Proceedings of the Western States and Provinces Twenty-eighth Biennial Pronghorn Workshop
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Learning from the Past – Adapting for the Future

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Editorial Note – Are pronghorn the Rodney Dangerfield of game animals?

Mike Cox is a colleague I respect at the Nevada Department of Wildlife. He has repeatedly suggested that pronghorn are, quite possibly, the Rodney Dangerfield of game animals – they don't get no respect!

At times, this certainly seems so. Where pronghorn live, they are often plentiful and people may take them for granted. Grasslands and shrublands occupied by pronghorn are not considered by many to be as picturesque as that occupied by mule deer or mountain goats. Places where they live are more proximal to areas where most of us live than those areas occupied by enigmatic species like caribou.

As I was searching the web for information relevant to the Twenty-eighth Biennial Western States and Provinces Pronghorn Workshop, I found reference to 2 separate workshops being held in the month prior to the pronghorn workshop designed to share knowledge on sasquatch! My guess is that these workshops may have been better attended than the pronghorn workshop!

Value is placed on wildlife in a variety of ways. An early supervisor and mentor of mine, Harley Shaw, opined in his chapter "Only Prey" in the book *Counting Sheep* "…that *any* species (or single organism, for that matter) is special after emerging from the evolutionary process of the millennia." He also acknowledged that we do indeed place rank on species, and his glib response to a hunter enamored with bighorn sheep addressing Harley as he finished field work on mountain lions delivered his perspective about bighorn sheep relative to mountain lion – and produced the title of that later chapter! It was unclear where pronghorn fit for the hunter in this particular scenario.

Another way we establish value is to compare prices of auction tags. Routinely pronghorn auction tags bring $20,000–40,000, whereas mule deer, elk, and bighorn sheep bring $100,000–400,000. If we look at the number of wildlife conservation organizations established to benefit the various species, the number is overwhelming. Pronghorn have long boasted very few, with the Arizona Antelope Foundation notably persistent.

Yet pronghorn are unique. They are an important part of our ecosystems and human communities. They add value to our lives and the places we live. They are beautiful, fast, and magnificent table fare! And during August 13–15, 2018, 93 biologists, wildlife veterinarians, students, technicians, and administrators with 29 states, universities, or conservation organizations from 2 countries and 2 tribal nations gathered to discuss the state of our knowledge about these magnificent creatures and the people who have advanced our knowledge. Pronghorn help us understand our relationships with landscapes and the management of the rangeland they occupy.

Using Harley's definition, pronghorn are special. And pronghorn are deserving of our respect! In the following pages, I believe you will see why.

-- Brian Wakeling

Proceedings of the Western States and Provinces Twenty-eighth Biennial Pronghorn Workshop 2018

Learning from the Past – Adapting for the Future

A Compilation of Papers Presented at the Annual Meeting

Reno, NV
August 13–15, 2018

Edited by
Brian F. Wakeling and Cody Schroeder

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Yoakum and You: The James D. Yoakum Papers

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Abstract James Donovan "Jim" Yoakum was a giant in the field of wildlife management and an unabashed lifelong advocate for wildlife of all kinds. His passion, though, was the pronghorn (*Antilocapra americana*), to which he devoted much of his life's work, beginning in graduate school at Oregon State University under the guidance of Dr. Arthur Einarson. Yoakum's professional career began in 1957 as a range manager for the Bureau of Land Management (BLM). Four years later he was promoted and became the first wildlife biologist hired by BLM. Yoakum retired from that position in 1986, but not from his passion. He remained a dedicated member of The Wildlife Society's Nevada Chapter and Western Section. Additionally, he continued to participate and contribute papers for the Biennial Pronghorn Workshop meetings. Yoakum's career culminated in 2 seminal pieces of work on the pronghorn: his magnum opus, co-authored by Dr. Bart O'Gara and published in 2004, *Pronghorn: Ecology and Management* and *Pronghorn Bibliography*. The bibliography, which first appeared in 1967, was dedicated to Yoakum and presented in its entirety at the 24th Biennial Pronghorn Workshop in 2014. Yoakum's legacy lives on in the memories of his friends and colleagues and in the 47 boxes of materials and nearly 40,000 photographs that make up the James D. Yoakum Papers, housed in the Special Collections Department at the University of Nevada, Reno. These materials serve as a tangible resource for future generations to learn about Jim Yoakum and his important contributions in the continued study of the pronghorn and in the field of wildlife habitat management.

Keywords *Jim Yoakum, The Wildlife Society Western Section, Biennial Pronghorn Workshop, Pronghorn,* Antilocapra americana, *wildlife conservation, wildlife photography, range management*

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In 2013, close friends of the late Jim Yoakum and the executors of his estate asked administrators at the Mathewson-IGT Knowledge Center located on the campus of the University of Nevada, Reno (UNR) to make UNR the permanent repository for his papers and photographs.

The University agreed to acquire the materials and house them in the Special Collections Department where they could be properly organized, stored, and cared for by trained archivists. Faculty members from Special Collections soon arrived at Yoakum's home in Verdi, Nevada that he purchased with a Veterans Affair loan and lived in beginning in 1967. With the help of friends and colleagues, Manuscripts and Archives Librarian Jacque Sundstrand began the task of appraising and identifying a lifetime's worth of materials, boxing them up, and taking them back to the archive at the University. When the dust cleared, there were more than 55 boxes containing correspondence, technical reports, memoranda, studies, papers, articles, daily journals, theses and dissertations, ephemera, artifacts, and thousands and thousands of slides and photographs.

While going through the written and paper-based materials (or as we call it in the archival profession, "processing") and trying to make sense of what was there, it was evident that Yoakum did not throw much away. It was equally evident that he kept impeccable records of his work and projects. For example, beginning in 1970, as any good bureaucrat would do, he kept daily journals to document mileage, expenses, activities, and his wildlife sightings.

Although Yoakum retired from BLM in 1986, he did not retire from the practice of recording his activities. His daily journals, which sometimes describe the mundane, such as the bacon and eggs for breakfast and the results of a dental appointment, continued until just days before his death on 20 November 2012. The classification and numbering systems that he developed for his numerous slides (which were meticulously stored in pine boxes) and photographs are quite extensive and detailed too.

The paper-based materials have been processed and arranged into 6 series and further subseries based on subject and type of material. Special Collections is still working through the sea of photographs, but so far, more than 25,000 have been numbered, described, and recorded. These papers and photographs are a reflection and representation of Yoakum's life and times both personally and professionally.

So how and why did Yoakum end up with so much material and why is it important?

James Donovan Yoakum was born 14 June 1926 (Flag Day) and grew up in the small community of Templeton, California in the central coastal region of the state. His teenage years were spent in the oyster beds of Morro Bay where he picked and planted oysters. He enjoyed spending his days observing the flora and fauna of the near-pristine marine ecosystem in his own backyard.

In 1944, at the height of USA involvement in World War II, and just prior to his eighteenth birthday, Yoakum left high school to enlist in the US Navy where he would spend the next 3 years aboard a ship where he experienced vicious fighting, including the battle for Iwo Jima. Though his military service was relatively brief, it had a profound effect on his life; the constraints of being aboard a ship convinced him that he would much prefer devoting his life and work to the wide-open spaces of the American West. Additionally, the GI Bill provided a vehicle for him to receive an education (something no one else in his family had done), acquire property, and pursue a career in wildlife biology. These facets of his early life are reflected within his papers from brief military records, to logistics regarding the use of the GI Bill, and his letters of acceptance to college.

After spending some time as a fire lookout in the backcountry around Big Sur, California, Yoakum applied to Humboldt State University, a small college located in Arcata, California. He was accepted in 1949 and began classes in the fall. In 1953 he graduated with a B.S. in Wildlife Management and a minor in Range Management. As noted in his personal memoir, it was during his undergraduate program that he realized the value of reference documents as tools, which lead him to begin amassing a large library of books, scientific journals, periodicals, technical reports, and other literature. This trend continued throughout his life as he actively sought and gathered for and loaned materials from his sizeable personal library.

In 1954, Yoakum continued his education at Oregon State University in Corvallis, Oregon on a fellowship from the Oregon Cooperative Wildlife Research Unit. It was there that he began his research on the pronghorn (*Antilocapra americana*) in and around Lakeview, Oregon. Yoakum fell in love with the animal's ability to exist in the sparse, wide-open grasslands of North America where there are few people and little sign of "civilization."

Another formative event for Yoakum was meeting Oscar "Ock" Demming, the first Wildlife Biologist at the Hart Mountain-Sheldon National Antelope Refuge Complex. Among other things, Ock encouraged Yoakum to "stand by his convictions," advice that he followed for the rest of his life.

Ock was also instrumental in instilling in Yoakum the need to document pronghorn habitat requirements, assess food habit investigations, and report manipulation practices attributing to the enhancement of pronghorn habitats. Three years later, Yoakum completed his Master's thesis entitled "Factors Affecting the Mortality of Pronghorn Antelope in Oregon," under the guidance of the esteemed Dr. Arthur Einarson, and graduated with his M.S. in Wildlife Management.

Not long after graduation, BLM hired Yoakum as a range manager in Vale, Oregon. The position offered field assignments in pronghorn habitat management where he was able to continue his study of the unique ungulate. In that formative period of his life, Yoakum also began to make a name for himself locally when he raised 2 orphaned bobcat (*Lynx rufus*) kittens named "Rufus" and "Bobby." These wildcats often showed up in the local newspapers, elementary school classrooms, and even on "Walt Disney's Wonderful World of Color."

After 2 years in Oregon, Yoakum transferred to Ely, Nevada where he continued to conduct comparative wildlife-habitat relationship studies, photograph wildlife, attend conferences and workshops, and publish technical papers. He also took on the additional task of writing a weekly wildlife column in the local newspaper. In 1961 after more than a decade of education and field experience, Yoakum accepted a position as a wildlife biologist with BLM—the first such position of its kind with that bureau. Unlike many federal employees who relocated often, Yoakum spent most of his career with BLM in northern Nevada, first in Ely and later in Reno.

Having no mentors, predecessors, or instruction manuals for his position, Yoakum's main responsibilities as BLM's wildlife representative included informing the public, conservation organizations, and scientific societies of BLM's intentions to recognize the need for coordination and enhancement of wildlife, fisheries, and recreation on public lands.

He began by developing and establishing wildlife habitat management programs and initiated various research and enhancement projects including meadowland restoration, wildlife economics, big game habitat investigations, fish projects, rangeland bitterbrush plantings, restoration of the bighorn sheep (*Ovis canadensis)* populations, and spring conservation for the Devil's Hole pupfish (*Cyprinodon diabolis)* in south central Nevada, which even caught the attention of then Secretary of the Interior, Stewart Udall.

In addition to his official duties, BLM also actively supported and encouraged Yoakum's participation in The Wildlife Society's (TWS) activities at the local, regional, and national levels. Yoakum helped the establishment of both the Western Section in 1963, and later the Nevada Chapter in 1966. So valuable were his contributions to TWS that the James D. Yoakum Award was created to recognize the long-term, outstanding service of members of the Western Section.

BLM actively supported his participation in international projects, including working with the governments of Peru, Bolivia, Mexico, and Canada as well as interagency teaching assignments at Humboldt State University, Colorado State University, and UNR.

After retiring from BLM in 1986, Yoakum continued working as a consultant in wildlife biology and management (his consulting firm aptly named "Western Wildlife") with much of his efforts focused specifically on the study and management of the pronghorn and its habitat, including the translocation of pronghorn to Carrizo Plain in San Luis Obispo County in southern California. He continued taking photographs of wildlife, wrote monographs and book chapters, reviewed books and journals for publication, provided lectures to universities and governmental agencies, and completed contracts for various governmental agencies.

Yoakum amassed tens of thousands of photographs and published more than 50 professional papers. His legacy, though, was cemented in 2 major projects (in addition to his 2002 Berrendo Award) that he completed in the decades after his retirement. Both represent a culmination of his life's work and research. The first, Yoakum's magnum opus co-authored by Dr. Bart O'Gara (longtime director of the Montana Cooperative Wildlife Research Unit at the University of Montana), and published in 2004, is the seminal work on the pronghorn (nearly 7lbs. and 903 pages) entitled *Pronghorn: Ecology and Management*.

This book, often referred to as "the bible" was originally conceived by Richard McCabe of the Wildlife Management Institute in the 1970s as a much smaller semi-technical text. However, over time it grew with Yoakum focusing on the habitat portions, and O'Gara staying in the lab to focus on the biological aspects of the pronghorn. As indicated in the papers, the chapter manuscripts went through many iterations and passed through the hands of many experts in the field before being finalized.

This book reflects an amalgamation of hard work and contributions from many researchers. For their work, Yoakum and O'Gara received The Wildlife Society's Outstanding Editorship Award for 2006. Yoakum's other major undertaking, published after his death, was *Pronghorn Bibliography: A Review of Literature and Contributions to a Bibliography from 1649–2011*, which again represents a lifelong project that required the collaboration of many experts and scholars including co-editors Jorge Cancino and Paul F. Jones. The original pronghorn bibliography, created in 1967 included just 354 citations. A revised version in 1991 included 2736 citations. The final edition dedicated and presented at the 26th Biennial Pronghorn Workshop in Alpine, Texas included still more citations.

Jim Yoakum passed away on 21 November 2012; with him went a lifetime of dedication to the wildlife profession. In the later years of his life, Yoakum was quoted as saying, "Wildlife has been my entire life, all of my life." As was evidenced by interactions with several individuals at the 28th Biennial Pronghorn Workshop held in Reno, Yoakum is regarded by friends and colleagues as an iconic figure within the wildlife community.

According to memories posted to a website maintained by The Wildlife Society, those that knew him appreciated and respected him for his expertise, especially regarding the pronghorn, but also his friendliness and collegiality. Many can recall having social, well-informed, and even dogmatic conversations with Yoakum where he often played the role of devil's advocate. Steve Kohlmann, a close friend and colleague wrote: "Jim leaves a big void of scientific expertise and knowledge about a species few today seem to care about. But more importantly, Jim's deep commitment and caring for sound stewardship, even when it was unpopular with the agencies, is becoming a rarity in our profession. He leaves a legacy few can match."

The James D. Yoakum Papers (2013-27) are available to anyone on-site at the University of Nevada, Reno's Special Collections Department located inside the Mathewson-IGT Knowledge Center. https://library.unr.edu/SpeColl

The complete guide can be found online at:

https://archive.library.unr.edu/public/repositories/2/resources/3406

Evaluating the efficacy of early Nevada aerial pronghorn surveys

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Abstract Aerial surveys to examine pronghorn (*Antilocapra americana*) population demographics have been used for decades in Nevada, and the techniques employed in those surveys have varied through time. I examined data from of 1972–1980 to evaluate the ability of historical surveys to detect population demographic trend differences through time. Nevada became a founding member of the Interstate Antelope Conference in 1949 and participated in the development of early aerial survey guidelines. These guidelines recommended biannual aerial surveys: a winter count and a summer composition survey. Nevada began recording more details such as location, altitude, and vegetation for each group observation in 1974, which increased the challenge of classifying pronghorn during surveys. Nevada used this system into the late 1980s. I compared pronghorn observations for timing, location, and composition compared with random distributions of data. Sightability differences and several key demographic parameters may have the most potential to affect management decisions. Clumped distributions and rapid movements may skew local samples. During summer, male distribution within groups seen from aircraft overlapped spatially with females, but male and female occurrence by group were not significantly correlated. Even with large sample sizes, male:female ratios often varied more than expected. These results suggest the seasonal behavior of pronghorn may introduce bias in demographic variables and subsequent management decisions.

Key words *bias, composition, Great Basin, Nevada, pronghorn, population surveys, sex-ratios, sightability*

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Aerial surveys are generally considered the most objective and unbiased survey for most species (e.g., Keegan et al. 2011). Aerial surveys for pronghorn (*Antilocapra americana*) have been used for decades to monitor population size and demographics within Nevada, although the techniques employed have varied over time. Nevada, California, and Oregon experimented with aerial survey methods in the 1940s (Einarsen 1948). Nevada flew its first pronghorn surveys in 1948 and became a founding member of the Interstate Antelope Conference (IAC) in 1949. The IAC was established to promote cooperation among state and federal agencies managing pronghorn in the northwest Great Basin and develop standardized guidance on management activities such as aerial survey (Griffith 1962). This interstate population was among the largest relic herds remaining on public lands in the 1920s (Nelson 1925).

By the early 1950s, Nevada adopted the survey guidelines that recommended biannual surveys each year: a winter survey for total count (abundance) generally flown during March and an August herd composition survey. The male:female ratios collected in both winter and summer surveys were used together with the total count and hunter success to develop annual harvest management recommendations.

