Proceedings of the Sixteenth Biennial
PRONGHORN ANTELOPE WORKSHOP

April 18 - 21, 1994

KANSAS DEPARTMENT OF WILDLIFE AND PARKS

Emporia, Kansas

PROCEEDINGS

of the

SIXTEENTH BIENNIAL

PRONGHORN ANTELOPE WORKSHOP

Edited by

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Kansas Department of Wildlife and Parks

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Emporia, Kansas

April 18-21, 1994

Keith E. Sexson, Workshop Chairman

PREFACE

The Kansas Department of Wildlife and Parks hosted the 16th Pronghorn Antelope Workshop at Emporia, Kansas during April 18-21, 1994. Sponsors of the workshop included the North American Pronghorn Foundation, the KS Chapter of The Wildlife Society, and the Division of Biological Sciences of Emporia State University. Forty-nine people attended. Representatives from 11 states were present. Jorge Cancino, a representative from Mexico, registered for the meeting, however, he was unable to attend.

The goal of these meetings is to elevate our knowledge on the biology and management of pronghorn. At this workshop we continued to foster the exchange of ideas among pronghorn managers and researchers, and to provide a forum for research findings to be expressed. Seventeen technical reports were presented. Status reports were submitted by seven states.

A field trip was conducted through the pronghorn reintroduction site in the tallgrass prairie of Lyon and Chase counties, Kansas. Graduate students from Emporia State University shared their knowledge of this location and the history of the program. The Ross Natural History Reservation of Emporia State University served as the host for an evening cookout following the field trip.

These proceedings were edited for style and reformatted for consistency. Minor spelling and grammatical changes were made during this process, and we offered some suggestions. Our suggestions did not include study design or statistical analysis. Some manuscripts had to be retyped and thus created an opportunity for typographic errors. We apologize for those errors. Jim Yoakum served as the presenter and reviewer for the papers submitted by Jorge Cancino. Connie Boyce assisted with typing, while Christiane Roy and Cindy Moore assisted with graphics.

This proceeding is dedicated to the memory of Edson Fichter. His art work graces the opening of both our Technical Session and Provincial and State Status Report Section. He will be missed.

A business meeting was held on April 21, 1994. California will host the 17th biennial workshop in 1996.

Lloyd B. Fox, and Elmer J. Finck, Proceedings Editors

A lone buck,
I record (though he and I are both component
In the wide montage of earth and sky).
7 does and 5 fawns
½ mile southwest

The telescope transports them nearer
Through the restless air ...
The open notebook lies upon my pack ...
The pencil moves through hours of afternoon
Driven by compulsion
And commitment interfused.

A doe allows a fawn to nurse
16 seconds -- 2 fawns in running play,
rump-patches flared.
The buck walks
toward the doe-fawn group...

A Rock Wren's crystalline terlee-terlee-terlee
Translates the everlasting stillness --
The academic pages blur --
An old earth music quickens in my head
And though the mists of unforgotten dreams
A boy's will whispers free:
My homing is this lonely vale
Is more a search for feeling
Than for understanding --
That I am more possessed perhaps
With merely being here.

Pages 44 and 45 from: Fichter, Edson. 1988. Pahsimeroi--land beyond words. Blue Scarab Press, Pocatello, ID. 48pp.

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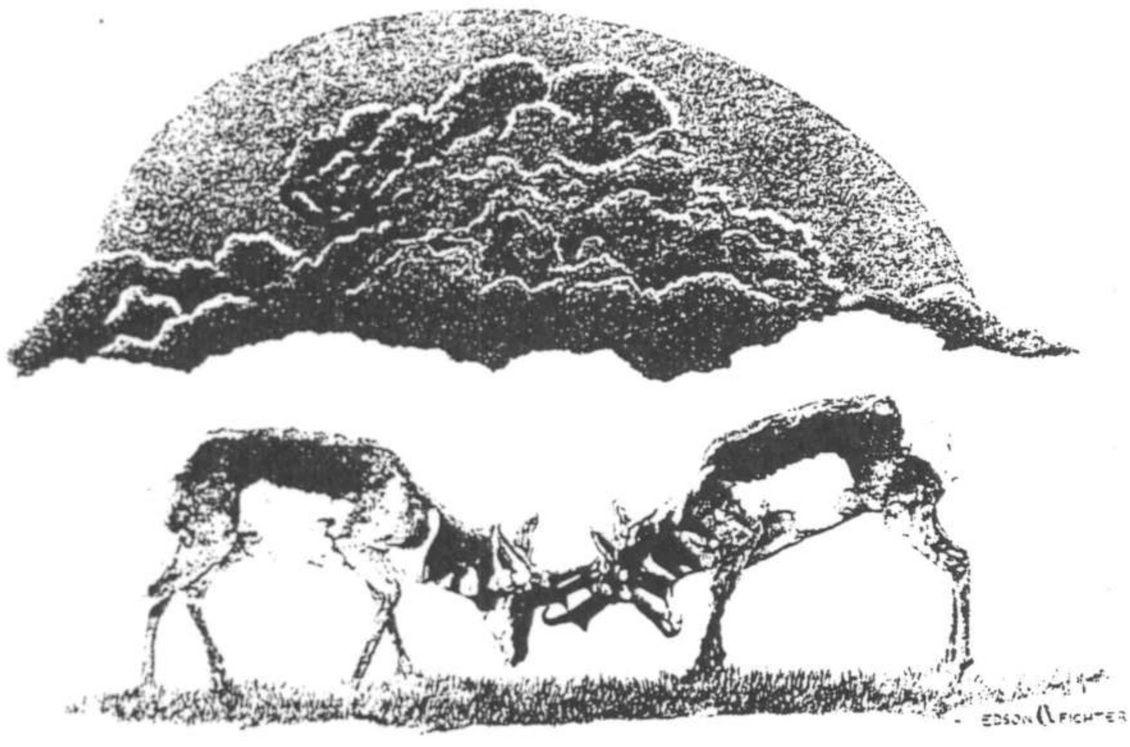
SUMMARY OF PRONGHORN WORKSHOPS HELD TO DATE

Meeting Dates and Locations	Number Attending	Chairman	Host Agency
April 14-16, 1965 Santa Fe, NM	18	W. Huey	New Mexico Dep. of Fish and Game
Feb. 16-17, 1966 Denver, CO	32	G.D. Bear	Colorado Game, Fish and Parks Dep.
Feb. 5-6, 1968 Casper, WY	97	J.L. Newman	Wyoming Game & Fish Commission
Jan. 27-28, 1970 Scottsbluff, NE	85	K.I. Menzel	Nebraska Game & Parks Commission
June 19-22, 1972 Billings, MT	85	H.O. Compton	Montana Fish & Game Dep.
Feb. 19-21, 1974 Salt Lake City, UT	52	D.M. Beale	Utah Division of Wildlife Resources
Feb. 24-26, 1976 Twin Falls, ID	68	R. Autenreith	Idaho Dep. of Fish and Game
May 2-4, 1978 Jasper, Alberta	84	M.W. Barrett	Alberta Fish & Wildlife Division
April 8-10, 1980 Rio Rico, AZ	64	J.S. Phelps	Arizona Game & Fish Dep.
April 5-7, 1982 Dickinson, ND	69	J.V. McKenzie	North Dakota Game & Fish Dep.
April 10-12, 1984 Corpus Cristi, TX	45	C.K. Winkler	Texas Parks & Wildlife Dep.
March 11-13, 1986 Reno, NV	43	M. Hess	Nevada Dep. of Wildlife
May 31-Jun. 2, 1988 Hart Mt., OR	43	D. Eastman	Oregon Dep. of Fish & Wildlife
May 22-24, 1990 Silver Creek, CO	45	T.M. Pojar	Colorado Division of Wildlife
Jun. 8-11, 1992 Rock Springs, WY	91	P. Riddle	Wyoming Game & Fish Commission
April 18-21, 1994 Emporia, KS	49	K. Sexson	Kansas Dep. of Wildlife and Parks

PROVINCIAL AND STATE

STATUS REPORTS



Two Pronghorn Sparing
Dr. Edson Fichter's final drawing of pronghorn.

ARIZONA ANTELOPE STATUS REPORT - 1994

Amber Alexander, Arizona Game and Fish Department, Phoenix

POPULATION ESTIMATES

Arizona's pronghorn antelope population is composed of three sub-species; *Antilocapra americana americana*, *A. a. mexicana*, and *A. a. sonoriensis*. Our antelope population is approximately 14,500 of which 13,800 are *americana*, 500 are *mexicana*, and 200 are *sonoriensis*. Game management units with the largest populations are units 5B, 10, 19A, and 19B. These units contain nearly 40% of Arizona's total

Antelope in Arizona are surveyed during June-August primarily from fixed-wing aircraft (Piper Super Cub, or STOL Cessna 182 or 206). Surveys are completed prior to the hunt an after most fawn mortality. A record total of 10,363 *americana* were surveyed in 1993, resulting in buck:doe:fawn ratios of 40:100:39 (Fig. 1). A record total of 368 *mexicana* were surveyed, resulting in ratios of 77:100:27. Fawn survival has been above average throughout the state for the last 3 years, probably due to higher levels of precipitation. *Sonoriensis*, an endangered species, are not hunted or routinely surveyed. In a 1993 Arizona survey, 114 *sonoriensis* were seen. Further survey and radio-telemetry work in cooperation with the USFWS and Mexico is planned for the future.

Harvest

In 1993, 675 antelope were harvested. Application rates for the three weapon types continue to increase. When archery hunting first began in 1974, only 16 hunters applied for the 50 permits available. In 1993, 1046 archers applied for 666 permits resulting in 1.6 applicants per permit. Demand for muzzleloader and centerfire rifle permits is much greater than for archery permits. Draw odds were 4.1 to 1 for muzzleloader permits and 17.4 to 1 for centerfire rifle permits. Minor adjustments were made to the 1994 permit levels to more accurately allocate permits by demand (Fig.2). Additional 1993 harvest information is shown below:

Weapon	Permits	Hunters	Days Afield	Harvest	% Success
CFR	645	633	1496	484	77
Mzl	153	149	486	80	54
Arch	666	615	3391	111	18

One of the most significant results of Arizona's antelope harvest is in the Boone and Crockett scores. Trophies in excess of 90 points have been taken. Based on Boone and Crocketts' 10TH edition 1993 Records of North American Big Game, Arizona has produced 7 of the top 20 scores. Arizona has also recorded 22 antelope trophies with scores $\geq$ 85 points since 1985.

MANAGEMENT PLANS, STRATEGIC PLANS, AND GUIDELINES

The Arizona Game and Fish Department (AGFD) provides its Wildlife Managers with an antelope management plan. This document gives guidance on how to survey, make hunt recommendations, fence, supplemental feed, etc., their antelope populations. The 1992-1996 Strategic Plan states the goals and objectives the AGFD has for antelope management. Antelope are managed for post-hunt buck to doe ratios of 25-30:100 and fawn to doe ratios of 30-40:100. When ratios fall below these guidelines permits are decreased and when above permits are increased. Other plan objectives include maintaining an antelope population of 8,200-8,900, and harvesting 550-600 antelope a year (Fig. 3). By 1996, we aim to identify critical antelope habitats and insure their protection and improvement where possible. Season dates for 1994 will be 8/19 - 9/1 for archers, with stratified seasons for firearms hunters of 9/16 - 9/19, and 9/23 - 9/26 or 9/23 - 9/28. The six day hunts are to promote trophy hunting in specific units.

TRANSPLANTS

Arizona has engaged in a fairly active antelope transplant program since its first release with Nevada antelope in 1924. Recently, Arizona has had the good fortune of having the money and excess bighorn sheep to initiate trades with several western states for pronghorn antelope. Usually, we are helping remove depredating animals, however, we have been "in the market" for the *mexicana* sub-species to repopulate historic range. Our most recent transplant of 54 came from Wyoming in February 1993 and was released near Hillside, AZ. This transplant has met with limited success, primarily due to mountain lion predation.

RESEARCH

The AGFD recently completed a 5-year (1989-1994) study of antelope home ranges, movement patterns, and habitat selection in central Arizona. The study concluded that population isolation, habitat fragmentation, movement corridors, and brush and tree invasion are management concerns.

Mortality research suggested that mountain lions are a significant predator on antelope in semidesert grasslands. Since many Arizona antelope populations occur in woodland situations, a study was done to estimate juniper densities relative to the level of antelope use. Research to develop a statewide antelope habitat model is now being initiated.

Sonoran pronghorn research has been underway for several years. Research is primarily concerned with habitat use, fawning rates, and movement patterns. Research is conducted in cooperation with the USFWS and the Mexican government.

Other research, in cooperation with the National Biological Survey, is being conducted at Wupatki National Monument and Petrified Forest National Park. The AGFD has also provided funds to Arizona State University and Northern Arizona University for graduate projects. These projects deal with 24-hour habitat selection, fawn bedsite characteristics, and antelope watering frequency and movements relative to water availability. Another project concerns habitat modelling and nutrition analysis but is not funded by the AGFD.

A report on the effectiveness of aerial coyote control has been produced. The AGFD is engaged in a program to aerially gun transplant sites and units where the fawn crop falls below 20:100 for 2 consecutive years.

SPECIAL PERMITS

The AGFD auctions or raffles special permits for fund raising purposes. Since 1984, over $2,199,454 has been raised through this program. The most successful have been for bighorn sheep ($303,000 for a permit) and elk ($67,000 for a permit). Our highest antelope permit was auctioned for $13,000. As of 1993, a total of $86,521 has been raised from antelope permits alone. These funds are earmarked for antelope management and have been expended on the antelope transplant program and coyote control efforts.

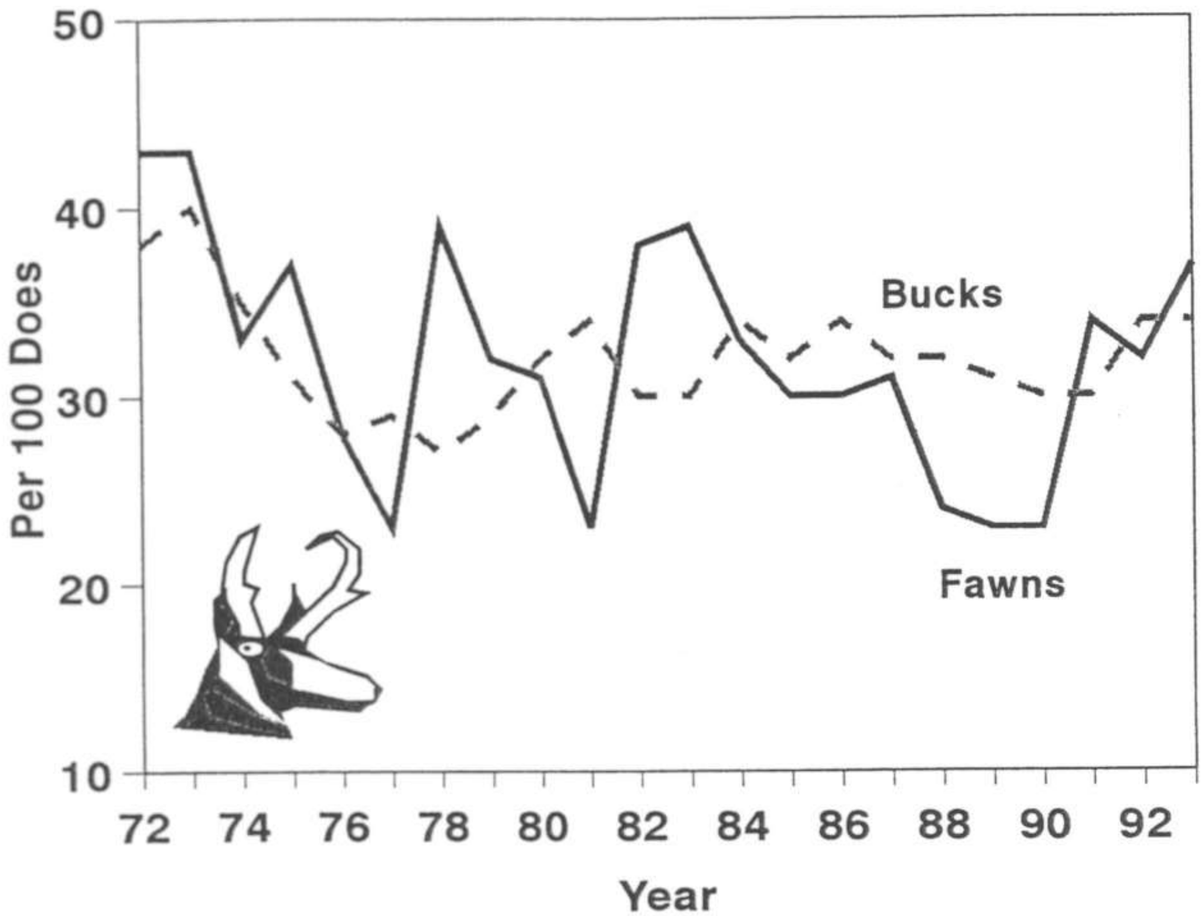


Figure 1. Statewide trends of buck:doe:fawn ratios for 1972-1993.

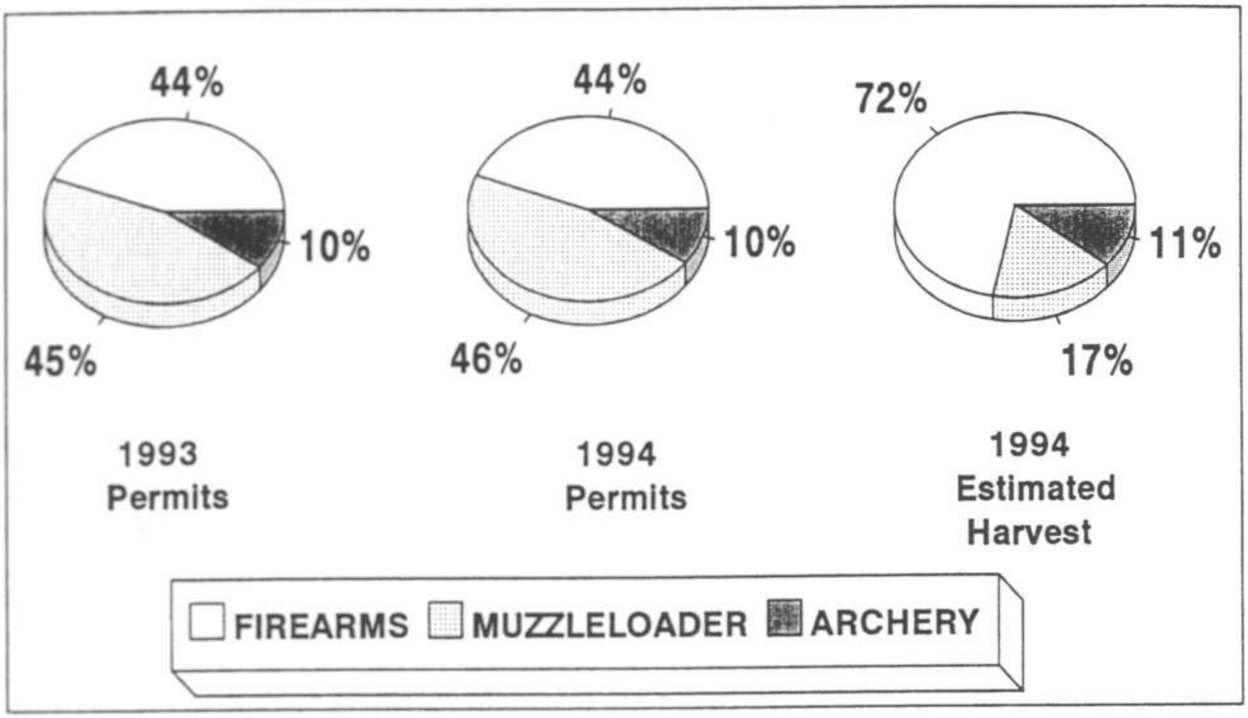


Figure 2. Percentage of permits for 1993 and 1994, and 1994 estimated harvest by 3 weapon types.

	PLAN OBJECTIVE	1993 RESULTS
HARVEST	550-600	675
HUNTERS	1,100-1,250	1397
HUNTER DAYS	3,500-4,100	5373

Figure 3. Antelope strategic plan objectives and 1993 results.

COLORADO PRONGHORN STATUS REPORT - 1994

Thomas M. Pojar, Colorado Division of Wildlife

The estimate of pronghorn herd sizes in Colorado is based on fixed-wing total coverage aerial surveys, population modeling, or a combination of surveys and modeling. The 1992 statewide population estimate was 53,412. The statewide objective is to maintain the population at 50,000 to 55,000. Harvest, which is regulated by limited licenses, has been relatively stable in recent years ranging from about 7,500 to 9,500. Statewide rifle hunter success is 75-80% and archery is consistently in the neighborhood of 25%. However, we still have the unique situation in the northwest part of the state where archers hunt from blinds over water holes and have a success rate of 60-70%. In this area, archery harvest is controlled by limited licenses and in the remainder of the state archery licenses are unlimited.

On average, about 15% of the estimated statewide population is harvested annually. A major exception to this generalization is a herd unit in the northwest region of the state. This herd has been estimated, by the above methods, to number about 6,500 animals and total annual harvest is about 2,000, which is slightly over 30% of the herd. It is possible the population size of this herd is being underestimated. Past experimental sample based surveys (quadrats and line transect sampling) have indicated the population to be about 16,000-18,000 animals and a recent (spring 1993) fixed-wing line transect survey produced an estimate of 20,000. Harvest will be increased based on this information, but at this time exact numbers are not available.

Demand for the opportunity to hunt pronghorn in Colorado is greater than the number of licenses available. In 1992, the demand for doe licenses was 1.64 times the number available and, for bucks, the number of applications was 3.76 times the number of licenses. In some areas, the demand for buck licenses is 25-50 times the number of permits available. These are usually areas with low pronghorn numbers and proximity to concentrations of human populations. However, an area that is remote from human population centers and has high pronghorn density has hunting demand that exceeds available permits by 2.35 and 8.52 for does and bucks, respectively.

Prevailing management challenges in Colorado include: 1) managing toward biological carrying capacity to meet demand by the hunting public yet minimize damage complaints from landowners and 2) implementing an affordable, reliable method to estimate pronghorn numbers and herd structure to more efficiently manage pronghorn herds.

Colorado pays very little annually, relative to other big game species, in damage claims (about $2,000) due to pronghorn. However, there is an abundance of landowner complaints which influence manager's herd size objectives. Alleged damage includes, but is not limited to, competition with domestic livestock for forage, damage to winter wheat from trampling and consumption, spreading of noxious weeds, consumption of established alfalfa and destruction of newly seeded alfalfa. Solutions to these problems are difficult, especially when damage is perceived even though research demonstrates that no damage is incurred. Winter wheat damage is the major complaint and limiting factor to managing for higher pronghorn numbers on the shortgrass prairie of Colorado's eastern plains. A cooperative research effort by Colorado State University and the Division of Wildlife is underway to estimate the extent and timing of pronghorn winter wheat use.

Better information to improve population simulations is always in demand because harvest quotas are based on these simulations in Colorado. Line transect sampling is attractive because it offers efficient use of aircraft time and can be done in fixed-wing aircraft, which is less expensive than helicopter time. However, proper execution of line transect methodology is problematic when applied to highly mobile subjects from a moving platform. In addition, model selection for analysis is subjective and can result in a variety of density and variance estimates. Quadrat based surveys require use of a helicopter, which is expensive, and usually quadrats must be physically marked on the ground, which is also very expensive. Recent Global Positioning System (GPS) technology may eliminate the need to place and maintain quadrat markers, which would eliminate one of the major expenses involved in quadrat sampling. Quadrat sampling is still expensive, relative to transect sampling, because of the cost of helicopter time. Estimates of variance and density from quadrat data, however, is direct and without subjectivity. A 3-year research project has been initiated to compare line transect (fixed-wing) and quadrat pronghorn density estimates in northwestern Colorado. Testing of the reliability of a GPS receiver in locating quadrats is included in this effort.

Aligning buck:doe ratios in simulations with observed data is sometimes difficult without significant changes in other parameters in the simulation. A common situation is that the simulated buck:doe ratio gravitates to 1:1 and exceeds observed ratios. This leads to 3 possible adjustments in the simulation process: 1) reduce the simulated population size, 2) assume higher natural mortality on the male side of the population, or 3) disregard the observed ratio as being biased. In recent pronghorn counting experiments, estimated buck:doe ratios were about 15 bucks:100 does less on strip transect surveys (helicopter) compared with helicopter quadrat surveys, which suggests there may be an undercounting bias for bucks on strip transects. No overcounting bias was detected on quadrat surveys. Other evidence from an intensely monitored Colorado pronghorn population strongly suggests that males do incur higher natural mortality than females because harvest could not account for the reduced number of bucks in the population. Using radio marked animals, a research effort in underway to investigate the rate of differential natural mortality between male and female pronghorn. It is likely that undercounting bias and differential mortality are the keys to resolving the common discrepancy in observed and simulated buck:doe ratios.

KANSAS PRONGHORN STATUS REPORT - 1994

Keith E. Sexson, KS Dept of Wildlife & Parks, Pratt
Lloyd B. Fox, KS Dept of Wildlife & Parks, Emporia

POPULATION ESTIMATES

Aerial counts using fixed-wing aircraft are conducted in July (production counts) and January (winter counts). Counts in January 1992 produced estimated population levels of 1,300 to 1,500 pronghorn in the major west central Kansas pronghorn range. However, the survey in 1993 produced estimated of only 900 to 1,000 pronghorn in the core range. There are an additional 300 animals in scattered herds located in the southwest, south central and east central portions of Kansas. Production surveys in the major range provided an estimated ratio of 73:100:70, bucks:100 does:fawns in 1991, while the survey in July 1992 produced an estimated ratio of 65:100:50.

Archery Season

Archery pronghorn permit availability changed from 150 per year in 1989 to unlimited permit availability in 1990 and afterwards. The 1992 archery pronghorn season was nine days in length, i.e., September 19 through 27, 1992. The open area included parts of 14 counties in west central Kansas. Each hunter was mailed a questionnaire. Permits were issued to 112 archery hunters in 1992 and 107 of them actively pursued pronghorn for a total of 419 hunter days. They harvested 14 bucks and 4 does or fawns. Similarly, the 1993 archery season was held from September 18 through 26, 1993 within the same area. Permits were issued to 114 archery hunters in 1992 and 110 of them actively pursued pronghorn for a total of 440 hunter days. They harvested 21 bucks and 3 does or fawns.

Firearm Season

A firearm season for pronghorn in Kansas was held from October 2 through 5, 1992. Three management units were established and 180 permits were available. Hunter demand exceeded permit availability. Permits were unavailable for nonresidents, and 620 resident hunters applied for a firearm permit. Each hunter was mailed a questionnaire. One hundred and seventy two hunters spent 214 days afield and harvested 152 bucks and 8 does or fawns. In 1993, the firearm season was held from October 1 through 4, 1993. Unit boundaries remained the same as the previous year. Applications for the 210 permits were received from 718 people. One hundred and ninety nine hunters spent 263 days afield and harvested 155 bucks and 31 does or fawns.

Relocations

Pronghorn were captured near Lamar, CO in 1991 and transported to Kansas. Forty-nine animals were released in Chase County and 49 were also released at the Cimarron National Grasslands in Morton County. Pronghorn were captured near Pueblo, CO in 1992. These animals were transported to the same release sites as in 1991, with 41 pronghorn being released in Chase County and 44 pronghorn released in Morton County.

Research

Graduate research projects on pronghorn ecology were conducted in east central Kansas under the direction of Elmer Finck of the Department of Biology at Emporia State University. Brad Simpson completed a thesis in 1992 titled, "Behavior, home range, and habitat use of pronghorn translocated to tallgrass prairie in east-central Kansas." Shannon Rothchild completed a M.S. thesis in 1993 titled, "Mortality, home range, and habitat use of pronghorn fawns within tallgrass prairie of eastern Kansas."

NEBRASKA PRONGHORN STATUS REPORT - 1994

Karl Menzel, Nebraska Game and Park

Aerial surveys are conducted mainly in the panhandle, and normally sample about 7,400 square miles. Counts in 1993 indicated about 4,200 pronghorns, a reduction of 20% from the preceding year. The fawn:doe ratio of 50:100 was about the same as the preceding 2 years, and none of the units was significantly different between years.

The North Sioux Unit, in the northwest portion of the Panhandle, has in recent years held 60 to 70% of Nebraska's antelope. Estimates there, in a survey area of 650 square miles, were between 2,950 and 3,500 the past 3 years.

Parts of Wyoming and South Dakota adjoining the North Sioux experienced moderate to heavy losses by March, 1993 and fawn crops were about half of normal. We noted few losses and the fawn:doe ratio of 55:100 approximated the preceding 5 year average of 65:100 (range 61 - 71).

Because of low pronghorn numbers in recent years, hunting has been restricted. Rifle permits were reduced from 1,250 in 1985 (previous high of 1,800 in mid '70s) to only 60 in 1989. Archery hunting remains statewide and unlimited with a 4 month season, although hunters were generally restricted to bucks. Archery permit sales, which had ranged from 156 in 1975 to 175 in 1984 and 160 in 1990, increased to 263, 412, and 492 in 1991 through 1993 respectively. Harvest was 95 (23% success) in 1992, about 3 times as high as the pre-'91 record.

Part of this increase in archery may have been because of inability to obtain a firearm permit, but it was more likely due to better chances for a good buck. At least 12 of 19 bucks taken in 1990, 17 of 45 in 1991, and 15 of 78 in 1992 qualified for Pope and Young.

Seven hundred and ten rifle permits were issued in 1993, and 577 pronghorns were taken. The North Sioux Unit had 79% success compared to a normal 90%, but with gumbo soils and 14 inches of snow the day before opening this success was not surprising.

Part of Nebraska's management plan includes transplanting to expand range or to speed recovery. In January and February and in December 1993 we obtained 200 pronghorns from Colorado which were released in central Sheridan County in the northeastern Panhandle.

Following the early '93 release we received comments/complaints from some North Sioux ranchers about not using our own antelope, which some considered too abundant. Therefore, arrangements were made for a release, trapping equipment was revamped, and preliminary flights were made to locate a suitable concentration and trapping site. These were unsuccessful. Consequently we flew the entire North Sioux survey area, and located only 800 animals where there had been about 3,000 prior to hunting season.

We have not attempted winter counts in the North Sioux before, but in other areas have obtained estimates reasonably to remarkably close to results from summer surveys. This summer will be interesting. In the meantime, with seasons set in March and no opportunity for change, we opted for 200 buck only permits. Even this would be high, but hopefully winter counts (part with patchy snow) missed animals and hopefully some moved interstate and will return.

We have traditionally set seasons early, at least partly to accommodate planning by hunters, since the odds of obtaining a permit are not good. It is likely that our current predicament will provide sufficient reason to go later, although timing of Commission meetings and required application and drawing periods will not allow completion of summer surveys.

At the last Workshop we presented results of a study which showed improved pronghorn production in each of 2 years as a result of aerial coyote gunning. The following year (1992) showed no difference in production between the area where coyotes were killed in 1990 and 1991 vs the control area.

NEW MEXICO PRONGHORN STATUS REPORT - 1994

POPULATION

New Mexico's current pronghorn population is estimated near 36,000 animals. Primary populations occur throughout the eastern plains, with the highest densities located in the northeast. They also occur in less abundance along the western side of the state. While populations in northern New Mexico appear to be stable to increasing due to favorable weather conditions, southern populations have experienced declines. Precipitation recordings for that part of the state during the last year are well below normal levels. Fawn survival for many of the southern units are extremely low, in all likelihood, due to poor range condition.

SURVEYS

Aerial surveys are conducted during March and April to determine herd composition and population trends. These surveys are conducted from fixed-wing aircraft (Cessna Skymaster) owned by the department. The surveys are flown on north and south lines in ½ mile interval strips to attempt a 100% count of all animals in the survey area. The majority of the units are surveyed on a two year rotational cycle, while some units are surveyed every year.

HUNTING

During the 1993-94 season, there were 12 pronghorn antelope hunts in which the Department concluded hunt agreements with over 1,100 landowners. Agreements are signed with each landowner to allow hunting for a specific number of public hunters, drawn by lottery, and a specific number of hunters that the landowners authorize to purchase a license. Hunters for the muzzle-loader and rifle hunts are assigned and restricted to specific ranches, while bow licenses remain valid throughout the state.

