Templeton, California. This is a rural area of central-coastal California, which was historic pronghorn range but pronghorn had been extirpated from this area and it was several years before Jim had actual contact with this species. However, in the summer of 1952 after one of the most severe winters in 100 years, Jim worked as a summer "temp" for the California Game and Fish Department surveying what remained of pronghorn and sage grouse populations in northeastern California. A couple years later, on a summer day in June, 1954, he arrived at Hart Mountain National Antelope Refuge in Oregon to begin his master's study on the "whys" of low pronghorn numbers on the refuge. Here Jim experienced the wide open shrub/steppe plains and inhaled the pungent sagebrush aroma and began asking "why? why? are there so few surviving pronghorn?" As part of his research he raised 7 neonates to study growth, feeding habits and survival factors. As Jim later wrote, "[i]t was during this time period that I became fascinated with these native ungulates, and dedicated the rest of my life to studying and restoring populations in western North America."

Jim was tireless in his advocacy for the maintenance and restoration of pronghorn habitat and the well-being of pronghorn populations. He always offered insightful and strong (sometimes forceful) recommendations to land managers and wildlife management agencies on best practices to foster preferred plant communities that were, as Jim was fond of saying, forage that is both "nutritious" and "succulent".

#### "The Book" – persistence and dedication

There are countless publications with Jim as author or co-author, however, the crown jewel of his publications is "The Book". The first mention of The Book was at the 1976 Workshop in Twin Falls, Idaho and those in attendance witnessed the conception of a fantastic idea. The gestation period for such an undertaking was long, with the time between conception and delivery "a couple three years". There were doubters that the birth would take place. They were wrong. With Jim's dogged determination, persistence and dedication, he and close friend and colleague Bart O'Gara produced a masterful work that the contributors and editors can look to with exuberant pride. The book, *Pronghorn Ecology and Management*, was published in 2004 and the first printing sold out within a

year; a new record for more than 35 Wildlife Management Institute publications. The book was reprinted in 2006 and a 3<sup>rd</sup> printing may be required.

The quality of this book was recognized by the Wildlife Publications Awards Committee of The Wildlife Society. The editors, Jim Yoakum and Bart O'Gara, received the **Wildlife Publications Award – Outstanding Edited Book Category** in 2005.

#### Special recognition award

Today, we wish to honor Jim and dedicate this Workshop to his memory, recognizing his lifetime of contributions spanning over 50 years. His enthusiasm for the well being of pronghorn was contagious. Anyone who has spent time with Jim has felt this and has been affected. It is an absolute delight to absorb some of Jim's lifetime observations and studies including discussions of "nutritious" and "succulent" plants, livestock grazing, predation, and all the other "whys" affecting pronghorn. Jim has left us a legacy of admiration for pronghorn and the will to enhance and preserve the well-being of these little hot rods of the prairie.

### THANK YOU JIM! WE WILL LIVE YOUR LEGACY!

# ARIZONA ANTELOPE FOUNDATION SOUTHEASTERN ARIZONA GRASSLANDS PRONGHORN INITIATIVE

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ABSTRACT On 16 November 2011 the Arizona Antelope Foundation (AAF) was awarded a National Fish and Wildlife Foundation 3-year grant of \$230,000 to support the AAF's 5-year Southeastern Arizona Grasslands Pronghorn Initiative initiated in April 2010. Matching non-federal contributions valued at \$230,000 include AAF and private land owner project labor and materials, Pima County Sonoran Conservation Plan land acquisition funds, and Arizona Game and Fish Department (AGFD) Big Game Tag Habitat Partnership Funds. The "Southeast Arizona Collaborative Grassland Workgroup", created in February 2010, collaboratively drafted a southeastern Arizona Regional Pronghorn Strategy to increase pronghorn population numbers, distribution, and connectiveness. Partners in this working group include AAF, AGFD, Bureau of Land Management, U. S. Forest Service, U. S. Department of Agriculture, U. S. Fish and Wildlife Service, Pima County, Arizona Wildlife Federation, The Nature Conservancy, Audubon Society, Tombstone High School, and local ranchers/landowners. Long-term goals for this 3-year grant are to establish a region-wide dynamic geodatabase with integrated multi-species layers to prioritize grasslands restoration/maintenance activities for pronghorn and other sensitive grassland species; permanently record pronghorn travel corridors, and remove or modify barriers, including fences, shrubs, and trees; target and plan grassland treatments and burns in priority habitat locations on an annual and long-term basis to benefit the highest number of keystone grassland species; supplement at least one pronghorn population and increase numbers in two subpopulations; and improve grassland habitat in five pronghorn subpopulation zones. We discuss our progress to date and outline the multiple relationships that are ensuring that the initiative succeeds for the longterm benefit of southeastern Arizona's pronghorn herds.

#### WESTERN STATES AND PROVINCES PRONGHORN WORKSHOP PROCEEDINGS 25:7

# PRONGHORN (*ANTILOCAPRA AMERICANA*) HABITAT MODELING IN THE BIG CHINO VALLEY, ARIZONA

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**ABSTRACT** Pronghorn populations in Arizona are increasingly affected by habitat fragmentation from urban sprawl, road construction, and fencing. The Big Chino Valley (BCV), one of the largest contiguous pronghorn habitats in Arizona, is threatened by plans for urban development and highway construction. Between November 2007 and November 2009, we monitored 32 pronghorn (Antilocapra americana) fitted with Global Positioning System (GPS) radio collars in the BCV. We used GPS location data to model potential pronghorn habitat at a landscape scale with the Genetic Algorithm for Rule-set Prediction (GARP). We included information from several environmental variables to create two predictive habitat models, one using vegetation type and one using a soils layer to estimate vegetative potential throughout the study area. The GARP model constructed with vegetation types outperformed the model built on soils and predicted that pronghorn selected primarily grassland or forbland vegetation, even though the study area was predominantly pinyonjuniper woodland and chaparral. Our model also suggested landscape features that deterred pronghorn movements, such as developed roads, fences, and tumbleweeds. Pronghorn showed temporal and spatial variation in use of many private ranches in the BCV and often contrary to expected use based solely on habitats present on the ranches, and we speculate that other environmental factors, like hunting pressure or agricultural practices may influence pronghorn use of these areas.

# WESTERN STATES AND PROVINCES PRONGHORN WORKSHOP PROCEEDINGS 25:8

# SEASONAL EFFECTS OF FORAGE QUALITY AND DIETARY COMPOSITION ON PRONGHORN (*ANTILOCAPRA AMERICANA*) IN A DESERT ENVIRONMENT

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ABSTRACT A population of pronghorn on White Sands Missile Range (WSMR), in south-central New Mexico, has declined since 1980. While this decreasing trend has coincided with intermittent periods of severe drought, competition with the non-native South African gemsbok is presumed as a contributor to the overall decline of the population. Thus the goal of this study was to relate seasonal changes in forage quality throughout pronghorn habitat on WSMR, and relate these seasonal changes to diet composition and nutrition, and evaluate dietary overlap between pronghorn and gemsbok. Dietary quality (fecal nitrogen [FN] and fecal 2,6-diamonphelic acid [FDAPA]) reflected seasonal differences in available forage as well as severe drought. Average FN increased in pronghorn from 1.4% in the cool-dry season (2010) to 2.1% in the warm-dry season (2010). In contrast, FN decreased in pronghorn from 2.1% in the warm-dry season of 2010 to 1.4% in the drought of the warm-dry season of 2011. Diet composition revealed pronghorn consumed 75 species with forbs representing the major component in the diet (42-68%) in contrast to grasses (2–21%). Although gemsbok and pronghorn share the same habitat (were often seen grazing together), an analysis of dietary overlap between the two species revealed low (17%) to moderate (37%) overlap and suggests the gemsbok are not negatively influencing forage selection of pronghorn on WSMR. Gemsbok dietary quality did not differ between the warm-dry season of 2010 and the drought of the warm-dry season of 2011, revealing resiliency in the gemsbok compared to the pronghorn during abnormally low precipitation periods.

# WESTERN STATES AND PROVINCES PRONGHORN WORKSHOP PROCEEDINGS 25:9

# **EVALUATION OF PRONGHORN HABITAT IN SOUTHEASTERN CALIFORNIA**

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**ABSTRACT** After a decline in the U. S. population of Sonoran pronghorn (*Antilocapra americana sonoriensis*) to <30 individuals in 2003 the Sonoran Pronghorn Recovery Team determined that recovery efforts should attempt to reintroduce additional populations within historic habitat. With a program to restore pronghorn to the Kofa National Wildlife Refuge in Arizona already underway we evaluated 3 areas in southeastern California and one area in Baja California as potential reintroduction sites. Factors considered in our evaluation were historic presence, presence of key areas, suitable topography, potential barriers to movement, land status, water sources, sources of disturbance, potential for population expansion, vegetation structure, presence of winter browse, presence of succulent vegetation and herbaceous forbs, and the potential for competition from other ungulates. Each of the 3 areas visited in California—Chuckwalla Bench, Rice Valley, and Anza-Borrego Desert State Park—were deemed capable of possibly supporting a pronghorn population. The most promising sites, however, were the Tres Pozos area in Baja California and the Chuckwalla Bench area in Imperial County, California. Both of these areas appear capable of supporting a desert pronghorn population of 50–150 animals using current management methodologies.

#### WESTERN STATES AND PROVINCES PRONGHORN WORKSHOP PROCEEDINGS 25:10-36

Although not considered in the 1939 Executive Order establishing Cabeza Prieta National Game Range, that area's "desert antelope" attracted attention when 40 animals in 6 groups were observed by A. A. Nichol and E. A. Goldman during a 1940 evaluation of the range's flora and fauna (Brown 2012). These pronghorn, along with those in southeastern California, northeastern Baja California, and Sonora were later classified as *Antilocapra americana sonoriensis* after Goldman (1945) described a new subspecies on the basis of an individual doe pronghorn collected by V. Bailey on the Costa Rica Ranch southwest of Hermosillo, Sonora (Hall and Kelson 1959). Later, and without further study, this subspecies was included in the original list of federally endangered species in 1967, and awarded protection under the Endangered Species Act of 1973 having already been presumed extirpated in California and Baja California (Jaeger 1956).

A series of investigations into the animal's status, food habits, and distribution in southern Arizona and adjacent Sonora began in 1967 (Carr 1969, Carr 1970, Carr 1971, Carr 1972, Carr 1973, Arizona Game and Fish Department 1984, Wright and DeVos 1985, Hervert et al. 2000). These studies, while centered in what was now called the Cabeza Prieta National Wildlife Refuge (NWR) and adjacent Barry M. Goldwater Gunnery Range, covered the breadth of the animal's range in Sonora as well as in Arizona. These investigators reported that the subspecies was nomadic, able to survive without free water, and to number between 40 and 200 animals (Hervert et al. 2001). A Sonoran Pronghorn Recovery Plan, initiated in 1982 and modified in 1998, called for the provision of emergency waters, irrigated forage plants, and a captive breeding program to prevent the extinction of the subspecies (Wilson et al. 2005). These efforts greatly accelerated after a prolonged drought in 2002–3 that reduced the U. S. population by 80% to approximately 29 animals (Hervert et al. 2005). It was therefore decided to establish additional populations outside of the animal's present range as a hedge against another regional climatic catastrophe and plans were initiated to re-establish a population in King Valley on the Kofa NWR in western Arizona (Bright 2011).

A landscape modeling exercise in southwestern Arizona evaluated pronghorn recovery potential in several locales (O'Brien et al. 2005). The results from this effort were used to help prioritize translocation sites in the Californias. Using these methodologies and the Management Guidelines outlined in Autenrieth et al. (2006), we evaluated 3 areas in southeastern California and one area in Baja California as potential reintroduction sites.

Although pronghorn have been extirpated from the Sonoran Desert of southern California, the presence of these animals in this region is well documented. Pronghorn were historically found throughout this subtropic desert in southern California and Baja California, but declined rapidly during the latter part of the nineteenth century and first quarter of the twentieth century due to increasing human population and hunting pressure (Jaeger 1957, Brown et al. 2006). The last remaining pronghorn in the Sonoran Desert in California resided in the vicinity of Salt Creek Wash west of the Chuckwalla Bench in 1941, just as the U. S. Army was beginning desert training in the region (Jaeger 1956:17):

"During the autumn of 1941 Dr. D. C. Clark, Paul Walker, and Frank Wilkins of Redlands, California were camping on the south side of the Chuckawalla mountains of the Colorado Desert of California. On the mesa one mile southeast of Williams Mine and four miles southeast of Chuckawalla Springs they reported seeing a small band of pronghorn antelope and were able to get within [182.88 m] of them. The animals were down-wind and were approached from behind a small intervening rise which explains how they were able to come as close to the herd as they did.

These men are competent observers and know well the pronghorn because of previous experience with them. I cannot doubt the authenticity of their account—the last record of pronghorn on our Colorado Desert.

These interesting animals were able to maintain their stand up to the time of World War II because this was an exceedingly wild area, practically without roads and little visited by man. Through it runs the large Milpitas Wash whose numerous fan-like branches drain most of the northeast slope of the Chocolate Mountains and broad fans of alluvium between these mountains and the Colorado River. Here was a place of abundant food, shelter and opportunity to successfully evade predators and hunters.

It is very doubtful if any of that original group of pronghorn survived the war period since the district was widely over-run by military men on maneuvers. Old roads and jeep and tank trails literally run everywhere over this once remote region."

Prior to this time, Nelson (1925) had summarized this state's known desert populations as a band of 5 animals in the "Colorado Desert" along the Imperial-San Diego County line, presumably near present day Ocotillo. Stephens (1906) also made reference to "a small band or two in the deserts in the southeastern part of the [s]tate."

In similar habitats in Baja California, more removed from human encroachment, pronghorn survived longer. The Tres Pozos (Three Wells) area south of Laguna Salada in northeastern Baja California was a major sport hunting ground for this species until well into the 1920s, and provided several specimens for museum collections (Funcke 1919, Cudahy 1928, Mellink 2000, Brown et al. 2006). A pronghorn population in the Sonoran Desert just east of the Colorado River in Mohave County, Arizona also survived into the early 1970s before succumbing to a highway construction project south of Lake Havasu City (Brown and Webb 2007).

Two pronghorn populations outside of the Sonoran Desert have been reestablished in Southern California in the past few decades. One population was introduced to the Carrizo Plain, San Luis Obispo County, from animals transplanted from the Modoc Plateau (Koch and Yoakum 2002, Longshore et al. 2008). This population fluctuates between 50–100 animals, and has spread north as far as Cholame Valley and southeast around the southern edge of the San Joaquin Valley to the Wind Wolves Preserve, just west of Grapevine Canyon and Interstate 5. The second population is centered in the northwestern portion of the Antelope Valley on the Tejon Ranch. This population was established in 1985 from 55 animals from the Modoc Plateau (Los Angeles Times 1985). Neither of these populations is within the range of the "Sonoran [p]ronghorn" however (Hall and Kelson 1959).

Historically, California desert pronghorn populations would have been genetically and demographically connected with populations in the northern portions of the Baja California peninsula both within the Sonoran Desert and along the coast (Brown et al. 2006). No pronghorn remain in the Mexican State of Baja California, but the Peninsular pronghorn remaining in Baja California Sur are protected and managed by the Mexican government. The current confusing state of subspecies taxonomy has resulted in a situation where 4 subspecies have been described as inhabiting the Sonoran Desert, whereas populations from Saskatchewan, Oklahoma, central California, Minnesota, and central Arizona comprise the nominate subspecies (Brown and Ockenfels 2008).

Present population estimates for the Sonoran pronghorn in Arizona as of November 2012 are 78 animals in 2 pens on the Cabeza Prieta NWR, 20 animals in a pen on the Kofa NWR, with an estimate of 100 animals in the wild. The most recent estimate for Sonora at the end of 2011 is approximately 250 animals in 2 wild populations (J. Hervert, personal communication).

Much of southeastern California is under federal jurisdiction, including significant acreages in military withdrawals, wilderness areas, and national parks (Fig. 1). We investigated whether suitable habitat for pronghorn currently exists within these areas.

#### **METHODS**

We made 5 visits in 2010 and 2011 to 3 historical pronghorn locations in the Sonoran Desert region of southeastern California (Table 1).

Tuble 1. Elections and dates of areas visited and evaluated.							
Chuckwalla Bench	1–3 December 2010						
Rice Valley	4–6 January 2011						
Chuckwalla Bench	10–12 January 2011						
Anza-Borrego Desert State Park	28 February–2 March 2011						
Chuckwalla Bench/Kofa NWR	12–14 September 2011						

Table 1. Locations and dates of areas visited and evaluated.

Prior to our visits we researched each area's suitability based on the historical presence of pronghorn, available size, land status, and climate. In regards to the latter, we were especially concerned that minimum temperatures coupled with annual and seasonal precipitation amounts, while not identical to presently occupied habitats, were characteristic of the Sonoran Desert (Table 2). We then met with regional land managers and wildlife biologists to discuss their opinions as to the possibility of reestablishing pronghorn in their area of expertise. Each area was then evaluated as to the size and quality of potential pronghorn habitat based on the following criteria modified from the Pronghorn Management Guide developed by Autenrieth et al. (2006):

### Proceedings of the 25<sup>th</sup> Biennial Western States and Provinces Pronghorn Workshop



Figure 1. Federal land ownership in southeastern California. Note the extensive wilderness areas and the amount of flat valley acreage encompassed by them.

- 1. Records of historic distribution. An intensive literature search (Brown et al 2006) was conducted to determine when, where, and roughly how many pronghorn were historically present. These data were then followed up with interviews when appropriate people could be located.
- 2. Key areas (springs, wetlands, dunes, etc.) present. In short, we looked for areas of potential special value, either in the way of vegetative diversity, year-long water availability, or escape terrain free of disturbance.
- 3. Sufficient habitats having suitable topography. Pronghorn prefer a variety of open landscapes in habitats ranging from level terrain, gentle slopes, low hills, and knolls of moderate grade. Steep hillsides and rocky crags with numerous boulders are generally avoided.
- 4. Fences, highways, and other barriers. Of primary concern were structures, both manmade and natural, that could restrict pronghorn movement. These included, but were not limited to, canals, fenced right-of-ways, human settlements, agricultural lands, large bodies of water, and rugged mountain ranges. Those areas having these features in or adjacent to potential pronghorn habitat were rated downward.
- 5. Land status favorable for recovery. The general assumption was that Bureau of Land Management (BLM) and other federal agencies with a conservation mandate would consider Sonoran pronghorn in their management plans. The same assumption was made for Anza-Borrego Desert State Park. Wilderness areas with reduced human disturbance were deemed desirable as were military withdrawals having limited access, especially if water developments and other management actions could still be accommodated within their borders. Private and state lands, open to commercial leases and sale, were rated lower as were federal lands dedicated to energy development or other non-compatible uses.
- 6. Water sources adequate. Access to present and future wildlife water developments was a prime consideration in rating an area's suitability. Natural waters and waters maintained for wildlife on a year-long basis were deemed especially valuable if located in potential pronghorn habitat. Less valuable were waters designed to benefit desert bighorn sheep, livestock, or other human use.
- 7. Lack of vehicle and other disturbances. The ability to restrict and regulate off-road traffic by dirt bikes, tote goats, four-wheel vehicles, and other potential disturbing influences was an important consideration. Hence, areas closed to vehicle traffic to protect desert tortoises or other conservation features received a higher priority than areas open to such traffic.
- 8. Potential for population expansion. Should a key area or other site appear desirable for a pronghorn transplant we wanted to determine whether a released population could expand into other areas and result in a minimum population of 50 animals. Ideally, a release area should be able to support 50–100 pronghorn.
- 9. Vegetative structure compatible (<0.762 m tall). An important consideration was the height of the dominant vegetation. Plants >0.762 m high obscure visibility of resting pronghorn. Although some over-story plants are desirable as shade, both standing and resting pronghorn prefer open, uncluttered vistas as a means of avoiding predation. A lack of plants <0.762 m tall, however, could result in a lack of fawning cover.
- 10. Palatable winter browse plants present. Previous work on other populations (e.g., Brown and Ockenfels 2008) has shown that shrubby browse plants provide needed proteins during winter months and times of drought. The presence of such species as jojoba (*Simmondsia chinensis*) and Mormon tea (*Ephedra trifurca*) was therefore another consideration when determining an area's suitability.

