



In Cooperation with the University of Arizona, School of Natural Resources

Sonoran Pronghorn Literature: An Annotated Bibliography



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U.S. Geological Survey



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By Paul R. Krausman, John R. Morgart, Lisa K. Harris, Chantal S. O'Brien, James W. Cain III, Steve S. Rosenstock.

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**U.S. Department of the Interior
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USGS Southwest Biological Science Center
Sonoran Desert Research Station
University of Arizona
School of Natural Resources
125 Biological Sciences East
Tucson, Arizona 85721

U.S. Department of the Interior
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P. Patrick Leahy, Acting Director

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Authors

Paul R. Krausman and James W. Cain III
325 Biological Sciences East Building
School of Natural Resources
University of Arizona
Tucson, AZ 85721

Lisa K. Harris
Harris Environmental
1749 East 10th Street
Tucson, AZ 85719

John R. Morgart
New Mexico Ecological Services Field Office
U.S. Fish and Wildlife Service
2105 Osuna, Northeast
Albuquerque, NM 87113

Chantal S. O'Brien and Steve S. Rosenstock
Arizona Game and Fish Department
2221 West Greenway Road
Phoenix, AZ 85023

U.S. Geological Survey Sonoran Desert Research Station Personnel

Charles Van Riper III, Station Leader
Steve P. Gloss, Ecologist
William L. Halvorson, Research Ecologist
Cecil R. Schwalbe, Ecologist
Michael R. Kunzmann, Ecologist

Program and Expertise Areas of USGS and UA Personnel

Administration & Outreach

Cori Dolan
Wendy Parrish
Charles Van Riper III

Fire Management

Cori Dolan
James Feldmann
Bill Halvorson

Avian Ecology

Claire Crow
Glenn Johnson
Mike Kunzmann
Chris O'Brien
Brian Powell
Charles Van Riper III

Invasive Species Research

Patricia Guertin
Jim Malusa
Phil Rosen
Cecil Schwalbe
Brent Sigafus
Dennis Suhre

Data Management

Mike Kunzmann
Brent Sigafus

Inventory & Monitoring

Patricia Guertin
Bill Halvorson
Brian Powell
Cecilia Schmidt

Ecology of Amphibians & Reptiles

Kevin Baker
Cristina Jones
Dave Prival
Phil Rosen
Cecil Schwalbe
Brent Sigafus
Eric Stitt
Dennis Suhre

Vegetation Mapping & Ecology

Patricia Guertin
Bill Halvorson
Jim Malusa

USGS Southwest Biological Science Center <http://sbsc.wr.usgs.gov>

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EXECUTIVE SUMMARY

The Sonoran pronghorn (*Antilocapra americana sonoriensis*) is 1 of 5 subspecies of pronghorn in North America. Sonoran pronghorn historically ranged from eastern California into southeastern Arizona and south to Sonora, Mexico. Sonoran pronghorn currently inhabit the Sonoran Desert in Southwestern Arizona and northern Sonora, Mexico. Unfortunately, their future in North America is uncertain. In the United States, as of December 2004, there were <51 free-ranging individual Sonoran pronghorn. This subspecies has been listed as endangered by the United States Fish and Wildlife Service since 1967. Because of the rapid decline in population size, biologists and managers increased management efforts to reverse the downward spiral to extinction.

To assist with enhanced management we have compiled an annotated bibliography of most of the works published on Sonoran pronghorn including peer-reviewed papers ($n = 31$, including submitted manuscripts), books ($n = 26$), theses and dissertations ($n = 5$), conferences, proceedings and symposiums ($n = 31$), reports ($n = 84$), abstracts ($n = 14$), popular articles ($n = 41$), and others ($n = 4$). These are the same categories under which we list annotations.

Most of the articles involve *A. a. sonoriensis*. We present the scientific name of other pronghorn when clarification is needed.

PEER-REVIEWED ARTICLES

Bleich, V. C. 2005. In my opinion: politics, promises, and illogical legislation confound wildlife conservation. *Wildlife Society Bulletin* 33: 66-73.

The author discusses the 1872 Mining Law, the Taylor Grazing Act, the Wild Horse and Burro Act, the Endangered Species Act, and the California Desert Protection Act, and their interaction and influence on the

management of wildlife including Sonoran pronghorn.

Bright, J. L., and J. J. Hervert. 2005. Adult and fawn mortality of Sonoran pronghorn. *Wildlife Society Bulletin* 33: 43-50.

The authors documented adult mortality and fawn recruitment of Sonoran pronghorn in Arizona. This population is endangered ($n < 30$) and is decreasing due to low fawn recruitment and adult mortality. The authors radiocollared Sonoran pronghorn to monitor survival and recruitment from 1995 to 2002. They relocated each radiocollared pronghorn during weekly telemetry flights from a fixed-wing airplane and recorded group composition to determine recruitment. Mortalities detected during flights were investigated as soon as possible (i.e., <48 hours) to document adult mortality. Adult mortality rates varied from 11 to 83%/year. Adult pronghorn were killed by coyotes, bobcats, mountain lions, capturing efforts, drought, and unknown causes. Fawn mortality varied from year to year and was correlated with the amount and timing of rainfall. Drought may be a major factor in the survival of adults and fawns. A lack of nutritious forage and water, caused by dry conditions, led to high fawn mortality, and during a particularly severe drought, caused adult mortality. Drought may also indirectly affect adult mortality by causing animals to use areas where predators are more successful. Disease may affect mortality but remains largely uninvestigated. Management applications aimed at increasing fawn recruitment and reducing adult mortality should increase the chances of survival of this species. Providing sources of highly nutritious forage during early spring and summer when fawns are susceptible to poor nutrition may increase their chances of survival. Providing water sources and nutritious forage in areas where predators are less successful may increase adult and fawn survival. Predator control may be useful in limited situations, but would likely be prohibitively expensive with little chance of

making a difference over the entire range of Sonoran pronghorn.

Cancino, J., V. Sanchez - Sotomayor, and R. Castellanos. 2005. From the field: capture, hand raising, and captive management of peninsular pronghorn. *Wildlife Society Bulletin* 33: 61-65.

The peninsular pronghorn (*Antilocapra americana peninsularis*) in Baja California peninsula is an endangered subspecies. The authors constructed captive breeding facilities in the Vizcaino Desert, within the current range of peninsular pronghorn to assist in population recovery. The captive breeding facilities included fences, shade, feeders, an irrigation system, observation towers, housing for caretakers, and a visitor center. The authors document the initial 3-year cycle of the captive management, just 1 step of the recovery effort, from the first capture (of 5 fawns in 1998) to the final count of 90 captive peninsular pronghorns at the end of 2003. The authors identified problems with the identification of the animals, their segregation, movements and accidents with fences. Overall the captive rearing facility has been a partial success and the first translocation of animals into the wild was scheduled for 2004.

Castillo-Sánchez, C. 1994. La Reserva de la Biosfera el Pinacate y Gran Desierto de Altar. *Ecologica* 3: 25-26.

The author describes the Pinacate in Sonora, Mexico as a reserve in part, for Sonoran pronghorn. The Sonoran pronghorn in Sonora, Mexico is threatened by uncontrolled human activity.

deStefano, S., S. L. Schmidt, and J. C. deVos, Jr. 2000. Observations of predator activity at wildlife water developments in southern Arizona. *Journal of Range Management* 53: 255-258.

Wildlife water developments have been constructed and maintained throughout the arid western United States to benefit big

game and upland game bird populations. Management and recovery of water sources may be important for the recovery of Sonoran pronghorn. There is debate, however, over possible detriments to wildlife from artificial water sources in deserts and other arid environments. One concern is that water developments attract predators, which then impact the prey populations that these developments are intended to benefit. To examine the extent of predator activity around water developments, the authors examined 15 paired water and non-water (random) sites for sign (i.e., scats, tracks, visual observations, animal parts such as feathers and bones, and carcasses) of predators and prey. Predator sign was 7X greater around water sites than non-water sites ($P = 0.002$). Coyote sign accounted for 79% of all predator sign and was 7X greater near water than away from water ($P = 0.006$). Amount of sign for all prey species combined was not different between paired sites ($P = 0.6$), but results for individual species and groups of species was variable: passerine and gallinaeous bird sign was greater around water sites ($P = 0.008$), ungulate sign was not different between water and non-water sites ($P = 0.20$), and lagomorph sign was almost 2X greater away from water than near water ($P = 0.05$). Predators were probably attracted to wildlife water developments to drink rather than hunt: without water developments, predators may be even more concentrated around the fewer natural water sites.

deVos, J.C., Jr., and W.H. Miller. 2005. Habitat use and survival for Sonoran pronghorn in years with above average rainfall. *Wildlife Society Bulletin* 33: 35-42.

Sonoran pronghorn occur in an arid desert in northwestern Sonora, Mexico and southwestern Arizona; their numbers have declined since 1920. Causes of the decline are largely speculative, but include habitat alteration by humans, excessive herbivory by domestic livestock, illegal harvest, and exposure to domestic livestock diseases. The authors initiated this study to develop information on habitat use and survival to aid

in developing recovery strategies for Sonoran pronghorn. They captured 19 Sonoran pronghorn and monitored their movements and habitat use patterns from 1983 through 1991 and compared these locations to random locations to assess habitat use. The authors also calculated survival. Sonoran pronghorn used the creosotebush-white bursage-paloverde-mixed cacti association greater than expected. Locations of Sonoran pronghorn close to water occurred more frequently than random locations and areas most distant from waters were used less than expected. Sonoran pronghorn used areas within 1 km of roads less than random locations and locations >1 km from roads were used as expected or greater than expected as distance increased from roads. Mean annual estimated survival for females was 0.96, with mean estimated annual male survival of 0.92. Female mortality was attributed to coyote predation. Males died of unknown causes. Sonoran pronghorn had very low mortality rates and the population expanded to levels that likely have not occurred since the 1920s.

Fox, L. M., P. R. Krausman, M. L. Morrison, and R. M. Katting. 2000. Water and nutrient content of forage in Sonoran pronghorn habitat, Arizona. California Fish and Game 86: 216-232.

Authors examined diets of Sonoran pronghorn to determine if they could meet their total water requirements with and without selective foraging. Water availability was based on seasonal measures of plant species composition, moisture, and nutrient content at 2 sites within Sonoran pronghorn range in southwestern Arizona from June 1995 to May 1996. Authors measured vegetation forage availability using the dry-weight-rank and comparative yield methods and preformed water and organic nutrient content of vegetation using standard laboratory procedures. Water and nutrient content of plants varied significantly between the 2 sites and among 5 seasons. Plant species consumed by pronghorn were higher in moisture and selected nutrients than those not used for forage. Daily maximum water intake predicted by diet models ranged from

1.1 to 6.1 L/animal/day. After subtracting water theoretically required for excretion, respiration, and evaporation (approximately 50%), predicted water intake from forages was not adequate to meet minimum water requirements (1.8 to 3.4 L/animal/day) for 14 of 20 simulated diets. Water developments may improve Sonoran pronghorn habitat if water is a limiting factor for the population and water requirements cannot be met by forage consumption.

Fox, L. M., P. R. Krausman, M. L. Morrison, and T. H. Noon. 2000. Mineral content of Sonoran pronghorn forage. California Fish and Game 86: 159-174.

The objective of the authors was to determine the mineral content of forage species available for Sonoran pronghorn on the Cabeza Prieta National Wildlife Refuge (CPNWR) in southwestern Arizona. They measured vegetation abundance at 2 sites within Sonoran pronghorn range from June 1995 to May 1996 using the dry-weight-rank and comparative yield methods. They determined plant mineral contents for forage species and for species not consumed by pronghorn by collecting, freezing, drying, and analyzing vegetation samples for up to 15 species over 5 seasons. Quantities of minerals present in forage species used by pronghorn showed slight variability by site or season, and were not different in non-forage species. The authors constructed theoretical diet models for pronghorn based on published literature and field data. They used the models to describe dietary intake of plant dry matter and minerals by pronghorn with and without selective use of forage. They compared predicted mineral intake by pronghorn to published requirements for domestic sheep. Diets consumed by pronghorn using plants available on the CPNWR were deficient in sodium, phosphorus, copper, zinc, and selenium.

Goldman, E. A. 1945. A new pronghorn antelope from Sonora. Proceedings of the Biological Society of Washington 58: 3-4.

The author provides the location of the type specimen for the Sonoran pronghorn (i.e., “40 miles north of Costa Rica, a ranch on the northern side of the Rio de Sonora, southwest of Hermosillo, Sonora, Mexico.”). The type specimen is an adult female (No. 250938, U. S. National Museum) collected by V. Bailey and F. Winthrop 11 December 1932. The Sonoran pronghorn is smaller than the American (*A. a. americana*) or Mexican (*A. a. mexicana*) pronghorn.

Goodwin, S. L. 2000. Conservation connections in a fragmented desert environment: The U.S.-Mexico border. Natural Resources Journal 40: 989-1016.

Natural resource agencies from the governments of the United States and Mexico, along with a number of non-governmental organizations, are forming conservation connections across the international border to protect their shared natural heritage in the transboundary Sonoran and Chihuahuan deserts. But they face many challenges: population growth, water scarcity, jurisdictional barriers, and pressures from illegal immigration and narcotics smuggling. Despite these challenges, many important binational projects are underway that will make a true difference in the long-term management of the natural resources of the border region including Sonoran pronghorn.

Grinnell, G. B. 1929. Pronghorn antelope. Journal of Mammalogy 10: 135-141.

The author discusses life history characteristics of pronghorn in North America and claims that pronghorn were once more abundant than buffalo. He states that pronghorn in southern Arizona, southeastern California, and Mexico are slightly different from those in the north. Differences were not stated.

Halloran, A. F. 1957. A note on the Sonoran pronghorn. Journal of Mammalogy 38: 423.

Because pronghorns of south-central Arizona have been diluted by transplants from northern Arizona, the herd on and adjacent to the Cabeza Prieta Game Range and Organ Pipe Cactus National Monument, southern Pima and Yuma counties, are the only pure Sonoran pronghorn in the United States. There are <100 Sonoran pronghorn in the United States, and they range into northern Mexico. A highway between Sonoita and San Luis, Sonora, has opened up the habitat in Mexico to traffic.

Hayden, J. 1985. Food animal cremations of the Sierra Pinacate, Sonora, Mexico. Kiva 50: 232-248.

The Amargoson Pinacateños, a dialect subgroup of the Papago, occupied the Sierra Pinacate, Sonora, Mexico from the midithermal period until historic times. The North American natives cremated the bones of food animals (primarily bighorn sheep but also Sonoran pronghorn). Most cremations were within 400-800 m of camps and tinajas. Game was brought to camp, butchered, and eaten. Burnt offerings were made of some of the bones outside of the camp areas. The significance of cremating partial skeletons of game is uncertain but may be to quiet the spirits of dead animals so they would not alarm those still alive, or as part of a “conservation ethic.” The practice may be limited to Sierra Pinacate.

Hayden, J. 1987. Talking with the animals Pinacate reminiscences. Journal of the Southwest 29: 222-227.

Recollection of Juan Hernandez, a watchman for the cinder mine in the Sierra Pinacate, Sonora, Mexico, who could talk and walk with wildlife are recorded by the author. On one occasion, he talked and walked with Sonoran pronghorn on a trail between Elegante and Papago Tanks.

Hervert, J. J., J. L. Bright, R.S. Henry, L. A. Piest, and M. T. Brown. 2005. Home range and

habitat use patterns of Sonoran pronghorn in Arizona. *Wildlife Society Bulletin* 33: 8-15.

The authors investigated home range and habitat preference of Sonoran pronghorn from 1994 to 2002 as part of a recovery program. Home range-size varied from 43 km² to 2,873 km² with an average of 511 km² ($n = 22$). The authors classified vegetation into 3 associations: creosote – bursage (CB); palo verde - mixed cacti (PV); or palo verde-chain fruit cholla (PVC). Individual pronghorn did not use vegetation associations similarly to each other ($\chi^2_{42} = 779, P < 0.001$). Most pronghorn ($n = 17$) used PVC more than expected and used CB and PV less than or equal to availability. Those pronghorn ($n = 5$) that used CB more than expected or equal to availability had significantly larger home ranges ($\bar{x} = 1,321 \text{ km}^2$) compared to those that preferred PVC ($\bar{x} = 272.7 \text{ km}^2, t = 86, P = 0.028$). The authors pooled locations of all pronghorn to determine the influence of season and range condition (based on rainfall) on vegetation association preference. Range condition and season influence vegetation association use by pronghorn. Pronghorn used CB more than expected during the cool season of 1997 - 1998. Pronghorn used washes more than expected in all seasons and range conditions ($\chi^2 = 277, P < 0.001$). This information is useful to managers planning recovery actions (i.e., forage enhancement, water development, and captive breeding).

Hosack, D. A., P. S. Miller, J. J. Hervert, and R. C. Lacy. 2002. *Mammalia* 66: 207-229.

The Sonoran pronghorn is 1 of 5 subspecies of pronghorn and was listed as an endangered species in 1967. The current United States distribution of Sonoran pronghorn is restricted to southwestern Arizona. The most current United States population estimates have suggested that the population numbers between 130 and 160. Population viability analysis, using the Vortex simulation model, was used to examine the threats facing the population and the prospects for management actions to secure its future. Eight parameters (i.e., extent and severity of

inbreeding, fecundity, fawn survival, adult survival, impacts of catastrophes, harvest, carrying capacity, and numbers and sex/age composition of the present population) were varied to explore the long-term risk of extinction. The results indicated that, given the most reliable estimates of the variables used, the Sonoran pronghorn has a 1% probability of extinction within the next 25 years, a 9% probability of extinction within the next 50 years, and a 23% probability of extinction within 100 years. The Vortex analysis suggested that if the population size falls below approximately 100 individuals, the probability of extinction increases markedly. In addition, the population viability analysis has shown that the current Sonoran pronghorn population is most sensitive to fawn survival rates. Adult survival rates were also strongly correlated with the likelihood of species survival. The population simulation modeling efforts suggested that this population of Sonoran pronghorn, the only one in the United States, is at serious risk of extinction.

Huey, L. M. 1942. A vertebrate faunal survey of the Organ Pipe Cactus National Monument Arizona. *Transaction of the San Diego Society of Natural History* 9: 219-220.

The author reported pronghorn in Hermosillo, Mexico and in Santa Rosa Valley near Monument 183, Sonora, Mexico. They were likely Sonoran pronghorn based on geography.

Jensen, C. D. 2002. Sonoran pronghorn, cumulative impacts and the Endangered Species Act: a litigation case study. *Federal Facilities Environmental Journal* 13: 29-39.

Recent litigation between an environmental advocacy group and multiple federal agency defendants regarding federal agency responsibilities under the Endangered Species Act is instructive for natural resource practitioners. The judicial opinion provides insight into the proper content of Biological Assessments, Biological Opinions, and Recovery Plans. For the federal agency natural resource practitioner who will either

prepare or review 1 of these 3 types of documents, this case study provides the opportunity to learn from previous mistakes.

Krausman, P. R., and L. K. Harris. 2002. Military jet activity and Sonoran pronghorn. European Journal of Wildlife Research 48: 140-147.

Forty percent of the habitat for the endangered Sonoran pronghorn in the United States is on the Barry M. Goldwater Range (BMGR), a bombing and gunnery range located in southwestern Arizona, USA. Wildlife and land managers have expressed concerns that military aircraft activity may be detrimental to Sonoran pronghorn. The authors observed the response of Sonoran pronghorn to military jet activity from 4 vantage points in BMGR from February 1998 to June 2000. We obtained behavioral observations on 172 days and obtained 44,773 observation events (i.e., 1 observation/30 seconds). Pronghorn were exposed to 109 direct military overflights, but only 6 were <305 m above ground level. Overall, behavior of males and females was not significantly different and the presence of military aircraft did not cause changes in behavior.

Krausman, P. R., L. K. Harris, C. L. Blasch, K. K. G. Koenen, and J. Francene. 2004. Effects of military operations on behavior and hearing of endangered Sonoran pronghorn. Wildlife Monographs 157.

The objectives in this study were to determine whether military activities (e.g., overflight noise, noise from ordnance delivery, ground-based human activity) on the Barry M. Goldwater Range (BMGR) affect the behavior and hearing of Sonoran pronghorn. The authors contrasted the behavior of pronghorn activity (i.e., on the Buenos Aires National Wildlife Refuge [BANWR], Arizona). Forty percent of the landscape used by the endangered Sonoran pronghorn in the United States is within the 5,739 km² BMGR, a bombing and gunnery facility in southwestern Arizona. The range

of Sonoran pronghorn covers about 88% of BMGR. The 179 Sonoran pronghorn that lived in the United States in December 1992 declined to 99 by December 2000. The Sonoran pronghorn has been listed as endangered for >30 years, but population limiting factors are unknown. Because Sonoran pronghorn use BMGR, land and wildlife managers raised concerns about the potential effects of military activities on the population. Possible indirect effects of military activities on Sonoran pronghorn, aside from direct mortality or injury, from ordnance delivery, chaff, flares, live ammunition, aircraft mishaps, interference from ground vehicles and personnel, include alteration of behavior or physiology.