Harvest projections for the 1993-94 season, indicate that a total of 7,119 hunters harvested 5,234 pronghorn. Total archery harvest was 415 by 1,615 hunters for a 26% success rate. Total muzzle-loader harvest was 115 by 337 hunters for a 38% success rate. Total rifle harvest was 4,640 by 5,103 hunters for a 91% success rate. Total harvest during a special hunt for the handicapped, was 64 by 64 hunters for a 100% success rate.

TRANSPLANTS

Through cooperation with the Bureau of Land Management, private landowners, and the Department, pronghorn antelope capture took place on three private ranches in northeastern New Mexico during the month of January 1994. The capture was designed to reduce excessive population pressure on private land and to enhance populations at nine sites around the state.

Capture was accomplished using an antelope corral trap, described by Russell (1964) and modified by NMDGF in 1992 and at this capture. Modifications included the increased use of tarps along the wing fences, and in the holding and handling pens.

The capture resulted in a total of 1,093 pronghorn being processed at the traps. Ultimately, a total of 1,021 animals were successfully released at the identified sites. The difference from the processing numbers are attributed to escapes during processing, animals intentionally released at the trap sites, and mortality caused by trapping.

RESEARCH

Currently there are no research projects being conducted in New Mexico on pronghorn antelope.

PRONGHORN ANTELOPE STATUS REPORT FOR TEXAS - 1994

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Pronghorn antelope in Texas are found in a variety of habitats at scattered locations in the High Plains, Edwards Plateau and Trans-Pecos Ecological Regions. The Trans-Pecos habitat is primarily desert grasslands and scattered mountain ranges, and large cattle ranches represent the primary land use. The majority of the Edwards Plateau population is confined to one large ranch with several smaller herds located in the western portions of the region. The habitat is a shortgrass prairie dominated by stands of mesquite, juniper, pricklypear and isolated stands of live oak. The High Plains population consists of scattered herds that are found in isolated blocks of grasslands surrounded by extensive tracts of farmland. Vegetation on these grasslands ranges from shortgrass prairies dominated by mesquite, juniper, sandsage, shinnery oak or yucca in the southern and western parts of the region to rolling sandhills and mid to tallgrass prairies in the northeastern High Plains.

Population estimates and herd composition data are obtained annually by flying low- altitude strip counts at ¼-mile intervals on selected ranches in each herd unit during the period of mid-June through July. During 1993, 293 hours were expended on the statewide census.

The estimated pronghorn population in Texas has fluctuated between 11,835 and 24,572 animals during the past 17 years, and has averaged about 17,692 antelope. The statewide distribution of pronghorn numbers is approximately 78% in the Trans-Pecos, 19% in the Panhandle, and 3% in the Edwards Plateau. The number of does per buck observed in 1993 was 2.6 in the Panhandle, 1.8 in the Edwards Plateau, and 1.6 in the Trans-Pecos for a statewide ratio of 1.7 does per buck. Fawn production decreased significantly in the Trans-Pecos and Edwards Plateau regions from 45 and 77 fawns/100 does in 1992 to 25 and 22 fawns/100 does in 1993, respectively. Fawn survival in the Panhandle district increased slightly from 28 fawns/100 does in 1992 to 34 fawns/100 does in 1993. The estimated statewide pronghorn population in 1993 was 17,265 antelope, representing a decline of 13% compared to the 1992 estimate of 19,766. Low fawn production during drought conditions in the Trans Pecos and Edwards Plateau regions contributed to this decrease. Another important factor was the loss of approximately 900 antelope on one ranch due to the extended drought in the Edwards Plateau.

The pronghorn antelope season in Texas opens on the Saturday nearest October 1 and continues for 9 consecutive days. The bag limit is one antelope per hunter per year by permit only. Archery and all firearms, except for those using rimfire ammunition, are legal for harvesting antelope.

Because the majority of land in Texas is privately owned, permits are issued directly to qualified landowners or their agents. Permits cannot be sold, but the landowners can charge a trespass fee. A total of 1,611 buck permits were issued in 1993 to 347 landowners (Avg. of 4.6 permits/landowner) representing 6.6 million acres of antelope range. Of the landowners receiving permits, only 260 (75 percent) of the landowners allowed pronghorns to be hunted on their property. A total of 602 hunters harvested 523 buck antelope, representing a success rate of 87%. Permit utilization in 1993 was 37%, which was similar to the 1992 utilization rate of 36%. No doe permits were issued in 1993. Antelope hunting on public lands is confined to the Rita Blanca National Grasslands in Dallam County (Panhandle region). Hunters are selected by a drawing which is conducted through the Texas Parks & Wildlife Department's public hunting program. The number of permits issued for the hunt has ranged from 6-14 in recent years. In 1993, 8 permits were issued and 3 antelope bucks were harvested.

No relocation efforts or pronghorn research was conducted in 1992 or 1993.

PRONGHORN ANTELOPE WORKSHOP 1994

WYOMING STATE REPORT

Pronghorn are managed in Wyoming by objective, a process that includes both biological and political consideration towards management of the species. The state's pronghorn are divided into herd units (populations) delineated by herd homogeneity, topography, fences and highways.

DISTRIBUTION

Pronghorn are found statewide in non-forested areas within 51 herd units comprising 116 hunt areas. In a 1988 estimate, they seasonally occupied 68,768 square miles of habitat, of which 6,169 square miles were considered crucial.

POPULATION ESTIMATE AND 5 YEAR TRENDS

The 1992 spring population estimate was 515,477 animals, 30.4% above the statewide objective of 395,260. The population currently is substantially below that estimate for two reasons. One, to bring the population down to objective a large number of doe/fawn licenses were issued in 1992 and two, a number of pronghorn in the southwest and central to east-central parts of the state died during the 1992-93 winter. Although not severe climatically, the winter of 1992-93 was severe to many pronghorn that experienced previous years of drought and mild winters. Population estimates and the relationship to objectives for the period 1988-92 are presented in Table 1.

Population data obtained annually include spring population estimates (May), herd classifications or compositions (July-September) and harvest information. The population estimate is based on this information and)POP-II computer simulations of each herd unit (Data Analysis Unit) in the state. The use of aerial line transects to estimate spring antelope populations was instituted in 1990. This procedure has been well accepted and has improved with time. Most herd units are flown every other year.

Table 1. Population estimates and relationship to objective for pronghorn in Wyoming, 1998-92.

YEAR	POPULATION ESTIMATE	POPULATION OBJECTIVE	ABOVE OR BELOW OBJECTIVE
1988	363,785	374,160	- 10,375 (2.8%)
1989	366,170	381,660	- 15,490 (4.1%)
1990	413,243	384,660	+ 28,583 (7.4%)
1991	508,634	395,260	+113,374 (28.7%)
1992	515,477	395,260	+120,217 (30.4%)

PRODUCTIVITY AND RECRUITMENT

Preseason pronghorn classification surveys, conducted July through September, ranged from 59 to 78 fawns and 45 to 54 bucks per 100 does on a statewide basis for the period 1988-92 (Table 2). Recruitment into all age classes has not been a significant problem for pronghorn populations in Wyoming; however, the heavy harvest of adult males and females in some areas during recent years has reduced the average age of some herds.

The winter of 1992-93 not only caused direct losses in many age classes, but fawn production in the spring was reduced.

Table 2. Statewide average preseason pronghorn classifications in Wyoming, 1988-92.

	Year				
	1988	1989	1990	1991	1992
Bucks/100 Does	45	49	50	54	53
Fawns/100 Does	78	70	75	68	59

HARVEST STRATEGIES

The estimated (preliminary) 1993 antelope harvest, determined by mail survey, in Wyoming was 65,468 animals (Table 3). This represents a drop of over 20,000 from 1992. Doe harvest dropped over 13,000. Hunter success was 133.2% (hunters can hold more than one license). Success per license purchased (total harvest/total license sales) was 77.8%. In 1993, of 49,148 total hunters 43.1 % were resident and 56.9% were nonresident.

Pronghorn herds occupying predominately public land are often managed towards higher buck/doe ratios than areas with mostly private lands. A ratio of 40 bucks/100 does is the objective for many of these public land populations, particularly in western Wyoming where large tracts of public lands allow higher populations to be maintained without complaints of antelope damage to private lands. This "trophy"management approach is often not possible in herds on chiefly private land because actual or perceived conflicts with agriculture.

Wyoming issues two antelope license categories: any antelope and doe/fawn. In populations managed for trophies, herd numbers are controlled by issuing doe/fawn licenses. Depending on the hunt area, a hunter could hold one regular and from one to five doe/fawn licenses. In recent years, each hunter could purchase nine antelope licenses, but in most cases could only harvest one buck. On public lands, this system has worked well; on private lands, access fees and low buck quality have left many licenses unsold. All any antelope licenses are distributed through a limited-entry draw system. Those any antelope licenses remaining after all draws are sold first come first serve.

In response to the high mortality during the 1992-93 winter, antelope license quotas in 1993 were reduced by 24,040 licenses (21.2%) from 1992 (Table 4).

Table 3. Statewide pronghorn harvest by all hunters in Wyoming, 1988-93.

Year	Number Hunters	Harvest Buck	Doe	Fawn	Total	Percent Success	Days/ Animal
1988	41,028	27,487	24,130	3,003	54,620	133.1	2.1
1989	40,769	28,906	22,200	3,249	54,355	133.3	2.2
1990	41,528	29,597	23,110	3,051	55,758	134.3	2.1
1991	46,619	34,501	26,953	3,648	65,102	139.6	2.0
1992	55,130	39,170	42,139	4,604	85,913	155.8	1.9
1993[1]	49,148	33,079	28,875	3,514	65,468	133.2	2.2

[1]Preliminary

Table 4. Antelope license quotas and sales in Wyoming for 1991-93.

Year	Quota[1]	Resident Not Sold[2]	Nonresident Not Sold[2]	Doe/Fawn Quota	Doe/Fawn Not Sold
1991	42,825	1,702	2,430	42,080	8,457
1992	52,900	5,805	7,022	60,540	8,159
1993	43,600	1,588	2,183	45,800	1,463

[1]Any antelope for residents and nonresidents.

[2]Any antelope.

TRANSLOCATION

Except for interstate movement of local population control, where harvest is not a workable management option, antelope are not trapped and transplanted within the state. In 1993, antelope were trapped near Sheridan as a population control measure and moved to Arizona, Nevada and the Wind River Indian Reservation.

SPECIAL STUDY RESULTS

The following special study projects were initiated and completed within the last five years.

* Reaction of mule deer and pronghorn to petroleum development on crucial winter range.

* Lander area habitat burn; electric fence livestock control.

* Antelope hunter attitude survey.

* Sublette antelope crucial winter range assessment.

* Inventory of the location and types of fences on BLM lands in relation to big game migration corridors.

* Line transect training video.

* West Green River pronghorn herd boundary definition.

* Evaluating composition surveys.

ONGOING RESEARCH

There are three ongoing projects.

* Uinta-Cedar Mountain pronghorn herd unit definition and line transect evaluation.

* Comparison of ground and air pronghorn composition surveys.

* Understanding recruitment in pronghorns.

MANAGEMENT PROBLEMS

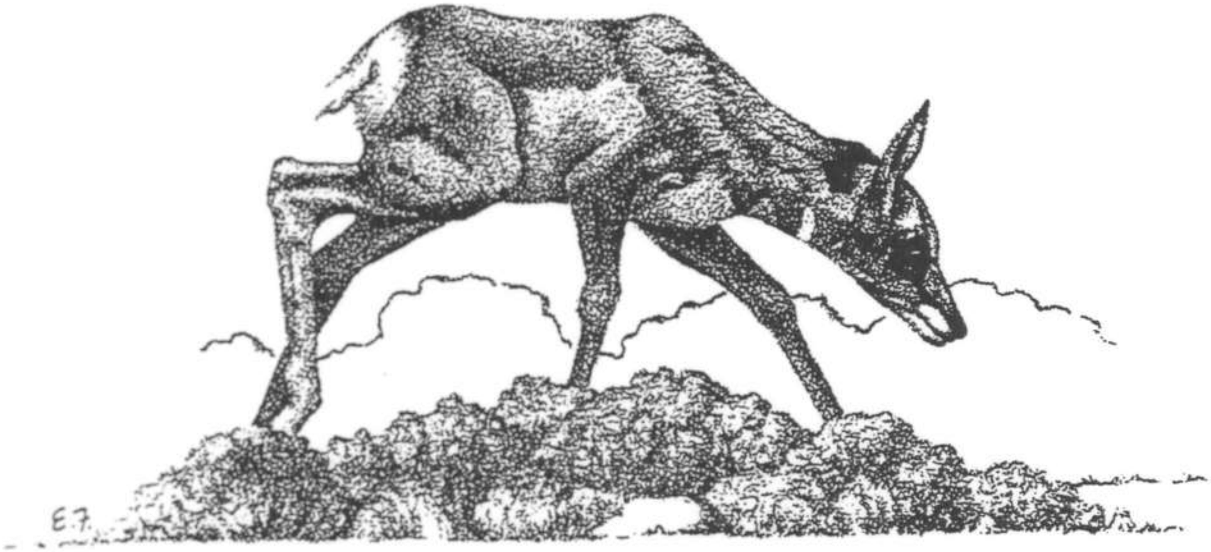
Of concern in Wyoming is the problem of how to maintain quality pronghorn hunting on private lands. Though sportsman and landowners desire high buck/doe ratios with a large number of older bucks, agriculturists have been increasingly intolerant of the high pronghorn populations necessary to achieve this goal. Present management strategies are to maintain at least 30 bucks/100 does for herds occupying largely private land areas.

Fencing continues to be a problem in Wyoming. Highway and federal grazing allotment fences often restrict seasonal migration of antelope. We continue to work on or with other agencies regarding the problem of fencing across big game migration/movement corridors. Despite this, thousands of pronghorn are killed directly or indirectly by fences in every severe winter.

Perceived pronghorn damage to agricultural land continues to be a significant problem in Wyoming. Landowners have been reluctant to accept studies showing that pronghorn do not compete for forage with domestic livestock nor that pronghorn foraging on winter wheat do not lower wheat production.

Some segments of the hunting public contend that the Department did not respond to the high winter mortality of 1992-93. However, managers did lower permit quotas by 24,040 to offset antelope winter losses that year, and management will focus on population recovery over the next years.

TECHNICAL SESSION



STATUS OF PRONGHORN MANAGEMENT AT HART MOUNTAIN NATIONAL ANTELOPE REFUGE

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Abstract: Management of pronghorn (*Antilocapra americana*) habitat on the Hart Mountain National Antelope Refuge (HMNAR) in Oregon from 1936-1990 traditionally used livestock as a tool to enhance vegetation. From 1989 to 1994, resource inventories and management strategies were re-assessed and a Comprehensive Management Plan/Environmental Impact Statement was developed (U.S. Fish and Wildlife Service 1994). As a consequence, pronghorn species and habitat management practices have been completely changed with implementation of reform techniques and practices. The current management program curtails livestock grazing for 15 years and establishes prescribed burning as the primary management practice to restore pronghorn habitat to its ecological potential.

PROC. PRONGHORN ANTELOPE WORKSHOP 16:23-34

Key words: Pronghorn, management, livestock, Hart Mountain, CMP/EIS, habitat, fire.

Hart Mountain National Antelope Refuge (HMNAR) was established in 1936 for wildlife with a specific objective to perpetuate pronghorn. Since establishment, domestic sheep and cattle have been the major land-use. During the late 1960's, a resource management plan was implemented identifying cattle grazing as the primary practice to enhance vegetation on pronghorn habitats (U.S. Fish and Wildlife Service 1970). Several technical publications subsequently attributed improvements of vegetation condition to corresponding increases in pronghorn numbers as a result of the prescribed livestock grazing systems (Anderson et al. 1990 a and b). Twenty years later, a Comprehensive Management Plan/Environmental Impact Statement (CMP/EIS) was completed to provide a framework for short and long term wildlife management (U.S. Fish and Wildlife Service 1994).

It was the initiation of the CMP/EIS that provided manpower and funds to develop new programs that should benefit pronghorn and other wildlife. The objective of our paper is to discuss effects of these new endeavors specific to pronghorn.

RESULTS

Population Estimates and Distribution

Biologists with Nevada Division of Wildlife and Oregon Department Fish and Wildlife (ODFW) estimate that 7,000-9,000 pronghorn use the interstate region of Nevada and Oregon in the vicinities of HMNAR and Sheldon National Wildlife Refuge (SNWR). During 1990-93, more than half of the animals of the interstate region used the refuges as a summer range, a winter range, or year-round range. Mid-winter surveys conducted by ODFW surveyed HMNAR and the vicinity of Big Springs Table on SNWR. Results showed the increased importance of HMNAR as a winter range for animals of the interstate region (Table 1), since the refuge supports higher populations during winter than during summer. Increased numbers seemingly result from emigration of animals that summer in the Bureau of Land Management (BLM) property between the Nevada border and the refuge boundary. Recent trends in winter populations and distribution are unprecedented in refuge records, and evidently underscore the importance of monitoring change in population size and winter distribution.

Table 1. Average number of pronghorn counted during mid-winter aerial surveys, Sheldon-Hart Mountain Biological Unit[a], Nevada-Oregon, 1969-1993[b].

Year	SNWR	Sagehen	HMNAR	West Beatty's Butte	Unit total
1970-74	1,265	513	291	-[c]	-
1975-79	1,429	449	314	-	-
1980-84[d]	1,470	310	336	0	2,176
1985-89	2,082	756	617	144	3,434
1990-93	966	1,222	1,333	692	4,212

[a] Unit consisted of SNWR (vicinity of Big Springs Table); Sagehen (BLM north of Sheldon, Oregon); HMNAR, Oregon; and West Beatty's Butte (BLM south and east of Hart Mountain, Oregon). Areas not surveyed included western SNWR and the Massacre-Macy Lake subunit, Nevada.
[b] Aerial surveys conducted by ODFW.
[c] Dash indicates area not surveyed.
[d] Data for 1982 not included (partial survey).

The need for a re-assessment of use of geographic areas and cover types was identified early in the comprehensive planning process. The need was founded on the following considerations:

1. The year-round pronghorn distribution has not been systematically evaluated since the 1950's, despite data indicating major changes occurred in population size and seasonal distribution.
2. Proponents of cattle grazing claimed that reduction or elimination of livestock grazing ultimately would result in substantial changes in pronghorn distribution that would result in little or no use of the refuge by pronghorn.
3. Sites used for fawning and fawn-rearing were determined to be critical to pronghorn. Although management guidelines called for minimizing disturbance on fawning grounds, few data were available to assess the distribution of those sites.

Aerial transects were systematically surveyed for pronghorn on a monthly basis between 1991-93. Preliminary results showed that although pronghorn used a variety of cover types on an annual basis, low sagebrush received the most use in all seasons and years except during summer 1992 and winter 1993 (Table 2). Lakebed was intensively used during summer-fall and was the principal cover type used during the summer 1992. Grassland, i.e., recently burned sites, was used consistently during summer-fall, and during the mild winter of 1992. Most pronghorn wintered in low sagebrush in 1991 and 1992, however, salt desert shrub was the dominant cover type used during the severe winter of 1993.

The absence of cattle grazing on refuge rangelands during 1991-93 had no apparent influence on pronghorn distribution nor was there any indication that this factor detrimentally affected productivity of pronghorn and pronghorn habitat. Aerial surveys revealed that pronghorn seasonally used the same geographic areas from year to year. At a finer scale, difference in seasonal use of cover types within geographic areas seemingly was related to changes in water and food availability that occurred in response to climatic variation.

Locations were recorded for 151 does during a survey of "fawning areas" conducted during 24 May 1993 (Pyle and Reiswig, in prep.). In general, distribution of does corresponded to the distribution of low sagebrush that dominates 36,500 ha of the refuge. Doe densities appeared highest in areas with an interspersion of low sagebrush, intermittent drainages, and lakebeds. It seems likely that the wet winter and spring of 1993 improved availability of vernal forbs in low sagebrush, influenced doe distribution, and fostered maximum dispersion of does in low sagebrush during the fawning period. Our data indicate that land managers ought to periodically survey does to assess their use of geographic areas and cover types, and to compare patterns of use among years with different population size and climatic conditions (Pyle and Reiswig, in prep.).

Table 2. Percentage seasonal[a] use of cover types by pronghorn on HMNAR, 1991-93.[b]

Vegetation type and year	Winter	Spring	Summer	Fall
Black sagebrush				
1991	0	0	0	0
1992	0	0	t[a]	0
1993	-[b]	0	0	0
Grassland[c]				
1991	0	9	6	7
1992	15	1	3	7
1993	-	1	6	18
Juniper				
1991	0	0	1	1
1992	1	0	1	1
1993	-	0	t	4
Lakebed				
1991	0	2	29	7
1992	2	3	56	14
1993	-	0	t	7
Low sagebrush				
1991	100	90	63	75
1992	79	94	26	76
1993	-	76	91	71
Meadow				
1991	0	1	3	0
1992	0	0	14	1
1993	-	0	1	0
Mountain big sagebrush				
1991	0	0	0	0
1992	0	t	0	0
1993	-	t	t	0
Mountain shrub				
1991	0	t	t	0
1992	0	0	0	0
1993	-	0	0	0
Silver sagebrush				
1991	0	0	t	7
1992	3	t	1	1
1993	-	0	1	0
Wyoming big sagebrush				
1991	0	1	1	1
1992	0	2	0	0
1993	-	23	1	1

[a] t=trace (<1%).
[b] No pronghorn were observed on the refuge, which was covered by deep snow.
[c] Primarily composed of upland sites burned within the last 15 years.

HABITAT INVENTORY AND MANAGEMENT

Vegetation resources of HMNAR were assessed during development of the CMP/EIS. Vegetation types were delineated, succession stages of vegetation types were classified, and area of types and stages was computed (Table 3). Although a variety of upland vegetation types occur on the refuge, 95% of uplands was composed of 3 cover types including low sagebrush, Wyoming big sagebrush, and mountain big sagebrush. Among upland vegetation types, 92% was classified as late-successional, e.g., shrub- and tree-dominated. The low amount of area in early- and mid-seral succession has resulted in low landscape diversity. Low diversity is attributed mainly to fire exclusion (Kauffman 1990).

Cover characteristics were assessed within principal late-successional vegetation types of uplands (Table 4). Analysis showed excessive amounts of shrub cover in all cover types relative to site potential for late succession stages (Winward 1991). Additionally, comparison of characteristics in 1968 and 1992 indicated that cover had not changed substantially. High amounts of shrub cover can depress cover of native herbaceous species (Winward 1991). Although increased cover of shrubs and reduced cover of herbaceous plants are attributed to intensive livestock use before refuge establishment, maintenance of these conditions is attributed to fire exclusion after refuge establishment (Pyle 1991). Apparently, excessive shrub cover is maintained until it is reduced significantly by a disturbance factor such as fire (Laycock 1991).

Resource condition was systematically inventoried in 95% (170 km) of stream-associated riparian zones. Within this area, potential dominant vegetation was classified as sedge-rush-bluegrass, i.e., dry-wet meadow, (33%), quaking aspen (18%), willow (18%), mixed deciduous shrub (15%), bluegrass-ryegrass, i.e., dry meadow, (14%), and other (2%) by percentage stream kilometers. Resource condition differed within and among riparian vegetation types (Table 5). Low and moderate resource conditions were prevalent among all riparian vegetation types, except mixed deciduous shrub. Streambank erosion, altered channel morphology, reduced water tables, and encroachment of sagebrush characterized low and moderate resource conditions in alluvial valleys. Prevalence of low and moderate resource conditions was attributed to over-grazing by cattle (U.S. Fish and Wildlife Service 1994).

FIRE MANAGEMENT

Fire management increased during 1990-93. Objectives ranged from prescribed burning, to restore wildlife habitat, and suppression of wildfires. Eight sites located in a variety of vegetation types were prescribed burned during 1990-93. Vegetation types burned included mountain big sagebrush, low sagebrush, meadow, and aspen.

Objectives were to enhance habitat diversity, e.g., interspersion of succession stages, and to increase cover of native forbs, grasses, and aspen (on aspen sites). Treatments averaged 85 (0.1-276) ha and totaled 599 ha. Habitat response was excellent, drought notwithstanding. Native perennial forbs and grasses dominated burned sites in the initial years after treatment. Pronghorn and bighorn sheep were observed consistently using burned mountain big sagebrush and low sagebrush sites during summer and fall.

Table 3. Hectares of existing succession stages of upland vegetation types, HMNAR, Oregon.

	Succession stage				
Biome Vegetation type	Early	Mid	Late	Very late	Total
Desert scrub					
Black greasewood	0	0	284	-	284
Black sagebrush	0	0	262	-	262
Salt desert shrub	0	0	626	-	626
Spiny hopsage	0	0	151	-	151
Squirreltail	0	-	66	-	66
Winterfat	0	0	485	-	485
WY big sagebrush	602	0	35,648	6,285	39,535
Conifer forest					
Ponderosa pine	0	0	28	0	28
White fir	0	0	0	5	5
Conifer woodland					
Western juniper	0	0	0	1,979	1,979
Montane shrub					
Mountain mahogany	0	0	0	586	586
Mountain shrub	35	16	888	255	1,194
Shrub-grassland					
Basin big sagebrush	0	0	1,282	-	1,282
Big sagebrush-bitterbrush	983	707	1,411	1,312	4,413
Fescue	0	-	60	-	60
Low sagebrush	2,792	478	36,150	3,021	42,441
Mountain big sagebrush	214	752	7,690	1,002	9,658
Wheatgrass	0	-	1,133	-	1,133
Terrestrial non-vegetated					
Terrestrial non-vegetated	2,172	0	0	0	2,172
Total	6,798	1,953	86,164	14,445	109,360

Five wildfires occurred at HMNAR during 1990-93. These fires averaged one (0.04-2) ha in size and burned a total of six ha. Results from routine aerial surveys of pronghorn distribution indicated that pronghorn intensively used sites burned by wildfires in the late 1970's and mid 1980's. Pronghorn use of wildfire sites apparently was associated with the occurrence of green-up of cheatgrass and forbs after early fall rains.

Table 4. Percentage shrub, grass, and forb cover in 4 late-successional vegetation types in 1968 and 1992, HMNAR.

	Shrub cover		Grass cover		Forb cover	
Vegetation type	68	92	68	92	68	92
Low sagebrush	24	25	9	11	10	8
Mountain big sagebrush	31	31	43	18	13	11
Sagebrush-bitterbrush	45	40	28	15	10	3
Wyoming big sagebrush	25	23	10	5	2	2

Table 5. Percentage kilometers of resource condition classes of riparian vegetation types, HMNAR.

	Resource condition			
Vegetation type	Low	Moderate	High	Very high
Bluegrass-ryegrass	50	29	13	8
Mixed deciduous shrub	19	20	11	52
Other types	82	0	0	18
Quaking aspen	41	31	17	11
Sedge-rush-bluegrass	78	9	13	0
Willow	58	32	4	6
Total	50	25	11	14

VEGETATION PLANTINGS

A wildfire burned 4,452 ha of low sagebrush, mountain big sagebrush, and mountain shrub cover types in August 1985. Bitterbrush, which was considered an important feature of pronghorn summer range where interspersed with low sagebrush was a prominent component of the mountain shrub stands. The wildfire covered about a third of the area occupied by bitterbrush at HMNAR. After the fire, few bitterbrush seedings were noted, a response that is attributed to the decadent condition of the bitterbrush prior to burning, the high severity of the fire, depletion of the bitterbrush seed pool, and incidence of drought.

Bitterbrush seeds collected from adjacent rangelands in Nevada were used to restock the burn. Seeds were germinated in a nursery, grown for a year, and planted on the wildfire site. A total of 8,000 seedlings was planted in 1988 and another 17,000 seedlings were planted in 1993 in a cooperative project between the U.S.F.& W. Service and Oregon Hunter's Association. Evaluation of survival indicated a low survival rate (20%) of 1988 plantings, which was attributed to persistent drought. Evaluation of survival indicated that 95% of the seedlings planted in 1993 survived through the first growing season.

SPECIES MANAGEMENT REPORT

A species management report was developed in 1990 to provide a framework for planning and management of pronghorn populations and habitat (Pyle and Smith 1990). The report consisted of a review and evaluation of technical information on pronghorn ecology; and development of population objectives and habitat objectives; and an evaluation of management practices, including inventory methods, habitat improvement techniques, recreational hunting goals, and predator control considerations. Principal conclusions of the report included:

1. Long-term productivity, recruitment, and population size of pronghorn in native rangelands of the northern Great Basin are regulated primarily by availability of forbs and water during spring through summer, and secondarily by mortality associated with severe winters.
2. Management practices that maintain water distribution and increase forb availability will (a) sustain higher levels of productivity, and (b) reduce variability in pronghorn productivity.
3. Fire and climate were the two primary historic factors that regulated forage quality and quantity on rangelands used by pronghorn.
4. Prescribed fire is the primary management practice available to HMNAR managers for enhancement of availability of native forbs on summer ranges of pronghorn.

The report was peer-reviewed and findings were incorporated into the CMP/EIS.

LIVESTOCK MANAGEMENT

Total annual cattle animal unit months (AUMs) averaged 12,834 (10,406-17,228) during 1970-89, but AUMs were reduced 76% in 1990. During 1991-93, pronghorn rangelands were completely rested from cattle use except for a minor amount of trespass. Rest from cattle grazing was a result of two factors: voluntary non-use associated with drought (1991) followed by a lawsuit that suspended permits in non-use areas pending completion of the CMP/EIS.

Current surveys indicate an estimated 90 feral horses (*Equus caballus*) reside on the HMNAR. The CMP/EIS identifies the need for all the these animals to be removed because they compete with native ungulates for preferred forage.

FOOD HABITS STUDY

A cooperative study was initiated in October 1993 that involves the U.S. Fish and Wildlife Service, the Oregon Cooperative Wildlife Research Unit, and other cooperators. Initial objectives of the study include determination of composition and quality of pronghorn, bighorn sheep (*Ovis canadensis*), mule deer (*Odocoileus hemionus*), feral horse, feral burro (*Equus assinus*), and domestic cattle diets. Thus far, 1,000 pellet groups have been collected on a monthly basis from multiple study areas. Information assessed from the first year of collection will form a baseline for future comparison and evaluation of difference in diet and nutrition that may result from habitat management practices such as prescribed burning.

COMPREHENSIVE MANAGEMENT PLAN

A process initiated in 1989 to develop a CMP for HMNAR was completed this year. This plan described the goals, objectives, and strategies of wildlife and habitat management for the next 15 years (U.S. Fish and Wildlife Service 1994). As a result of contentions over livestock grazing, the U.S.F.& W. Service determined in 1991 to prepare an EIS for the CMP.

The Preferred Alternative of the CMP/EIS calls for no livestock grazing on the refuge in the next 15 years. This assessment was based on several factors including:

1. Habitat evaluations indicated that the condition of most upland habitat was sub-optimal with respect to the amount and diversity of native perennial forbs and grasses, and the level of habitat diversity. Supplies of forbs and grasses were deficient as a result of excessive shrub cover,

especially in Wyoming big sagebrush and low sagebrush habitats. Habitat diversity was low as a result of maintenance of a high proportion (92%) of uplands in late-successional stages dominated by sagebrush and encroached by western juniper.

2. A systematic evaluation of riparian habitats revealed that most (74%) were in low to moderate condition. In low gradient reaches, available pronghorn habitat was impaired because channel alteration lowered water tables, reduced summer water supplies, diminished meadow vegetation, and increased sagebrush, e.g., low-moderate riparian resource conditions.
3. Review of technical information and refuge records disclosed that, despite the increasingly conservative management of cattle, there was no indication that habitat conditions changed substantially over the last 35 years. Additionally, hypotheses had not been tested to determine whether cattle can enhance vegetative condition for pronghorn at HMNAR (DeLong and Yoakum 1994).

The CMP/EIS emphasizes use of prescribed fire to reduce shrub cover, increase native forbs and grasses, increase habitat diversity, and improve condition of upland habitats. In riparian habitats, non-structural methods such as rest from livestock use are emphasized to restore channels, water supplies, and wetland vegetation. Prescribed fire should be used periodically to maintain productivity of wetland vegetation.