The IAC acknowledged challenges in surveys, primarily uncertainty about interstate movements and inconsistent male:female ratios. Updated guidelines were published in the 1980 IAC proceedings (Salwasser 1980). Although Nevada had used the biannual survey protocol for 25 years, its survey procedure was modified in 1979 to accommodate changes in the big game quota allocation process. During this period, both annual surveys showed a corresponding population growth trend (Figure 1). After experimenting with February surveys to replace the traditional March survey, the winter survey was discontinued, and quotas were based solely on summer survey data.

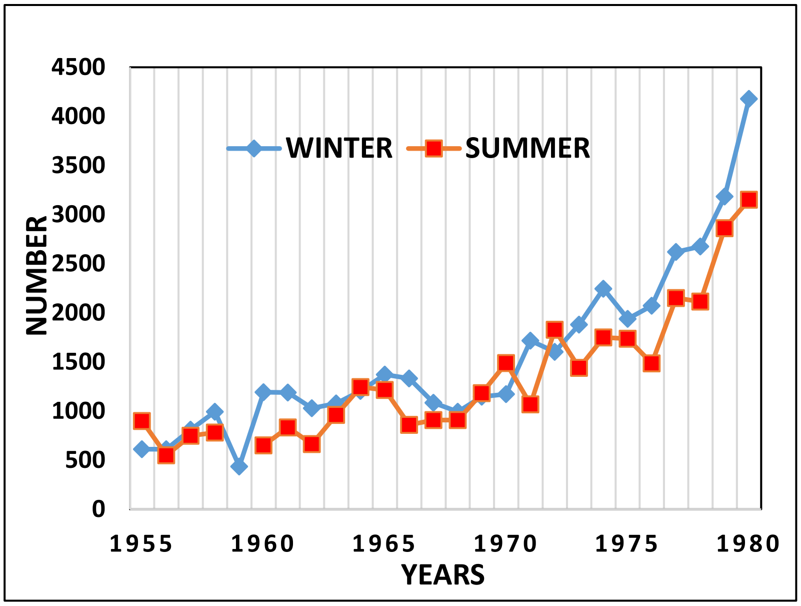

Figure 1. Nevada summer and winter pronghorn survey totals, 1955–1980, for Washoe and Humboldt county (excluding Sheldon National Wildlife Refuge). Summer and winter pronghorn numbers counted between 1955 and 1980 were correlated (r = 0.9389, n = 25, P < 0.01)

The biannual pronghorn surveys provided adequate statewide data between 1955 and 1980. Yet challenges occurred in surveying individual populations within discrete management units. Some management units did not receive biannual surveys and sometimes samples sizes were too small or variable, and occasionally even large samples from bigger populations yielded unexpectedly biased male:female ratios. In northern Washoe County, the quota recommendation was prepared from data for the total area and then divided among 3 smaller hunting units using a proportional data averaging process. Adequate records were not kept on missing or bad surveys or when data averaging was used to make quota recommendations; variability amongst individual management units were often overlooked.

I reexamined this historical data looking for trends in survey patterns and bias in samples collected. I looked for evidence of movement and buck distribution in the population that could influence survey data. My objective was to provide insights that could assist with current surveys, female harvest recommendations, population growth projections, and translocation recommendations.

STUDY AREA

I examined pronghorn survey data from northwest Nevada collected during 1972–1980. The data was collected primarily in Washoe County, which comprises Game Management Units (GMUs) 011, 012, 013, 014, and 015. The Sheldon National Wildlife Refuge (SNWR) occupies about 751 km^2 of the northeast corner along the Oregon border. The northern Washoe study area comprises a total area of 8,290 km^2 with about 90% of available pronghorn habitat occurring within Washoe County.

Located in the northern Great Basin, the area consists of high lava plateaus and rolling country characteristic of the Columbia Plateau, but it is interspersed with a few higher fault block mountains and several large basins, some with big alkali playas. Elevation in the area ranges from Granite Peak at 2,737 m to the adjacent Black Rock Desert floor at 1,204 m. Sagebrush (*Artemesia* spp.) steppe and desert salt shrub are the dominant vegetation types with some interspersed juniper (*Juniperus* spp.) woodlands throughout the study area. Limited permanent water sources are available and most of the precipitation occurs as snow in winter. The majority of north Washoe is public land administered by the Bureau of Land Management (about 75%), with the balance being private holdings in the lower valleys. About 6,150 km^2 of pronghorn habitat were identified in 105 Townships (Tsukamoto 1983). In 1980, the study area was estimated to support about 40% the pronghorn within Nevada. Pronghorn occupy the area yearlong, although some seasonal movement occurs among contiguous habitat in California, Oregon, the SNWR, and adjoining areas in Nevada. The extent and timing of short and long-distance migrations are not well documented, occurring irregularly depending on range and weather conditions (but see Collins 2016 and Larkins et al. 2018).

METHODS

From 1955 to 1980, the pronghorn habitat was flown with fixed-wing aircraft (Cessna 206) or helicopter (Bell 47G-3B-1) systematically in blocks on each of the biannual surveys, usually covering all habitat unless severe weather interfered with flying. The fixed-wing aircraft was used during 1972–1977, 1979, and 1980, whereas the helicopter was used during 1973 and 1977–1980 (Table 1). Winter surveys were routinely flown in March, whereas summer surveys occurred in August. Groups observed on winter surveys were classified as males and females, while groups surveyed during summer were classified as males, females, or young. The blocks, pattern, and direction of grids and altitude flown were selected based on conditions at the time of survey with the intent to collect the largest sample possible. All habitat was flown on a regular grid, but distance between grids were reduced when pronghorn were detected. These alterations were not consistent. Additionally, if weather delayed flights, the lowest pronghorn density areas were skipped to maintain schedules, which had the potential to introduce bias.

While surveying a block of habitat in an improvised grid pattern, the aircraft immediately left the transect line to classify pronghorn and returned to near the sighting location to resume grid coverage. The classification passes involved flying more maneuvers compared to formal transect or quadrat surveys, but improved classification accuracy. For larger groups, several aerial passes were necessary to obtain composition estimates while attempting to avoid double counting individuals.

Beginning in 1974, pronghorn group locations (observations) were recorded to the nearest legal township using the US Public Land Survey System. Additionally, data on legal section, elevation, and vegetation type were recorded beginning in 1977. Typically, a township includes 36 sections, about 2.59 km^2 each. Altitude was recorded from the aircraft altimeter based on the closest pass flown over the group. While data on every group observation was recorded at the time,

Table 1. Data recorded on aerial surveys for pronghorn in north Washoe County, Nevada, 1972–1980. Pronghorn numbers and group numbers were recorded for each survey, and in 1974 group sighting location were recorded by township. In 1977, the location section, elevation and vegetative type were noted.

Survey period	Aircraft	Days	Pronghorn observed	Groups observed	Township recorded	Section recorded	Elevation recorded	Vegetation type recorded
1972 March	Cessna 206	2	1,023	197				
1972 August	Cessna 206	4	1,416	153				
1973 March	Cessna 206	3	1,262	105				
1973 August	Both	3	1,187	159				
1974 March	Cessna 206	2	1,519	86				
1974 August	Cessna 206	3	1,333	160	Yes			
1975 March	Cessna 206	7	1,255	58	Yes			
1975 August	Cessna 206	3	1,326	146	Yes			
1976 March	Cessna 206	6	1,489	131				
1976 August	Cessna 206	3	1,194	172	Yes			
1977 March	Cessna 206	6	2,127	250	Yes	Yes	Yes	Yes
1977 August	Bell 47	5	1,729	183	Yes	Yes	Partial	Partial
1977 September	Bell 47	2	417	76	Yes	Yes	Yes	Yes
1978 March	Both	6	1,981	215	Yes	Yes		Yes
1978 August	Bell 47	5	1,455	158	Yes	Yes	Yes	Yes
1978 September	Bell 47	2	569	32	Yes	Yes	Yes	Yes
1979 February	Cessna 206	4	2,367	33	Yes		Yes	Yes
1979 August	Bell 47	4	2,165		Yes	Yes	Yes	Yes
1980 February	Cessna 206	4	3,114	47	Yes	Yes		Yes
1980 August	Bell 47	5	2,271		Yes	Yes	Yes	Yes
Total		79	31,199	2,361				

Table 2. Aerial survey effort in northern Washoe County, Nevada during 1972–1980. Area covered by surveys was similar among years.

Parameter	February	March	August
Total surveys	2	6	7
Survey time (hrs/yr)	20.0	24.3	19.4
Survey rate (km^2/hr)	307	253	317
Total pronghorn observed/year	2,740	1,522	1,377
Pronghorn observed/km^2 surveyed	0.44	0.25	0.22
Pronghorn observed/hr	137	63	71
Pronghorn groups observed/year	40	137	162
Mean pronghorn group size	68.5	11.1	8.5
Total groups observed/ km^2 surveyed	0.006	0.022	0.026
Total groups observed/hr	2.0	5.6	8.3
Proportion of range where pronghorn not observed	0.983	0.942	0.932

Table 3. Elevational distribution of pronghorn observed on 3 representative surveys in March 1977, August 1978, and February 1979, in norther Washoe County, Nevada.

Survey date	Number observed	Percent observed by elevation category (m)						Mean (m)
		<1,372	1,372–1,524	1,525–1,676	1,677–1,829	1,830–1,981	>1,981	
March 1977	2,120	0%	8%	11%	34%	44%	2%	1,808
August 1978	1,378	0%	9%	6%	49%	24%	11%	1,836
February 1979	1,927	2%	30%	15%	52%	2%	0%	1,650

no subsequent statistical analysis was applied to the data during the years of study.

I tabulated the survey data from 1972 to 1980. Parameters such as group size and composition, distribution, and sampling rate were compared by season (survey month) to assess their effect on data used in the original IAC quota algorithm and in population models. Any variations I found in male:female ratios in the data were of interest as were possible indications of pronghorn movement.

Sixty random samples were taken from a typical pronghorn composition survey to assess composition variation. The data from August 1978 survey was used as the base sample, consisting of 1,458 pronghorn, comprising 297 males, 814 females, and 347 young in 158 groups. The sample population ratios were 0.365 male:female and 0.426 young:female. I selected 60 random samples in 3 sets of 20 samples each, at sample rates of 10%, 25% and 50% of the base sample. Random subsampling of 10% of the observations comprised 16 groups each, 25% comprised 40 groups each, and 50% comprised 79 groups each. This sample population is similar in size to many Nevada populations.

The ratios for each of the 60 random samples were compared with the total 1978 August sample ratios using the 2x2 contingency test to see the closeness of fit for the 2 ratio pairs. The test was chosen because it was non-parametric and the samples vary from an ideal normal distribution, showing a central tendency but with a number of outlying ratios well away from the mean.

Pearson correlation coefficients (r) were computed for the male:female and young:female ratio samples by group size for the 3 survey periods (February, March, August) to determine if linear relationships existed amongst these variables. I used t-tests for pairwise comparisons (Zar 2010).

RESULTS

Survey effort varied annually from 2 to 7 days, and the number of animals classified on each survey ranged from a low of 417 to 1,981, averaging about 1,600 animals in summer and 1,900 in winter (Table 2). Fifty days were flown with fixed-wing aircraft and 29 with a helicopter. Experiments with a February survey revealed that surveys 3–4 weeks earlier than those generally scheduled had not allowed any dispersal to begin and group sizes were too large for effective classification.

The mean observations/hr and observations/km were similar for individual animals and groups during March and August, but substantially higher in February (Table 2). Effort was similar among the 3 periods averaging about 21 hours of flight time while covering the same north Washoe area (6,150 km^2 in 105 townships). February aerial surveys averaged a group sighted for every 30 minutes flown, whereas March and August surveys averaged about 10 minutes of flight for every group observed. While group size was greater in February, the groups were more widely dispersed and concentrated in smaller, critical areas. An overall mean of 293 km^2 of habitat was surveyed each hour (Table 2).

Observations of pronghorn ranged in elevation between 1,340 and 2,255 m. The distribution for the 3 surveys was concentrated in a 300 m band between 1,675 and 1,975 m with a combined annual average of 68% of the pronghorn observed within this range (Table 3). The percentage observed within the band ranged from 54% in February to 78% in March. Mean elevation by survey period was 1,650 m in February, 1,807 m in March, and 1,832 m in August. Pronghorn were found at various elevations in February, and 47% of animals were observed below 1,675 m compared with 19% in March and 15% in August. Aspect, degree of slope, snow depth and persistence, and sagebrush presence may have affected pronghorn elevation in winter.

During August 83% of the observed pronghorn occurred within sagebrush (*Artemisia* spp.) dominated communities, whereas in the winter surveys sagebrush was associated with 95% of pronghorn sightings, although it was not always the dominant habitat type. In August 1978, 357 (48%) of the pronghorn in GMU 015 were concentrated on the playas throughout the area. Based on this survey, it appeared that <10% of the habitat was occupied by pronghorn at a density of 4X greater than on the remainder of the unit, which may have been influenced by seasonal plant availability and forage conditions.

Between 1972 and 1978, group size averaged 8.5 pronghorn/group (n = 1,131 groups) observed during August, 10.2 pronghorn/group (n = 1,042 groups) observed during March, and 68.5 pronghorn/group (n = 80 groups) observed in February surveys (Table 2). Confidence intervals from August surveys (99% CI; 7.71–9.35), March surveys (99% CI; 9.27–11.18), and February surveys (99% CI; 53.55–83.47) indicate February group size was the largest ($P < 0.05$), whereas no difference existed between group size for March and August surveys. Over 90% of the groups in both August and March comprised ≤25 pronghorn/group, while 83% of groups in February were >25 pronghorn/group and 57% contained >50/group.

Pronghorn distribution routinely differed by month of survey. Pronghorn distributions from seasonal surveys from March 1977, August 1977, and February 1980 differed during each survey ($P < 0.05$; Figure 2). Pronghorn were most concentrated in February and most dispersed in March, although pronghorn distributions were heterogeneous with some clumping in each survey. In mid-winter, pronghorn occupied about half of the area occupied during August and one-third of the area occupied in March. Substantial portions of the February range were also used by pronghorn in March and August, 71% and 60%, respectively (Table 4). The greatest seasonal overlap of range occupation occurred between March and August at 80%. Only 7 townships, or 6.7% of the habitat, were shared in common among all 3 surveys. The greatest densities were observed in February when >100 pronghorn were seen in 10 townships and >200 were seen in 4 townships. A mean of 142 pronghorn/township occurred in February, 32 pronghorn/township occurred in March, and 33 pronghorn/township occurred in August. The range (3–782) in pronghorn number per township was large for February, but narrower in March (1–124) and August (1–107) (Table 4). The most extreme use of midwinter ranges occurred during the 1979 and 1980 surveys (Figure 2).

Plotting the pronghorn distribution by township for the same monthly survey over 5 years revealed substantial variation (Figure 3). The overall chance of observing pronghorn during August in a given township averaged 46% (range 38–51% for a given year), whereas the probability of observing them in a township where pronghorn were sighted in any of the other 4 years averaged 60%.

Tallying the number of pronghorn that were seen in the same townships all 5 years accounted for 32% of the total, 35% were seen in the townships occupied for 4 of 5 years, and 33% were seen in the townships occupied between 1 and 3 of the 5 years. Pronghorn were observed all 5 years in only 12% of the occupied townships, in 4 of 5 years in 22%, and in 1 to 3 of the 5 years in 66% of the townships

Group size during August surveys influenced male:female ratios but had no detectable effect on young:female ratios (Figure 4). Male:female ratios for groups of

Table 4. Summary statistics for pronghorn observation distributions in 3 representative surveys from March 1977, August 1977, and February 1980 in northern Washoe County, Nevada.