- 11. Succulent vegetation (e.g., cacti) present. Again, previous studies (Hervert et al. 2005) have shown that *Opuntia fulgida* and other cacti are an important source of moisture during times of drought. The presence of cacti is therefore deemed a desirable feature when Sonoran pronghorn are considered.
- 12. Herbaceous perennial forbs present. The species and presence of annual forbs depends on the amount of winter or summer precipitation received. Very little such forage is produced during drought years. The presence or absence of herbaceous perennials such as globe-mallow (*Spheralcia* spp.) was therefore deemed an important feature of the area being considered.
- 13. Competition from other ungulates. Browse and herbaceous forbs are fed on by nearly every species of ungulate from wild burros (*Equus asinus*) to desert mule deer (*Odocoileus hemionus eremicus*). Pronghorn, being diminutive in stature, and naturally inclusive with their own species, can suffer when competing for food and space when resources are scarce (Brown et al. 2004). We therefore considered the presence of feral livestock, burros, and large numbers of desert mule deer a detriment when evaluating potential release sites.

A previous trip to Baja California had provided similar information for the Trez Pozos area south of Laguna Salada and west of San Felipe that was used as a model for the California investigations (Clark and Brown, unpublished report; Appendix 1).

# **RESULTS AND DISCUSSION**

#### **Chuckwalla Bench**

The Chuckwalla Bench refers to a region south of the Chuckwalla Mountains and north of the Chocolate Mountains in Riverside and Imperial Counties. The area evaluated is bounded on the east by State Highway 78 and the Milpitas Wash, and on the west by Salt Creek and the Orocopia Mountains. The total area of suitable pronghorn habitat comprises approximately 2,225 km<sup>2</sup> (Fig. 2). Elevations range from approximately 150 m at both ends of the "Bench" to more than 750 m in the highest portion of the central plateau. Approximately 325 km<sup>2</sup> in the central portion exceed 600 m elevation and support a low growth of vegetation thought to be prime desert pronghorn habitat transitional between typical Sonoran and Mojave desertscrub (pink area in Fig. 2, Fig. 3). The calculated mean annual precipitation for this area is between 20 and 32 cm with 35.1% falling during the May–September summer monsoon period (Lowe 1964, Table 2). Both winter and summer precipitation are measurably greater than that falling in present Sonoran pronghorn habitat.

Chuckwalla Bench is a portion of a much larger undeveloped region that includes several wilderness areas and is over 4,800 km<sup>2</sup> in size. Much of this area, some 1,860 km<sup>2</sup>, is under military withdrawal as a gunnery range with public entry restricted. Mean annual precipitation ranges from a low of approximately 14 cm along Milpitas Wash at the area's eastern edge to >30 cm on the "Bench" (Table 2, Fig. 2). Artificial water catchments have been constructed throughout the area by volunteers to bolster the mule deer population with additional catchments in the more mountainous areas serving as drinkers for bighorn sheep (*Ovis canadensis*). We visited several catchments in open terrain that would be accessible to pronghorn (Fig. 4).

The principal land manager is the BLM, which administers the majority of the "Bench" as well as the wilderness areas and a "Chuckwalla Area of Critical Environmental Concern" established to protect a high-density population of the threatened desert tortoise (*Gopherus agassizii*). Other major managers include the Department of Defense, which administers the southern portion of the "Bench" and the adjacent Chocolate Mountain Gunnery Range (Fig. 1).



Figure 2. Pronghorn Habitats in the Chuckwalla Bench area. The pink highlighted area is the upper "Bench" and consists of approximately 325 km<sup>2</sup> of high quality habitats.



Figure 3. The central portion of Chuckwalla Bench consists of over 325 km<sup>2</sup> over 600 m in elevation, resulting in a landscape cooler, wetter, and with better forage than typical Sonoran Desert conditions.

	Elevation			Mean Annual	Mean May-	Mean Tempera	Annual ature (°C)	Mean Annual
Location	(m)	Latitude	Longitude	(cm)	(cm)	Minimum	Maximum	(°C)
Pitiquito, SO, Mexico	330	30°40.5'	112°03'	24.00	14.55 (57.6%)			21.7
Gila Bend, AZ	225	32°57'	112°43'	15.57	6.15 (39.5%)	13.3	31.8	23.2
OPCNM, AZ	509	32°14'	112°45'	24.23	11.15 (46%)	12.3	30	21.4
Sonoyta, SO, Mexico	393	31°52'	112°51'	19.56	9.91 (50.6%)			21.1
Ajo, AZ	537	32°22'	112°52'	21.34	10.39 (48.7%)	14.9	28.8	22.2
Sentinal, AZ	211	32°51'	113°13'	11.76	5.23 (44.5%)	12.6	31.4	22.0
Puerto Peñsco, SO, Mexico**	4	31°18.5'	113°33'	8.64	2.87 (33.1%)			20.1
Mohawk, AZ	163	32°44'	113°45'	10.74	4.50 (41.8%)	14.8	31.9	23.4
Tacna 3NE, AZ	106	113°41.5'	113°57'	10.39	4.01 (38.6%)	12.2	31.2	21.9
Parker Reservoir, CA (Rice Valley)	134	34°19'	114°09'	14.10	3.99 (28.2%)	16.7	30.1	22.7
Blythe, CA (Chuckwalla Bench)	121	33°37'	114°36'	9.73	3.45 (35.5%)	13.2	31.2	22.4
San Felipe, BC, Mexico	10	31°02'	114°50'	5.66	2.13 (37.7%)			24.0
El Major, BC, Mexico (Trez Pozos)	20	32°08'	115°17'	4.9	2.18 (44.6)%			22.0
Chuckwalla Bench, CA ***	750	33°29'	115°20'	32.51	11.40 (35.1%)			
Mexicali, BC, Mexico (Tres Pozos)	4	32°39'	115°27'	7.34	2.03 (27.8%)			22.4
Brawley, CA (Anza- Borrego)	-33.5	32°59'	115°32'	6.73	1.63 (24.2%)	13.4	31.4	22.2
Hayfield Reservoir, CA (Rice Valley)	418	33°42'	115°38'	9.98	2.97 (29.8%)	12.9	29.2	21.1
Borrego Springs, CA	219	33°16'	116°21'	8.33	2.16 (25.9%)	11.4	30.7	22.6
Blair Valley, CA*** (Anza-Borrego)	790	33°03'	116°24'	31.6	8.20 (26%)			

Table 2. Precipitation data for stations near present and proposed pronghorn habitat in the Sonoran Desert.

\* A table of monthly mean precipitation for each location is provided in Appendix A.

\*\* Ameliorated by coastal dew

\*\*\*As per 10–13 cm per 300 m elevation (Lowe 1964)



Figure 4. Over 100 water catchments have been constructed on Chuckwalla Bench for ungulates. Many of these are in flat open terrain accessible by pronghorn.

The vegetation is highly variable and changes in response to elevation. At the lower elevations, the washes are dominated by blue palo verde (Cercidium floridum), ironwood (Olneya tesota), and catclaw acacia (Acacia greggii). Open flats contain creosote bush (Larrea tridentata), burrobush (Ambrosia dumosa), ratany (Krameria spp.), desert holly (Atriplex hymenolytra), other saltbushes (Atriplex spp.), brittlebush (Encelia farniosa), desert lavender (Hyptis emoryi) and wolfberry (*Lycium* sp.). Forbs were abundant at the time of our visit and consisted of Indian wheat (Plantago spp.) which is a dominant ground cover over large areas, desert trumpet (Eriogonum *inflatum*), spurges (*Euphorbia* spp.), and Sahara mustard (*Brassica tournefortii*) within sandy areas populated by galleta grass (*Hilaria rigida*) (Fig. 5). Cacti and succulents commonly found include pencil cholla (Cylindropuntia ramosissima), teddy bear cholla (C. bigelovii), golden cholla (C. echinocarpa), Munz's cholla (C. munzii), and Mojave yucca (Hesperoyucca shidigera) sometimes accompanied by graythorn (Zizyphus obtusifolia var. canescens), and two species of Mormon tea (*Ephedra* spp.). As the bench increases in elevation toward the central plateau, jojoba becomes increasingly common, and the proportion of Mojave yucca and cholla increase (Fig. 6). This plateau also hosts several regionally rare plants such as Munz's cholla, the shrub Tetracoccus hallii, and two local species of Ditaxis. Munz's cholla, which grows to six feet, is an ecological analog to the chainfruit cholla (*Cylindropuntia fulaida*) of southern Arizona, an important browse plant during drought for some pronghorn populations (Brown and Ockenfels 2008, Fig. 7). Overall plant diversity is high due to the range in elevations and varied topography, more so than on the Cabeza Prieta NWR (Arizona Game and Fish Department 1984).



Figure 5. Galleta grass and forbs dominate large areas of the lower elevations of the Chuckwalla Bench.



Figure 6. Jojoba and Mormon tea increase in density with rising elevations toward the center of the Chuckwalla Bench.



Figure 7. Munz's cholla is a large cholla endemic to the Chuckwalla Bench that is an ecological analog of chain-fruit cholla, an important pronghorn browse plant in Arizona and Sonora.

Table 3.	Checklist of habitat requirements for pronghorn relocation and restoration in the
Chuckwa	alla Bench area.

	None to Few	Poor to Moderate	Moderate to Good	Good to Excellent
1. Records of historic distribution			Х	
2. Key areas (springs, wetlands, dunes, etc.)				
present			Х	
3. Sufficient habitats having suitable topography				Х
4. Fences, highways, and other barriers				Х
5. Land status favorable to recovery				Х
6. Water sources adequate			Х	
7. Lack of vehicle and other disturbances				Х
8. Potential for population expansion			Х	
9. Vegetative structure compatible (<0.762 m)				Х
10. Palatable winter browse plants present				Х
11. Succulent vegetation (e.g., cacti) present				Х
12. Herbaceous perennial forbs present		Х		
13. Competition from other ungulates			Х	

Notes:

- 1. Small numbers present until 1940s when population eliminated by military activities (Jaeger 1956, Jaeger 1957), local people recall pronghorn being present on Chuckwalla Bench (G. Mulcahy, personal communication).
- 2. No wetlands noted but a wide variety of open habitats including desert pavement, sandy plains, mesas, bajadas, and wide arroyos (Fig. 8).
- 3. Open habitats having lava, gravel, and sand substrates ranging from approximately 200 m elevation along Milpitas Wash to >750 m on Chuckwalla Mesa.
- 4. Entire area circumscribed by paved highways and California Aqueduct with almost no paved roads within area of interest.
- 5. More than 90% of the land is government owned with a 1,860-km<sup>2</sup> military withdrawal and most of the remainder being in BLM-administered wilderness, and some isolated railroad sections.
- 6. Area reportedly well watered by wildlife drinkers, some springs with a few wells present (G. Mulcahy and L. Lesicka, personal communications).
- 7. More than 60% of the area closed to vehicle use due to wilderness classification or military withdrawal, off road travel prohibited on remainder.
- 8. Area appears capable of supporting a pronghorn population 2–3 times that present on Cabeza Prieta NWR, 70–450 individuals depending upon weather conditions.
- 9. Except for wooded washes and arroyos, the dominant vegetation is *Larrea tridentata*, *Ambrosia dumosa*, and *Hilaria rigida*.
- 10. Abundant winter browse of *Simmondsia chinensis*, two species of *Ephedra*, two species of *Krameria*, and two species of *Atriplex*.
- 11. Several species of cacti present including four species of cholla, some barrel and hedgehog cacti.
- 12. Herbaceous forbs mostly annuals with a carpet of *Plantago insularis* and other native annuals commonly present, few perennial herbs such as *Eriogonum wrightii*, *Sphaeralcea* sp., *Lotus greeni*, or *Hibiscus coulteri* noted however.
- 13. No cattle or horses present for many years, some localized burro sign in eastern portion, mule deer sparse to locally common.



Figure 8. At the highest elevations of the Chuckwalla Bench, the topography is rolling hills and bajadas.

# **Rice Valley**

Rice Valley is northwest of Blythe, California, north of the Big Maria Mountains. Most of the southern portion of the valley is within Rice Valley Wilderness area, administered by the BLM. Immediately to the west, across railroad tracks and the sparsely traveled Midland-Rice Road, is the Palen McCoy Wilderness, comprising the western portion of the valley. The northern portion of the valley is bounded by the abandoned town of Rice, the Colorado River aqueduct, and U. S. Highway 62. The majority of the valley resides at approximately 250 m elevation, and varies from 300 to >400 m elevation (Fig. 9).

Pronghorn habitats in and adjacent to Rice Valley include over 1,000 km<sup>2</sup>. The greater region bounded by U. S. Highway 62, U. S. Highway 177, U. S. Highway 95, and Interstate-10 including mountains contains about 3,500 km<sup>2</sup>. The vegetation of the area is characteristic of the Lower Colorado Valley subdivision of the Sonoran Desert and is predominately creosote bush and burrobush with *Hilaria rigida* and Mormon tea occupying certain dunes (Fig. 10). Associated plants include pencil cholla and ratany with dense stands of ironwood and blue palo verde in the washes with jojoba present in the higher portions of the valley (Fig. 11). Rice Valley is generally composed of fine soils, with gravel valley floors and large sandy plains (Fig. 12). The topographical relief is less varied than in the Chuckwalla Bench area with fewer hills and low mountain ranges.

Rice Valley, the farthest north of the areas investigated, is located in a transition zone between the lower, drier Sonoran Desert and the higher Mojave Desert. The area can be expected to receive significant summer precipitation with an accompanying bimodal forb season, compared to other areas in California—a factor that would benefit pronghorn by having late summer forage available (Table 2).



Figure 9. Pronghorn habitats in the Rice Valley area include over 1,000 km<sup>2</sup>.



Figure 10. Rice Valley supports several dune areas with Mormon tea and other perennial browse plants.



Figure 11. Several washes dominated by ironwood and blue palo verde are found throughout Rice Valley.



Figure 12. Flat gravel and sandy mesas dominate Rice Valley.

	None to Few	Poor to Moderate	Moderate to Good	Good to Excellent
1. Recent records of historic distribution	Х			
2. Key areas (springs, wetlands, dunes, etc.)				
present		Х		
3. Sufficient habitats having suitable topography			Х	
4. Fences, highways, and other barriers			Х	
5. Land status favorable to recovery				Х
6. Water sources adequate	Х			
7. Lack of vehicle and other disturbances				Х
8. Potential for population expansion			Х	
9. Vegetative structure compatible (<0.762 m)			Х	
10. Palatable winter browse plants present		Х		
11. Succulent vegetation (e.g., cacti) present		Х		
12. Herbaceous perennial forbs present		Х		
13. Competition from other ungulates	Х			

Table 4.	Checklist of habitat requirements fo	r pronghorn relocation and restoration in the
<b>Rice Vall</b>	ley area.	

Notes:

- 1. Recent (>1900) records of historic distribution in Rice Valley are lacking, the nearest known population having been documented from the Arizona side of the Colorado River in 1971.
- 2. No wetlands other than seasonal marshlands north of the investigated area.
- 3. Much open country of varying relief but low hills fewer than Chuckwalla Bench.
- 4. Interior fences lacking and the canal barrier northward passable.
- 5. Mostly BLM land including the Rice Valley Wilderness Area but a large area is planned for solar energy development (G. Mulcahy, personal communication).
- 6. Wildlife waters are reported to be few and natural waters nearly non-existent (G. Mulcahy, personal communication).
- 7. Most of area closed to off road vehicle use.
- 8. Population expansion possible northwest toward Joshua Tree National Monument and eastward to Colorado River (Fig. 9).
- 9–10. Vegetation composition and structure typical of Lower Colorado River subdivision of Sonoran Desert but such forage plants as jojoba and Mormon tea may make this area more sustainable for pronghorn than Cabeza Prieta NWR (Fig. 13).
- 11. Cacti and/or succulent vegetation local and not abundant.
- 12. Herbaceous perennials such as *Spharelcea* spp. not noted as abundant during time of visit.

13. All livestock allotments retired, mule deer sign relatively sparse, some burro sign noted toward Colorado River.



Figure 13. Jojoba and other perennial browse plants are frequent in Rice Valley.

#### Anza-Borrego Desert State Park

Anza-Borrego Desert State Park is the largest state park in the U. S., comprising over 2,500 km<sup>2</sup>. Much of this acreage is mountainous, but two portions of the park contain an estimated 670 km<sup>2</sup> deemed suitable for desert pronghorn (Fig. 14). One area evaluated is the Carrizo Valley region adjacent to Highway S-2 in the southern portion of the park (Fig. 14). This area, including Mason, Blair, and Portrero Valleys, supports limited grasslands and other high quality habitats with deerweed (*Lotus scoparius*) and jojoba in abundance (Fig. 15). However, these areas total only 260 km<sup>2</sup>, and are constrained by rugged slopes and mesquite-choked drainages. Eastward, these habitats merge into "badlands" of unsuitable terrain dominated by creosotebush and ocotillo (*Fouqueria splendens*, Fig. 16). Lee (1997) found similar constraints to pronghorn in his evaluation of the area.

The largest area of suitable habitat is Borrego Valley, surrounding the community of Borrego Springs (Fig. 14). The valley is privately owned, while the surrounding upper portions of the valley, and adjacent slopes and mountains are included in the state park. The valley consists of >400 km<sup>2</sup> of desert plains, agricultural fields, and suburban habitats. Disturbed areas composed of vacant lots and abandoned agricultural fields, have now been reclaimed by saltbushes and mustards with many small forbs offering suitable foraging areas. The valley experiences year round visitor use by several thousand people, and the pronghorn here would need to be acclimated to the presence of humans.



Figure 14. Pronghorn habitats in Anza-Borrego Desert State Park. The northern polygon is the Borrego Valley, and the southern polygon is composed of the Mason, Blair, Portrero, and Carrizo Valleys.