The authors conducted the study on the North and South Tactical Ranges (NTAC and STAC), BMGR, from February 1998 to June 2000. Hearing exams were conducted in Camp Verde, Arizona the University of Arizona, and on the East Tactical Range (ETAC), BMGR. Interactions between pronghorn and military activity were restricted to 4 observation points that provided viewing areas from which pronghorn and military activity could be seen from ≤ 10 km. The authors systematically located pronghorn with spotting scopes and telemetry. When located, the authors described pronghorn behavior and military activity using scan sampling. The authors tested hearing using auditory brainstem responses (ABR). The authors could not test the hearing of Sonoran pronghorn because of their endangered status, so they contrasted hearing of pronghorn near Camp Verde, Arizona, and desert mule deer that were and were not exposed to sound pressure levels of military activity. They recorded behavior observations of Sonoran pronghorn on 172 days (44,375 observation events [i.e., 1 observation/30 second]) over 373 hours. These data were compared with 93 days of behavioral data (24,297 observation events) over 202 hours for pronghorn not regularly influenced by military aircraft. Overall, the authors did not detect behavioral differences (i.e., time spend bedding, standing, foraging, traveling) between males and females. Pronghorn

exposed to military activity, and those that were not, bedded the same amount of time. Pronghorn at BMGR foraged less and stood and traveled more than pronghorn not exposed to military activity. These trends were the same with and without anthropogenic activity. Only 7.3% of behavioral events occurred with identifiable stimuli. Military overflights occurred 363 times (0.8%) and non-military overflights occurred 77 times (<0.2%). Pronghorn rarely responded to military aircraft, but often moved >10 m when ground stimuli were present.

Ambient noise levels ranged up to 123.14 decibels (dB). The average sound pressure level on days with military activity was 65.3 dB compared to 35.0 dB without military activity. Because, the authors obtained hearing test from deer and pronghorn, they were able to develop an ungulate weighting filter on the noise generated from overflights of A-10 and F-16 aircraft. Desert ungulates do not hear sound pressure levels generated from the aircraft as well as humans do (i.e., 14-19 dB lower).

The military activity examined had only marginal influence on Sonoran pronghorn. Pronghorn used the ranges shared with the military throughout the year and behavioral patterns of pronghorn were similar with and without the presence of military stimuli. Furthermore, pronghorn behavior exposed to military activity was similar to behaviors of pronghorn not exposed to regular military activity. The auditory characteristics of pronghorn were similar for those that have and have not been exposed to military activity. The population of Sonoran pronghorn in the United States continues to decline and is in serious danger of extirpation. Clearly, additional work needs to be done, but military activity as measured herein is not a limiting factor.

Krausman, P.R., L.K. Harris, S.K. Haas, K.K.G. Koenen, P. Devers, D. Bunting, and M. Barb. 2005. Sonoran pronghorn habitat use on landscapes disturbed by military activities. Wildlife Society Bulletin 33:16-23

The Sonoran pronghorn population in the United States declined to ≤ 33 animals in January 2003. Low population numbers and unstable recruitment are concerns for biologists managing this subspecies. The authors examined habitat use by pronghorn from 1999 to 2002 on a portion of the Barry M. Goldwater Range (BMGR) used for military exercises. They overlaid locations of pronghorn ($n = 1,203$) on 377 1-km² blocks within the North (NTAC) and South Tactical Ranges (STAC), BMGR; they classified vegetation associations and disturbance status (e.g., airfields, targets, roads) for each block. Locations of pronghorn were distributed in proportion to vegetation associations on NTAC and STAC. Sightings of pronghorn were biased toward disturbed blocks with 73% of pronghorn locations occurring in proximity to mock airfields, high-explosive hills (e.g., targets for live high-explosive bombs and rockets), other targets, and roads. Disturbed landscapes on the BMGR may attract Sonoran pronghorn by creating favorable forage. Habitat manipulations simulating the effects of military disturbances on the landscape (e.g., improved forage) may improve remaining Sonoran pronghorn habitat.

Krausman, P.R., J.R. Morgart, L.K. Harris, C.S. O'Brien, J.W. Cain III, and S.S. Rosenstock. 2005. Introduction: management for the survival of Sonoran pronghorn in the United States. Wildlife Society Bulletin 33:5-7.

The authors review the history of the decline of Sonoran pronghorn and provide a brief overview of recovery efforts. The paper is an introduction to the Special Section on Sonoran pronghorn published in the Wildlife Society Bulletin in 2005.

Landon, D. M., P. R. Krausman, K. K. G. Koenen, and L. K. Harris. 2003. Pronghorn use

of areas with varying sound pressure levels. *Southwestern Naturalist* 48: 725-728.

The Sonoran pronghorn, a subspecies in danger of extinction, inhabits an area of the Barry M. Goldwater Range (BMGR) in southwestern Arizona. Since 1941, BMGR has been a training site for military pilots. The authors evaluated whether this subspecies of pronghorn used areas, as defined by noise levels produced by military aircraft, in proportion to their availability. Radiocollar-equipped pronghorn were monitored during September 1994 to August 1998, and their locations were recorded on a map of sound levels. In general, pronghorn used areas with lower levels of noise (<45 decibels [dB]) more than expected and areas with higher levels (≥ 55 dB) less than expected. More intensive monitoring, habitat influences, and additional measurements of noise in the area, could produce a clearer picture of the factors that determine areas of use within the BMGR by Sonoran pronghorn.

Miller, G. S., and R. Kellogg. 1955. List of North American recent mammals. *Bulletin of the United States National Museum* 205: 817.

The type locality for Sonoran pronghorn is "forty miles north of Costa Rica, a ranch on northern side of Rio de Sonora, southwest of Hermosillo, Sonora, Mexico."

Monson, G. 1968. The desert pronghorn. *Desert Bighorn Council Transactions* 12: 63-69.

The author claims that Sonoran pronghorn should be classified as the same subspecies and referred to as desert pronghorn. Their range has been reduced through over hunting, and the best hope for their survival lies in improved public interest and game law enforcement. These pronghorn forage for dried forbs and have no need for drinking water. Research is needed to better understand the ecology of desert pronghorn.

Morgart, J. R., J. J. Herver, P. R. Krausman, J. L. Bright, and R. S. Henry. 2004 Sonoran pronghorn use of anthropogenic and natural

water sources. *Wildlife Society Bulletin* 33: 51-60.

The Sonoran pronghorn is one of the most endangered ungulates in North America. The use of water to improve their habitat in southwestern Arizona has been limited because, in part, published reports claimed these desert ungulates do not use free-standing water. Because free-standing water has been beneficial to habitat improvement of other desert ungulates, the authors set up cameras at anthropogenic waters to see if they were used by pronghorn, examined literature and agency files related to Sonoran pronghorn and water, and interviewed ranchers that have been in Sonoran pronghorn habitat since the 1930s regarding their observations of use of livestock waters by pronghorn. The authors documented, from direct observation and photographic evidence, Sonoran pronghorn drinking free-standing water. Published reports claiming that Sonoran pronghorn do not drink were erroneous. Ranchers, agency files, and biologists from numerous state and federal agencies documented Sonoran pronghorn drinking. Federal and state agencies should be aggressive in examining how water developments can be used to assist in recovery of endangered Sonoran pronghorn.

O'Brien, C., S. S. Rosenstock, J. J. Herver, J. L. Bright, and S. R. Bol. 2005. Landscape-level models of potential habitat for Sonoran pronghorn. *Wildlife Society Bulletin* 33: 24-34.

A population of the endangered Sonoran pronghorn exists in the United States and 2 populations exist in Mexico. Because of the vulnerability of small, remnant populations of this subspecies to stochastic events, an important aspect of recovery planning is identifying suitable areas for establishment of new populations. To support translocation efforts, the authors developed landscape-level Classification and Regression Tree (CART) and logistic regression models of potential Sonoran pronghorn habitat in southwestern Arizona through a 2-part modeling process. First, the authors used approximately half of Sonoran pronghorn

locations ($n = 3,219$, collected from 1994 to 2002 from radiocollared animals in the United States) and unused points (total $n = 3,142$, randomly generated in areas within the range of Sonoran pronghorn below 21% slope, but >1.6 km from pronghorn locations) to create habitat models from 5 explanatory variables (i.e., slope, aspect, biome, distance to wash, and soil category). The authors validated models with the second half of pronghorn and unused points. Both models determined whether areas would or would not be used by Sonoran pronghorn based upon values of explanatory variables at Sonoran pronghorn locations and unused points. The CART model correctly identified 63% of pronghorn locations and 65% of unused points. The logistic regression model correctly identified 57% of pronghorn locations and 62% of unused points. Second, the authors created a predictive GIS map of Sonoran pronghorn habitat and applied it to the evaluation area. Both models identified $>12,000$ km² of potential habitat for Sonoran pronghorn on the evaluation area. The models are a first step towards identification of potential translocation sites for Sonoran pronghorn. Potential reintroduction sites should be further evaluated with respect to habitat factors that were not included in our models, including barriers to pronghorn movements, water supplies, and forage resources.

O'Gara, B. W. 1978. *Antilocapra americana*. Mammalian Species 90: 1-7.

The species account of pronghorn (*Antilocapra americana*) presents a taxonomic history and diagnosis for the species followed by general characters, distribution, fossil record, form, function, ontogeny and reproduction, ecology, behavior, genetics, and remarks. Information specific to Sonoran pronghorn include type locality (i.e., 64 km north of Costa Rica, southwest of Hermosillo, Sonora, Mexico) and distribution (i.e., desert plains of central and western Sonora, north to southern Arizona). The authors question the validity of the 5 subspecies (i.e., *A. a. americana*, *A. a. mexicana*, *A. a. peninsularis*, *A. a. oregona*,

and *A. a. sonoriensis*) because of transplants of *A. a. americana* into ranges of other subspecies.

Paradiso, J. L., and R. M. Nowak. 1971. Taxonomic status of the Sonoran pronghorn. Journal of Mammalogy 52: 855-858.

Measurements of skulls of 4 specimens of pronghorn from near Caborca, Sonora, Mexico, show marked similarities to the holotype of *Antilocapra americana sonoriensis* and differ from specimens of *A. a. americana*, *A. a. mexicana*, and *A. a. peninsularis* in the same characteristics as does the holotype of *A. a. sonoriensis*. These differences provide strong support for the continued recognition of *A. a. sonoriensis* as a distinct subspecies of *A. a. americana*.

Wallace, C. S. A., and S. E. Marsh. 2005. Characterizing the spatial structure of endangered species habitat using geostatistical analysis of Ikonos imagery. International Journal of Remote Sensing: in press.

This study used geostatistics to extract measures that characterize the spatial structure of vegetated landscapes from Ikonos satellite imagery for mapping endangered Sonoran pronghorn habitat. The fine (1 m panchromatic and 4 m multispectral) resolution data provides detailed spatial information at the scale of individual trees or bushes to enable analysis of vegetation structure and pattern. Information derived from the satellite imagery was evaluated statistically and used to construct 2 independent models of pronghorn preference by coupling the structural measures with Sonoran pronghorn sighting data.

Both models map similar landscapes, and validation results confirm their effectiveness at predicting the locations of an independent set of pronghorn sightings. The geostatistical analysis extracts measures of landscape structure by calculating local estimates of the nugget, sill, and range variogram parameters 25X25-meter image windows. These variogram parameters,

which describe the spatial autocorrelation of the image pixels, are shown in previous studies to discriminate between different species-to-species vegetation associations. The study demonstrates the use of the derived parameters in a practical application to define landscapes of preferred habitat for Sonoran pronghorn. Such information, although not a substitute for field-based knowledge of the landscape and the associated ecological processes, can provide valuable reconnaissance information to guide natural resource management efforts.

Wallace, C. S. A., J. J. Walker, and S. E. Marsh. 2005. Characterizing landscapes accessed by the endangered Sonoran pronghorn antelope using logistic regression of geospatial data, and principal component and fourier analysis of hypertemporal remote sensing data. To be submitted to International Journal of Remote Sensing.

This study evaluates and compares the result of using different geospatial analysis techniques to characterize Sonoran pronghorn habitat in southwest Arizona. The first habitat model was developed in a GIS-environment by applying logistic regression to field-based measurements of landscape characteristics available for Organ Pipe Cactus National Monument, Arizona. Other habitat models were developed by extracting and analyzing measures of landscape temporal dynamics from NOAA AVHRR NDVI data at known pronghorn locations. Landscape dynamics were derived using standardized principal component and Fourier analysis of the AVHRR data. Both approaches relied on an extensive database of pronghorn sightings and examined the influence of seasonal differences on migration patterns and model results.

Validation results confirm the effectiveness of all models. The GIS models produce a final predictive ability between 66 and 86%, and demonstrate the improvement that sophisticated statistical techniques can bring to habitat modeling. The AVHRR models discriminate between sightings and random points, and show a reasonable fit to

the GIS models, both visually and statistically. These findings are significant because the AVHRR models can be easily constructed, provided that a sightings data set is available and can be matched with coincident AVHRR NDVI imagery.

BOOKS

Bartlett, J. R. 1854. Personal narrative of explorations and incidents in Texas, New Mexico, California, Sonora, and Chihuahua, connected with the United States and Mexican Boundary Commission during the years 1850, '51, '52, and '53. Volume (I, II): 1-1125. Appleton and Company, New York, New York, USA.

Deer and antelope were occasionally seen along the Gila River near the Mohawk Mountains, but wagons alarmed them.

Cadieux, C. L. 1986. Pronghorn, North America's unique antelope. Stackpole Books, Harrisburg, Pennsylvania, USA.

In this book about pronghorn in North America the author summarizes some of the work published on Sonoran pronghorn. He also challenges the classification of Sonoran pronghorn as a separate subspecies because it was classified based on only 2 specimens. The author contends it never existed as a separate subspecies. The author further suggests that pronghorn from northern populations should be translocated into the range of Sonoran pronghorn to enhance the "chances for survival... by the infusion of new blood lines from healthier populations." Furthermore, the author suggests that when *A. a. mexicana* moved from Texas to Arizona, it is certainly possible that the gene pool of *A. a. sonoriensis* was diluted.

Cancino, J. and C. Castillo. 2000. Familia Antilocapridae. Pages 817-824 in Alvarez-Castañeda, S. T., and J. L. Patton editors. Mamíferos del noroeste de México II. Centro de

Investigaciones Biológicas del Noroeste, S. C. Mexico.

Sonoran pronghorn is the only species that represents this family. It has 12 extinct taxa, and the major difference in the fossil record is in size and form of the horns. This paper includes a description, distribution and life characteristics of pronghorn including the Sonoran subspecies.

Cockrum, E. L. 1960. The recent mammals of Arizona: their taxonomy and distribution. University of Arizona Press, Tucson, Arizona, USA.

The author presents the scientific name, authority, and distribution of Sonoran pronghorn.

Davis, G. P. 1982. Man and wildlife in Arizona. Arizona Game and Fish Department and Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, Tucson, Arizona, USA.

The author presents accounts of wildlife observed by early explorers of Arizona. Pronghorn occupied a wide array of landscapes wherever there was relatively open country.

Emory, W. H. 1857. Report on the United States and Mexican Boundary Survey Volume 1 Senate Executive Document 108, 34th Congress, 1st Session. A. O. P. Nicholson, printer, Washington, D. C.

Many pronghorn were seen near Pozo Verde, Sonora, southwest of the Baboquivari Mountains, Arizona.

Grubb, P. 1993. Order Artiodactyla. Pages 377-414 in D. E. Wilson, and D. M. Reeder, editors. Mammal species of the world, second edition. Smithsonian Institution Press, Washington, D. C., USA.

The author presents the status of the Sonoran pronghorn as "CITES-Appendix I (Mexican populations); U.S. ESA and IUCN-Endangered as *A. a. peninsularis* and *A. a. sonoriensis*."

Hall, E. R., and K. R. Kelson. 1959. The mammals of North America. The Roland Press, New York, New York, USA.

The authors present the scientific name, type, locality, and marginal records for Sonoran pronghorn.

Hoffmeister, D. F. 1986. Mammals of Arizona. University of Arizona Press, Tucson, Arizona, USA, and Arizona Game and Fish Department, Phoenix, Arizona, USA.

Range, diagnosis, and remarks about Sonoran pronghorn are presented that relate to subspecies classification.

Honacki, J. H., K. E. Kinman, and J. W. Keoppl, editors. 1982. Mammal species of the world. Allen Press and Association of The Systematic Collection, Lawrence, Kansas, USA.

The authors list the protected status for Sonoran pronghorn as "CITES-Appendix I and U.S. ESA-Endangered as *A. a. sonoriensis* subspecies only."

Hornaday, W. T. 1925. Camp-fires on desert and lava. Charles Scribner's Sons, New York, New York, USA.

This popularly written book chronicles a November 1907 field expedition by the author and several companions to northern Sonora, Mexico and the Pinacate Mountains region. The purpose of the expedition was an exploration of a generally unknown region and the documentation of its natural history. The party traveled due west from Tucson, Arizona to a point south of Ajo, continued south down the Valley of the Ajo, and entered Mexico at Sonoyta. The author observed that pronghorn were once plentiful in Arizona along the course traveled, but rifle hunting had eliminated the animal in this area. Pronghorn in Mexico were not observed until the party reached the eastern edge of the Pinacate lava flow, where they saw 6. They also saw about 30 pronghorn at the edge of the sand hills at the south end of MacDougal Pass, and another band of 5 on the lava plain between Papago Tanks and Tule Tanks.

Three males and a female were collected by the expedition for museum specimens. The author noted that 2 of the males were typical of the standard type of *Antilocapra americana*. The third had a strange-looking mane that might tempt some taxonomists to describe a new subspecies.

The author observed that heavy dew likely provided the moisture requirements of burrowing rodents without access to scattered water holes. Conversely, he thought it unlikely that use of dew would be sufficient to meet the water needs of larger organisms such as mountain sheep, pronghorn, and other hoofed animals.

International Union for Conservation of Nature and Natural Resources. 1972. Mammalian Red Data Book. International Union for Conservation of Nature and Natural Resources, Morges, Switzerland.

The document lists the sparse information available on Sonoran pronghorn, which is included in the list of endangered species.

International Union for Conservation of Nature and Natural Resources. 1972-1978. Red data book. I. Mammalia, Morges, Switzerland.

The Sonoran pronghorn are classified as endangered.

Leopold, A. S. 1959. Wildlife of Mexico. University of California Press, Berkeley, California, USA.

The author presents an account of the general life history of pronghorn in Mexico. The Sonoran pronghorn is a disappearing subspecies “very much in need of special attention.”

Lowe, D. W., J. R. Matthews, and C. L. Moseley, editors. 1990. Sonoran pronghorn. Pages 427-428 in The official world wildlife fund guide to endangered species of North America. Beacham Publishing, Washington, D. C., USA.

The editors provide brief accounts of the description, behavior, habitat, historic

range, current distribution, and conservation and recovery for Sonoran pronghorn. The loss of essential habitat is listed as the major limiting factor. Better management of habitat on public lands (i.e., Cabeza Prieta Game Range, Organ Pipe Cactus National Monument, Luke-Williams Gunnery Range) is critical to the survival of this subspecies.

Lumholtz, C. 1912. New trails in Mexico. Charles Scribner’s Sons, New York, New York, USA.

The author describes travel in Sonora, Mexico in 1909-1910. References to pronghorn in the area state that they eat cholla cactus and inhabit the area west of Rio de Sonoita.

Matthews, J. R., and C. J. Mosely. 1990. Sonoran pronghorn *Antilocapra americana sonoriensis*. Pages 427-428 in The official World Wildlife Fund guide to endangered species of North America. Beacham Publishing, Washington, D.C.

This account briefly presents highlights description, behavior, habitat, range, conservation, and recovery of Sonoran pronghorn. At publication, so little was known of this pronghorn, the authors concluded that research should be conducted on all life history traits.

Nowak, R. M., and J. L. Paradiso. 1983. Walker’s Mammals of the world. Fourth edition. Volume 2. John Hopkins University Press. Baltimore, Maryland, USA.

The authors present a general description and life history characteristics of pronghorn. The Sonoran pronghorn is listed as endangered and are on Appendix 1 of CITES.

O’Connor, J. 1939. Game in the desert. Derrydale Press, New York, New York, USA.

An early account of the life history of pronghorn that describes their speed (100 km/hour), coloration, historic population estimates (60,000,000), limiting factors (i.e.,

hunting, habitat alteration), habitat, diet and use of water (i.e., herds in southwestern Arizona "... never touches open water..."), migration, behavior, morphology, predation, hunting, reproduction, physiology, and miscellaneous observations. Many of the author's impressions are from his experience with pronghorn from Anderson Mesa, Arizona.