Parameter	March 1977	August 1977	February 1980
Total pronghorn observed	2,125	1,653	2,974
Townships (%) with pronghorn	66 (63)	50 (48)	21 (20)
Mean (SD) number of pronghorn in occupied township	32 (31.1)	33 (30.5)	142 (179.4)
Range in number of pronghorn in occupied township	1–124	1–107	3–782
Number (%) of townships with >100 pronghorn	5 (8)	0 (0)	10 (48)
Number (%) of townships with >200 pronghorn	0 (0)	0 (0)	4 (19)
Number (%) of townships shared with March 1977 survey	- -	40 (80)	15 (71)
Number (%) of townships shared with August 1977 survey	40 (61)	- -	14 (67)
Number (%) of townships shared with February 1980 survey	15 (23)	14 (28)	- -

TWNSP	18E	19E	20E	21E	22E	23E	24E
47N							
46N							
45N							
44N							
43N							
42N	*60*						
41N	*244*				*416*		
40N	*3*		*75*				
39.5N							
39N	*6*					*19*	
38N					*127*		
37N		*107*	*300*				*105*
36N		*70*	*782*	*70*		*30*	
35N			*22*			*141*	
34N					*154*		
33N							
32N			*52*				
31N		*154*					
30N							
29N							
28N	*37*						

TWNSP	18E	19E	20E	21E	22E	23E	24E
47N	*1*	*37*		*9*			
46N	*5*	*27*		*29*			
45N	*1*	*26*					
44N	*24*		*35*	*112*	*29*		
43N	*36*		*12*	*33*	*8*		
42N	*23*						
41N	*10*	*4*		*84*	*103*		
40N	*8*	*47*	*76*	*2*	*12*	*10*	
39.5N			*14*	*7*			
39N	*2*	*2*	*124*	*49*	*20*	*12*	
38N	*12*			*17*	*20*	*10*	
37N	*2*	*36*		*22*	*2*		
36N	*50*					*47*	
35N	*47*	*123*	*30*	*33*	*75*	*70*	
34N	*27*	*49*	*123*		*4*	*27*	
33N	*28*	*34*			*23*		
32N	*45*	*28*	*14*				
31N		*7*					
30N	*21*						
29N	*37*						
28N	*29*						

TWNSP	18E	19E	20E	21E	22E	23E	24E
47N			*14*	*7*			
46N			*15*	*43*			
45N	*50*	*5*		*5*			
44N	*23*	*96*	*1*		*43*		
43N	*4*	*3*	*50*				
42N	*96*			*18*		*14*	
41N	*6*		*36*	*107*			
40N	*70*	*15*	*24*	*26*	*18*		
39.5N			*17*	*8*			
39N	*21*	*94*	*11*	*20*		*71*	
38N	*5*	*10*		*39*			
37N	*76*						
36N				*20*	*19*		
35N	*85*	*15*	*86*	*22*	*47*		
34N	*10*	*68*	*74*	*4*		*3*	
33N	*19*	*20*					
32N							
31N							
30N							
29N							
28N							

Figure 2. Pronghorn distribution by township in 3 representative surveys during March 1977 (red), August 1977 (yellow), and February 1980 (blue) in northern Washoe County, Nevada. The number of pronghorn observed in each township is provided. The distribution in February differed from March and August (P < 0.01), and distributions in March and August also differed (P < 0.05). Townships are in correct position but not to scale. Township coordinates (Mount Diablo Meridian Township North Range East) are given on the left and top margins respectively on each graph.

TWNSP	18E	19E	20E	21E	22E	23E	24E
47N		3	25	15			
46N			8	8		3	
45N	25	15		8			
44N	15	15	15	44	25	3	
43N	15	8	25	8	8	3	
42N	25	15		15		3	
41N	3	3	3	25	25	3	3
40N	44	44	25	25	25	3	
39.5N			8	15			
39N	15	25	44	44	8	15	
38N	25	8	15	15	8	8	
37N	25	3	15	8	8	15	3
36N	15	8	8	15	25	3	
35N	44	44	25	15	25	8	
34N	44	44	44	8	8	25	
33N	25	25	3				
32N	3	3					
31N	3						
30N							
29N	8						
28N		3					

Figure 3. The distribution of pronghorn observed during August surveys in northern Washoe County, Nevada during 1974–1978. The color of the cell indicates the number of years pronghorn were observed within a specific township: 5 years in red, 4 years in goldenrod, 3 years in yellow, 2 years in green and 1 year in blue. The 5-year annual average number of pronghorn seen by township is shown. Pronghorn were seen in 85 townships in 5 years but ranged from 40–54 townships in any single year. Townships are in correct position but not to scale. Township coordinates (Mount Diablo Meridian Township North Range East) are given on the left and top margins.

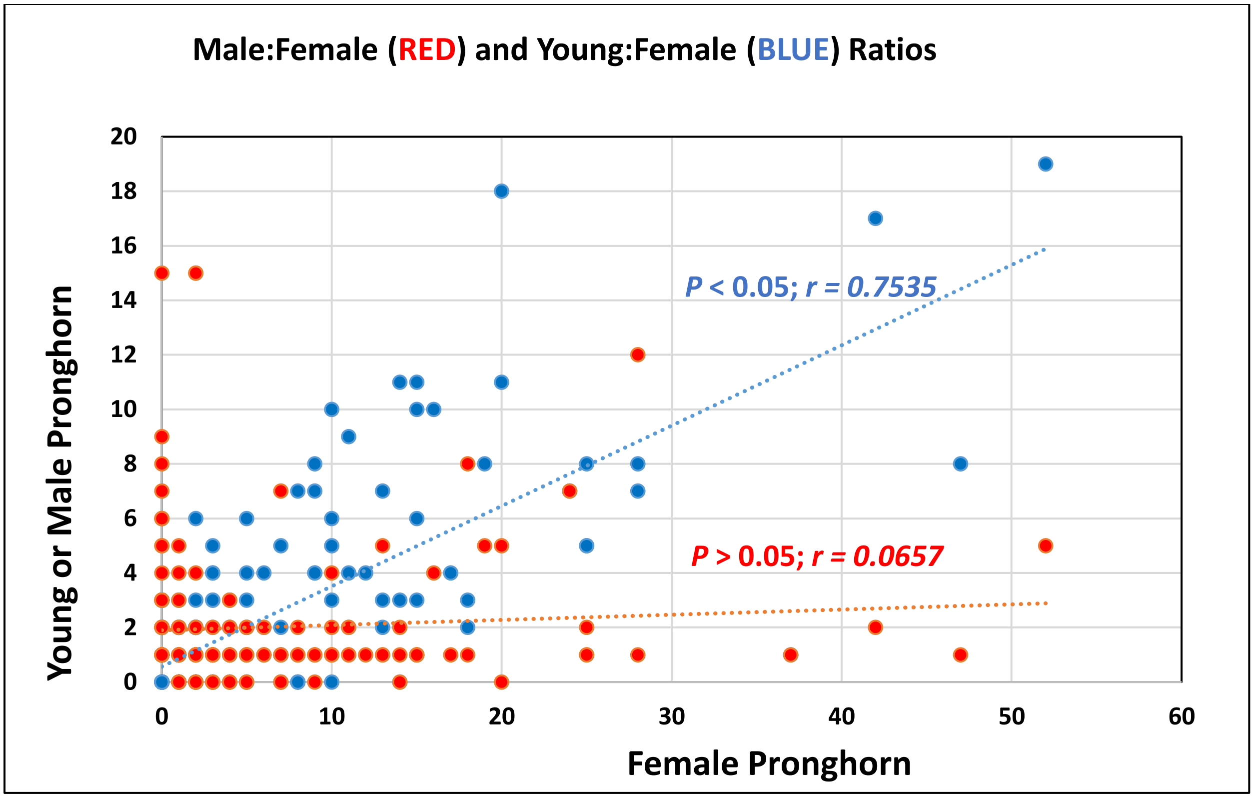

Figure 4. Correlations for pronghorn male and young numbers corresponding with the female number by group during an aerial survey in north Washoe County, Nevada in August 1977. The scatter points and correlations are red (not significant) for the male versus female comparisons and blue (significant) for the young versus female comparisons. The disparity between correlations in this data was similar for all 7 August surveys in this area. Young:female ratios were positive and strong, and male:female were not statistically signficant.

≤10 were significantly higher ($P < 0.01$) and in groups >100 the ratios were significantly lower ($P < 0.05$). Males were seen in 86.6% of groups observed, females were seen in 59.9% of groups observed, and young were seen in 50.3% of the groups observed in August. Composition of groups consisted of 39.5% male-female-young groups, 38.2% male-only, 8.9% female-young, 8.3% male-female, 3.2% female-only, 1.3% young-only, and 0.6% male-young.

Group size and sex ratios in the 60 random subsamples drawn from the 1978 August survey were highly variable. For example, at the 10% sample level, the largest number of pronghorn sampled in the 20 random samples was 3.5X larger than the smallest sample, although both consisted of 16 groups. At the 50% sample level, the largest sample was 1.3X the smallest. While the group numbers stayed the same in each sampling level, the population observation rate varied from 5–16% in the 10% subsample, 16–32% in the 25% subsample, and the 43–57% in 50% subsample.

Composition also varied substantially with group size. The male:female ratios for 17 of the 60 random samples (28%) were significantly different than the male:female ratio for entire sample, while only 4 young:female ratios of the 60 samples (7%) differed significantly. By chance in the random test, the mix of same-sex and mixed-sex groups selected in each run varied changing the sample ratio simulating random samples observed in surveys. Even sampling at a rate of 50%, the male:female ratio ranged between 0.246 to 0.552 male:female in only 20 random samples. The random testing clearly demonstrated the occurrence of erratic male:female ratios in survey results in northern Washoe County in the 1970s.

DISCUSSION

August male:female ratios were the most variable in relation to group size and number of females in a group, probably influenced by breeding behaviors and dominance of males. February surveys could yield the least variability because males are mixed amongst groups of females and group size tends to be largest. Yet accurately classifying sex for large groups is very difficult because adult males are growing their new horn sheaths and yearling males (>8 months old) are nearly as big as adults but have indistinct cheek patches. Group size influenced male:female ratios during all 3 sampling periods, and March surveys seemed to yield male:female ratios with the least variance. Managers should remember difficulty classifying males from the air increases with group size (Pojar 2004), and the male:female ratio is also affected by seasonal flux in distribution by sex and sample bias.

August surveys yielded stable young:female ratios and young increased consistently and predictably with the number of females observed. Young:female ratios are not always closely correlated with population growth (Hess 1986, 1999). Population growth is influenced by overwinter survival of young as well as adult survival yearlong. Dependence only on recruitment data may be misleading at times.

Composition of groups was variable from area to area, even in the 3 adjacent hunting units in the biggest population in the state. Three areas in 7 years differed in male:female ratios in 13 of the 21 comparisons (61%). This variation could be the result of varying hunt strategies, harvest levels, or recruitment, but because of the variability in group size among areas it is impossible to eliminate sampling error. My analysis demonstrated that even large samples, occasionally yielded biased male:female ratios.

Movements and migration of pronghorn have been a concern, but only recently have interstate movements across the Nevada-Oregon border been better defined (Collins 2016, Larkins et al. 2018). Anecdotal observations provide evidence for interstate movements between Nevada and California, but these movements are not well documented. The frequency and degree of interstate movements remain a challenge for the management of many species.

Pronghorn behavior during different times of the year may contribute to biases in survey data. In August surveys, I found substantial distributional variation among years over a 5-year period. Variable distribution of pronghorn was documented in earlier range use studies at Hart Mountain (Good 1977, Herrig 1974), but the recent telemetry study conducted at the Sheldon-Hart Mountain refuges by Collins (2016) provided the strongest supporting evidence. Pronghorn may distribute themselves differently based on breeding chronology or seasonal plant phenology. Buechner (1950) described Texas pronghorn behavior: "Antelope are more flexible than many other animals . . . as they range more widely to find the necessities of life." Fluctuating differences in range conditions and patchiness are common features of desert ecosystems. Clearly, pronghorn select high quality habitat.

Survey samples are challenged by issues other than habitat occupancy and group size composition (Yoakum et al. 2014). Group size may also influence detection rates. Smaller groups are less likely to be detected than larger groups (Rivest et al. 1995, Hervert et al. 1998, Lubow and Ransom 2007, Jacques et al. 2014). Because group size influences male:female ratios, differential detections rates may confound sample ratio estimates inconsistently.

Many of the problems found were well known in the larger Great Plains pronghorn populations where a variety of sample-based survey techniques were used to mitigate some biases (Yoakum et al. 2014). Great Plains sample-based survey solutions may not work with the low density in the Great Basin, but notably some Great Plains studies identified detection probability as a significant factor in aerial surveys for pronghorn. It affects aerial surveys in the Great Basin. A wild horse study in southwestern Wyoming in sagebrush habitat (Lubow and Ransom 2007) identified the skill of the individual observer, size of the horse group, and vegetative cover as primary influences on sightability, and the ruggedness of terrain and the position of the sun relative to the observer as moderately influential. A larger aircraft was used, flown higher and over a bigger area surveying the horses than most pronghorn sample-based surveys. A double-observer technique identified the detection rate. They reported a 60–65% chance of missing a single horse, 45% chance of missing a five-horse group, 20% chance of missing a 10-horse group, with most groups 15 or larger counted. Their observation rate ranged between 70–84%, averaging 74%. Despite the difference in animal size, the same factors were all influential in Nevada pronghorn surveys.

Despite this variability, Nevada was able to confirm that the estimates yielded from the surveys were generally plausible because the state historically compared results with Change-In-Ratio (Seber 1982) estimates for some species, like mule deer (*Odocoileus hemionus*) populations (Hess 1985, 1997). Because mule deer behave in more predictable migrations and have longer antler retention than horn sheaths in pronghorn, mule deer surveys generally yield more dependable ratio data. Although effects from harvest during high harvest years have been detected for mule deer, similar high harvests have not been prescribed on pronghorn populations in Nevada. Essentially, this remains untested for pronghorn.

MANAGEMENT IMPLICATIONS

My analysis and review of historical data collected in Nevada has identified at least 3 sources of bias with male:female ratios obtained from aerial pronghorn surveys. Group size influences male:female ratios, unpredictable distributions influence the ability to obtain a suitable sample, and group size, especially in variable summer months, may influence detection and further confound survey sample bias. Further, interstate or interjurisdictional movements may influence our ability to monitor populations. There is no evidence that these biases have resulted in overharvest or inappropriate management actions, probably due in part to the conservative management strategy used for pronghorn. Greater survey effort generally comes at a greater expense and may not guarantee improved survey data. Inherent biases are important to be aware of when assessing survey data, and long-term data sets can help biologists and managers make informed decisions.

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On 11 July 1953, Nevada Fish and Game wildlife technicians Don Johnson and Ray Meschkat were killed in an accident while landing in the Commission Super Cub at the Sheldon refuge during pronghorn surveys.

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Pronghorn migration and survival: A statistical analysis of a southeastern Oregon population

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Abstract In January 2015, the Oregon Department of Fish and Wildlife (ODFW) initiated a study on seasonal movements, migratory behavior, and survival of pronghorn (*Antilocapra americana*) in southeastern Oregon. Fifty female pronghorn were captured on winter range, fitted with Global Positioning System (GPS) collars, and released. Radiocollars recorded GPS locations every 13 hrs and transmitted locations to a central storage server where ODFW personnel downloaded data for analysis. ODFW monitored the location data and mortality signals to identify pronghorn mortalities between January 2015 and July 2017. Objectives of this study were to delineate seasonal range boundaries, identify migration corridors, quantify interchange between Sheldon-Hart National Antelope Refuge properties and surrounding Wildlife Management Units (WMU), quantify interstate movements with Nevada, estimate the percentage of the wintering population remaining in the Beatys Butte WMU (outside of Hart Mountain National Antelope Refuge) through summer and fall that are available to hunters, and to generate annual survival estimates for adult does. We found pronghorn were facultative migrators with variable timing, routes, and distances for migrations. Further, pronghorn used areas on Hart Mountain National Antelope Refuge and areas in Nevada disproportionately on a seasonal basis. Differences in seasonal distributions indicate that boundaries for existing hunting seasons in this area of Oregon need to be expanded to all animals in the population and that annual inventories would be more informative if conducted during summer. Further, additional management coordination across administrative boundaries (state and federal) is necessary to better manage this population.

Key words *Hart Mountain National Antelope Refuge, migration, movements, Nevada, Oregon*

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Pronghorn antelope (*Antilopcapra americana*) are an important big game species throughout the western United States, including Oregon. As a result of conservative harvest management, the number of pronghorn counted in Oregon has increased from less than 2,000 animals in 1945 to an estimated 18,000–21,000 animals in 2017. Pronghorn are generally considered a premier species to hunt in Oregon. Interest is high and the odds of drawing some pronghorn tags rival those for drawing a high-demand bighorn sheep (*Ovis canadensis*) tag.

Pronghorn population data are collected in Oregon primarily during winter when animals are concentrated on winter ranges. However, harvest seasons tend to occur during summer with animals dispersed on summer ranges. This difference in timing can lead to challenges when allocating hunting effort. Although landownership in Oregon is largely public, differing distributions of animals on accessible Bureau of Land Management (BLM) lands, National Wildlife Refuge lands, and/or privately-owned lands may result in limited access by hunters. Pronghorn movements may cross jurisdictional boundaries (e.g, state boundaries), which may further complicate allocation of hunting opportunities.

Throughout their range, pronghorn commonly display migratory behavior between distinct summer and winter ranges (Hoskinson and Tester 1980, Sawyer et al. 2005, White et al. 2007). Pronghorn migrational movements and seasonal ranges may be affected by human influences such as fences, roads, and changes in habitats on seasonal ranges. Yet, little work has been done in Oregon documenting pronghorn movements and seasonal ranges. Dalton (2009) evaluated migration triggers and resource selection on seasonal ranges in southeastern Oregon and found that snow cover and vegetation greenness triggered spring pronghorn migrations, whereas only snow cover triggered fall migrations. Pronghorn appeared to benefit from migration-specific seasonal home ranges used by animals that had higher values of vegetation greenness compared to portions of the range not used directly by animals. Collins (2016) evaluated seasonal distribution and movement routes of pronghorn radiocollared on Hart Mountain National Antelope Refuge (HMNAR). She found that pronghorn were conditionally migratory, and demonstrated wide variation in directional movements with high overlap in seasonal ranges.