Figure 15- Areas of dearweed, jojoba, and other perennial browse species are found throughout Anza-Borrego Desert State Park.



Figure 16. Badlands to the south and east of both Borrego Valley and Carrizo Valley would constrain pronghorn movements.

Table 5.	Checklist of habitat requirements for pronghorn relocation and restoration in the
Anza-Bo	rrego Desert State Park area.

	Non-			
	existent	Poor to	Moderate	Good to
	to Few	Moderate	to Good	Excellent
1. Records of historic distribution		Х		
2. Key areas (springs, wetlands, dunes, etc.)				
present			Х	
3. Sufficient habitats having suitable topography		Х		
4. Fences, highways, and other barriers		Х		
5. Land status favorable to recovery			Х	
6. Water sources adequate		Х		
7. Lack of vehicle and other disturbances			Х	
8. Potential for population expansion		Х		
9. Vegetative structure compatible (<0.762 m)			Х	
10. Palatable winter browse plants present			Х	
11. Succulent vegetation (e.g., cacti) present			Х	
12. Herbaceous perennial forbs present			Х	
13. Competition from other ungulates			Х	

Notes:

1. Records are few with remains of one animal recovered within Anza-Borrego Desert State Park (Nelson 1925, Brown et al. 2006).

- 2. Two high elevation grassland areas exceeding 670 m elevation located within southern mapped area (Fig. 14).
- 3. Open, level areas within the state park are limited and much of the topography too steep for pronghorn.
- 4. The area contains relatively few fences and most barriers are topographical or due to dense vegetation.
- 5. Most of the potential habitat is contained within the boundaries of Anza-Borrego Desert State Park, which has an active land acquisition program. Some private lands are present in key areas however.
- 6. Water sources are limited and confined to a few game waters for desert mule deer and desert bighorn sheep, and not in the better pronghorn habitats.
- 7. Although the potential for vehicle disturbance is low, the potential for benign human disturbance is high in several key areas.
- 8. There is little potential for pronghorn population expansion.
- 9. The structure of the Sonoran Desert vegetation in the valley floors is comparable with that experienced by present populations of desert pronghorn in Arizona and Sonora. Moreover, there are at least two small areas of open grassland >600 m elevation in Mason, Blair, and Portrero Valleys (Fig. 14).
- 10. Mormon tea, jojoba, and other perennial browse plants are present (Fig. 17).
- 11. Areas of succulent vegetation are present and cacti are ubiquitous throughout the state park (Fig. 18).
- 12. The potential pronghorn sites have not been grazed by ungulates for a long time and perennial forbs were present.
- 13. No sign of burros, cattle, or other domestic ungulates noted and deer population pressures appear minimal.



Figure 17. Mormon tea and other perennial browse plants are frequent.



Figure 18. Succulents are well represented in the park.

## **Adjacent Areas**

Several other areas in southern California were evaluated cursorily and are in need of further investigation. One area we evaluated was a former Lockheed Aircraft missile site in Portrero Valley in western Riverside County. This area of grassland and coastalscrub, which is not within the Sonoran Desert and outside the presumed range of the Sonoran pronghorn, is located east of U. S. Highway 79, east of Lake Perris State Recreation Area and the San Jacinto Wildlife Area. Several large public landholdings link the 36 km<sup>2</sup> Portrero Valley Unit to >81 km<sup>2</sup> of suitable adjancent pronghorn habitat. These habitats include Lake Perris State Recreation Area (35.6 km<sup>2</sup>), San Jacinto Wildlife Area Davis Road Unit near Mystic Lake (40.5 km<sup>2</sup>), and the adjacent BLM Area of Critical Environmental Concern (4.1 km<sup>2</sup>). While this acreage is limited, the particularly rich assemblage of coastal valley grassland, coastalscrub, and wetlands within these preserves provide excellent year round forage and water sources (Fig. 19). Potential issues with fencing and predation would need to be mitigated before any reintroduction into this area is attempted however.



Figure 19. Portrero Valley in western Riverside County and the adjacent San Jacinto Wildlife Area and Lake Perris State Recreation Area provide high quality foraging areas, but many constraints remain regarding pronghorn movement in the area.

Shaw et al. (1998) evaluated the feasibility of reintroducing pronghorn into Joshua Tree National Park and concluded that habitats within the park ranged from low to poor quality for pronghorn. They also reported that the park does not enclose a large enough area of suitable habitat to sustain a viable population through extended dry periods. The largest valley, Pinto Basin, consists of approximately 400 km<sup>2</sup>, but is exceedingly dry and without adequate forage. Sustaining a population within the national park would also require significant management efforts to provide supplemental food and water during droughts, and possibly supplemental transplants to prevent genetic inbreeding.

Although Pinto Basin may not support a pronghorn population within the park limits, offsite habitats to the north, including the adjacent Sheephole and Cleghorn Lakes Wilderness Areas, contain flat open terrain at slightly higher elevations. This combined area of >1,300 km<sup>2</sup> incorporates an area that should be investigated further as a potential pronghorn reintroduction site.

## CONCLUSION

We concluded that all three of the California locales could support a small population of 50–150 desert pronghorn using current Sonoran Pronghorn Recovery Team management procedures. In addition to the cooperation of land management agency personnel, such a program would require such overt management actions as closed areas, and the provision of artificial foods and water in the Rice Valley and Anza-Borrego Desert State Park areas. Only the Chuckwalla Bench area is deemed large enough and variable enough to be capable of supporting a viable Sonoran pronghorn population with the management program presently in place.

	Chuckwalla	Dico Vallov	Anza-Borrego
	Delicii	Rice valley	Desert State Fark
1. Records of historic distribution	Good	Poor	Moderate
2. Key areas (springs, wetlands, dunes, etc.)			
present	Good	Moderate	Good
3. Sufficient habitats having suitable topography	Excellent	Good	Moderate
4. Fences, highways, and other barriers	Excellent	Good	Moderate
5. Land status favorable to recovery	Excellent	Excellent	Good
6. Water sources adequate	Good	Poor	Moderate
7. Lack of vehicle and other disturbances	Excellent	Excellent	Good
8. Potential for population expansion	Good	Good	Moderate
9. Vegetative structure compatible (<0.762 m)	Excellent	Good	Good
10. Palatable winter browse plants present	Excellent	Moderate	Good
11. Succulent vegetation (e.g., cacti) present	Excellent	Moderate	Good
12. Herbaceous perennial forbs present	Moderate	Moderate	Good
13. Competition from other ungulates	Good	Poor	Good

Table 6. Summary checklist of habitat requirements for pronghorn relocation and restoration.

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### Proceedings of the 25<sup>th</sup> Biennial Western States and Provinces Pronghorn Workshop

Appendix A. Mean monthly precipitation.

		Mean Monthly Precipitation (cm)									Total Mean		
	_					_			_			_	Precipitation*
Location	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	(cm)
Pitiquito, SO, Mexico	1.96	1.09	0.94	0.38	0.05	0.58	4.50	6.83	2.69	1.78	1.04	3.56	24.00
Gila Bend, AZ	1.57	1.60	1.60	0.56	0.28	0.13	1.85	2.59	1.30	1.02	1.30	1.75	15.57
OPCNM, AZ	2.21	1.85	2.16	0.64	0.25	0.25	3.45	4.85	2.34	1.88	1.47	2.84	24.23
Sonoyta, SO, Mexico	1.70	0.94	1.17	0.48	0.10	0.05	2.67	4.83	2.34	1.75	0.89	2.67	19.56
Ajo, AZ	1.80	1.60	1.96	0.71	0.25	0.18	2.95	4.88	2.13	1.37	1.42	2.08	21.34
Sentinal, AZ	1.42	1.04	0.97	0.53	0.08	0.33	1.55	2.62	0.66	0.64	0.74	1.19	11.76
Puerto Peñsco, SO, Mexico*	0.74	0.56	0.38	0.10	< 0.03	0.03	0.43	0.97	1.45	1.63	0.61	1.75	8.64
Mohawk, AZ	0.97	1.14	0.84	0.43	0.05	0.15	0.97	2.13	1.19	0.64	0.58	1.70	10.74
Tacna 3NE, AZ	1.17	1.12	1.09	0.38	0.23	0.03	1.07	1.65	1.04	0.69	0.86	1.07	10.39
Parker Reservoir, CA (Rice Valley)	2.24	1.93	1.68	0.56	0.20	0.10	0.89	1.52	1.27	1.17	1.09	1.45	14.10
Blythe, CA (Chuckwalla Bench)	1.22	1.22	0.91	0.33	0.08	0.08	0.48	1.78	1.04	0.66	0.64	1.30	9.73
San Felipe, BC, Mexico	0.69	0.20	0.43	0.23	0.00	0.23	0.28	0.76	0.86	0.84	0.15	0.99	5.66
El Major, BC, Mexico (Trez Pozos)	0.51	0.28	0.33	0.05	0.03	0.03	0.20	0.91	1.02	0.61	0.13	0.81	4.90
Chuckwalla Bench, CA **	4.06	4.06	3.05	1.09	0.25	0.25	1.60	5.84	3.45	2.21	2.11	4.32	32.51
Mexicali, BC, Mexico (Tres Pozos)	0.97	0.61	0.66	0.28	0.05	0.05	0.25	1.04	0.61	0.76	0.71	1.35	7.34
Brawley, CA (Anza-Borrego)	1.02	0.99	0.66	0.28	0.08	0.03	0.13	0.76	0.64	0.56	0.43	1.17	6.73
Hayfield Reservoir, CA (Rice Valley)	1.68	1.35	1.12	0.28	0.18	0.03	0.61	1.50	0.66	0.76	0.69	1.09	9.98
Borrego Springs, CA	1.32	0.46	0.91	0.36	0.03	0.00	0.33	1.42	0.38	0.76	0.99	1.35	8.33
Blair Valley, CA** (Anza-Borrego)	1.96	1.09	0.94	0.38	0.05	0.58	4.50	6.83	2.69	1.78	1.04	3.56	24.00

\* Ameliorated by coastal dew

\*\*As per 10–13 cm per 300 m elevation (Lowe 1964)
## SEASONAL COMPOSITION AND NUTRITIONAL QUALITY OF PRONGHORN DIET IN THE SOUTHERN HIGH PLAINS OF TEXAS

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**ABSTRACT** In a continuously changing landscape, obtaining adequate nutrition for survival is a challenge for many wildlife species. An understanding of diet and nutrition therefore plays a crucial part in management. The pronghorn in the Southern High Plains (SHP) of Texas is one such species. There is little information concerning diet or nutrition to aid in management of the species and potentially increase its numbers. Because of this information gap, seasonal diet composition of pronghorn was evaluated on two study sites in Texas using microhistological analysis. Changes in diet quality were also examined using fecal nitrogen (FN) as an index. The diet of the pronghorn in the SHP was dominated by forbs and succulents (more than 70% of the diet). Species that dominated the diet included filaree (*Erodium texanum*), scarlet gaura (*Gaura coccinea*), croton (*Croton potossii*), cacti (*Opuntia* spp.), and peavine (*Astragulus nutallianus*). Fecal nitrogen was high throughout the study. The pronghorn in the SHP is mainly a forb-eating species and can maintain adequate nutrition in field conditions. Thus maintaining vegetation that is dominated by forbs will benefit pronghorn in the SHP.

### WESTERN STATES AND PROVINCES PRONGHORN WORKSHOP PROCEEDINGS 25:37-46

**KEY WORDS** *Antilocapra americana*, diet composition, fecal nitrogen, microhistological analysis.

Historically, pronghorn (*Antilocapra americana*) ranged across the plains from south-central Canada through the west of the United States, south to San Luis Potosi, Mexico (Lee et al. 1998, Yoakum 1994). Prior to the European settlement, an estimated population of 35 million pronghorn roamed the plains (Nelson 1925) with the highest densities occurring within short-grass prairies (Yoakum 1978). Habitat loss combined with fragmentation, encroachment by woody species, fire suppression, fencing, unregulated year round hunting, and dietary overlap with cattle resulted in a decline in the population by over 99% by 1900 (Yoakum 1968). Currently, populations can be found in small pockets across the pronghorn's historic range. Reestablishment efforts in 1924 started with 30,500 individuals (Yoakum 1968). Currently, the entire pronghorn population is estimated to be around one million individuals (Lee et al. 1998).

Two of the five subspecies of pronghorn (*A. a. americana* and *A. a. mexicana*) occur in Texas (Swepston and Hailey 1991) and were historically distributed over the western two-thirds of the state (Davis and Schmidly 1994). Texas falls within the southernmost range of the pronghorn and thus numbers have been low relative to other portions of its range. Herd distribution is restricted to small fragmented populations with 70% occurring in the Trans-Pecos, 20% in the Panhandle, and 10% in the Lower Plains (Sewpston and Hailey 1991). Over the last twenty years, the Texas pronghorn population has been on the decline. The population dropped from 25,000 individuals in 1986 to roughly 11,000 in 2003 (Texas Parks and Wildlife Department 2003, unpublished report). The cause of this decrease is unknown.

An understanding of the diet and nutrition of wildlife species is important for their management. For many wildlife species such as the pronghorn, however, this knowledge is incomplete. Studies have indicated that pronghorn feed primarily on forbs, grasses, and shrubs. However, the proportion in the diet depends on availability and varies spatially and seasonally. Pronghorn diets from Oregon (Mason 1952), Saskatchewan

(Dirschl 1963), Utah (Beale and Smith 1970), and Yellowstone National Park (Singer and Renkin 1995) show a dominance of browse plant species. Other studies from Kansas (Hlavachick 1968) and Colorado (Schwartz and Nagy 1976) indicate grasses dominated pronghorn diet. Yet other results from Texas (Buechner 1950, Koerth et al. 1984), Oregon (Mason 1952), Utah (Beale and Smith 1970), and New Mexico (Beasom et al. 1982) show a negligible use of grasses by pronghorn antelope. Forbs dominated the diet in places such as Texas (Buechner 1950, Roebuck 1986), Alberta (Mitchell and Smoliak 1971), western Kansas (Sexson 1979), eastern New Mexico (Beasom et al. 1982), and central Arizona (McDonald 2004). Other studies, however, suggest only seasonal dominance of forbs in spring and/or summer (Mason 1952, Dirschl 1963, Hlavachick 1968, Severson et al. 1968, Beale and Smith 1970, Mitchell and Smoliak 1971, Schwartz and Nagy 1976). Couey (1946), Bayless (1969), and Smith and Malechek (1974) examined seasonal diets (fall, winter, and summer, respectively) and reported browse was more important than forbs. Studies by Sexson (1979) and Hlavachick (1968) also revealed the importance of cacti in pronghorn diet. Analysis of the available literature indicates pronghorn diet does not appear to follow any set pattern across its entire range. The disparity from various areas could be due to differences in vegetation diversity or total availability. Uncertainty concerning important components of the diet causes uncertainty in habitat management plans. Thus knowledge of pronghorn diet in each management zone will be invaluable to a successful management program.

Dietary information of pronghorn is lacking for populations in the SHP of Texas. This information has become important at this time because the pronghorn population has been declining (Texas Parks and Wildlife Department 2003, unpublished report). Knowledge about diet and diet quality of the pronghorn will enhance the management of the species. Objectives of this study were to determine the seasonal composition and quality of the diet of pronghorn and to compare diet composition to vegetation availability. It is hypothesized that pronghorn diet will track vegetation availability and that quality of pronghorn diet will decline from spring to early fall.

### **STUDY AREA**

The study was conducted on two sites situated in Lynn and Borden Counties, Texas. Site 1 in Lynn County is located at 33°07'N and 101°35'W, while Site 2 in Borden County is located at 32°46'N and 101°31'W. The region is characterized by a warm, temperate, subtropical climate with dry winters and long hot summers (U. S. Department of Agriculture 1975). Daily high temperatures average between –2.8°C in January to 34.4°C in July (U. S. Department of Agriculture 1959). The area receives an average annual precipitation of 47.8 cm with most of it falling in May and June (U. S. Department of Agriculture 1975).

Located at about 910 m above sea level, the region has a nearly level to gently sloping terrain dotted with playa lakes (U. S. Department of Agriculture 1959). Furthermore, it has rough broken land with deep sandy loam and loamy soils. On the southern portion are rolling hills and gorges. The vegetation is shortgrass prairie characterized by blue grama (*Bouteloua gracilis*) and buffalo grass (*Bouchloe dactyloides*). A wide range of forbs, as well as cacti (*Opuntia* spp.) grow in the area. The shrub layer consists mainly of rolling areas of mesquite (*Prosopis* spp.) bushes and juniper (*Juniperus* spp.).

## METHODS

Fecal samples were collected on an opportunistic basis during the last three weeks of each month from April to November in 2004 and April to September in 2005. Groups or individual pronghorn were located and followed to collect fresh fecal samples. After animals defecated they were allowed to leave the area and then pellets were collected. All fecal pellets were collected within two hours of defecation.

Samples were dried in an oven at 60°C for 48 hours and stored in air tight bags until they were analyzed. The pellet groups for each month were combined to provide one composite sample for diet analysis. Composite samples were divided into two, and one part was sent to the Wildlife Habitat Nutrition Laboratory (Department of Natural Resource Sciences, Washington State University, Pullman, USA) for analysis. Microhistological analysis was used to determine species composition. Plants were identified to the species level. Four slides were made for each composite sample and 25 random fields were observed per

slide (Holecheck et al. 1981). The area covered by each species was recorded and the proportion of each species in the diet was calculated.

The remaining composite fecal samples were ground through a Wiley-mill to pass a 1 mm screen. Samples were analyzed using a TruSpec CHN analyzer (carbon-hydrogen-nitrogen; LECO Cooperation, St. Joseph, Michigan) to obtain the nitrogen content of the feces (FN). A series of standard samples containing known concentration of nitrogen were run through the CHN analyzer. These standards cover the range of interest. In order to determine changes in the quality of the diet using FN as an index, an analysis of variance (ANOVA) was used with month and site as the factors.

## RESULTS

Forty-three plant species were identified as part of the pronghorn diet in the SHP. These species included 5 grasses, 35 forbs and succulents, and 3 shrubs. There were also some unidentified grasses and forbs and four unknowns. Pronghorn diet contained more than 70% forbs in all months (Table 1). Grass and shrubs composed less than 20% of the diet in all months. The most important plant species are shown in Table 2. The percentage of filaree (*Erodium texanum*) and scarlet gaura (*Gaura cocinea*) were the highest overall for individual species. These two species were impossible to differentiate in the feces and were present throughout the study. In 2004 the second highest species was croton (*Croton potossii*) while in 2005 the second highest was milkvetch (*Astragalus nuttallianus*). Milkvetch was important in June on both study sites in 2005 (62% and 20%, respectively; Table 2A and 2B). The percentage of croton ranged from 1% to 46% on Site 2 and 1% to 27% on Site 1. On both sites seeds from *Opuntia* spp. comprised the bulk of the diet in September of 2004 (Table 2A). On the Site 2 it made up 67% of the diet and on Site 1 it constituted 42% of the diet. In September 2005 *Opuntia* spp. seeds constituted 18.3% and 9.8% of the diet on Site 1 and Site 2, respectively (Table 2B). For monthly breakdown of individual species percentages see Dankwa-Wiredu (2006).