SUMMARY

When the Pronghorn Antelope Workshop conducted its 1988 conference on the HMNAR, cattle grazing was identified as the primary tool to improve vegetation on pronghorn habitats (U.S. Fish and Wildlife Service 1970). Now, six years later, the HMNAR has developed and implemented a complete new management program following the development of an EIS and Comprehensive Management Plan (U.S. Fish and Wildlife Service 1994). Management advances associated with development and implementation of the plan include:

1. Recognition that more than 90% of upland cover types were in a state of late succession. This equated to a super-abundance of shrubs with low production of native grasses and forbs.
2. Identified two major factors that were primary causative agents for present un-balanced vegetation and forage conditions:
   (a) over a hundred years of excessive livestock grazing, and
   (b) an active suppression program of all rangeland wildfires.
3. Recommended an annual program of prescribed burning to decrease dominant shrubs and increase production of native herbs and shrubs. Other vegetation manipulation practices (mechanical or herbicidal) should

not be used unless prescribed burns did not meet treatment objectives.

4. Eliminated all cattle grazing for 15 years and recognized the need to eradicate feral horses that were non-compatible with native wildlife under present vegetation conditions.
5. Instigated a monthly survey program to describe pronghorn use and selection of geographic areas and cover types. This resulted in the most comprehensive pronghorn survey to date in the Great Basin region.
6. Initiated a fire management program that emphasizes routine application of prescribed fire to maintain and restore pronghorn habitat. The goal is to treat 9,000-14,400 ha of late-successional vegetation types of uplands over next 15 years.
7. Started a food habitat study for wild and domestic ungulates on and adjacent to HMNAR. Data also will be collected on forage availability and nutritional values of preferred forage species.

These seven advances usher in a new period of reform of management and conservation of wildlife at HMNAR. It likewise establishes new precedents for management of the second most abundant native ungulate in the United States--the pronghorn.

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PRONGHORN REINTRODUCTIONS TO MONO COUNTY, CALIFORNIA: 12 YEARS AFTER

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Abstract: Pronghorn *(Antilocapra americana)* were reintroduced to southern Mono County, California, where previous reintroduction efforts had failed. In 1982 43 pronghorn were released in Adobe Valley, which an environmental assessment (EA) had rated "fair" habitat (McCarthy 1981). All but six pronghorn died or dispersed within the first year, and the six remaining established winter range in areas rated "very poor." In 1984 and 1985 more pronghorn (24 and 50, respectively) were translocated to the winter range. The animals were held in an enclosure for several days before release. Newly released pronghorn joined with those previously established. With each successive release the percentage of newly translocated pronghorn remaining in the area after one year increased. Pronghorn explored several areas, and by 1987 formed two distinct populations based in Hammil Valley and Queen Valley, both rated "very poor" habitat in the EA. The Hammil population ceased seasonal migrations, remained near an alfalfa ranch year-round, and declined to n=8 (R=0.84). Some groups from the Queen Valley population continued seasonal migrations; all areas used were virtually uninhabited and without alfalfa. This population increased to $n \geq 75$ (R=1.17). The use of valleys rejected by the EA and the difference in R between the two populations may be attributable to factors changing since the EA, misestimated by the EA, or not considered in the EA. These factors may include snow depths, forage quality, water availability, predation, human disturbance, and phenotypic differences in behavioral tendencies among individual pronghorn.

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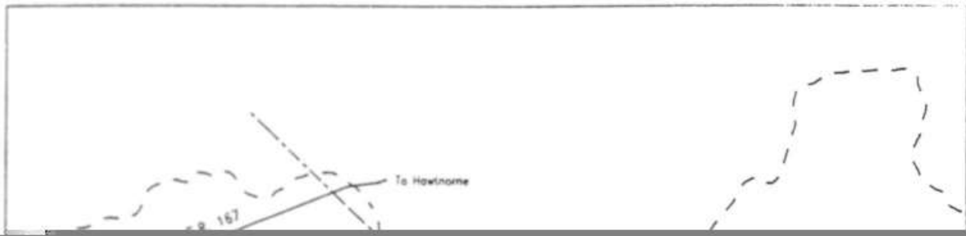
County, CA (Fig. 1) in the 1940's, released in Adobe Valley and Mono Basin, established a population to the north in the Bodie Hills (Pyshora pers. comm.). Pronghorn released in Adobe Valley in 1950 dispersed in several directions and slowly died out (McCarthy 1981).



In 1981 an interagency team from California Department of Fish and Game (CDFG), U.S. Forest Service (USFS), Los Angeles Department of Water and Power, and Bureau of Land Management (BLM) proposed another reintroduction of pronghorn into southern Mono County. The objective, as stated in the Environmental Assessment (EA), was to introduce up to 100 pronghorn with a goal of doubling the herd over 10 years (McCarthy 1981). The interagency team studied five potential release sites in Mono County and adjacent Mineral County, Nevada and rated them according to habitat suitability criteria developed by Yoakum (1980), including water availability, quality and quantity of forage, and vegetation height. Other factors were also evaluated: size and topography of release areas, mean precipitation, snow depths, competition with other herbivores, predation levels, and potential for crop depredation. Adobe Valley was rated as "fair" habitat based on adequate water availability, forage production (except forbs) and vegetation height, and was chosen as a release site. However, only six of 42 pronghorn released there in 1982 remained in the area after one year, and these established winter range in valleys rated "very poor" (McCarthy 1981, Goldsmith 1988a, 1988b).

In 1984 and 1985 more pronghorn were released at Marble Creek on the winter range. The Marble Creek augmentation site was selected to place animals in an area apparently preferred by the pronghorn remaining from the 1982 translocation. In our paper we examine the longterm results of all three releases.

STUDY AREA

The study area extends from the Sierra Nevada east to the White Mountains and is divided by lower ranges, and by the large alluvial fans of the White Mountains, to form several valleys. It encompasses the five release areas considered in the EA (McCarthy 1981) - Adobe, Benton-Queen and Hammil Valleys, Mono Basin, and north of Montgomery Pass - plus two areas eliminated from the EA as unsuitable, Long Valley and the Volcanic Tableland (Fig. 1). All are in southern Mono County, California, except Queen Valley and north of Montgomery Pass, which are in Mineral County, Nevada. The climate is characteristic of the Great Basin high desert. Elevations range from 1,250 m to 3,600 m and vegetation varies with elevation, soils and precipitation, but is predominantly Great Basin sage and shadscale scrub interspersed with alkali meadow communities. Primary tree species at higher elevations are singleleaf pinyon (*Pinus monophylla*) and Jeffrey pine (*P. jeffreyi*). Most of the area is administered by the BLM or USFS, with livestock allotments supporting light to locally intensive grazing. Private agricultural lands dominate the valley floor in Hammil Valley, with alfalfa the main crop during the study period; Benton Valley also had some alfalfa, and Queen Valley had one small field which was fallow from 1988 to 1990, then fenced to exclude pronghorn in 1991. Benton and Hammil valleys also have small residential communities.

METHODS

Release methods

In March 1982 CDFG captured 43 pronghorn in Siskiyou County, northern California and released them in Adobe Valley after holding them for less than one day in a small enclosure of three-strand barbed wire partially covered with burlap sheeting, with a gap between the burlap sheeting and the ground. One author (Russi) constructed a more substantial holding facility for the 1984 release. The site chosen, within the winter range of the small established group, enclosed 11 acres including a 0.25 km portion of Marble Creek that provided adequate forage and water. The holding facility was built of 3-strand barbed wire fence, 1.3 m in height, covered on the inside with heavy weight (10 oz.) burlap sheeting reaching to the ground and weighted by rocks. CDFG captured 24 pronghorn in Modoc County, northern California and released them into the enclosure, where they were held for eight days before release. The same method was attempted for release of 50 pronghorn from Modoc County in 1985, but all escaped the holding facility by the first evening after very high winds tore the burlap sheeting off the fence.

Monitoring

Eight of the 43 pronghorn released in 1982 were fitted with radio telemetry collars; four of 24 were radio collared in the 1984 release, and 10 of 50 in 1985. Also, most animals were fitted with colored and numbered ear tags.

One author (Goldsmith) conducted intensive followup monitoring of the 1982 release, locating animals on an almost daily basis by telemetry and by scanning with binoculars and spotting scope. She recorded location, group size and composition, fawn production and survival, and several aspects of behavior and habitat use (Goldsmith 1988a, 1988b, 1990, 1992).

BLM wildlife biologists (primarily the other two authors) conducted followup monitoring of the later releases. Pronghorn were located almost daily for several days immediately following each release, then once or twice weekly through 1985, weekly through 1986, twice a month 1987-1991 (except 1989), and as time permitted in 1989, 1992 and 1993. Information recorded included location, group size and composition, behavior, mortalities and use of alfalfa fields. Locations were marked on 7.5 or 15 min. topographical maps. Individuals were identified when possible by radio collar, ear tag, or morphological features. Observations reported by other reliable parties were also recorded.

An effort was made to maintain functioning radio collars on 20% of adult females. From 1988 to 1991 a total of 10 pronghorn were captured by CDFG personnel and fitted with radio collars retrieved from mortalities.

RESULTS

1982 Release

The 43 pronghorn released in Adobe Valley remained in one group for two days, then began to disperse individually and in small groups. Of 29 known to disperse (as opposed to known mortalities or individuals not observed), 22 moved northwest toward their former home; a few explored valleys to the southeast. Dispersing groups travelled straight-line distances as long as 120 km (actual travel routes were observed to be much longer) through unsuitable habitat including woodlands, narrow rocky canyons, and mountains of up to 2,610 m elevation. At least 12 animals joined the population established earlier in the Bodie Hills. Several made long exploratory trips, as far as 90 km roundtrip, and returned to Adobe Valley. By October of the first year only five females and one male remained in Adobe Valley; these established a winter range at lower elevation in Benton Valley. No fawns had been recruited into this group by 1984 (Goldsmith 1988a, 1988b).

1984 and 1985 Releases

Pronghorn translocated in 1984 were released from the holding facility by removing approximately 20 m of the burlap fence and allowing the animals to leave the enclosure at their own rate. All pronghorn walked or trotted out and moved off slowly as a group. They remained together for two days, then broke into smaller groups that explored to the north and south. Five days after leaving the holding facility, a group of six pronghorn encountered the group from 1982. Pronghorn from the two translocations continued to be seen together thereafter.

In 1985 the pronghorn, escaping the holding facility after winds tore the burlap from the fence, scattered in small groups of one or two. Five of the 50 pronghorn were found dead soon after; necropsies were performed for two of these and indicated multiple internal hemorrhages, possibly due to hyperthermia during capture. Twelve days after release, individuals from all three translocations were seen together in one group.

The percentage of newly translocated pronghorn remaining in the release area after one year increased with each successive release (Fig. 2).

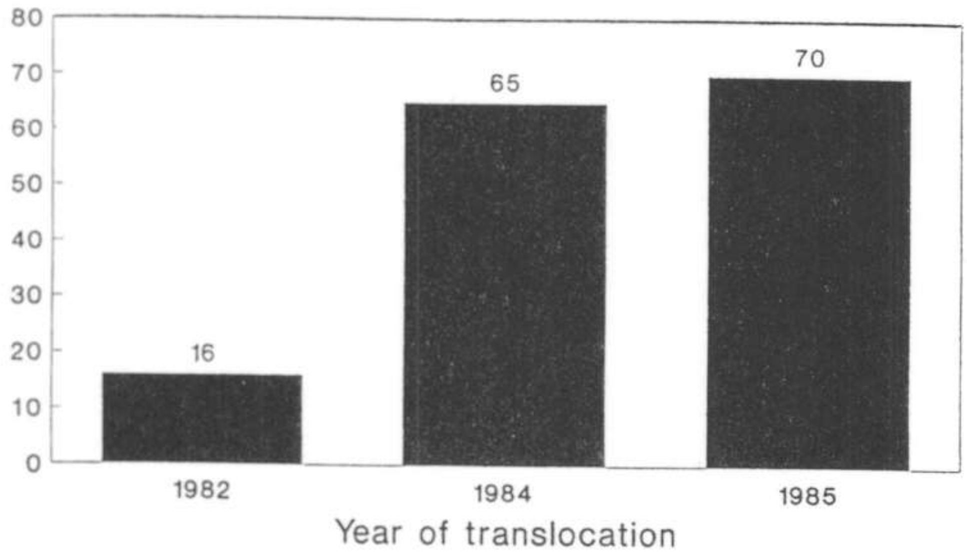


Fig. 2. Number of pronghorn translocated to Mono County, California and the percent remaining alive one year after their release.

Longterm Results

Exploration, migration, and home ranges - Pronghorn remaining from the 1982 release explored widely, but during their first year established monthly home ranges and a seasonal migration pattern used again in 1983 (Goldsmith 1988a, 1988b). The releases at Marble Creek began a new period of exploration. Summer use areas in 1984 included Adobe, Hammil, Benton and Queen valleys, the Mono Basin, and north of Montgomery Pass. Most of these small groups coalesced to winter at Marble Creek. One group remained in Adobe Valley through the winter, possibly due to less than average snow depths. The same areas were used in summer 1985; also, in spring 1985 and 1986 a group moved west from Hammil Valley to exploit abundant ephemeral vegetation on the Volcanic Tableland, then continued west into Long Valley.

In the winters of 1985 and 1986 pronghorn met in large winter groups in Hammil, Queen and Benton valleys. By 1987 two distinct winter groups were recognized, one in Hammil Valley (n=25) and one in Queen Valley (n=29); thereafter these appeared to function as separate populations, with no observed interchange between them.

Drought conditions precluded spring forb growth on the Volcanic Tableland in 1987. No pronghorn from Hammil were observed on the Volcanic Tableland or in Long Valley that year. In early 1988 7-10 pronghorn were observed on the Volcanic Tableland; thereafter (aside from mainly north-south movements of individual males) the entire Hammil population remained in Hammil Valley year-round, despite good forb production in some years. Mono Basin observations also ceased in 1987.

Some individuals, mostly adult males, continued to range over long distances. A radio-collared male released in 1984 moved northeast to Stone Cabin Valley, Nevada, over 100 km from the release site. On two occasions lone males were seen above 3,600 m elevation in the White Mountains (1 was interacting with 11 bighorn rams). North-south movements along the western base of the White Mountains were more common. Movement of males between the Queen Valley and Hammil Valley populations was not documented, but may have occurred.

In an extreme example of movement by an adult female, the doe identified as 280 (radio collar signal 159.280) spent the summer and fall of 1986 in Long Valley and left on November 27, leaving behind four fawns that had been associated with her (these were captured by baited drop net and released into their parent group in Hammil Valley). She moved east onto the Volcanic Tableland, then north to Marble Creek by mid-December. By early April 280 had continued north to Benton Valley. By July 17 1987 she was in Queen Valley, where she remained thereafter.

Alfalfa use - Percentages of groups observed on alfalfa were calculated annually (Table 1). Use of alfalfa fields declined in 1986, a year of abundant native forb and shrub growth, then increased in the drought year of 1987. High percentages of groups observed on alfalfa in later years probably reflect decreased use of telemetry rather than increased use of alfalfa. Pronghorn on flat, green fields are easily observed by passersby. Considering only telemetry observations gives a much lower percentage (Fig. 3).

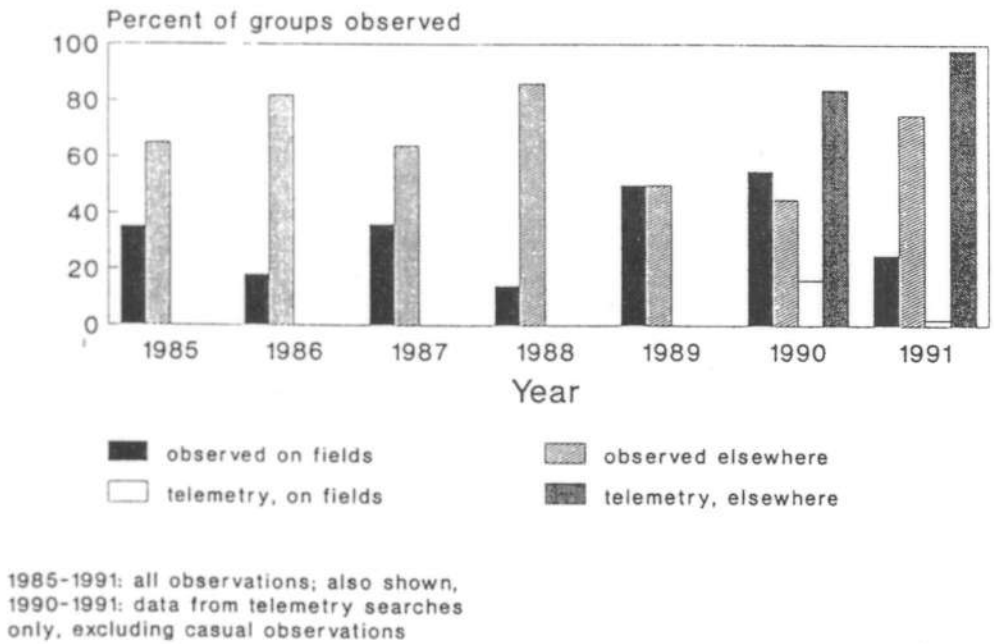


Fig. 3. Pronghorn use of alfalfa fields in Mono County California, 1985 - 1991.

Mortalities - The 1982 and 1984 translocations resulted in 12-15% pronghorn mortality in the first year. At least 10% released in 1985 were dead by September, including 40% of those radio-collared.

Table 1. Observations of alfalfa field use by pronghorn in southern Mono County, California, 1985-1991

	All observations		Observations using telemetry[a]	
	Groups observed	% observed on alfalfa	Groups observed	% observed on alfalfa
1985	123	35	*	*
1986	62	18	*	*
1987	91	36	*	*
1988	69	14	*	*
1989	22	50	*	*
1990	82	55	25	16
1991	89	25	53	2

[a] Before 1990 observers did not record whether observations involved a telemetry search.

There were 32 known mortalities recorded from 1986 through 1992 (Table 2). Radio-collared pronghorn accounted for 13 of 27 adult mortalities. Radio collars increased the probability of locating a carcass; it is unknown whether they also increased the wearer's vulnerability. One pronghorn (280) died as a result of injuries incurred during net-gun capture to replace a nonfunctioning collar in 1991. Other deaths resulting from human activities included legal and illegal hunting, and accidents involving vehicles or farm equipment.

Population growth - No fawns were recruited in 1982 and 1983 (Goldsmith 1988a, 1988b), but in mid-1985 yearlings were seen. Overall, fawn recruitment began to equal or exceed adult mortalities by 1987. From 1987 to 1993 the overall growth factor R=1.08.

After 1987, when the Hammil Valley group became a separate population, it began to decline (Fig. 4; R=0.84). Fawn recruitment was negligible and adults, especially males, were lost (Table 3). The group remained at the south end of the valley year-round, mostly on the alluvial fan in shadscale scrub vegetation, and made frequent visits to the southernmost alfalfa ranch. In 1992 the last radio-collared Hammil pronghorn died and a decision was made not to continue telemetry efforts. The group consisted of seven females and one male in December 1993. In April 1994 three females were killed when they collided with a vehicle, leaving at most four females and one male. Other than occasional sightings of one male, no pronghorn have been seen in Hammil Valley since that time.

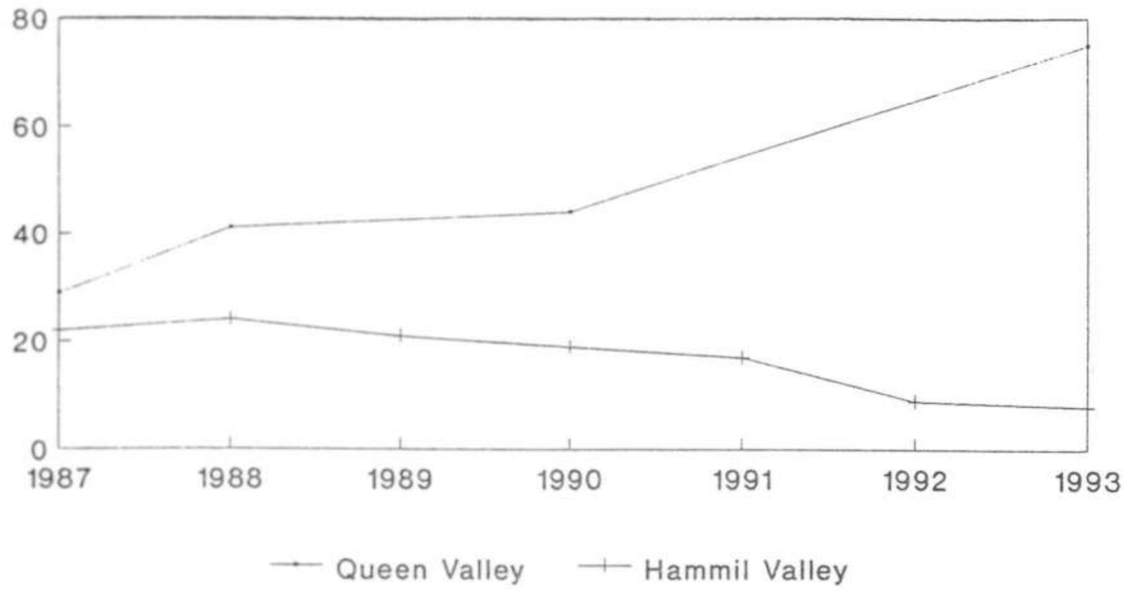


Fig. 4. Trends in the December census data for two pronghorn populations in Mono County California, 1987 -1993.

In the same time period the Queen Valley population increased (Fig. 4; R=1.17). High counts for each year were generally made in December, when one or more large winter groups had formed (Table 3). Most pronghorn remained in Queen Valley year-round. Pronghorn occasionally moved into northern Benton Valley during winters with deep snow. Some subgroups continued seasonal migrations to Adobe Valley and north of Montgomery Pass. At present no telemetered pronghorn remain in the Queen Valley area. Reports from area residents indicate an increasing number and increasing winter use by pronghorn over a large area north of Montgomery Pass. In January 1994 a Queen Valley resident reported a group of 31 in the valley, with two groups of approximately 20 and 25 north of Montgomery Pass. Thus the Queen Valley population, including those found north of Montgomery Pass, was approximately 76 pronghorn, with the possibility of other groups that had not been counted.

Table 2. Recorded mortalities among pronghorn in southern Mono County, California, 1986-1993.

	Queen Valley	Hammil Valley	Other areas	Total
Adult or yearling				
Predation		2	1	3
Road kill	3	3	2	8
Poaching?[a]	2	2	1	5
Legal hunt[b]	4			4
Recapture[c]	1			1
Cause unknown	1	4	1	6
Fawn				
Accidental[d]		2		2
Cause unknown	2		1	3

[a] Poaching strongly suspected but unconfirmed.
[b] In Nevada (Queen Valley and north of Montgomery Pass)
[c] Death resulted from injuries incurred when recaptured to replace radio collar.
[d] Death resulted from accidents involving farming equipment.

DISCUSSION

After 12 years, the reintroduction of pronghorn to southeastern Mono County is considered by the CDFG and BLM as a qualified success. The 117 animals released on three occasions have not doubled as per the original EA objective, but have recovered from sharp decreases due to death and dispersal to approximately 80 individuals. One apparently viable population has been established, but not where the EA anticipated; another population nears extinction. What factors contributed to this outcome?

Additive effect of successive releases

As in any translocation effort, the pronghorn of the initial release had to find sites providing suitable forage, water, cover, vegetation height, fawning areas and winter range. Pronghorn from later releases may have benefitted from associating with the survivors of previous releases, which had gained some experience of the area. In Arizona, Britt (1980) reported successful establishment only after three releases, over 10 years, of 126 pronghorn.

Table 3. Number of fawns (ff) observed in summer (☼), and population size and composition as observed in winter (December), for two pronghorn populations in southern Mono County, California, 1987-1993.

	Hammil Valley					Queen Valley					
	☼	December census				☼	December census				
	ff	♀	ff	♂	Σ	ff	♀	ff	♂	Σ	Winter total
1987	2	11	2	9	22	9	19	7	3	29	51
1988	3	14	2	8	24	20	31	6	4	41	65
1989	2	12[a]	0[a]	9[a]	21[a]	--[b]	14[a]	2[a]	5[a]	21[a]	42[a]
1990	2	11	0	8	19	10	33	2	9	44	63
1991	6	10	1	6	17	12	--	--	--	--	--
1992	1	8	0	1	9	2	--	--	--	--	--
1993	1	7	0	1	8	10	--	--	--	75[c]	83

[a] No December census in 1989; October observations are given.
[b] -- indicates no observation recorded.
[c] Group of 31 (including 11 ♂) in Queen Valley, plus two groups of unknown composition north of Montgomery Pass.

The Marble Creek holding facility

Holding newly translocated pronghorn for several days in a large enclosure with forage and water, allowing them to recover from capture and to observe their new surroundings, may have contributed to success (in terms of percent remaining after one year) in 1984. In 1985 pronghorn which were held only a few hours, dispersed rapidly in smaller groups and may have experienced a higher rate of mortality from capture effects.

Range of movement

Pronghorn showed a tendency to travel long distances and explore other areas, even crossing unsuitable habitat, which may have been underestimated by those who selected Adobe Valley as a release site (McCarthy 1981, Goldsmith 1988a). Possibly pronghorn would have remained in Adobe Valley if habitat quality had not been suboptimal. However, the EA judged habitat quality to be poorer in the other areas, and predicted a lower chance of success if pronghorn dispersed to them (McCarthy 1981).

Habitat suitability

Habitat rated as only "fair" by McCarthy (1981) likely contributed to the poor initial outcome of the Adobe Valley release (Goldsmith 1988a, 1988b, 1992). However, pronghorn later used areas rated "poor" (north of Montgomery Pass) and "very poor" (all others), and increased in some while declining in, or ceasing use of, others. This may be explained by one or more of the following: habitat quality changed or varied over the years, some factors were misestimated, the relative importance of the factors considered should be reevaluated, or other factors should also be considered.

Snow depths were rated by the EA as sufficient to limit pronghorn use in some winters north of Montgomery Pass and, for short periods, in Adobe Valley (McCarthy 1981). Snow depth in Adobe Valley likely prompted establishment of lower elevation winter range, which was ultimately used year-round. Winter migrations to lower elevation are common in California pronghorn populations (McLean 1944, Pyshora 1977).

Vegetation heights were rated most favorable north of Montgomery Pass and in Hammil Valley. Pronghorn established year round populations in both areas. Tall vegetation can impede visual communication, predator detection and escape (Kitchen 1974). Goldsmith (1988a) found that pronghorn preferentially used parts of Adobe Valley with vegetation height lower than the average for the valley. Low vegetation may have prompted pronghorn use of Hammil Valley, but other factors limited their success in that area.

Forage composition was rated most favorable in Adobe Valley in terms of grass/browse ratio, but all sites were found lacking in forbs, possibly due to the timing and intensity of inventories (McCarthy 1981). As in many locations in the Great Basin, abundance of forbs varies both spatially and temporally and may affect pronghorn use and success in a given area. Forbs are a seasonally important component of pronghorn diets in California and in the Great Basin (Ferrel and Leach 1952, Beale and Scoter 1968, Yoakum 1983).

Precipitation recognized as unsuitably low throughout the study area (McCarthy 1981), was below average 1982-1994; drought may have contributed to the overall low rate of increase. The loss of forb production on the Volcanic Tableland, and subsequent termination of the Hammil population's seasonal migration to Long Valley, may have been a factor in its decline.

Alfalfa depredation was anticipated by the EA (McCarthy 1981), but did not become a problem (ranchers did not object), and alfalfa did not become an important part of the diet. Although they were captured on alfalfa in Siskiyou County, where crop depredation had been a reason for translocating them (McCarthy 1981), the pronghorn released in 1982 made little use of alfalfa fields in Mono County (Goldsmith 1988a, 1988b). The Modoc County pronghorn released in 1984 and 1985 were unfamiliar with alfalfa fields, but learned to use them in Mono County. However, alfalfa use remained light, especially when forb and shrub growth was abundant. Pronghorn declined in Hammil Valley, while they increased in Queen Valley in the absence of alfalfa. Alfalfa availability in Hammil Valley did not compensate for deficiencies of habitat quality.

Water availability was rated highest in Adobe Valley (McCarthy 1981), but a new pipeline and series of reservoirs increased water sources in Queen Valley. Long Valley was eliminated from the EA because it was thought too isolated from winter range. However, pronghorn accessed Long Valley by crossing the Volcanic Tableland, eliminated from the EA for its complete lack of water and general unsuitability. Long Valley offered abundant streams and springs. In Hammil Valley pronghorn used a spring high on the southern alluvial fan and overflow irrigation water in the alfalfa fields in the valley bottom, and a guzzler intermittently provided water between the spring and alfalfa fields. Most of the year little to no surface water was available between these sources and Marble Creek at the north end of Hammil Valley. This may have been a factor in the isolation and decline of the Hammil Valley group.

Predation was anticipated by the EA to be high in all valleys, especially Adobe Valley (McCarthy 1981), and may have limited population growth. The relative role of predation in each valley is unknown but may have contributed to differential fawn survival. Mountain lions, coyotes and bobcats are known to occur in all areas that pronghorn used.

Human disturbance, a factor not evaluated in the EA (McCarthy 1981), may account for the difference in success between the Queen Valley and Hammil Valley populations. During the study period, residential and agricultural development increased in Hammil and Benton valleys. This may have reduced the area pronghorn were able or willing to use. Ranch activity in Hammil Valley may impact pronghorn directly, e.g. accidents involving farm machinery, and indirectly, e.g. avoidance of areas with human activity. Pronghorn may have been intentionally harassed in Hammil Valley (one boy reported that his father liked to chase them with his crop-dusting plane). Poaching may account for the disproportionate loss of adult males in Hammil Valley. Queen Valley has a single cattle ranch whose one fulltime resident takes a protective attitude toward the pronghorn.

Behavioral tendencies of individual pronghorn

An unpredictable, but important, factor in the outcome of reintroduction efforts is the variation in individual pronghorn behavior. Newly relocated animals are separated from learned or traditional habitat use patterns and familiar social bonds. In Adobe Valley, individuals differed in movements, choice of habitat, group associations, and vigilance for predators. Such expressions of phenotypic individuality may determine if and where new populations are established (Goldsmith 1990, 1992).

As patterns of group movement formed, individuals continued to vary in their movements and associations. Loss of an individual could affect the movements of a group, depending on associations. Ingress and egress between groups could be lost as well. The loss of far-ranging males from the Hammil Valley population may have contributed to its isolation and thus its further decline.

MANAGEMENT IMPLICATIONS

Reintroduction efforts should anticipate relocated pronghorn's ability and tendency to travel long distances through unsuitable habitat in order to find other areas for seasonal or year-round use. Sites should be chosen carefully, with consideration given to the role of human disturbance. Short-term success may be improved by releasing pronghorn into a large holding facility for several days, and a series of reintroductions over time may enhance longterm success. Still the outcome may be unpredictable, especially in marginal habitat, as habitat conditions vary and as individual pronghorn preferences are expressed.

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PRONGHORN IN TALLGRASS PRAIRIE: STATUS OF THE FLINT HILLS HERD

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Abstract: We present data for an on going study of pronghorn (*Antilocapra americana*) in the tallgrass prairie of east central Kansas in the Flint Hills region of the state. The depredation rate on fawns and doe/fawn sex ratios are similar to other populations of pronghorn. There appears to be a commensal relationship between pronghorn and domestic cattle that allows the continued existence of the herd on our study site.

PROC. PRONGHORN ANTELOPE WORKSHOP 16:50-53

Key words: *Antilocapra americana*, pronghorn, Kansas, tallgrass prairie, doe/fawn ratio, buck/doe ratio.

North American pronghorn (*Antilocapra americana*) were once native to the Flint Hills region of eastern Kansas (Brennan 1931, Sexson and Choate 1981). Recent reintroduction of pronghorn into the Flint Hills by the Kansas Department of Wildlife and Parks (KDWP) provides the opportunity for extensive research, which is needed to determine if pronghorn can once again roam in self sustaining herds in the tallgrass prairie.