We studied pronghorn movements and survival in a portion of the northern Great Basin of south-central Oregon. Specifically, we address 4 objectives in this study:

1. Delineate boundaries of seasonal (spring, summer, fall, winter) ranges, and identify migration corridors.
2. Quantify amount of interchange between HMNAR and surrounding Wildlife Management Units (WMU), and interchange of animals between Oregon and Nevada.
3. Estimate the percentage of the wintering population remaining in the Beatys Butte WMU (outside of HMNAR) through summer and fall.
4. Generate annual survival estimates for adult does in south-central Oregon.

STUDY AREA

Study area boundaries were ultimately defined by movements of radio-collared animals (Figure 1). The minimum convex polygon encompassing all locations collected during the study identified 19,266 km^2 in south-central Oregon and northwest Nevada. The final study area encompassed all of HMNAR in Oregon and Sheldon National Wildlife Refuge in Nevada.

Elevation ranged from about 1,300-2,500 m with most areas used by pronghorn typified by flat to gently rolling topography. Vegetation was characteristic of northern

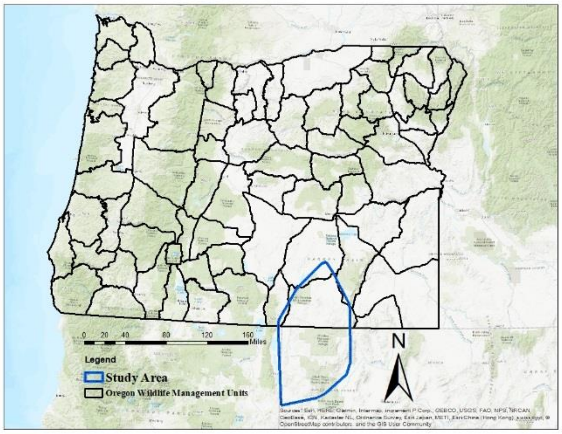

Figure 1. Study area for analyzing female pronghorn movement in southcentral-southeastern Oregon, USA, 2015–2017. Study area boundary represents the minimum convex polygon bounding all valid pronghorn GPS locations collected during study.

Great Basin grasslands and included a strong shrub component consisting primarily of sage (*Artemisia* spp.), rabbitbrush (*Chrysothamnus viscidiflorus*), and spiny hopsage (*Atriplex spinosa*). Open juniper (*Juniperus occidentalis*) woodlands occurred in some parts of the study area. Pronghorn populations were naturally occurring in the area with an estimated wintering population of 5,000 animals at time of capture. Conservative buck-only hunting and limited livestock grazing were the primary management activities affecting pronghorn on the study area.

Climate was characteristic of northern Great Basin. Summers were typically warm ($\bar{x}$ monthly temperature = 26˚ C) with cold ($\bar{x}$ monthly temperature = -4˚C), generally dry winters. Also typical of the Great Basin were seasonal extreme temperatures, reaching a low of -29˚ C in winter 2017–2018 and a high of 39˚C during summer 2016.

METHODS

Female pronghorn were captured using a helicopter netgun on winter range. Animals were restrained, outfitted with a Lotek LifeCycle Global Positioning System (GPS) radiocollars (Lotek Wireless, Inc., 115 Pony Drive, Newmarket, Ontario, Canada L3Y 7B5), and released at the site of capture. Radiocollars attempted to collect a valid location estimate twice daily at 13-hr intervals throughout the life of the radiocollar. No biological samples or measurements were collected or recorded at time of capture.

Radiocollars were monitored remotely by ODFW district personnel. Estimated dates of mortalities was primarily based on email notification from the Lotek monitoring system and by monitoring movement of individual animals. Mortalities were checked as feasible by ODFW staff, but cause of death was not determined for most mortalities.

Final location data were downloaded during fall 2017. Data were investigated for obvious errors and were compared to other data provided by ODFW (e.g., capture and mortality dates) that could be used to identify non-obvious erroneous locations. All point estimates prior to capture or occurring after mortality date were removed. Further, all data with a "No Sats" error or a value of zero for either Latitude or Longitude were deleted.

Seasons were delineated based on movement data using Net Squared Displacement (NSD; Figure 2). NSD is the square of the absolute distance of each location from the initial location (Singh et al. 2016). Since all pronghorn were captured on winter range NSD represents the distance of each subsequent location from each animal's capture location on winter range.

We calculated NSD for each collared pronghorn for the entire period the animal was alive. We generated individual plots of

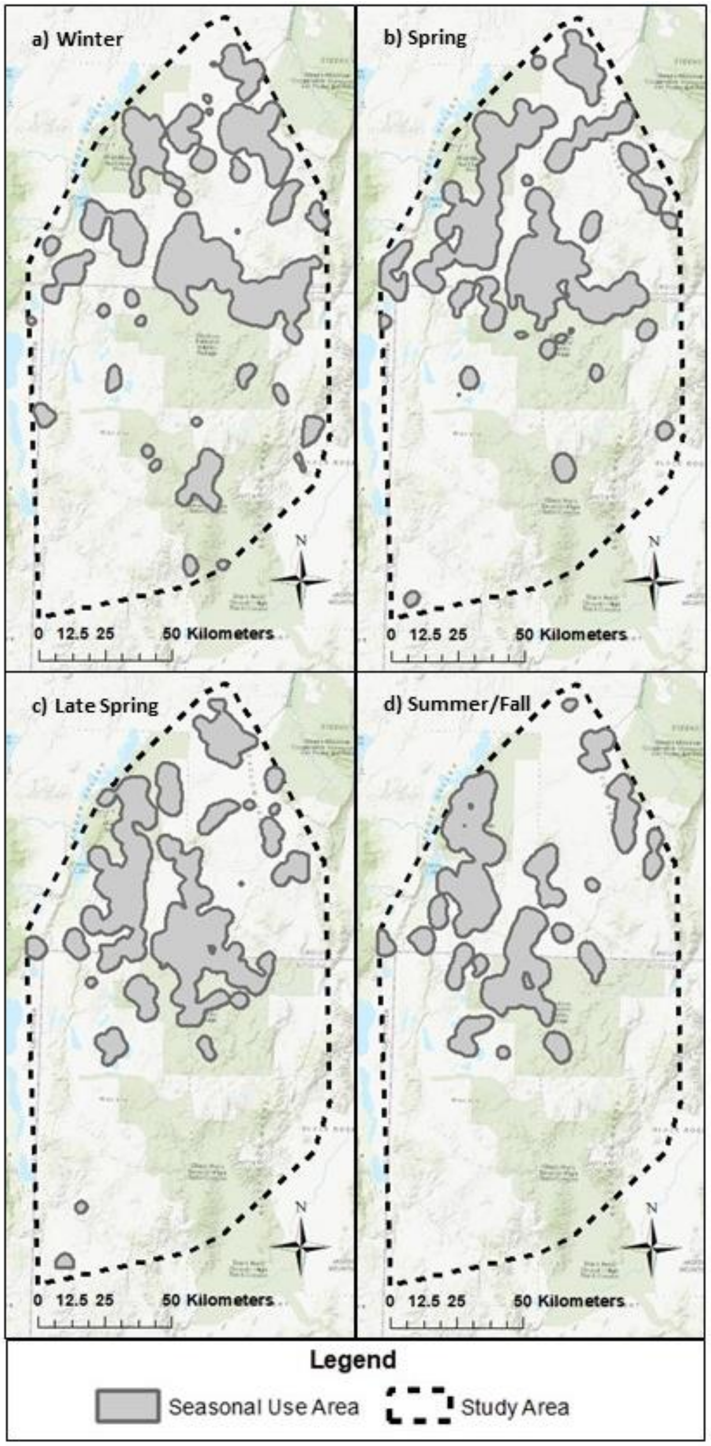

Figure 2. Seasonal female pronghorn habitats in southcentral-southeast Oregon, USA, 2015-2017. Seasons are based on NSD movement data and are defined as: a) winter: 1 November – 28 February; b) spring: 1 March – 30 April; late spring: 1 May – 30 June; and summer-fall: 1 July – 31 October. Areas are delineated by the 20% of the minimum convex polygon with the highest density of GPS locations within the season date.

NSD through time (date) and graphically assessed movement distances simultaneously for all 50 pronghorn to identify population-wide movement patterns. Animals exhibiting clear seasonal shifts in NSD were classified as migratory. NSD plots were visually assessed to determine timing of movements. Seasons were then graphically determined from the composite NSD plots of animals exhibiting clear migratory behavior. Each pronghorn GPS location was assigned to a season based on that date of the estimate. Alllocations within a season were then used to delineate seasonal range boundaries using 90% Kernel Density in ArcGIS.

Pronghorn are facultative migrators and as such distinct migration dates may not exist at the population level. In the absence of a strict "migration season" within the seasonal location dataset, we identified migratory movements of individuals directly. We used segmented regression (natural log of NSD verses distance to the next point; package 'segmented' in Program R, v. 3.4.0 [R Core Team 2017]) to determine the breakpoint in movement distance that indicated the movement was migratory. Movements greater than the estimated breakpoint were classified as a migratory steplength. Similar to delineating seasonal ranges, we calculated migratory steplength line density using a kernel density estimator in ARC.

Amount of time spent on and off HMNAR was calculated simply as the percent of location estimates within the HMNAR external boundary or within the Beattys Butte WMU but not on HMNAR. Percentages were determined seasonally to inform harvest management decision within the study area.

We used Kaplan-Meier survival analysis, a commonly-used non-parametric statistical survival analysis. We modeled annual survival for the first year directly without covariates, predictor variables, or separate groupings because all pronghorn were adult does captured at the same time. Because all animals were collared and released at the same time and no additional animals were added to the sample at future time points, after some initial time period the surviving animals represent a biased subset of the larger population because most non-survivors have already been winnowed out of the sample. Therefore, we estimated apparent survival during year 2 as the proportion of pronghorn alive in month 24 by the proportion alive in month 12.

RESULTS

Fifty female pronghorn were captured during January 2015. One animal died because of capture myopathy immediately after capture. The length of time that individuals were monitored ranged from a low of 27 days to a high of 909 days per animal ($\bar{x}$ = 702 days/animal). Nineteen animals died during the study. Of the remaining animals, most radiocollars failed after about 2 year and 3 months of deployment. No radiocollar transmitted longer than 2.5 years after deployment. Consequently, movement and seasonal range analyses could only be conducted for 2 years.

After removal of erroneous locations and points collected prior to capture or post mortality, there were 61,886 GPS locations collected between 15 January 2015 and 13 July 2017 available for analysis. Number of valid GPS locations/animal ranged from a low of 60 for an animal that died at day 27 to a high of 1,666 for an animal living until collar failure in early July 2017. There was an average of 1,237.7 (SD 489.9) locations per animal.

Graphical assessment of NSD-based movement metrics for all 49 pronghorn showed that the proportion of radiocollared animals migrating varied between years. In year 1, 74% (37 of 48) of radiocollared animals migrated with a complete year of data, whereas during year 2, 98% (39 of 40) of the radiocollared animals migrated. For pronghorn exhibiting clear migratory behavior, 4 distinct "seasons" were identified as winter (1 November–28 February), spring (1 March–30 April), late spring (1 May–30 June), and summer-fall (1 July–31 October). Number of seasons and calendar date boundaries were based solely on the NSD movement data.

Although the minimum convex polygon area encompassing all pronghorn locations was almost 20,000 km^2, the greatest amount of the area actually used by pronghorn was only 20% (20%) during winter and spring when 3,843 km^2 and 3,890 km^2 were used, respectively. During late spring, area of use declined to 3,642 km^2. The lowest area of use (15%) occurred during summer and fall when 2,946 km^2 were used. Based on number of polygons identifying areas of use, animals were most dispersed during winter when 32 discrete polygons were identified (Figure 2). Animals were most concentrated during summer and fall when only 18 distinct areas were identified.

Segmented regression found a threshold of change in the relationship between NSD and steplength distance of 3,179 m (95% CI: 2,663.8–3,693.0), suggesting that steplengths greater than about 3,200 m reflected migratory movements between seasonal ranges. Using this threshold, 13.7% of all steplengths (8,475 of 61,836 animal movements) represented a migratory movement (Figure 3A). Evaluating the density of migration steplengths shows clear north-south and east-west migratory corridors (Figure 3B). These are the areas with the highest density of migratory steplengths.

Pronghorn showed increasing use of HMNAR as seasons transitioned from winter to summer-fall, with the highest proportional use of the HMNAR in August and September (Figure 4). After collapsing data to the season level and adjusting for number of GPS locations within season, pronghorn showed disproportionately low use of the HMNAR during winter, proportional use equivalent to random during spring, and disproportionately high use during late spring and summer-fall (χ^2 = 1374.7, df = 3, P < 0.001, Figure 4). Pronghorn were disproportionately migrating into and out of the NAR rather than randomly crossing the border (χ^2 = 596.1, df = 1, P < 0.001). Only 283 of 61,836 total tracks crossed the NAR boundary and 180 of the 283 tracks were migratory.

Pronghorn appeared to use habitat in Nevada disproportionately across seasons (χ^2 = 68.67, df = 3, P < 0.001, Figure 5). After adjusting for total GPS locations within each season, pronghorn occurrence in Nevada was slightly greater than expected in winter and summer-fall and lower than expected in spring. Yet the low magnitude of differences between observed and expected suggest a lack of a biologically meaningful difference in seasonal occurrence in Nevada. Similar to refuge boundary crossings, border crossings were disproportionately migratory compared to what would be expected if movement into or out of Nevada were random (χ^2 = 68.67, df = 3, P < 0.001). Of 883 tracks crossing into or out of Nevada, 404 were migratory suggesting pronghorn were actively migrating across the border.

The proportion of seasonal GPS locations within the Beatys Butte WMU but outside of HMNAR was highest in winter (70.8%) and lowest in late spring (54.4%, Figure 6). Spring (61.3%) and summer-fall (56.2%) were intermediate to the extremes. In terms of Beatys Butte WMU use by individual animals in different seasons, there was a shift from 100.0% of pronghorn occurring in the WMU outside HMNAR in winter to 92.0% during spring and 86.0% during late spring (Figure 7). During the summer-fall season 100.0% of radiocollared

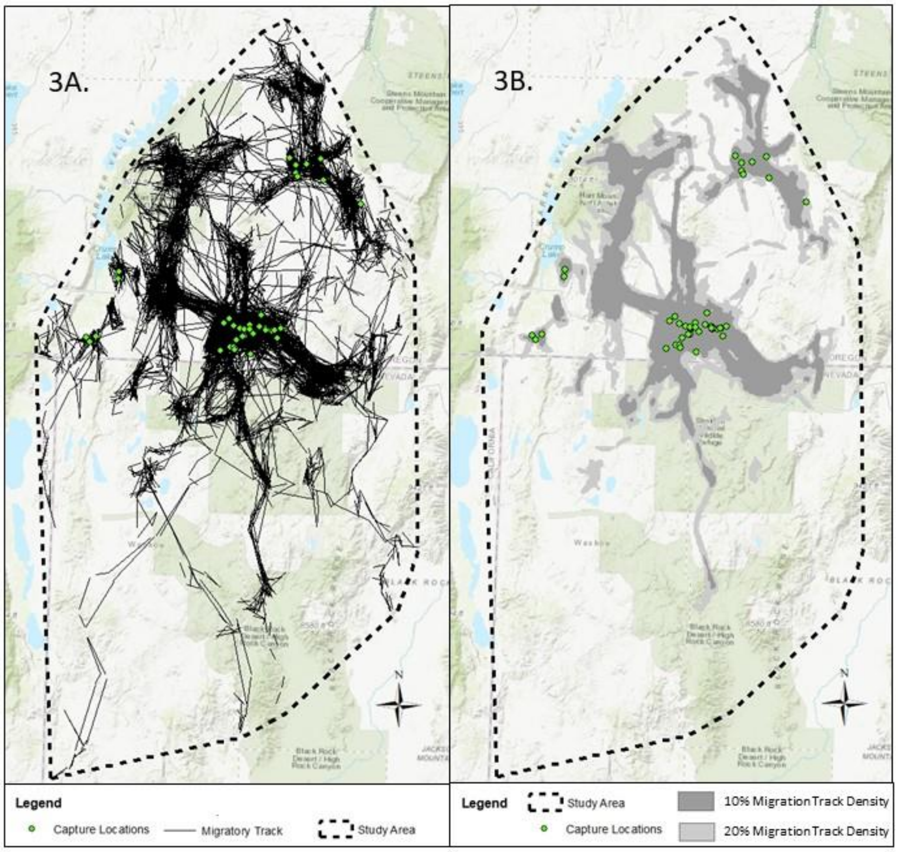

Figure 3. Migratory steplengths (3A) and migratory steplength density (3B) for GPS-collared female pronghorn in southcentral-southeastern Oregon, USA, 2015-2017. Migratory density surface is the 20% and 10% portion of the study area that has the highest density of migratory steplengths. Green points represent capture locations.