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

This comprehensive work is the most authoritative book on all pronghorn. Aspects of the life history characteristics of Sonoran pronghorn that are included in the book are taxonomy, distribution, conservation, abundance, physical characteristics, behavior, diet, management, and their future.

Oliver, D.K. 2003. Tracks in the sand. Bandit Press, Duncan, Arizona, USA.

The author presents a series of eclectic takes from outside city limits. In relation to Sonoran pronghorn he describes driving with Ken Voget when they saw 4 pronghorn and paced them in their vehicle at 72 km/hour. The author also describes a 1978 survey of pronghorn in Mexico when 52 Sonoran pronghorn were observed.

Pumpelly, R. 1870. Across America and Asia; notes of a five years journey around the world, and a residence in Arizona, Japan, and China. Leopoldt and Holt, New York, New York, USA.

Pronghorn occupied areas adjacent to the eastern border of historically described Sonoran pronghorn range.

Seton, E. T. 1929. The common prongbuck prong-horn, antelope or prong-horned antelope of America, Cabrit or Cabrie, pied goat of the plains. Pages 413-467 in Lives of game animals Volume 3 - Part 2 hoofed animals. Doubleday, Doran and Company, Garden City, New York, USA.

General life history accounts of pronghorn are provided but in 1929 only 3 races were described: *Antilocapra americana americana*, *A. a. mexicana*, and *A. a. peninsularis*. Names for pronghorn include goat (English), verrendos (Spanish), berrendos (Spanish), berendos (Spanish), cabra (Spanish), cabrito or cabrie (a Basque corruption of the Spanish cabra, a goat), cabrito (Spanish), cabrit (French), cabbrie, caberey (native word adapted), teuthlalmacoma or temamacome (Aztec). Pronghorn are referred to in Mexico as Aberendos. Pronghorn were nearly as numerous as the Buffalo. In 1800 they might easily exceed 40,000,000.

Tinker, B. 1978. Mexican wilderness and wildlife. University of Texas Press, Austin, Texas, USA.

Natural history and habitats for pronghorn in Mexico are presented based on surveys of pronghorn habitat conducted from 1922 to 1924. Population declines have occurred due to overgrazing of livestock, illegal hunting, and predation. The decrease in numbers from 1,300 in the 1920s to 400 in the 1970s is alarming, and conservation efforts need to be initiated immediately.

United States Fish and Wildlife Service. 1973. Threatened wildlife of the United States. Bureau of Sport Fishery and Wildlife, U.S. Government Printing Office, Washington, D.C., USA. Resource Publication 114.

The distinguishing characteristics, past and present distribution, status, population size ($n = 1,075$ in 1968 in North America) and life history characteristics for Sonoran pronghorn are presented.

Yoakum, J. D., B. W. O'Gara, and V. W. Howard, Jr. 1996. Pronghorn on Western rangelands. Pages 211-226 in P. R. Krausman, editor. Rangeland Wildlife. Society for Range Management, Denver, Colorado, USA.

All 3 subspecies of pronghorn in Mexico, including the Sonoran pronghorn are endangered. Less than 1% of the North American population of pronghorn is endangered.

THESES AND DISSERTATIONS

Cutler, P. L. 1996. Wildlife use of two artificial water developments on the Cabeza Prieta National Wildlife Refuge, Southwestern Arizona. Thesis, University of Arizona, Tucson, Arizona, USA.

The author studied vertebrate use of 2 artificial water developments on the Cabeza Prieta National Wildlife Refuge in southwestern Arizona from March 1994 to August 1995 to assess their use by wildlife, especially regarding endangered Sonoran pronghorn. The water developments lie within designated wilderness, and were constructed in the late 1950s specifically for Sonoran pronghorn. The author used remote cameras to detect large mammals, live trapping for small mammals, pitfall trapping for reptiles, transect surveys for birds, pond surveys for amphibians, and mist-netting to detect bats. She observed 201 vertebrate species, but Sonoran pronghorn were not detected in remote camera photos. Large mammals, bats, birds, and amphibians used free-standing water, but the distribution of species within all taxa may have been affected by the dense growth of mesquite trees at each site. Maintenance of the sites may not benefit Sonoran pronghorn, and conflicts with wilderness management.

Fox, L. M. 1997. Nutritional content of forage in Sonoran pronghorn habitat, Arizona. Thesis, University of Arizona, Tucson, Arizona, USA.

The author determined if Sonoran

pronghorn could meet water and mineral requirements through consumption of forage. She sampled vegetation using dry weight rank and comparative yield methods in southwestern Arizona from June 1995 to May 1996 to determine preformed water, nutrient content, mineral content, and vegetation abundance. Water and nutrient content of plants varied between 2 sites and among 5 seasons ($P \leq 0.05$). Plants consumed by pronghorn were higher in moisture and nutrients ($P \leq 0.05$) than non-forage species. The author constructed a model for Sonoran pronghorn diet based on field data. She used the model to describe dietary intake. Water intake predicted by diet models ranged from 1.1 to 6.1 L/animal/day; often exceeding predicted total water requirements (1.8 - 3.4 L/animal/day). Models predicted that forage provided adequate water for pronghorn during 5 seasons at 1 of 2 study sites and deficiencies for 5 of 11 minerals at both study sites.

Hughes, K. S. 1991. Sonoran pronghorn use of habitat in southwest Arizona. Thesis, University of Arizona, Tucson, Arizona, USA.

From April 1988 to August 1988 and from March 1989 to August 1989. The author studied habitat utilization of the endangered Sonoran pronghorn on the Cabeza Prieta National Wildlife Refuge and the Organ Pipe Cactus National Monument, southwestern Arizona. Pronghorn groups were small ($\bar{x} = 2.5$) and dispersed widely throughout the study area. The author never saw Sonoran pronghorn drinking water. Cacti were the major diet components in the dry seasons. Forbs were the major diet component in the wet season. Cover, plants, and vertical obstruction was generally greater in occupied areas than in unoccupied areas. Plants in occupied areas were higher in protein than plants in unoccupied areas. The percentage of indigestible material (e.g., cellulose) in plants from occupied areas was generally less than in unoccupied areas. Data represent the characteristics of vegetation in areas used by Sonoran pronghorn. They could be applied in an intensive habitat management program to improve the quality of pronghorn habitat.

Walker, J. J. 2000. A GIS model of Sonoran pronghorn antelope habitat in Organ Pipe Cactus National Monument. Thesis, University of Arizona, Tucson, Arizona, USA.

The goal of this research project was to identify and evaluate the key physical, biogeographical, and spatial factors that characterize habitat occupied by the endangered Sonoran pronghorn antelope in Organ Pipe Cactus National Monument (OPCNM), Arizona. The author hypothesized that an empirically selected range of natural and anthropogenic factors could spatially define the animals' preferred habitat on a seasonal and annual basis. A database of >500 radiocollared pronghorn sightings recorded within OPCNM between 1995 and 1999 formed the basis of the study. The database was linked to digital coverages of vegetation and soil type, elevation, slope, aspect, distance to human disturbances, visibility, and terrain ruggedness within a Geographic Information System (GIS) environment. The variables were statistically evaluated for the strength of their relationship with the sightings, and the most highly correlated variables were used in logistic regression modeling. The regression results were then used to create probability maps of pronghorn occupation. Although the annual model accounted for only a small amount of habitat variability (R^2 [adj] = 0.12), the binary presence/absence probability map correctly predicted 70% of the test data points at a threshold of 0.5. The results indicate that the given and derived landscape variables were highly effective in delineating areas of the monument most likely to be accessed by the pronghorn on a seasonal basis.

Wallace, C. S. A. 2002. Extracting temporal and spatial information from remotely sensed data for mapping wildlife habitat. Dissertation, University of Arizona, Tucson, Arizona, USA.

The research accomplished in this dissertation used mathematical and statistical techniques to extract and evaluate measures of landscape temporal dynamics and spatial structure from remotely sensed data for the purpose of mapping wildlife habitat. By

coupling the landscape measures gleaned from the remotely sensed data with various sets of animal sightings and population data, effective models of habitat preference were created. Measures of temporal dynamics of vegetation greenness as measured by National Oceanographic and Atmospheric Administration's Advanced Very High Resolution Radiometer (AVHRR) satellite were used to effectively characterize and map season-specific habitat of the Sonoran pronghorn. Various measures that capture different aspects of the temporal dynamics of the landscape were derived from AVHRR Normalized Difference Vegetation Index composite data using 3 main classes of calculations: basic statistics, standardized principal components analysis, and Fourier analysis. Pronghorn habitat models based on the AVHRR measures correspond visually and statistically to GIS-based models produced using data that represent detailed knowledge of ground-condition. Measures of landscape spatial structure derived from IKONOS high spatial resolution (1-m) satellite data using geostatistics effectively map details of Sonoran pronghorn antelope habitat. Local estimates of the nugget, sill, and range variogram parameters calculated within 25X25-meter image windows describe the spatial autocorrelation of the image, permitting classification of all pixels into coherent units whose signature graphs exhibit a classic variogram shape. The variogram parameters captured in these signatures have been shown in previous studies to discriminate between different species-specific vegetation associations. The synoptic view of the landscape provided by satellite data can inform resource management efforts. The ability to characterize the spatial structure and temporal dynamics of habitat using repeatable remote sensing data allows closer monitoring of the relationship between a species and its landscape.

CONFERENCES, PROCEEDINGS, AND SYMPOSIUMS

Abarca, F. J., R. M. Lee, and J. C. deVos, Jr. 1994. Conservation opportunities in borderlands: the Arizona-Sonora perspective. Pages 548-557 in DeBano, L. F., G. J. Gottfried, R. H. Hamre, C. B. Edminster, P. F. Ffolliott, and A. Ortega-Rubio, technical coordinators. USDA Forest Service. Rocky Mountain Forest and Range Experiment Station. General Technical Report RM-GTR-264, Fort Collins, Colorado, USA.

The Arizona-Sonora borderland contains species from the Chihuahuan, Madrean, Sinaloan, and Sonoran biogeographic provinces, which provides a great opportunity for management and research of shared natural resources. This area is characterized by 11 protected areas including wildlife refuges and biosphere reserves. Approximately 75% of species listed as threatened, endangered, and candidate in Arizona, also occur in Sonora. Portions of the Colorado, Sonoyta, Concepción, Santa Cruz, San Pedro, and Yaqui rivers-containing many of these species- are also shared between these 2 border states. Proposed economic developments along the borderland will represent a challenge to protect and manage the flora and fauna found in this area. The Arizona Game and Fish Department maintains joint efforts with several private and public groups and agencies on both sides of the border to ensure long-term existence of threatened and endangered species and their habitats. Conservation and management programs for the Sonoran pronghorn, bighorn sheep, Gould turkey, masked bobwhite, desert tortoise, native fishes, Mexican spotted owl, Mexican wolf, thick-billed parrot, maroon-fronted parrot, and breeding birds in Sonora are already underway. These efforts include surveys and monitoring activities and reintroduction within their historic range. A key element of several projects has been development of management plans addressing conservation needs for these species.

Baker, R. H. 1958. The future of wildlife in northern Mexico-a problem in conservation education. North American Wildlife Conference Transaction 23: 567-575.

Sonoran pronghorn are rare in Mexico due to increases in hunting and livestock operations. The decline of pronghorn in Mexico is better known than that of any other big game animal. There is general indifference of local people towards wildlife values. This has contributed to the decline of wildlife in Mexico.

Ballard, W. B., S. S. Rosenstock, and J. C. deVos, Jr. 1997. The effects of artificial water developments on ungulates and large carnivores in the Southwest. Pages 64-105 in Environmental, Economic, and Legal Issues Related to Rangeland Water Developments. Center for the Study of Law, Science and Technology, Arizona State University, Tempe, Arizona, USA.

Since the mid-1940s the Arizona Game and Fish Department, in addition to several other Southwest state and federal agencies have pursued active wildlife water development programs. Until the mid-1960s water developments were constructed primarily to benefit game bird populations. Since that time, water developments have been directed, in part, towards benefitting several ungulate species, including, mule deer, elk, pronghorn, and Coues white-tailed deer. Provision of water also has been a principal management strategy for desert bighorn sheep in the Southwest. Recently, water development programs have been criticized with respect to their benefits for wildlife populations, and the possibility that they may in fact be detrimental; by enhancing predator populations and concentrating predators at water units resulting in mortality sinks for prey species. To evaluate these concerns the authors reviewed literature concerning the physiological importance of water and the effects of water developments on ungulates and large carnivore populations in the Southwest. Water is an essential physiological requirement for all wildlife. A wide variety of wildlife species use free water

when it is available. Evidence strongly suggests that availability of free waters play an important role in the distribution, movement, habitat use, reproduction, or survival of wildlife. Some desert bighorn sheep populations may have benefited as a result of water development. A number of studies have demonstrated correlations between sheep distribution and availability of water. However, the developments have not always resulted in increased sheep populations and several sheep populations exist apparently in the absence of free-standing water. Mule deer, white-tailed deer, elk, and possibly pronghorn distribution of population performance have been enhanced by water developments. Apart from anecdotal observations of predation events at water units, there is little information on the effects of water developments on carnivore densities, distributions, or kill rates. The authors concluded that additional research is necessary to document the effect of water developments on ungulates, carnivores, and their interrelationships.

Brown, D.E., W.F. Fagon, R. Lee, H.G. Shaw and R.B. Turner. 2002. Winter precipitation and pronghorn fawn survival in the Southwest. Pronghorn Antelope Workshop 20: 115-122.

Using consistent observer and survey procedures in an arid area of southern New Mexico, we found a significant correlation between October through March precipitation and pronghorn fawn survival the follow August ($r^2 = 0.67$, $P < 0.02$). Further linear regression analysis indicated less robust but still significant relationships between winter precipitations and subsequent fawn survival rates in semi desert grassland area in central Arizona ($r^2 = 0.26$, $P < 0.05$). Neither of the areas tested showed a significant relationship between summer precipitation and the succeeding year's fawn survival, and postulate that forb production, as affected by winter rainfall, is more important than grass production and hiding cover in determining fawn survival in semi desert grassland habitats. Because significant relationships have also been reported for winter rainfall and

pronghorn fawn survival in Arizona's Sonoran Desert ($r^2 = 0.51$) we consider forb production to be the most important variable limiting pronghorn fawn production in arid areas. Although both winter rainfall and April Palmer Drought Severity Indices correlated with fawn survival rates in other arid and semiarid areas, neither winter rainfall nor drought indices correlated with fawn survival rates on the more mesic Anderson Mesa in northern Arizona ($r^2 = 0.03$). These data suggest that fawn survival rates following winters having < 5 to 8 cm of precipitation are insufficient to maintain pronghorn population levels, and that other limiting factors have greater influence over fawn survival in higher elevation, more mesic situations.

Cancino, J., C. Castillo, C. Manterola, F. Ramirez, J.M. Reyes, R. Rodriguez-Estrella, and V. Sanchez-Sotomayor. 2000. National pronghorn recovery plan for Mexico. Pronghorn Antelope Workshop 17: 45-49.

Considering the circumstances of the 3 native pronghorn subspecies in Mexico, the species is endangered. The subspecies *A. a. mexicana* was distributed in a great portion of the Mexican Plateau, including portions of the United States. *A. a. sonoriensis* mainly occupied northeast Sonora and southwest Arizona. The only subspecies endemic to Mexico (*A. a. peninsularis*), was found in the Baja California Peninsula. Habitat occupied by these subspecies has dramatically diminished in Mexico. *A. a. mexicana* can only be found on some ranches in Chihuahua where they are in separate herds isolated by fences. *A. a. sonoriensis* and *A. a. peninsularis* are only reported in the "El Pinacate" region and in the Vizcaino Desert, respectively. Translocation of a fourth subspecies (*A. a. americana*) to Mexico has occurred on ≥ 3 occasions. There are some gaps in the biology and ecology information of the desert pronghorns (*A. a. peninsularis* and *A. a. sonoriensis*). Pronghorn protection in Mexico started in 1922 with the establishment of a closed season, in force even now. In 1988 the Vizcaino Desert was declared a Biosphere Reserve; it even

included all habitat currently occupied by *A. a. peninsularis*. Preparation of a National Pronghorn Recovery Plan for Mexico is proposed, with the main objective of species recovery and removal from the protected species list. The proposed National Pronghorn Recovery Plan will include: a general description of the species and its habitat; historical management actions during the last 25 years; general and specific objectives; a strategy for fulfilling objectives; and projects that are in development at present. A multi-disciplined group, with legal, management, and technical/academic capabilities is needed to prepare and implement the recovery plan, hopefully with minimal influence from political dynamics.

Cancino, J., and F. Reygadas. 1999. Historical notations regarding pronghorn (*Antilocapra americana*) in Mexico. Pronghorn Antelope Workshop 18: 81-83.

Some evidence exists and assumptions are made regarding humans and pronghorn in northern Mexico based on petroglyphs 2,000 years old, antique documents, oral tradition, and ethnographic descriptions of the first naturalist voyagers.

Carr, J. N. 1972. The Sonoran pronghorn an endangered species. Pages 38-45 in Symposium on Rare and Endangered Wildlife of the Southwestern United States. New Mexico Department of Game and Fish, Santa Fe, New Mexico, USA.

The author summarizes the available information on taxonomy, distribution, limiting factors, management, and future management needs for Sonoran pronghorn. International cooperation between Mexico and the United States will be necessary for the survival of Sonoran pronghorn. In the United States additional water sources are needed, coyote control may be warranted, and additional data need to be obtained so informed decisions can be made.

Castillo-Sánchez, C. 1999. Highways and wildlife conservation in Mexico: the Sonoran pronghorn antelope at the El Pinacate y Gran Desierto de Altar Biosphere Reserve along the Mexico-USA Border. International Conference on Wildlife Ecology and Transportation 3: 289-291.

The Sonoran pronghorn is considered an endangered species in Mexico. Since 1991 a binational effort between Federal and State Governments in Mexico and several Federal and State agencies in the United States have been working together on the recovery program for this shared subspecies. Some unconfirmed reports of Sonoran pronghorn and other large mammals crossing between Mexico and the United States have been recorded. Mexico faces a new challenge: Mexico Interstate highway 2 will change it from a 2-lane highway to a 4-lane speedway. It will sweep across 142 km of prime pronghorn habitat within the Pinacate Biosphere Reserve and over 201 km along the Sonora-Arizona border. This is an important development project that will bring long social, economic, and communication benefits to the region. Negative environmental impact must be taken into account and be prevented or mitigated. Highway crossings along natural biological corridors between Organ Pipe National Monument and Cabeza Prieta National Wildlife Refuge on the United States side, and El Pinacate Reserve on the Mexican side should be built.

Davila, C., J. A. 1960. Sheep and antelope. Desert Bighorn Council Transactions 4: 101-106.

The legal status of ungulates in Mexico is presented. The author states that there is a likely possibility that Sonoran pronghorn will become extinct without strict management. Law enforcement is necessary for species protection.

deVos, J. C., Jr. 1990. Selected aspects of Sonoran pronghorn research in Arizona and Mexico. Pages 46-52 in P. R. Krausman and N. S. Smith, editors, Managing Wildlife in the

Southwest. Arizona Chapter of The Wildlife Society, Phoenix, Arizona, USA.

Information on Sonoran pronghorn in Arizona is largely based upon anecdotal reports buried within agency reports. Until recently, little management or life history oriented information was available on this endangered subspecies, which occurs in the southwest portion of Arizona and the northwest region of Sonora, Mexico. In 1983, the Arizona Game and Fish Department in cooperation with the United States Air Force, United States Fish and Wildlife Service and the National Park Service began studying the Sonoran pronghorn. Aerial and ground surveys have been used to collect habitat use and natural history information. Home-range sizes were larger than reported for other pronghorn species. Males had larger home ranges (~56.1 km²) than females (~45.2 km²) but the difference was not statistically significant ($P < 0.05$). Fawning occurred later than previously reported with a peak in early April. Movements around military use zones were non-random ($P < 0.001$).

deVos, J. C., Jr. 1988. Sonoran pronghorn research in Arizona. First International Pinacate Symposium: 26-29.

Research has been conducted on Sonoran pronghorn since 1983. The Arizona Game and Fish Department have developed new information on capture methods, range and movement patterns, sex and age ratios, fawning period and mortality, water use and population size. This study has been the basis for identifying additional research needs.

deVos, J. C., Jr. 1999. Status and management needs of pronghorn habitat in Arizona. Pronghorn Antelope Workshop 18: 7-15.