Pronghorn were initially reintroduced into the tallgrass prairie of Chase County, Kansas in 1978, 1979, 1982, and 1983 by KDWP (Sexson and Choate 1981). Aerial survey was the only method used to monitor these reintroductions. In 1991 and 1992, additional pronghorn were released into the same area. These most recent additions to the herd are being monitored by graduate students at Emporia State University and KDWP personnel. The purposes of our study are to provide a history and early prognosis of the viability of pronghorn in tallgrass prairie.

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STUDY AREA

The study site, which is in the Flint Hills, is located in east central Chase County and western Lyon County, Kansas near the Bazaar cattle pens, located near the Kansas Turnpike. The semi-confined area is bordered by the Cottonwood River on the north, the South Fork of the Cottonwood River on the west, and the Kansas Turnpike on the southeast. The area consists of 20,400 ha (Horak 1985) and is privately owned. Most of the area is burned annually in the early spring and grazed by cattle in the remainder of the spring and summer months.

Winters for the study site are characterized by cold, dry weather. The dates of first and last frost are likely to occur in 50% of the years is October 9 to April 20 (Neill 1974), respectively. The month of January has the lowest average daily minimum/maximum temperatures of -7° C and 5.6° C, respectively. Snowfall is light, averaging 42.5 cm per year and usually melts within a week (Neill 1974).

Topography of the Flint Hills region consists of gently sloping to steeply sloping uplands. Dominant grasses of the area as reported by Horak (1985) include: Indian grass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), big bluestem (*Andropogon gerardii*), and little bluestem (*A. scorparius*), lead plant (*Amorpha canescens*), common ragweed (*Ambrosia artemisiifolia*), western ironweed (*Vernonia baldwinii*) and purple prairie clover (*Dalea purpurea*). Shrubs found in the area are smooth sumac (*Rhus glabra*), buckbrush (*Symphoricarpos orbiculatus*), and osage orange (*Maclura pomifera*) (Horak 1985).

RESULTS AND DISCUSSION

Release of pronghorn into the Flint Hills occurred during three different times periods In 1978 and 1979, 37 and 98 pronghorn, respectively, were released. Due to a slow yearly decrease in population size, it was determined that additional animals must be released. In 1982 and 1983, 127 and 24 pronghorn, respectively, were released. This population also began to decrease in size. The population then fell to about 50 individuals, a level where it seemed to remain. A third release occurred in 1992 and 1993.

In 1990, there was a renewed interest to release pronghorn into the Flint Hills. However, this time the release was to be monitored and studied in order to determine some basic ecology of pronghorn in the tallgrass prairie. In 1991 and 1992, 50 and 41 pronghorn, respectively, were released.

In 1991, pronghorn were caught near Lamar, Colorado and were released in late January by KDWP. Twenty-two adults, 11 yearlings, and 17 fawns were released at this time. The buck/doe ratio of this release was 10/100 and the fawn/doe ratio was 57/100. Fifteen adults (13 females, 2 males) were fitted with radio collars. Currently, only one female remains in the study area with an active radio collar from this release.

In 1992, pronghorn were caught near Pueblo, Colorado and were released in February by KDWP. Twenty-three adults, three yearlings, and 15 fawns were released at this time. The buck/doe ratio of this release was 13/100 and the fawn/doe ratio was 65/100. Twenty-one adult females and two yearling females were fitted with radio collars. Currently, two females and one male remain in the study area with active radio collars from this release.

Herd counts conducted in the winter of 1993-94 showed that 80 pronghorn were still in the study area. The buck/doe ratio was 70/100 and a fawn/doe ratio of 30/100. This fawn/doe ratio does not appear to be lower than what has been reported for by surrounding states (See papers within this proceedings). However, due to the relatively small herd size, a higher fawn/doe ratio is needed every year in order to sustain an overall increase in herd size.

Research is continuing on the Flint Hills pronghorn herd. Fawn mortality and bedsite selection studies were conducted in the first two fawning seasons of 1991 and 1992 (Rothchild 1993), and are being continued in 1993 and 1994 by James Regehr, who is also studying fawn behavior. Home ranges and habitat use characteristics of adults was studied by Simpson (1992). Arn Eccles is currently studying winter and spring use of areas by pronghorn, in which information is being set up in a GIS (Geographical Information System) with Idrisi and Tosca (Clark University, Worcester, MA). David Ganey has begun studying forage use by pronghorn in the study area.

Monitoring the Flint Hills pronghorn herd is becoming increasingly difficult as the number of radio-collared individuals remaining in the study area decreases. In the fawning season following the 1992 release, 28 females had radio collars. During the 1992 fawning season, eight females had active radio collars. Currently, only three females still remain in the study area with active radio collars. The remainder of radio-collared individuals introduced in 1991 and 1992 either moved off the study site, died, or had transmitter batteries fail.

It is assumed that late winter and early spring period is a critical survival time for pronghorn in the Flint Hills. During this period range forage quality is low, wheat and alfalfa fields are not available, and brushy species of plants are not abundant. Also, there is a severe reduction in forage quantity when spring burns occur that cover almost the entire study area. Yet, when data were plotted of known death dates for 24 radio-collared pronghorn on the study area, death dates were random (P=0.20), with several occurring in late summer and early fall.

Based on current data and past observations, it appears likely that the tallgrass prairie can support a self-sustaining pronghorn herd. However, elimination of a portion of predators during the fawning season could greatly increase the success of the Flint Hills pronghorn herd. Also, landowners and operators must be convinced that pronghorn do not present a harm to their livelihood but, instead, offer a benefit to them in the form of notoriety, watchable wildlife, or other incentives. There appears to be a commensalism between cattle and pronghorn in the tallgrass prairie.

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AN EVALUATION OF PRONGHORN COMPOSITION SURVEYS

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Abstract: We compared fixed-wing aerial pronghorn (*Antilocarpa americana*) composition estimates to ground estimates at four locations in Wyoming. We found no significant differences (α=0.05) between pooled ground and aerial surveys, except for buck ratio estimates at only one site. We also tested for observer differences in ground surveys by having all observers classify the same pronghorn groups. Individual observers' did not differ when classifying identical pronghorn groups. Stepwise logistic regression revealed that when pronghorn group size increased, the probability of observer agreement decreased. However, precision was low for most ground and aerial estimates reducing our ability to detect small statistical differences if they existed.

PROC. PRONGHORN ANTELOPE WORKSHOP 16:54

Key words: Pronghorn, aerial surveys, composition estimates, observer variability, Wyoming.

This presentation was a preliminary report. Additional data were collected and results submitted to JWM for review.

ANALYZING PRONGHORN HABITAT USE PATTERNS WITH GIS TECHNOLOGY

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Abstract: We describe a way to use a Geographical Information System (GIS) for habitat analysis, by testing of pronghorn (*Antilocapra americana*) habitat avoidance-selection along highways and around water sources (Ockenfels et al. 1994). First, pronghorn were captured and located for three years. We then imported their X,Y coordinates into GIS-software ARC/INFO® (Environmental Systems Research Institute, Redlands, California). We extracted (CLIPPED) the highway distribution for the study area from an existing statewide GIS coverage, whereas we digitized water sources into an ARC/INFO database. For habitat use estimation, we used the NEAR function to measure the distance (m) between each location and the nearest highway and the nearest water. To determine habitat availability, we used BUFFER to create isometric distance (100 m) zones along highways and concentrically around water sources. The number of locations expected in each zone (based on percent area) was then calculated for highways and waters. Finally, we used Chi-square contingency tables, Bonferroni simultaneous confidence intervals, and Jacobs' *P* to compare the distribution of how far locations were from highways and from waters against the number expected. GIS technology is more than a map-making system, it is a powerful analytical tool.

PROC. PRONGHORN ANTELOPE WORKSHOP 16:55-63

Key words: *Antilocapra americana*, Arizona, GIS, habitat use, highways, pronghorn antelope, roads, selection, technique, water.

Biologists often search for better techniques to help them understand an animal's life history. In our paper, we present a way to use Geographical Information System (GIS) technology in habitat avoidance-selection testing. We illustrate this by showing how we helped Ockenfels et al. (1994) determine if pronghorn avoided areas along highways and around water sources in Central Arizona.

GIS technology is gaining rapid acceptance in the wildlife profession. Although often considered a map-making tool, a GIS is really an integrated computer system, i.e. hardware and software are matched with data and personnel, that collects, stores, retrieves, manipulates, transforms, analyzes, and displays spatial (geographically-referenced) information (Burrough 1986).

In using GIS technology, we dealt with three basic habitat concepts:

(1) use patterns;
(2) habitat availability; and
(3) avoidance-selection theory.

We use pronghorn as an example; however, the same concepts and uses hold for other animals.

Habitat use patterns describe how animals, such as pronghorn, use their environment (Thomas and Taylor 1990). Biologists, through a variety of techniques, estimate the percentage of use of each habitat component to determine which is used the most, which the least, and so forth. These data are simply a summary of what was observed that alone provide insight into managing pronghorn. For example, a statement about pronghorn typically living or being located X percent of the time in undulating terrain explains something about their habitat use patterns.

Use patterns alone can not answer all management concerns. In fact, they can be misleading. To further understand how habitat characteristics affect pronghorn, biologists must incorporate the second concept, habitat availability into their analysis (Neu et al. 1974, Johnson 1980). Habitat availability is often defined as how much of a particular habitat characteristic is present within the area studied.

Estimating availability is not without substantial problems (Johnson 1980, Alldredge and Ratti 1986, Thomas and Taylor 1990), but common sense can help in designing ways to alleviate most concerns. A thorough review of the literature is essential before attempting to estimate availability. With habitat availability properly estimated (= known), biologists have a reference to better judge the patterns of use they observe in the field and to judge relative habitat importance.

The way biologists typically evaluate what they observed animals using as opposed to what was available requires the third concept, habitat avoidance-selection theory (Neu et al. 1974, Johnson 1980). Using this concept, biologists can better determine the quality of pronghorn habitat. They can determine which characteristics are suitable to pronghorn and which are unsuitable. Biologists can even determine the degree of suitability of each characteristic.

We consulted B. F. Wakeling and D. D. Haywood for statistical support. A. Alexander and R. E. Schweinsburg reviewed the manuscript. This manuscript was supported by Federal Aid in Wildlife Restoration Project W-78-R.

DETERMINING HABITAT USE PATTERNS

The first step to undertake is to determine how pronghorn use habitat. To do this Ockenfels et al. (1994) captured 47 (29♀, 18♂) pronghorn during 1989-91 with a net-gun fired from a helicopter (Firchow et al. 1986). Each pronghorn was radio-collared so that they could be located on a regular basis.

Based on the season, biologists located the pronghorn 1-2 times per week from the air and once per week from the ground. Each location was plotted on 7.5′ U.S. Geological Survey (USGS) topographic maps from which biologists derived Universal Transverse Mercator (UTM; nearest 0.1 km) coordinates for our computer files.

After location efforts were completed, we corrected the data and imported it into ARC/INFO. Each file record consisted of the following items:

(1) pronghorn identification number;
(2) month, day, and year of location;
(3) east-west UTM; and,
(4) north-south UTM.

We purchased a statewide GIS database of paved primary and secondary highways in Arizona from USGS (Digital Line Graph for 1:100,00-scale maps). Using the CLIP function of ARC/INFO, we used our study area boundary to extract only those highways within the area.

We digitized all water sources within the area that were on USGS topographic maps into a GIS cover. Water locations were field verified by biologists during further efforts to locate pronghorn. As unmapped waters were encountered in the field, we plotted them on USGS 7.5′ maps, derived the UTM coordinates, and encoded the coordinates directly into the GIS cover.

In ARC/INFO, we overlaid (brought together) the pronghorn location coverage and the highway coverage; we did the same for the water coverage. Using the NEAR function, we measured the distance between each location and the nearest highway, then did the same for distance to the nearest water (Fig. 1a, b). We summarized the resultant data into 400-m intervals to simplify the use patterns (Table 1). We subset the highway data by first discarding any location ≥2,000 m from the nearest highway. This was done to remove effects of the original capture scheme that was based on studying movement corridors and vegetation differences and not on evaluating highways. Thus, only those pronghorn whose home ranges could be affected by highways were evaluated.

Table 1. Distances of female pronghorn locations from highways and water sources, and percent area available within isometric buffers along highways and around water sources.

Distance class (m)	No. of locations	% of locations	% of area	Expected no. of locations[a]
Highways				
0 - 399	255	16.5	21.8	337.9
400 - 799	422	27.2	20.3	314.7
800 - 1,199	338	21.8	20.0	310.0
1,200 - 1,599	284	18.3	19.2	297.6
1,600 - 1,999	251	16.2	18.7	289.9
	1,550	100.0	100.0	1,550.1
Waters				
0 - 399	399	10.3	13.7	452.2
400 - 799	1,101	33.4	31.5	1,039.8
800 - 1,199	1,056	32.0	31.9	1,053.0
1,200 - 1,599	600	18.2	22.1	729.5
≥1,600	205	6.2	0.7	23.1
	3,301	100.1	99.9	3,297.6

[a] Expected number based on percent area (% area * total locations). Round-off occurred at one significant digit.

DETERMINING HABITAT AVAILABILITY

Our next step was to estimate habitat availability along highways and around water sources. Using the BUFFER command in GIS, we established a series of isometric (400 m) zones along highways (to a maximum of 2,000 m) and around waters (Fig. 1c, d). We converted the areal extent ARC/INFO calculated for each zone into km² during the process.

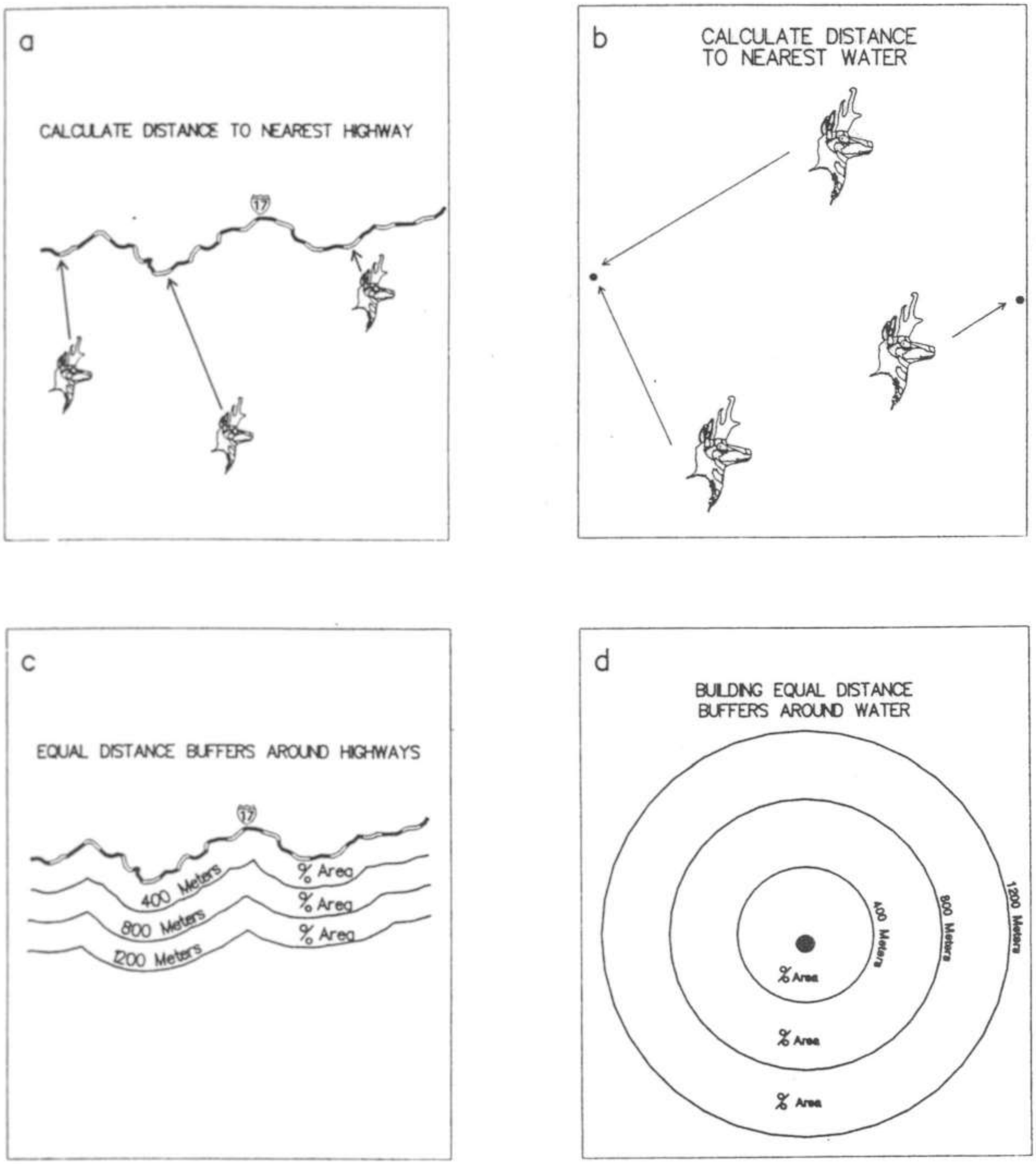

Fig. 1. Representation of using GIS to measure distance between pronghorn locations and nearest highway (a) and nearest water source (b) using the NEAR sub-routine in ARC/INFO®), and using GIS to create isometric distance zones along highways © and around water sources (d) with the BUFFER sub-routine in ARC/INFO).

Using the GIS, we obtained the area (km^2) occurring within 2,000 m of the highways and the area (km^2) within the study boundary. For our habitat availability, we used the estimated number of locations that should have occurred within each distance zone (multiply the percent area within each distance zone along highways and around waters by total number of locations, and then divide by total number of locations; Table 1).

DETERMINING AVOIDANCE-SELECTION OF DISTANCE ZONES

We now had the two components necessary to do avoidance-selection testing:

(1) number and percentage of locations within each zone as an estimate of use; and,

(2) the estimated number of locations that should have occurred within each zone as an estimate of availability.

Using a statistical software package, we ran two contingency tables to test if use along highways and use around water were proportionate to availability. We used contingency tables rather than goodness of fit tests because we preferred to be conservative. Contingency tables are recommended if availability is only estimated rather than being known (Thomas and Taylor 1990). As our test criteria, we used the Chi-square value, however, in many cases the log-likelihood *G*-test is often preferred (Zar 1984).

Since the contingency tables indicated use along highways ($\chi^2 = 31.55$, 4 df, $P < 0.001$) and around waters ($\chi^2 = 175.62$, 4 df, $P < 0.001$) differed from what was expected, we proceeded to the next step. Bonferroni 90% simultaneous confidence intervals were constructed around each set of use values (Table 2; Neu et al. 1974, Byers et al. 1984). We used these confidence intervals to determine which cells of the contingency table were used out-of-proportion to availability. If expected use was outside the confidence interval, observed use did not equal the expected use.

The last step in the habitat analysis was to use Jacobs' *P* to determine the relative magnitude and direction of avoidance-selection (Jacobs 1974). Jacobs' *P* was only calculated if the Bonferroni simultaneous confidence interval did not contain the expected use (Table 2). Jacobs' *P* ranges from -1.00 for total avoidance to 1.00 for total selection.

The avoidance-selection analyses indicated to Ockenfels et al. (1994) that habitat along highways and around waters was used out-of-proportion to availability. The effects were slight, as Jacobs' *P* values did not need to be calculated (i.e., use = availability) or the values were relatively close to 0 (Table 2). For example, from the data we present, Ockenfels et al. (1994) were able to conclude that areas within the first 400 m along highways or around waters were only slightly avoided. They found that the only substantial selection (i.e., a high positive Jacobs' *P*) was for the small areas of habitat ≥1,600 m from water (but no areas were ≥3,200 m from water). Although Jacobs' *P* was high, relative size of area and number of locations suggests that importance of this demonstrated difference in use was probably low, in fact, it may have been an artifact of our study design.

Table 2. Bonferroni simultaneous confidence intervals[a] and Jacobs' *P*[b] values for avoidance-selection of female pronghorn locations along highways and around water sources.

Distance class (m)	% of locations	Bonferroni 90% CI	% of area	Jacobs' *P*
Highways				
0 - 399	16.5	14.3 - 18.7	21.8	-0.17
400 - 799	27.2	24.6 - 29.8	20.3	0.19
800 - 1,199	21.8	19.4 - 24.2	20.0	
1,200 - 1,599	18.3	16.0 - 20.5	19.2	
1,600 - 1,999	16.2	13.8 - 18.2	18.7	-0.09
Waters				
0 - 399	10.3	9.1 - 11.5	13.7	-0.16
400 - 799	33.4	31.5 - 35.3	31.5	
800 - 1,199	32.0	30.1 - 33.9	31.9	
1,200 - 1,599	18.2	16.6 - 19.7	22.1	-0.12
≥1,600	6.2	5.2 - 7.2	0.7	0.81

[a] Chi-square indicated use differed from availability along highways ($\chi^2 = 31.55$, 4 df, $P < 0.001$) and around waters ($\chi^2 = 175.62$, 4 df, $P < 0.001$).

[b] Jacobs' D indicates direction and magnitude of avoidance-selection. Jacob's D is only calculated if % of area does not fall within the Bonferroni 90% confidence interval.

DISCUSSION

Using GIS technology improved the ability of biologists to determine if highway and water distributions affected pronghorn use patterns. The improvements were mainly in speed, precision, and ease-of-use.

For example, we could have used rulers to measure distances between locations and highways, but we would have had to measure 4,996 distances by hand. This would have been a time-consuming task. A computer is much faster at such repetitive tasks, and computers are more precise. To ensure reasonable hand-measurement accuracy and precision, we would have had to have made more than one measure for each location that would have been a tedious undertaking. Measuring to the nearest water would have doubled the workload from that of highways alone.

To calculate area, we would have had to use a compass to draw the isometric zones, and used either a dot-grid, manual planimeter, or electronic planimeter to determine area. Again, the GIS is designed to easily do these tasks with greater accuracy and precision (Burrough 1986).

With the steps we described in the preceding pages, Ockenfels et al. (1994) were able to conclude that pronghorn habitat use patterns were slightly affected by highways and by water distribution in Central Arizona, and they provided resource managers with scientifically-based data and analyses to back up any conclusions.

GIS can also be used to analyze many other habitat related patterns. To list a few, we could have tested whether pronghorn selected or avoided prescribed burns, housing developments, areas along woodlands or forests, and canyon edges. Following the procedures we have used in our paper, biologists can add a powerful analytical tool to their tool-chest of techniques, a GIS.

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HABITAT SELECTION BY PRONGHORN IN A SHORTGRASS/PINYON- JUNIPER COMMUNITY IN NORTHWEST ARIZONA

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Abstract: Pronghorn (*Antilocapra americana*) habitat selection and availability was studied on the Yavapai Ranch located in the northwest corner of the west half of the Prescott National Forest. The study area is a 92 km^2 checkerboard of public and private land. The area is characterized by rolling hill terrain covered by shortgrass vegetation with pinyon-juniper at higher elevations. Utilization data were collected from 60 independent animal observations made between April-August, 1993. Data recorded at each observation included location, slope, aspect, macro/micro topography and habitat, herd composition and activity. Woody species density and height were collected using a 1/100 ha (25 X 4m) macroplot, while similar herbaceous characteristics were gathered using 20 X 50 cm microplots located at 5, 10, 15, and 20 m along the midline of the macroplot. Ground cover (% cover by class) was determined using a 25 m line-intercept located along the midline of the macroplot. Habitat availability was described using 467 systematically located points to collect similar data. Results showed an 85% utilization of slopes < 5%, increasing to 98% for slopes < 10%. Ninety-five percent of the observations occurred on rolling hill terrain with micro-topographic utilization centering on flats, hillsides, and rolling hills (approximately 93%). Macro-habitat use showed 40% for grassland and 60% for grassland-shrub, while micro-habitat displayed 31% and 69% utilization, respectively. Pronghorn used areas with 57% herbaceous ground cover, 41% bare rock/litter, and only about 2% shrub cover. Mean vegetation height by class was 10.0 cm for grass, forbs were 4.0 cm, 35.0 cm for cacti, 25.0 cm for shrubs, and 100.0 cm for trees, with a mean vegetation height (omitting trees) of 18.5 cm. Mean vegetation densities of use sites were 32 and 52 plants/m^2 for grass and forbs respectively, and 190, 952, and 7 plants/ha for cacti, shrubs, and trees, respectively.

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Key words: Pronghorn , *Bouteloua gracillis*, *Hilaria* spp., *Chrysothamnus* spp., *Gutierrezia sarothrae*, Habitat Selection, Shortgrass, Pinyon-juniper.

Much of the pronghorn research in the United States has centered on the large populations in the states, of Montana and Wyoming. Past literature (Sundstrom et al. 1973, Amstrup 1978, Kindschy et al. 1982) has dealt with pronghorn habitat use in these areas, while very little information is available on habitat selection in the Southwest. Yoakum (1980) has described habitat in a sagebrush/grassland-steppe community, while Scheutze (1993) has provided seasonal and diurnal habitat selection patterns in a desert-grassland setting. Concurrent to our study, the Arizona Game and Fish Department has initiated a project designed to describe and quantify habitat spanning the state. However, a large portion of pronghorn habitat in Arizona is located in non-traditional shortgrass/pinyon-juniper areas. As a result, pronghorn habitat selection in these areas has gone relatively undocumented.

The objectives of our study were:

1) To describe habitat use by pronghorn within a short-grass/pinyon-juniper community;
2) To evaluate pronghorn preference in relation to habitat availability.

Funding and support on our project was provided by the Prescott National Forest, with assistance from the Yavapai Ranch management and staff.

STUDY AREA

The study is being conducted on the New Water area of the Yavapai Ranch which is located in the northwest corner of the west half of the Prescott National Forest, approximately 125 km west of Flagstaff, Arizona. The study site comprises 88.5 km^2 bounded by BLM land to the north and west, and private land in the Maria Bacca float to the south. The ranch is a checkerboard of public and private land which is currently being run under an inter-agency coordinated resource management program. General topography of the area is described by rolling hill terrain with elevations ranging from 1,400 to 2,600 m.

The habitat is characterized by shortgrass communities dominated by blue gramma (*Bouteloua gracillis*) and ring muhli (*Muhlenbergia torreyi*) at lower elevations, blending into pinyon-juniper (ex. *Pinus edulis* and *Juniperus deppeana*) at upper elevations. The shortgrass areas are interspersed with varying shrub densities consisting mainly of broom snakeweed (*Gutierrezia sarrothrae*) and rabbitbrush (*Chrysothamnus nauseosus*). Cactus species are typified by *Opuntia spp.* and *Yucca spp.*. Water sites are available for both cattle and wildlife through man-made tanks located in each of six pastures. Pronghorn on the ranch display limited migration to surrounding private lands during the late fall through winter, and begin moving back onto the study area around April 1 for the fawning season.

METHODS

During the period of April through August, 1993, 60 animal observations were made. Animal locations were determined by direct observation. Where possible, locations were confirmed using a global positioning system. At each observation site, abiotic data collected included slope, aspect, and macro- and micro-topography type (Table 1). "Macro" was defined as the landscape scale, while "micro" refered to conditions within the plot.

Table 1. Class designations for selected abiotic traits.

<u>Topography Classes</u>
- Hilltops
- Hillsides (> 4% slopes)
- Rolling hills
- Flats (0-4% slope)
- Swales
- Drainages

<u>Habitat Classes</u>
- Grasslands (< 5% shrubs)
- Grassland-Shrub (5-30% shrubs)
- Shrubland (> 30% shrubs)
- Pinyon-Juniper

<u>Cover Classes</u>
- Bare rock/Litter
- Herbaceous
- Shrubs < 0.5m
- Shrubs > 0.5m
- Trees

Biotic vegetative data recorded were macro- and micro-habitat type (Table 1), with macro and micro being defined as above. A 0.01 ha (25 X 4 m) macro-plot centered on the observation site was used to collect density and mean height per species for trees, shrubs, and cacti. Herbaceous data were collected using four 25 X 50 cm Daubenmire plots situated at 5, 10, 15, and 20 m along the midline of the macro-plot. Herbaceous data also consisted of species density and mean height. Cover class data (Table 1) were gathered from a 25 m line-intercept located along the mid-line of the macro-plot. Animal information consisted of herd size, sex, age (adult or fawn), and activity at the time of the sighting.

Between September and November of 1993, 467 systematically located plots were sampled. Plots were located at 250 m intervals along east-west running transect lines, which were spaced 300 m apart. Data collected at each plot site were identical to that collected at animal observation sites. Distance to water information was derived using a GIS software package.

Data were analyzed using a Chi-square test to determine the statistical significance of comparisons between "use" versus "availability" (Zar 1984). The hypothesis being tested was that animals use habitat criteria in proportion to it's availability. Animal observations were equated to the "use" (observed) factor, while the systematic data were treated as the "available" (expected). For the purpose of our study, the selected experimental probability level was 0.05. Habitat traits with significant differences were further tested for proportionality of the individual cell values (Zar 1984). Comparison of the use versus available numbers for significant cells yielded the direction of selection, either preference or avoidance. Those cells which were insignificant as a result of the proportionality test displayed variable classes that were used equal was to availability. Cover data was summarized into means per class for both use and availability, and a Dunnet's mean separation test was used to determine significance between class means (Zar, 1984).

RESULTS

Analysis showed at least one level in each of the abiotic factors to be significant (Table 2). Pronghorn selected slopes of < 5%, while avoiding slopes of 5-10%. Pronghorn showed an aspect selection preference for north and northeast aspects, while avoiding south and southwest aspects. Macro-topographic selection was for rolling hill terrain, while hillsides and flat expanses were avoided. Similarly, within the micro-topography we observed a corresponding selection for rolling hills and drainages while avoiding hillsides. All other terrain types were used as available. The results of the distance to water data analysis indicated that pronghorn preferred areas < 0.8 km from known water sources, and avoided areas from 2.5-3.2 km.

Of the biotic factors sampled, eight were determined as having levels significantly related to pronghorn habitat use (Table 3). Macro-habitat data indicated that only pinyon-juniper areas were selected against. All other areas were used proportionate to availability. Grassland-shrub micro-habitat areas were exclusively selected, while grasslands were avoided. Pronghorn selected areas with shrub densities < 1,000 plants/ha, while avoiding all other areas. Concurrently pronghorn selected locations with grass densities < 10 plants/0.1 m^2, while avoiding areas with > 10 grass and 15 forb plants/0.1 m^2. Areas with shrub heights of < 25 cm were selected, while areas of > 50 cm were actively avoided. Pronghorn also used areas of < 10 cm of grass height and 5-17.5 cm of forb height at a rate greater than available. Further, pronghorn avoided areas with a forb height < 5 cm, and grass and forb heights > 25 cm.

Information derived from the ground cover analysis showed that pronghorn used areas with a mean bare ground/litter component of 43%, which was less than the mean for the area. Mean herbaceous cover of use sites was greater than that available (54% and 39%, respectively). All other cover classes were found to be insignificant (Table 4).

Table 2. Abiotic habitat traits used by pronghorn in a shortgrass/pinyon-juniper community in Central Arizona.

Habitat Variable	Variable Class	% Use	% Available	Test of Proportionality
SLOPE(%)				
	< 5	85.45	33.33	7.318778 (1.96)
	5-10	12.73	63.51	7.060195
	> 10	1.82	3.16	0.544422
	$\chi^2 = 67.6$	$P = 0.0001$		
ASPECT				
	North	49.09	22.41	4.188513 (1.96)
	N.East	21.82	5.46	4.230701
	East	10.91	12.36	0.305184
	S.East	0.00	1.72	0.981126
	South	0.00	6.61	1.963434
	S.West	3.64	14.66	2.246913
	West	30.91	30.75	0.024184
	N.West	1.82	6.03	1.279032
	$\chi^2 = 64.4$	$P = 0.0001$		
MACRO-TOPO				
	Hill Top	0.00	4.02	1.514026 (1.96)
	Hillside	1.82	26.15	3.994972
	Roll Hill	94.55	37.93	7.832346
	Flat	0.00	30.46	4.767812
	Swale	0.00	0.29	0.398044
	Drainage	3.64	1.15	1.415199
	$\chi^2 = 81.11$	$P = 0.0001$		
MICRO-TOPO				
	Hill Top	0.00	2.01	1.061074 (1.96)
	Hillside	23.64	46.55	4.364454
	Roll Hill	23.64	6.03	3.186132
	Flat	43.64	44.54	0.125365
	Drainage	9.09	0.86	4.065543
	$\chi^2 = 76.32$	$P = 0.0001$		
DISTANCE TO WATER				
	< 0.4	18.18	6.36	3.023051 (1.96)
	0.4-0.8	21.82	16.23	1.995026
	0.8-1.2	18.18	22.88	0.795382
	1.2-2.4	25.45	22.55	0.499264
	2.4-3.2	16.36	28.23	2.841059
	> 3.2	0.00	3.75	1.457081
	$\chi^2 = 23.42$	$P = .0001$		

Table 3. Biotic habitat traits used by pronghorn in a shortgrass/pinyon-juniper community in Central Arizona.