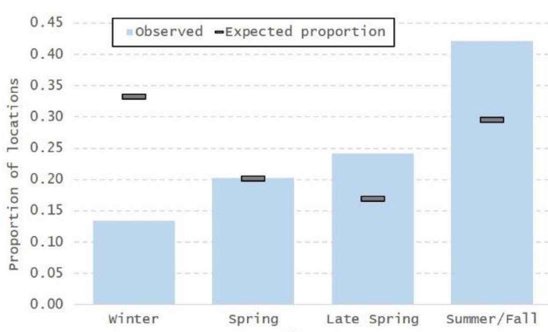

Figure 4. Observed versus expected-at-random proportional seasonal use of the Hart Mountain National Antelope Refuge by GPS-collared female pronghorn, Oregon, USA, 2015-2017.

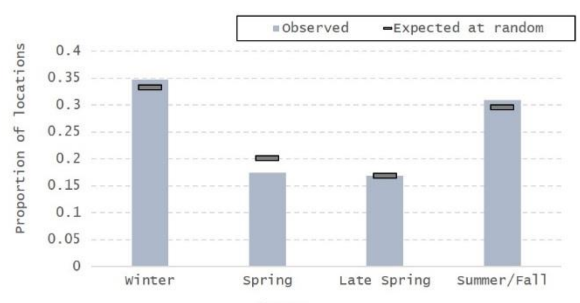

Figure 5. Proportion of total pronghorn GPS monthly locations that occurred seasonally within Nevada, USA, 2015-2017.

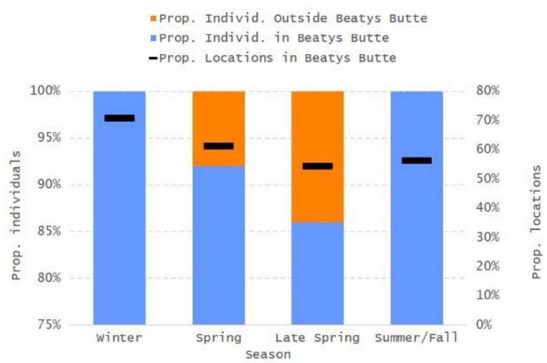

Figure 6. Population prevalence (individuals) and total use (locations) of the Beatys Butte Wildlife Management Unit outside of the National Antelope Refuge across seasons in Oregon, USA, 2015-2017.

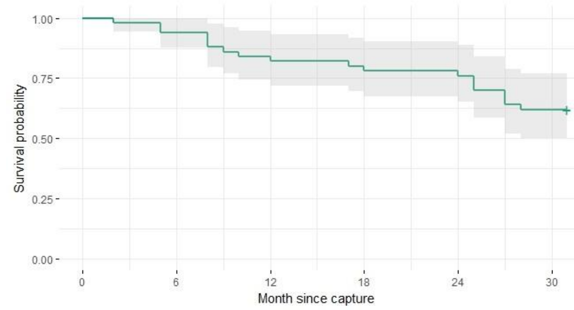

Figure 7. . Kaplan-Meier survival (green line) and 95% confidence interval (gray band) for GPS-collared female pronghorn in southcentral/ southeast Oregon, USA, 2015-2017.

animals spent some time in Beatys Butte WMU.

Survival through the first year (January 2015 to December 2015) was 82.0% (95% CI 72.0–93.4%) and 76.0% through the second year (January 2015 to December 2016, Figure 7). Apparent annual survival rate for year 3 (January 2016 to December 2016) was 92.7%. The apparent survival estimate of 92.7% is not the estimated survival rate of all pronghorn does in 2016, but rather the survival of our remaining sample of females given that they had already survived 2015. For the entire study period (31 months), survival was 62.0%.

DISCUSSION AND MANAGEMENT IMPLICATIONS

Other studies of pronghorn migration report that pronghorn are conditionally migratory (Collins 2016) or find variation in number of animals migrating between years range to winter range to amount of snow received during winter (Hoskinson and Tester 1980, White et al. 2007, Collins 2016, Jakes et al. 2018), even though fall migration might begin prior to snowfall on winter range (White et al. 2007, Jakes et al. 2018). Most authors attribute year to year variation in number of animals migrating from summer ranges (Hoskinson and Tester 1980, Sawyer et al. 2005, White et al. 2007), or may be triggered by snow events (Dalton 2009, Jakes et al. 2018).

We found that number of animals migrating varied between years where 74% migrated the first year and 98% migrated the second year. As evidenced by annual increases in monthly snowfall and average monthly snow depth (Table 1), winter conditions during our study worsened between the first winter when animals were captured (October 2014–March 2015) and the last winter (October 2016–March 2017). Our data support hypotheses that pronghorn are conditionally migratory (Collins 2016) and only move as far as needed to secure adequate resources during winter (Hoskinson and Tester 1980).

Similar to Collins (2016), radiocollared animals in our study showed a great deal of variation in timing of movements, directions of migration movements, and in spatial distribution of animals throughout the year. This resulted in no clear polygon of seasonal range that was

Table 1. Metrics of winter condition collected from NOAA monitoring stations on Hart Mountain National Antelope Refuge and at Adel, OR.

Winter	$\bar{x}$ Monthly Low Temp (˚C)	$\bar{x}$ Monthly Daily Temp (˚C)	Total Snow Accumulation (cm)	$\bar{x}$ Monthly Snow Depth (cm)
October 2014–March 2015	-15	1	28.1	0.52
October 2015–March 2016	-15	-1	33.7	1.4
October 2016–March 2017	-15	-2	42.3	2.1

fully distinct from other seasons due to the large overlap of use areas. However, we did find that pronghorn in this study did not use the entirety of the study area as it was defined by the minimum convex polygon encompassing all locations.

Animals during our study were captured on winter ranges during the mildest of the winters we analyzed. We observed maximum dispersal of use areas during the winter period, and winter conditions in successive years increased in severity. Dalton (2009) found that pronghorn in southeastern Oregon used areas during winter with a lower snow depth compared to snow depth at random sites in the study area. We suggest that the wide distribution of animal use areas across all winter periods combined is a result of pronghorn moving in response to the increasing winter severity in search of areas with the least snow. Pronghorn use areas during the combined summer periods likely reflects selection of micro sites providing resources desired by individual animals. Further analyses are required to determine what specific resources were selected for.

Pronghorn radiocollared on Beatys Butte winter ranges showed increasing use of the HMNAR in Oregon as seasons transitioned from winter to summer-fall, and showed disproportionately low use of HMNAR during winter. Further, our study animals showed a high propensity to spend time in Nevada, especially during winters with heavier snowfall. Our results mimic those reported by Collins (2016) with only period and location of capture differing between the studies. This indicates that pronghorn in the Beatys Butte-HMNAR area in south-central Oregon represent a large meta-population encompassing 2 state jurisdictions (Oregon, Nevada) and 1 federal management jurisdiction (US Fish and Wildlife Service Hart Mountain–Sheldon National Antelope Refuge).

Two primary management implications stem from observed animal movements in this study. First and foremost, data collection processes and harvest management strategies need alignment. Historically ODFW surveyed pronghorn populations during winter animal concentrations. Yet data indicate that animal distributions differ dramatically from areas occupied when animals are subject to harvest during late summer. HMNAR has historically conducted annual pronghorn surveys in July. Recently, ODFW shifted timing of pronghorn surveys to summer. This summer population information combined with measured winter survival probabilities and animal distributions identified in this study will provide for more robust population modeling at an appropriate scale to inform harvest management decisions.

Second, the spatial scale and location of this meta-population necessitates a strong communication and shared decision process involving the states of Oregon and Nevada and staff from HMNAR. Some limited communication occurs, yet more in depth discussions of harvest management objectives is warranted because the population occupies multiple jurisdictions.

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Western state and province pronghorn status report, 2018

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Abstract The Nevada Department of Wildlife hosted the 28th Biennial Pronghorn Workshop during 13–16 August 2018 in Reno, Nevada. This workshop is a Western Association of Fish and Wildlife Agencies (WAFWA) sanctioned event and represents about 16 western states and 2 provinces within pronghorn (*Antilocapra americana*) range. The hosting state typically sends out a standardized questionnaire that is passed on to each subsequent host every 2 years. We received 17 completed questionnaires from various western states and 1 province. This status report provides a summary of the results we received for pronghorn demographics, survey methodology, harvest data and season structure, and various other activities pertaining to pronghorn conservation and management.

Key words *WAFWA, western states and provinces, pronghorn status*

Proceedings of the Biennial Western States and Provinces Pronghorn Workshop 28:29–35

POPULATION ESTIMATES AND SURVEY METHODS

The combined pronghorn (*Antilocapra americana*) population estimate for 17 western states and provinces (excluding Alberta, Nebraska, and Baja California Sur) totaled 915,848 in 2017 (Table 1). This represents an approximate 9% increase from the estimated 837,164 reported in 2015 (Vore 2016). Populations across the range appear stable to slightly increasing in most areas with the exceptions of North Dakota, South Dakota, and Saskatchewan. These states indicated their herds were below population objectives. About 47% of the North American population occurs in Wyoming with over 436,000 reported for 2017 and about 80% of the populations occur in 4 western states (Wyoming, Montana, Colorado, and New Mexico) considered the "core area" of suitable pronghorn habitat (Figure 1).

Demographic indicators such as fawn:doe ratios varied widely among reporting jurisdictions, ranging from a low of 20 fawns:100 does in Oklahoma to a high of 74 fawns:100 does in both North Dakota and Wyoming (Table 1). Buck:doe ratios were also highly variable among jurisdictions, ranging from a low of 29 bucks:100 does in Oklahoma to a high of 53 bucks:100 does in Texas. The overall average reported for all jurisdictions was about 47 bucks:100 does.

Survey methodology remained largely unchanged from those reported in the previous pronghorn proceedings report (Vore 2016). Fixed-wing surveys were the most widely used method followed by ground-based observations, while only 6 states reported using a helicopter for abundance or composition surveys. Timing of pronghorn

Table 1. Population surveys and demographic information for states and jurisdictions for North America collected during 2017.

State-Province	Population Estimate	Ratio Per 100[1] Buck:Doe	Ratio Per 100[1] Fawn:Doe	Survey Method [2]	Months Surveyed
Arizona	11,000	32 (33)	27 (27)	FW-H-G	June–August
Baja California Sur	NA				NA
California	3,055			H	February
Colorado	85,600	51 (51)	57 (49)	FW-H-G	May–August
Idaho	13,000			FW-H-G	Sporadic
Kansas	3,000	34 (36)	35 (49)	FW	July–August
Montana	157,965	41 (48)	59 (72)	FW-G	July (FW), April–May (G)
Nebraska	NA				NA
Nevada	30,000	47 (43)	37 (42)	H-G	September
New Mexico	48,000	39 (35)	33 (38)	FW	July–August
North Dakota	6,038	38 (37)	74 (62)	FW	July
Oklahoma	1,840	29 (28)	20	FW-G	August, February–March
Oregon	22,000	51 (32)	35 (36)	H-G	July, late winter
Saskatchewan	15,000	50 (51)	61 (58)	G	July
South Dakota	47,700	36 (34)	62 (78)	FW-G	April–June
Texas	18,000	53 (56)	39 (34)	FW-G	June–July
Utah	16,700	51 (44)	44 (48)	FW-G	March–April
Washington	150	NA	NA	FW-G	February
Wyoming	436,800	51 (50)	74 (58)	FW-G	June–August
Total	915,848				

[1] 2017 ratio (long-term mean ratio)

[2] FW = Fixed-wing aircraft, H = Helicopter, or G = Ground surveys

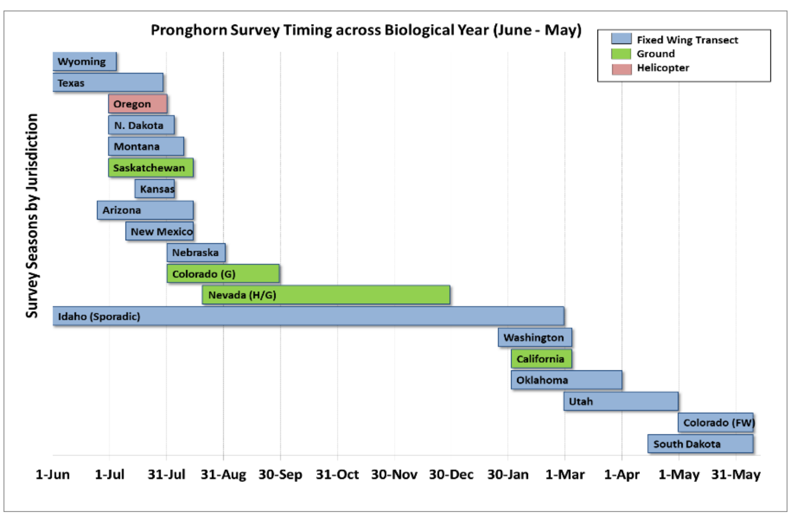

Figure 1. Timing of pronghorn survey by jurisdiction and method of survey.

surveys varies widely by jurisdiction (Figure 2). Surveys using fixed-wing aircraft methods generally ranged from April to September (Table 1.), although substantial deviations occurred among some jurisdictions (Figure 1). Only 7 of 17 (41%) jurisdictions reported using some form of sightability correction factor in their survey methodology or population estimate.

HARVEST SUMMARY

A total of 84,468 pronghorn (56,497 bucks and 27,971 does, Table 2.) were harvested in North America during 2017 (excluding Alberta, Nebraska, Washington, and all Mexican states), which is about 11,000 more than were reported in 2015 (Vore 2016). Wyoming reported the largest percentage (50%) of the total harvest reported for North America, while Kansas (217) and Oklahoma (128) reported the fewest total harvest (Table 2) amongst all states and jurisdictions.

Harvest data collection and estimation methods varied widely among states and jurisdictions. A majority of states (75%) reported using some form of internet-based harvest reporting, or a combination of mail-in, phone, and web-based harvest reporting. Only 3 states, Nevada, New Mexico, and Saskatchewan, are solely using internet-based questionnaires for harvest reporting. Harvest reporting was mandatory for about 44% of states and provinces, while Oklahoma is the only state that requires mandatory harvest report through a physical check process. Harvest reporting rates were also highly variable and ranged as low as 20% for Wyoming to 100% for Oklahoma. About 40% of jurisdictions collect either horn length or age data and use that information to inform management decisions.

HUNTING SEASON STRUCTURE

Hunting remains an important component of pronghorn management for many jurisdictions and hunting seasons are designed to provide opportunity for both resident and non-residents alike. Season lengths and weapon classes legal for hunting pronghorn varied widely among many states (Figure 2). Standard rifle or any legal weapon hunts were generally offered in the late summer to autumn months, while several northern states offered these seasons in early October and extended into mid-November (Figure 2). Archery hunts were generally offered in August and extended into mid to late September. The length of season dates was highly variable, ranging from 3-day seasons in New Mexico to as long as 40 days in Saskatchewan, averaging about 21 days across all jurisdictions that reported. Archery season dates varied from 9 days in New Mexico to as long as 88-day seasons in Montana (Figure 2). Only 9 out of 16 states (56%) have muzzleloader hunting seasons for pronghorn.

PREDATION MANAGEMENT

Five states reported having some type of predation management program to benefit pronghorn including Arizona, Montana, Nevada, Texas, and Wyoming. The reported objectives for these programs varied by jurisdiction but generally were to increase survival of fawns (Arizona and Nevada) to protecting recently translocated pronghorn herds (Texas). The programs were largely focused on removal of coyotes (*Canis latrans*). Success of these programs were measured using fawn:doe ratios, fawn production, or monitoring survival rates. Arizona, Montana and Texas, reported a measurable positive benefit from these predator removal programs.

Table 2. Pronghorn harvest by weapon class and jurisdiction as reported for 2017.