Arizona's pronghorn populations are lower than historic highs. Further, pronghorn distribution has been reduced due to a variety of factors; some reduction is due to habitat loss and some is the result of poor management practices. Habitat losses and fragmentation have resulted from urbanization, and construction of highways

and utility corridors. Fire suppression and livestock grazing have resulted in grassland invasion by woodland and shrubland vegetative species. Today, less than 1% of Arizona's pronghorn habitat is classified as high quality and less than 1% of the area occupied by pronghorn is classified as high density. Human population growth and urban expansion is expected to continue, so impact to habitat will continue, but strong land-use planning may reduce impacts of urban expansion. The real key to pronghorn management in Arizona, and likely other western states, is aggressive habitat improvement to restore grasslands to pre-European settlement conditions. Without habitat restoration and land-use planning efforts, Arizona's pronghorn populations will decline in the face of urban and woodland expansion.

Gonzalez-Romero, A., and A. L. Terrazas. 1993. Distribucion y Estado actual del berrendo (*Antilocapra americana*) en Mexico. Pages 409-420 in R. A. Medellin, and G. Ceballos, editors. Avances en el Estudio de los Mamiferos de México. Publicaciones Especiales, Volume 1, Asociación Mexicana de Mastozoología, A. C., México, D. F.

During the winter of 1984 the population of pronghorn in Sonora, Chihuahua, Baja California Sur and Coahuila were censused to evaluate the present status of the species in Mexico. The total population was estimated in 266 animals, 81.42% less than the number estimated 60 years before. The main causes of the observed decline are habitat destruction, poaching, and competition with cattle.

González-Romero, A., P. Galina-Tessaro, and S. Alvarez-Cárdenas. 1985. Wild bighorn sheep and pronghorn antelope in the Pinacate, Sonora: a dwindling resource. Pages 233-242 in E. E. Whitehead, C. F. Hutchinson, B. N. Timmermann, and R. G. Varady, editors. Arid Lands Today and Tomorrow, Westview Press, Boulder, Colorado, USA.

This paper is the result of preliminary work, but it is enough to draw attention to the urgent need for protecting Pinacate, Sonora, Mexico. Sonoran pronghorn populations are small, and proposals for hunting should be rejected and poaching has to stop. If not, the survival of Sonoran pronghorn will become more difficult.

Hervert, J. J., J. L. Bright, L. A. Piest, M. T. Brown, and R. S. Henry. 2001. Sonoran pronghorn recovery: habitat enhancements to increase fawn survival. Pronghorn Antelope Workshop 19: 19-27.

Sonoran pronghorn are listed as endangered. From 1994 to 1998, fawn recruitment has varied from zero fawns in 1996 and 1997 to 33/100 females in 1998. Fawn mortality occurs during late spring and summer. Recruitment is correlated with the amount and timing of rainfall. During the spring, nutritious forage is necessary for increased energy demands of lactating females and newly weaned fawns. When winter rains are above normal, and corresponding forage conditions are good, fawns survive at least through spring. The second period of high fawn mortality was noted during July and August. This is most likely due to increasingly higher temperatures, reduction and desiccation of forage, and increased water needs of fawns. Recruitment of fawns is key to recovery of Sonoran pronghorn. The authors outline a proposal to provide additional and longer lasting forage through habitat manipulations and irrigation. Increased nutritious forage and supplemental water at critical times, when females are lactating and fawns are foraging for themselves, may increase fawn recruitment.

Hervert, J., R. S. Henry, and M. T. Brown. 1998. Preliminary investigations of Sonoran pronghorn use of free standing water. Pages 126-137 in Proceedings of A Symposium on Environmental, Economic, and Legal Issues Related to Rangeland Water Developments. The Center for the Study of Law, Science and Technology, Arizona State University, Tempe, Arizona, USA.

Sonoran pronghorn use of water sources was monitored with a combination of cameras, direct observation, and radio receiver-data logger systems. A bomb crater filled with water on the Barry M. Goldwater Air Force Range in 1995. As many as 15 Sonoran pronghorn used the source of water on a daily basis from 24 June through 14 July, 1995. Sonoran pronghorn visited the water source during daylight hours. Coyote and pronghorn encounters were recorded. Predation of Sonoran pronghorn was not documented. Adult pronghorn appeared to dominate single coyotes in open habitats immediately adjacent to the bomb crater. The source of water was allowed to go dry and the responses of 2 radiocollared female pronghorn were documented. Group size decreased and the animals dispersed (pronghorn no. 4 moved 30.6 km, pronghorn no. 22 moved 56.2 km) to the southeast within 2 weeks of the crater going dry. Free-standing water in the bomb crater appeared to influence the distribution and group size of Sonoran pronghorn during summer 1995. Other water sources were monitored, but visitation by pronghorn was not detected.

Krausman, P. R. and B. Czech. 1997. Water developments and desert ungulates. Pages 138-154 in Environmental, Economic, and Legal Issues Related to Rangeland Water Developments. Center for the Study of Law, Science and Technology, Arizona State University, Tempe, Arizona, USA.

The authors examined the requirements and use of water by desert bighorn sheep, Sonoran pronghorn, and desert mule deer. Desert bighorn sheep require 4% of their body weight in water/day, pronghorn require 1.8-2.6 L/29kg animal/day to 3.4-5.0

L/64kg animal/day and desert mule deer consumed 1.5-6.0 L/day during summer. All ungulates require water but their use of free standing water varies. Populations of sheep and deer use water catchments regularly (1.4 days/visit) to infrequently and Sonoran pronghorn have not been observed drinking from catchments. The importance of water catchments to productivity and recruitment of desert ungulates, and their role in the animals' habitat should be evaluated scientifically.

O'Gara, B. W., and J. D. Yoakum, editors. 1992. Pronghorn management guides. Pronghorn Antelope Workshop 15: 1-101.

A compendium of management guidelines for pronghorn from Canada to Mexico is presented by numerous authors. Comments related to Sonoran pronghorn are about their use of water and capture techniques. High density populations are associated with abundant drinking water. Pronghorn in semi-arid regions and deserts (e.g., Sonoran pronghorn) have little available water and exist at low densities. The net gun is the tool of choice for capturing Sonoran pronghorn.

Pender, T. A. 1984. Arizona pronghorn antelope status report. Pronghorn Antelope Workshop 11: 7-8.

The population of Sonoran antelope in the United States declined to 48 individuals. Ten Sonoran pronghorn were captured, fitted with radiocollars, and released to obtain data related to habitat use, distribution, movement, and fawning.

Phelps, J. S. 1978. Sonoran pronghorn habitat in Arizona. Pronghorn Antelope Workshop 8: 70-77.

The most important conservation measure to preserve habitat for Sonoran pronghorn has been the minimization of anthropogenic influences in the landscapes they use. In the discussion following the paper the author states that no one "has ever seen a Sonoran antelope drink water."

Ramirez, F., J. Cancino, J. M. Reyes, and V. Sanchez-Sotomayor. 1999. Collaborative programs for Mexico and the United States to enhance pronghorn: a review. Pronghorn Antelope Workshop 18: 74-80.

During the last 25 years, there have been numerous cooperative endeavors by Mexico and the United States to enhance pronghorn in Mexico. Most notable has been the capture of herds in the United States and releases in Mexico. Other joint efforts include population surveys, diet studies, predator control training, endangered species modeling, and financial contributions. Historical and current herd distribution, estimated population numbers, and translocations sites are reported for pronghorn subspecies in Mexico. In addition, a listing of literature references is provided for cooperative investigations and research projects for all subspecies.

Reat, E. P., O. E. Rhodes, Jr., J. R. Heffelfinger, and J. C. deVos, Jr. 1999. Regional genetic differentiation in Arizona pronghorn. Pronghorn Antelope Workshop 18: 25-31.

Mitochondrial haplotype diversity was examined in pronghorn (*Antilocapra americana*) to elucidate overall levels of genetic diversity and regional differentiation of the Arizona pronghorn population. Arizona pronghorn ($n = 389$) were analyzed for halotype variation using polymerase chain reaction (PCR) protocols. The resulting amplified fragments were digested using 1 of each of the following restriction enzymes: *Aci-I*, *Bsp-1286*, *Hha-I*, *Hinf-I*, *Rsa-I*, and *Ssp-I*. Four composite haplotypes were observed in Arizona pronghorn, including 3 composite haplotypes (A, C and J) previously observed in North American pronghorn and a single haplotype (K) that is potentially unique to Arizona. The A haplotype, once proposed as a potential genetic marker associated with Mexican pronghorn (*A. a. mexicana*), was found throughout the Arizona pronghorn range in high frequency. Haplotype K was found in highest frequency within the central portion of the historical pronghorn range in Arizona. In addition, there was differentiation

in haplotype frequencies of Arizona pronghorn among regions (Arizona strip, northwestern, central, northeastern, and southeastern) of the state.

Russo, J. 1965. Arizona antelope. Proceedings of the Antelope States Workshop 1: 37-49.

This is a general article about pronghorn in Arizona. The author refers to Sonoran pronghorn as different from other pronghorn in the state because they inhabit elevations <1,639 m. Approximately 75% of antelope range in Arizona is >1,639 m.

Stephen, C. L., J. C. deVos, Jr., J. R. Heffelfinger, and O. E. Rhodes, Jr. 2002. Genetic distinction of the Sonoran pronghorn. Pronghorn Antelope Workshop 20: 72-83.

The Sonoran pronghorn is a federally listed, endangered subspecies whose distinctness has come into question repeatedly in the last few decades. Previous genetic work on the subspecific taxonomy of *A. americana* included samples from throughout North America, however, sample sizes were severely limited from the *A. a sonoriensis* range. In this study, we build a mitochondrial DNA (mtDNA) data set of approximately 500 nucleotides and 167 individuals from 3 Arizona populations (including 35 *A. a sonoriensis* individuals), from Texas, and from New Mexico. This data set are used to explore the relationship of the *A. a sonoriensis* population with respect to neighboring pronghorn populations. Little phylogenetic signal is recovered using maximum parsimony. Two of the 4 haplotypes found in Sonoran pronghorn are found in other populations. Only minor geographic differentiation between sampled populations is found in the statistical parsimony network. These results suggest that Sonoran pronghorn have only recently been fragmented from other southern populations. Comparison of population genetic diversity indicates that the Sonoran

pronghorn have sustained a prolonged bottleneck event.

Stokes, J. D. 1952. Antelope management in California. Western Association of State Game and Fish Commission Proceedings. 32: 99-101.

In 1852, big game including pronghorn were protected in California by closed hunting season for 6 months. This was California's first game law. By 1883 pronghorn were so scarce that the season was permanently closed. The author suggests that if the southern desert ranges are to be restocked, translocations should come from Mexico. Drought and a lack of water, however, precluded translocation.

Taylor, W. P. 1936. The prong-horned antelope in the Southwest. North American Wildlife Conference 1: 652-655.

The author describes the importance of refuges to pronghorn in the Southwest and calls for restocking historic range. Sonoran pronghorn are described as a "remnant of the antelope that formerly were relatively much more common through the region." This race is subject to poaching in the United States and Mexico. International agreements are necessary for the animals survival. The Cabeza Prieta Wildlife Refuge and an area in Mexico "between the international boundary and the head of the Gulf of Lower California" should be established as refuges. Law enforcement should be adequate to reduce poaching and funds for conservation should be established in addition to hunting revenue. The population can increase with management.

Thompson-Olais, L. 1992. Recovery efforts for endangered Sonoran pronghorn. Pronghorn Antelope Workshop 15: 109-114.

Cabeza Prieta National Wildlife Refuge has lead responsibility for recovery of Sonoran pronghorn. In 1982 a Recovery Plan was completed to implement recovery efforts for this species. The estimate for the United States population is about 80-120 pronghorn. In 1991, 34 Sonoran pronghorn were sighted

in Sonora, Mexico. In May 1991, a Core Working Group was formed with 6 agencies to coordinate the recovery efforts for Sonoran pronghorn and to review the Recovery Plan. The group's primary goal is obtaining an updated, revised population estimate for the pronghorn. The group along with other agency expertise is planning a bi-national test survey to determine what type of survey will produce an updated population estimate.

Ticer, C. L. D., R. A. Ockenfels, and J. C. deVos, Jr. 2000. Pronghorn fawning dates in Arizona. Pronghorn Antelope Workshop 17: 50-55.

Knowing or predicting fawning dates helps manage neonate pronghorn fawns and their habitat. The authors compiled fawning dates from areas in northern, central, southwestern, and south-central Arizona, and as information from other states and Mexico became available, to better understand fawning. In Arizona, the authors recorded date, location, and estimated age of detected fawns during ground telemetry work. They notice that fawning dates differed across Arizona, with fawning mostly in March-April at southwestern, in April-June at central, and in May-June at northern sites. Overall, the earliest fawning reported in the literature occurred in January on the Baja Peninsula, and in February in Texas and southwestern Arizona. Differences among fawning dates in Arizona seemed to be the result of different climatic zones, which influence timing of seasonal spring green-up. Mean fawning dates for 7 sites in Arizona were linearly related with elevation ($r^2 = 0.95$), the mean number of frost free days ($r^2 = 0.87$), mean minimum spring air temperature ($r^2 = 0.84$), and mean date of last freeze ($r^2 = 0.71$). Multiple regression of mean fawning dates on non-correlated variables produced 2 reasonable models: the combinations of mean elevation with latitude ($r^2 = 0.99$) and with mean summer precipitation ($r^2 = 0.99$).

Yoakum, J. 1968. A review of the distribution and abundance of American pronghorn antelope. Antelope States Workshop 3: 4-14.

The author discusses the causes of decline for pronghorn populations in North America (from 35,000,000 to 20,000) as uncontrolled hunting and habitat loss. Restoring pronghorn population has benefited from law enforcement habitat improvement and translocation. Sonoran pronghorn are among those that have not recovered.

REPORTS

Anonymous. 1990. Estrategia de recuperacion del berrendo Sonorense. Reporte final de la primera fase. Centro Ecológico de Sonora, Sonora, Mexico.

This document is a final report of the project strategy for the recuperation of the Sonoran pronghorn in the Gran Desierto de Altar, Sonora during 1989 to 1990. The authors discuss the capture operation, conservation, and management of Sonoran pronghorn. The operation was authorized by the Dirección General de Conservación Ecológica de los Recursos Naturales, and included a partnership with the Arizona Game and Fish Department at the University of Arizona. The document reports on fieldwork that resulted in a population number of 33 (7 M, 21 F, 4 juveniles, and 1 unknown). The document includes a taxonomic description of the Sonoran pronghorn. The report concludes that the number of Sonoran pronghorn is low (<50 individuals), the distribution is small and the population is limited to Caborca, Plutarco Elias Calles, Puerto Peñasco y San Luis Río Colorado, all of which are isolated. Also, the sex composition is not the optimal for long term viability. The factors that affect the population are poaching, farming, mines for mineral extraction, the use of native flora and fauna and the lack of law enforcement by the government in the Reserve Biosfera "El Pinacate."

Anonymous. No date. Final supplemental environmental impact statement re-analysis of cumulative impacts on the Sonoran pronghorn. Organ Pipe Cactus National Monument, Arizona, USA.

At Organ Pipe Cactus National Monument, the National Park Service (NPS) is re-analyzing the cumulative impact of actions on the Sonoran pronghorn. The “cumulative impact” is the impact on the environment that results from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such actions. The Sonoran pronghorn is an endangered species that inhabits Sonoran Desert habitats found primarily on federally-managed lands in southwestern Arizona, and in northern Sonora, Mexico. Current estimates indicate that approximately 100 pronghorn exist in the United States today. Factors threatening the continued survival of the pronghorn include lack of recruitment (survival of fawns), insufficient forage or water, drought coupled with predation, physical manmade barriers to historical habitat, illegal hunting, degradation of habitat from livestock grazing, diminishing size of the Gila and Sonoyta rivers, and human encroachment. The NPS is re-analyzing cumulative impacts on the pronghorn in response to a court order ruling (civil action No. 99-927) that found the environmental impact statement (EIS) on the 1997 Organ Pipe Cactus National Monument General Management Plan/Development Concept Plans/Environmental Impact Statement (GMP/DCP/EIS) failed to address the cumulative impacts of activities on the pronghorn. Past, present, and foreseeable future actions described in this supplement are being added to actions contained in the 1997 (GMP/DCP/EIS) and analyzed to assess cumulative impacts on the Sonoran pronghorn. Under the New Proposed Action Alternative, the cumulative impacts of all actions are likely to result in a continued, incremental reduction in the ability of Sonoran pronghorn to maintain a viable population in the United States. Although

there are many beneficial actions included in this cumulative scenario, they are outweighed by adverse impacts.

Anonymous. 1994. Implementation of a program for the Sonoran pronghorn (*Antilocapra americana sonoriensis*). Ecological Center of Sonora, Sonoran State Government, Sonora, Mexico. Technical Report 1994.

This document is a continuation of the technical report presented in 1993. The authors present the results of research, education and management for the Biosfera el Pinacate and the Gran Desierto de Altar, and includes information from August 1993 to November 1994. The mean home range for 7 female Sonoran pronghorn is 140 km² and 39 km² for 7 males. The mean estimated population number of Sonoran pronghorn in the area was 246 for 1993. Three ranges were being included in the management program.

Anonymous. 2004. Protecting endangered species on military lands: the Sonoran pronghorn. United States Department of Defense and United States Fish and Wildlife Service bulletin. Division of Partnerships and Outreach, Endangered Species Program, United States Fish and Wildlife Service.

This bulletin outlines the background of the status of Sonoran pronghorn, and briefly presents the current efforts to develop a captive breeding facility. Cooperative efforts between all involved are necessary to restore the habitat and species to rangelands in the Southwest.

Anonymous. 1981. The Sonoran pronghorn. Arizona Game and Fish Department, Game Branch. Special Report 10. Federal Aid in Wildlife Restoration Act, Project W-53-R, Work Plan 1, Job 1.

Authors provide a summary of data on the natural history of Sonoran pronghorn. To date, research information has been scattered, and this publication pulls notes together, supplies new information, and indicates research needs. Life history and

natural history traits addressed include taxonomy, habitat, distribution, diet, observations, and flora of the Cabeza Prieta Game Range. Each of these is addressed separately in this volume by the author of each section.

Arizona Game and Fish Department. 1985. Interim report on the Sonoran pronghorn antelope (*Antilocapra americana sonorienses*) October 1983-March 1985. Arizona Game and Fish Department, Phoenix, Arizona, USA.

This report is a summary of the classification, taxonomy, habitat, population estimates, limiting factors, and management of Sonoran pronghorn in the United States. This baseline information was used to establish management guidelines for the animal.

Arizona Game and Fish Department. 1998. Threatened native wildlife in Arizona. Arizona Game and Fish Department, Phoenix, Arizona, USA.

This list of 116 species subspecies identifies Sonoran pronghorn as a species of the greatest concern from an “endangered species” perspective.

Arizona Game and Fish Department. In preparation. Wildlife of special concern in Arizona. Arizona Game and Fish Department, Phoenix, Arizona, USA.

This list of 116 species and subspecies identifies wildlife of the greatest concern to the Arizona Game and Fish Department from an “endangered species” perspective. Sonoran pronghorn are included in the list, which was first developed in 1975, and revised in 1976 and 1978. This document is in preparation until approved by the Arizona Game and Fish Commission but should be used in lieu of previous lists.

Bright, J. L., and J. J. Hervert, and M. T. Brown. 2001. Sonoran pronghorn 2000 aerial survey summary. Arizona Game and Fish Department, Technical Report 180.

Aerial line transects were used to survey Sonoran pronghorn, 13-17 December 2000. The population estimate was 99, 95% CI = 69-392. The population declined from the 1998 survey but not different statistically. Low rainfall yield poor forage conditions that contribute to the population decline.

Bright, J. L., J. J. Hervert, R. Paredes, J. R. Morgart, and C. Castillo-Sanchez. 2001. Sonoran pronghorn 2000 Mexican aerial survey summary. Arizona Game and Fish Department, Technical Report 195.

The authors used aerial line transects to survey Sonoran pronghorn habitats in Mexico. Population size and 95% CI were estimated with sighting probability models. The survey was conducted from 4 to 8 December 2000. The population estimate was 346 (288-445, 95% CI). Most animals were east of Highway 8 ($n = 311$; 261-398, 95% CI). West of the highway the estimate was 34 (27-45, 95% CI). This is less than the population size in 1993 ($n = 414$; 317-644, 95% CI).

Bright, J. L., J. J. Hervert, L. A. Piest, R. S. Henry, and M. T. Brown. 1999. Sonoran pronghorn 1998 aerial survey summary. Arizona Game and Fish Department, Technical Report 152.

The authors used aerial line transects to survey Sonoran pronghorn habitats in the United States. Population size was estimated using the Lincoln-Petersen Index with 95% CI. The survey was conducted from 4 to 8 December 1998. The population estimate was 172 pronghorn (23-321 95% CI). Using a sighting probability model the estimate was 142 (125-167 95% CI). The population declined from 1994 to 1996 by 30-50% and continued to decline in 1997. Increased rain contributed to improved vegetation that enabled fawns to survive in 1998.