Habitat Variable	Variable Class	% Use	% Available	Test of Proportionality
MACRO-HABITAT				
	Grass	40.00	34.48	0.795941 (1.96)
	Gr-Shrub	60.00	52.30	1.063851
	Shrub	0.00	4.89	1.674847
	P/J	0.00	8.33	2.222324
	$\chi^2 = 8.38$	$P = 0.0317$		
MICRO-HABITAT				
	Grass	0.00	46.55	6.543246 (1.96)
	Gr-Shrub	100.00	43.39	7.804476
	Shrub	0.00	6.32	1.917755
	P/J	0.00	3.74	1.457081
	$\chi^2 = 71.67$	$P = 0.0001$		
SHRUB DENSITY (1,000/Ha)				
	< 1	65.45	39.08	3.674774 (1.96)
	1 - 2	20.00	50.57	4.225112
	2 - 4	10.91	23.56	2.110858
	4 - 6	3.64	9.48	1.430717
	> 6	0.00	6.03	1.871209
	$\chi^2 = 28.97$	$P = 0.0001$		
SHRUB HEIGHT (cm)				
	< 25	54.55	33.91	2.950378 (1.96)
	25-50	40.00	41.09	0.153037
	50-100	5.45	16.67	2.155923
	> 100	0.00	8.33	2.222324
	$\chi^2 = 15.78$	$P = 0.0015$		
TREE DENSITY (plants/Ha)				
	< 100	94.55	87.36	N/S
	100-500	5.45	11.49	
	> 500	0.00	1.15	
	$\chi^2 = 2.66$	$P = 0.1720$		
TREE HEIGHT (cm)				
	< 100	96.37	90.81	N/S
	100-200	3.64	4.31	
	200-300	0.00	3.74	
	> 300	0.00	4.02	
	$\chi^2 = 5.29$	$P = 0.0938$		

Table 3 (continued)

Habitat Variable	Variable Class	% Use	% Available	Test of Proportionality
CACTUS DENSITY (plants/Ha)				
	< 200	40.00	56.36	N/S
	200-500	23.64	16.36	
	500-700	9.09	7.27	
	700-1000	9.09	7.27	
	> 1000	18.18	12.73	
	$\chi^2 = 6.18$	$P = 0.0704$		
CACTUS HEIGHT (cm)				
	< 10	60.00	69.54	N/S
	10-20	23.64	14.08	
	20-30	1.82	6.03	
	30-50	10.91	6.90	
	> 50	3.64	3.45	
	$\chi^2 = 7.24$	$P = 0.0694$		
GRASS DENSITY (PLANTS/0.1 m^2)				
	< 5	43.63	3.16	9.91 (1.96)
	5-10	32.73	17.82	2.58
	10-15	16.36	34.77	2.71
	> 15	7.27	44.25	5.22
	$\chi^2 = 270.33$	$P = 0.0001$		
GRASS HEIGHT (cm)				
	< 5	14.55	1.44	5.11 (1.96)
	5-10	20.00	2.01	6.00
	10-17.5	25.45	13.51	1.83
	17.5-25	21.82	26.72	0.77
	> 25	10.91	48.28	5.20
	$\chi^2 = 167.98$	$P = 0.0001$		
FORB DENSITY (PLANTS/0.1 m^2)				
	< 5	78.18	66.38	1.74 (1.96)
	5-10	16.36	11.49	1.03
	10-15	3.64	8.33	1.21
	> 15	1.82	13.79	2.53
	$\chi^2 = 10.78$	$P = 0.006$		
FORB HEIGHT (cm)				
	< 5	18.18	42.82	3.47 (1.96)
	5-10	34.55	9.20	5.25
	10-17.5	25.45	13.51	2.30
	17.5-25	12.73	7.18	1.41
	> 25	9.09	27.30	2.91
	$\chi^2 = 63.28$	$P = 0.0001$		

Table 4. Dunnett's mean separation test of cover class means comparing areas of pronghorn use with habitat availability.

COVER CLASS	% USE	% Available	*q*	*q*'0.5(2),55
BareRock/Litter	43.56	58.61	3.88	2.01
Herbaceous	53.62	38.88	3.80	2.01
Woody <0.5m	2.77	2.11	0.17	2.01
Woody >0.5m	0.05	0.10	0.01	2.01
Trees	0.00	0.30	0.08	2.01

DISCUSSION

The shortgrass/pinyon-juniper communities of the Southwest, such as that studied in our project, typically encompass a wider range of slopes, topography, and habitat types than those found in traditional pronghorn habitats. As a result, pronghorn habitat selected may also differ. Recognition of the preferred habitat traits within these "non-traditional" communities is essential for incorporation into a more comprehensive management plan.

Slope selection by pronghorn fit the general concept of relatively flat areas < 5%. This is a downward modification of the < 10% slope selection found by Amstrup (1978). However, on our study site, slopes ranged up to approximately 20%, with steeper slopes being associated with pinyon-juniper areas. These areas were avoided. The avoidance here may be due in part to the vegetative community and predator avoidance. The pinyon-juniper areas offer concealment for large predators such as coyote (*Canis latrans*), bobcat (*Felis rufus*), and mountain lions (*Felis concolor*), all of which are present on the study site. This effect is substantiated by the macro-habitat results, which showed avoidance of the pinyon-juniper areas. Concurrently, recent field observations concentrating on the pinyon-juniper areas have shown that the limited pronghorn use of these areas tends to occur on the "fringe" interface between the grassland-shrub and pinyon-juniper.

Aspect selection results are also likely related to vegetation. Northern aspects are typically cooler and moister than southern slopes, hence, north slopes tend to have a higher forage production. Most likely it is this difference in vegetation rather than an actual thermal relationship to the animal that is causing this selection pattern.

Topography and habitat selection is also likely a function of predator avoidance. Howard et al.(1990) and Yoakum (1980) both reported pronghorn habitats typified by wide open, expansive terrain. Flat expanses generally offer long fields of view. This factor, coupled with the short vegetation found on our study site, would provide an excellent environment for early predator detection. Conversely, these conditions allow predators to locate pronghorn as prey. As a trade off, selection for rolling hill terrain serves to permit pronghorn use of the natural relief contours to disrupt the visual pattern and provide limited refuge, while maximizing predator detection.

In conjunction with the topographic selection, pronghorn in our study selected grassland-shrub habitats, which differs from the pure grassland mosaics described by Schmidt and Gilbert (1978). Within these grassland-shrub areas, the shrub component preferred consisted of densities < 1,000 plants per ha and heights < 25 cm. These characteristics lend increased concealment without compromising the pronghorn's line of sight, or infringing on it's escape capabilities. Drainage areas were also selected as a topographic feature and are probably a result of the increased vegetation production and species composition occurring in these areas.

The herbaceous components selected may relate to foraging and bed site selection. Forbs are believed to comprise a major component of the pronghorn diet (Sundstrom et al. 1973, Yoakum 1990). Common forbs found on our study site were thistle (*Cirsium* spp), lupines (*Lupinus* spp), and mallows (*Spharalcea* spp), and do not display tall vegetative growth (typically found at heights of < 10 cm). Avoidance of forbs < 5 cm may be due to the fact that these plants do not provide adequate bulk for the amount of energy expended in foraging. Conversely, forbs > 17.5 cm may have increased fiber contents that detract from their quality as a forage. This may be a partial explanation for the avoidance of forbs with those heights. One possible explanation for pronghorn avoidance of areas with forb densities > 15 plants/0.1 m^2 may be that the higher densities of forbs are associated with the smaller plants caused by inter- and intra-species plant competition. In a 0.1 m^2 area, nutrients will be limited, especially during stress periods, i.e., low precipitation or intense grazing. Competition for soil nutrients with other forbs and grasses may yield stunted growth forms. However, this relationship was not studied in our project, it is suggested that a full analysis of the forage quality is necessary to gain further insight into the possible relationships of these theories.

Grass selection is thought to center around bedding requirements. In relation to bedding, previous studies by Dorothy et al., (1993) have shown that pronghorn require less vegetative height than previously expected (heights < 17 cm), while Kinschy et al. (1982) indicated a preference for mean plant heights ranging from 37.5 to 60 cm. The mean plant height within pronghorn use sites was 43.5 cm including trees, and 18.5 cm excluding trees. We found that areas with grass heights of < 10 cm, and densities < 10 plants/0.1 m^2 were preferable. The lower height component in our study is thought to be related to the growth form of the grass species. Typical grasses include muhleys (*Muhlenbergia* spp), grammas (*Bouteloua* spp), squirrel tail (*Sitanion hystrix*), tobosa (*Hilaria mutica*), and curly mesquite (*Hilaria berlangerii*). These species typically display a "hummocked" growth form such that depressions of 1 to 4 cm occur in areas around the plants. This leads to an effective height of up to one third higher than a 10 cm plant itself. Pronghorn are able to utilize these depression areas when bedding in order to gain an increased margin of cover in areas of sub-optimal height. Use of these areas is greater than availability indicating a selection, which may be based on line of sight. It seems that in our study, the shrub component is important in concealing the animals, while the forb component selection is a factor of the diet, and grass selection is associated with sight lines of the pronghorn.

Pronghorn selected areas < 0.8 km from water that indicates water sites are important to developing pronghorn habitat. It should be noted that the pronghorn were generally found in pastures with water sources, which were unavailable to cattle. In those pastures with livestock, there was almost continual use of the water source by livestock that may have limited pronghorn use in these areas.

Several studies have reported pronghorn use of areas with approximately 50% herbaceous cover and 50% bare-rock/litter cover (Yoakum, 1980, Kindschy et al. 1982, Howard et al. 1990). The results of the Dunnet's mean separation test indicated a 54% and 44% split between herbaceous cover and bare-rock/litter cover, respectively. These numbers coincide with those found in previous studies, affirming the preferred ground cover requirements to be maintained within areas containing pronghorn habitat.

MANAGEMENT IMPLICATIONS

Neff (1986), in describing general pronghorn habitat characteristics in Arizona, stated that "the loss or non-use of suitable habitat is a matter of concern as a potential population limiting factor." The habitat use reported in our study (Table 5), can be interpretated as criteria in habitat suitability models to determine acceptable habitat for pronghorn within shortgrass/pinyon juniper community types. Our study serves to expand the definition of pronghorn habitat, and will aid in the alleviation of the concerns voiced by Neff (1986). By offering an updated habitat description, wildlife professionals both in the field and in the planning stage will be more effective in maintaining pronghorn populations. This information is beneficial for all phases of wildlife management, including relocation and population control projects.

Table 5. Summary of habitat selection and avoidance by pronghorn in a shortgrass/pinyon-juniper community in Central Arizona.

Selection	Avoidance
Abiotic Trait Selection:	
Macro-topography:	Macro-topography:
Rolling Hills	Hillsides
	Flats
Micro-topography:	Micro-topography:
Rolling Hills	Hillsides
Drainages	
Slopes < 5%	Slopes > 5%
North and Northeast aspects	South and Soutwest aspects
< .8 km from water sources	> 2.4 km from water sources
Biotic Trait Selection:	
Macro-habitat:	Macro-habitat:
none	Pinyon-Juniper
Micro-habitat:	Micro-habitat:
Grassland-Shrub	Shrubland
	Grassland
Shrub density < 1,000/Ha	Shrub density > 1,000/Ha
Shrub height < 25 cm	Shrub height > 50 cm
Grass density < 10 plants/0.1 m^2	Grass density > 10 plants/0.1 m^2
Grass height < 17.5 cm	Grass height > 25 cm
Forb height 5 - 17.5 cm	Forb density > 15 plants/0.1 m^2
	Forb height < 5, > 25 cm

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JUNIPER DENSITIES RELATIVE TO PRONGHORN USE IN CENTRAL ARIZONA

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Abstract: Juniper (*Juniperus* spp.) density data are important in planning pronghorn (*Antilocapra americana*) habitat improvement projects in the Southwest. To determine the relationship between pronghorn use of an area and juniper densities in Arizona, we captured, radio-collared, and located 47 (29♀, 18♂) pronghorn during 1989-92. Based on telemetry locations, we subjectively delineated four pronghorn use levels (high, moderate, low, and no-use) on aerial photographs and centered transect lines within these areas. We randomly located 1 ha belt plots perpendicular to transect lines and then counted the number of junipers per plot. Trees per ha differed ($P < 0.05$) by relative use level. Fewest number of trees ($\bar{x} = 4.66$/ha) occurred in high use areas, whereas the non-use area had the greatest number of trees ($\bar{x} = 154.57$/ha). In general, tree densities increased as pronghorn use decreased. Resource managers should design habitat improvements so that only large isolated or small clumps of trees remain to ensure greatest pronghorn use.

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Key words: *Antilocapra americana*, Arizona, habitat use, junipers, pronghorn, tree densities.

Characteristics of grasslands and grass-shrublands used by pronghorn have been well documented (Yoakum 1974, 1979, 1980, Autenrieth 1978, Kindschy et al. 1982, O'Gara and Yoakum 1992, Ockenfels et al. 1994), but specific characteristics of other habitats used by pronghorn still need to be defined. It has long been known that pronghorn use woodlands, particularly juniper woodlands adjacent to grasslands (Buechner 1950, Wallmo 1951, Britt 1980). These reports do not describe the woodlands' characteristics. Unfortunately, simply acknowledging woodland use by pronghorn does not provide managers with enough information to adequately plan habitat improvements.

Tree densities in woodlands range from savanna-like conditions to closed canopies. Information on pronghorn use relative to specific tree densities would assist managers in the creation and restoration of pronghorn habitat, especially in woodlands. Therefore, our objective was to estimate juniper densities in different habitat areas relative to the intensity of pronghorn use.

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STUDY AREA

The 1,367 km^2 study area (34°20'N, 112°7'W) extended from Black Canyon City north to Cienega Creek, and east-west from the Verde River to the town of Prescott Valley in Central Arizona (Fig. 1). Topography varied between flat to undulating areas, rolling hills, broken hills and mesas, and mountainous terrain. Elevation ranged from 630-2,300 m, with most areas between 950-1,700 m. Dominant mid-elevation habitats were short-grass prairie, semidesert grassland, chaparral, and juniper woodland, with limited Upper Sonoran Desert and montane coniferous forest at elevation extremes (Brown 1982).

Climate was mild with long term minimum-maximum daily temperatures averaging 0-13 C in January and 19-35 C in July (Sellers and Hill 1974). Precipitation occurred as summer thunderstorms from mid-July through September and as gentle winter storms in December-February (Sellers and Hill 1974). Snow cover seldom lasted more than two weeks.

Short-grass prairies were dominated by ring muhly (*Muhlenbergia torreyi*) and various grama (*Bouteloua* spp.) grasses. Catclaw (*Acacia greggii*), agave (*Agave* spp.), cholla/prickly pear (*Opuntia* spp.), and oak (*Quercus* spp.) were scattered throughout short-grass prairies, particularly along drainages. Semidesert grasslands were characterized by tobosa (*Hilaria mutica*) and grama grasses. Patches of catclaw, mesquite (*Prosopis juliflora*), and Wright's buckwheat (*Eriogonum wrightii*) were common. Broom snakeweed (*Gutierrezia sarothrae*), prickly pear, and numerous annual grasses characterized poorer sites.

Savanna-like (<10% canopy cover) and open (10-30% canopy cover) juniper woodlands occurred within and adjacent to short-grass prairies and semidesert grasslands. Scattered, large oak trees occurred along drainages in short-grass prairies. Closed (≥30% canopy cover) juniper woodlands were interspersed with dense scrub oak (*Q. turbinella*) and skunkbrush (*Rhus trilobata*) chaparral along northeastern boundaries and on northern exposures. Scattered pinyon pine (*Pinus edulis*) occurred in higher elevation juniper woodlands. Plant nomenclature follows Kearney and Peebles (1960).

METHODS

We captured pronghorn during 1989-91 with a net-gun fired from a helicopter (Firchow et al. 1986). Pronghorn were collared with radio-transmitters and eartagged. We located pronghorn 2-3 times per week using aerial and ground methods and recorded Universal Transverse Mercator (UTM) coordinates to the nearest 0.1 km for each location.

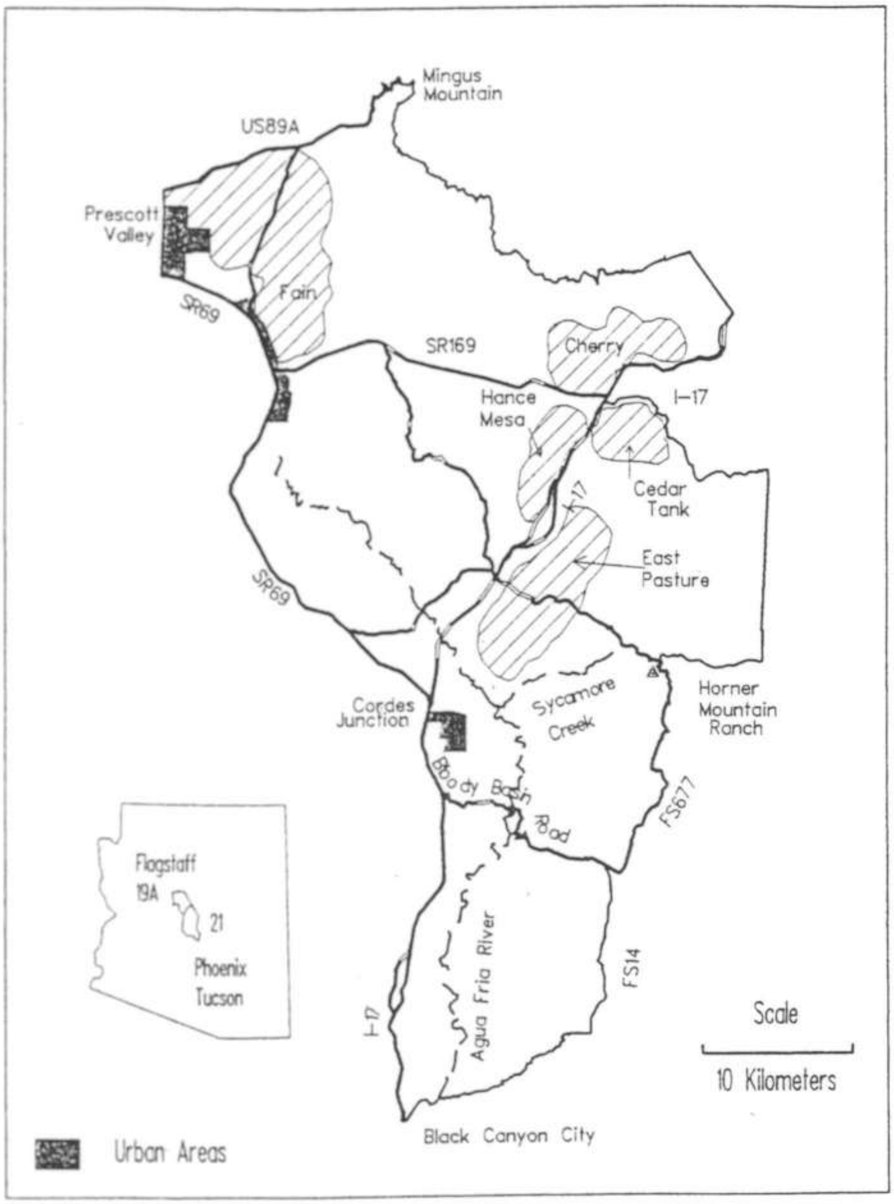

Figure 1. Location of study area and areas of pronghorn use sampled for juniper densities, Central Arizona, 1989-92.

We transferred pronghorn locations to a Geographic Information System (GIS) and plotted them on a base map. Areas of relative pronghorn use levels were then subjectively delineated. Use levels were: (1) high, (2) moderate, (3) low, and (4) no known pronghorn use. Use areas were based on habitat type, relative density of pronghorn locations, estimated percent annual use, and estimated pronghorn (collared and uncollared) using the area. We named areas (Fig. 1) according to local map features: Fain (high use/short-grass prairie), East Pasture (high use/semidesert grassland), Hance Mesa (moderate use/semidesert grassland and low use/open woodland), Cherry (moderate use/savanna and low use/open woodland), and Cedar Tank (no-use/closed woodland). We included a non-use area to evaluate the full spectrum of relative use areas.

We overlaid ≥1 north-south parallel transect lines through each area on 1989 aerial color photographs (1:12,000 scale; Fig. 2). One ha belt plot overlays were then placed perpendicular to transect lines a random distance apart (Table 1). We counted juniper trees within each belt plot overlay four times and averaged the counts to minimize observer error.

Table 1. Number of transects and random 1 ha belt plots for estimating juniper densities in five areas with different levels of pronghorn use, Central Arizona, 1989-92.

	Area				
Use level	Hance Mesa	Cherry	Fain	East Pasture	Cedar Tank
High			3(9)	3(9)	
Moderate	1(8)[a]	2(10)			
Low	1(8)	2(10)			
No-use					2(6)

[a] No. of transects (no. of plots).

We plotted trees per ha against a normal curve to examine normality. Our data did not fit a normal curve; therefore, we tested mean rank of trees per ha between use levels with Kruskal-Wallis ANOVA (Zar 1984:176). By using nonparametric analysis of variance (K-W ANOVA), we did not have to assume a given distribution nor equality of variances. We calculated mean (± SD) trees per ha by use levels for general comparisons and to assist in interpreting mean rank results. We did not test means because of marked non-normality. We set $\alpha = 0.05$.

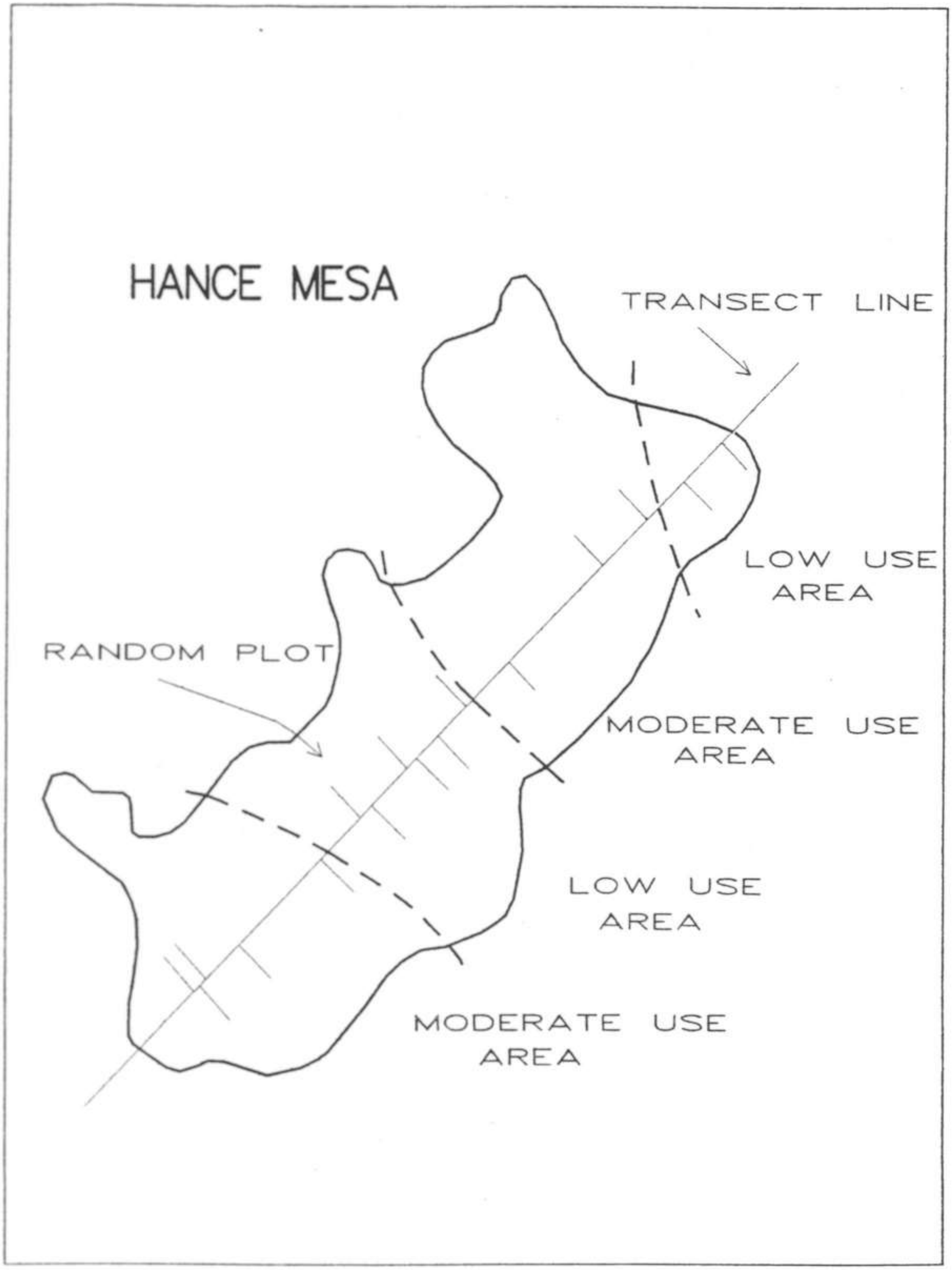

Figure 2. Example of random sampling scheme (transect with perpendicular random 1 ha plots) on aerial photographs to estimate juniper densities, Hance Mesa, Central Arizona, 1989-92.

RESULTS

Forty-seven pronghorn (29♀, 18♂) were collared in four capture operations from six areas during 1989-91. Initially, 21 (13♀, 8♂) pronghorn were captured in October 1989 (Ockenfels et al. 1994). Additional captures were necessary because of unanticipated high mortality rates (Ockenfels 1994). Pronghorn were located 4,996 times. Females were located 3,301 (66.1%) times compared to 1,695 (33.9%) for males.

Fewer belt plots were completed in the non-use area because our emphasis was on actual pronghorn use areas (Table 1). Also, tree densities were fairly uniform for the six non-use belt plots (Table 2).

Table 2. Mean trees[a] per ha estimated from aerial photographs in five pronghorn use areas, Central Arizona, 1989-92.

	Hance Mesa		Cherry		Fain		East Pasture		Cedar Tank	
Plot no.	No. of trees	Use[b]	No. of trees	Use	No. of trees	Use	No. of trees	Use	No. of trees	Use
1	79.0	M	55.8	L	0	H	0	H	171.5	N
2	81.5	M	52.3	L	0	H	4.0	H	79.0	N
3	49.3	L	42.0	L	0	H	34.3	H	93.8	N
4	105.0	L	63.8	L	0	H	2.0	H	177.3	N
5	70.3	L	64.8	L	9.3	H	11.3	H	200.8	N
6	36.3	L	13.3	M	6.0	H	5.0	H	205.0	N
7	61.8	L	16.8	M			0	H		
8	91.3	L	8.0	M			0	H		
9	61.8	M	23.3	M			5.0	H		
10	55.5	M	12.0	M			1.0	H		
11	35.8	M	10.0	M			4.0	H		
12	28.8	M	49.8	M			2.0	H		
13	47.3	L	58.8	M						
14	58.3	M	42.0	M						
15	65.0	L	8.3	M						
16	32.8	M	105.8	L						
17			124.5	L						
18			118.0	L						
19			52.0	L						
20			88.8	L						

[a] Average of four separate readings for each plot from aerial photographs.
[b] H = high use; M = moderate use; L = low use; N = non use.

Juniper tree densities differed ($\chi^2 = 46.287$, $P < 0.001$, $n = 60$) by relative pronghorn use level. Mean trees per ha were lowest in high use areas and highest in non-use areas (Table 3). Decreased pronghorn use occurred as tree densities increased.

Table 3. Mean juniper trees per ha estimated from aerial photographs for four relative pronghorn use levels, Central Arizona, 1989-1992.

Use level	No. of plots	Trees per ha	SD
High	18	4.7	8.1
Moderate	18	37.5	24.3
Low	18	74.7	25.7
No-use	6	154.6	54.6

DISCUSSION

As tree densities increase, visibility decreases and pronghorn are more vulnerable to predation. Thus, pronghorn typically select open, grassland habitats that provide excellent visibility and mobility (Autenrieth 1978, Hailey 1979, Yoakum 1979, 1980, Kindschy et al. 1982, Neff 1986, Ockenfels et al. 1994).

Pronghorn visibility is believed to be obstructed when shrubs, cacti, or trees are >0.61 m in height (Sundstrom et al. 1973, Kindschy et al. 1978, 1982, Yoakum 1980, O'Gara and Yoakum 1992). Ockenfels et al. (1994), however, found that pronghorn use actually starts to decline when mean vegetation height exceeds >0.33 m. High vegetation, beyond reducing visibility, also decreases pronghorn mobility (Goldsmith 1990). Visibility and mobility are undoubtedly related to pronghorn survival.

Pronghorn use of areas with junipers generally occurs during mid-summer and winter (Ockenfels et al. 1994). This is probably related to forage and thermal cover. Woody plants provide winter forage for pronghorn when forbs are not available (Yoakum 1990) and tall woody vegetation also provides thermal cover during low temperature periods. Additionally, pronghorn in Arizona commonly select for large, isolated trees during mid-summer, presumably for shade (Ockenfels et al. 1994).

Reduced use of woodlands occurs in areas where junipers are dense enough to easily obstruct visibility and mobility. Increased density decreases the spacing between trees, which increases the amount of roots in an area, thereby decreasing available water and nutrients to plants. Tree spacing also dictates the amount of solar radiation available for understory growth. These dense areas do not provide adequate forage and there is little reason for pronghorn to venture into them.

MANAGEMENT IMPLICATIONS

Reduction of juniper tree densities within or near pronghorn use areas would improve habitat for pronghorn. On average, reductions to $\leq$38 trees per ha would ensure at least moderate pronghorn use, whereas <5 trees per ha would increase chances for high pronghorn use. There are a variety of methods available to reduce tree densities.

Fuelwood cuts or mechanical removal, e.g., chaining followed by prescribed burning, are common ways to reduce juniper densities (Britton et al. 1987, Vallentine 1989). Rasmussen et al. (1986) recommended burning juniper woodlands every 10-20 years to support healthy wildlife communities. Chemical control of junipers is another option, but is generally not as cost effective as burning and often lacks plant selectivity that may result in killing desirable plant species (Vallentine 1989).

Vallentine (1989) recommended leaving a mosaic of treated and untreated areas when reducing woody plant densities. We agree, and for pronghorn, trees should be left along drainages, ridge tops, and steeper slopes. Single, large trees should be left in flat, open areas for thermal cover (Ockenfels et al. 1994). After treatments are completed, reseeding of native grasses and forbs may be beneficial and should increase pronghorn use. Grazing controls for livestock and wildlife may be necessary in treated areas to prevent overgrazing and lessen chances for reestablishment of junipers, other trees, and shrubs (Stoddart et al. 1975).

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PRONGHORN FAWN BED SITE SELECTION IN A SEMIDESERT GRASSLAND COMMUNITY OF CENTRAL ARIZONA

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Abstract: Pronghorn (*Antilocapra americana*) fawn survival is linked to the selection of bed sites that provide protection from predators and adverse environmental conditions. Additionally, the distance bed sites are to water may indirectly affect fawn survival. To better understand selection, we measured macro- ($\geq$40-m^2 plot) and micro-habitat ($\leq$40-m^2 plot) characteristics at neonate (<3 weeks old; n = 57) and postneonate (>3 weeks old; n = 54) pronghorn fawn bed sites in 1990 and 1991 in a semidesert grassland of Central Arizona and compared them to the same characteristics at 524 random plots. Selection of many bed site characteristics differed by fawn age probably due to differences in antipredator detection and avoidance strategies. Neonates selected bed sites that adequately camouflaged them from predators while not compromising their ability to visually detect predators. Postneonate bed sites mostly occurred in areas used by nursery herds, more closely resembling bedding areas used by adults rather than areas used by neonates. Postneonate bed sites contained lower woody vegetation heights, densities, and percent cover than the neonate bed sites. Neonates selected distances of 400-800 m from water, whereas postneonates showed no significant selection.