	Rifle			Muzzleloader			Archery			Total		
State-Province	Bucks	Does	Total	Bucks	Does	Total	Bucks	Does	Total	Bucks	Does	Total
Arizona	375	0	375	63	0	63	110	0	110	548	0	548
California	184	0	184	0	0	0	6	0	6	190	0	190
Colorado	5,239	2,748	7,987	468	162	630	478	48	526	6,185	2,958	9,143
Idaho	896	324	1,220	100	20	120	393	62	455	1,389	406	1,795
Kansas	137	5	142	28	1	29	41	5	46	206	11	217
Montana	9,103	4,235	13,338	0	0	0	956	110	1,066	10,059	4,345	14,404
Nevada	2,100	1,000	3,100	31	0	31	115	0	115	2,246	1,000	3,246
New Mexico	2,857	359	3,216	113	0	113	157	0	157	3,127	359	3,486
North Dakota	264	11	275	0	0	0	6	0	6	270	11	281
Oklahoma	41	63	104	0	0	0	22	2	24	63	65	128
Oregon	1,000	131	1,131	54	6	60	84	6	90	1,138	143	1,281
Saskatchewan	410	2	412	0	0	0	0	0	0	410	2	412
South Dakota	2,692	1,093	3,785	0	0	0	529	52	581	3,221	1,145	4,366
Texas	659	0	659	0	0	0	0	0	0	659	0	659
Utah	695	1,025	1,720	46	0	46	104	0	104	845	1,025	1,870
Wyoming	25,796	16,498	42,294	110	0	110	35	3	38	25,941	16,501	42,442
Total	52,448	27,494	79,942	1,013	189	1,202	3,036	288	3,324	56,497	27,971	84,468

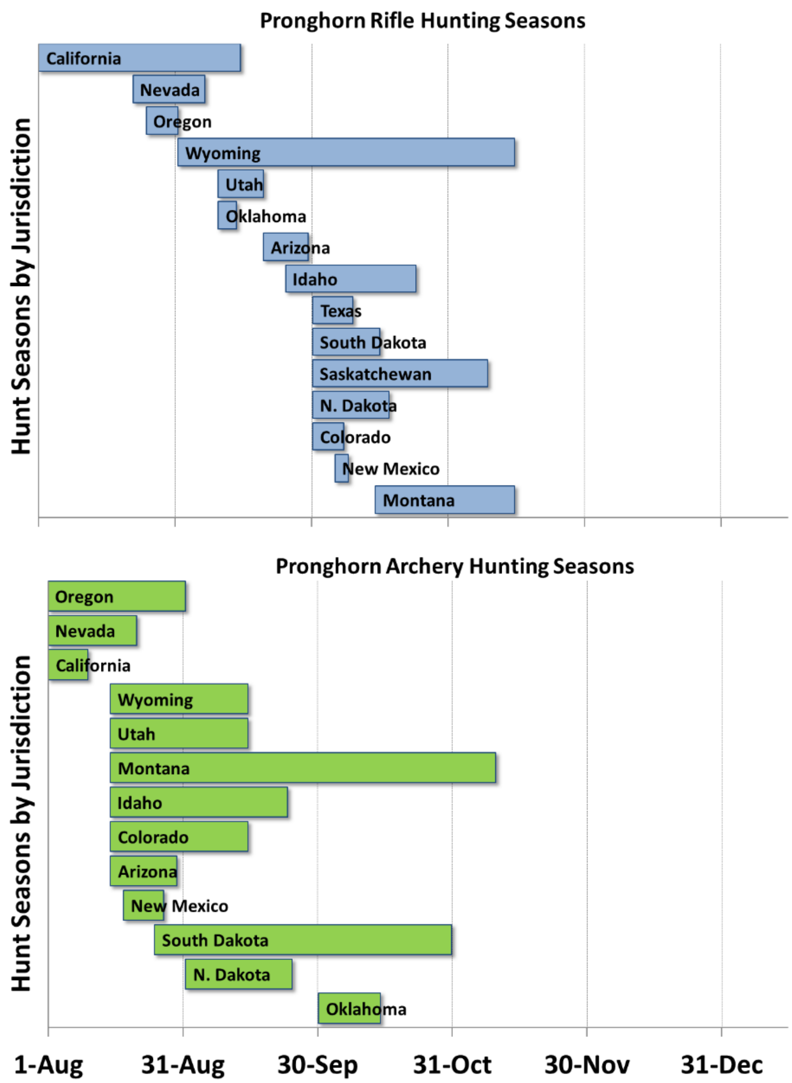

Figure 2. Season lengths and general dates for rifle (top panel) and archery (bottom panel) hunting seasons for pronghorn by jurisdiction throughout North America for hunting seasons held in 2017.

HABITAT MANAGEMENT

Habitat management remains an important component of pronghorn management for many states and jurisdictions. Seven of 15 jurisdictions (47%) reported they were actively participating in on the ground habitat enhancement efforts (Figure 3). Specific types of habitat projects were variable but generally included prescribed fire, fire rehabilitation, water developments, conifer thinning, and fence modifications. Wyoming also reported they have invested in highway crossing structures for pronghorn and other ungulates.

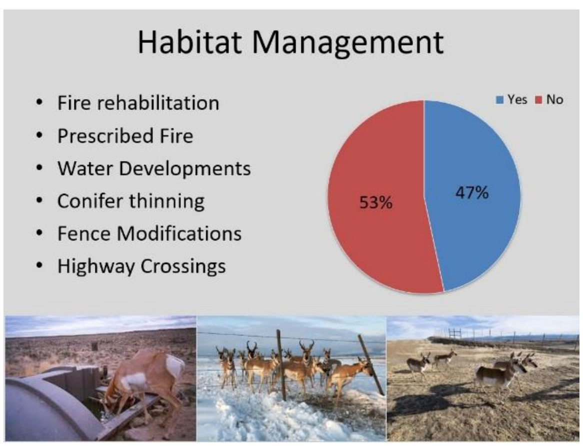

Figure 3. Responses of state or provinces who reported having active habitat management programs specifically for pronghorn (about 47% of all states responded yes). Specific types of habitat management were variable, but fence modifications and conifer thinning were the most common. Above, Wyoming also constructed highway crossing structures for ungulates including pronghorn and mule deer.

PRONGHORN RESEARCH AND TRANSLOCATION

Research is a major component of managing pronghorn for at least 8 jurisdictions and much of the active research is focused on movements patterns, migration corridors, and habitat selection studies. Texas, Utah, and Idaho were focusing on neonatal or juvenile fawn survival. Wyoming has active research partnerships with University of Wyoming focusing on migration corridors and mapping stop-overs. Oregon presented research results from a study on Beatty’s Butte also focusing on seasonal movements and use of corridors (Larkins et al. 2018). Eleven states indicated they have future research projects in the works or plan to initiate projects at some future point.

Translocation remains an active area of research and management for at least 6 states (Arizona, Colorado, Nevada, New Mexico, Texas, and Utah). Reasons for translocating pronghorn ranged from augmenting existing herds to restoring pronghorn herds to historical ranges where they had been extirpated.

DISCUSSION

The results from the 2017 state and province questionnaire yielded similar results to previous pronghorn workshop proceedings. Populations across North America continue to be strong and many herds are growing. The total combined population estimate of 915,000 pronghorn for North America, was the highest reported in recent years, and the number of harvested pronghorn (~85,000), was also a record high. Still much work needs to be done to return pronghorn to populations seen historically. States are investing greatly in research and habitat restoration efforts, including fence modifications, water developments, habitat treatments, and wildlife crossing structures, but increasing human populations, urban development, energy extraction, and highway crossings continue to be a problem for some states and provinces. More research into identification of movement corridors and barriers to movements such as fencing and roads was identified by many states.

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Abstracts of Presented Papers

Abstracts of Presented Papers and Posters

(alphabetical by lead author)

USING NON-INVASIVE SAMPLING TO MONITOR PREGNANCY, NUTRITION, AND STRESS IN ADULT FEMALE PRONGHORN

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Abstract: Populations of pronghorn (*Antilocapra americana*) in Idaho have declined, and have not rebounded, since their peak in the late 1980s. Ample debate exists on various factors (disease, juvenile survival and recruitment, resource limitations, predation, and climate) that may limit prey populations. We are investigating some of the factors that may influence pronghorn population growth rates and fawn:doe ratios (i.e., recruitment) by conducting non-invasive fecal sampling across 5 populations in southern Idaho. Field work will be divided into 3 sessions: pre-parturition (April–May); lactation (June); and pre-migration (September). Fecal sampling will be used to 1) determine pregnancy rates via fecal hormone concentrations, 2) measure physiological stress via cortisol, 3) determine metrics of nutritional condition via fecal nitrogen (FN) and fecal 2,6-diaminopimelic acid (DAPA), and 4) estimate seasonal diet composition. In addition to interpreting each factor individually, we will examine relationships amongst various factors (e.g., pregnancy and nutrition). Fecal hormone work has not been conducted with pronghorn so appropriate hormone concentrations need to be established and validated. We will also conduct a hormone degradation study to determine the length of time these hormones (progesterone, estradiol, cortisol) remain viable in feces to establish a sampling protocol for managers. From this research, we will elucidate factors that may be limiting pronghorn populations, provide insight on the physiological measures influencing pronghorn productivity, and provide parameters useful for population modelling.

MODELING TRANSLOCATION STRATEGIES FOR PRONGHORN POPULATIONS IN THE TRANS-PECOS, TEXAS

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Abstract: In 2011, Texas Parks and Wildlife Department (TPWD) and the Borderlands Research Institute began an effort to boost pronghorn (*Antilocapra americana*) populations in the Trans-Pecos region of Texas. Restoration efforts included translocating groups of pronghorn from the Texas Panhandle. A decrease from >17,000 pronghorn in the 1980s to a low of <3,000 in 2012 led to the initiation of translocation efforts. Habitat fragmentation in the Trans-Pecos has led to metapopulation arrangements that TPWD manages as 11 unique units. This study sought to evaluate the effectiveness of various strategies in restoring regional pronghorn populations to a targeted population of 10,000, estimated the probability of meta unit population quasi-extinction, and meta unit population extinction over a 20-year period. We built a stage-based simulation model using TPWD survey data and survival data from recent studies. There were 13 different iterations of the model that each tested a unique translocation scenario. The models illustrate that sustained translocation strategies can increase pronghorn populations in the Trans-Pecos beyond the additive increases contributed by each translocation, though the goal of 10,000 pronghorn was not consistently reached across

every tested scenario. The most successful translocation strategy modeled involved translocating 1,000 pronghorn over 10 years to Trans-Pecos meta units that historically showed the most sustained success and were closest to their targeted population goal when a release site was chosen for each translocation year.

RANGE IMPROVEMENT PRACTICES TO IMPROVE WILDLIFE HABITAT

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Abstract: Wildfires in the Intermountain West are an annual event. The introduction and subsequent invasion of cheatgrass (*Bromus tectorum*) onto millions of hectares of rangelands throughout the West has resulted in devastating wildfires. With each passing wildfire season, more critical wildlife habitats are burned and converted to annual grass dominance. Cheatgrass truncates secondary succession by out-competing native perennial grass seedlings for limited moisture at the seedling stage and providing a fine textured, early maturing fuel that has increased the frequency of wildfire from an estimated 60–110 years down to 5–10 years in many habitats. The best known method at suppressing cheatgrass and its associated fuels is through the establishment of long-lived perennial grasses. Range improvement practices through mechanical and chemical applications can improve success rates of rangeland rehabilitation efforts, ultimately benefitting those wildlife species that depend on these habitats. Plant material testing of native and introduced species, including 'Immigrant' forage kochia (*Bassia prostrata*) have substantially contributed to rangeland rehabilitation success rates that ultimately benefit wildlife populations. Aggressive weed control practices are necessary to decrease cheatgrass competition at the seedling stage. Chemical (pre-emergent herbicides) have yielded as much as 98.7% cheatgrass control and increased seeded species success by more than 900%. Mechanical and chemical weed control practices along with the use of adaptive and desirable plant species has resulted in successful rangeland rehabilitation projects that have benefitted many wildlife species including pronghorn (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), and sage-grouse (*Centrocercus urophasianus*).

PATH SEGMENTATION TECHNIQUES FOR INDENTIFYING MIGRATORY AND PARTIALLY MIGRATORY UNGULATES

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Abstract: Methods for characterizing patterns and behaviors in movement ecology can be simple (classifying movement strategy with net squared displacement) or complex (Bayesian partitioning of Markov models). However, estimating the timing of migration with any of these methods tends to result in inconsistent or difficult-to-interpret results. For instance, behavioral change point analysis is too sensitive and overestimates the number of states (migration or non-migration), while the more complex methods are too computationally intensive for this simple task. At the Nevada Department of Wildlife, we have deployed over 1600 collars in the last 5 years. To decrease the number of hours spent manually estimating migration, we developed an algorithm that uses binary search of the net squared displacement values. This method successfully identifies migration timing more often and with less human

input than other methods we have used. Here we present a brief overview of the algorithm as well as its applications to mule deer (*Odocoileus hemionus*) migrations in Nevada.

FIVE THOUSAND YEARS OF COMMUNAL PRONGHORN TRAPPING IN THE GREAT BASIN

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Abstract: Aboriginal hunter-gatherers in the Great Basin began constructing large-scale traps such as corrals and drivelines by 5,000 years ago. These features were built through communal effort to capture large numbers of pronghorn (*Antilocapra americana*) during their seasonal migrations. Aboriginal corrals are concentrated in a geographic band that stretches across eastern California, Nevada, and western Utah, closely correlating with the current distribution of single needle pinyon pine. These data suggest that pronghorn north–south migration patterns were consistent for millennia in the Great Basin; the construction of modern north-south highways in the middle of most Great Basin valleys probably severely reduced pronghorn numbers in the Great Basin. Current numbers of pronghorn in the Great Basin are likely a fraction of what they were prior to Euroamerican settlement.

THE RISE, FALL, AND FUTURE OF PRONGHORN ON MODOC PLATEAU, CALIFORNIA

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Abstract: Pronghorn (*Antilocapra americana*) populations on California's Modoc Plateau have undergone 3 distinct phases over the past 6 decades. From the 1950s through the 1970s, the population increased steadily at a rate of ~5% annually throughout the region. The population remained relatively stable over the next decade, until it experienced a 35% decline over the winter of 1992–1993. Since then, the pronghorn numbers have continued to decline overall, but with different management units experiencing different population dynamics. We tracked reproduction and survival of adult females and fawns from 2014 through 2016 to determine factors preventing population recovery. We radiocollared 48 adult females and 42 fawns and followed them until their death or the end of the study. Overall annual survival for adult females was 69%, which is low compared to other pronghorn populations. Mountain lions (*Puma concolor*) accounted for 62% of all mortalities. In contrast, fawn survivorship was 43%, similar to or higher than those observed in other populations. A matrix model based on vital rates observed in this study predicted a 5% annual decline in the population, matching the observed regional population trajectory from 1993–2003. Projected population growth was most sensitive to changes in adult survival. A combination of mountain lion management and landscape management leading to a 30% reduction in lion predation is predicted to stabilize pronghorn population growth.

PREDATOR MANAGEMENT IN NEVADA

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Abstract: During the 2003 Nevada legislative session, a law was enacted requiring a fee of $3 USD on every big game and turkey (*Meleagris gallopavo*) application for predator management. The original legislative intent of this fee was to invest in 1) predator management, 2) predator research), 3) protection of sensitive species, and 4) public outreach. Additional requirements by Commission policy include an annual predator plan, an annual predator report, and the solicitation of input from the public, contractors, and other governmental jurisdictions. During the 2015 legislative session, the list of eligible expenditures were reduced to 1) predator management, 2) research on predator control techniques, and 3) protection of sensitive species. The revised statute also required that 80% of revenues be spent on lethal predator management. I will give a brief summary of the history of the $3 predator fee, predator management in Nevada, the fiscal year 2019 predator plan, and the implications for pronghorn (*Antilocara americana*) management in Nevada.

MODELING THE RESPONSE OF PRONGHORN TO VARYING DEGREES OF FENCING ON THE LANDSCAPE

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Abstract: Pronghorn (*Antilocapra americana*) are an endemic ungulate to the prairies of North America and their distribution is influenced by anthropogenic features on the landscape. Few studies have documented the influence of fences on pronghorn at large scales because of the difficultly in mapping the spatial location of fences. Using spatial and modelled fence location data for the Northern Sagebrush Steppe we modeled how fence density at the second–order (home range) and how the number of fence crossings at the third–order (with-in home range) affected selection by migrant and resident pronghorn. We then used the fitted fence density models at the second–order to assess the change in relative probability of use by pronghorn based on changes in fence density. We examined 2 fence density scenarios: 1) removal of fences and 2) doubling the existing fence density. We present the relationships of fence density and number of fence crossings from the final models and the change in probability of use from the 2 scenarios to demonstrate the effects of fences on selection by pronghorn.