In 2004, the concentration of FN ranged from 2.05-3.73% on Site 1 and 2.27-3.19% on Site 2 (Fig. 1A). In 2005, FN ranged from 2.51-2.62% on Site 1 and 2.83-3.78% on Site 2 (Fig. 1B). The concentration of FN was not different between Site 1 and Site 2 (P = 0.77) and there was no difference in the FN concentration among months (May– November) in 2004 (P = 0.12). In 2005, however, there was a difference between the FN concentration on Site 1 and Site 2 (P = 0.02). There was no difference between the FN concentration within the months (June–September, P = 0.81).

## DISCUSSION

Pronghorn diet in the SHP of Texas is dominated by forbs. This finding agrees with Buechner (1950) and Roebuck (1982) in the northern plains and Trans-Pecos regions of Texas. The proportion of forbs in the diet was, however, greater in this study than what was reported previously. In this study grass and shrubs did not compose a major part of the diet (Table 1). Overall, grasses and mesquite were not heavily utilized by pronghorn and this may be an indication that pronghorn in the SHP may show a preference for some forbs while avoiding grasses in the diet. Thus brush control, using fire or other means, which enhances forb production (Blaisdell 1953, Box and White 1969) will benefit pronghorn. Five eyes (Chamaesaracha spp.), broom snakeweed (Gutierrezia sarothrae), and nightshade (Solanum spp.) contained the highest amounts of crude protein (B. Dankwa-Wiredu, unpublished data) and were expected to have a high incidence in the diet. The low occurrence of these species in the diet suggests that factors other than crude protein account for pronghorn diet selection. The high incidences of cacti seeds in the diet in September on both sites indicate fruits from cacti form part of the diet of pronghorn during this month. During this month digestibility of vegetative plant material is quite low and thus the succulence of the fruit and high digestibility may have contributed to the use of cacti. Low digestibility of cacti seeds may explain the high incidence in the fecal samples. Since high frequency was recorded on both sites, the use of cacti fruits may be widespread in the SHP and not a site-specific phenomenon. Contrary to many pronghorn diet studies, Roebuck et al. (1982) also indicated high frequency of cacti seeds in September. Hoover et al. (1959) and Hlavachick (1968) indicated that cacti were important in the annual diet of pronghorn (11% and 40%, respectively) but did not mention whether it was mainly the fruits or the pads. Courtney (1986) reported that pronghorn in Alberta

would feed on the pads of cacti once fire has burned off the spines, but made no mention of fruits. It may be important to maintain some cover of cacti where pronghorn populations exist in the SHP. Throughout spring, summer, and early fall filaree and scarlet gaura constitute a major part of the pronghorn diet. Percentages of these species recorded in this study are much greater than what has been found in Arizona (4.6–57% in this study and 5–14% McDonald 2005). This result indicates, within the SHP, a good production of filaree during early spring and scarlet gaura during spring, summer, and early fall will benefit pronghorn.

Fecal nitrogen has been used as an index to determine changes in diet quality of several ungulate species (Leslie and Starkey 1985, Irwin et al. 1993, Cook et al. 1994b, Hodgman et al. 1996, Kucera 1997). In both 2004 and 2005, FN did not change among months. This consistency indicates the quality of diet did not change over the course of the study. Similar quality was obtained irrespective of the month or availability of plant growth stage. This agrees with Schwartz et al. (1977) who reported pronghorn maintained high nutritional quality irrespective of forage availability. In one example, pronghorn reportedly achieved this during winter, when their normal diet was of low quality, by switching to winter wheat (Torbit et al. 1993). It appears pronghorn in the SHP do not have a few preferred species, but rather switch between a wide array of species in order to obtain adequate nutrition. In this regard, the pronghorn has been called an opportunistic feeder (Yoakum 2004) and the consistency in the diet shows it is able to obtain a good quality diet irrespective of the season. The mean amount of FN recorded in this study (2.88%) is greater than the mean of 2.2% recorded for other ungulate species including elk (*Cervus elaphus*), white-tailed deer (Odocoileus virginianus), mule deer (Odocoileus hemionus), and desert bighorn sheep (Ovis canadensis). The FN level in this study is, however, similar to that recorded for pronghorn in Oregon and Nevada (1.52–3.12%, Hansen et al. 2001). Fecal nitrogen levels as low as 0.85–1.37% has been reported to be adequate for pronghorn in other regions (McDonald 2005). Thus the levels of FN in this study may indicate that pronghorn in the SHP had adequate nutrition for maintenance, growth, and lactation throughout the study.

The results of this study have important management implications. Pronghorn in the SHP are highly dependent on forbs. Therefore activities which will ensure adequate forb production will benefit pronghorn. Using fire or other means to prevent encroachment of shrubs and enhance forbs will benefit pronghorn in the SHP. Although cacti are considered a nuisance and many land owners would like to eradicate them, it may be advisable to maintain some cacti cover to provide food for pronghorn. The pronghorn in the SHP were able to maintain a high nutrition quality throughout the study period. During the two years of this study, the SHP received higher than average amounts of rainfall, it is therefore important that changes in the diet should be monitored during dry years. This will give wildlife managers a clearer picture of the changes that occur in the pronghorn diet. The high amounts of FN recorded indicate that nutrition may not be the reason for the decline in pronghorn numbers in the SHP. It is suggested that studies regarding inbreeding, fawn recruitment, and the impact of agricultural chemicals (e.g., herbicides, pesticides) should be conducted. Such investigations would provide wildlife managers with information so they can better manage this declining population.

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Table 1. Percentage of grass, forbs, and shrubs in monthly pronghorn diet obtained from fecal analysis of samples from two sites in the Southern High Plains of Texas, (A) 2004, (B) 2005.

(A)

	Sit	e 1			Site 2						
Month	Ν	Grass	Forbs	Shrub	Unk	Ν	Grass	Forbs	Shrub	Unka	
May	4	12.0	85.3	0.0	2.7	4	10.9	83.7	4.3	1.1	
June	3	7.0	88.8	1.0	3.2	10	1.5	89.1	3.5	5.9	
July	5	5.7	85.6	2.6	6.1	12	8.1	90.3	1.6	0.0	
August	3	2.6	93.1	1.6	2.7	5	7.3	86.4	5.0	1.3	
September	6	1.7	86.8	6.3	5.2	8	0.7	96.2	0.0	3.1	
October	3	2.0	91.1	3.4	3.5	6	7.8	84.4	4.9	2.9	
November	-	-	-	-	-	15	14.5	74.7	5.6	5.2	

<sup>a</sup> Unknown other species. Includes flowers, seeds, composite hair, and berries that did not fall into the other categories.

**(**B**)** 

Site 1							Site 2					
Month	n	Grass	Forbs	Shrub	Unk	n	Grass	Forbs	Shrub	Unka		
April	-	-	-	-	-	3	0.8	93.2	0.0	6.0		
May	-	-	-	-	-	4	1.4	96.8	0.7	1.1		
June	3	4.5	91.0	0.0	4.5	4	1.2	92.5	6.3	0.0		
July	4	3.1	85.9	5.5	5.5	7	2.2	89.3	6.7	1.8		
August	-	-	-	-	-	-	-	-	-	-		
September	3	1.3	89.5	1.8	7.4	3	4.9	87.7	3.9	3.5		

<sup>a</sup> Unknown other species. Includes flowers, seeds, composite hair, and berries that did not fall into the other categories.

## Proceedings of the $25^{\rm th}$ Biennial Western States and Provinces Pronghorn Workshop

Table 2.	Percent composition of important species in prongho	rn diet (from feca	l analysis) on a monthl	y basis on two sites	in the Southern
High Pla	ins of Texas in (A) 2004 and (B) 2005.				

\_\_\_\_\_

(A)

	Site 1						Site 2						
Plant Species	Мау	Jun	Jul	Aug	Sept	Oct	May	Jun	Jul	Aug	Sept	Oct	Nov
Croton potosii	10.3	9.7	12.5	2.2	21.6	26.6	45.6	3.2	19.6	6.6	-	15.7	21.4
Ratibida columnifera	16.2	2.5	6.1	0.8	3.7	1.5	0.5	1.0	-	0.7	0.4	1.0	0.2
Gaura coccinea/	47.6	54.7	34.8	60.2	4.6	29.5	17.5	57.0	24.1	51.4	24.7	24.9	23.1
Cutiomogia agrothrae				16	2.2	0.0	0.7				07	ГO	16
Gutierrezia sarotnirae	-	-	-	1.0	2.3	9.8	0.7	-	-	-	0.7	5.8	4.0
Monardo pectinata	-	1.0	1.2	0.6	1.7	4.4	-	2.5	1.1	-	-	1.5	4.2
<i>Opuntia</i> spp. seed	2.4	2.5	2.3	3.3	2.3	1.0	-	-	18.8	11.0	67.0	11.6	0.9
<i>Opuntia</i> spp.	-	4.9	4.1	3.8	1.7	1.5	11.8	2.9	3.7	4.1	1.4	5.6	4.9
Other forbs	-	-	-	6.0	41.8	-	1.1	3.9	2.7	2.3	-	2.9	0.5
Prosopis juliflora	-	-	1.2	-	5.2	3.4	4.3	2.0	1.1	3.6	-	2.4	5.6

(B)

		Site 1				Site 2		
Plant Species	Jun	Jul	Sept	April	May	Jun	Jul	Sept
Astragalus nuttallianus	61.8	4.9	14.9	1.9	0.4	20.1	1.8	-
Croton potosii	1.1	10.2	1.3	-	-	4.3	3.9	1.0
Ratibida columnifera	-	0.6	4.2	1.3	2.0	2.9	8.2	3.4
Gaura coccinea/Erodium								
texanum	0.6	24.7	14.7	51.8	20.7	23.3	24.7	31.1
Helianthus spp.	4.5	3.1	1.3	0.7	0.4	2.0	3.2	2.9
<i>Linum</i> spp. flower	4.0	2.5	-	18.8	49.4	2.0	7.3	4.4
<i>Opuntia</i> spp. seed	-	1.9	18.3	-	-	-	3.2	9.8
<i>Opuntia</i> spp.	-	1.9	7.1	-	1.4	12.6	15.4	7.3
Other forbs	1.4	7.4	4.9	0.7	2.2	5.5	8.6	1.5



June

Month

1 0.5 0

POIL

May

Figure 1. Fecal nitrogen (%) in composite samples of pronghorn feces on two sites in the Southern High Plains of Texas (A) 2004 and (B) 2005. The average fecal nitrogen for other ungulates is shown as a broken line.

September

JUM

## PRONGHORN RESPONSE TO WIND ENERGY DEVELOPMENT ON WINTER RANGE IN SOUTH-CENTRAL, WYOMING

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**ABSTRACT** Landscapes with high potential for wind energy development often coincide with suitable wintering habitat for pronghorn (Antilocapra americana). Evaluating the influence of energy development to pronghorn on winter range is particularly critical given that they encounter elevated energetic demands during this time of year. The goals of our study were to compare resource selection and survival for pronghorn that encounter wind energy infrastructure (Dunlap Ranch [DR]) compared to pronghorn that do not (Walcott Junction [W]]) over 3 winters (2010, 2010–2011, and 2011–2012) in south-central Wyoming. In addition, we evaluated the displacement of DR pronghorn by wind energy infrastructure components. In January 2010 we captured and attached Global Positioning System-transmitters to 70 female pronghorn (35 in the DR and 35 in the WJ); Global Positioning System collars were recovered in May 2012. Overall, 24 pronghorn died in the DR and 10 in the WJ, with the majority of deaths occurring in winter 2010–2011 for DR pronghorn and in the summer months for WJ pronghorn. We used the Kaplan-Meier product-limit estimator modified for staggered entry to estimate survival for each population. At the end of our 2.5-yr study survival (*Ŝ*) was 0.30 (95% CI: 0.14–0.46) in the DR and 0.68 (95% CI: 0.52–0.85) in the WJ. We found no relationship between DR pronghorn daily net displacement and distance to wind energy infrastructure ( $r^2$ < 0.012) across all 3 winters. We are currently modeling resources selection as well as employing the Cox proportional hazards model to compare survival between pronghorn in each population.

## PRONGHORN OFFSPRING SURVIVAL IN A LOW DENSITY TRANSLOCATED POPULATION: IS BIRTH SYNCHRONY A MECHANSIM FOR THE ALLEE EFFECT?

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**ABSTRACT** The Allee effect is an ecological process in which low density populations experience reduced population growth rates and increased extinction risk. Also referred to as "inverse" or "positive" density dependence, the Allee effect has previously been demonstrated for pronghorn (Antilocapra americana) and carries significant management implications. Recruitment in pronghorn populations is largely influenced by predation of neonatal fawns. Pronghorn offset predation by exhibiting birth synchrony, where high offspring production during a short interval of time decreases per-capita predation rates. However, the benefits of birth synchrony are density dependent and insufficient offspring production in reduced populations may increase predation rates to produce an Allee effect. We examine birth synchrony as a mechanism for the Allee effect in a low density translocated pronghorn population located within the Carrizo Plain National Monument in California. We calculated changes in per-capita population growth rate using 10 years of winter flight information and measured offspring survival within seasonal birth distributions by attaching 20 lightweight breakaway Global Positioning System collars to fawns over three years (roughly half the total number of fawns produced). Offspring survival was higher on average than we expected (mean = 69%, *n* = 45) however, our results indicate that this population is experiencing an Allee effect and that birth synchrony appears to degrade at small population size. Understanding Allee effects and the underlying mechanisms are critical for management of low density pronghorn populations.

## POST-RELEASE MOVEMENTS OF TRANSLOCATED PRONGHORN IN THE TRANS-PECOS OF TEXAS

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**ABSTRACT** Understanding the movements and behavior of translocated animals are important aspects of translocations. We assessed the behaviors and movements of the translocated pronghorn (Antilocapra americana) by utilizing Global Positioning System (15 F, 13 M) radio-collars. Global Positioning System radio-collars were designed to obtain 1 location/hr with a 300-day battery life. The average dispersal distance for each of the 5 release sites was 9.3 km and range from 5.8–15.9 km in the 300 days following translocation. In the first 24 hours, dispersal averaged 4.9 km and ranged from 1.4–8.7 km. The differences in dispersal for each release site suggest habitat and resource availability, fences, resident pronghorn, capture myopathy, and other factors influenced the degree of dispersal exhibited. Home ranges were measured by utilizing 100% Minimum Convex Polygon (MCP) and Fixed Kernal Density Estimator (KDE) at both 95% and 50% contours. Home range sizes when utilizing 100% MCP was 131.28 km<sup>2</sup> with KDE 95% and 50% being 83.82 and 16.59 km<sup>2</sup>, respectively. Pronghorn movements averaged 306.96 m/hr with diurnal and nocturnal movements averaging 491.64 and 274.81 m/hr, respectively. Pronghorn movement rates increased with ambient temperature. Home range sizes and movements were most influenced by forage availability, life-cycle events, and environmental conditions. This information provides wildlife managers information about how pronghorn initially adapt to new environments and will assist in improving monitoring and site preparation efforts for future translocations.

## POST-RELEASE SURVIVAL OF TRANSLOCATED PRONGHORN IN THE TRANS-PECOS OF TEXAS

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**ABSTRACT** Translocating pronghorn (Antilocapra americana) has been a key component in improving and sustaining pronghorn populations in the western United States especially those areas where pronghorn were nearly extirpated in the early 1900s. Unfortunately few translocation efforts were monitored to determine their effectiveness and post-release survival of pronghorn. Following a historic decline of pronghorn populations in the Trans-Pecos, we initiated a restoration project to evaluate pronghorn protocols for the State of Texas using contemporary technology (e.g., Global Positioning System [GPS] radio-collars). We supplemented the Trans-Pecos pronghorn herds by capturing 200 pronghorn from surplus populations in the Panhandle region. Following transport, 194 pronghorn (176 F, 18 M) were released in February 2011. Monitoring consisted of 80 (40%) pronghorn being equipped with either GPS (15 F, 13 M) or Very High Frequency (47 F, 5 M) radio-collars. Global Positioning System radio-collars were designed to obtain 1 location/hour with a 300-day battery life. The objective of this study was to monitor survival and determine sources of mortality. Within 18 months, we documented 69 (86%) mortalities for radio-collared pronghorn. Causes of mortality were unknown causes (n = 37, 54%), predation (n = 17, 24%), capture myopathy (n = 8, 12%), car collisions (n = 2, 3%), and *Haemonchosis* spp. infestation (n = 2, 3%). Unknown causes were assumed to be drought-related. Following initial release, 21 (30%) mortalities occurred in the first 4 weeks with capture myopathy and predation being the main causes. Although mortality was high, this information will be used to modify the pronghorn translocation protocols for Texas.

## PRONGHORN PERMEABILITY ASSOCIATED WITH FENCE CHARACTERISTICS IN NORTHERN ARIZONA

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ABSTRACT Previous studies have documented that fences and fenced roads can be substantial barriers to pronghorn movements. In order to evaluate the effects of fences and fence characteristics on pronghorn connectivity, we expanded on a dataset initiated to inform highway mitigations. We outfitted 54 pronghorn with Global Positioning System collars between January 2007 and December 2010, generating 179,500 locations. Fences within the study area were classified according to characteristics (e.g., height, wire type, condition) and modifications to create a time-sensitive dataset of fence classes. We tabulated crossing rates and evaluated the permeability for each fence class including a no-fence control line using ratios of crossing rates to availability. Temporal patterns of fence-crossing hotspots were evaluated with a focus on areas that underwent mitigation modifications during the study. Pronghorn were found to cross the no-fence control lines twice as often as actual fences. There was a significantly higher proportion of crossings in fence sections with a bottom wire height of 16" or higher. There were also significantly more crossings than expected at sections of fence between 200m and 400m from the highway. There was an increase in crossings of the highway after right-of-way fencing was removed. These findings indicate that ensuring a minimum of 16" of clearance under the bottom wire, pulling fence lines back from the roadside, and/or removing them altogether where possible would help restore connectivity in the northern Arizona pronghorn meta-population. A cooperative effort is underway to implement these mitigations in key areas.