Bright, J. L., and J. J. Hervert. 2002. Sonoran pronghorn population monitoring progress report: 1999-2001. Arizona Game and Fish Department, Technical Report 209.

The primary objectives of the study were to obtain data on productivity, recruitment, mortality, habitat use, and use of water by Sonoran pronghorn in the United States from January 1999 through December 2001. Radiocollared animals were used to obtain data. Productivity was 1.0, 1.2, and 1.2 fawns/female in 1999, 2000, and 2001, respectively. Climate, predation, and disease contributed to mortality. Density of creosote bush may contribute to the avoidance of areas by Sonoran pronghorn. The study documented that Sonoran pronghorn drink free-standing water when available.

Bureau of Sport Fisheries and Wildlife. 1973. Threatened wildlife of the United States. Resource publication 114. United States Government Printing Office, Washington, D. C.

The account discusses distinguishing characteristics, distribution, status, numbers, breeding, reasons for decline, conservation measures, and other traits of Sonoran pronghorn. In some years, no pronghorn are in the United States, and the United States is dependent on the 1,000 pronghorn (in 1957) in Mexico. Management depends on international cooperation.

Burt, W. H. 1938. Faunal relationships and geographic distribution of mammals in Sonora, Mexico. University of Michigan, Museum Zoology Miscellaneous Publication 39: 1-77.

An early description of a pronghorn from Sonora, Mexico is presented. It is likely a Sonoran pronghorn, based on geographic location.

Carr, J. N. 1969. Endangered species investigation: Sonoran pronghorn. Arizona Game and Fish Department, Federal Aid in Wildlife Restoration Project W-53-R-19, Work Plan 8, Job 1.

Literature was reviewed to become

familiar with work done on the Sonoran pronghorn and for historical data. Field trips were made into the Organ Pipe National Monument, the Cabeza Prieta Game Range and the Luke Air Force Gunnery Range to become familiar with the habitat and to look for pronghorn. Pronghorn were seen on 2 occasions.

Carr, J. N. 1970. Endangered species investigation: Sonoran pronghorn. Arizona Game and Fish Department, Federal Aid in Wildlife Restoration Project W-53-R-20, Work Plan 8, Job 1.

Sonoran pronghorn surveys were conducted the Organ Pipe National Monument, the Cabeza Prieta Game Range, Luke Air Force Gunnery Range, and the Papago Indian Reservation. A 2-day trip was made into northwest Sonora, Mexico to investigate Sonoran pronghorn habitat. Various life history data, including predator-prey relationships and food and water habitats, were gathered.

Carr, J. N. 1971. Endangered species investigation: Sonoran pronghorn. Arizona Game and Fish Department, Federal Aid in Wildlife Restoration Project W-53-21, Work Plan 8, Job 1.

Sonoran pronghorn surveys were conducted in southwestern Arizona and Sonora, Mexico. Investigations of the pronghorn herd near Lake Havasu City continued and included the collection of 1 mature male. This was sent to the National Museum in Washington, D. C. for classification. Literature research indicates that a considerable reduction of Sonoran pronghorn populations and range has occurred. Overgrazing, conversion of desert land to farms and unlawful hunting has been primarily responsible.

Carr, J. N. 1972. Endangered species investigation: Sonoran pronghorn. Arizona Game and Fish Department, Federal Aid in Wildlife Restoration Project W-53-22, Work Plan 7, Job 1.

Sonoran pronghorn surveys were conducted in southwestern Arizona. A review of rainfall data and examination of free water presently available for the Sonoran pronghorn indicate that the drying of the Gila River in Arizona and other rivers in Sonora, Mexico may have been the most significant cause of this species becoming endangered. Observation data from the past 4 years indicate a definite movement of pronghorn during the hot, dry summer months to areas which contain available water.

Carr, J. N. 1973. Endangered species investigation: Sonoran pronghorn. Arizona Game and Fish Department, Federal Aid in Wildlife Restoration Project W-53-R-23, Work Plan 7, Job 1.

Sonoran pronghorn surveys were conducted in southwestern Arizona. A review of climatic conditions (temperatures) was examined, and a review of water requirements for pronghorn was examined. These data indicate that free water is a requirement and that water development in Sonoran pronghorn habitat would be beneficial. Observation data from last year support the seasonal movement trend data from last year.

Carr, J. N. 1981. Habitat of the Sonoran pronghorn. Pages 11-19 in Anonymous, The Sonoran pronghorn. Arizona Game and Fish Department, Game Branch. Special Report 10. Federal Aid in Wildlife Restoration Act, Project W-53-R, Work Plan 1, Job 1.

Physiography of landscapes used by Sonoran pronghorn in Southwestern Arizona is characterized by black-faulted mountains separated by broad alluvial valleys. The area is hot and dry, with air temperatures up to 45° C. Soil temperatures may reach 53° C. The area normally averages 10 cm of precipitation per year. Rainfall normally occurs from July to September and during winter. Historically,

pronghorn obtained water from the Gila River and Rio Sonoyta, which are now normally dry. Several water catchments have been developed for pronghorn. Vegetation in the area is characterized by the Lower Colorado subdivision and the Arizona uplands division.

Castillo, C. 1993. Informe técnico y programa de manejo para el berrendo sonorense (*Antilocapra americana sonorenensis*) en Sonora, Mexico, 1993. Gobierno del Estado de Sonora, Centro Ecológico de Sonora, Sonora, Mexico.

The low number of Sonoran pronghorn is of concern for Mexican and American governments. However, Sonoran pronghorn populations remain at low numbers and there is no clear trend to work recovery. Mexican actions for protection of the pronghorn were initiated in 1922 with installation of a hunting ban. In the United States, the Sonoran subspecies was included in the endangered species list since 1967. Later in 1982, the United States Fish and Wildlife Service initiated the Sonoran Pronghorn Recovery Plan. Common efforts from Mexico and the United States for recovery of the pronghorn have included actions on both sides of the border. The information presented in this document intends to set the basis for a management program focusing in medium and long terms procedures for recovery and conservation of the Sonoran pronghorn in Mexico. The document is organized in 9 chapters including literature cited and appendixes. Major chapters refer to: 1) population characteristics, distribution, and habitat. This chapter presents information from a 28 month radiotelemetry study. 2) Socioeconomics from people living in the habitat of pronghorn. Information on housing locations, human population densities, infrastructure, land ownership, and economic activities is detailed. 3) The third part of the report is a proposal for a management program, that present objectives, and specific plans for monitoring, protecting, and enhancing pronghorn populations.

Castillo-Sánchez, C. 1992. Estrategias para la Recuperación del Berrendo Sonorense. 2a. Fase: Captura, Marcaje, y Protección. Informe Técnico Final-Período. 1991. Centro Ecológico de Sonora, Hermosillo, Mexico.

This report includes information about historical and current distribution of the Sonoran pronghorn, population estimation, reasons for population decline, a description of the study area and methodology to capture and mark pronghorn. Nine individuals were captured during December 1990.

Radiocollars were placed on each Sonoran pronghorn. The document describes each observation for each Sonoran pronghorn.

Centro Ecológico de Sonora. 1990. Estrategia de recuperacion del berrendo Sonorense. Reporte final de la primera fase. Centro Ecológico de Sonora, Hermosillo, Sonora, Mexico.

This project was reported in Spanish and conducted in the Great Altar Desert, Sonora, during 1989-1990. This project consisted of 3 different areas of activity; Mexican and United State interagency coordination, conservation outreach and education, and pronghorn research and management. Conservation education activities on behalf of the Sonoran pronghorn included an extensive media campaign including television, radio, newspaper, graphics (poster, pamphlets), and videos. This media campaign was carried out in Hermosillo, Santa Ana, Altar, Pitiquito, Caborca, Puerto Peñasco, Plutarco Elías Calles and San Luis Río Colorado in Sonora, extending indirectly to Mexicali in Baja California and Tucson and Phoenix, Arizona. In addition to the regional media campaign, a direct education program consisting of oral presentations was undertaken to familiarize the local communities of the urgent protection needs of the pronghorn. In the rural sector, the same campaign was carried out at cooperative ranches, private ranches, indigenous communities, inns, stations and new agricultural centers. In rural areas approximately 100 posters and 700 pamphlets were distributed to 137 families who reside

within the pronghorn's range. Three ground-based censuses and 1 aerial census were conducted during the project to provide information to guide future management activities. The censuses were made in summer, autumn and spring.

The aerial census was useful in corroborating results of the land censuses. The pronghorn population estimate derived from these censuses was 33, the largest number seen in the region in 3 years. However, the total number of pronghorn estimated for the state of Sonoran does not exceed 50. This number is well below that considered necessary for a stable population, indicating that the Sonoran pronghorn is critically endangered. Seven males were encountered, 21 females, 4 young, and 1 undetermined (3%). The male-female ratio is 1:3 and the female-young ratio is 5.25:1. Age class information indicates that the Sonoran pronghorn population has an unstable population structure. The observed female-young ratio shows a very low number of young in relation to the number of females. Human activities in the area appear to have caused the most damage to the pronghorn population. As part of this project, the following activities were analyzed, in their order of importance: illicit hunting, over-grazing, the opening of agricultural camps and illegal extractive activities, especially of volcanic cinders and cactus. Enforcement of laws is critical to minimize human influences if the survival of this endangered subspecies is to be successful.

Cockrum, E. L. 1981. Taxonomy of the Sonoran pronghorn. Pages 2-10 in Anonymous. The Sonoran pronghorn. Arizona Game and Fish Department, Game Branch. Special Report 10. Federal Aid in Wildlife Restoration Act, Project W-53-R, Work Plan 1, Job 1.

Taxonomy of pronghorn is questioned. Sonoran pronghorn were classified based on 2 specimens (adult F, no. 256938, U. S. National Museum; skull only of adult F, no. 3691, United States National Museum). Because age, sex, and individual variations of cranial measurements in a given

population vary, the differences between the 2 specimens above and other subspecies is expected. The author compared the skulls with skulls of other subspecies and concluded that *A. a. sonoriensis* did not warrant subspecific status. Because there is a mosaic of geographic distributions for the 5 subspecies, the use of subspecific names for the different populations is not justified.

Cutler, T. L., M. L. Morrison, and D. J. Griffin. 1996. Wildlife use of Jose Juan and Redtail Tank, Cabeza Prieta National Wildlife Refuge, southwestern Arizona. U. S. Department of Defense Contract N68711-93-LT-3026. Final Report.

See Cutler (1996) (Theses and dissertations).

Defenders of Wildlife. 1998. Population viability analysis workshop for the endangered Sonoran pronghorn (*Antilocapra americana sonoriensis*) in the United States. Proceedings from a Population Viability Analysis workshop. Washington, D. C., USA.

See Hosack et al. 2002 (Peer-reviewed).

deVos, J. 1989. Evaluation of Sonoran pronghorn movements around military activity sites on Barry M. Goldwater Air Force Range. Arizona Game and Fish Department, Phoenix, Arizona, USA.

The objective of this study was to determine if movement of radiocollared Sonoran pronghorn was influenced by military activities on the Barry M. Goldwater Air Force Range, southwestern Arizona. Ten radiocollared pronghorn were located 2X/month within zones 0-200, 201-400, 401-800, 801-1,600, 1,601-3,200, 3,201-4,800, 4,801-6,400, 6,401-8,000, and >8,001 m surrounding military use areas. Based on 596 locations Sonoran pronghorn were more frequently within 1,600 m of a military use zone compared to chance alone and also used areas >8,000 m from military use zones greater than expected by chance alone. The presence of a military use zone is not a factor

in determining habitat use patterns by Sonoran pronghorn.

deVos, J. C., and J. E. Scott. 1988. Sonoran pronghorn progress report. Arizona Game and Fish Department, Phoenix, Arizona, USA.

Ten Sonoran pronghorn were captured 28-29 November 1987, fitted with radiocollars and released. There was a single capture related mortality. The report summarizes the location, sex, chase time, age, body temperature and other related information about collared pronghorn. Locations of radiocollared animals are presented in an index.

Duerr, A., M. A. McLeod, and E. L. Smith. 1999. Sonoran pronghorn use of 2 tactical ranges on the Barry M. Goldwater Range. Dames and Moore, Job Number 01016-736-050, Dames and Moore, Tucson, Arizona, USA.

The authors examined vegetation used by Sonoran pronghorn on the Barry M. Goldwater Range, Arizona, 1996-1998. Pronghorn "selected areas with less cover of large shrubs than was generally available... Pronghorn appear to avoid the dominant large shrub, creosote bush, on the tactical ranges." In summer, pronghorn used more large shrubs and trees and less small shrub cover than during other seasons.

Edwards, C. L., and R. D. Ohmart. Food habits of the Sonoran pronghorn. 1981. Pages 34-44 in Anonymous. The Sonoran pronghorn. Arizona Game and Fish Department, Game Branch. Special Report 10:1-55. Federal Aid in Wildlife Restoration Act, Project W-53-R, Work Plan 1, Job 1.

The diet of Sonoran pronghorn is described based on fecal pellets collected on the Cabeza Prieta Game Range from 1974 through early 1977, and October 1977 through September 1978. Feces were examined microscopically and compared to plant reference collections. Diet consisted of forbs (69%), shrubs (22%), cacti (7%), and grasses (0.4%).

Geraghty and Miller, Inc. and SWCA, Inc. 1996. Biological assessment for Sonoran pronghorn on the Barry M. Goldwater Range. United States Air Force 56 CES/CEVN, Luke Air Force Base, Arizona, USA.

This Biological Assessment (BA) has been prepared to address potential impacts of existing and proposed activities on the eastern segment of the Barry M. Goldwater Range (BMGR) on the Sonoran pronghorn. Though the United States Air Force (USAF) has primary jurisdiction over the land and air-space of BMGR, the range is divided into an eastern and a western segment. Military activities in the western segment are controlled by the United States Marine Corps and military activities in the eastern segment, also known as the Gila Bend segment of the BMGR, are controlled by the USAF. Activities addressed in this BA are limited to those occurring in the eastern segment of the BMGR.

González-Romero, A., and A. L. Terrazas. 1985. Current status of the pronghorn (*Antilocapra americana*) in Mexico: a survey. Report of the Instituto de Ecología, AC to Dirección de Flora y Fauna Terrestres, EDUE.

This study was conducted in winter 1984 to determine the distribution, density and population structure, and limiting factors for the pronghorn in Mexico. Data were obtained from field trips, road and foot surveys, fixed observation points, direct and indirect observations, and questionnaires. The authors do not state when field work was conducted. The distribution of pronghorn has decreased to 5-10% of their historic range. Sonoran pronghorn exist in the lower Colorado River region. The minimum population is 33 and may be ≥ 63 . Limiting factors include climate, predation, habitat loss, and poaching. Without active management Sonoran pronghorn in Mexico will become extinct within 6 years. To reverse this trend management agencies need to obtain the support of the public enforce laws, initiate research, enhance and create water sources, establish preserves, and hire law enforcement officers.

Guenther, A. F. 1980. Sonoran pronghorn antelope. Pages 65-67 in Arizona big game investigations 1979-80. Arizona Game and Fish Department, Federal Aid in Wildlife Restoration Project W-53-R-30.

Population surveys of Sonoran pronghorn included 20 males, 26 females, 9 fawns, and 6 unclassified pronghorn. The author estimates there are 150-200 antelope in the United States Range conditions were good. Recommendations for needed information include watering frequency, influence of the United States Air Force on pronghorn, refine survey methods, and a full time researcher should be hired to work on Sonoran pronghorn.

Guenther, A. F. 1981. Sonoran pronghorn antelope. Page 69 in Arizona big game investigations 1980-1981 part 1. Arizona Game and Fish Department, Federal Aid in Wildlife Restoration Project W-53-R-31.

Concerns are raised about the influence of the Border Patrol and Air Force on Sonoran pronghorn. A full-time researcher should be hired to thoroughly study the endangered species.

Hall, J. A., P. Comers, A. Gondor, R. Marshall, and S. Weinstein. 2001. Conservation elements of and a biodiversity management framework for the Barry. M. Goldwater Range, Arizona. The Nature Conservancy of Arizona, Tucson, Arizona, USA.

This document provides the results from the Nature Conservancy's site conservation planning process for the Barry M. Goldwater Range, Arizona. Sonoran pronghorn were not addressed as conservation elements due to their endangered status. Their management is addressed by the endangered species recovery team and the political arena. The document does consider Sonoran pronghorn when considering desired future ecological conditions, monitoring objectives and information needs, and the effect of the species' distribution on recommendation for a network of Special Natural Areas for the Range. Geospatial data

are provided for Sonoran pronghorn location across the Barry M. Goldwater Range, Cabeza Prieta National Wildlife Refuge, and Organ Pipe Cactus National Monument.

Hand, G. O. 1862. George O. Hand's diary. Arizona Historical Society, Tucson, Arizona, USA.

On 28 July 1862 the author saw "great droves of antelope" in the vicinity of Oatman Mountain east of Agua Caliente.

Harris Environmental Group, Inc. 1999. Sonoran pronghorn monitoring on the Barry M. Goldwater Air Force Range. Annual report, Spectrum Sciences and Software, Inc., Gila Bend and Barry M. Goldwater Range Complex, Gila Bend, Arizona, USA.

The authors describe a monitoring program for Sonoran pronghorn on the North (NTAC) and South Tactical Range (STAC), Barry M. Goldwater Range, Arizona, 15 July 1998-11 July 1999. Observers look for pronghorn 2 hours prior to scheduled bombing missions around high explosive detonation areas. All observations of pronghorn (i.e., date, time, location, activity, group sizes, estimated herd size, age and sex when possible) are recorded and presented to the United States Air Force at the end of each observation. If pronghorn are observed, targets were closed due to the presence of pronghorn on the range. The ranges (i.e., North and South Tactical Range, Range 1) were monitored on 82, 69, and 5 occasions, respectively. Approximately 339 targets were closed on NTAC, 493 on STAC, and 14 on Range 1 due to the presence of Sonoran pronghorn.

Harris Environmental Group, Inc. 2000. Sonoran pronghorn monitoring on the Barry M. Goldwater Air Force Range. Final report, Spectrum Sciences and Software, Inc., Gila Bend and Barry M. Goldwater Range Complex, Gila Bend, Arizona, USA.

The authors describe a monitoring program for Sonoran pronghorn on the North (NTAC) and South Tactical Range (STAC),

Barry M. Goldwater Range, Arizona, 15 July 1999-14 July 2000. Observers look for pronghorn 2 hours prior to scheduled bombing missions around high explosive detonation areas. All observations of pronghorn (i.e., date, time, location, activity, group sizes, estimated herd size, age and sex when possible) are recorded and presented to the United States Air Force at the end of each observation. If pronghorn are observed, targets were closed due to the presence of pronghorn on the range. The ranges (i.e., North and South Tactical Range, Range 1) were monitored on 162, 233, and 4 occasions, respectively. Approximately 639 targets were closed on NTAC, 675 on STAC, and 0 on Range 1 due to the presence of Sonoran pronghorn.

Harris Environmental Group, Inc. 2001. Sonoran pronghorn monitoring on the Barry M. Goldwater Air Force Range. Final report, Spectrum Sciences and Software, Inc., Gila Bend and Barry M. Goldwater Range Complex, Gila Bend, Arizona, USA.

The authors describe a monitoring program for Sonoran pronghorn on the North (NTAC) and South Tactical Range (STAC), Barry M. Goldwater Range, Arizona, 15 July 2000-14 July 2001. Observers look for pronghorn 2 hours prior to scheduled bombing missions around high explosive detonation areas. All observations of pronghorn (i.e., date, time, location, activity, group sizes, estimated herd size, age and sex when possible) are recorded and presented to the United States Air Force at the end of each observation. If pronghorn are observed, targets were closed due to the presence of pronghorn on the range. The ranges (i.e., North and South Tactical Range, Range 1) were monitored on 174, 254, and 3 occasions, respectively. Approximately 549 targets were closed on NTAC, 967 on STAC, and 0 on Range 1 due to the presence of Sonoran pronghorn.

Harris Environmental Group, Inc. 2002. Sonoran pronghorn monitoring on the Barry M. Goldwater Air Force Range. Final report,

Spectrum Sciences and Software, Inc., Gila Bend and Barry M. Goldwater Range Complex, Gila Bend, Arizona, USA.