PROC. PRONGHORN ANTELOPE WORKSHOP 16:86-103

Key words: Pronghorn, *Antilocapra americana*, cover, fawn age, habitat model, habitat selection, neonate, postneonate, survival, water.

Pronghorn fawn bed site selection is an important factor affecting fawn survival (Bodie 1978, Bromley 1978, Barrett 1981, O'Gara et al. 1986, VanSchmus 1990, Alldredge et al. 1991, Canon and Bryant 1992). Adequate cover seems to be a crucial component of fawn bed site selection (Autenrieth 1984). Cover protects fawns from predators (Beale 1973, Bromley 1978, Neff and Woolsey 1980, Autenrieth 1982) and from adverse environmental conditions that may cause hypothermia and illness (Hepworth 1965, Beale 1978, Bodie 1978, Bromley 1978, Barrett 1981, Autenrieth 1982). Adequate visual detection of predators at bed sites may also be crucial to fawn survival (Bromley 1978). In fact, Smith and Beale (1980) found that fawns did not select sites offering the greatest opportunity for concealment, instead fawns would select for more open areas on high ground rather than bed in nearby tall cover.

Aside from the value of cover, the distance fawn bed sites are from water can secondarily affect fawn survivability by acting as a limiting factor to lactating does (Beale 1974). Furthermore, fawn bed site characteristics may differ with age of the fawn (Tucker and Garner 1983, Barrett 1984). Thus, it is imperative to understand fawn bed site selection to manage pronghorn populations.

The pronghorn population in Arizona has grown from approximately 700 animals in 1924 to more than 10,000 in the mid-1980's (Nelson 1925, Lee 1992). Although the increase was substantial, chronic low fawn survival in many areas of the state is still considered a significant pronghorn management problem (Neff 1986). We suspected that continuing low fawn survival may be related to the availability of quality bed sites.

We found that quantitative data regarding pronghorn fawn bed site characteristics for semidesert grassland communities were lacking. Our study was conducted to provide such information to better understand fawn bed site requirements and ways to improve fawn survival on semidesert grasslands in Arizona. Specifically, our objectives were:

1. To describe bed site habitat characteristics of pronghorn fawns,
2. To evaluate differences in bed site habitat characteristics between neonatal and postneonatal pronghorn fawns, and
3. To determine bed site selection by comparing selected bed site characteristics with habitat availability .

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STUDY AREA

The study area was located in Central Arizona and encompassed 1,229 km^2 of mesa tops and rolling hills dissected by steep canyons. The study area boundaries extended from the Black Hills mountain range, which separated the northern perimeter of the area from the Verde Valley, south to just north of Black Canyon City. Elevation ranged from 945 m in the south to 1,585 m in the north.

Annual precipitation was 25-45 cm, with >50% falling from April through

September (Brown 1982). The climate was mild to hot with average monthly temperatures ranging from 10 C in the winter to just above 38 C in the summer (Sellers and Hill 1974).

Soils in the semidesert grasslands of Central Arizona primarily consist of Springerville-Cabezen (Mollisol Order) and Barkerville-Moano (Mollisol and Entisol Orders) soil associations (U.S. Dept. Agric. 1972).

Vegetation was characteristic of a semidesert grassland community (Brown 1982). Tobosa (*Hilaria mutica*) and grama (*Bouteloua* spp.) were the dominant grasses. In areas of disturbance, much of the bunchgrasses have been replaced with curly mesquite (*Hilaria belangeri*), red brome (*Bromus rubens*), cheatgrass (*Bromus tectorum*), wild oat (*Avena fatua*), broom snake-weed (*Gutierrezia sarothrae*), and prickly pear cacti (*Opuntia* spp.). Perennials such as red three-awn (*Aristida longiseta*) had also replaced many tobosa stands. Grass stands were interspersed with shrub-form mesquite (*Prosopis juliflora*), catclaw acacia (*Acacia greggii*), shrub-live oak (*Quercus turbinella*), skunk-brush (*Rhus trilobata*), Wright's buckwheat (*Eriogonum wrightii*), and range ratany (*Krameria parviflora*). Predominant forb species included western ragweed (*Ambrosia psilostachya*), plantago (*Plantago patagonica*), filaree (*Erodium cicutorium*), lupine (*Lupinus kingii*), bluedick (*Dichelostemma pulchellum*), wild onion (*Allium* spp.), and globemallow (*Sphaeralcea coulteri*). Junipers (*Juniperus* spp.) were the predominant overstory within the chaparral boundaries of the study area, but also occurred within isolated pockets and adjacent to canyons.

METHODS

We determined potential pronghorn fawning areas by monitoring movements and activities of isolated pregnant does from March through June of 1990 and 1991. We observed does for "head-dipping" behavior indicative of does with fawns (Autenrieth and Fichter 1975). Does with fawns were monitored up to four hours, or until a fawn was located. Does with fawns could be monitored with optics up to 1.2 km away, if a second person was present. If only one person was present, does with fawns were monitored from a closer distance of <1 km, depending on topography and vegetation.

Once located, fawns were watched for the "head low" behavior characteristic of fawns seeking a bed site (Autenrieth and Fichter 1975). Once the fawn bedded, we used 10x50 binoculars and a 16-36X spotting scope to fix on the exact bed site. Hand signals or hand-held radios were then used to guide a person to the site. If a second person was not available, the observer located the bed site by fixing on a characteristic clump of vegetation or rock. Bed site data were gathered immediately only if the fawn abandoned the site.

If the fawn was <4 days old, they usually maintained an "immobility response" (Autenrieth and Fichter 1975), and we would mark the site and return within five days to collect data. Fawns ages were estimated by body size, behavior, pelage, and umbilical chord characteristics as described by Autenrieth and Fichter (1975). Fawns <3 weeks old were defined as neonates, and fawns >3 weeks old were termed postneonates.

We recorded the locations of each bed site using Universal Transverse Mercator (UTM; ± 0.1 km) coordinates taken from U.S. Geological Survey (USGS) 7.5' topographic maps. At each bed site location, we measured macrosite (≥40-m^2 plot) characteristics, including percent slope with a clinometer, aspect with a compass, and assigned macro- and micro-habitat types to the site (Table 1). Macrosite topographic features were termed "major" and microsite features termed "minor."

Table 1. Variable names and descriptions recorded for the pronghorn fawn bed site selection study in a semidesert grassland of Central Arizona, 1990-91.

Variable	Description	
Topography	1.	Flats (0-4° slope)
	2.	Hillsides (>4° slope)
	3.	Drainage: those areas of topography where naturally occurring permanent and seasonal water runoff accumulates for drainage purposes.
	4.	Rolling Hills (4-10° slope)
	5.	Other: (a) Hilltop (b) Swale (c) Canyon bottom
Habitat Type	1.	Grassland (>95% grass)
	2.	Grassland-shrub (5-30% shrubs)
	3.	Shrubland (>30% shrubs)
	4.	Savannah (5-10% trees)
	5.	Open Woodland (10-30% trees)
	6.	Other

Water sources were identified on USGS maps, field verified, and their UTM coordinates entered into a database overlay. We used Geographic Information System

(GIS) technology to estimate the distance between each bed site location and the nearest documented water source.

We centered a 40-m^2 circular plot around each bed site to estimate microsite vegetation characteristics of grasses, forbs, shrubs, cacti, and trees. We minimized observer bias by limiting the number of people gathering data to three, all of whom were trained until individual estimates were consistently within 5% of each other. Species richness was estimated by counting the number of species in each vegetation category. We ocularly estimated visual obstruction height of each vegetation category. Using a U.S. Soil Conservation Service visual guide as a means of reducing observer bias (U.S. Dept. Agric., unpubl. rep. M7-I-2291), we ocularly estimated percent ground or canopy cover for all vegetation categories and percent bare ground/rock.

We estimated availability of habitat characteristics from 524 randomly-selected points (Marcum and Loftsgaarden 1980). The habitat characteristics collected at these random locations (Arizona Game and Fish Department, unpubl. data) were the same as those collected at fawn bed sites.

Statistical significance for all analyses was set at $\alpha = 0.05$. We initially tested for heterogeneity of all variables with Chi-square contingency tables (Zar 1984). We tested for differences in bed site distance to water relative to age (neonate, postneonate) of the fawn using a Chi-square contingency table (Zar 1984). We tested the remaining bed site characteristics with a log-likelihood *G*-test in a contingency table (Zar 1984). If differences by age were significant, we then tested each age against availability using the log-likelihood *G*-test in a contingency table; if not, we lumped all age data and tested altogether as fawns.

If contingency tables indicated significant differences from availability, Bonferroni simultaneous confidence intervals were calculated to determine which level of characteristics fawns showed selection for or avoidance of (Neu et al. 1974, Byers et al. 1984). If avoidance or selection was detected for a cell, Jacobs' *P*, a selectivity index, was then calculated to indicate the direction and magnitude of avoidance or selection (-1.00 to 1.00; Jacobs 1974).

Because herbaceous (grass and forbs) species composition, visual obstruction height, and percent cover typically change seasonally with weather patterns and grazing regimes, and because these data were not collected at the random locations during the same season as the bed site observations, selectivity analysis of herbaceous densities and heights were not performed.

RESULTS

Topography

We located and measured 111 (57 neonate, and 54 postneonate) pronghorn fawn bed sites in the 1990 and 1991 field seasons. Fawn selection of major topography for bed sites differed from availability ($G = 139.21$, 3 df, $P < 0.001$), but did not differ by fawn age ($G = 1.29$, 1 df, $P = 0.256$, Table 2). Fawns selected low rolling hills and avoided all other topographic types. Conversely, fawn bed site selection of minor topography for bed sites did differ by fawn age ($G = 16.51$, 2 df, $P < 0.001$, Table 2). Both neonate and postneonate fawns selected flats. Neonates used hillsides as available, while postneonates strongly avoided them. Neonates strongly avoided drainages, while postneonates used them as available.

Table 2. Number of pronghorn fawn bed sites and random plots by abiotic habitat characteristics in a semidesert grassland of Central Arizona, 1990-91.

Variable	Class	No. of bed sites	% of bed sites	Bonferroni 90% Ci[a]	No. of bed sites expected	% of bed sites expected	Jacobs' D^b
Major Topography							
	Neonate and Postneonate[c]:						
	Flats	1	0.9	00.0-03.1	17	15.6	-0.91
	Hillsides	8	7.2	01.1-13.3	18	16.4	-0.43
	Rolling Hills	102	91.9	85.4-98.4	42	37.6	0.90
	Other	0	0.0	00.0-00.0	34	30.3	-1.00
Minor Topography							
	Neonate[d]:						
	Flats	32	56.1	39.7-72.5	39	34.7	0.41
	Hillsides	20	35.1	19.3-50.9	49	44.5	
	Drainage	0	0.0	00.0-00.0	11	9.9	-1.00
	Other	5	8.8	00.6-18.2	12	10.9	
	Postneonate:						
	Flats	42	77.8	63.7-91.9	39	34.7	0.74
	Hillsides	3	5.6	02.2-13.4	49	44.5	-0.86
	Drainage	2	3.7	02.7-10.1	11	9.9	
	Other	7	13.0	01.6-24.4	12	10.9	
Slope (°)							
	Neonate and Postneonate[c]:						
	<5	87	78.4	69.1-87.7	44	39.5	0.70
	5-10	19	17.1	08.6-25.6	35	31.7	-0.38
	>10	5	4.5	00.2-09.2	32	28.8	-0.79
Distance to Water (m)							
	Neonates[d]:						
	<400	9	15.8	03.3-28.3	7	11.7	
	400-800	24	42.1	25.2-59.0	15	26.6	
	800-1200	21	36.8	20.3-53.3	18	30.9	
	1200-1600	2	3.5	02.8-09.8	11	20.2	-0.75
	1600-3200	1	1.8	02.7-06.3	6	10.6	-0.73

[a] Bonferroni simultaneous confidence intervals calculated according to Neu et al. (1974) andByers et al. (1984).
[b] Jacobs' *D* calculated according to Jacob (1974).
[c] Did not differ by age (G, $P > 0.05$).
[d] Differed by age (G, $P < 0.05$).

Fawn selection of slope for bed sites did not differ ($G = 5.56$, 2 df, $P = 0.062$) by fawn age, but did differ ($G = 83.92$, 2 df, $P < 0.001$) from availability (Table 2). Fawns selected slope classes of <5 %, and avoided all other slope classes. Fawn bed site selection according to aspect was not analyzed because all but five bed sites occurred on slopes of <10%. Aspect of a slopes of <10% may not be a significant variable that could be easily measured or estimated by pronghorn.

Water

Fawn bed site selection in relation to distance to water differed with fawn age ($\chi^2 = 41.48$, 4 df, $P < 0.001$, Table 2). Neonates selection of distance to water classes differed from availability ($\chi^2 = 18.68$, 4 df, $0.005 > P < 0.001$). Neonates selected areas 400-800 m from water, avoiding areas >1,200 m from water, and used all other areas as available. Postneonates showed no active avoidance or selection for any distance class ($\chi^2 = 9.43$, 4 df, $P > 0.050$).

Habitat Types

Fawn selection of macro-habitat type for bed sites differed with fawn age ($G = 11.05$, 3 df, $P = 0.011$, Table 3). Neonates selected grassland-shrub macro-habitats, used grasslands and savannahs in proportion to availability, and avoided all others. Whereas, postneonates selected savannah macro-habitats, used grassland and grassland-shrub habitats as available, and avoided all other habitat types. Micro-habitat selection for bed sites did not differ with fawn age ($G = 0.16$, 1 df, $P = 0.687$, Table 3). Both neonates and postneonates selected grassland and grassland-shrub micro-habitats, and they avoided all other habitats.

Species Richness

Species richness of grasses at bed sites differed with fawn age ($G = 25.97$, 2 df, $P < 0.001$). The majority (82%) of neonate bed sites occurred where there were ≤ 3 grass species, whereas 94% of postneonate bed sites occurred where there were ≥ 3 grass species (Table 4).

Species richness of forbs at bed sites did not differ with fawn age ($G = 1.54$, 2 df, $P = 0.462$). The majority of neonate (89%) and postneonate (81%) bed sites occurred in areas of ≥ 3 forb species (Table 4).

Table 3. Number of pronghorn fawn bed sites and random plots by habitat type in a semidesert grassland of Central Arizona, 1990-91.

Variable	Class	No. of bed sites	% of bed sites	Bonferroni 90% Ci[a]	No. of bed sites expected	% of bed sites expected	Jacobs' *D*[b]
Macro-habitat							
	Neonate[c]:						
	Grassland	14	24.6	09.5-39.7	9	15.1	____
	Grassland-shrub	36	63.2	46.3-80.1	17	29.2	0.61
	Shrubland	0	0.0	00.0-00.0	4	7.1	-1.00
	Savannah	6	10.5	00.2-21.2	9	16.0	____
	Open Woodland	1	1.8	02.9-06.5	13	23.5	-0.89
	Other	0	0.0	00.0-00.0	5	9.2	-1.00
	Postneonate:						
	Grassland	13	24.1	08.7-39.5	8	15.1	____
	Grassland-shrub	21	38.9	21.4-56.4	16	29.2	____
	Shrubland	0	0.0	00.0-00.0	4	7.1	-1.00
	Savannah	19	35.2	18.0-52.4	9	16.0	0.48
	Open Woodland	1	1.9	03.0-06.8	12	23.5	-0.88
	Other	0	0.0	00.0-00.0	5	9.2	-1.00
Micro-habitat							
	Neonate and Postneonate[d]:						
	Grassland	37	33.3	21.8-44.8	22	20.2	0.33
	Grassland-shrub	74	66.7	55.2-78.2	55	49.0	0.35
	Shrubland	0	0.0	00.0-00.0	15	13.5	-1.00
	Open Woodland	0	0.0	00.0-00.0	8	7.3	-1.00
	Other	0	0.0	00.0-00.0	11	9.9	-1.00

[a] Bonferroni simultaneous confidence intervals calculated according to Neu et al. (1974) andByers et al. (1984).
[b] Jacobs' *D* calculated according to Jacob (1974).
[c] Differed by age (G, $P < 0.05$).
[d] Did not differ by age (G, $P > 0.05$).

Table 4. Herbaceous vegetation characteristics of pronghorn fawn bed sites (40-m² plots) in a semidesert grassland of Central Arizona, 1990-91.

Variable	Neonates			Postneonates			Overall		
	$\bar{x}$	SD	*n*	$\bar{x}$	SD	*n*	$\bar{x}$	SD	*n*
Species Richness (no. plant spp.)									
Grass	2.6	1.0	57	3.4	1.0	54	3.0	1.1	111
Forbs	4.7	2.4	57	4.3	1.9	54	4.5	2.1	111
Density (no. plants)									
Grass	458.9	315.3	31	704.4	515.5	24	566.0	428.4	55
Forbs	704.3	450.9	31	462.9	262.5	24	599.0	396.1	55
Height (cm)									
Grass	29.0	10.9	57	29.6	13.2	54	29.3	12.0	111
Forbs	13.3	9.6	54	11.6	7.7	54	12.4	8.7	108
Cover (%)									
Grass	11.3	11.7	57	14.3	11.4	54	12.8	11.6	111
Forbs	11.0	9.7	57	6.3	7.0	54	8.7	8.8	111

Species richness of shrubs at bed sites did not differ with fawn age (G = 1.98, 3 df, P = 0.577, Table 5). Both fawn age groups selected areas with ≤1 shrub species in a 40-m² area, used areas with 2 shrub species per plot as available, and avoided areas with >2 species in a 40-m² area.

Species richness of cacti at bed sites did not differ with fawn age (G = 0.07, 1 df, P = 0.797, Table 5). Fawns selected areas with no cacti species present, used areas with 1 cacti species/40-m² as available, and avoided areas with ≥2 cacti/40-m².

Species richness of trees at bed sites did not differ with fawn age (G = 3.41, 1 df, P = 0.065) or by availability (G = 3.69, 1 df, P = 0.055).

Table 5. Woody plant species richness at pronghorn fawn bed sites (40-m² plots) and random 40-m² plots in a semidesert grassland of Central Arizona, 1990-91.

Plant category	No. of species bed sites	No. of bed sites	% of bed sites	Bonferroni 90% Ci[a]	No. of bed sites expected	% of bed sites expected	Jacobs' D[b]
Shrubs	Neonate and Postneonate[c]:						
	0	44	39.6	28.0-51.2	11	9.4	0.73
	1	28	25.2	14.9-35.5	15	13.5	0.37
	2	27	24.3	14.1-34.5	31	28.2	—
	>2	12	10.8	03.4-18.2	54	48.9	-0.78
Cacti	Neonate and Postneonate[c]:						
	0	61	55.0	43.2-66.8	37	33.0	0.43
	1	46	41.4	29.7-53.1	44	39.9	—
	2	4	3.6	00.8-08.0	21	19.3	-0.73
	>2	0	0.0	00.0-00.0	9	7.8	-1.00

[a] Bonferroni simultaneous confidence intervals calculated according to Neu et al. (1974) andByers et al. (1984).
[b] Jacobs' D calculated according to Jacob (1974).
[c] Did not differ by age (G, P > 0.05).

Plant Density

Fawn bed site selection as influenced by grass density did not differ with fawn age (G = 7.70, 3 df, P = 0.053), that was likely the result of a limited sample size. Forty two percent of neonate bed sites were found in areas with 250-500 plants/40-m², whereas only 12.5% of postneonate bed sites were found in similar grass densities (Table 4).

Fawn bed site selection for forb density also did not differ with fawn age (G = 0.05, 2 df, P = 0.974). The majority (67.7%) of neonate bed sites occurred in areas of ≥500 plants/40-m², whereas the majority (91.7%) of postneonate bed sites occurred in areas of ≤500 plants/40-m² (Table 4).

Fawn bed site selection of shrub density differed with fawn age (G = 15.43, 3 df,

$P = 0.0001$, Table 6). Both neonates and postneonates selected for areas with no shrubs, and avoided areas with shrub densities of >10 shrubs/40-m². However, neonates used shrub densities of 1-10 plants/40-m² as available, whereas postneonates only used 6-10 plants/40-m² as available.

There were no differences in selection of cacti densities between fawn age classes ($G = 4.16$, 2 df, $P = 0.125$, Table 6). Similarly, there was no difference in tree densities by age class ($G = 3.41$, 1 df, $P = 0.065$, Table 6). Fawns selected areas with no cacti or trees, used areas with 1-2 cacti or trees/40-m² as available, and avoided areas with greater densities.

Table 6. Woody vegetation density (per 40 m²) at pronghorn fawn bed sites and random plots in a semidesert grassland of Central Arizona, 1990-91.

Plant category	Density class	No. of bed sites	% of bed sites	Bonferroni 90% CI[a]	No. of bed sites expected	% of bed sites expected	Jacobs' *D*[b]
Shrubs	Neonate[c]:						
	0	20	35.1	19.3-50.9	5	9.4	0.68
	1-5	9	15.8	03.7-27.9	6	10.7	—
	6-10	12	21.1	07.6-34.6	6	9.5	—
	>10	16	28.1	13.2-43.0	40	70.4	-0.72
	Postneonate:						
	0	24	44.4	27.5-61.3	5	9.4	0.77
	1-5	2	3.7	02.7-10.1	6	10.7	-0.51
	6-10	2	3.7	02.7-10.1	5	9.5	—
	>10	26	48.1	31.1-65.1	38	70.4	-0.44
Cacti	Neonate and Postneonate[d]:						
	0	61	55.0	43.7-66.3	36	32.8	0.43
	1-3	38	34.2	23.4-45.0	45	40.1	—
	>3	12	10.8	03.8-17.8	30	27.1	-0.51
Trees	Neonate and Postneonate[d]:						
	0	90	81.1	72.2-90.0	80	72.5	—
	1-2	21	18.9	10.0-27.8	26	23.3	—
	>2	0	0.0	00.0-00.0	5	4.2	-1.00

[a] Bonferroni simultaneous confidence intervals calculated according to Neu et al. (1974) andByers et al. (1984).
[b] Jacobs' *D* calculated according to Jacob (1974).
[c] Differed by age (G, $P < 0.05$).
[d] Did not differ by age (G, $P > 0.05$).

Plant Obstruction Height

Selection of mean grass height did not differ with fawn age ($G = 1.46$, 2 df, $P = 0.482$). Mean grass height at bed sites was 29.31 cm ($SD = 12.04$, $n = 111$, Table 4). Fawn selection of mean forb height did not differ with fawn age ($G = 0.74$, 2 df, $P = 0.691$). Fawns used a mean forb height of 12.44 cm ($SD = 8.67$, $n = 111$, Table 4).

Unlike mean grass or forb height, selection of mean shrub height differed with fawn age (G = 33.25, 3 df, P = 0.001) and with availability (G = 88.90, 3 df, P = 0.001, Table 7) when shrubs were present. Average shrub height of areas used by neonates were taller ($\bar{x}$ = 44.69 cm, SD = 28.98, n = 37) than areas used by postneonates ($\bar{x}$ = 23.49 cm, SD = 8.45, n = 30). Both fawn age groups selected areas with no shrubs. Neonates used areas with shrub heights of 1-30 cm as available, while avoiding shrub heights of >30 cm. Postneonates avoided most shrub heights, but used shrub heights of 31-60 cm as available.

Selection of mean cacti height differed with fawn age (G = 8.43, 2 df, P = 0.015, Table 7). Mean cacti height was taller in areas used by neonates ($\bar{x}$ = 55.08 cm, SD = 32.52, n = 25) than those used by postneonates ($\bar{x}$ = 29.52 cm, SD = 18.09, n = 25). Both neonates and postneonates selected bed site areas with no cacti, avoided areas with cacti heights of 1-30 cm, and used areas with cacti heights >30 cm as available.

Table 7. Woody vegetation height at pronghorn fawn bed sites (40-m² plots) and random plots in a semidesert grassland of Central Arizona, 1990-91.

Variable	Height (cm)	No. of bed sites	% of bed sites	Bonferroni 90%CI[a]	No. of bed sites expected	% of bed sites expected	Jacobs' D[b]
Shrubs	**Neonate[c]:**						
	0	20	35.0	20.8-49.2	5	09.4	0.68
	1-30	4	7.0	00.0-14.6	7	11.6	—
	31-60	4	7.0	00.0-14.6	22	38.0	-0.78
	>60	29	51.0	36.2-65.8	23	41.0	—
	Postneonate:						
	0	24	44.0	28.9-59.1	5	09.4	0.77
	1-30	1	2.0	00.0-06.3	6	11.6	-0.73
	31-6	15	28.0	14.3-41.7	21	38.0	—
	>60	14	26.0	12.6-39.4	22	41.0	-0.33
Cacti	**Neonate[c]:**						
	0	32	56.0	42.0-70.0	19	34.0	0.42
	1-30	0	0.0	00.0-00.0	12	21.2	-1.00
	>30	25	44.0	30.0-58.0	26	44.8	—
	Postneonate:						
	0	29	54.0	39.6-68.4	18	34.0	0.39
	1-30	3	5.0	00.0-11.3	11	21.2	-0.67
	>30	22	41.0	26.7-55.3	24	44.8	—

[a] Bonferroni simultaneous confidence intervals calculated according to Neu et al. (1974) and Byers et al. (1984).
[b] Jacobs' D calculated according to Jacob (1974).
[c] Differed by age (G, P<0.05).

We did not test selection of mean tree height by fawn age because of small sample size. When trees were present, mean tree height used by neonates was 173.81 cm (SD = 57.89, n = 7); postneonates used a mean tree height of 229.24 cm (SD = 148.69, n = 14).

Plant Cover

Selection of percent grass cover at bed sites did not differ with fawn age (*G* = 6.74, 3 df, *P* = 0.081). Mean percent grass cover at fawns bed sites was 12.77 (SD = 11.58, *n* = 111, Table 4).

Selection of percent forb cover at bed sites differed with fawn age (*G* = 9.78, 3 df, *P* = 0.021). Neonate bed sites consisted of a greater mean percent forb cover ($\bar{x}$ = 10.98, SD = 9.68, *n* = 57) than did postneonate bed sites ($\bar{x}$ = 6.28, SD = 6.99, *n* = 54, Table 4).

Selection of percent shrub cover at bed sites differed with fawn age (*G* = 7.73, 2 df, *P* = 0.021, Table 8). Neonates and postneonates selected <5% shrub cover and avoided areas with >10% cover. However, neonates used the 5-10% shrub cover class as available and postneonates avoided it.

Table 8. Woody vegetation cover at pronghorn fawn bed sites (40-m^2 plots) and random plots in a semidesert grassland of Central Arizona, 1990-91.

Variable	Cover (%)	No. of bed sites	% of bed sites	Bonferroni 90% Ci[a]	No. of bed sites expected	% of bed sites expected	Jacobs' D[b]
Shrubs	**Neonate[c]:**						
	<5	29	50.9	35.1-66.7	11	20.0	0.61
	5-10	19	33.3	18.4-48.2	15	26.0	___
	>10	9	15.8	04.3-27.4	31	54.0	-0.72
	Postneonate:						
	<5	31	57.4	41.3-73.5	11	20.0	0.69
	5-10	7	13.0	02.1-23.9	14	26.0	-0.40
	>10	16	29.6	14.8-44.5	29	54.0	-0.47
Cacti	**Neonate and Postneonate[d]:**						
	<2	78	70.3	59.9-80.7	53	47.9	0.44
	2-5	19	17.1	08.6-25.6	24	21.8	___
	>5	14	12.6	05.1-20.1	34	30.3	-0.50

[a] Bonferroni simultaneous confidence intervals calculated according to Neu et al. (1974) and Byers et al. (1984).
[b] Jacobs' *D* calculated according to Jacob (1974).
[c] Differed by age (*G*, $P < 0.05$).
[d] Did not differ by age (*G*, $P > 0.05$).

Selection of percent cacti cover did not differ with fawn age (*G* = 0.73, 2 df, *P* = 0.693, Table 8). Fawns selected areas with <2% cacti cover, they avoided >5% cacti cover, and used the 2-5% cacti cover class as available.

Selection of percent tree cover at bed sites did not differ with fawn age (*G* = 3.41, 1 df, *P* = 0.065) or with availability (*G* = 4.96, 2 df, *P* = 0.084). Mean percent tree cover at fawn bed sites was only 3.06% (SD = 11.08, *n* = 111).

Selection of bare/rock did not differ with fawn age (G = 0.08, 2 df, P = 0.961). Mean percent bare/rock cover of fawn bed sites was 62.90 (SD = 22.51, n = 111).

Selection of total vegetative cover (grass, forb, shrub, and cacti) did not differ with fawn age (G = 0.28, 1 df, P = 0.597). Mean percent total vegetative cover was 31.78 (SD = 20.21, n = 111).

DISCUSSION

We suggest that the differences in pronghorn fawn bed site selection by fawn age was the result of differing antipredator detection and avoidance strategies. Neonate fawns must rely on camouflage as well as the ability to visually detect predators, whereas the postneonate relies on the same strategies as adults that include visual detection and flight. While the adult pronghorn's greatest defense against predators is the ability to "see and flee," the fawns have not yet developed the physical agility and swiftness to do so until the postneonate stage, when they then join adults in nursery herds.

Until then, the neonate must rely on alternate antipredator defensive strategies, such as camouflage and timely visual detection of predators. Therefore, neonates must select bed sites that would provide adequate cover to camouflage, while not obstructing the visual watch for predators. The behavior response of bedded neonates approached by predators, i.e., coyote or field biologist, is to flatten heads to the ground and remain motionless. Such behavior further supports this antipredator strategy. Postneonate fawns, able to utilize their well-developed legs, typically chose to outrun and outmaneuver predators, therefore not requiring the same camouflage bed site cover characteristics as neonates.

Generally, areas with minimal topographic relief provided both age groups of bedded fawns with an unobstructed view, while minimizing the ability of predators to approach undetected because of cover. Neonate fawns avoided topographic areas with excessive topographic relief, such as drainages, that minimized the field-of-view and provided good travel corridors for predators. The use of steeper hillsides by bedded neonates reflects their need to have a higher vantage point from which to visually detect oncoming predators.

Our finding of neonate fawn selection for areas less than 800 m distance to water sources generally concurred with other studies (Barrett 1981, 1984; Ockenfels et. al. 1992). However, Barrett (1984) did not find a significant difference between fawn age and distance to water sources. Fawn bed site distances to water may be more a reflection of the lactating requirements of adult does, thus the need for nearby water sources, than true selection by the fawn. Because of the increased amounts of water needed to meet the physiological demands for lactation, coupled with the limited mobility of neonatal fawns, does with neonate fawns need to be relatively close to water. As fawns become more mobile, such as in the postneonate stage, does seem to be more willing to travel greater distances for water in order to protect their now visible fawns from predators that may frequent areas near water holes.

In general, fawns avoided areas containing substantial woody vegetation, i.e. shrubs, cacti, trees. However, when woody vegetation was present, neonates used areas with greater vegetation heights, densities, and percent cover than the postneonates. This greater association of neonates with woody vegetation height is consistent with the results of Tucker and Garner (1983) in a similar habitat in Texas; they found neonates using areas with taller vegetation than did postneonates. The average shrub height used by the neonate fawns in Texas was only 19 cm, considerably lower than the 45 cm mean used by the neonates of our study. Our shrub heights more closely approximate those found by Autenrieth (1984) in Idaho.

Similarly, Barrett (1984) found that neonates bedded closer to sagebrush than did postneonates. These data still does not explain a fawn's selection of areas without woody vegetation. Bed sites used by neonates seem to be a fine- line compromise between adequate cover for camouflage, but open enough for visual detection of predators. The areas used by both age groups contained similar grass heights, but since the woody vegetation in the areas neonates used was, on average, taller than the grass, we speculate that in Central Arizona neonate bed site selection of areas with a woody vegetation component is a compensation for insufficient tall grass. Unfortunately, we did not have random data to compare against our use sites that may have clarified this. However, since Barrett (1981) found that stands of grasses >25 cm tall (ours was 29 cm) constituted important bedding cover and contributed to fawn survival, such speculation may not be warranted. Investigations into the relationship between available grass and woody vegetation densities and percent cover of each may offer a better explanation.