# **OPENING UP THE PRAIRIES: EVALUATING THE USE OF GOAT-BARS BY PRONGHORN**

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**ABSTRACT** It is well known that pronghorn prefer not jump fences but instead prefer to cross under the bottom wire. If the bottom wire is too low, the fence becomes a barrier and restricts movement by pronghorn. There have been a number of enhancement techniques proposed to facilitate the movement of pronghorn across fences. One of the techniques is the goat-bar; a length of Polyvinyl Chloride pipe, with a slit cut length ways, used to raise the bottom wire by clipping it to the wire above. Though there is anecdotal information suggesting pronghorn will use sites enhanced with goat-bars we are not aware of any studies that confirm these accounts. Our study tests whether pronghorn will use sites enhanced with goat-bars for crossing fences using a Before-After-Control-Impact study design. During the winter of 2011–2012, 42 trail cameras were set up on fence posts and monitored to see if pronghorn were crossing for 34–35 days. Following this "control" period, 21 of the camera sites had a goat-bar installed and all 42 cameras were monitored for another 195–196 days. There was no evidence of a difference in the mean crossings/day (t =-1.53, P = 0.14) between the control and goat-bar sites. In addition, there was no evidence of an interaction between the effects of treatment and time (f = 2.36, P = 0.13). There was no evidence of a difference in the mean attempts/day (t = -1.90, P = 0.07) between the control and goat-bar sites and no evidence of an interaction between the effects of treatment and time (f = 3.62, P = 0.06). Though we were able to capture images of pronghorn using goat-bars, our analysis suggests that they do not improve movement by pronghorn. We believe this is due to pronghorn using "known" crossing locations and not exploring alternative crossing points. We discuss implications for the use of goat-bars as a technique to enhance movement by pronghorn.

## WESTERN STATES AND PROVINCES PRONGHORN WORKSHOP PROCEEDINGS 25:52–58

KEY WORDS Alberta, Antilocapra americana, Canada, fences, goat-bar, pronghorn.

It is well documented that fences have negative effects on pronghorn due to their reluctance to jump and a propensity to crawl under the bottom wire of fences (O'Gara 2004). These negative effects manifest themselves as direct mortality when pronghorn become entangled (Yoakum 2004), as movement barriers when pronghorn are unable to cross the fence (Berger 2004, Suitor 2011) or as indirect mortality when they become injured or lose a significant amount of hair from their neck and back (Jones 2013). To minimize the negative effects of fences, recommendations to make fences pronghorn or wildlife friendly have been made (e.g., Autenrieth et al. 2006, Paige 2008, Paige 2012). Examples include the removal of sheep or page wire fences and replacement with 3- or 4-strand fences, using double stranded smooth wire for the bottom wire and/or raising the bottom wire on existing fences to 45 cm (Autenrieth et al. 2006, Paige 2008, Paige 2012). These enhancements, though effective, are time consuming and/or costly. Alternatives have been proposed that focus on individual sections of a fence that reduce implementation time and costs. These include using a goat-bar, staple-lock modified fence, or leaving gates open when domestic livestock (hereafter cattle) are not present (Paige 2008, Paige 2012). Logically the first two proposed enhancements should work for pronghorn, particularly if they raise the bottom wire to an optimal height of 45 cm (Autenrieth et al. 2006, Paige 2008, Paige2012). Anecdotal information suggests this is the case, particularly for goat-bars, though we are unaware of any formal studies that have tested their effectiveness.

We initiated a study to test whether proposed fence enhancements do in fact allow easier passage by pronghorn. We first tested the goat-bar using a Before-After-Control-Impact (BACI) study design during the winter of 2011–2012. A goat-bar is typically a 3 m piece of white Polyvinyl Chloride (PVC) pipe that has a slit cut lengthwise down the middle using a table saw. The bottom wire of the fence is inserted into the slit of the PVC pipe and then raised and clipped to the wire above it (Fig. 1) (Autenrieth et al. 2006). This results in both the first and second barbed wire being trapped inside the PVC and a greater distance between the bottom of the PVC and the ground. We hypothesized that during the pre-development period pronghorn would have similar mean crossings/day and mean attempts/day at both the control and goat-bar sites, and following the installation of goat-bars there would be increased mean crossings/day and decreased mean attempts/day at the enhanced sites as opposed to the control sites by pronghorn. If our hypothesis was correct then our results would indicate that goat-bars do significantly increase the permeability of a fence for pronghorn.



Figure 1. Typical goat-bar set up to allow easier passage by pronghorn under a fence (line drawing by K. Rumbolt).



Figure 2. Distribution of trail cameras at the control and goat-bar sites within Canadian Forces Base Suffield located in southeastern Alberta, 5 October 2011–21 May 2012.

### **STUDY AREA**

We conducted our study on the Canadian Forces Base (CFB) Suffield, located in southeastern Alberta (Fig. 2). The military base is 2,690 km<sup>2</sup> (Canadian National Defence 2008) of natural prairie, that supports one of the highest densities of pronghorn in Alberta. The goat-bars were setup after cattle were removed from the base in November and we removed the goat-bars and cameras prior to cattle being turned back into the base in the mid-May. We targeted the existing fences along Interface, South Buffalo, and Bingville Roads along the eastern edge of CFB Suffield (Fig. 2). The total length of fence line along the 3 roads was approximately 25.47 km.

#### **METHODS**

The chosen fence lines along the 3 roads were broken up into 100 m sections using ArcMap Version 10 (Environmental Systems Research Institute, Inc., Redlands, CA). We randomly selected 42 sections of fence and then randomly selected one of the fence posts within each section to set up our trail cameras to monitor the interaction by pronghorn with the fence. After 34–35 days we randomly selected half (n = 21) of the sections of fence and installed a goat-bar at these sites and continued to monitor all trail cameras for another 195–196 days. We used 38 Reconyx PC800 and 4 Bushnell Trophy Cam XLT digital trail cameras to monitor the fence sections. During initial set-up and each time the cameras were visited the distance from the wires to the ground or snow was measured. We also noted whether any tumble weeds had been caught in the fence and whether they were acting as a barrier (after which they were removed), and whether any hair was caught on the barbs of the fence or loose on the ground.

We categorized each individual or group of pronghorn caught on camera within the first fence section as paralleling fence (no attempt to cross), attempting to cross (head low, either near or under fence

but backed away), or successfully crossed under. Pronghorn that successfully navigated completely from one side of the fence to the other side were considered to have crossed the fence. We counted each individual animal or groups of animals as one unit when categorizing the behavior. In the event that an animal triggered the camera then disappeared from view, we viewed the cameras placed adjacent to the area (during that time period) to confirm that the animal did not move to another camera location. We classified photos into events with a new event occurring after 5–10 minutes. From the photos, we identified individuals as either being male or female, estimated the number of individuals involved in the event, and noted any additional observations (e.g., loss of hair, injuries). We standardized all cameras by calculating the number of events/day for each behavior (paralleling, attempting or successfully crossing).

We expected that pronghorn would preferentially select for enhanced fences in comparison to the un-modified fences. We ran our analysis separately for whether pronghorn attempted or successfully crossed. Our Before-After-Control-Impact (BACI) design included multiple control and multiple impact (goat-bar) sites with multiple days of monitoring for each site and time. We tested if the mean difference was the same for the control and treatment (goat-bar) groups using the unequal variance *t*-test (Schwarz 2010). We determined if there was a BACI effect using an analysis of variance where our BACI model took the form:

Y = (Treatment) × (Time) × (Treatment × Time) × (Site)

where the variable Treatment took the values impact (goat-bar) and control, the variable Time took the values of before and after, the interaction term,Treatment×Time, represents the potential impact (i.e., is the change in mean between before and after the same for both the control and treatment sites), and the variable Site is equivalent to each individual camera and is a source of random variation (Schwarz 2010). The *P* value associated with the interaction term indicates whether there is a BACI effect. We used JMP Version 10 (SAS Institute, Inc. Cary, NC) for all of our analyses.

## RESULTS

Trail cameras were set up on CFB Suffield on 5 October 2011 at both the control (n = 21) and treatment (n = 21) sites. On 8–9 November 2011, goat-bars were installed at the 21 treatment sites. All cameras and goatbars were taken down on 21 May 2012. For the control cameras, the before period lasted 33.20 days (SE = 1.16) and the after period lasted 194.00 days (SE = 1.56). For the treatment cameras, the before period lasted 34.30 days (SE = 0.11) and the after period lasted 193.90 days (SE = 1.39). Differences in days resulted from elk opening cameras and they were no longer taking photos of the fence section. The mean height of the bottom wire at the control sites was 27.02 cm (SE = 2.12) for both the before and after periods, while at the treatment sites the mean was 30.72 cm (SE = 1.74) for the before period and 49.00 cm (SE = 1.14) for the after period following the installation of the goat-bar. We did not correct bottom wire heights for snow depth.

At the control sites, there were no successful crossings by pronghorn during the before period and 3 successful crossings during the after period. For the goat-bar sites there were 3 successful crossings during the before period and 7 after the installation of the goat-bar. There was no evidence of a difference in the mean crossings/day (t = -1.53, P = 0.14) between the control and goat-bar sites. In addition there was no evidence of an interaction between the effects of treatment and time (f = 2.36, P = 0.13). There were more events classified as attempting to cross the fence by pronghorn than successfully crossing. At the control sites, there were no attempts during the before period and 20 during the after period. At the treatment sites there were 7 attempts during the before period and 10 following the installation of the goat-bar. There was no evidence of a difference in the mean attempts/day (t = -1.90, P = 0.07) between the control and goat-bar sites, and no evidence of an interaction between the effects of treatment and time (f = 3.62, P = 0.06). Though both tests are not significant for attempting they are approaching significant levels, which is likely due to the increase in attempts at the control sites following the installation of goat-bars at the treatment sites.

## DISCUSSION

We have documented the use of goat-bars by pronghorn but the presence of goat-bars does not significantly increase the likelihood of a pronghorn crossing a fence. This fact is supported by the increase, though not statistically significant, in the number of attempts at the control sites following the installation of goat-bars at the treatment sites. These results may be an artifact of using a complete randomized study design and a combination of two things occurring over the course of the study. We believe that pronghorn are either ignoring or avoiding the goat-bars and selecting "known" crossing sites when moving back and forth across the existing fences. This hypothesis is supported by the large number of events that classified the pronghorn behavior as paralleling the fence and instances where pronghorn were captured on camera crossing the fence outside of the fence section under surveillance at a known crossing site. For example, at Site 42 pronghorn were recorded approaching from both directions and successfully crossing a fence at a known crossing site where the bottom wire was 47.5 cm from the ground (Fig. 3). In this instance, a male pronghorn walks past a goat-bar that is in clear view and choose to cross where the other pronghorn had, even though the height of the goat-bar was also 47.5 cm from the ground and he could have easily passed under (Fig. 3).



Figure 3. Series of images of a male pronghorn passing by a goat-bar (height = 47.5 cm) to cross the fence at a "known" crossing location where the bottom wire height was 47.5 cm.

Based on this assessment we plan to modify our study design for the winter of 2012–2013 to incorporate the propensity of pronghorn to use known crossing sites and continue to evaluate the effectiveness of goat-bars to allow easier passage by pronghorn. This new design will utilize 3 cameras per set-up, where one camera will monitor the fence section that contains a known crossing site, one camera will be placed on the next fence section to the left, and will serve as the control site and the last camera will be

placed to the right of the known crossing section and will be the treatment site. We will repeat this set-up 12 times for a total of 36 cameras. Following the before period (approximately 1 month) the bottom wire at the known site will be lowered to 30–35 cm and a goat-bar will be installed at the treatment site with a minimum height of 40 cm. We will then monitor all cameras until the end of the winter (April–May). This design allows us to assess if pronghorn are adamant on using existing sites and when these sites are no longer available, if they will readily select sites with goat-bars or move to another location.

Our analysis presented in this paper and with the results from the 2012–2013 season, we will be better situated to determine if goat-bars are a viable option for increasing fence permeability for pronghorn. Our current results indicate that goat-bars may be better suited to be used on new fences that pronghorn have not encountered before than on fences where there are known crossing sites. Along new fences where the bottom wire is below the recommended 40 cm, installing goat-bars at strategic locations may force pronghorn to use them in order to cross the fence. Over time pronghorn may become accustomed to using them and, therefore, goat-bars would be a viable option in these areas. Our results also highlight the need for further research into techniques recommended to enhance fence permeability for pronghorn. The first is the use of white PVC for the goat-bar. The use of alternative colors to the standard white PVC should be evaluated. The second area needing further research is how cattle will react to goat-bars (and other enhancement techniques). If the use of goat-bars is going to be employed by the ranching community, there needs to be certainties that goat-bars will not allow cattle to escape the pasture they are intended to stay in. We will be conducting research in these 2 areas over the next few years.

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## EVALUATION OF DISTANCE SAMPLING AS A TECHNIQUE TO MONITOR PRONGHORN IN KANSAS

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**ABSTRACT** Accurate and reliable survey results are crucial for proper pronghorn management. Aerial strip transect counts have been conducted biannually in Kansas since 1963. Summer counts (15 July-15 Aug) were conducted to obtain buck:doe:fawn ratio estimates. Winter counts (15 Dec-28 Feb) were conducted to obtain population abundance estimates. We conducted distance sampling surveys 13–14 August 2012 and strip transect counts 18–19 July 2012. The date surveys and counts were conducted had an impact on survey results. Pronghorn cluster size (group size) increased by 57% (3.98 to 6.23) between July and August. Consequently, encounter rate decreased by 70%, from 0.127 pronghorn/km to 0.038 pronghorn/km. The population abundance estimate obtained from the distance sampling survey was 1,638 pronghorn (CV = 23.1%). The strip transect count from the previous winter was 1,437 pronghorn. We analyzed the individual effect of covariates on population estimates. Analyzed covariates were observers, habitat type, pronghorn behavior, distance from road to transect, time of day, cloud cover, and position of the sun relative to observer. The observer covariate was the "best fit" model (i.e., lowest Akaike Information Criterion [AIC] value). Adding multiple covariates in a model did not result in lower AIC values. The distance sampling survey produced statistically precise estimates (CV = 23.1%) albeit with a small sample size (n = 65) and required less flight time than the strip transect counts. To obtain statistically reliable population estimates and buck:doe:fawn ratios in Kansas, we suggest the optimal time for distance sampling surveys to be mid-July.

## PRONGHORN USE OF PRESCRIBED BURN AREAS IN THE SOUTHERN HIGH PLAINS OF TEXAS

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**ABSTRACT** The pronghorn (*Antilocapra americana*) population in Texas has been declining. The population fell from >25,000 in 1986 to about 11,000 in 2003. Several factors are hypothesized to account for this decline in numbers. Available anecdotal information indicates pronghorn are attracted to burned areas. There is, however, no information on how long burned areas are attractive or the degree of difference in use between burned and non-burned plots. This study investigates the role that fire may play in reclaiming lost habitat for the benefit of pronghorn. We burned two 8.09-ha plots on two sites in the Southern High Plains in 2004 and 2005 to evaluate pronghorn use. The burned plots together with non-burned plots were monitored with wildlife cameras for 336 hrs /month. Pronghorn used the burned areas more than the non-burned plots up to a maximum of four months after the burn (April–June) and then use declined thereafter. On Site 2 use of the burned plot was higher in June and July 2004 (*P* = 0.003 and *P* = 0.01) while on Site 1 use of the burned plot was higher only in April 2004 (*P* = 0.001). In spring, the openness, early green up and improved nutrition created by winter burns appear to attract pronghorn to such areas.

#### WESTERN STATES AND PROVINCES PRONGHORN WORKSHOP PROCEEDINGS 25:60-68

KEY WORDS Antilocapra americana, patch burning, wildlife monitoring.

Fire has been used for centuries by several cultures living in grasslands to eliminate old plant growth, encourage early green up, and attract herds of ungulates (Higgins 1986, Williams 2003). More recently, use of prescribed fires has gained popularity in short grass prairie communities. Prescribed burning involves intentionally igniting fire to a predetermined confined area to achieve specific management objectives (National Wildlife Coordinating Group 1994). These management objectives include reducing invasive species (e.g., mesquite), reducing fuel buildup, increasing water availability, establishing a clean seedbed, and restoring or maintaining native ecosystems (U. S. Department of Interior 1992).

Deming (1963) and Yoakum (1980) observed pronghorn using burned areas in the Hart Mountain National Antelope Refuge, Oregon, and Long Valley, California and Nevada. Pronghorn had not been seen in these areas for years. Pronghorn in Alberta used burned areas and even consumed cacti after the fire had removed spines (Courtney 1989). These observations suggest there are certain characteristics about burned areas which are very attractive to pronghorn. It is, however, unclear what specific characteristics make burned areas appealing to pronghorn. It may be fire induced changes in the palatability, availability or quality of forage, or the openness and patchy pattern that a fire creates. Studies regarding other species, such as cattle (Mitchell and Villalobos 1999, Vermeire et al. 2004), beavers (Kellyhouse 1979, Ream 1981), bison (Shaw and Cater 1990, Boyce and Merrill 1991, Vinton et al. 1993), and deer (Wallmo 1981), have provided some insights concerning animal preference of burned to non-burned areas. These studies reveal increases in forage crude protein, maintenance of sub-climax vegetation, changes in plant community composition, and increased diversity in age structure of vegetation created by fire all contribute to animal use of burned areas. Comparable conditions may be created by fire in the Southern High Plains (SHP) and serve to attract pronghorn. However, similar evidence concerning pronghorn is not available. Scientific literature provides prescriptions for how fire can be used to improve habitat for pronghorn. According to Holechek (1981) pronghorn require a mosaic of very open areas, areas with low, sparse shrubs and areas with taller, denser shrubs for fawning. Pronghorn may also be favorably influenced by increases in herbaceous plants and reduction of shrubs after fire (Higgins et al 1989). Kindschy et al (1978), McCarty (1982), and Yoakum (1982) recommended prescribed burning as a means of improving habitat for pronghorn. Yoakum and O'Gara (1990) suggested burns should be <405 ha and maintain shrub coverage of 5–10%. This pattern should provide suitable shrub-to-grass ratio for pronghorn habitat. It is unclear, however, how these relate to pronghorn in the SHP of Texas.

The pronghorn population in Texas has declined from >25,000 in 1986 to approximately 11,000 in 2003 (Texas Parks and Wildlife Department, unpublished report). Even though the cause of the decline is not known, it is thought that habitat loss may be one of the major reasons (D. Lucia, Texas Parks and Wildlife Department, personal communication). Recently, the use of prescribed burning to reclaim rangelands overtaken by woody species such as mesquite (*Prosopis* spp.) and juniper (*Juniperus* spp.) has gained popularity in the SHP of Texas. Even though reclamation is targeted towards livestock, pronghorn and other wildlife species may also benefit. There is, however, little information on how beneficial these fires will be for pronghorn. We hypothesize that because burned area forage will have higher crude protein content, higher digestibility, and greater species diversity, pronghorn will use these areas more than non-burned areas. As a result, pronghorn will be observed more within burned plots. Our objective for this study was to evaluate effects of burning on pronghorn use of burned habitat.

## **STUDY AREA**

The study was conducted on 2 sites situated in Lynn and Borden Counties, Texas. Site 1 in Lynn County is located at 33°07'N and 101°35'W, while Site 2 in Borden County is located at 32°46'N and 101°31'W. The region is characterized by a warm, temperate, subtropical climate with dry winters and long hot summers (U. S. Department of Agriculture 1975). Daily high temperatures average between –2.8°C in January to 34.4°C in July (U. S. Department of Agriculture 1959). The area receives an average annual precipitation of 47.8 cm with most of it falling in May and June (U. S. Department of Agriculture 1975).