The authors describe a monitoring program for Sonoran pronghorn on the North (NTAC) and South Tactical Range (STAC), Barry M. Goldwater Range, Arizona, 1 January 2001-31 December 2001. Observers look for pronghorn 2 hours prior to scheduled bombing missions around high explosive detonation areas. All observations of pronghorn (i.e., date, time, location, activity, group sizes, estimated herd size, age and sex when possible) are recorded and presented to the United States Air Force at the end of each observation. If pronghorn are observed, targets were closed due to the presence of pronghorn on the range. The ranges (i.e., North and South Tactical Range, Range 1) were monitored on 164, 260, and 1 occasion(s), respectively. Approximately 514 targets were closed on NTAC, 1,083 on STAC, and 0 on Range 1 due to the presence of Sonoran pronghorn.

Harris Environmental Group, Inc. 2002. Sonoran pronghorn monitoring on the Barry M. Goldwater Air Force Range. Sonoran pronghorn monitoring protocol; unofficial working document. Gila Bend and Barry M. Goldwater Range Complex, Gila Bend, Arizona, USA.

This is an unofficial document that will be modified as necessary to reflect changes in the monitoring policies and procedures to determine if Sonoran pronghorn are in or adjacent to military targets scheduled for live ordnance on the Barry M. Goldwater Range, Arizona. The report is intended for use of employees of Harris Environmental Group, Inc. working as Sonoran pronghorn monitors on the Barry M. Goldwater Range as a training tool and reference guide.

Harris Environmental Group, Inc. 2003. Sonoran pronghorn monitoring on the Barry M. Goldwater Air Force Range. Final report, Spectrum Sciences and Software, Inc., Gila

Bend and Barry M. Goldwater Range Complex, Gila Bend, Arizona, USA.

The authors describe a monitoring program for Sonoran pronghorn on the North (NTAC) and South Tactical Range (STAC), Barry M. Goldwater Range, Arizona, 2002. Observers look for pronghorn 2 hours prior to scheduled bombing missions around high explosive detonation areas. All observations of pronghorn (i.e., date, time, location, activity, group sizes, estimated herd size, age and sex when possible) are recorded and presented to the United States Air Force at the end of each observation. If pronghorn are observed, targets were closed due to the presence of pronghorn on the range. The ranges (i.e., North and South Tactical Range) were monitored on 185 and 230, respectively. Approximately 224 targets were closed on NTAC and 543 on STAC due to the presence of Sonoran pronghorn.

Harris Environmental Group, Inc. 2004. Sonoran pronghorn monitoring on the Barry M. Goldwater Air Force Range. Final report, Spectrum Sciences and Software, Inc., Gila Bend and Barry M. Goldwater Range Complex, Gila Bend, Arizona, USA.

The authors describe a monitoring program for Sonoran pronghorn on the North (NTAC) and South Tactical Range (STAC), Barry M. Goldwater Range, Arizona, 2003. Observers look for pronghorn 2 hours prior to scheduled bombing missions around high explosive detonation areas. All observations of pronghorn (i.e., date, time, location, activity, group sizes, estimated herd size, age and sex when possible) are recorded and presented to the United States Air Force at the end of each observation. If pronghorn are observed, targets were closed due to the presence of pronghorn on the range. The ranges (i.e., North and South Tactical Range) were monitored on 202 and 211, respectively. Approximately 155 targets were closed on NTAC and 251 on STAC due to the presence of Sonoran pronghorn.

Hervert, J. J., J. L. Bright, M. T. Brown, L. A. Piest, and R. S. Henry. 2000. Sonoran pronghorn population monitoring: 1994-1998. Arizona Game and Fish Department, Technical Report 162.

The authors investigated Sonoran pronghorn productivity, fawn recruitment, use of military target areas, habitat preferences, diet, and use of free standing water in southwestern Arizona and provided recommendations for recovery actions. In addition, they assessed the suitability of using satellite telemetry for home range studies. Productivity and fawn recruitment were variable from year to year and closely correlated with precipitation. In years with above average rainfall and favorable forage conditions, they observed higher overall productivity, more twin fawns and increased recruitment. Conversely, below normal levels of precipitation resulted in lower observed productivity and recruitment. Fawn mortality did not differ between areas of their range with active military training activities and areas without. Pronghorn showed preferences for some military target areas, most likely due to increased forage and water availability in these disturbed soils. Sonoran pronghorn selected bajada habitat in all seasons, washes in the dry summer, and avoided creosote-bursage flats except in wet winters when they were used equal to availability. Forbs made up the largest percentage of the diet in wet summers, browse was highest in dry conditions and wet winters. Use of chain fruit cholla habitats increased in dry summers, and cholla fruit made up a larger percentage of the diet. Pronghorn were documented drinking from several water sources in the summer months, however, use was not detected at other monitored water sources. Adult mortality was generally low, with the possible exception being during winter droughts. The advantages of satellite telemetry (i.e. ease of data collection, elimination of disturbance to study animals) appeared to be negated by insufficient accuracy, decreased sample sizes, length of transmitter life and problems with sampling frequency. Fawn recruitment is the most important factor influencing this

population, therefore, management and recovery actions should be aimed at this segment of the population. Increasing nutritious forage for lactating females and fawns during dry conditions should improve fawn survival rates. The effects of providing free-standing water on fawn recruitment should be investigated. Further study into pronghorn use of target areas should provide the military with alternatives for reducing conflict between Sonoran pronghorn and the military mission.

Hervert, J. M. [sic], B. Henry, M. Brown, D. W. Belitsky, and M. E. Kreighbaum. 1995. Sonoran pronghorn population monitoring: progress report. Arizona Game and Fish Department, Technical Report 98.

The study objective is to estimate productivity and recruitment of Sonoran pronghorn on the Barry M. Goldwater Air Force Range, Arizona, 1994. Twenty-two antelope were captured in November and December 1994 and fitted with radiocollars. Productivity was 1.0 fawn/female and survival was 45 fawns/100 females.

Hervert, J. J., R. S. Henry, M. T. Brown, and L. A. Piest. 1996. Sonoran pronghorn population monitoring: progress report. Arizona Game and Fish Department, Technical Report 110.

The objective of this study is to obtain productivity and recruitment estimates for Sonoran pronghorn on the Barry M. Goldwater Air Force Range, Arizona, 1995-1996. Data, analysis, and conclusions are preliminary. Productivity was estimated at 0.33 fawns/female and recruitment of fawns was 6/100 females. Coyotes are the primary predators. Drought conditions likely contributed to mortality.

Hervert, J. J., L. A. Piest, W. Ballard, R. S. Henry, M. T. Brown and S. Boe. 1997. Sonoran pronghorn population monitoring: progress report. Arizona Game and Fish Department, Technical Report 126.

Objectives of the study were to obtain

data related to life history characteristics of Sonoran pronghorn (e.g., productivity, survival, mortality, habitat use) 1 July 1996-30 June 1997. The study area was the current range of Sonoran pronghorn in the United States (i.e., Interstate 8 to the north, the International Boundary to the south, the Gila and Tinajas Altas mountains to the west, and Arizona State Highway 85 to the east). During 1 July 1996 to 30 June 1997, 360 aerial locations of pronghorn were obtained during 48 telemetry flights. Single fawns were with 3 of 6 collared adult females. Recruitment of fawns was 0.15/female. One adult female was killed by a coyote. The population of Sonoran pronghorn was 164. Military activity may hinder habitat use in some areas but improve conditions for forage in other areas.

Hervert, J. J., L. A. Piest, R. S. Henry, and M. T. Brown. 1997. Sonoran pronghorn 1996 aerial survey summary. Arizona Game and Fish Department, Technical Report 124.

Aerial line transects were used to survey Sonoran pronghorn 7-13 December 1996 in the United States. The estimate was 216, 95% CI = 82-579. The population declined from 1994 to 1996 by 30-505 due in part to drought that began in summer 1994. Without rain the population will likely continue to decline.

Holland, J. 2004. Regional Sonoran pronghorn studbook. Los Angeles Zoo, Los Angeles, California USA.

The author initiated a studbook for the captive breeding facility for Sonoran pronghorn on the Cabeza Prieta National Wildlife Refuge, Arizona.

Hughes, K. S., and N. S. Smith. 1990. Sonoran pronghorn use of habitat in southwest Arizona. Arizona Cooperative Fish and Wildlife Research Unit Project. 14-16-009-1564 RWO 6, Final Report, Tucson, Arizona, USA.

See Hughes (1991) (Theses and dissertations).

Jones, F. L. 1954. Report on resurvey of proposed antelope planting sites. California Department of Fish and Game, Sacramento, California.

In a survey of possible translocation sites, the author may have found potential sites for Sonoran pronghorn in California. However, there was not enough known about the life history characteristics of the subspecies to make biologically based recommendations.

Kennerly, C. B. R. 1856. Report on the zoology of the [Whipple] expedition. Pages 5-17 in Volume 4. Reports of explorations and surveys...House Executive Document 91, 33rd Congress, 2nd Session. A. O. P. Nicholson, printer, Washington, D. C.

The author describes seeing pronghorn in northern Sonora, Mexico where they were less shy and easily hunted compared to other areas.

Krausman, P.R., L. K. Harris, and J. Francine. 2001. Long-term study of the noise effects of military overflight on the Sonoran pronghorn Barry M. Goldwater Range, Luke Air Force Base, Arizona. U. S. Air Force Contract F41624-98-C-8020-P00003.

See Krausman et al. 2004 (Peer-reviewed).

Krausman, P.R., L. K. Harris, and J. Francine. 2001. Noise effects of military overflights on Sonoran pronghorn. Final report. Air Force Center for Environmental Excellence, Luke Air Force Base, Arizona, USA. Contract F41624-98-C-8020

See Krausman et al. 2004 (Peer-reviewed).

Marr, C. H., and A. L. Velasco. 2004. Effects of military aircraft chaff on water sources available to Sonoran pronghorn. Draft report, U.S. Department of Navy, Southwest Division, San Diego, California, USA.

While federally endangered Sonoran pronghorn populations have plummeted on

the Barry M. Goldwater Range in southwestern Arizona, biologists have questioned some range activities that may increase risk potential to the pronghorn. Sonoran pronghorn on the Barry M. Goldwater Range in southwestern Arizona are exposed to military radio-frequency chaff that is used by aircraft during training exercises. Chaff are fibrous, glass strands coated with metallic aluminum that disrupt an enemy's radar; strands also were coated (historically) with a strip of lead to increase flutter [performance]). Considering the amount of chaff released over the last 50+ years, and the metals used on the chaff fibers, the risk potential to Sonoran pronghorn was high enough to warrant investigation. Sonoran pronghorn population levels are so low that any additional stress placed upon species could be detrimental to the existence of the species. As a result, the authors studied Sonoran pronghorn oral exposure to chaff on the Barry M. Goldwater Range, Cabeza Prieta National Wildlife Refuge, Organ Pipe Cactus National Monument, and Luke Air Force Range (herein these properties are referred to collectively as BMGR), and Kofa National Wildlife Refuge (KNWR) as a reference site. Out sampling results indicated that exposure to aluminum, or other metals in chaff will not cause adverse effects to Sonoran pronghorn. Chaff was detected more frequently on the BMGR than on KNWR but the difference was not statistically significant ($P = 0.0578$). Increased chaff detection on BMGR did not appear to influence mean aluminum concentrations in soil or sediment, as aluminum concentrations were within Arizona background concentrations. The authors used conservative parameters in the model to estimate "worst case" aluminum exposure for pronghorn. The authors are confident that chaff releases at current levels have little potential to adversely affect Sonoran pronghorn. However, the authors recommend expanded investigations of Sonoran pronghorn risk potential at the more heavily impacted military training sites. We detected chaff at these locations more frequently, but did not test for all chemical compounds present at these sites. Their concerns

originate from frequent observations of burned and unburned explosives residues in the North Tac and HE Hill areas. A survey for explosives in soil, sediment, plant, and water at these sites is highly recommended. The authors also recommend monitoring Sonoran pronghorn serum concentrations for sodium, phosphorus, and zinc based on work by Fox et al. (2000) and the possibility for aluminum potentiating a phosphorus deficiency.

Marsh, S. E., C. Wallace, and J. Walker. 1999. Evaluation of satellite remote sensing methods for regional inventory and mapping of desert resources. Final report to Organ Pipe Cactus National Monument. University of Arizona, Tucson, Arizona.

Geographic information system (GIS) data sets of vegetation associations, geology, soil, topography, riparian areas, washes, and roads were used to describe the relationship of Sonoran pronghorn to the landscape at Organ Pipe Cactus National Monument, Arizona. However, development of these data is expensive and time consuming. The authors compared the results obtained from GIS information with data from the National Oceanic and Atmospheric Administration's Advanced Very High Resolution Radiometer (AVHRR) satellite. The AVHRR evaluated each image pixel equivalent to 1 km² on the ground. Some of the AVHRR measures correspond well to the GIS-based model. A better fit between GIS-based habitat models and the AVHRR can be achieved by creating a more sophisticated AVHRR model that is a synthesis of the different variables.

Mearns, E. A. 1907. Mammals of the Mexican Boundary of the United States. Part 1, families Didelphiidae to Muridae. Bulletin of the U. S. National Museum 56:221-231.

Antilocapra americana mexicana are described with general life history notes from the International Boundary Survey. Pronghorns from the range of Sonoran pronghorn are mentioned as they were not given subspecific status until 1945.

Pronghorn (Sonoran) were found on either side of the Pozo Verde Mountains and were “plentiful on the plains around Pozo le Luis, Sonora, Mexico.” Numerous tracks were observed in the Tule Desert. Pronghorn were seen in Tule Wells and the Lecheguilla Desert between the Tule and Gila mountains.

Michler, N. 1857. From the 111th meridian of longitude to the Pacific Ocean. Report on the U.S. and Mexican boundary survey. 1: 101-125.

Pronghorn occurred adjacent to the eastern border of historically described Sonoran pronghorn range.

Nelson, E. W. 1925. Status of the pronghorned antelope, 1922-24. U. S. Department of Agriculture, Washington D.C., Department Bulletin 1346.

This is one of the earliest comprehensive reports on pronghorn (*Antilocapra americana*) and discusses former and present abundance, characteristics, habitat, conservation and control, conservation organizations, refuges, restocking, capturing and translocation, and abundance and distribution by states and provinces in the United States, Canada, and Mexico. The author states of the Sonoran pronghorn, “In 1923 bands aggregating about 75 antelope were reported to have been ranging in Yuma County, near the international boundary. Seven head were reported in 1924 between the Mohawk and the Cabeza Prieta ranges. Antelope in Sonora are practically all west of the railroad extending from Nogales on the Arizona border south of Guaymas and in the region lying north of a line drawn from Hermosillo west to the coast of the Gulf of California.” Those in northwest Sonora cross the Arizona-Mexico border and are monitored by the Permanent Wild Life Protection Fund, which hired Ben H. Tenker as an honorary game guardian for northern Sonora to protect antelope and mountain sheep for 10 years (1923-1932). Tenker counted 595 pronghorn from 4 areas in Sonora, November 1924.

Nichol, A. A. 1941. Game reconnaissance of southwestern Arizona, south of the Gila River. Arizona Game and Fish Department Report, Arizona 9-R, Special.

The author provides an account of the findings of a field survey trip that covered the triangular section of southwestern Arizona that is bounded on the east by the Gila Bend-Ajo-Quitobaquito road, on the north by the Gila River, and on the south by the International Boundary. The author describes topography of the area, cover, and wildlife. He estimated the area contained 60 Sonoran pronghorn and claimed that the limiting factor was water.

O'Brien, C. S., S. S. Rosenstock, and S. R. Bol. 2004. Sonoran pronghorn habitat evaluation: Yuma Proving Ground, Kofa National Wildlife Refuge, and adjacent areas. Arizona Game and Fish Department, Final Report, Collection Agreement #Non-98-0715.

A population of endangered Sonoran pronghorn exists in the United States, and 2 populations exist in Mexico. Because of the vulnerability of small, remnant populations of this subspecies, an important aspect of recovery is identifying areas suitable for translocation of new populations. To support future translocation efforts, we evaluated potential habitat quality on a 25,000-km² area in southwestern Arizona that included Yuma Proving Ground (YPG), Kofa National Wildlife Refuge (KNWR), and adjacent areas.

The authors followed a 3-step modeling process. First, they used a subset of locations collected 1994-2002 from radiocollared Sonoran pronghorn in the U.S. and randomly generated unused locations to create Classification and Regression Tree (CART) and logistic regression models of habitat use. The CART model used slope, aspect, biome, distance to wash, and soil type (derived from existing Geographic Information System [GIS] coverages) to predict habitat use patterns by Sonoran pronghorn, while the logistic regression model used all variables except biome. The CART model correctly identified 63% and the logistic model 57% of pronghorn locations,

and the CART model correctly identified 65% and the logistic model 62% of unused points.

Second, the authors validated models using the remaining pronghorn locations and unused points. Cross-validation of the CART model yielded overall correct classification of 62%, with classification accuracy of 61% for used locations and 63% for unused points. Cross-validation of the logistic regression model produced 60% overall classification accuracy, with 58% and 62% accuracy for used and unused points, respectively.

Finally, they created a GIS map of potential habitat quality for Sonoran pronghorn on the evaluation area. Both models identified >12,000 km² of potential habitat for Sonoran pronghorn including 6 areas outside of current range YPG, KNWR, Barry M. Goldwater Range, and adjacent Bureau of Land Management lands. Both models identified Castle Dome Plain, Palomas Plain, King Valley, Hyder Valley, La Posa Plain, and Lechuguilla Desert as potential habitat. In addition, the CART model also classified Yuma Desert as potential habitat. On current range, both models identified Childs Valley and La Abra Plain as habitat. The CART model also identified the Tule Desert as potential habitat on current range.

The available GIS layers captured only relatively coarse features of vegetation and terrain, so we used aerial transects to obtain finer-scale classifications of the 3 focal evaluation areas on YPG and KNWR. Aerial vegetation surveys of Castle Dome Plain, King Valley, and La Posa Plain found similar vegetation and topography to current range, but a lack of chain fruit cholla, which is preferred on current range. Measurements on current range found no difference in potential visibility of mammalian predators between preferred palo verde/mixed cacti with chain fruit cholla and the avoided creosotebush/bursage vegetation types. Further habitat use studies on current range that focus on habitat measurements at pronghorn locations are needed.

The models are a first step towards identifying translocation sites for Sonoran pronghorn. Candidate translocation sites should be further evaluated using ground-

based assessments of factors not included in our models that affect habitat quality, such as fences, highways, canals, other barriers to pronghorn movements, forage and water availability, military activity and other human disturbances, and predator abundance.

Peeples, T. L. 1980. Sonoran antelope. Arizona big game investigations 1978-80. Arizona Game and Fish Department, Federal aid in Wildlife Restoration Project, W-53-R-30.

A live Sonoran pronghorn was removed from the Wellton-Mohawk Canal near Avenue 32E on 15 June 1979. There is not enough data on Sonoran pronghorn in management unit 40B (West) to make informed decisions.

Peeples, T. L. 1981. Sonoran pronghorn antelope. Pages 68-69 in Arizona big game investigations 1980-81 part 1, Arizona Game and Fish Department, Federal Aid in Wildlife Restoration Project, W-53-R-31.

The authors estimate there are <150 Sonoran pronghorn in the United States. Range conditions are good to average. More data are needed to make informed decisions.

Phelps, J. S. 1981. Biological observations on the Sonoran pronghorn. Pages 28-33 in Anonymous, The Sonoran pronghorn. Arizona Game and Fish Department, Game Branch. Special Report 10. Federal Aid in Wildlife Restoration Act, Project W-53-R, Work Plan 1, Job 1.

Fawns have been observed as early as 7 March. A gestation period of 240 days would initiate peak breeding in the first week of July. Mean herd size is 3-8 and does not vary through the year. There is no documentary evidence that pronghorn drink free-standing water. Available forage limits distribution. The coyote is the only documented predator of Sonoran pronghorn. Mortality factors documented include drowning in canals, vehicle accidents, and illegal hunting.

Phelps, J. S. 1981. Present distribution of the Sonoran pronghorn. Pages 23-27 in Anonymous, The Sonoran pronghorn. Arizona Game and Fish Department, Game Branch. Special Report 10. Federal Aid in Wildlife Restoration Act, Project W-53-R, Work Plan 1, Job 1.

There are 300-450 Sonoran pronghorn straddling the international boundary, which move freely across the border in both directions. The present distribution was developed from observations of pronghorn from 1968 to 1980 in the United States and from surveys in Mexico from 1969 to 1974 and 1978. The current range is south of I-8 midway between Yuma and Gila Bend, Arizona, south to just northwest of Caborca, Mexico and a small area southwest of Caborca, Mexico. The Mexican population is fragmented due to agricultural development, human habitation, roads, habitat exploitation, and illegal hunting. In the United States, habitat has been altered by overgrazing. However, the creation of the Cabeza Prieta Game Range, Organ Pipe Cactus National Monument, and Luke-Williams Gunnery Range in the late 1930s have protected Sonoran pronghorn habitat.