LANDSCAPE GENOMIC ANALYSIS OF WYOMING PRONGHORN INFORMS POPULATION BIOLOGY AND NOMADIC BEHAVIOR

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Abstract: Landscape structure plays a central role in animal habitat use and movement. By determining how genetically different animals are from each other in the context of the landscape they live in, we can learn what types of landscape features most influence species distributions and movements. Genetic analyses complement other types of research such as GPS tracking by providing insight on the influence of landscape features on many generations of animals. We investigated landscape genetic patterns of pronghorn (*Antilocapra americana*) across the state of Wyoming, the core of remaining pronghorn range. Samples were collected in collaboration with the Wyoming Game and Fish Department, the Wyoming State Veterinary Laboratory, the Wyoming Cooperative Fish and Wildlife Research Unit, and the University of Wyoming Department of Ecosystem Science and Management during pronghorn captures and from harvested pronghorn. We applied genotyping-by-sequencing to identify thousands of single nucleotide polymorphism loci throughout the genome to characterize patterns of pronghorn genetic differentiation. This genomic method provides the statistical power to perform individual-based analyses (rather than more traditional population-based analyses), which is important for highly mobile organisms like pronghorn that might not cluster into distinct population units. Preliminary results provide support for the nomadic nature of this species, and further analyses will reveal the landscape features that most impact observed genetic patterns. Understanding how natural and

human-constructed landscape features influence genetic connectivity will provide valuable information for the long-term management and conservation of pronghorn in Wyoming and throughout their range.

PRONGHORN XING: IT'S ABOUT MORE THAN JUST TRYING TO GET TO THE OTHER SIDE!

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Abstract: In the Northern Great Plains, pronghorn (*Antilocapra americana*) undertake seasonal and long distance movements to meet life requirements. In southeastern Alberta, southwestern Saskatchewan, and northeastern Montana, highways fragment the landscape and cause direct morality and disrupt movement patterns. In 2017, Pronghorn Xing was launched in Alberta and Saskatchewan as a citizen science program developed to ground truth seasonal movement pinch-points identified by connectivity modeling across highways and increase public engagement in pronghorn science and conservation. In 2018, the program was expanded to include northeastern Montana, with a focus on engaging students in local high schools. Pronghorn Xing includes the use of smartphone technology and associated on-line mapping tool to increase efficiency, accuracy, and ease of data collection. We demonstrate the utility of the data at highlighting potential hot spots of pronghorn–road interactions. Ultimately, the dataset generated will be used to inform strategies to improve wildlife movement and improve both wildlife and human safety.

INFLUENCE OF AGRICULTURE ON PRONGHORN MOVEMENT, SURVIVAL, AND DIET IN THE TEXAS PANHANDLE

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Abstract: Pronghorn (*Antilocapra americana*) occur in 27 of the 56 counties in the Texas Panhandle Wildlife District. Pronghorn primarily feed on forbs, but little is known about how crops may be incorporated into their diet. Pronghorn may make seasonal tradeoffs when selecting between agricultural and rangeland environments. We are studying movements, home range, and response(s) to the rangeland–agricultural landscape using satellite collars deployed on 64 pronghorn in 2 study areas. We are examining dietary components of these study animals to more closely identify how they are using these habitats from a nutritional perspective. We are initiating a dietary component to the collaborative research project on pronghorn movements and resource selection using DNA metabarcoding of pronghorn fecal samples. To date, we have collected 102 fecal samples, 40 from native rangeland, 53 from croplands, 9 samples from unknown origin, and at 6 different sampling periods. Fifty samples were collected from bucks, 37 from does, and 15 from unknown sex. Samples are collected fresh from individuals after observed defecations, with site characteristics and GPS location noted. From 34 samples sent to Northern Arizona University for analysis, we

detected 58 plant genera. We will analyze the differences between diet and food habits between male and females spatiotemporally to more clearly identify how pronghorn use food resources in both landscapes. These data will be useful to identify plant species or genera that appear most frequently in pronghorn fecal samples that may help guide land managers in making regional pronghorn management decisions.

LAND COVER SELECTION VERSUS AVAILABILITY OF PRONGHORN IN THE TEXAS PANHANDLE

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Abstract: The North American prairie ecosystem is rapidly being replaced by urban expansion and agricultural activities. Native shortgrass and mixed-grass prairie land cover classes are regarded as habitat for pronghorn (*Antilocapra americana*). The effects of expanding agriculture development on pronghorn in the Texas Panhandle have not been documented. In February 2017, we attached satellite GPS collars with 2-hour fix intervals to 64 pronghorn in study areas near Dalhart and Pampa, Texas, each with 32 collars evenly distributed between sexes. We paired a used location (n = 204,800) with a random location within 1,266m, 90^{th} percentile of step lengths made by study animals to calculate odds ratios for use of the Texas Ecological Mapping System (TEMS) land cover classes in the Texas Panhandle. Pronghorn in the Dalhart study area selected mixed-grass prairies and Conservation Reserve Program–Improved grasslands over other classes like agricultural fields (30%) and sand prairies (25%) that are proportionally more available. Pronghorn in the Pampa study area selected agricultural field and sandy shrubland land covers while mixed-grass prairie (33%) and shortgrass prairies (18%) were proportionally more available. Selection for land cover classes varied among seasons and between sexes. Females, for example, selected classes containing more cover than males did during the fawning season. Identification of seasonal land cover use by pronghorn in relation to agricultural area use can help state wildlife managers to protect key areas of pronghorn forage and cover.

ENVIRONMENTAL CONSTRAINTS ON PRONGHORN NEONATE SURVIVAL ACROSS IDAHO

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Abstract: Neonatal survival in ungulates is 1 of several factors that can limit population growth. We examined whether neonatal survival might be limiting pronghorn (*Antilocapra americana*) populations in Idaho by estimating survival rates of fawns along a gradient of environmental variables across 3 study areas. We radiocollared pronghorn neonates (n = 217) in 3 distinct study sites across Idaho during 2015 and 2016. We determined the relative abundance of predators and alternative prey in all 3 study areas. We also examined variables (NDVI, fecal nitrogen, diaminopimelic acid [DAPA]) that can serve as surrogates of habitat quality and their influence on nutritional condition of does, and therefore fawn survival. We used Program MARK with known fates models to determine survival rates for 8 biweekly intervals. Mean annual fawn survival during the monitoring period across years and study sites was 0.42 (SE = 0.04). Our top model contained 3 variables: body mass index, lagomorph abundance, and DAPA, with the top model accounting for 84.3% of the model weights.

HOME RANGE OF TRANSLOCATED PRONGHORN IN THE TRANS-PECOS REGION OF TEXAS

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Abstract: Within the Trans-Pecos region of Texas, pronghorn (*Antilocapra americana*) were once as numerous as 17,000 individuals. However, population declines began in the 1980s with numbers falling below 3,000 in 2012. This population decline was because of several factors. Drought in the Chihuahuan Desert had a large effect on the amount of forage available to support the pronghorn population. Historical overgrazing and fire suppression led to brush encroachment, causing a decrease in the amount of available habitat. Additionally, predation and parasites have been attributed to causes of population decline in Texas. In 2011, restoration efforts were initiated through translocating pronghorn to supplement declining populations. While translocation strategies have helped to increase pronghorn numbers in the Trans-Pecos thus far, translocations of large ungulates can be challenging. To evaluate translocation outcomes and movement post-release during restoration events, 40 adult females translocated in 2017 were affixed with Global Positioning System radiocollars and were programed to stay on the individuals until summer 2018. Ongoing research is focused on home ranges, movements, and habitat use for comparison of pronghorn in other regions. Expected outcomes from this study will benefit management by providing information on the effects of releasing the animals into a new environment, gaining knowledge of habitat used, and identifying movement corridors.

POTENTIAL HABITAT FEATURES INFLUENCING NEONATAL PRONGHORN SURVIVAL IN THE NORTHERN SACRAMENTO MOUNTAINS OF NEW MEXICO

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Abstract: Juvenile recruitment is often cited as the limiting factor for population growth and persistence in pronghorn (*Antilocapra americana*) populations. Low recruitment near Capitan, NM from 2013–2015 prompted continued research into limiting factors for fawn survival during 2016–2017. Between May 3 and June 1, 2016 and 2017, 101 fawns ($\leq$ 5 days old) were captured, 25% of which were associated with translocated does. Naïve survival estimates for 2016 and 2017 were 23% and 20%, respectively. Overall Mayfield daily survival rate was 0.964, and Kaplan Meier survival estimates for 2016 and 2017 were 0.11 and 0.12, respectively. Predation, mainly attributed to coyote (*Canis latrans*) and bobcat (*Lynx rufus*), accounted for 69% of mortalities; 76% of fawn mortalities occurred $\leq$18 days of age. Habitat data were collected at 79 capture locations (56 in 2016, 45 in 2017) and 170 random locations (94 in 2016, 75 in 2017) at several spatial scales. Preliminary analyses indicate annual variation in most habitat features. Mean vegetation height, woody density, percent forb cover, and percent woody cover varied ($P < 0.05$) between fawn

bed sites and random locations. Similarly, bed site habitat characteristics such as mean vegetation height, percent woody cover, and distance to nearest road ($P < 0.05$) varied between fawns that survived and those that did not within each year. These preliminary analyses will be used to develop *a priori* MARK survival models and expand into GIS and local weather data to more precisely characterize features that might influence fawn survival in this portion of New Mexico.

GREEN, GREEN, ROCKY INTERSTATE: USING GPS-TELEMETRY TO PREDICT PAST MIGRATIONS BEFORE INTERSTATE-80

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Abstract: Upon its completion, the Wyoming section of Interstate-80 severed migration corridors known to be used by pronghorn (*Antilocapra americana*) to access critical winter range. Today, the interstate acts as an impermeable barrier to pronghorn movement across southern Wyoming. The purpose of this study is to predict the historical location of lost migration corridors to best inform placement of new overpasses. We will use a step-selection function to assess the features significant to pronghorn migration corridors using a large pronghorn GPS-collar dataset (n = 167 individuals, n = 3 herds). Explanatory variables will include topographic features, spring forage quality, autumn forage quality, snow depth and landscape heterogeneity. The resulting step-selection function will then be used as a resistance surface to predict the likely locations of historical migration corridors. To verify our predictions, we have established trail cameras along 26 underpasses between Elk Mountain and Evanston, Wyoming. If our model is accurate, then we expect there to be overlap with the predicted corridors and high-use underpasses. The predictive map of corridor likelihood from this study will be used to inform land managers of optimal locations to restore movement across the interstate and help ameliorate the effect of this statewide barrier.

COLVILLE CONFEDERATED TRIBES PRONGHORN REINTRODUCTION PROJECT

KELLY SINGER, Colville Confederated Tribes, WA, USA.

Abstract: The Colville Reservation is about 566,560 hectares in size, located in north central Washington, and composed of 12 Tribes with traditional territories that span the majority of eastern Washington and the Columbia Basin. The Tribes of the region historically used pronghorn (*Antilocapra americana*) for subsistence in addition to salmon (*Oncorhynchus* spp.) and other natural resources (Hart 2003). At one time, pronghorn were as numerous as the bison (*Bison bison*) in the interior grassland and plains of the western states (McClung 1993). "Antelope were hunted only during the summer and fall. They roamed in considerable numbers about the prairies south of the Columbia River, especially in the vicinity of the Grand Coulee" (Ray 1933). Pronghorn were extirpated from the State of Washington during European settlement; archeological and ethnographic records substantiate their sparse existence by the 1900s (Ray 1933). In 2004, the Colville Tribes Fish and Wildlife Department (CCTFWD) began a feasibility study to reintroduce pronghorn onto the Colville Reservation. We used protocols developed by the USFWS known as Habitat Evaluation Procedures that measure the quality and quantity of available habitat for selected wildlife species and apply a numerical value known as a Habitat Suitability Index. We used pronghorn model to evaluate whether Colville Reservation lands would adequately fulfill the habitat requirements for pronghorn. In 2014, the Tribes initiated informal discussions with the Nevada Department of Wildlife (NDOW) and began planning the first of 2 transplants that would occur from Nevada to the Colville Reservation. On January 27, 2016 the first CCTFWD reintroduction effort in coordination with NDOW successfully aerial captured and transplanted 52 pronghorn, 42 with GPS collars, from the Simpson Park Mountains to the Colville Reservation. On October 23 and 24, 2017, another 98 pronghorn, 48 with GPS collars, were transplanted from Elko, NV to the Colville Reservation. The CCTFWD

continues to monitor habitat use, seasonal movements, cause specific mortality, annual recruitment, and overall population composition using a combination of GPS collar data with ground and aerial surveys. Educational outreach to landowners in the public and private sector regarding pronghorn-friendly fencing is ongoing and may be the biggest challenge facing this reintroduced population.

BEYOND PROTECTED AREAS: PRIVATE LANDS AND PUBLIC POLICY ANCHOR INTACT PATHWAYS TO MULTISPECIES WILDLIFE MIGRATION

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JOSEPH T. SMITH, University of Montana, W.A. Franke College of Forestry and Conservation, 32 Campus Drive, Missoula, MT 59812, USA.
DAVID E. NAUGLE, University of Montana, W.A. Franke College of Forestry and Conservation, 32 Campus Drive, Missoula, MT 59812, USA.

Abstract: Conserving and managing for wildlife migration can pose great challenges to land managers, as the scale of migration can eclipse the area encompassed by seasonal habitat requirements. The Northern Sagebrush Steppe (NSS) spans the prairies of Alberta, Saskatchewan, and Northern Montana. Here, both pronghorn (*Antilocapra americana*) and greater sage-grouse (*Centrocercus urophasianus*) make the longest recorded migrations for both species as a strategy to negotiate both environmental gradients and anthropogenic factors. We fit Brownian Bridge Movement Models to identify key migratory pathways for pronghorn and sage-grouse to assess migratory overlap spatiotemporally between these 2 species. We used pathways to identify conservation and management opportunities from a multispecies standpoint, and assessed how well sage-grouse Priority Areas for Conservation conserved multispecies migration. As cultivation poses the greatest threat to migration in this landscape, we developed a prioritization tool that identifies strategic areas for conservation easement consideration based on overlapping multispecies migratory pathways, relative risk of cultivation, and land tenure. Currently, we found that Northern Montana continues to sustain migration by both species, though portions of these pathways face continued risk from cultivation. Given this increased risk and limited resources, this approach identifies opportunities to work with private landowners and work together towards conservation while maintaining working landscapes.

DO WE SEE AN INCREASE IN SUCCESSFUL FENCE CROSSINGS BY PRONGHORN WHEN A GATE IS LEFT OPEN?

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Abstract: Between 2013 and 2016, we set up trail cameras on 4 fence gate posts in a known winter range and migration corridor for pronghorn (*Antilocapra americana*) within the National Wildlife Area of the Suffield Canadian Forces Base in southern Alberta, Canada. We processed and analyzed camera trap images and video clips to determine the mean number of successful crossings/day of pronghorn from 1 pasture into another when the gate was open verses when the gate was closed. Preliminary results indicate that no significant difference ($P = 0.21$) exists in the mean number of successful animal crossings/day between open or closed gates. We suggest more research is necessary comparing animal crossings/day at open and closed gates using a Before-After-Control-Impact study design with a larger sample size. Consideration for how environmental variability (e.g., snow depth) affects crossing rates when gates are left open and closed is also recommended.

DEVELOPING BEST MANAGEMENT PRACTICES FOR HANDLING AND TRANSLOCATION OF PRONGHORN: LESSONS LEARNED

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In western US states, pronghorn (*Antilocapra americana*) are regularly translocated to establish new populations or supplement existing populations. Capture and translocation of pronghorn may result in higher injury and mortality rates in comparison with other North American ungulate species. The risk of acute capture injury and post-release mortality can be reduced by careful pre-capture planning, working with an experienced capture team, using appropriate sedatives and tranquilizers, and providing supportive care during transport and release. We report the results of a 2017 pronghorn translocation from Nevada to Washington State and further discuss best management practices for pronghorn capture based on experiences from wildlife professionals from multiple western US states.