Located at about 910 m above sea level, the region has a nearly level to gently sloping terrain dotted with playa lakes (U. S. Department of Agriculture 1959). Furthermore, it has rough broken land with deep sandy loam and loamy soils. On the southern portion are rolling hills and gorges. The vegetation is shortgrass prairie characterized by blue grama (*Bouteloua gracilis*) and buffalo grass (*Bouchloe dactyloides*). A wide range of forbs, as well as cacti (*Opuntia* spp.) grow in the area. The shrub layer consists mainly of rolling areas of mesquite (*Prosopis* spp.) bushes and juniper (*Juniperus* spp.).

## **METHODS**

Two sites with known pronghorn populations in the SHP were selected for the studies. Due to low pronghorn numbers and drought conditions in the region, we selected plots where pronghorn had been seen within a year preceding the study and plots also had to have enough fine fuel to carry a fire. In 2004 and 2005, we selected a pair of 8.09-ha plots on each of the sites with one plot at random selected for burning. The second plot served as a control. We cleared a 2.44-m mineral line in February around the perimeter of the plots selected for burning. In early March, plots were burned using drip torches to start fires. On days of the burns in both 2004 and 2005, temperatures were between 4–15°C, relative humidities between 40–60%, and wind speeds between 0–16 kph.

After burning, plots were fenced with an electric fence consisting of 2 smooth wires 38 and 81 cm above the ground (Spillett et al. 1967). The top wire was connected to a 9-volt solar electric fence charger (Parker McCrory Manufacturing Company, Kansas City, MO) while the bottom wire had no power. The fence was maintained March–November in 2004 and March–September in 2005. Pronghorn cross fences by crouching underneath the wire and the 2-wire electric fence is recommended for the species (Spillett et al. 1967). This kind of fence allows pronghorn and other wildlife species (e.g., deer [*Odocoileus* spp.], bobcat [*Felis rufus*], and coyotes [*Canis latrans*]) to cross while keeping domestic cattle out.

We mounted 24 TrailTimer EZ-Cam 'Plus 500' game cameras (TrailTimer, St. Paul, MN) on T-posts at 0.9 m around the perimeter of the plots to monitor pronghorn use (Gee 2001). Film was changed when cameras were moved between sites every 2 weeks. The cameras were located 100 m apart and had a density of 1:0.68 ha. Each paired plot was monitored simultaneously for 14 consecutive days in a month. Each site was monitored for a total of 336 hrs/month. Cameras were programmed for a 5-minute delayed reaction time. Thus once a picture was taken, the infrared sensor beam was not reactivated until 5 minutes had passed. This setting helped prevent taking pictures of the same individual over a prolonged period of time. Pictures of other large wild ungulates and wildlife species were expected. Use was defined as the normal activities engaged in by pronghorn such as feeding, resting, and moving. The number of sightings of pronghorn was used as the measure of use.

Vegetative regrowth following fire is strongly influenced by soil moisture content at the time of the fire and post-fire precipitation (Wright and Bailey 1982). As some aspect of the post-fire vegetative regrowth is presumed to be the primary attractant for pronghorn use of burned areas, there is no biological reason for pronghorn to be attracted to burned plots until after some threshold amount of regrowth has occurred. Thus, because timing of burns, precipitation, and subsequent regrowth, camera placement at sites were not synchronous between sites or years, comparisons were confined to individual sites within years. Binomial proportions analysis tested for differences of use between burned and non-burned plots (Ott 1988). In using this test, each picture frame was considered as a single event. Graphs were used to assess the trend of use of burned areas by pronghorn. To assess use trend, we considered each individual in the picture frames to be one use event. Females with fawn(s) were considered as one use event, and also if an individual stayed within a single spot and had more than one picture taken, it was considered as a single use event.

## RESULTS

Prescribed burning in 2004 produced patch burns in a mosaic pattern while burns in 2005 produced a more uniform pattern. In both years the burned plots greened up faster than the non-burned plots. **Site 1** 

In 2004, 18 pronghorn were recorded on 18 frames on the burned plot while on the non-burned plot 2 pronghorn were recorded on 2 frames. There was no difference in use in all of months except April where greater use was recorded on the burn than the non-burned plot (P < 0.01, Table 1A). In 2005, 4 pronghorn were recorded on 4 frames on the burned plot and 3 pronghorn on 3 frames on the non-burned plot. Similar use was recorded for burned and non-burned plots in April and May (P = 0.08). In June, greater use was recorded on the non-burned plot (P = 0.04, Table 1C).

## Site 2

In 2004, 119 pronghorn were recorded on 94 frames in the burned plot and 104 pronghorn on 73 frames in the non-burned plot. There was a difference in use between burned and non-burned plots within June, July, and September. During June and July, the burned plot was used more than the non-burned plot ( $P \le 0.01$ ). While in September the non-burned plot was used more than the burned plot (P < 0.01, Table 1B). No difference in use was observed for May, August, or October. Pronghorn were not recorded in April or November. In 2005, 7 pronghorn were recorded on 7 frames in the burned plot and 12 pronghorn on 10 frames in the non-burned plot. There was no difference in use for all 6 months of the study (April–September, Table 1D). An examination of the total number of pronghorn in the frames revealed that when pronghorn numbers were low (n < 5, as in 2005) no consistent trend in use was apparent (Fig. 1).

## DISCUSSION

Spring burns do appear to have some effect on pronghorn habitat usage with high levels of variability. The first 4 months (April–July) after a winter burn constitutes the time period with the highest potential usage by pronghorn. Depending on prevailing site conditions, the burned areas would be used in all 4 months or less. This trend may occur because fires made vegetation more accessible to pronghorn by removing old growth and allowing for early green up. Studies on cattle showed that cattle on burned areas had better weight gain than non-burned areas up to 90 days after burning (Greene 1929, McGinty et al. 1983, Svejcar 1989). It is

possible pronghorn frequented burned areas more during a similar time frame because of possible improvement in animal performance. As this benefit declined so did pronghorn use of the burned plots.

While we expect prescribed burning to affect the attractiveness of areas to pronghorn, burning did not affect average crude protein content of the species that constitute pronghorn diet (Danka-Wiredu 2006). Some of the major individual species like croton (*Croton pottosii*) and filaree (*Erodium texanum*) consumed by pronghorn, however, had a crude protein (CP) content 1–5% higher in the burned plot from April–July. Digestibility was also similar for plant communities except in 2004 when grass digestibility was higher in the burned plots (Danka-Wiredu 2006). This increased digestibility in 2004 corresponds to the higher numbers of pronghorn recorded in that year as compared to 2005 when grass digestibility was the same in burned and non-burned plots. Pronghorn and other small ruminants are highly tied to digestibility of their diet due to their small size (Schwartz and Ellis 1981). In addition, Schwartz and Ellis (1981) reported that when pronghorn fed on grass, they selected species with high digestibility. As pronghorn can selectively forage (Schwartz et al. 1977), this potential for increased dietary protein content may have served as an attraction for pronghorn. It appears diet quality was a contributing factor to the higher use seen within burned areas within the first 4 months after the burn in this study.

Complicating measures of attractiveness is the fact that the SHP received above average rainfall starting in the fall of 2004 and continuing through the summer of 2005. Under normal rainfall conditions, CP and digestibility of the regrowth of defoliated vegetation is greater than those same qualities of undefoliated vegetation. However, increased water input can dilute and even reverse the increases in CP and digestibility that can occur following regrowth of defoliated vegetation (Milchunas et al. 1995). A similar phenomenon may occur when defoliation occurs because of burning. Nevertheless, above average rainfall resulted in the presence of lush vegetation and water available over the entire region in 2005. The surrounding fence might then have acted as a deterrent to pronghorn. This increased availability of good quality food and water may have made the non-burned areas equally attractive and caused the pronghorn to be dispersed over a wider area resulting in the fewer number of pronghorn seen during 2005.

Prescribed burning may be an important tool for managers trying to increase pronghorn numbers. Earlier green up and higher quality forage may provide an important food source for pronghorn within the SHP, especially females that are pregnant or fawning. Having well-nourished mothers may also lead to better survival rates for the fawns and benefit pronghorn in the SHP. It is probable that during years of normal rainfall, increased CP and digestibility will be recorded in burned areas and further research during normal years is encouraged. We would also suggest varying the size of burns. Yoakum and O'Gara (1990) recommended burning up to 405 ha and our burns may have been missed by pronghorn groups or too small for long-term usage. In conclusion, our data suggest that winter burns can attract pronghorn and further research may indicate that this is a useful management strategy in the SHP.

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Table 1. Comparison of camera-captured use of burned and non-burned plots by pronghorn in the Southern High Plains of Texas using binomial proportions tests ( $\alpha = 0.05$ ) in 2004 ([A] Site 1, [B] Site 2) and 2005([C] Site 1, [D] Site 2). Asterisks (\*) indicate significant differences.

(A)				(B)					
	Frames				Frames				
		Non-					Non-	_	
Month	Burned	burned	P-value		Month	Burned	burned	P-value	
Apr	15	1	0.001*		Apr				
May	1	0	0.1587		May	13	8	0.1335	
Jun	1	0	0.1587		Jun	32	14	0.0032*	
Jul	0	1	0.1587		Jul	40	23	0.0132*	
Aug	0	0			Aug	7	13	0.0869	
Sep	1	0	0.1587		Sep	2	13	0.0021*	
Oct	0	0			Oct	0	2	0.0778	
Nov	0	0			Nov	0	0		
(C)				(D)					
	Fra	mes			Frames				
		Non-					Non-		
Month	Burned	burned	P-value		Month	Burned	burned	P-value	
Apr	2	0	0.0778		Apr	4	3	0.352	
May	2	0	0.0778		May	1	3	0.1587	
Jun	0	3	0.0439*		Jun	0	0		
Jul	0	0			Jul	0	0		
Aug	0	0			Aug	1	3	0.1587	
Sep	0	0			Sep	1	1	0.5	
Oct	0	0			Oct	4	3	0.352	
Nov	0	0			Nov	1	3	0.1587	

Figure 1. Plotted trend in use of burned and non-burned plots by pronghorn (*Antilocapra americana*) in 2004 ([A] Site 1, [B] Site 2) and 2005([C] Site 1, [D] Site 2).



## IDENTIFYING IMPEDIMENTS TO LONG-DISTANCE PRONGHORN MIGRATION TO FACILITATE CONSERVATION

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**ABSTRACT** Major land use changes are challenging our concept of space, openness, and free-roaming wildlife in the western USA. Long-distance migrations continue to be threatened and industrial landscapelevel changes will continually require better knowledge about how animals use landscapes. New Mexico, Montana, and Wyoming all face large-scale energy development projects with grave potential to affect the spectacle and ecosystem services provided by migration. If such ecological processes are to be conserved information on the relative magnitude of effects is critical to conservation planning. Migrations must be rigorously characterized to identify and enumerate existing impediments and to predict where anthropogenic change may hinder or sever migrations in the future. To make reasonable management prescriptions, spatial analysis of animal movement data are ideal. To assess threats to a long-distance migration of pronghorn (Antilocapra americana) in a rural setting experiencing a natural gas production boom in Greater Yellowstone we used Brownian bridge movement models. We delineate impediments and barriers to migration by assessing hazard-induced stopovers as indicators of sites which are compromised by anthropogenic obstacles. Pronghorn avoided dense natural gas field development during migration. Highways with relatively high-volume traffic and non-wildlife friendly fences produced complete barrier effects. Areas of high use probability allowed us to identify previously undocumented impediments to pronghorn movement. These findings demonstrate the importance of considering the effects of growth prior to development and identify areas where targeted mitigation may alleviate existing pressure on migratory animals.

## AN INVESTIGATION INTO THE RECENT PRONGHORN DECLINE IN THE TRANS-PECOS REGION OF TEXAS

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**ABSTRACT** We are investigating the roles of parasites, diseases and pronghorn fawn survival of pronghorn in the Trans-Pecos region as a limiting factor. We collected samples of hunter-harvested pronghorn in October 2009, 2010, and 2011 to evaluate parasite loads, as well as the occurrence of blue tongue, epizootic hemorrhagic disease, and copper and selenium levels. We obtained 246 pronghorn samples from 2009 through 2011. Prevalence of barber pole worm was 94%, that is 201 of the 215 samples that were analyzed had barber pole worms. In 2009, the average number of barber pole worms/pronghorn was 510, in 2010 the average was 286, and in 2011 the average was 381. In 2011, we captured and radio-collared 26 fawns over 4 study sites in the Trans-Pecos region. We found mortality on these fawns to be very high, with only 1 out of the 26 surviving. We attributed 23 out of the 25 mortalities to predation. Coyote predation accounted for 28%, bobcat predation accounted for 24%, other mortality factors accounted for 8%, and 40% of predation could not be attributed to a specific predator. One of our collared fawns was never located after capture and therefore mortality was assumed. In 2012, we captured and radio-collared 34 fawns. Mortality was not as high as the previous year, with 7 of the 34 surviving. Coyote predation accounted for 22%; bobcat predation account for 37%; other, which included eagle and fox predation, abandonment and unknown mortality, accounted for 26%; and unknown predation accounted for 15%.

## COSTS AND BENEFITS OF INTENSE COYOTE REMOVAL TO INCREASE PRONGHORN FAWN RECRUITMENT IN NORTHERN ARIZONA

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**ABSTRACT** Limited lethal removal of coyotes (*Canis latrans*) has been demonstrated repeatedly to positively influence pronghorn (Antilocapra americana) fawn recruitment and population growth, yet the realized financial costs are rarely discussed. We used intense limited lethal removal of coyotes using aerial gunning and foothold traps to increase pronghorn fawn survival and population trend in 2 Game Management Units (Units) in Arizona (Units 4A and 10), while we conducted no treatment in 2 neighboring Units (Units 5A and 9). During 2010–2012, we spent about \$120,000 USD to remove 669 coyotes in Unit 10, and fawn to doe ratios increased from an average of 18:100 before treatment to an average of 40:100 during treatment. Total observed animals on surveys increased from 135 in 2010 to 626 in 2012. In neighboring Unit 9, although an increase in fawn:doe ratios was noted, no increase in observations or observation rate was detected. A similar relationship existed between Units 4A and 5A. Before the treatment period began, the Arizona Game and Fish Department offered 50 firearms and no archery permits in Unit 10, which had increased to 70 firearms and 60 archery permits by 2012. This resulted in an increase of 403 hunter days (144 to 547) as well. Unit 9 increased from 20 to 25 firearms permits during this same time period, with an increase of 23 (48 to 71) hunter days. Unit 4A increased from 10 to 15 firearms permits, with an increase of 41 (37-78) hunter days, whereas Unit 5A saw 10 firearms permits throughout this period and an increase of 5 archery permits (5 to 10), with an overall increase of 58 (48 to 106) hunter days. Permit revenue increased by \$10,425 USD in the treated units, whereas the increase in permit revenue was only \$1,250 USD in the untreated units. Based on 2006 estimates of the value of a hunter day to local economies, the increase expenditures by hunters in addition to tag and license revenues was \$88,045.20 USD, whereas the increase in hunter expenditures was estimated at \$4,618.90 USD in the untreated units. It is less straightforward to consider the benefits to wildlife viewing. When viewed in this context, limited lethal removal of coyotes may be a cost-effective action.

# PRONGHORN STATE AND PROVINCIAL STATUS REPORTS AND LONG-TERM TRENDS

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**ABSTRACT** Population and harvest information were gleaned from past proceedings of the pronghorn workshop in order to assess long-term trends in both data sets. The overall pronghorn population estimate decreased from 2009 to 2011 driven by large declines across the northern extent of the pronghorn range. Populations remain higher in 2011 than in 1964 in most states and provinces despite a higher percentage of the overall population having shifted to the core area of Colorado, Montana, New Mexico, South Dakota, and Wyoming. In total, 11.3% of the estimated population was harvested in 2011 with large increases in female harvest in several states. Several severe winters led the northern tier of states and provinces to reduce harvest or close hunting seasons altogether. Additional information on private land issues, hunter opportunity, management issues, and current and future research needs was also included.

### WESTERN STATES AND PROVINCES PRONGHORN WORKSHOP PROCEEDINGS 25:72-88

**KEY WORDS** *Antilocapra americana*, harvest, harvest reporting, management, population, private land, provinces, research, states.

Early workshop proceedings only included population and harvest information for states and provinces in attendance as individual presentations. Beginning in 1998 information was requested from all Western Association of Fish and Wildlife Agencies (WAFWA) member states and provinces, and it has become customary for the host state or province to present that information as a cohesive data set.

I sent surveys to all 18 WAFWA member states and provinces with extant pronghorn populations and received responses from all of them. Information was also requested from Mexico, but without a central point of contact no information was received. I asked respondents to provide information for the 2011 biological and harvest years (June 2011–May 2012). Standard survey questions included: survey methodology and timing, population estimate and management objective, average bucks and fawns per 100 does, harvest and success rate by weapon type, and number of hunters by residency status. In addition to the standard questions, I also included additional questions that would facilitate further discussion at the workshop and were of particular interest to New Mexico Department of Game and Fish personnel (Appendix A).

All past data were gleaned from past proceedings of this workshop (Yoakum 1968, McKenzie 1982, Riddle 1992, Hack and Menzel 2002, Schilowsky 2010).

## **RESULTS AND DISCUSSION**

### Population

The range-wide pronghorn population estimate was 847,494 individuals in 2011 (Fig. 1). Excluding Montana, this was a 14.8% decrease in the reported population estimate from the 2009 state status report (Schilowsky 2010). While half of the respondents reported stable or slightly increasing populations, the significant decreases realized by the remaining half of respondents decreased the overall population estimate. The most significant declines were in the northern states and provinces with North Dakota, Saskatchewan, and South Dakota all reporting population declines >50%. Montana was not included in the comparison as they did not provide a 2009 estimate.

Overall, long-term pronghorn population trends increased from 1964 to 2011 with individual decreases in Alberta, Nebraska and North Dakota, and no change in Montana (Fig. 2). Although large proportional increases occurred in peripheral populations during this time, the 5 core states of Wyoming, Montana, Colorado, New Mexico, and South Dakota (Hack and Menzel 2002) increased their overall
proportion of the pronghorn population from 75 to 84%. Wyoming still holds 55% of the global pronghorn population.

More recently, most populations remained relatively stable or increased from 2001 to 2011 with the exception of Alberta, California, Montana, North Dakota, and Saskatchewan (Fig. 2). While California, Montana, and North Dakota realized decreases from -15 to -5%, Alberta and Saskatchewan realized the largest decreases with -34.2 and -43.9%, respectively.

The population-weighted fawn:doe ratio was 52.7:100 in 2011. This high number is driven largely by the 59:100 average reported by Wyoming. Most respondents reported an average fawn:doe ratio around 40:100, but Texas reported the lowest average fawn:doe ratio at 15:100 and South Dakota the highest at 67:100 (Fig. 3). Reporting on fawn:doe ratios from previous workshops has been too haphazard to provide any meaningful comparison.