Phelps, J. S. 1974. Endangered species investigations: Sonoran pronghorn. Arizona Game and Fish Department, Federal Aid in Wildlife Restoration Project W-53-R-24, Work Plan 7, Job 1.

Ground and air surveys for pronghorn were conducted in southwestern Arizona. Data collected indicated a July breeding period followed by a March fawning period. Data concerning herd composition and movements were collected and recorded.

Phelps, J. S. 1975. Sonoran pronghorn investigations. Arizona Game and Fish Department, Federal Aid in Wildlife Restoration Project W-53-R-25.

Aerial surveys have demonstrated their value by supplying observations necessary to verify the presence of pronghorns in areas not reasonably accessible

by ground techniques. Use of aerial surveys to census populations and determine population parameters appears to be a matter of obtaining sufficient aircraft time to do an adequate survey. Total observations over the past 2 years indicate an expected observation rate of 1 pronghorn/hour of aircraft time. Forty to fifty observations would be necessary to achieve any reliable estimator of population size or recruitment. An effort should be made in the forthcoming year to achieve this objective. Eighteen pronghorn observations were recorded during the project year. The observations were transcribed to a base map at the Game and Fish Department offices in Phoenix. The map, displaying 7 years observations, is beginning to show the distribution of Sonoran pronghorn in Arizona. Fawns were observed on April 15 and April 18, 1975. The fawns' ages were estimated at a minimum of 1 month. The latest date birth could have occurred was early March, placing the period of breeding activity in July.

Phelps, J. S. 1976. Sonoran pronghorn investigations. Arizona Game and Fish Department, Federal Aid in Wildlife Restoration Project W-53-R-26.

Eight years (1968-1976) of observations of Sonoran pronghorn in Arizona are presented.

Phelps, J. S. 1977. Sonoran pronghorn investigations. Arizona Game and Fish Department, Federal Aid in Wildlife Restoration Project W-53-R-27.

A 9-year summary of observations of Sonoran pronghorn in Arizona is presented.

Phelps, J. S. 1978. Sonoran pronghorn investigations. Arizona Game and Fish Department, Federal Aid in Wildlife Restoration Project W-53-R-28.

Thirty-two Sonoran pronghorn were observed from 1 July 1977 to 30 June 1978: 14 in Arizona and 18 in Sonora, Mexico. Habitat in Mexico is briefly described.

Phelps, J. S. 1979. Sonoran pronghorn investigations. Arizona Game and Fish Department, Federal Aid in Wildlife Restoration Project W-53-R-29.

The author summarizes the distribution of Sonoran pronghorn in North America and observations of pronghorn from 1968 to 1978 in Arizona. Locations of pronghorn in Mexico are presented from 24 March to 5 April 1978.

Phelps, J. S., and P. M. Webb. 1981. Historic distribution of the Sonoran pronghorn. Pages 20-22 in Anonymous, The Sonoran pronghorn. Arizona Game and Fish Department, Game Branch. Special Report 10. Federal Aid in Wildlife Restoration Act, Project W-53-R, Work Plan 1, Job 1.

The historic distribution of Sonoran pronghorn extends from east of the Salton Sea, California to just west of Tucson and Nogales, Arizona and west of Hermosillo, Mexico. The northern boundary extends from south of Phoenix, Arizona and north of the Salton Sea, California, south to Hermosillo, Mexico and along the eastern side of Baja, California, parallel with Caborca, Mexico.

Robinson, A. T., S. R. Boe, R. A. Ockenfils, R. E. Schweinsburg, and J. J. Hervert. 2000. Estimated probabilities that military aircraft encounter Sonoran pronghorn in training routes. Contract Report N68711-98-LT-80029, Department of the Navy, San Diego, California, USA.

The authors estimated probabilities that military aircraft, during low-altitude training flights will overfly (encounter) Sonoran pronghorn based on simulated flight paths over known pronghorn locations and randomly generated, habitat-stratified (vegetative type) locations within 9 flight corridors on the Barry M. Goldwater Air Force Range and Cabeza Prieta National Wildlife Refuge, Arizona. Using Geographic Information System (GIS) technology, the authors generated 100 random flight lines for each corridor, and for each flight line overlaid a random sample of locations of Sonoran

pronghorn. Probabilities of encounter and mean numbers of individuals encountered were calculated for 2 data types (actual and habitat-stratified random locations) using 7 flight strip widths (0.1, 0.2, 0.4, 0.8, 1.6, 3.2, and 6.4 km) within each corridor for 2 months and 2 population sizes (March-low and -high, and October-low and -high; low = 100 and high = 250 individuals). Probability of encountering a group of Sonoran pronghorn and numbers of individuals encountered tended to be greater in March than in October and differed among corridors. For any give sortie, <1 pronghorn, on average, is likely to be encountered for a flight strip width ≤ 0.4 km. The authors ranked corridors (from minimum to maximum value) for each of 7 criteria: (1) area of each corridor, (2-3) proportion of the 2 most frequently used vegetative types [chain-fruit cholla and creosotebush-white bursage] to the total available habitat, (4-5) probabilities of encountering a group of Sonoran pronghorn for both data types, and (6-7) mean number of individuals encountered for both data types. Rankings of corridors based on the 2 vegetative types agreed with rankings based on probabilities of encounter and number of individuals encountered derived from actual location data. Selection of flight corridor and season affect probability of encountering Sonoran pronghorn.

School of Renewable Natural Resources. 1980. Cabeza Prieta National Wildlife Refuge Management Plan. School of Renewable Natural Resources, University of Arizona, Tucson, Arizona, USA.

This document is a management plan for Cabeza Prieta National Wildlife Refuge developed by students in a natural resource recreation class. Published data about the history, physical-biological resources, recreation, and current use and management are summarized. The students recommend that more information is needed for the management of Sonoran pronghorn, including subspecies status, habitat requirements, behavioral characteristics, effects of predation, translocation methods, capture

techniques, and understand how they coexist with other wildlife. They recommended that water for pronghorn not be developed unless it was demonstrated to be a limiting factor.

Snow, T. K. 1994. Sonoran pronghorn aerial survey summary 1992-1994. Arizona Game and Fish Department, Technical Report 51.

Three aerial surveys for Sonoran pronghorn were conducted from December 1992 to March 1994 in the U.S. and Mexico. Population estimates were calculated from average group size and double-counts. The mean population size was 197 and 155 in 1992 and 1994, respectively in the U.S. In 1993, 246 Sonoran pronghorn were estimated in Mexico.

Tunnickliff, B. et al. 1986. National resource management plan for Luke Air Force Range. School of Renewable Natural Resources, University of Arizona, Tucson, Arizona, USA.

This document is a natural resources management plan for Luke Air Force Range, Arizona. It describes the planning process, evaluations, recommended administrative-management framework, and resource management synopsis, goals, and recommendations. The authors review published literature related to Sonoran pronghorn and make 6 recommendations. 1. Continue to remove domestic livestock in pronghorn habitat. 2. Continue to enhance or develop new water sources. 3. Maintain the current taxonomic status until it is proved to be wrong. 4. Continue with life history research. 5. Avoid disturbance within 10 km of waters used by pronghorn. 6. Manage Sonoran pronghorn in wilderness.

United States Fish and Wildlife Service. 1998. Final revised Sonoran pronghorn recovery plan. United States Fish and Wildlife Service, Albuquerque, New Mexico, USA.

There are <300 Sonoran pronghorn in the U.S. and 200-500 in Sonora, Mexico. In the United States, their habitat is Sonoran Desert in broad alluvial valleys. Ephemeral

washes are important for thermal protection. In Mexico, Sonoran pronghorn also use cholla. Cacti are an important part of their diet. Drought, limited forage, and limited water contribute to the low numbers. The recovery effort should first downlist the subspecies to threatened. Recovery criteria is ≥ 1 population in the United States with ≥ 300 animals in a self-sustaining population and ≥ 1 other self-sustaining population in the United States. for ≥ 5 years. To downlist a stable population has be maintained for 5 years with protection of habitat. To meet this criteria water and forage need to be enhanced, the present range needs protection, habitat studies are necessary, limiting factors have to be determined, another population has to be established, surveys need to be refined, and taxonomic status need to be verified. The total cost of recover is >\$9,000,000. Downlisting will be considered in 2005.

United States Fish and Wildlife Service. 1982. Sonoran pronghorn recovery plan. United States Fish and Wildlife Service, Denver, Colorado, USA.

This is the first recovery plan for the endangered Sonoran pronghorn. The report presents a summary of life history characteristics and states that population limiting factors are unregulated hunting and habitat loss. Recovery objective are to maintain a United States population of 300 animals for 5 years prior to downlisting.

United States Fish and Wildlife Service. 1994. Sonoran pronghorn recovery plan revision. United States Fish and Wildlife Service, Albuquerque, New Mexico, USA.

There are <300 Sonoran pronghorn in the United States and >500 in Sonora, Mexico. The Sonoran pronghorn is endangered and on Appendix 1 of the Convention on International Trade and Endangered Species of Wild Fauna and Flora. Pronghorn use broad alluvial valleys bordered by block-faulted mountains. Creosote flats bordered by arroyos with palo verde, mesquite, and ironwood are commonly used.

Limiting factors are unknown. The recovery objective is to downlist after viable herds reach >500 animals in the United States. To reach delisting, managers need to develop scientifically based survey methods, use telemetry to better understand life history traits, evaluate translocation and breeding programs, establish new herds, study taxonomy, and gain a better knowledge of pronghorn physiology. The estimated cost of recovery over 5 years is \$1,040,000. An estimated date of recovery was not established.

United States Fish and Wildlife Service. 2003. Supplement and amendment to the 1998 Final Revised Sonoran Pronghorn Recovery Plan (*Antilocapra americana sonoriensis*). United States Fish and Wildlife Service, Albuquerque, New Mexico, USA.

This document supplements and amends the Final Revised Sonoran Pronghorn Recovery Plan (Recovery Plan) (USFWS 1998) in response to a court-ordered remand (Federal District Court, Washington, D.C. 12 April 2001) to the United States Fish and Wildlife Service (USFWS) to reassess and incorporate Sonoran pronghorn recovery criteria and to incorporate objective measurable criteria for the delisting of the pronghorn, and provide estimates of time required to carry out those measures needed to achieve the plan's goal and intermediate steps toward that goal. This amendment updates selected sections of the Recovery Plan to ensure that the best and most current data available are considered. Accordingly, updates on recent Sonoran pronghorn population surveys in the United States and Mexico, mortality investigations, disease testing, and the effects of military overflights on behavior and hearing are presented. In addition, the discussion of recovery criteria is prefaced by an assessment of the five factors that must be considered when determining if a species meets the requirements for listing as threatened or endangered under the Endangered Species Act (ESA) of 1973. The Sonoran pronghorn was initially designated endangered in 1967 under the Endangered

Species Preservation Act of 1966. The subspecies was "grandfathered" in under the ESA, and as a consequence, formal listing factors were never established. The five factors described in section 4(a)(1) of the ESA are: 1) the present or threatened destruction, modification, or curtailment of its habitat or range; 2) overutilization for commercial, sporting, scientific, or educational purposes; 3) disease or predation; 4) the inadequacy of existing regulatory mechanisms; and 5) other natural or manmade factors affecting its continued existence. A discussion of the five factors is presented in this amendment to the Recovery Plan. Also, recovery criteria established in the Recovery Plan for downlisting/delisting are reassessed and discussed. The criteria for downlisting remain valid and achievable. Specified recovery efforts are applied to the appropriate listing factors outlined on page 22 of the Court Order. The USFWS believes these recovery efforts will in the short-term lead to downlisting the Sonoran pronghorn from endangered to threatened, and in the long-term, will contribute to the delisting of the species. Finally, the implementation table presented in the Recovery Plan is expanded to include a breakdown of all recovery actions. The table has been updated to provide estimates of time necessary to carry out measures needed to effect recovery of Sonoran pronghorn as articulated in the Recovery Plan.

Villa-Ramírez, B. 1978. Especies mexicanas de vertebrados silvestres, raras o en peligro de extinción. Institute of Biology, University National, Mexico. 49. Series Zoology 1: 302-320.

The author reports that Sonoran pronghorn are in critical danger of extinction.

Wallace, C. S. A., J. J. Walker, and S. E. Marsh. 2002. Modeling Sonoran pronghorn antelope habitat: comparing logistic regression of geospatial data with principal component and Fourier analysis of multi-temporal remote sensing data. Office of Arid Land Studies, University of Arizona, Tucson, Arizona, USA.

This study evaluates and compares the result of using different geospatial analysis techniques to characterize Sonoran pronghorn antelope habitat in southwestern Arizona. The first habitat model was developed in a GIS-environment by applying logistic regression to field-based measurements of landscape characteristics available for Organ Pipe Cactus National Monument. Other habitat models were developed by extracting and analyzing measures of landscape temporal dynamics from NOAA AVHRR NDVI data at known pronghorn locations. Temporal measures were derived using standardized principal component and Fourier analysis of the AVHRR data. These measures capture dynamics that include vegetation phenology, and were selected to provide regional information on vegetation cover and communities. Both GIS-based and remote sensing-based modeling approaches relied on an extensive database of pronghorn sightings, and examined the influence of seasonal differences on migration patterns and model results.

Validation results confirm the effectiveness of all models. The GIS models produce a final predictive ability between 66 and 86 percent. The AVHRR models discriminate between sightings and random points, and show a reasonable fit to the GIS models, both visually and statistically. These findings are significant because the AVHRR models can be easily constructed, provided that a sightings data set is available and can be matched with coincident AVHRR NDVI imagery.

Wright, R. L. and J. C. deVos Jr. 1986. Final report on Sonoran pronghorn status in Arizona. Arizona Game and Fish Department Phoenix,

Arizona, USA. Contract number F0260483MS143.

The primary objective of this study was to obtain basic life history data on Sonora pronghorn that can be used to manage for the continued existence of this endangered subspecies. Authors discuss classification, habitat, population estimates, past management practices, movements, climate, diet, behavior, natality and mortality. Understanding these data and preserving habitat are critical to the survival and management of Sonora pronghorn in the United States.

ABSTRACTS

Amor, C. D., O. A. Ryder, R. Romey, and R. A. Medellin. 2001. Genetic variation among pronghorn populations using mitochondrial DNA control region as a molecular marker. Pronghorn Antelope Workshop 19: 106.

Mexican pronghorn populations have been declining drastically in the last century as a result of habitat fragmentation and loss, predation and poaching. The latest census data indicates there are approximately 1,000 individuals representing 3 subspecies. Of the three, the peninsular pronghorn subspecies is the most threatened, comprising only 10% of the total number of pronghorn present in Mexico. In order to ensure the survival of this species, conservation management of the remaining populations is necessary. One key element to contribute towards this management is the analysis of genetic variation found among pronghorn subspecies and populations. This will help to understand their recent demographic history, the effects of range reduction on gene flow and genetic variation. To accomplish this goal, we compared genetic variation between Mexican and United States populations using the mitochondrial d-loop control region as a molecular marker. The majority of DNA samples from Mexico that were obtained for these studies were extracted from horns, bone marrow, old tissue, hair, and feces, all of

which were collected by non-invasive methods. Oligonucleotide primers designed to amplify the d-loop control region were used in PCR reactions to produce a 500 base pair product. The sequence from 93 individuals from Mexico and USA were obtained including representatives of all 5 subspecies. The authors found 29 haplotypes, which indicates a high level of variation, suggesting that reported severe population bottlenecks during the last century did not strongly reduce the genetic variability within the species. The authors found a low level of genetic differentiation between the populations. The data that was obtained in this study shows signs of a rapid population explosion of the pronghorn populations, as a result of the extinction of many of their predators and competitors during the megafauna extinction, and the prairie expansion during the Holocene. The results obtained from this study will help to understand the recent evolutionary history of the pronghorn populations, and will be valuable for making management decisions designed to reestablish populations of the endangered subspecies in Mexico.

Bernatas, S., R. Spauling, P. J. Mock, and D. King. 1999. Infrared survey of Sonoran pronghorn on the Barry M. Goldwater Range. Pronghorn Antelope Workshop 18: 101.

The purpose of this study is to conduct aerial surveys from fixed-wing aircraft using infrared (IR) technology to determine population levels, sex ratios, and group size of endangered Sonoran pronghorn (SPH). Approximately 90% of the known range of the SPH in the United States lies under restricted airspace or military operations areas (MOAs) utilized by the United States Air Force (USAF). As a federal agency, the United States Air Force is mandated by the Endangered Species Act of 1973 (87 Stat. 884) to manage and protect endangered species inhabiting lands under their jurisdiction. A prerequisite to effectively manage a population is knowledge of the size or density of that population. Information on size or density of a population allows for an

understanding of mortality, natality, rate of increase or decrease, dispersal, and competition. A reliable method to determine these population characteristics is vital to the study of population dynamics, assessing management activities, impact assessment, developing management programs, and resource protection. The knowledge of these population characteristics is especially important in managing an endangered species such as SPH. Previous IR technologies have lacked the ability to determine to sex and age of animals or confirm the species of the animal picked up on the sensor. The most current civilian IR technologies have the ability to determine the species and the sex and age class of the animal. The survey altitude is high enough to avoid disturbance to the animals, reducing startling effects and double counting. This study describes a new censusing technique using light, fixed-wing aircraft and forward looking IR (FLIR) with natural-color zoom camera lens to detect and verify SPH.

Bright, J. L., J. J. Hervert, L. A. Piest, M. T. Brown, and R. S. Henry. 2001. Pronghorn Antelope Workshop 19: 112.

The current range of Sonoran pronghorn in the United States is limited to southwestern Arizona. Vegetation is described as the Lower Colorado River Valley or Arizona Upland subdivisions of the Lower Sonoran Desert Life Zone. We studied home ranges and habitat use of radiocollared Sonoran pronghorn from 1994 to 1999. Habitat was classified primarily by topographic features into 5 categories: flats, bajadas, hills, washes, and other. Habitat associations of pronghorn were recorded on weekly aerial telemetry flights. We used estimates of the expected proportions of vegetation associations, which were derived by plotting random points. Seasons were based on local temperature and precipitation patterns. Observed use was compared to expected use by seasons using chi-square tests. We also mapped the distribution of chain-fruit cholla and compared use of these

areas to areas lacking this species. The results of these analyses will be presented.

Castillo, C., J. C. DeVos, Jr., and J. J. Hervet. 2000. The status of Sonoran pronghorn in Sonora, Mexico. Pronghorn Antelope Workshop 17: 107.

The Sonoran pronghorn is of great biological interest in Mexico. As with the other pronghorn subspecies in Mexico, Sonoran pronghorn are listed as endangered by the Mexican government. The listing is the result of an apparent widespread decline in the number of pronghorn in Sonora, from a population thought to exceed 1,000 animals to one that was estimated at less than 50. Possible causes of the decline include illegal hunting, habitat loss and competition with domestic livestock. Beginning in 1989, the Centra Ecologico de Sonora, in cooperation with the Arizona Game and Fish Department began investigating life history and habitat use patterns for Sonoran pronghorn. An initial aerial survey resulted in classification of 33 Sonoran pronghorn. Subsequent surveys resulted in a population estimated at 313 animals. We have conducted 4 captures to equip animals with VHF and satellite telemetry. Important findings have been documented regarding mortality rates, movement patterns and habitat use. These were useful in developing education programs to reduce impacts to Sonoran pronghorn. Results of monitoring efforts may support establishing the Pinacate Biosphere Reserve. We discuss various aspects regarding life history and current status of Sonoran pronghorn.

deVos, J. C., Jr. 1996. Habitat selection patterns by Sonoran pronghorn in southwest Arizona. Page 34-37 in T.J. Tibbitts, and G.J. Maender, editors. First conference on research and resource management in southern Arizona national park areas. Cooperative Park Studies Unit, University of Arizona, Tucson, Arizona, USA.

The Sonoran pronghorn is listed as an endangered species in both the United States

and Mexico due to reduced population levels. The cause of the population decline is likely the result of many, interrelated factors of which habitat alterations by humans and their livestock are frequently listed impacts. If true, logically understanding how Sonoran pronghorn use habitats and what habitat characteristics are selected for or against would be important to recovery. The Arizona Game and Fish Department, in cooperation with the United States Fish and Wildlife Service, National Park Service, the Bureau of Land Management, and the Department of Defense initiated a habitat use and life history study of Sonoran pronghorn. During this study, 19 Sonoran pronghorn were fitted with radiotelemetry units and monitored for the life of the collar. To assess habitat use patterns, various habitat-related geographic information system covers were used: vegetation, distance to water, distance to roads, distance to ephemeral waterways. The author used chi-square analysis, Bonferroni confidence intervals, and Jacob's D to test the hypotheses that use of each of these habitat covers was random. Sonoran pronghorn showed selection and avoidance for different buffers in each habitat cover. This was particularly true for the within riparian zone and the 1-km (0.6-mi) buffer. In contrast, Sonoran pronghorn avoided those buffers beyond the 2-km buffer with avoidance increasing in the more distant buffers.

deVos, J. C., Jr., and L. Thompson-Olais. 2000. Using the Vortex model to assess minimum viable population for Sonoran pronghorn. Pronghorn Antelope Workshop 17: 108.