The mean total canopy cover at fawn bed sites in Central Arizona was slightly less than the 40% Autenrieth (1984) suggested as a guideline of minimum mean canopy cover. Furthermore, our mean percent woody vegetation cover was slightly less than the overall shrub cover noted in areas with higher annual precipitation rates (Autenrieth 1982, Pyrah 1974, Alldredge et al. 1991), still, it was more than the 3.1% measured at fawn bed sites in a semidesert grassland of Trans Pecos, Texas (Canon and Bryant 1992).

The use of areas containing trees by postneonates is most likely related to thermal regulation. By the time pronghorn fawns in Central Arizona reach the postneonate stage, daytime ambient temperatures can be much warmer, with temperatures >38 C not uncommon. It is during these warmer months that adults commonly retreat to the shade of trees (Ockenfels et al. 1994). During the postneonate stage, fawns are more closely associated with the adults. It is reasonable to expect fawns to bed in the same type of habitat.

MANAGEMENT OPTIONS

Differences between neonate and postneonate pronghorn fawn bed sites are apparent. Since neonate bed sites are separate from adults, whereas postneonate bed sites are not, it is likely that management strategies must be targeted for neonate bed site availability to optimize fawn survival. However, fawns in the neonate stage are seldom seen by field personnel without hours of patient observation. Furthermore, fawning dates seem to differ by area, making it difficult to determine the exact timing of management. Therefore, research to determine fawning dates by area seems warranted.

The importance of the placement of accessible water for lactating does may greatly influence fawn bed site selection. Since travel of does with neonate fawns is restricted, it is likely that placement of accessible water sources, in combination with adequate early forb green-up, substantially influences where the does select fawning areas. Such an influence indirectly affects fawn bed site selection by restricting availability of preferential microhabitats. A GIS could be used to help place water sources within 800 m of areas containing quality pronghorn fawn bedding habitat.

Basically, the selected bed site habitat for neonate fawns in semidesert grasslands of Central Arizona occurred in: grassland and grassland-shrub areas containing small flats of <5% slope within gentle rolling hills; within 800 m of water; with >3 forb species, but lower species diversity of other vegetation; a mean grass height of 29.3 cm; and areas with <5% woody vegetation cover.

Postneonate fawns selected bed site habitat that occurred in: grassland and grassland-shrub areas within savannahs containing small flats of <5% slope within gentle rolling hills; with >3 forb and grass species, but lower species diversity of other vegetation; a mean grass height of 29.3 cm; and areas with <5% woody vegetation cover.

The greatest differences between neonate and postneonate bed sites were that neonate sites were closer to water sources, had greater forb diversity, and areas had taller, more dense, and greater percent cover of woody vegetation. Further research is needed to determine if increasing grass heights or shrub densities is a management tool to increase fawn survival.

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MORTALITY AND BEDDING SITE SELECTION OF PRONGHORN FAWNS IN TALLGRASS PRAIRIE

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Abstract: During 1991 and 1992, 12 and 34 pronghorn fawns (*Antilocapra americana*), respectively, were captured in tallgrass prairie of east central Kansas and monitored through August of each year. Ten fawns captured during 1991 and 31 fawns captured during 1992 were fitted with ear tag radio transmitters. Summer natural mortality rates were calculated from all fawns captured and found to be 58% and 90% in 1991 and 1992, respectively. Bedding sites were more prevalent on slopes during 1991 ($\chi^2 = 37.01$, $P < 0.001$) and 1992 ($\chi^2 = 215.47$, $P < 0.001$). A quadratic relationship was found when the age of sibling fawns and the distance between their individual bedding sites were compared. We suggest the increased mortality of 1992 compared to 1991 was a result of increased movements by fawns during 1992.

PROC. PRONGHORN ANTELOPE WORKSHOP 16:104-116

Key words: *Antilocapra americana*, fawn, mortality, bedding sites, tallgrass prairie, Kansas.

Prior to the advancement of European settlers across the continent in the late 1800's, pronghorn (*Antilocapra americana*) flourished in western North America, with an estimated total population of 30-40 million (Nelson 1925). The area inhabited by pronghorn included parts of the tallgrass prairie ecosystem in west central North America (Einarsen 1948, Yoakum 1978).

Since the drastic decline in pronghorn numbers, proper management techniques increased the total U. S. population to 406,400 by 1976 (Yoakum 1978) and today the total population is estimated to be greater than 500,000. The population regrowth occurred with the assistance of successful translocations of pronghorn into what once was native range, e.g., western Kansas (Sexson and Choate 1981). However, today pronghorn are not prolific in all areas of their native range. One of these areas includes

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the tallgrass prairie ecosystem, which is at the eastern edge of the former pronghorn range.

Aerial surveys conducted from 1986-1990 estimated the population within the tallgrass prairie of the Flint Hills of Kansas at 46 animals. More recently, in 1991 and 1992, the Kansas Department of Wildlife and Parks carried out additional translocations to enhance the existing population in the Flint Hills of Kansas.

Important factors to be assessed, following restoration, are the reproductive success of the translocated females and the establishment of a viable population (O'Gara and Yoakum unpublished data). In order to assess reproductive success one must have an understanding of summer fawn mortality (Vriend and Barrett 1978).

Pronghorn fawns are hiders, who increase their chance of survival by relying on their ability to seclude themselves from predators (Lent 1974, Kitchen 1974, Bromley 1977). Hider neonates act independently in their selection of bedding sites, but are dependent upon their parental females to initiate activity such as nursing bouts (Byers and Byers 1983, Alldredge et al. 1991).

Research has shown depredation as a leading cause of pronghorn fawn mortality (Beale and Smith 1973, Barrett 1978, Von Gunten 1978, Corneli 1980, McNay 1980, Neff and Woolsey 1980, Trainer et al. 1983, Autenrieth 1984, O'Gara and Malcolm 1988). Connolly (1978) has concluded that depredation could be a major source of mortality in ungulate fawns and subsequently limit the growth of ungulate populations.

Barrett (1981) studied fawn bedding sites in the mixed-grass prairie of southeastern Alberta. However, no researchers have studied the characteristics of fawn bedding sites in tallgrass prairie.

The purpose of our study was to ascertain fawn summer mortality rates. We also documented location of fawn bedding sites and compared the age of sibling fawns to the distance between their individual bedding sites.

Monetary support and equipment for our research was provided by the Wichita and Kansas City Chapters of Safari Club International, the Division of Biological Sciences at Emporia State University, The Faculty Research and Creativity Committee at Emporia State University, and the Kansas Department of Wildlife and Parks. We thank the landowners and tenants of the study area for allowing access to their property.

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STUDY AREA

The study area was located in southeastern Chase County and southwestern Lyon County. The study area (Fig. 1) consisted of 335 km^2 and was bounded by the Cottonwood River on the north, the South Fork of the Cottonwood River on the west and the Kansas Turnpike on the south and east sides (Horak 1985). The river channels were bordered by riparian habitat, which is typically avoided by pronghorn. The Kansas Turnpike was fenced with a net-woven wire fence flush with the ground to prohibit pronghorn movement on to the Kansas Turnpike.

The study site consisted of approximately 86% upland and sloping and 14% lowland. Cultivation occurred in less than 2% of the study area (Neill 1974). There were three fawning areas within our study site: the Rogler area in the southwest, the Cattle Pens area located in the south central, and the Phenis Creek area located along the Chase and Lyon counties line in the east (Fig. 1).

The climate of the study area was continental, characterized by long, hot summers and long, cold winters with relatively short springs and autumns. The mean annual maximum temperature was 20.2° C and the mean annual minimum temperature was 6.5° C. The average yearly rainfall was 80.4 cm, with 71% occurring between April and September (Neill 1974). The average snowfall per year was 42.5 cm.

The major vegetation of the study area included grasses such as Indian grass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), Scribner's panicum (*P. scribnerianum*), big bluestem (*Andropogon gerardii*), little bluestem (*A. scoparius*), Canada wild rye (*Elymus canadensis*), and June grass (*Koeleria cristata*). Some common forbs included goldenrods (*Solidago* spp.), purple prairie clover (*Dalea purpurea*), scurfy pea (*Psoralea tenuiflora*), pitcher sage (*Salvia pitcheri*), common ragweed (*Ambrosia artemisiifolia*), western ironweed (*Vernonia baldwinii*), and broomweed (*Gutierrezia dracunculoides*). Lead plant (*Amorpha canescens*) was the most replete shrub.

The study area was privately owned and human access was limited. Traditional four or five strand-barbed wire fence separated the area into large pastures. Annual burning during March and April occurred across the whole area and grazing of cattle occurred from mid-April through mid-October throughout the majority of the study area.

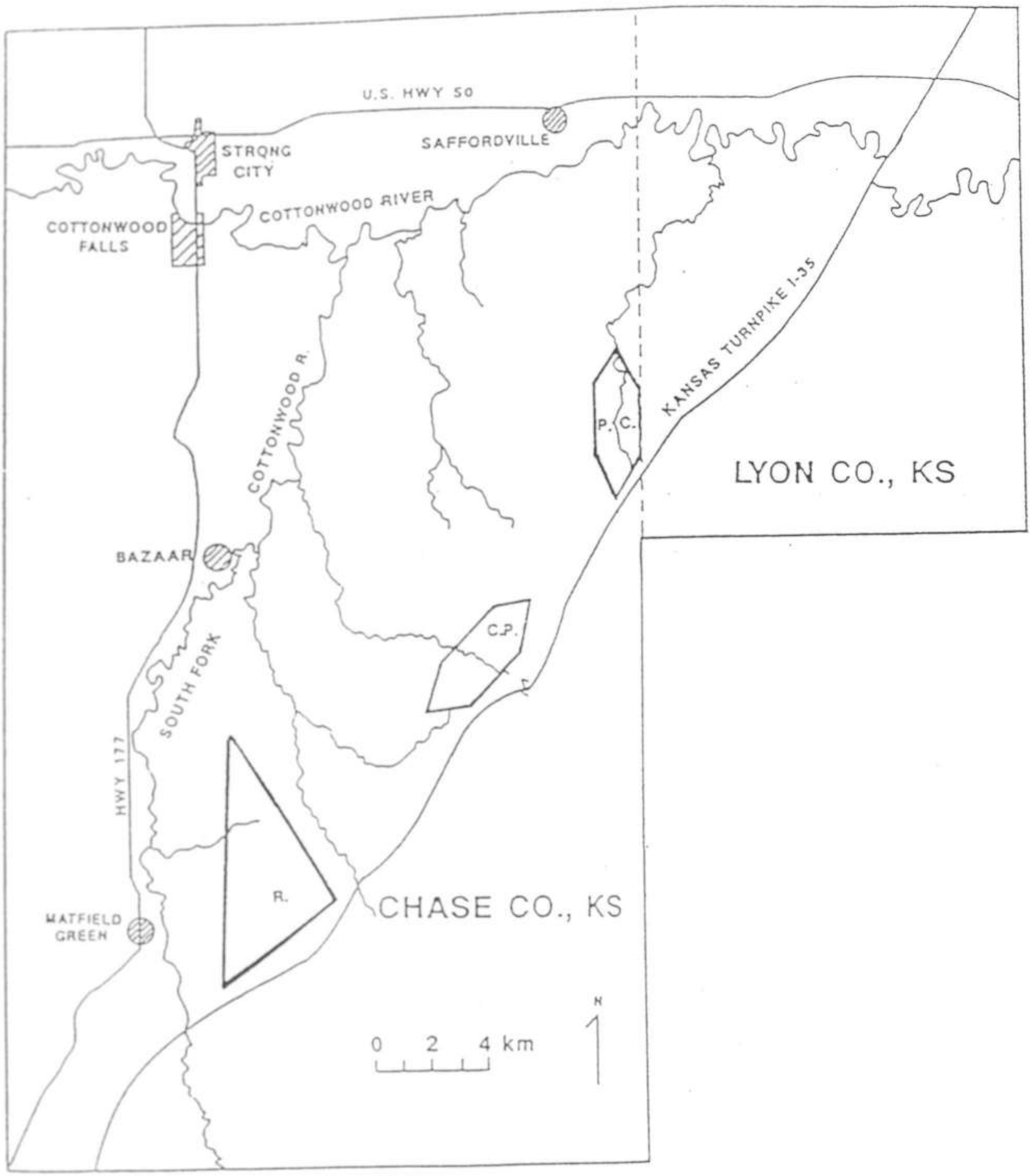

Fig. 1. Total pronghorn fawn study area shown with the 3 fawning areas (R = Rogler Area, C. P. = Cattle Pens Area, and P. C. = Phenis Creek Area) within Chase and Lyon counties, Kansas, (adapted from Simpson 1992).

MATERIALS AND METHODS

Fawn Capture

In January 1991, 19 adult and 11 yearling pronghorn females were translocated to the study area. Thirteen adults and 10 yearlings were fitted with radio collars. Nineteen of the females fitted with radio collars survived to the 1991 fawning season (Simpson 1992). During February 1992, 22 adult and two yearling females, all fitted with radio collars were translocated to the study area. Seventeen females released in 1992, along with 17 radio-collared females released in 1991 survived to the 1992 fawning season. It was from these animals, along with unmarked females that existed on the study area prior to the 1991 translocation, that fawns were captured for our study.

Pronghorn fawns, approximately 4 hr to 10 days of age, were captured on the Rogler and Cattle Pens areas in 1991, and on all three fawning areas in 1992. Using a net measuring 1.2 m X 1 m, with a 3.1 m handle, we captured fawns in their bedding sites with and placed them in a canvas bag. For each fawn captured, the age, sex, and capture location were recorded. Ages were determined by pelage and umbilical cord condition and behavior during capture according to Bromley's (1977) criteria.

Fawns were fitted with solar (seven panels with 0.5 volts/panel, 30 ma maximum full sunlight, pulse rate varied with light intensity, 151 MHz, Advanced Telemetry Systems, Ibanti, MN) or battery (190 ma lithium battery, 45 pulses per minute, 150-151 MHz, Wildlife Materials, Inc. Carbondale, IL) powered ear tag radio transmitters weighing 16 g and 10 g, respectively. Colored, numbered ear tags weighing 3 g were fitted in the opposite ear. The expected life was 720 and 60 days for the solar and battery powered transmitters, respectively. After fitting ear tags, fawns were placed back into the canvas bag, moved approximately 40 m from the processing site, and released.

Fawn Location

Using a Wildlife Materials (Carbondale, IL) 150-151 MHz receiver and H-element antenna, we recorded visual locations of fawns fitted with radio transmitters daily or every other day. Efforts were made not to flush fawns from bedding sites. Fawn locations were recorded through 31 August or until death. Data recorded for each visual observation of a living fawn included date, location, topographic site, and age of fawn. Locations were recorded to the nearest 1 ha on 7.5 minute United States Geological Survey (USGS) maps using Universal Transverse Mercator (UTM) coordinates. Topographic sites were recorded as uplands, slopes, and lowlands.

When a dead fawn was found, the appearance and location of remains were noted. The immediate area of the dead fawn was searched for predator signs. Percent mortality was calculated through 31 August during each year of the study.

Fawn Bedding Sites

When a bedded fawn was located, the bedding site was marked with an iron stake or marking tape at a distance of 15-25 m and a general description of the site was noted. When individual bedding sites of twin fawns were located in succession during the same day, the distance (m) between the two sites was recorded.

Chi-square goodness of fit analysis was used to test the null hypothesis that fawn bedding sites were evenly distributed among topographic sites. Regression analysis (SAS 1985) ascertained the relationship between fawn ages and the distance between sibling fawn bedding sites.

RESULTS

Fawn Capture

A total of 46 pronghorn fawns, 23 females and 23 males, were captured during our study (Table 1). All fawns captured appeared strong and healthy. During 1991 the fawning period was 28 May through 12 June with a mean fawning date of 6 June. In 1992 the fawning period was 17 May through 15 June with a mean fawning date of 3 June.

During 1991, five were fitted with solar powered transmitters, five with battery powered transmitters, and two fawns were fitted with ear tags only. In 1992, 28 fawns were fitted with solar powered transmitters, three with battery powered transmitters, and three fawns were fitted with ear tags only.

Fawn Mortality

Data on 43 of the 46 marked fawns were used for mortality analysis. Because we were interested in documenting natural mortality, three of the fawns captured in 1992 were excluded from the analysis because they were abandoned by the female shortly after capture. At capture the three abandoned fawns appeared normal and healthy, but we were unable to verify reacceptance of these fawns by their mothers after capture.

As of 31 August 1991, 7 of 12 marked fawns were dead, a 58% mortality rate. By 31 August 1992, 28 of 31 marked fawns were dead, a 90% natural mortality rate. This equals a 75% mortality rate for summers 1991 and 1992 combined. Three fawns captured in 1991 survived to 31 August 1992.

Table 1. Distribution of twin sets and fawns captured during 1991 and 1992 in Flint Hills of Kansas.

	1991		1992		Total	
	Fawns	Twin Sets	Fawns	Twin Sets	Fawns	Twin Sets
Phenis Creek	0	0	10	2	10	2
Cattle Pens	3	0	12	4	15	4
Rogler	9	4	12	4	21	8
Total	12	4	34	10	46	14

Data from the 28 radio marked fawns indicated that natural mortality occurred in greater percentages at an earlier age in 1991 compared to 1992. Eighty-three percent of the fawns that died in 1991, did so within approximately the first three weeks of life. However, only 52% of the natural mortality in 1992 occurred within approximately the first 3 weeks of life. Known or probable depredation accounted for 83% and 71% of the natural mortality that occurred in 1991 and 1992, respectively (Rothchild 1993).

Fawn Bedding Sites

During 1991 ($\chi^2 = 37.01$, $P < 0.001$) and 1992 ($\chi^2 = 215.47$, $P < 0.001$) the location of fawn bedding sites was not evenly distributed among the three topographic areas of lowlands, slopes, and uplands. Locations of fawn bedding sites indicated a prevalent occurrence of bedding sites on sloping areas (Table 2).

Thirty observations of twin fawn bedding sites occurred in succession during 1991 and 1992 combined. Regression analysis demonstrated a quadratic relationship between the age of sibling fawns and the distance between their individual bedding sites (Fig. 2).

Table 2. Observations (n) of radio-ear tagged pronghorn fawns during summers 1991 and 1992 by topographic site within the Flint Hills of Kansas.

Year	Upland	Lowland	Slope
1991	18	7	48[a]
1992	23	4	151

[a] Fawn bedding sites not evenly distributed during 1991 ($\chi^2 = 37.01$, $P < 0.001$) and 1992 ($\chi^2 = 215.47$, $P < 0.001$).

DISCUSSION

Fawn Mortality

Vriend and Barrett (1978) indicated high fetal rates of 1.70 - 1.90 fawns per mature female with high fawn mortality of 25 - 65%, up to 80%, during the summer following parturition throughout pronghorn ranges. This trend of moderate to high fawn loss after parturition was apparent in the population of pronghorn in the Flint Hills of Kansas. Results indicate that coyote depredation was the primary cause of fawn mortality during our study (Rothchild 1993).

The bedding sites selected by fawns during our study were not chosen at random and were usually located on sloping areas (Table 2) in grass proximate to a forb such as scurfy pea, western ironweed, goldenrod, and the shrub lead plant, which were greater in height than the surrounding vegetation (Rothchild 1993). This indicates fawns are attempting to locate the best suitable habitat for seclusion. Sloping areas may have provided an optimum combination of protection from adverse weather conditions such as wind and precipitation, while allowing visualization of the surrounding area. Fawns were occasionally observed bedded on or next to large rocks. Fawns have been reported to select bedding sites with similar characteristics to those we found in Chase County, Kansas. However, big sagebrush (*Artemisia tridentata*), which does not occur on our study site, is the shrub proximate to bedding sites in the majority of pronghorn range (Pyrah 1974, Autenrieth and Fichter 1975, Autenrieth 1976, McNay 1980, Barrett 1981).

During the first week of life sibling fawns are usually not together during nursing bouts or at bedding sites except for the first few hours of life. From the beginning of the second week through the fourth week of life sibling fawns are usually observed displaying increased interactions until they are together 100% of the time by the fourth week of life (Autenrieth and Fichter 1975). Barrett (1984) showed a negative linear correlation when he compared the distance between bedded siblings and their ages. The relationship of age and distance between bedded siblings in our study was quadratic. This is most likely due to limited sample size and because one set of sibling fawns was bedded together during every observation.

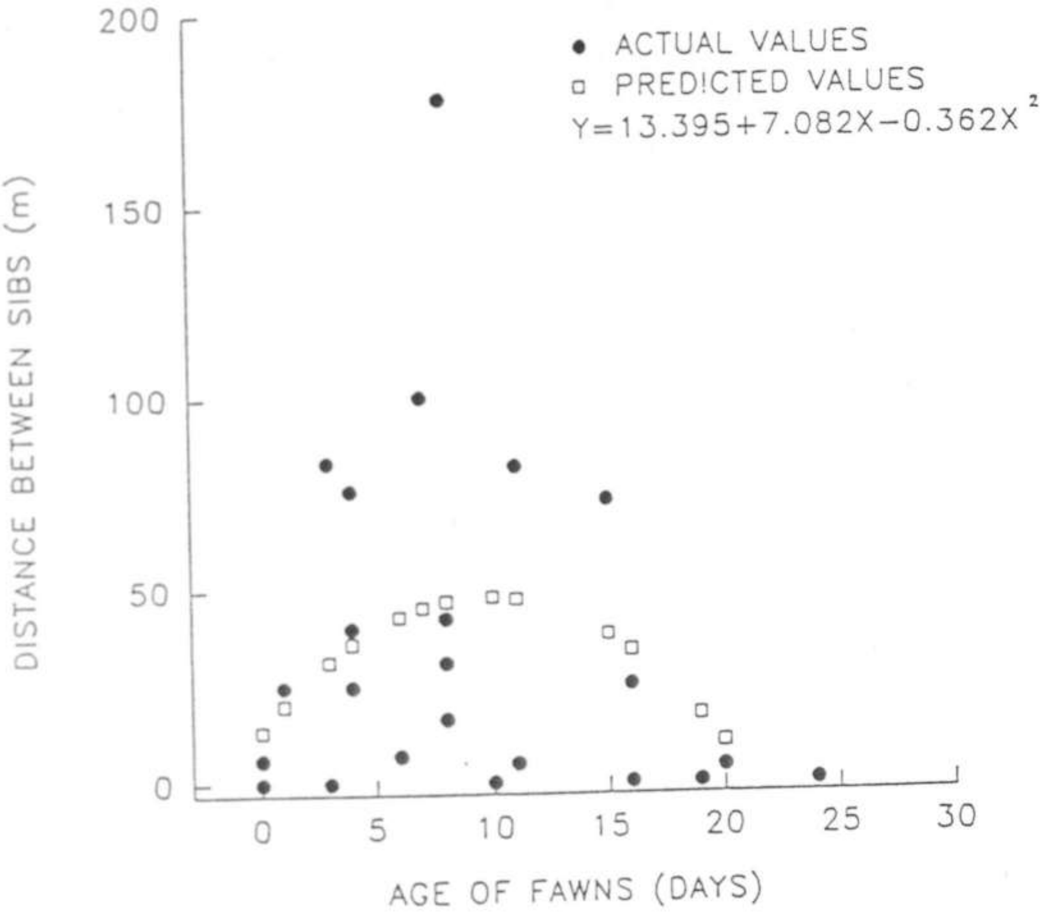

Fig. 2. The relationship of distance between bedded sibling pronghorn fawns radio ear tagged in Chase County, Kansas, during summers 1991 and 1992 expressed as a function of age.

The results of our study appear to indicate coyotes are a major cause of fawn mortality. During 1991 the fawn mortality rate was near an "acceptable" level (Vriend and Barrett 1978). During 1992 the mortality rate was above normal levels and most deaths were attributed to coyotes, however, fawns in 1992 had larger home ranges than 1991 and this may have made them more susceptible to depredation (Rothchild 1993). Therefore, factors affecting home range size may have more of an impact on fawn survival than just coyotes acting independent of other factors.

MANAGEMENT IMPLICATIONS

Franklin (1980) suggested a minimum of 50 breeding adults to maintain a viable population. The population within our study area was larger than this minimum requirement. O'Gara and Yoakum (unpubl. data) considered an increase of 20% to 30% in the numbers of restored animals within a 5 to 10 year period after the initial release to be necessary for the restoration effort to be successful. Therefore, it would be pre-mature to suggest that the restoration effort has been a success and pronghorn can maintain a viable population in the Flint Hills of Kansas based on the data we collected.

The findings of our study illustrate that pronghorn fawns within the tallgrass prairie ecosystem can survive at rates comparable to pronghorn in other ecosystems. The probable causes of relatively high mortality rates due to depredation that we found in Flint Hills of Kansas are similar to those of other pronghorn ranges. This indicates that a successful restoration can occur in Flint Hills of Kansas given the tremendous increase in pronghorn numbers since the 1920's (Yoakum 1986). However, factors such as habitat suitability and current rangeland practices in tallgrass prairie and their effect on carrying capacity need to be understood before proper management guidelines for pronghorn in tallgrass prairie can be written.

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PRONGHORN-WINTER WHEAT CONTROVERSY: HISTORICAL AND CURRENT PERSPECTIVES

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Abstract: Wildlife managers have responded to winter wheat damage complaints by reducing pronghorn (*Antilocapra americana*) numbers via hunting and trapping. Recent research has suggested pronghorn may not damage winter wheat, implying reducing pronghorn populations may not be necessary. I assess this statement by integrating plant physiology, plant-herbivore interactions, ungulate foraging theory, and pronghorn movement patterns. Lastly, I present the focus of my current research.

PROC. PRONGHORN ANTELOPE WORKSHOP 16:117-124

Key words: Colorado, game damage, plant-herbivore interactions, shortgrass prairie, winter wheat physiology.

In Colorado, >200,000 ha of native grasslands have been converted to winter wheat and approximately 75% of the pronghorn (*Antilocapra americana*) population resides in wheat growing areas (Torbit et al. 1993). In the early 1980's, farmer complaints concerning pronghorn damage of winter wheat were intense. The Colorado Division of Wildlife (CDOW) responded by reducing pronghorn numbers (50-55% in the Hugo area) through hunting and trapping (Torbit et al. 1993). Political backlash arose from those who believed too many pronghorn were removed.

Colorado's pronghorn population is again at political carrying capacity (K. Kinney, Colo. Div. Wildl., pers. comm.), implying any CDOW management objective that would increase pronghorn numbers would also increase political and restitution costs. Reducing pronghorn numbers again is an alternative, but if pronghorn do not reduce wheat yields that alternative may unnecessarily reduce recreational opportunity.

BACKGROUND INFORMATION

Winter Wheat Physiology

About 95% of Colorado's wheat is winter wheat, which is planted from late August through mid-October (Jenkins 1983:213-4, Hay and Walker 1989:159-163). Tillering (multiple shoot production) begins in November. Tillering duration is largely temperature dependent and is interrupted by a winter dormancy period. Tillering is important because (1) main shoots exceed ear-bearing tillers in yield, (2), 75% of the tillers do not produce ears, (3) not all tillers survive past the jointing stage, and (4) tillers inhibit reproductive shoot growth (Bremner 1969, Darwinkel 1980). These four points suggest winter wheat produces biomass exceeding that which is optimal for maximum grain production.

In February, after vernalization (induction of flowering by cold treatment), spikelet and floret development begins. At this time, the growing point in the crown stops vegetative production and starts making reproductive parts. Nutrients begin shifting from the stems and leaves to the developing grain heads (Spiertz 1977). This nutrient shift is important because it affects winter wheat forage quality (Torbit et al. 1993). Terminal spikelet formation and stem elongation, occur simultaneously. During the jointing phenological stage, the growing point, via stem elongation, moves from below-ground to above the soil surface. Anthesis (flowering) occurs in early May, and harvest follows in late June.

Winter Wheat Response To Grazing

Wheat yields should be unaffected by grazing during tillering because excess biomass is produced (Torbit et al. 1993). From November until April, wheat is commonly grazed by livestock. Dunphy et al. (1992) examined the effects of forage removal on wheat yields. Wheat forage was harvested at three distinct phenological stages: early, mid, and late-jointing. Maximum grain yields were obtained when forage removal was terminated by the early-jointing stage. Dunphy et al. (1992) cautioned that their results cannot be generalized to a specific, annual calendar date because jointing dates vary among years and among wheat cultivars.

Native Range Vegetation Physiology

Livestock winter wheat grazing has been initiated partly because the quality of wintertime native range forages is poor. During winter, native shortgrass prairie forages can be deficient in protein, phosphorus and vitamin A according to cattle maintenance standards (Cook et al. 1977). Wheat crude protein concentration should exceed that of native range plant species during the winter (Torbit et al. 1993). Wheat crude protein concentration starts decreasing in April when nutrients are relocated from stems and leaves to the developing grain head (Spiertz 1977). Crude protein concentrations of native range plant species peak in April and May (Schwartz 1977).

Sequential peaking in nutritional levels between winter wheat and native range plant species can be expected annually. The sequence arises from differences in metabolic pathways. Wheat is a C_3 species, while most native range plant species are C_4 species. Differences in carbon fixation between C_3 and C_4 pathways cause C_3 species to have lower optimum temperatures for photosynthesis and to germinate sooner in the spring when temperatures are cool (Caswell et al. 1973, Salisbury and Ross 1992). Despite metabolic pathway differences, this peaking will remain synchronous because the metabolic rates of both pathways are affected by the same major environmental variables: irradiance, temperature, nitrogen supply, and water stress (Tenhunen et al. 1976a,b, Van Soest 1982, Woledge and Parsons 1986).

Ungulate Foraging Theory

Ruminants must continuously sample a broad spectrum of foods to monitor spatial and temporal changes in essential nutrients, fiber content, availability, etc. (Provenza et al. 1992). Food selection on the basis of nutrient content requires an individual animal to be able to assess nutrient requirement, recognize comparative food value, and relate food capture to nutritional benefits. The animal need not necessarily taste or smell each nutrient. Animals given free access in a cafeteria-style experiment to 30-40 required nutrients selected a diet enabling growth about equal to that of animals consuming balanced laboratory diets (Robbins 1983:324).

Body size largely determines rumination efficiency (Welsh and Hooper 1988:114). Larger animals are more efficient in their digestion of plant parts, both within and between species, even when metabolic body size is the basis for comparison. Smaller ruminants, like pronghorn, are unable to ruminate large amounts of plant cell walls and must select higher quality material to survive. Pronghorn select forages which are relatively high in crude protein and low in cell wall content (Schwartz and Ellis 1981, Krueger 1986).

IMPLICATIONS

In light of the background information just given, if pronghorn grazing does not reduce wheat yield, two components should be true. One, winter grazing during the tillering stage should not compromise subsequent shoot and grain head development. Two, free-ranging pronghorn must voluntarily stop grazing wheat as it enters the jointing stage.

PRONGHORN GRAZING ON WINTER WHEAT

Torbit et al. (1993) addressed winter grazing of pronghorn on grain yields with a grazing treatment. Pronghorn density used during the experiment was 166 pronghorn/km^2. This density was 80 times the normal densities found in free-ranging pronghorn populations. Four winter grazing treatments were compared: early, late, continuous, and control (no grazing). All grazing was terminated by the mid-jointing stage. Even though pronghorn foraging noticeably reduced green biomass, especially on the late and continuously grazed treatments, these effects were mitigated by compensatory growth after grazing ceased. Grain yields among treatments were not significantly reduced ($P = 0.17$), despite reductions in green biomass. Tests for grazing treatment effects were somewhat insensitive in their ability to detect differences because variability was high among replicates within all treatments. A 21% decrease in grain yields on grazed plots would have been required before differences ($\alpha = 0.05$, β was not indicated) were detectable.

TIMING OF PRONGHORN WINTER WHEAT USE

Observational studies involving pronghorn and wheat have noted seasonal use patterns (Cole and Wilkins 1958, Hoover et al. 1959, Torbit et al. 1993). Pronghorn use of wheat is heavy in the fall and winter, while light in spring and summer. Monthly aerial surveys in northeastern Colorado found unmarked, free-ranging pronghorn used wheat fields from November through April, then abandoned them by early May. Data from five radiocollared pronghorn also support this pattern. Marked pronghorn abandoned wheat fields by 19 April 1985 and by 12 May 1986. Still, the exact timing of the shift in vegetation type used needs to be documented with marked individuals. Also explicit ties between the shift in vegetation used and winter wheat phenology are also lacking because winter wheat phenology was not reported for these studies.