The population-weighted buck:doe ratio was 47:100 in 2011. Arizona reported the average lowest buck:doe ratio at 26:100 and Wyoming the highest at 52:100 (Fig. 4). Harvest objectives are highly variable by state or province, but, on average, fall between the 25:100 ratio suggested for maximum population growth and the 50:100 ratio suggested for trophy production (O'Gara and Morrison 2004). Reporting on buck:doe ratios from previous workshops has been too haphazard to provide any meaningful comparison.

Arizona, Colorado, Nevada, New Mexico, Texas, and Utah were all engaged in transplanting pronghorn. Arizona, Colorado, New Mexico, Texas, and Utah transplanted surplus animals in state. Nevada transplanted animals to the Yakima Nation in Washington.

#### Harvest

The overall reported pronghorn harvest was 95,818 individuals (Fig. 5) from 166,787 licenses in 2011 (Table 1), or 11.3% of the total reported population estimate. This included rifle, archery, and muzzleloader hunts; and buck, doe, and fawn harvest. Overall success rates for pronghorn were 57.4%, while rifle, archery, and muzzleloader success rates were 59.7, 36.8, and 40.2%, respectively. Any further in-depth analyses into license numbers, hunter participation, and harvest are clouded by the issuance of multiple licenses in 8 states and differences in weapon-type data gathered by states and provinces.

Overall, long-term pronghorn harvest trends increased from 1964 to 2011 with individual decreases in Arizona, Montana, Nebraska, North Dakota, and South Dakota (Fig. 6). As populations increased during this time, harvest of does contributed heavily to the increase in overall harvest numbers. While Colorado and Wyoming increased doe harvest to manage increased populations, Montana and South Dakota drastically reduced doe harvest in response to recently decreased populations. All other states or provinces had little or no doe harvest in 2011 with most of that harvest focused in agricultural areas.

More recently, harvests remained relatively stable or increased from 2001 to 2011 (Fig. 6). Arizona, Idaho, New Mexico, and South Dakota all reported a reduced harvest in 2011, but that reduction was no more than 4% and considered relatively stable. The increase in Colorado was caused by increased doe harvest following a change in survey methodology, which indicated population estimates exceeded management objectives in many areas (A. Holland, personal communication).

Given recent declines in overall population estimates for Alberta, Montana, North Dakota, and Saskatchewan (Fig. 2), the subsequent decreases in harvest are expected. Alberta and Montana respectively harvested 75.6 and 62.3% fewer pronghorn in 2011 than in 2001. While North Dakota and Saskatchewan shut down hunting all together.

#### **Harvest Reporting**

Harvest reporting was mandatory for pronghorn hunters in 8 states in 2011 with an average reporting rate of 88.7%. Oregon hunters reported the least in a mandatory system at 60%, while Nebraska and Oklahoma hunters must visit a check station upon harvesting a pronghorn. Hunters from states or provinces that did not require harvest reporting had an average reporting rate of 58.5%. Wyoming hunters reported the least at 21%, while 90% of Kansas hunters reported their harvest.

Typically harvest information is gathered for use in sex-age-kill or other population reconstructionbased models, and is used more by government agencies for deer or elk (Walker 2011) than pronghorn. Given the assumptions of a sex-age-kill model, its limited ability to function accurately with drastic changes in inputs (Millspaugh et al. 2009), the higher overall detectability of pronghorn compared to deer or elk, limited identifiable age differences among individuals during surveys, and relatively smaller populations, it is not surprising that agencies rely more on trend analysis and less on modeling with pronghorn than deer or elk.

## **Non-resident Hunting**

Non-resident restrictions were variable by state or province, but when pronghorn hunts were limited, nonresident hunters comprised <20% of license holders. Colorado, Oklahoma, and Texas had no general restriction against non-residents applying for hunts. Kansas, Nebraska, and North Dakota restricted nonresidents to archery hunts, and Nebraska also allowed the take of does and fawns. South Dakota had a variable non-resident limit of <8% for rifle hunts based on population levels and an unlimited number of archery licenses. Saskatchewan was the only respondent that fully restricted all non-resident hunting of pronghorn.

## Youth Opportunity

Youth opportunity was generally limited for pronghorn. Half of responding states or provinces did not have specific licenses set aside for youth hunters. Colorado and Utah set aside a percentage of licenses for youth, while California, Idaho, New Mexico, and Oregon set aside a specific number of licenses. Nebraska provided an unlimited number of archery licenses for youth. Alberta, New Mexico, and Oregon had mentor/youth opportunities available. Kansas and Wyoming focused on reduced license fees. Montana had few opportunities available for youth pronghorn hunting. Overall, more youth opportunity was focused on deer and elk (Walker 2011) than pronghorn.

## **Private Land**

Wildlife are considered a public resource and there is no denying many species, including pronghorn, survive because private landowners allow them to do so. Pronghorn distribution is primarily tied to the western Great Plains (Jensen et al. 2004), thus pronghorn are primarily found on private lands. In the portions of the 12 Great Plains states and provinces pronghorn inhabit, lands are at least 50% privately owned, with the exception of Saskatchewan (Fig. 7). Distribution in the remaining 6 states is variable from 3 to 90% private ownership.

The preponderance of pronghorn on private lands creates unique challenges to their management. Every agency issues licenses, at least in part, through a public draw, while 14 agencies also issue licenses over the counter or through some sort of landowner program. Each landowner program was unique, but direct allocation of licenses, a certain percentage or number of licenses set aside, reduced fees, or special preference in the public draw were utilized to improve landowner participation in pronghorn management. These programs provide a means to regulate harvest and manage populations on private land while working directly with landowners.

Issues arise any time wildlife are present on private land and pronghorn are no exception. Most states or provinces use similar means to alleviate conflicts between landowners and pronghorn including population management hunts, hazing, crop depredation payments, fencing, and/or trap and transplant operations.

## **Predator Control**

Yoakum et al. (2004) provided an extensive review of predator control with respect to pronghorn and concluded it may be justifiable when the population is well below carrying capacity, fawn survival is exceptionally low, or following a transplant. Arizona, Montana, Nevada, Texas, Utah, and Wyoming all conducted predator control to varying degrees. Improvement in fawn recruitment was justification for all involved. Arizona and Montana reported increased fawn production following predator control and Arizona reported it was cost effective (Amber Munig, Arizona Game and Fish Department, unpublished data), although indirect benefits had to be included.

## **Hunt Management**

Pronghorn hunt management focused more on quality than opportunity with 9 states or provinces leaning toward quality, 5 toward opportunity, and 4 had no preference. The dominance of quality over opportunity was the opposite for deer and elk (Walker 2011), and likely resulted from earlier maturation of pronghorn compared to deer or elk, limited hunts in most populations, and differences in hunter expectations. Pronghorn are mature at 3 years old, after which horn size changes little (Mitchell and Maher 2001) compared to deer and elk that peak in antler size later in life (Stalling et al. 2002). Deer and elk harvest in the western states and provinces during a similar time period was approximately 1.4 million animals (Walker 2011) compared to <100,000 pronghorn, creating move exclusivity for a pronghorn hunt. Hunter expectations are often best summed up by Z. Lockyer's response on Idaho's management, "[q]uality areas are those with light hunter pressure, high aesthetic appeal away from population centers, minimal roads, and high probability of harvesting a mature buck".

## **Current Management Issues**

Pronghorn management issues generally fell into 4 categories:

- 1. Weather factors including drought conditions limiting or preventing growth in pronghorn populations in Colorado, New Mexico, Oklahoma, Texas, and Utah, water availability in Nevada, and winter kill in Saskatchewan and South Dakota.
- 2. Habitat loss and connectivity including highway construction and urban expansion in Arizona, energy development impacts in North Dakota and South Dakota, and maintaining long-distance migration corridors in Wyoming.
- 3. Land access issues in Arizona, Montana, and New Mexico, as large blocks of public land may become inaccessible without the participation of private landowners. Often a single landowner may control the access to large blocks of public land or the public land is checker-boarded with private.
- 4. Survey methodology issues including Kansas transitioning to distance sampling in order to gain confidence in their population estimates and Wyoming trying to find an estimator besides line-transect distance sampling that is more robust and safer to implement in rugged country.

Other than the 4 main categories, individual states or provinces noted unique issues. Recent fires in California may have large impacts on the pronghorn herd. Over-abundant populations were causing damage to eastern Colorado agricultural producers.

## **Current Research and Future Needs**

Current research focused on pronghorn movements in Arizona and Wyoming, corrections to survey methodology in South Dakota, and fawn survival in Utah. Arizona and Wyoming continued to conduct movement studies targeting the effects and mitigation measures associated with highway construction, energy development, or urban development (e.g., ideal locations for over- or underpasses, fence modifications, and land acquisitions and easements). South Dakota was evaluating the effectiveness of their fall recruitment surveys. Utah just implemented a fawn survival and causative mortality study.

Identified future research needs include fawn and adult survival and mortality factors, improvements to population and movement monitoring, identifying and delineating critical habitats, individual- and population-level responses to catastrophic wildfires, disease effects and mitigation, and energy development effects and mitigation.

In addition to the aforementioned research needs, a more in-depth comparison of past state and provincial status report data could be undertaken. Past comparisons have been arbitrarily set at 10 years. While a 10-year comparison may be sufficient for the more stable populations, usually large changes occur in peripheral populations more rapidly. The frustration in many of these analyses is holes in the past data. Information reporting is vastly better now that population and harvest information is gathered by the host agency, rather than presented individually by state or province. I urge states and provinces to continue providing a complete data set to the host agency to provide better analysis capabilities in the future.

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Figure 1. Pronghorn population estimate by state or province for 2011.



Figure 2. Pronghorn population estimates by state or province 1964–2011 and percent change in population estimate 2001–2011. Wyoming and Montana population estimates were reduced by a factor of 10 and 2, respectively, for graphical purposes.



Figure 3. Average pronghorn fawns per 100 does by state or province, 2011.



Figure 4. Average pronghorn bucks per 100 does by state or province, 2011.



Figure 5. Total pronghorn harvest by state or province in 2011. Includes male and female harvest, and all weapon types.



Figure 6. Total pronghorn harvest by state or province 1964–2011 and percent change in total harvest 2001–2011. Wyoming and Montana total harvests were reduced by a factor of 10 and 2, respectively, for graphical purposes.



Figure 7. Approximate percentage of private land within pronghorn range by state or province.

	Licenses				Harvest							
Chata are		Rifle	Muz	zleloader	А	rchery		Rifle	Muz	zleloader	A	Archery
Province	Buck	Doe/Fawn	Buck	Doe/Fawn	Buck	Doe/Fawn	Buck	Doe/Fawn	Buck	Doe/Fawn	Buck	Doe/Fawn
Alberta	195	75	N/A	N/A	77	0	137	29	N/A	N/A	15	0
Arizona	436	0	73	0	321	0	346	0	41	0	101	0
California	218	0	N/A	N/A	21	0	183	0	N/A	N/A	11	0
Colorado	9,024	14,329	1,312	0	855	0	4,490	5,641	139	67	339	32
Idaho	1,183	221	317	0	1,966	0	668	136	87	15	270	64
Kansas	154	0	48	0	287	0	106	2	25	1	46	9
Montana	20,550	8,417	N/A	N/A	5,597	873	7,753	4,483	N/A	N/A	654	85
Nebraska	736	102	153	0	972	0	474	89	111	3	214	22
Nevada	2,226	307	20	0	568	0	1,614	223	11	0	125	0
New Mexico	3,394	331	279	0	458	0	2,723	260	136	4	163	0
North Dakota	Closed	Closed	N/A	N/A	N/A	N/A	Closed	Closed	N/A	N/A	N/A	N/A
Oklahoma	105	450	N/A	N/A	N/A	N/A	86	147	N/A	N/A	N/A	N/A
Oregon	1,464	154	145	0	498	0	1,110	110	47	5	91	3
Saskatchewan	Closed	Closed	N/A	N/A	N/A	N/A	Closed	Closed	N/A	N/A	N/A	N/A
South Dakota	4,458	1,484	N/A	N/A	2,141	0	2,523	1,971	N/A	N/A	258	89
Texas	1,209	0	N/A	N/A	N/A	N/A	611	N/A	N/A	N/A	N/A	N/A
Utah	649	946	11	0	117	0	597	566	5	0	77	0
Wyoming	42,040	36,475	250	0	N/A	N/A	29,705	25,820	308	71	2,003	723
Total	88,041	63,291	2,608	0	13,878	873	53,126	39,477	910	166	4,367	1,027

Table 1. Pronghorn license and harvest information by state or province for bucks and does/fawns; and rifle, muzzleloader, and archery hunts in 2011. Some licenses are issued for either sex providing doe/fawn harvest without the issuance of a doe/fawn license.

## **Appendix A: Questionnaire**

State or Province: Agency: Report submitted by: Email: Phone:

## **Population Survey Methodology**

Aerial Survey Type and Method (e.g., line transect via fixed-wing, opportunistic via helicopter):

Ground Surveys (e.g., consistent route, targeted area):

How many years has your Agency been using the aforementioned technique(s)?

Aerial Timing (by Month):

Ground Timing (by Month):

## Population Survey Information

2011 Mean Population Estimate	
2011 Mean Population	
Management Objective	
Average Bucks per 100 Does	
Average Fawns per 100 Does	

Is estimate pre-hunt or post-hunt?

Is objective pre-hunt or post-hunt?

Are you satisfied with your survey methods and results? Why or why not?

## **Harvest Information**

How are harvest data collected in your State or Province (e.g., web-based, phone/mail survey)?

Is harvest reporting mandatory for pronghorn in your State or Province?

Approximately what percentage of hunters reports their harvest annually?

## <u>Rifle Hunts:</u>

Buck or Either-sex licenses issued	
Female/immature buck licenses issued	
Bucks harvested	
Females/immature bucks harvested	
Number of resident hunters	
Number of non-resident hunters	
Overall hunter success rate	

During which months are rifle hunts conducted (List all)?

What are the season lengths of the rifle hunts?

## Muzzleloader Hunts:

Buck or Either-sex licenses issued	
Female/immature buck licenses	
Issued	
Bucks harvested	
Females/immature bucks harvested	
Number of resident hunters	
Number of non-resident hunters	
Overall hunter success rate	

During which months are muzzleloader hunts conducted (List all)?

What are the season lengths of the muzzleloader hunts?

## Archery Hunts:

Buck or Either-sex licenses issued	
Female/immature buck licenses issued	
Bucks harvested	
Females/immature bucks harvested	
Number of resident hunters	
Number of non-resident hunters	
Overall hunter success rate	

During which months are archery hunts conducted (List all)?

What are the season lengths of the archery hunts?

## **Hunter Participation**

How are licenses issued in your State or Province (e.g., through public drawing, via landowner authorizations, over-the-counter)?

Can a hunter legally harvest >1 pronghorn in a given license year in your State or Province?

Does your Agency limit the number of non-resident hunters by statute or rule? If so, what is the limit?

Does your Agency reserve licenses for youth? How many?

What other means does your Agency utilize to recruit youth hunters, if any?

## Habitat Enhancement

Is your Agency actively involved with pronghorn habitat enhancements on Federal or State lands?

If so, what specific work is being done?

## **Private Lands**

Do landowners have the ability to hunt their own property or are they treated as just another hunter?

What percentage of occupied pronghorn habitat is privately owned?

Does your Agency have a program that provides monetary compensation for private landowners to grant access to public pronghorn hunters? Name and brief description of the program?

Approximately how many acres of private land have been opened to public pronghorn hunting in your State or Province through this program?

Does your Agency currently provide any type of incentive to private landowners engaging in habitat enhancements/restoration projects targeting pronghorn?

How are depredation issues dealt with in your State or Province (e.g., landowner tags, population management hunts, fencing)? Please explain.

## **Predator Control**

What types of predator control measures have been implemented by your Agency?

What were the objectives of those measures?

Have you seen a measurable response from these programs?

If so, what parameters responded?

Do you feel this work was cost effective?

## Miscellaneous

Does your Agency have specific areas that are managed more for Quality than for Opportunity? What proportion? What biological parameters designate a Quality area?

What current management issues is your Agency working to resolve?

Is your Agency currently transplanting pronghorn? If yes, explain.

Is your Agency currently conducting pronghorn research? If yes, explain.

Identify any research needs.

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## **Appendix B: Agency Contact Information**

## A MISMATCH BETWEEN MANAGEMENT AND CONSERVATION ACTIONS FOR TAXA, IN AND OUTSIDE THE RED-LISTS: THE CASE OF THE PRONGHORN AND A PROPOSAL

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ABSTRACT The International Union for Conservation of Nature (IUCN) Red List currently considers pronghorn (Antilocapra americana) as a "least concern" species with no major range-wide threats, while the Convention on International Trade in Endangered Species (CITES) indistinctively lists "population of Mexico" in Appendix I. However, a few years ago both lists included three out of five recognized subspecies. Specifically, the Mexican pronghorn (A. a. mexicana) was ranked by IUCN as "low risk" and CITES in Appendix II, peninsular pronghorn (A. a. peninsularis) was ranked by IUCN as "critical risk" and CITES in Appendix I, and Sonoran pronghorn (A. a. sonoriensis) was ranked by IUCN as "endangered" and CITES in Appendix I. Along its range, the distinct pronghorn subspecies in Canada, U. S., and Mexico are subjected to very different management strategies, including harvesting in Canada and the U.S. and on-going recovery programs, preventing the extinction of peninsular pronghorn in Baja California peninsula under the listing as "endangered" in the Norma Oficial Mexicana (NOM-059), and saving Sonoran pronghorn within its U.S. range in southern Arizona under the Endangered Species Act. We argue that pronghorn populations in the Sonoran Desert in Mexico and U.S. meet ecological and genetic criteria as two distinct evolutionary significant units based on recent analyses, but recognize that studies over the entire range of the species are needed. Also, peninsular and Sonoran pronghorn in Mexico contain small populations that increase their extinction risks. Both recovery programs have prevented the permanent loss of evolutionary potential within the species, despite that international red lists do not seem to always work in the same "frequency" and underestimate the biodiversity value for conserving warmadapted, historically isolated peripheral populations with sub-specific status that are at high risk of extinction in southern latitudes within northerly ranging temperate species. A clear mismatch exists for management of taxa in pronghorn.