The Sonoran pronghorn is listed as endangered subspecies in the United States and Mexico due to low population numbers throughout its range. Possible reasons for low population numbers include: illegal harvest, habitat loss or conversion to other uses, competition with domestic livestock, or drying of perennial waterways. Consistent with the Endangered Species Act, federal and state resource management agencies are investigating various aspects of life history and habitat use. A benefit of this work is a

better understanding of population demographics. While some life history aspects remain speculative due to the lack of definitive data, there is sufficient knowledge to use a computer model to simulate population persistence under various management/environmental conditions. The authors elected to use the computer model VORTEX for this assessment over other available models because of desirable attributes of this model. One of the most attractive aspects of VORTEX is the fact that it is a stochastic model that incorporates random variation in both climatic and population performance that are similar to processes that occur in natural settings. The authors chose to use 2 approaches in the modeling effort. First, they used available data on Sonoran pronghorn to develop a likely scenario for this subspecies in Arizona. Where data were not available they authors used data from surrogate subspecies from as similar as possible habitats. The authors then convened a meeting of the experts on Sonoran pronghorn and used a modification of the Delphi method to determine values of variables required for VORTEX. Once this was done, the authors modeled these input parameters to evaluate the probability of Sonoran pronghorn persistence under these population/life history values. The authors defined the minimum viable population as having a probability of persistence of greater than 0.95 for a period of 100 years. The authors started with an initial population of 25 animals and added animals in increments of 25 until the desired probability of persistence was achieved.

Hanna, J. D., J. Hervert, L. Thompson-Olais, and R. X. Barry. 1994. Aerial surveys for the endangered Sonoran pronghorn on the Barry M. Goldwater Air Force Range. The Wildlife Society Annual Conference 1: 38.

A small remnant population of Sonoran pronghorn persists in the extremely arid flatlands of southwestern Arizona and adjacent Mexico. The current range of the Sonoran pronghorn in the United States extends throughout several land management

jurisdictions, including Organ Pipe Cactus National Monument, Cabeza Prieta National Wildlife Refuge and the Barry M. Goldwater Air Force Range. As part of the recovery effort, an aerial survey of historic Sonoran pronghorn range was conducted for the first time in 1992 to test methodology. Analysis of data resulted in a U.S. population estimate of 251 pronghorn. Annual surveys and cooperation will provide population estimates and trends to enable effective management for recovery of the Sonoran pronghorn from its endangered status.

Hervert, J. J., L. A. Piest, W. B. Ballard, R. S. Henry, and M. T. Brown. 1999. Sonoran pronghorn use of disturbed plant communities: management implications. Pronghorn Antelope Workshop 18: 104.

We investigated habitat use patterns of Sonoran pronghorn using 6 to 16 radiomarked animals from December 1994 through December 1997. Mean annual home-range size was 107,789 ha for 1995; 126,328 ha for 1996, and 114,433 ha for 1997. Habitats disturbed by military training activities were used by pronghorn in greater proportion than expected ($P < 0.001$). The disturbed plant communities resulted in opening up habitats and seemed to be an attractant to pronghorn. Annuals (forbs, grasses) persisted longer in the disturbed habitats, thereby resulting in prolonged availability of preferred forage. Predation of adult pronghorn by coyotes and bobcats seemed to be related to vegetative type and to drought conditions.

Hervert, J. J., L. Thompson-Olais, B. S. Henry, S. S. Henry, and M. T. Brown. 2000. Recovery efforts for Sonoran pronghorn. Pronghorn Antelope Workshop 17: 106.

Fixed-wing aerial surveys of Sonoran pronghorn in 1992 and 1994 yielded population estimates in Arizona. Pronghorn with radiotelemetry collars are providing managers with data on productivity, recruitment, dependency on free-standing water, habitat use patterns, mortality rates,

and predation. These efforts reflect the recently revised Recovery Plan. Mitochondrial DNA analysis will assist with subspeciation validation. Management questions such as water development, the international border fence, and predator control are controversial and under investigation. Managers are faced with reconciling efforts to recover an endangered species with wilderness and ecosystem level approaches to land management.

Krausman, P. R., C. Blasch, L. K. Harris, and J. Francine. 2002. Hearing sensitivity of desert ungulates (*Odocoileus hemionus*) in 1997 and 1998 at Campe Verde, Tucson, and Barry M. Goldwater Range, Arizona. Proceedings of the Arizona/New Mexico Chapter of the American Fisheries Society and Arizona and New Mexico Chapters of the Wildlife Society Joint Annual Meeting 35: 39-40.

Land managers and biologists are concerned about sound pressure levels created by military jets over habitat of wildlife including desert ungulates. The authors conducted baseline auditory brainstem responses (ABR) (i.e., behavior hearing sensitivity) of American pronghorn and desert mule deer that were not regularly exposed to military aircraft (control animals) through standard audiometric insert tube phones. We measured general hearing function in the 1-4 kHz frequency range. We presented the stimuli at sound pressure levels up to 110 decibels and decreased in 10-decibel steps until responses were no longer observed. We contrasted the data from pronghorn and deer with similar data from desert bighorn sheep and humans. There was no difference in the ABR thresholds between the control and exposed animals. Furthermore, desert ungulate hearing is likely less acute than human hearing at most audible frequencies.

Krausman, P. R., L. K. Harris, S. K. Haas, K. Koenen, P. Landin, J. Leverich, and D. A. Whittle. 2002. Sonoran pronghorn habitat use and availability on a military range. Pronghorn Antelope Workshop 20: 113.

The Sonoran pronghorn population in the United States has been reduced because of habitat loss. Low population numbers coupled with unstable recruitment have raised concerns regarding this subspecies. We examined habitat use by pronghorn on the Barry M. Goldwater Range (BMGR) from 1999-2001. Pronghorn sightings ($n = 443$) were overlaid on 344 1-km² blocks within the North and South Tactical Ranges, BMGR, with vegetation association and disturbance status (e.g., airfields, roads, targets) identified for each block. Pronghorn locations were distributed in proportion to vegetation associations. Sightings were biased toward disturbed blocks with 72% of pronghorn locations occurring in proximity to mock airfields, high explosive hills, roads and targets. Disturbed habitat on the BMGR may attract Sonoran pronghorn by creating favorable forage and viewing conditions in a vegetatively monotypic environment. Environmental manipulations simulating the effects of some military disturbances on the landscape may improve remaining Sonoran pronghorn habitat.

Landon, D. M., P. R. Krausman, L. K. Harris, and K. K. Koenen. 2000. Response of Sonoran pronghorn to military activity. Page 54 in W. L. Halvorson, and B. S. Gebow, editors Third Conference on Research and Resource Management in the Southwestern Deserts, Extended abstracts. United States Geological Survey Sonoran Desert Field Station, University of Arizona, Tucson, Arizona, USA.

The Sonoran pronghorn has been listed as endangered since 1967, but limiting factors for this animal remain unknown. Almost half of the Sonoran pronghorn in the United States inhabit the Barry M. Goldwater Range (BMGR) near Ajo, Arizona. The presence of Sonoran pronghorn on the BMGR has raised concerns about the potential effects of military activities on the recovery of

Sonoran pronghorn. The purpose of this study was to evaluate the response of Sonoran pronghorn to military activity on the BMGR. Authors collected data from February 1998 through January 1999. They examined Sonoran pronghorn response to noise, military overflights, ordnance training, and ground activity (15,000 30-second observations, 800 military events). There was no marked change in the behavior of Sonoran pronghorn during any military event. The first year of this 4-year study suggests that Sonoran pronghorn response to military activity is negligible. Cooperation between the United States Air Force, The University of Arizona, Arizona Game and Fish Department, Harris Environmental Group Inc., and other federal and Arizona state agencies has facilitated and enhanced this ongoing study of Sonoran pronghorn response to military activity on the BMGR.

Lopez-Saavedra, E. E., R. Paredes, R. M. Lee, R. Schwelnsburg, and J C. deVos. 1998. Estudios de barrego cimarrón, berrendo y puma en la Reserva de la Biosfera del Pinacate y Gran Desierto de Altar (Bighorn sheep, pronghorn and mountain lion studies in the Pinacate and Great Altar Desert Biosphere Reserve. Page 308 in G. J. Gottfried, Edminister, C. B., and Dillon, Madelyn C. (compilers) 1998. Cross Border Waters: Fragile Treasures for the 21st Century; Ninth U. S./Mexico Border States Conference on Recreation, Fish and Wildlife; 1998, June 3-6. Proceedings RMRS-P-5. Fort Collins, CO, U.S.A. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

This project consists in the evaluation and the monitoring of wild populations and the habitat quality of desert bighorn sheep, Sonoran pronghorn and mountain lion (for mountain lions, only direct and indirect observations will be registered on the field and by using historical reports) in the Biosphere Reserve of the Pinacate and Grand Altar Desert. Thus, taking on account the actual situation of the three species mentioned before, in the sense of their population status and changes in land use in their actual,

historical and potential habitat, and on the lack of information regarding management activities, this project is proposed. This project has 3 main objectives. 1. To monitor and evaluate populations and habitat use of three important species. 2. To generate basic and applied information for management purposes. 3. To contribute to the management program of a natural protected area in a wildlife management and research chapter.

Malone, C. L., J. C. deVos, Jr., J. R. Heffelfinger, and O. E. Rhodes, Jr. 2002. Genetic distinction of the Sonoran pronghorn antelope. Pronghorn Antelope Workshop 20:15.

Genetic analysis of samples from Sonoran pronghorn do not support designation of a separate subspecies.

POPULAR ARTICLES

Anonymous. 2002. Run, run mottled Sonoran deer. Peñasco Magazine 13: 16-17.

The authors refer to Sonoran pronghorn as mottled deer. Their decline and recovery efforts are briefly discussed.

Askins, C. 1979. Pronghorn: the distant target. The American Hunter, March: 40-43.

The author describes hunting pronghorn in Sonora, Mexico mixed with some life history information. Some of it may be accurate.

Boyer, P. J. T. No date. The Pinacate and Gran Desierto del Altar Biosphere Reserve. Centro Intercultural de Estudios de Desiertos y Océanos 5: 15-16.

A brief description of the reserve is provided. Threats to Sonoran pronghorn include illegal hunting and habitat alteration due to livestock. Control of anthropogenic activity is critical to the maintenance and enhancement of the reserve.

Brown, D. E. 1992. Arizona's pronghorn challenge. Defenders 67: 24-34.

The capture of Sonoran pronghorn with a net gun fired from a helicopter is described in this popular article. Life history and a brief review of the conservation of Sonoran pronghorn is described: recognition of declining numbers due to hunting, livestock, military action, and other anthropogenic influences; establishment of refuge; listed as endangered; active studies; and eliminating hunting and livestock. Future management may require translocation, but now they are managed by climate and their fate is uncertain.

Brown, D. E. 1994. History of pronghorn in Arizona. Pronghorn 2(1): 6-7; 2(2): 5-7; 2(3): 1-9; 2(4): 1-7; 3(1): 3-5; 3(2): 3-5.

This series of articles is a concise history of pronghorn in Arizona documented with early quotes from naturalists and newspapers. The authors tell the story of decreasing numbers of pronghorn and conservation efforts to restore the species.

Brown, D. 1986. USA: Sonoran pronghorn. Safari, November/December 24-27.

The author discusses the classification of the Sonoran pronghorn (the last big game animal to be classified in North America), creation of refuges, its endangered status, and importance of climate to the animals survival.

Carr, J. 1970. The Sonoran pronghorn. Wildlife Views 17: 4-7.

The author presents general life history characteristics, distribution, population estimates, and limiting factors are discussed. Conservation will have to be an international effort.

Christopher, M. 1989. Rescuing Arizona's vanishing antelope. Ford Times, June: 37-47.

The author describes the first Arizona Game and Fish Department study of the Sonoran pronghorn, the "mysterious subspecies of pronghorn, which was fabeled

to thrive without drinking water." He describes daily activity of the researchers in obtaining data on the radiocollared pronghorn. The study revealed that pronghorn do drink water and the animals would need a captive breeding program to survive.

Davidson, B. R. 1971. Saving the Sonoran pronghorn. The American Rifleman, November: 38.

Poaching and lack of knowledge about Sonoran pronghorn have contributed to its declining population. Scientific management of pronghorn is necessary for their continued existence.

deVos, J. C. 1992. International Sonoran pronghorn projects. Wildlife Views: September: 16.

A brief summary of the international efforts to survey and capture Sonoran pronghorn in Sonora Mexico in the early 1990s.

deVos, J. C. 1983. Sonoran pronghorns captured. Arizona Wildlife Views 26: 1-3.

The author describes the first capture of Sonoran pronghorn in 1983 that began a cooperative study to examine the ecology of the species.

deVos, J. C, Jr. 1984. The making of an endangered subspecies. Wildlife Views, June

The decline of Sonoran pronghorn was caused by habitat alteration due to livestock grazing, dams, agriculture, and illegal harvest. Radiocollaring animals will provide more information from which informed decisions can be made.

deVos, J. C. 1995. The Sonoran pronghorn. Wildlife Views, March: 16.

The author provides a short description of taxonomy, description, habitat, distribution, biology, status, and management needs of Sonoran pronghorn.

Dominguez, G. 1997. A combat training range is where the antelope plays. Brooks Air Force Base, Texas. Center Views 3: 3-4.

The author presents general life history characteristics of Sonoran pronghorn and suggests military ordinance enhance vegetation quality within their range. Only 5% of pronghorn habitat is influenced by direct military training.

Friederici, P. 1999. Homeless on the range. National Wildlife. 37(6): 18-27.

General life history of Sonoran pronghorn is presented with concerns for the species survival.

Friederici, P. 2003. Looking for help. Defenders, Fall: 15-17.

This popular article describes the habitat changes that caused Sonoran pronghorn to decline. The author briefly outlines measures that are underway for habitat restoration, including watering vegetation and construction of a breeding facility.

Gaillard, NMI. No date found. The perils and wonders of a true desert. Cosmopolitan.

The author states that antelope can survive without obtaining free-standing water by eating cactus.

Halloran, A. F. 1954. The dwarf antelope of the Yuma flats. Arizona Wildlife Sportsman 25 (4): 26-28.

In 1925 there were 600 Sonoran pronghorn. Populations have been diluted with translocated pronghorns from northern Arizona, and some herds have decreased. Hunting has been restricted since 1922, but numbers have not increased. The author discusses a joint refuge in Arizona and Mexico to enhance habitat.

Hervert, J. 1996. Nomads of the desert: Sonoran pronghorn. Wildlife Views 39: 2-5.

Basic biological information about Sonoran pronghorn is presented, including home range size (1, 600 km²), population estimates (1992, 256; 1994, 184) and limiting factors (e.g., water, predators, diet). More information is needed before active management is attempted, especially the relationship of Sonoran pronghorn with free-standing water.

Hervert, J. 1997. Saving the Sonoran pronghorn. 1997. Bajada 5: 5.

General life history characteristics of Sonoran pronghorn are discussed and steps to recovery are mentioned. The latter include monitoring, surveys, population viability assessment, and a search for limiting factors.

Hervert, J. 1999. Sonoran pronghorn recovering. Pronghorn 6(2): 1-3.

The population of Sonoran pronghorn in the United States has fluctuated from 85-100 in 1986, to 200-250 in 1994, and 125 in 1996. The population is currently estimated at 140 and declining due in part to limited rainfall and forage. Methods to reverse the declining trend include enhancing the habitat by improving the quality of vegetation.

Hervert, J. 2001. The road to recovery. Wildlife Views 44: 10-13.

As population numbers of Sonoran pronghorn increased from 1986 ($n = 85-100$) to 1994 ($n = 200-250$), biologists were hopeful the trend would continue. Unfortunately, drought and no to low fawn recruitment reduced the population to only 99 animals at the end of 2000. Clearly, active management was necessary to enhance conditions for this endangered species. A management plan to enhance the habitat by removing creosote, irrigating forage, and creating water sources for pronghorns is presented as a mechanism to increase numbers of Sonoran pronghorn.

Hosack, D. 1997. Population viability analysis workshop for Sonoran pronghorn. Pronghorn News 1: 2.

See Hosack et al. 2002 (Peer-reviewed)

Humphrey, W. E. 1911-1912. Shooting the vanishing sheep of the desert. Outdoor Life: 28(6): 477-487; 29(1): 3-16; 29(2): 95-105.

The author describes a hunting expedition in and around the Tenaga Range in northern Mexico south of California, for Nelson's bighorn sheep. He also describes the hunt for pronghorn in the third installment of the 3 part series.

Ilkenson, B. 2003-2004. Pronghorn race extinction across the Sonoran Desert. Wild Earth, Winter: 61-65.

The author describes the declining population of Sonoran pronghorn and briefly discusses recovery efforts including water access sites, forage enhancement plots, seasonal area closures, and development of a semi-captive breeding enclosure within their range in the United States.

Ilkenson, B. 2002. Restoring the Sonoran pronghorn. Earth Island Journal, Autumn: 24-25.

The limited forage and water for Sonoran pronghorn are emphasized as limiting factors for this endangered subspecies.

Ilkenson, B. 2002. Staking out survival for Sonoran pronghorns. Américas 54: 6-13.

The author presents a brief view of life history characteristics of Sonoran pronghorn, discusses their current decline, and outlines potential measures for reestablishing the endangered species.

Ilkenson, B. 2002. Taking the hard road. Birdscapes, Fall 2002: 21.

This brief summary identifies roads, drought, fencing, railroads, border fencing,

highways, human foot traffic, water diversion, and overgrazing as threats to Sonoran pronghorn. A forage enhancement project is being planned to drill wells and add water to the environment in hopes of increasing the moisture available to pronghorn.

Jackson, T. 1980. Sonoran pronghorn recovery presents challenge. Wildlife Views 23: 1, 4.

The remaining Sonoran pronghorn in North America are on the brink of extinction and little is known about their life history characteristics. There is not enough information known about Sonoran pronghorn to begin active management for the recovery of the subspecies. A Sonoran pronghorn recovery team has been created to initiate the restoration of this animal.

Jecker, M. 1988. Antelope on the go in Southern Arizona. Wildlife Views: 24-25.

Only 100 Sonoran pronghorn exist in the United States. The refuges of Cabeza Prieta Game Range Organ Pipe Cactus National Monument, and Luke Air Force Gunnery Range protect habitat for Sonoran pronghorn.

Schroeder, A. H. 1961. An archeological survey of the Painted Rocks Reservoir, Western Arizona. The Kiva 27: 1-23.

Pronghorn occupied grassland areas adjacent to the northern border of historically described Sonoran pronghorn range.

Utter, J., B. Tunnicliff, M. Garcia, and S. Brickler. 1983. Planes and pronghorns share vast Luke Range. Arizona Land and People, December: 17-21.

The authors discuss the military use of Luke Air Force Range, cultural and major wildlife resources, and a resource plan that the School of Renewable Natural Resources started for Cabeza Prieta National Wildlife Refuge and the entire Luke Air force Range. The plan will be designed to identify and

address current and future management issues.

in desert plans and the population estimate was 1,000. Limiting factors include illegal harvest, predation, drought, and disease.

Wright, J. T. 1959. Desert wildlife. Arizona Game and Fish Department, Wildlife Bulletin 6.

The author lists the scientific name of the Sonoran pronghorn and provides the distribution in Arizona.

OTHER

Gonzalez, A., and A. Laffon. 1993. Distribution y estado actual del berrendo (*Antilocapra americana*) en Mexico. Pages 409-419 in R. A. Medellin y G. Cebellos, editors. Avances en el estudio de los mamíferos de Mexico. Publicaciones Especiales. Association Mexicana de Mastozoología, A. C. Mexico, D. F.

Article was not located.

Lopez-Fonseca, M. C. 1982. Field investigations in relation to the population and distribution of *Antilocapra Americana sonorensis* in the state of Sonora (Mexico). Memorias del Instituto Nacional de Investigaciones Forestales. Publicación Especial 37: 131-132.

Article was not located.

Smith, R. M. 1988. Taxonomic assessment of Arizona pronghorn. Memorandum to U.S. Fish and Wildlife Science Service, Regional Director, Region 2.

These are 11 skins or skulls of Sonoran pronghorn in museums, not enough to classify the animal to subspecies. The subspecific status is questionable until more data are available.

Villa R., Bernardo. 1958. Informal report on studies of bighorns and antelope in northern Mexico. Instituto de Biología, Mexico, D. F.

This document is a summary of field excursions into Sonoran pronghorn habitat in Mexico 1957. Ground and aerial surveys were made. Sonoran pronghorn were observed