Registered Attendees
(State Representatives Underlined)

Travis Allen, Nevada Department of Wildlife
Dallas Barber, Oklahoma Department of Wildlife Conservation
Joe Bennett, Nevada Department of Wildlife
Cole Bleke, Utah State University
Steven Borrego, Yakama Nation
Philip Boyd, Sul Ross State University-Borderlands Research Institute
<u>Erin Butler</u>, Arizona Game and Fish Department
Russell Castro, USDA-NRCS
Warren Conway, Texas Tech University
Melanie Cota, Bureau of Land Management Carson City District Office
Mike Cox, Nevada Department of Wildlife
Pat Cummings, Nevada Department of Wildlife
Manuel Deleon, USDA-NRCS
<u>Ryan DeVore</u>, Montana Fish, Wildlife and Parks
Glen Dickens, Arizona Antelope Foundation
Jeffrey Dolphin, Nevada Department of Wildlife
Tom Donham, Nevada Department of Wildlife
<u>Orrin Duvuvuei</u>, New Mexico Department of Game and Fish
Shawn Espinosa, Nevada Department of Wildlife
David Garcelon, Institute for Wildlife Studies
Clint Garrett, Nevada Department of Wildlife
Emily Gelzer, Wyoming Cooperative Fish and Wildlife Research Unit
Carlos Gonzalez, Borderlands Research Institute
<u>Shawn Gray</u>, Texas Parks and Wildlife
Rich Guenzel, Wyoming Game and Fish Department (Retired)
Chris Hampson, Nevada Department of Wildlife
Mike Hess, Nevada Department of Wildlife (Retired)
Bryan Hockett, Bureau of Land Management
<u>Andy Holland</u>, Colorado Parks and Wildlife
James Hoskins, Texas Parks and Wildlife Department
Brian Hudgens, Institute for Wildlife Studies
Kari Huebner, Nevada Department of Wildlife
Pat Jackson, Nevada Department of Wildlife
Andrew Jakes, National Wildlife Federation
Matt Jeffress, Nevada Department of Wildlife
Paul Jones, Alberta Conservation Assocation
Steve Kimble, Nevada Department of Wildlife
Charles Kneuper, USDA-NRCS
Lee Knox, Wyoming Game and Fish Deartment
Alice Koch, California Department of Fish and Wildlife
Bob Koch, California Department of Fish and Wildlife (Retired)
Jordan Kraft, Wyoming Game and Fish Department
Katrina Krause, Bureau of Land Management, Carson City

Melanie LaCava, University of Wyoming
Carl Lackey, Nevada Department of Wildlife
Autumn Larkins, Oregon Department of Fish and Wildlife
ANDY LINDBLOOM, South Dakota Game, Fish and Parks
Jacob Locke, Borderlands Research Institute
Jeremy Lutz, Nevada Department of Wildlife
Cody McKee, Nevada Department of Wildlife
Kody Menghini, Nevada Department of Wildlife
Dustin Mitchell, Utah Division of Wildlife
Hollie Miyasaki, Idaho Department of Fish and Game
Gary Mizer, Texas Tech University
Cooper Munson, Nevada Department of Wildlife
Tyler Nall, Nevada Department of Wildlife
Kyle Neill, Nevada Department of Wildlife
Jennifer Newmark, Nevada Department of Wildlife
Josh Nowak, University of Montana
HEATHER O'BRIEN, Wyoming Game and Fish Dept
Daniel Olson, Utah Division of Wildlife
Anthony Opatz, CKWRI - Texas A&M University Kingsville
Anne Orlando, US Forest Service
Brett Panting, Idaho Fish and Game
Ed Partee, Nevada Department of Wildlife
MATT PEEK, Kansas Dept of Wildlife, Parks and Tourism
Howell Pugh, Sul Ross State University-Borderlands Research Institute
Courtney Ramsey, Texas Tech University
Benjamin Robb, Wyoming Cooperative Fish and Wildlife Research Unit
Jack Robb, Nevada Department of Wildlife
Scott Roberts, Nevada Department of Wildlife
Salvador Salinas, USDA-NRCS
Jason Salisbury, Nevada Department of Wildlife
CODY SCHROEDER, Nevada Department of Wildlife
Mike Scott, Nevada Department of Wildlife
Kelly Singer, Colville Confederated Tribes
WESTON STORER, Oklahoma Department of Wildlife Conservation
Austin Teague, New Mexico Game and Fish
Rana Tucker, Arizona Game and Fish Department
Mike Verhage, Alberta Conservation Assocation
Brian Wakeling, Nevada Department of Wildlife
DON WHITTAKER, Oregon Department of Fish and Wildlife
Colton Wise, Institute for Wildlife Studies
Peregrine Wolff, Nevada Department of Wildlife

BUSINESS MEETING DRAFT MINUTES
TWENTY-EIGHTH BIENNIAL WESTERN STATES AND PROVINCES PRONGHORN WORKSHOP
4:00P, AUGUST 15, 2018
RENO, NV

1. Call to order

Brian Wakeling (Nevada) called the meeting to order at 4:00p.

2. Roll call of states

Cody Schroeder representing Nevada
Hollie Miyasaki representing Idaho
Don Whittaker representing Oregon
Andy Lindbloom representing South Dakota
Matt Peek representing Kansas
Andy Holland representing Colorado
Erin Butler representing Arizona
Ryan DeVore representing Montana
Shawn Gray representing Texas
Orrin Duvuvei representing New Mexico
Weston Storer representing Oklahoma
Heather O'Brien representing Wyoming

Others in attendance:
Brian Wakeling, Nevada
Kelly Singer, Colville Tribes
Steven Borrego, Yakama Nation
Autumn Larkins, Oregon
James Hoskins, Texas
Austin Teague, New Mexico
Dallas Barber, Oklahoma
Rich Guenzel, Wyoming (retired)
Jordan Kraft, Wyoming

3. Review agenda, other items of interest to discuss

Wakeling reviewed the agenda with attendees. No amendments to agenda, approved as is.

4. Approval of 2016 minutes

The minutes were reviewed and approved.

5. Progress on action items

   a. Update on WAFWA sanctioning, handling of registration, expenses, and other issues.

Wakeling reviewed the process used with WAFWA. WAFWA hosts the registration, which worked very effectively. WAFWA provided a credit card that could be used to cover expenses related to the workshop, but it was important to budget appropriately. The proceeds from one workshop carries over to the next, but Montana (prior host) had the first workshop handled under new process. The account for this workshop had a beginning balance of $67, but WAFWA was able to establish a direct billing account with the hotel so that advance deposits were unnecessary. WAFWA reviews each billing with workshop liaison (in this case Wakeling and Schroeder) prior to paying bills. WAFWA keeps a precise accounting spreadsheet of all revenue and expenses which they also review with workshop liaison prior to finalizing.

Nevada had a grand total of 92 registrants (83 participants, 7 guests, 2 vendors) that represented 29 agencies and organizations and 15 different states and provinces. Gross revenue totaled $19,925.00 and expenses totaled $14,718.05, leaving a preliminary balance of $5,206.95 before printing of a limited number of proceedings and before final audit.

   b. Revisit frequency of meetings

The frequency with which the workshop is held was discussed. This was a topic of discussion at the last business meeting, and the challenge of having an adequate number of presentations was prevalent again this year. The merits of changing to a 3-year cycle, similar to that used for the mountain lion and bear workshops was discussed. In this discussion, the increased funding for migration corridor research and conservation through the Department of Interior's Secretarial Order 3362 led participants to conclude that there will be an increase in activity on pronghorn in the near future and that it would be appropriate to see if this had an influence on research and management activity for the next workshop. No change to the frequency of the workshop was proposed.

   c. Information on WAFWA website

The proceedings of all the 27 prior pronghorn workshops are now posted on the WAFWA website. In addition, the Pronghorn Management Guidelines and the pronghorn bibliography are also posted, along with the current bylaws.

   d. Bylaws (current on website is 1998 version, reflects "pronghorn antelope"

The need to review and update the bylaws was discussed. Andy Lindbloom (South Dakota) anticipated that his state would host the next workshop, and the process for reviewing the bylaws was discussed. It was suggested that Lindbloom could establish a committee to review the bylaws, in discussion with WAFWA, and then propose a revision at the next business meeting if so desired.

6. Next host (and subsequent host)

South Dakota was selected to host the Twenty-ninth Biennial Western States and Provinces Pronghorn Workshop. Oklahoma was selected to host the Thirtieth.

7. Award information

The awards will be announced at the banquet this evening.

8. Adjourn

The meeting adjourned at 5:20p.

Awards

BERRENDO AWARD

This award is the most significant award offered through the WAFWA-sanctioned Pronghorn Workshop. One award per workshop is given to an individual or a group of collaborators who have made great contributions to management or research for pronghorn. The award is named for a desert pronghorn, an animal that epitomizes the difficulty of being a pronghorn.

Nomination Criteria:

1. An individual, organization, or group of collaborators that has gone well beyond normal job expectations in a project related to pronghorn.
2. These contributions need to afford significant scientific advances in the management or research of pronghorn.
3. These contributions can represent a single event or a long-term commitment to pronghorn.

Previous Recipients:

2002 Jim Yoakum (deceased)
2004 Bart O'Gara (deceased)
2006 Tom Pojar
2008 Richard Ockenfels
2010 Rich Guenzel
2012 Not awarded
2014 Tommy Hailey
2016 Jorge Cancino

2018 RECIPIENT

JOHN A. BYERS

Dr. John A. Byers is an animal behaviorist and Professor in the Department of Biological Sciences at the University of Idaho in Moscow, well-known for his long-term study of sexual selection, female mate choice, reproductive success, and other aspects of pronghorn behavior and ecology, which he has been conducting on the National Bison Range in Montana since 1981. His research has generated numerous peer-reviewed publications and other articles on the species. In 1998, The Wildlife Society awarded John the Book of the Year for his *American Pronghorn: social adaptions and ghosts of predators past*. John is also studying interactions among pronghorn, coyotes and wolves in Yellowstone National Park.

In 2003, John published *Built for Speed: a year in the life of the pronghorn* (Harvard University Press), an excellent popular book describing the pronghorn. This book promotes understanding of many aspects of the life history of the pronghorn. Its educational contribution helps build public support for pronghorn and may be as important to pronghorn conservation as some of the management actions implemented by agencies.

PRONGHORN HALL OF FAME

The Pronghorn Hall of Fame was created to honor historic individuals or groups-teams that accomplished outstanding services for pronghorn conservation prior to the establishment of the Berrendo Award (i.e., before 2002). Those involved in pronghorn conservation today owe much to the efforts of pronghorn biologists, managers, researchers, and other conservationists that produced worthy efforts prior to the establishments of any awards. The Pronghorn Hall of Fame awards are an ongoing effort to formally recognize the careers and long-term contributions of our predecessors. There is no limit as to the number of Hall of Fame awards to be given at a Pronghorn Workshop, however, it is likely that only 1 or 2 will be granted at any particular Pronghorn Workshop.

<u>Nomination Criteria</u>:

The nominee must be retired or deceased (criteria accepted at 2006 Pronghorn Workshop).

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

<u>Previous Inductees</u>:

A. Jim D. Yoakum and Bart W. O'Gara (2002 and 2004 Berrendo Award recipients) automatically inducted.
B. Tom M. Pojar (2006 Berrendo Award recipient) automatically inducted.
C. 2008 – Arthur S. Einarsen (OR), Helmut K. Buechner (TX), and T. Paul Russell (NM) elected as members.
D. Richard A. Ockenfels (2008 Berrendo Award recipient) automatically inducted.
E. 2016 – William G. Hepworth elected as member.

2018 INDUCTEES

JOHN A. BYERS and GEORGE TSUKOMOTO

In 2018, **John A. Byers** was automatically inducted into the Pronghorn Hall of Fame after receiving the Berrendo Award.

In addition, **George Tsukamoto**, who had retired from the Nevada Department of Wildlife was also inducted.

George Tsukamoto's definitive work on writing the first ever pronghorn species management plan for Nevada in 1983 set the stage for modern day pronghorn restoration efforts. George was a visionary, decades ahead of his time, who lead NDOW and dedicated sportsmen to restoring pronghorn, elk, and bighorn sheep to their historic ranges statewide. Over 1,400 pronghorn were translocated into Nevada during George's tenure with Game Division, much while he served as Chief of Game. George was instrumental in approving and securing funding for many water developments that benefitted pronghorn and other wildlife species. Bart O'Gara and Jim Yoakum acknowledged George Tsukamoto's assistance in their 2004 Wildlife Management Institute book, *Pronghorn Ecology and Management*.

George Tsukamoto had a very distinguished career with Nevada Department of Wildlife, starting in 1962 and working his way up through the ranks to Chief of Game from 1982 to 1995, before moving to Washington until 2005. George served as Interim Director of Nevada Department of Wildlife in 2013. George was renowned as both an outstanding biologist and an excellent administrator and leader which is a very rare combination. He was known for empowering biologists, promoting teamwork, and encouraging creative solutions. He is still highly regarded by his peers and current NDOW biologists. George serves as an official scorer for the Boone and Crockett Club. He served as president of the Western Section of The Wildlife Society in 1981–1982. Many within NDOW consider him to be the "father of big game management in Nevada." His leadership, passion, knowledge, and dedication guided the highly successful restoration, conservation, and management of pronghorn in Nevada.

SPECIAL RECOGNITION AWARD

Many people or organizations make significant contributions that aid in the management of pronghorn. These can include projects that are oriented to pronghorn management or research. The Special Recognition Award is a certificate recognizing the accomplishments of an individual or group. Up to 4 awards can be presented at each Workshop.

Nomination Criteria:

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

Previous Recipients:

2002 Karl Menzel, NE, Jorge Cancino, BCS, MX, Bill Rudd, WY, and Richard Ockenfels, AZ
2004 Rich Guenzel, WY, Alice Koch, CA, John Hervert, AZ, and Arizona Antelope Foundation
2006 Rick Danvir, UT, Fred Lindzey, WY, and Rick Miller, AZ
2008 Morley Barrett, AB, David Brown, AZ
2014 Joe Riis, SD, Hall Sawyer, WY, and Emilene Ostlind, WY
2016 Jorge Cancino, BCS, MX, and Paul Jones, AB, CA

2018 Recipients

Bill Rudd, Matt Kauffman, Ken Gray, Tom Warren, Charlie Clements, and Jim Young

Bill Rudd and Matt Kauffman were recognized for their efforts to establish The Wyoming Migration Initiative and to develop the program into an internationally leading effort for the identification and conservation of migration routes and stopover habitats, and the development of wildlife-friendly crossings. The Wyoming Migration Initiative evolved from years of efforts to identify important migration crossings of pronghorn and other ungulates, especially with regard to highway fences and energy development. These efforts ultimately led to the construction of highway overpasses for pronghorn in Wyoming and other ways to protect important migration habitats, facilitate crossings, reduce vehicle-wildlife collisions, and to mitigate development. A key lesson in these efforts was the need to effectively disseminate scientific information to managers, the public and other concerned parties in a timely manner to garner support.

A key aspect of The Wyoming Migration Initiative is public outreach, including videos and other materials made available via the internet and social media to convey research implications to lay audiences, conservation organizations, and public land managers. As an example, efforts to document Wyoming's Path of the Pronghorn migration from Jackson to Rock Springs were highly influential in generating public support for conservation of migration routes and key habitats, as well as the construction of highway overpasses at essential crossings. These demonstrated the advantages of informing the public to enlist support. The Wyoming Migration Initiative has expanded these efforts to mule deer and elk in western Wyoming.

The Wyoming Migration Initiative is internationally recognized as one of the leaders in applied research on ungulate migration ecology. The efforts of Bill Rudd and Matt Kauffman, through The Wyoming Migration Initiative, have significantly enhanced consideration and conservation of pronghorn and other migratory ungulates in Wyoming and elsewhere.

Ken Gray, Tom Warren, Charlie Clements, and Jim Young were recognized for their dedicated and passionate efforts to evaluate, conduct research and trials, promote, and implement the use of "Immigrant" forage kochia (*Kochia prostrata*) as a sagebrush surrogate in wildfire reseeding-noxious plant habitat restoration efforts on private and Bureau of Land Management (BLM) lands within northeastern Nevada. Their efforts greatly benefited thousands of pronghorn in low elevation winter ranges. These expansive areas dominated by cheatgrass with no vegetative structure or diversity resulted in the loss of nutritional forage needed for winter survival of pronghorn and mule deer. Nevada Department of Wildlife (NDOW) documented extensive pioneering of pronghorn herds that grew from several hundred to over a thousand animals during the last 20 years in habitats previously dominated by invasive annual grasslands that were partially rehabilitated with "Immigrant" forage kochia seedings. Previous efforts to restore sagebrush and other native species on these degraded low elevation ranges were mostly unsuccessful. Ken Gray, field biologist for NDOW who was managing mule deer and pronghorn populations clearly documented landscape scale impacts to his herds by massive catastrophic wildfires since the 1960s. Fires were attributable to highly volatile and dense fine fuel loads developed from decades of cheatgrass invasion into historic sagebrush-dominated upland communities that are critical habitats to sage grouse, mule deer, and pronghorn populations. Native plants and their seed banks were unable to compete with invasive nonnative plants converting huge areas of once productive big sagebrush-perennial grass communities to a monotypic wasteland of invasive plants that are inadequate to support pronghorn herds, especially under normal winter conditions.

The need existed to find an alternative surrogate species that was palatable, high in nutritional value, non-invasive, and that could successfully compete with cheatgrass and other shallow rooted nonnative annual plants. That is when Ken and BLM range ecologists reached out to Dr. Young and Charlie Clements with United States Department of Agriculture, Agriculture Research Service. They developed a collaborative group with broad expertise in ungulate ecology, habitat restoration, knowledge of wildfire reseeding process, seedbank and seedling survival research, and host of other valuable scientific and practical experience in seeking a solution to the problem. Through the group's tireless monitoring and research efforts, they were successful in having BLM approve the use of "Immigrant" forage kochia in the standard wildlife habitat post-fire seed mix used on previously low elevation and highly degraded sagebrush-dominated plant communities. Tom Warren, BLM rehabilitation manager, played a significant role in implementing these changes. Nevada's pronghorn population has doubled from 15,000 in 1990 to 30,000 in 2018, with many herds reliant and thriving on the sagebrush surrogate "Immigrant" forage kochia to meet their dietary needs.