## WESTERN STATES AND PROVINCES PRONGHORN WORKSHOP PROCEEDINGS 25:89

**KEYWORDS** *Antilocapra Americana*, Endangered, evolutionary significant unit, red list, policy, subspecies.

## GENETIC DIVERSITY IN TWO CRITICALLY ENDANGERED CAPTIVE BREEDING SUBSPECIES OF ANTILOCAPRA AMERICANA

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**ABSTRACT** Antilocapra americana, the lone survivor within the Antilocapridae, has 4 extant subspecies. The 2 inhabiting the Sonoran Desert in northwestern Mexico and outhwestern U.S., A. a. sonorensis and A. a. peninsularis, are among the most endangered mammals. What is left of their populations is kept in semi-captivity. Knowledge about genetic variation and differentiation is important for their conservation and management; unfortunately, this information is lacking. We describe and compare the genetic diversity of these two subspecies, using 18 microsatelite loci and the mitochondrial control region. Microsatellite DNA analyses show that these two pronghorn have very low genetic variation (mean number of alleles 4.7 and 2.8, and mean heterozygosis 0.54 and 0.37, respectively). Mitochondrial analysis indicates only 2 haplotypes for the peninsular and 4 for the Sonoran pronghorn, the haplotypes were unique to each population. Structure and factorial correspondence analysis show 2 clearly distinct groups, indicating strong genetic differentiation ( $F_{st}$  microsatelites = 0.402,  $\phi_{st}$  mtDNA = 0.836). These results mean that both subspecies have suffered a significant loss of genetic diversity due to population bottlenecks, and subsequent small population sizes and isolation. We also find that peninsular subspecies has a significantly lower genetic variation on all markers. Both markers demonstrated that these two subspecies represent distinct evolutionary significant units and efforts for their conservation are justified. From a conservation perspective, our results indicate that each subspecies needs immediate conservation actions including genetic monitoring and the design of a mating system reliant on genetic data to minimize relatedness and inbreeding.

## WESTERN STATES AND PROVINCES PRONGHORN WORKSHOP PROCEEDINGS 25:90

## HABITAT USE BY AMERICAN PRONGHORN (ANTILOCAPRA AMERICANA AMERICANA) ON ANDERSON MESA, NORTHERN ARIZONA

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**ABSTRACT** Anderson Mesa, a 4,180-km<sup>2</sup> plateau located southeast of Flagstaff, Arizona, supports an important and historically prominent population of American pronghorn. Improving habitat for pronghorn has been a primary goal in management of public and private lands on Anderson Mesa. Recent efforts have included extensive grassland restoration and fence modification projects. In November 2003 and 2004, we captured pronghorn (15 F, 1 M) via net-gunning from a helicopter and fitted them with Global Positioning System collars programmed to collect 2 locations/day over a 2-year deployment. Fourteen collars provided usable data that we used to quantify habitat use in higher (>2,100 m) and lower ( $\leq$ 2,100 m) elevation zones of Anderson Mesa. For each year and zone, we used a likelihood-based fixed kernel (FK) method to estimate individual home ranges (95% FK) and probabilistic utilization distributions (UDs). We used a generalized linear mixedmodel and information-theoretic approach to relate estimates of intensity of habitat use (the UDs) to multiple biotic and abiotic factors. Ninety-five percent FK home ranges averaged  $42.6 \text{ km}^2$  (SD = 29.2) and 59.9 km<sup>2</sup> (SD = 33.8) in high- and low-elevation zones, respectively. In the high elevation zone, distance to fence, woodland treatment, fence density, distance to water, tree canopy cover, and grassland area were strong predictors of pronghorn use. Those in the low-elevation zone were tree canopy cover, grassland area, slope, and vegetation cover type (grassland or shrubland). These results provide a baseline for evaluating responses to habitat improvements and potential wind power development on Anderson Mesa.

## WESTERN STATES AND PROVINCES PRONGHORN WORKSHOP PROCEEDINGS 25:91

# WHERE ARE ALL THE FENCES: MAPPING FENCES FROM SATELLITE IMAGERY

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**ABSTRACT** Fences are a common occurrence in southeastern Alberta. They serve to mark property lines, control grazing regimes, and protect us from collisions with wildlife along roads and highways. But they also act as barriers, preventing pronghorn from gaining access to water and feeding areas. In Alberta there has been limited information gathered on fence line locations at a large geographical scale, which hinders one's ability to assess their impact on pronghorn. This study evaluated the practicality and accuracy of mapping fence lines using high resolution satellite imagery. Fence lines were mapped in ArcMap by drawing lines in a shapefile that were identified by linear features on satellite images. The linear features on the satellite image represent cow trails that are created when domestic livestock repeatedly walk parallel to a fence. Using this approach we were able to map fence lines in 630 townships. Initial verification of the method was completed by visually comparing fences mapped from the images for the grazing reserves in southern Alberta to known fence locations provided by Alberta Public Lands Division, which confirmed we were in fact mapping fence lines. Preliminary accuracy assessments of fence line mapping within the native grassland community were very promising having an overall accuracy of 94%. By having a fence line layer we can now identify fence lines that are acting as barriers to pronghorn movement, and work with conservation organizations to enhance those fences to make them pronghorn friendly but still able to impound domestic livestock.

## WESTERN STATES AND PROVINCES PRONGHORN WORKSHOP PROCEEDINGS 25:92-98

The pronghorn (*Antilocapra americana*) is an indigenous species to the mixed-grasslands of southwestern Saskatchewan, northeastern Montana, and southeastern Alberta (Forrest et al. 2004). The mixed grasslands are comprised of flat or gently undulating hills that have enabled the pronghorn to develop remarkable adaptations to predator avoidance. The pronghorn is the fastest land mammal on the continent and has eyes that can detect movement up to 5 km away (Gates et al. 2012), making it largely unsusceptible to predation when fully mature. Yet, despite their physical adaptations and limited entry hunting for human consumption, pronghorn numbers over the past couple of years have remained rather low and in some cases decreased in the mixed-grassland region of Alberta (Alberta Fish and Wildlife Division 1990).

Some pronghorn are migratory, undergoing seasonal migrations to different ranges throughout their various life history events (Autenrieth and Fichter 1975, Suitor 2011). Pronghorns' survival on the northern fringe of their range is often based upon the ability to migrate in response to fluctuations in food and weather events since they require a large range to move throughout in order to find ample forage for the winter months (Bruns 1977). The pronghorns' needs for large intact tracts of native prairie make it highly susceptible to anthropogenic features that can hinder seasonal migrations. Features such as roads, oil and gas development, and fence lines act as barriers to seasonal migration patterns (Bright and Van Riper 2000). These barriers have led to high winter mortality events that can drastically reduce pronghorn populations (West 1970). Fence lines are among the most detrimental barriers to pronghorn winter survival because during cold winters with deep snow they prevent pronghorn from crawling under fences and moving to more suitable habitat (Hepworth and Blunt1966, Oakley and Riddle 1974).

The problem in evaluating the effects of fences on pronghorn habitat selection and movement, at a large scale, is the lack of spatial data (Kolar 2009, Suitor 2011). A number of modeling approaches have been developed to address this issue (Poor 2010, Suitor 2011). Suitor (2011) developed a modeling approach to determine relative fence densities across our study area as a surrogate for spatially-explicit fence line data. Modeling approaches have the limitation of not being spatially explicit but a general estimate of relative fence density, and therefore do not allow the assessment of the true effects fences in Alberta are having on pronghorn. Spatially-explicit fence line data have been difficult to gather in the past because the only method available to generate this information was physically mapping all fences within a study area, a process that is time consuming and expensive. Using ArcGIS (Environmental Systems Research Institute, Inc., Redlands, CA) and satellite imagery, we tested a method of mapping fence lines across a large geographical scale in Alberta. We tested the accuracy of our mapped fence lines by comparing a subset of mapped fence lines in the southeastern portion of our study area with a known fence line layer, derived from other projects occurring in the area and fence lines provided by Alberta Public Lands.

## **STUDY AREA**

The study area encompasses 630 townships is southeastern Alberta (Fig. 1). Southeastern Alberta has a hot dry climate that receives an average rainfall of approximately 304 mm per year (Climate Temp Info 2010). Its soil system is comprised of brown and dark brown chernozemic soils (Alberta Agriculture, Food, and Rural Development 2005). The two primary industries within our study area are resource extraction (oil and gas) and agriculture (primarily large scale cattle operations). The majority of the landscape is native shortgrass prairie with cultivation interspersed throughout.

## METHODS

## **Fence line Mapping**

Fence lines within our study area were mapped between 2010 and 2012. We used Valtus Imagery (Calgary, Alberta, Canada) to map potential fence lines (Fig. 2). The imagery data were captured between 1999 and 2001. It has a 1-meter resolution that allowed for the identification of potential fence lines.

Potential fence lines were located by identifying characteristics commonly associated with fences such as trails where domestic livestock had travelled along the fence, areas where different grazing regimes were evident, places where Texas gates were placed across roads, truck trails originating from a central point indicating a gate was in use, and each area fenced generally had access to water (Fig. 2). Utilizing these criteria it was possible to determine where fence lines likely existed. Fence lines were mapped (Fig. 2) using ArcEditor, which allows the user to draw and manipulate lines using the imagery as a background. Fence line mapping was conducted solely using imagery data and did not employ the use of landownership parcels or quarter-section dividers. Using the imagery alone allowed us to produce the lowest level of accuracy based upon user interpretation only.

## **Accuracy Assessment of Mapped Fence lines**

In 2011, we completed an accuracy assessment of our mapped fence lines in the southeastern portion of the study area (Fig. 1). We completed the assessment to ensure that we were mapping actual fence lines, before we allocated too much time to the mapping project. Fence lines were

checked for accuracy by applying 2,611 random points. Approximately 850 points were applied directly to line segments that represented known fence lines and mapped fences lines. The known fence layer represented fence lines for ranches in southeastern Alberta and were obtained from Alberta Public Lands for their grazing leases and the Multiple Species At Risk (MULTISAR) project, which had known fence lines for cooperating ranches. Random points were also applied randomly throughout the fence line polygon. This enabled us to classify each random point into one of 4 categories: mapped and known, known but not mapped, mapped but not known, or not mapped and not known. Using this system we were able to calculate an overall accuracy and assess where errors in mapping occurred. The accuracy of our mapped fence lines was calculated by taking the total number of random points. False positives represented the number of random points classified as mapped but not known divided by the total number of random points. False positives represented the number of random points classified as not mapped but known divided by the total number of random points.



Figure 1. Location of study area (tan) and area of accuracy assessment (blue) in Alberta



Figure 2. Example of the satellite imagery before (left) and after fence line mapping (right). Blue lines represent fence lines (imagery data supplied by Valtus Imagery).

## RESULTS

We mapped >67,000 km of fence lines in 630 townships in southeastern Alberta, and found an average of 106 km of fence per township. The spatial accuracy assessment of mapped fence lines was very high (Table 1). Ninety-four percent of mapped fence lines were also known fence lines. Fence lines that were mapped but not known contributed the largest source of error, which accounted for a 3.4 % error rate. The total percentage of error associated with mapping fence lines was 5.8% (Table 1).

	Number of random points	Percent
Accurately mapped	2,461	94.3
Inaccurately mapped (not known but mapped)	88	3.4
Inaccurately mapped (known but not mapped)	62	2.4
Total	2,611	100

Table 1. Accuracy assessment of fence mapping and associated errors.

## DISCUSSION

It was difficult to find any method that mapped fence lines at a large spatial scale in reviewed literature because it largely does not exist. Having the ability to accurately generate fence lines can offer researchers the opportunity to have an efficient and accurate strategy to identify barriers when examining pronghorn movements, migrations, and predator avoidance. Generated fence data will enable wildlife managers to identify critical crossing areas where pronghorn friendly enhancements can be applied to allow ease of passage for pronghorn. With an accuracy rate of 94% displayed by high resolution mapping, our method is a very effective tool to generate a spatially-explicit fence line layer. This study provided a baseline measure of accuracy developed by using imagery alone. We believe accuracy could be further increased if quarter-section dividers and landownership parcels were used during the mapping process. Enabling quarter section dividers and landowner parcels would provide insight into where property lines are located and where fence lines are likely to occur.

It should also be noted that the majority of the fence lines mapped were on native prairie where little or no cultivation of land was present. At current time, the overall accuracy of mapping cultivated lands remains unknown. There is a limited database of known fence lines within privately-owned cultivated areas making it difficult to generate accuracy ratings of mapped fence lines at the present time. It would be beneficial to conduct ground surveys throughout cultivated lands to develop more known fence lines to test the accuracy of mapping that occurs within these areas. This would allow for a better overall assessment of the accuracy of our fencing method.

For this study, the use of random points to generate simple "hits or misses" worked well as long as enough random points were generated to accurately represent the entire area. Utilizing three different placements of random points (points that were snapped to mapped fence lines, points that were snapped to random fence lines, and points throughout the polygon layer) was significant because it identified the type of errors that were occurring. By identifying the different errors that occurred it can aid in increasing the accuracy for future mapping events by providing mappers with information on whether fence lines should be mapped more or less liberally. Our results showed the highest source of mapping error (3%) occurred from over mapping, which is mapping fence lines where they did not exist. The other type of error, under mapping, accounted for 2%. With minimal error rates present and in relatively equal proportions, the methodology used to map fence lines was very effective and does not display any trends in associated errors where overall accuracy could be improved.

#### **Management Implications**

During the course of this study all literature reviewed regarding pronghorn survival and movements identified fence lines as being a prominent issue facing North America's pronghorn. Some articles suggested that the effects of fence lines lead to high winter die offs, while others merely stated they were obstructions that required excess navigation to cross. Either way, it was unanimous among pronghorn researchers that fences had a negative impact on pronghorn. It is highly probable in our study area, where high levels of snow fall are often encountered, that fence lines pose more of a barrier to pronghorn movement than in other areas of their range. With a wide array of fence enhancements available, future studies will determine the most effective and practical means for implementation by land managers. This will mean developing a method of fence enhancement that not only enables pronghorn passage but also fulfills the requirements of landowners.

With the majority of southeastern Alberta being privately owned, increasing landowner awareness about the negative impacts of ill-constructed fence lines is an effective tool to aid pronghorn populations. Theoretically, this is a relatively simple mandate, but in reality it has proven difficult to change a simple fence building process that has worked so effectively for so long. Landowners have voiced concerns that wildlife friendly fencing is ineffective at controlling livestock or that it is simply uneconomical to change the hundreds of miles of fencing that already exist. However, with the use of a fence line database, the Alberta Fish and Game Association has undertaken a pronghorn-friendly fencing project that identifies fence lines in critical pronghorn range and converts them into pronghorn-friendly fence lines. Approximately 50 km of fence lines/year are made pronghorn friendly by placing double stranded smooth wire on the bottom and raising the wire to 45 cm off the ground. The project, being in its fifth year, has continually expanded as success stories of wildlife-friendly fencing have spread among the ranching communities. The project has grown to the point where land owners are requesting more pronghorn-friendly fencing be completed than volunteer hours and funds permit.

## ACKNOWLEDGMENTS

We would like acknowledge MULTISAR and Alberta Public Lands for supplying us with a known fence line layer. This information was crucial in evaluating the effectiveness of fence line mapping and their cooperation was greatly appreciated.

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# ARTIFICIAL WATER UTILIZATION BY TRANSLOCATED PRONGHORN IN TRANS-PECOS, TEXAS

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**ABSTRACT** Understanding the water requirements for any wildlife species is prerequisite to considering a restoration or reintroduction effort. In February 2011, 200 pronghorn (*Antilocapra americana*) were translocated from the Texas Panhandle to the Trans-Pecos region of Texas to supplement declining populations. We utilized 15 Global Positioning System radio-collared pronghorn (8 M, 7 F) to assess water utilization with the radio-collars equipped to record 1 location/hr. Locations were separated by weeks post-translocation, temperature regimes, diurnal/nocturnal, male/female, and breeding/fawning to quantify their water utilization on artificial water sources. We attained 40,232 hourly locations averaging 2,682 per individual. We found 89.1% of the total hourly locations were  $\leq 2,500$  m from artificial water sources. Within the first 24 hours, pronghorn maintained a close distance to water with 99.4% of the locations  $\leq 2,500$  m for adult females during the first 5 weeks averaged 97.5% of locations  $\leq 2,500$  m. Water utilization did not differ between diurnal and nocturnal hours. We found 94.5% of locations  $\leq 2,500$  m for adult females during the fawning season. Further, we measured adult males during breading season having an average of 67.9% of locations  $\leq 2,500$  m. This information will help wildlife managers as they try to restore pronghorn populations to the Trans-Pecos.

## WESTERN STATES AND PROVINCES PRONGHORN WORKSHOP PROCEEDINGS 25:99

## **Summary of Pronghorn Workshops Held to Date**

Dates and Location	Attendance	Chair	Host
14-16 April 1965	18	W. Huey	New Mexico Department of
Santa Fe, New Mexico			Game and Fish
16–17 February 1966	32	G. D. Bear	Colorado Game, Fish, and
Denver, Colorado			Parks Department
5–6 February 1968	97	J. L. Newman	Wyoming Game and Fish
Casper, Wyoming			Commission
27–28 January 1970	85	K. I. Menzel	Nebraska Game and Parks
Scottsbluff, Nebraska			Commission
19–22 June 1972	85	H. O. Compton	Montana Fish and Game
Billings, Montana			Department
19–21 February 1974	52	D. M. Beale	Utah Division of Wildlife
Salt Lake City, Utah			Resources
24–26 February 1976	68	R. Autenrieth	Idaho Department of Fish
Twin Falls, Idaho			and Game
2-4 May 1978	84	M. W. Barrett	Alberta Fish and Wildlife
Jasper, Alberta			Division
8–10 April 1980	64	J. S. Phelps	Arizona Game and Fish
Rio Rico, Arizona			Department
5–7 April 1982	69	J. V. McKenzie	North Dakota Game and Fish
Dickinson, North Dakota			Department
10–12 April 1984	45	C. K. Winkler	Texas Parks and Wildlife
Corpus Christi, Texas			Department
11–13 March 1986	43	M. Hess	Nevada Department of Fish
Reno, Nevada			and Wildlife
31 May–2 June 1988	43	D. Eastman	Oregon Department of Fish
Hart Mountain, Oregon			and Wildlife
22-24 May 1990	45	T. M. Pojar	Colorado Division of Wildlife
Silver Creek, Colorado			
8–11 June 1992	91	P. Riddle	Wyoming Game and Fish
Rock Springs, Wyoming			Commission
18–21 April 1994	49	K. Sexson	Kansas Department of Wildlife
Emporia, Kansas			and Parks
5–7 June 1996	75	L. Colton	California Department of Fish
Lake Tahoe, California			and Game
23–27 March 1998	92	R. A. Ockenfels	Arizona Game and Fish
Prescott, Arizona			Department
14–17 March 2000	42	J. Cancino	Centro de Investigaciones
La Paz, Baja California Sur	,		Biologicas del Noreste-
Mexico			Direccion General de Vida
			Silvestre

Dates and Location	Attendance	Chair	Host
17–20 March 2002 Kearney, Nebraska	85	J. S. Abegglen	Nebraska Game and Parks Commission, U. S. Forest Service–Nebraska National Forest
1–4 May 2004 Bismarck, North Dakota	76	B. Jensen B. Stillings	North Dakota Game and Fish Department, U. S. Forest Service and Bureau of Land Management
16–19 May 2006 Idaho Falls, Idaho	143	B. Compton D. Toweill	Idaho Department of Fish and Game
13–16 May 2008 Canmore, Alberta	57	D. Eslinger K. Morton	Alberta Sustainable Resource Development, Alberta Conservation Association
18–21 May 2010 Laramie, Wyoming	77	M. Zornes	Wyoming Game and Fish Commission
10–13 December 2012 Santa Ana Pueblo, New Mexico	98	K. Rodden S. Liley R. Walker	New Mexico Department of Game and Fish