Pronghorn must be shown experimentally to stop foraging on wheat as wheat enters the jointing stage. Combining forage quality differences in wheat versus native range plant species with pronghorn preference for high crude protein and low cell wall content implies pronghorn will use winter wheat until native range plant species forage quality exceeds that of the winter wheat. This hypothesis requires that (1) native range plant species' forage quality must exceed that of wheat as wheat begins to joint, and (2) pronghorn must respond to nutritional changes in forage quality.

Alldredge et al. (1987) qualitatively examined monthly nutritional changes in pronghorn diets and compared a winter wheat diet to a native shortgrass prairie diet. Native shortgrass diet compositions were observed from three tame pronghorn using prairie adjacent to the CDOW's Foothills Research Facility. These diets were augmented by data from Schwartz (1977). Evaluating the change in winter wheat quality in relation to that of native range diets depended largely on two data points, May and June. Within month variation was not estimable because there was only one replication per month. Statistical tests of changes in relative nutritional levels were absent. Bi-monthly phenology measurements were recorded for native range species, but winter wheat phenology was not measured. Thus, the relationship between winter wheat phenology and changes in winter wheat forage quality still needs to be quantified. In addition, the temporal relationship between native forage phenology, wheat phenology, and pronghorn grazing preferences remains ambiguous.

OBJECTIVES

My study focuses on the nutritional hypothesis that pronghorn shift from winter wheat to shortgrass prairie species when wheat begins jointing. The first objective is to establish that individual, free-ranging pronghorn switch from foraging on winter wheat to native prairie, because of opposing trends in nutritional dynamics. A pilot study was conducted in 1993 that focused on elucidating movement patterns of free-ranging pronghorn.

METHODS

I collected data from late February through June. Fourteen female pronghorn were radiocollared. I visually relocated marked animals via aerial and ground telemetry. Nighttime, ground relocations were also attempted with a night-vision scope. Relocations were at least bi-monthly and I recorded the vegetation type of each relocation.

RESULTS

Effective sample size was reduced to 11 animals because of poaching and movement out of the study area. I discarded many aerial relocations because animals were responding to the aircraft and the vegetation type of their original position was unknown. Night relocations proved difficult because I was unfamiliar with the animals' behavior patterns and moving animals were difficult to relocate. Day-use and night-use of vegetation types did not appear different, except possibly during mid-April. I noted early morning movements away from agricultural fields in mid-April. Marked animals were last relocated on wheat April 10th, prior to wheat jointing. Even after marked animals were no longer located on wheat, they were usually within 3-5 km of wheat. Unmarked pronghorn were occasionally seen in wheat in early May.

DISCUSSION

My study focuses on a nutritional hypothesis: pronghorn switch from foraging on winter wheat to native prairie because of opposing trends in forage nutritional dynamics. Non-nutritional hypotheses for this switching behavior include amount of green biomass and movement to fawning areas. A hypothesis based solely on biomass implies the switching behavior would occur when native forage biomass exceeds that of wheat. Live biomass for native forage on the Pawnee grassland is 7 g/m^2 and 35 g/m^2 in early and late May respectively (Sims and Singh 1971). Torbit et al. (1993) found early-May wheat biomass to vary 29.8-121.7 g/m^2 among treatments and years. Thus, the biomass hypothesis might be dismissed because switching from wheat to native forage seems to occur in mid-April when native forage biomass is much lower than wheat biomass. A possible modification of the biomass hypothesis would be to incorporate a 'biomass threshold.' Above this threshold, pronghorn would have no preference. One problem with this hypothesis is justifying the choice of a given threshold.

A nutritional hypothesis incorporating biomass as a covariate is also possible, but probably not necessary. Biomass and phenology are affected by the same environmental variables (Tenhunen et al. 1976a,b, Van Soest 1982, Woledge and Parsons 1986) and should be highly correlated. Incorporation of both variables into a model should be redundant.

A "movement to fawning areas" hypothesis may not be an adequate explanation. If this were true, then only females should switch to native forage and males (and non-pregnant females) should continue to use wheat. This was not observed, even unmarked pronghorn stopped using wheat. Plus, fawning typically peaks in early June. An April switching date seems unnecessarily early for animals that do not move far.

SUMMARY

In the past, the Colorado Division of Wildlife has handled damage complaints of pronghorn on winter wheat by reducing pronghorn numbers. Such reductions may not be necessary because pronghorn may not damage winter wheat. Winter wheat yields should not decline from pronghorn grazing during tillering because excess biomass is produced. Pronghorn confined to wheat at densities 80 times higher than that found in free-ranging populations did not significantly reduce wheat yields (Torbit et al. 1993). My continuing study focuses on the nutritional hypothesis that pronghorn shift from winter wheat to shortgrass prairie species when wheat begins jointing. The first objective is to establish that individual, free-ranging pronghorn switch from foraging on winter wheat to native prairie, because of opposing trends in nutritional dynamics.

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PRONGHORN MANAGEMENT AND PRIVATE PROPERTY IN THE TEXAS PANHANDLE

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Abstract: Many of the problems associated with the management of pronghorn (*Antilocapra americana*) populations in private-land states differ from those faced by managers in states containing large expanses of public land. Our paper is a discussion of some of these problems as they apply to the pronghorn herd in the Texas Panhandle. This pronghorn population is characterized by small, fragmented herds that exist in one of the most intensively farmed areas of the United States. Some of the management problems in the Panhandle include low recruitment, depredation complaints from landowners, increasing demand for permits, and difficulty obtaining accurate census data due to herd movements.

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Key words: Pronghorn, management, private property, Texas, depredation complaints, permits.

Early expeditions that explored the Texas Panhandle (Marcy 1849, Michler 1850, Thwaites 1904-1907, Perkins 1941) reported pronghorn as very numerous. However, by the 1920's the pronghorn population in the region had been reduced to approximately 400, occurring in small isolated pockets (Texas Game, Fish and Oyster Commission 1945). Factors contributing to the decline were loss of habitat due to conversion of rangeland to farmland, development of extensive oil and gas fields, and illegal hunting. In an effort to reestablish pronghorn in the Panhandle regulatory district, 1,797 pronghorn were transplanted between 1939 and 1992 to sites throughout the district (Clark 1990). Results of these releases varied from very successful to complete failures.

CURRENT HABITAT

The counties in Texas that compose the Panhandle Regulatory District are divided into two major ecological areas. The High Plains area consists of approximately 7.9 million ha and is located in the western portion of the district. Historically, the vegetation consisted of a mixed prairie with various shortgrass species on upland sites and tallgrass prairie on the deeper sandy sites. The topography is nearly level to slightly rolling, and approximately 60% of this area has been converted to irrigated and dryland croplands for the production of wheat, cotton, sorghum, corn and sugar beets. The vegetation on the remaining rangeland varies widely, but the dominant plants are blue grama (*Bouteloua gracilis*), buffalograss (*Buchloe dactyloides*), little bluestem (*Andropogan scoparius*), sideoats grama (*B. curtipendula*), sand dropseed (*Sporobolus cryptandrus*), shinnery oak (*Quercus havardii*), sand sagebrush (*Artemisia filifolia*), honey mesquite (*Prosopis glandulosa*), pricklypear (*Opuntia* spp.), and yucca (*Yucca* spp.). Weather is characterized by high winds, dry winters and low rainfall (36-53 cm). The eastern side of the district lies in the Rolling Plains ecological region and consists of 9.8 million ha of rolling to broken terrain. Approximately 75% of the area is rangeland that is dominated by plant species, such as, honey mesquite, lotebush (*Ziziphus obtusifolia*), pricklypear, shinnery oak, sand sagebrush, redberry juniper (*Juniperus pinchotii*), little and big bluestem (*A. gerardii*), hairy grama (*B. hirsuta*), and buffalograss. The normal range for annual rainfall is 46-69 cm per year (Hatch et al. 1990).

The major challenges associated with managing pronghorns in these two ecological areas can be summarized under two categories:

(1) response to crop depredation complaints, and
(2) permit issuance.

MANAGEMENT CHALLENGES

Depredation Complaints

Complaints about pronghorn crop depredation and concern about competition with domestic livestock probably began when the first settlers arrived in the Texas Panhandle. Jones (1949) reported that some of the herds that were stocked in 1946 and 1947 were shot by farmers who were worried about depredation on their wheat fields. Because the majority of the pronghorn population is located in the intensively farmed High Plains ecological region, these complaints continue today. Clark (1990) conducted a mail survey of Panhandle landowners and found that 15% of the respondents considered the pronghorns on their property a liability, and 45% were convinced that they competed with their livestock for forage. Complaints concerning pronghorn in the Texas Panhandle can be grouped into three major categories:

(1) damage to both electric and barbed wire fences,
(2) competition with livestock for forage, and
(3) damage to a portion of the field from trampling the crops or overgrazing (some landowners believe that pronghorn do not move around the field like domestic cattle).

The crop involved in most landowner complaints about pronghorn depredation is winter wheat. In addition to the value of wheat for grain production, the grazing of feeder cattle on winter wheat has become a major industry in the Texas Panhandle. Many of the farmers do not own the cattle, but lease their property to the large feedlots in the region. Feeder steers/heifers are placed on these fields to graze prior to being taken into the feedlots for fattening. This provides the farmer with income from the grazing lease, as well as the option of harvesting the grain. In order to maximize the grazing period, many farmers plant their wheat in late August or early September. If adequate soil moisture is available, it is not unusual for pronghorn to begin grazing this early wheat when it first sprouts in mid-September and periodically graze it until mid-March. Complaints concerning pronghorn seem to increase during periods of dry weather when the wheat is slow to sprout or grow, and landowners often indicate that pronghorn are pulling the plants up by their roots.

Although they are less frequent than wheat depredation complaints, complaints concerning pronghorn damage to grain sorghum, corn, and cotton are received. These complaints mainly concern trampling of the plants during the summer months or damage to the grain head or terminal bud.

Census/Permit Issuance/Hunting Pressure

Permit issuance in the Panhandle Regulatory District is primarily based on the population estimates and herd composition counts derived from the annual aerial surveys conducted from mid-June to early July. Prior to 1990, only the largest herds were surveyed in a county on the assumption that these herds represented the population trend for the entire county. However, the census effort was expanded for two reasons:

(1) the number of permit requests increased from landowners with very small herds on their property, and
(2) a few pronghorn herds had declined in certain areas.

The entire pronghorn range in the Texas Panhandle was divided into herd units with boundaries that were defined by major highways or farm-to-market roads. These herd units range in size from approximately 7,300 to 186,000 ha. Currently, attempts are made to census those units, which contain the major herds and/or where permit requests are expected. The ranches/farms that are surveyed normally contain the bulk of the herd in that unit during the summer months. This provides more uniform data on the major herds in the Panhandle and allows Texas Parks & Wildlife Department to monitor changes in the individual herd units. Herd characteristics such as small herd size, low fawn production, and the isolated nature of some populations require that these herds be monitored on an annual basis if we are to continue to allow hunting. Results of the 1993 aerial survey give some indication of the small herd sizes we are trying to manage. We surveyed 28 of the 50 herd units in 1993. They averaged 110 animals per unit (range of 5-281). Fawn production within these units ranged from .05 to .75 fawns/doe.

The length of the annual aerial survey has increased in the district from approximately 66 hours to 115 hours. Also, the ability of the pronghorn to move between properties within the herd unit and in some cases across state lines, continues to effect the accuracy of the census in some units, particularly those containing small populations (<50 pronghorn). It is very easy to miss a portion or even all of the herd, if they have moved off the ranch being surveyed.

Because many of these herd units contain both farmland and grassland, we are dealing with numerous landowners and various sizes of land tracts. There are obvious difficulties in deciding whether or not to issue permits in a herd unit; however, there can be other problems associated with permit issuance on private lands:

(1) the permit request may exceed the number of bucks available for harvest,
(2) we must often justify sending more permits to one landowner than another,
(3) establishing a minimum acreage that is required for permit issuance,
(4) determining permit issuance to landowners who have several tracts of land scattered inside a herd unit,
(5) lessees may request permits without the landowners knowledge, and
(6) one partner may request permits without the knowledge of the other owner(s).

The pronghorn season in Texas opens on the Saturday nearest October 1 and continues for nine consecutive days. Permits are issued directly to qualified landowner or their agents and cannot be sold, but a hunter can be charged a trespass fee. Hunters are allowed only one pronghorn per year and the permits designate whether a buck or doe can be taken. Pronghorn hunting on public lands confined to the Rita Blanca National Grasslands in Dallam County. Participants in this hunt are selected by a drawing, which is conducted through the Texas Parks & Wildlife Department's public hunting program.

The policy used to determine the pronghorn harvest in the Panhandle District has changed over the years. The first hunt in 1953 called for the removal of 50% of the bucks from the ranches receiving permits plus some does on selected ranches. The current policy is based on achieving a 1:4 buck/doe posthunt ratio, and no does have been harvested since 1968. This more conservative approach to harvest, coupled with a population decline in some herds and an increase in the number of landowners requesting permits, has resulted in a significant reduction in the number of permits received per landowner. Thirty-one landowners received an average of 11.4 permits in

1953 as compared to an average issuance of 1.4 permits (range 1-8) to 190 landowners in 1993. It is anticipated that in some herd units where the demand for permits continues to grow, it may be necessary to limit every landowner to one permit. However, in those cases where the demand cannot be met, a system of drawing for permits or rotating permits among landowners may be attempted. Hunting pressure in the Texas Panhandle is characterized by heavy utilization of the permits by those landowners receiving one or two permits and limited usage by the larger landowners who receive three or more permits. During 1993, 73.6% of the 190 landowners in the district who received permits allowed hunting on their property. The 207 hunters harvested 155 bucks for a success rate of 75%.

CONCLUSION

The future of pronghorn in the Texas Panhandle depends on the continuation of an intensive census and management effort, plus acceptance by the landowners. The chances of a significant increase in the pronghorn population is poor because of low fawn survival and limited habitat. As the number of people in the region increases, so will the demand for permits. Landowners will have to accept a very limited number of permits or none in some cases.

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OBSERVATIONS OF PRONGHORN RESPONSE TO AN ELECTRIC FENCE

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Abstract: A 3-strand electric fence was installed 60 cm outside an existing 107 cm high fence, which was partly 4-strand barbed wire and partly net wire, around an irrigated alfalfa (*Medicago sativa*) field. Pronghorn (*Antilocapra americana*) in recent years have used the alfalfa field for a three month period beginning in mid-August and ending in mid-November. During this period, in the year prior to installation of the electric fence, the average daily use was 38 animals per day compared to two animals per day with the fence. There were 38 challenges to the fence at track beds and eight passages and, for the 88 days of the experiment, there were 459 observations of animals in the vicinity of the field outside the fence compared to 151 inside. The fence we used was designed for temporary livestock control and would be unsuitable as a permanent control measure. The fence seemed to be more effective near the barbed wire fence than near the net wire fence. When jumping the net wire, the animals broke the circuit with the ground and, thus, did not get shocked even if they did contact the electric wires. We presume pronghorn tended to avoid crossing the combination of barbed wire and electric fence because they were accustomed to crawling under the barbed wire and while doing so would contact the electric wire and get shocked.
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Key words: Pronghorn, *Antilocapra americana*, crop depredation, electric fence, alfalfa *Medicago sativa*.

In Colorado, as in some other states, the Division of Wildlife is responsible for wildlife damage to private property. Pronghorn were extirpated from a high mountain park in Middle Park, Colorado, during the 1920's. In the early 1980's, a pioneering population re-established itself and continues to grow (Pojar and Gill 1990). The lower elevation of the park (2,200 - 2,750 m) is shrub-steppe habitat type with sagebrush (*Artemisia* spp.) dominating the overstory (Tiedeman et al. 1987); meadows, near drainages, are used as irrigated native hayland. The exception is a 30 ha pivot irrigated alfalfa field, surrounded by arid sagebrush habitat that is used by a portion of the pronghorn herd during late summer and early fall. Use of the alfalfa by pronghorn is increasing as the population increases (Fig. 1). The Colorado Division of Wildlife (CDOW) has paid the landowner damage claims since 1987; the maximum damage claim for one season was $525. There are no other serious conflicts with the pronghorn herd because land use is almost exclusively grazing by domestic cattle, which have little dietary overlap with pronghorn on native range (Howard et al. 1990, Yoakum and O'Gara 1990). The management objective for this pronghorn population is to allow it to expand to carrying capacity, therefore, the CDOW desires to alleviate this one significant source of damage claims.

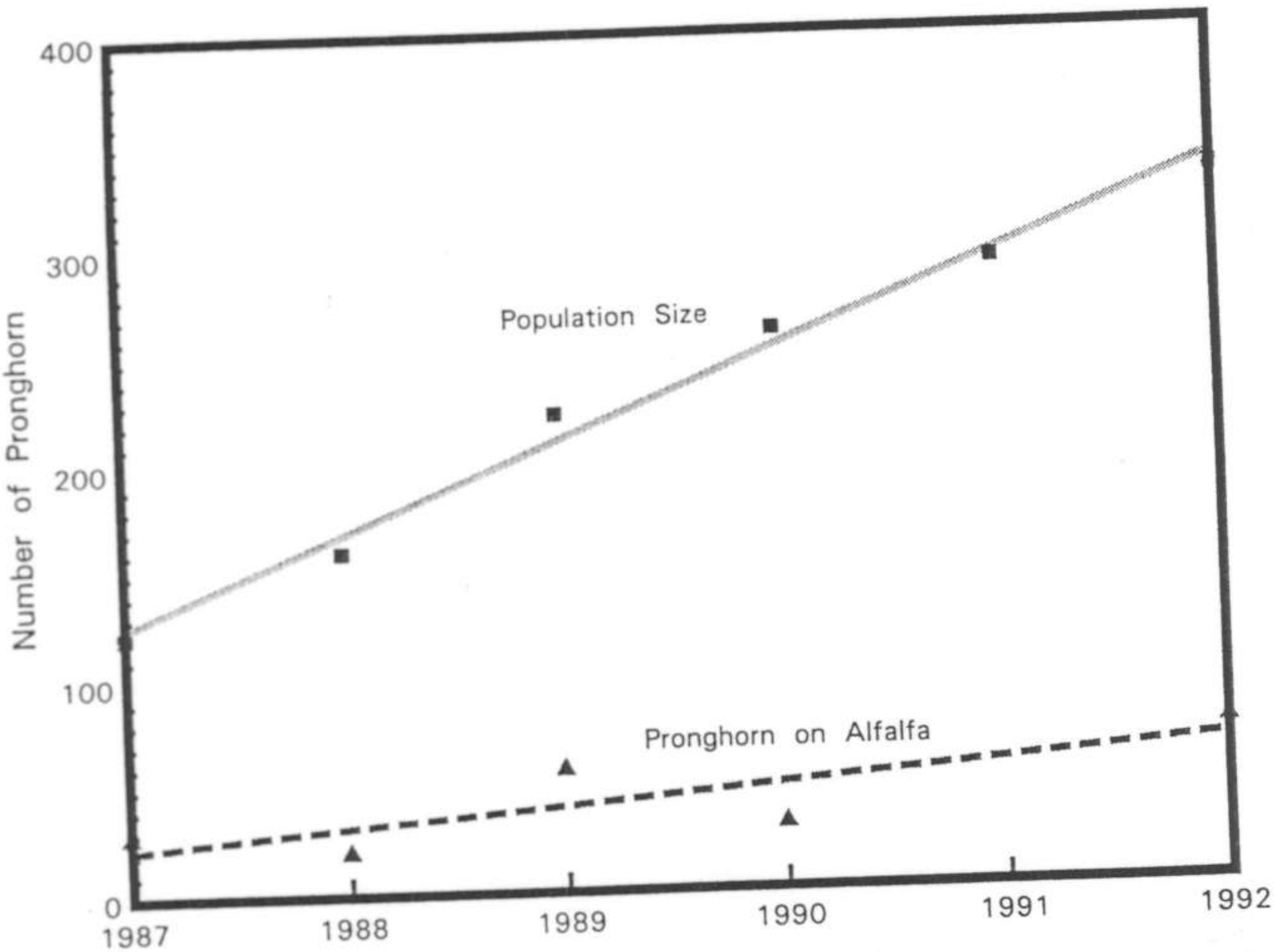

Fig. 1. Pronghorn population size in relation to the maximum number of pronghorn seen on the irrigated alfalfa field in Middle Park, Colorado 1987-92.

Electric fences have been used as cost-effective solutions to temporary animal management situations. Our intent was to determine if an electric fence would be an effective deterrent given the motivation provided by irrigated alfalfa in an arid sagebrush habitat. Electric fence has been successfully used to control depredation on orchards by white-tailed deer (*Odocoileus virginianus*) (Porter 1983, Palmer et al. 1985). A single strand of electrified barbed wire excluded pronghorn use of an area of pronghorn range in Yellowstone National Park that apparently had no special attractant (McAtee 1939).

Pronghorn are not well adapted to negotiating vertical barriers (O'Gara and Yoakum 1992) and normally prefer to go under fences (Einarsen 1948). Most traditional livestock fences, including buck-and-pole (Scott 1992), influence pronghorn movements (O'Gara and Yoakum 1992) depending on the level of motivation. Since pronghorn prefer to go under fences, we reasoned that a relatively low (56 cm) 3-strand electric fence in conjunction with the conventional livestock fences would deter pronghorn with what we considered to be "moderate" motivation to enter an irrigated alfalfa field.

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STUDY AREA

The study field is irregularly shaped and fenced with two different configurations of conventional livestock fencing (Fig. 2). The west and south (1.220 km) is fenced with 4-strand barbed wire (107 cm high) and the remainder (2.096 km) is fenced with 91 cm net wire topped with 1 strand of barbed wire, making it about 107 cm high. The customary entry into the field by pronghorn was under the barbed wire fence at specific "crossings" along the south and west boundary. They also entered the field through an open gate in the net wire fence and through portions of the net wire fence along the northwest boundary that were not maintained. The area outside the field's south, west, and northwest boundaries is typical pronghorn sagebrush habitat. Pronghorn have not customarily entered the field from the north or east boundaries due to the presence of an occupied farmstead on the northeast corner of the field; farmstead activity including machinery, farm dogs, heavily grazed sheep pasture, corrals, and stack yards all tend to deter pronghorn use of that area.

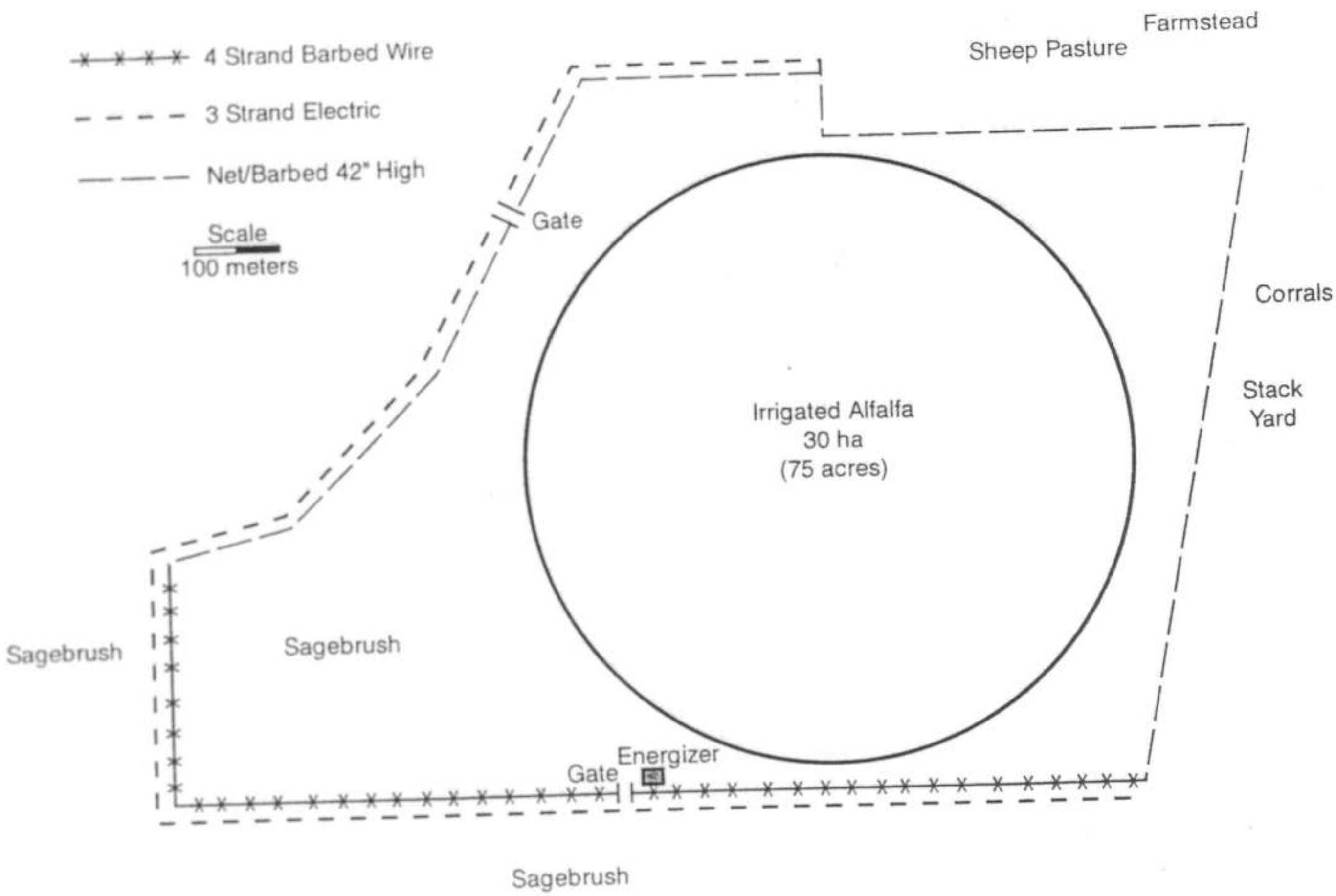

Fig. 2. Physical configuration of the irrigated alfalfa and fencing around it.

METHODS

An electric fence, composed of 3-strands of electroplastic twine mounted on 122 cm fiberglass posts spaced at 10 m intervals, was erected 60 cm outside the south, west, and northwest boundaries of the existing fence (Fig. 2 and Fig. 3). Total length of electric fence was approximately 2.147 km. It was powered by a deep cycle marine battery trickle charged with a 30 x 50 cm solar panel and an energizer that produced 6,800 volts of electricity. Along the east 500 m of the south fence, where the soil was moist from irrigation water, all 3-strands of the electric fence were electrified. For the remainder of the fence, the soil was too dry to carry an adequate electrical ground so the middle wire was used as the ground.

Electric fence was not added to the existing fence along the east boundary and the east portion of the north fence (see Fig. 2) because of lack of pronghorn use and conflict with farmstead activities.

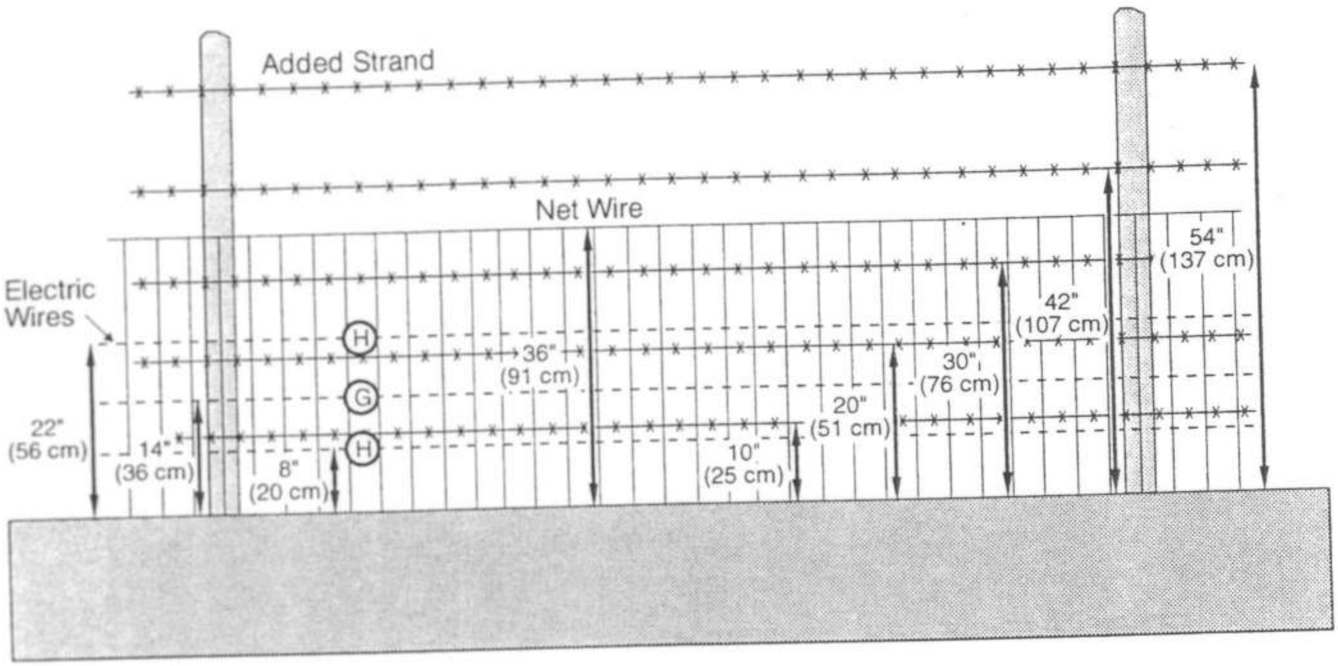

Fig. 3. Fence configuration and wire spacing.

Five areas where pronghorn customarily crossed under the barbed wire fence in past years were identified along the south and west fence. Track beds were established at these crossing points. Challenges to the fence and crossings were recorded at these track beds. A challenge constituted at least one footprint perpendicular to, and within, 30 cm of the fence. A crossing was the continuation of one set of tracks under, through, or over the fence.

The net wire fence along the northwest and west portion of the north boundary was repaired to preclude pronghorn passages under it and the gate was closed with 120 cm net wire.

Our intention was to make observations on a daily basis. A daily check included:

1) drive pronghorn, if any, out of the alfalfa field,
2) check fence voltage and correct any grounding of the wire, and
3) check the track beds and record challenges to the fence and crossings.

In addition, any pronghorn seen outside of the fence during our daily check were counted and recorded. Because of terrain and vegetation, we could detect pronghorn within about 500 m of the field.

We estimated pronghorn use of the alfalfa field prior to installation of the electric fence from counts made the previous year (1992). These counts were made at approximately two week intervals, at various times of day, during August-November.

For a number of reasons, application of statistical tests was not appropriate; these include, but are not limited to:

1) samples were not independent, i.e. one animal's response may have affected another's or its previous experience may have affected its subsequent response,
2) comparable data was not collected during a season when the electric fence was not in place, and
3) counts of animals in the vicinity of the field or on the field were not taken at standardized times.

RESULTS

The electric fence was in place and operational for 88 days, from August 21 to November 17, 1993. On 70 of these 88 days the field was checked as described in the methods section. The time of day the field was checked varied depending on when project personnel were in the area.

Searches conducted for radioed pronghorn in association with another project resulted in six counts of pronghorn on the alfalfa field in 1992 during the same season as our observations. The time of day the counts were made varied from 1120 to 1610 hrs.

Before the fence was installed, the daily mean number of pronghorn on the alfalfa field (1992) was 38.17 (n=6) compared to a daily mean of 2.16 (n=70) after the fence was installed in 1993 (Fig. 4). From track bed readings, there were 38 challenges and eight passages and, during our observation periods, there were 459 observations of animals in the vicinity of the field outside the fence and 151 observations inside.

DISCUSSION

The fence we used was designed for temporary control of livestock and we do not believe it is suitable as a permanent solution to controlling pronghorn. The major maintenance problem was loosening of the electroplastic twine from whipping by the wind and/or entanglement of animals. If not tightened periodically the twine would become tangled in the adjacent metal wire fence or vegetation causing a short circuit and reduction in voltage. This design of electric fence could not be left in place on a yearlong basis. Heavy snow would stretch the twine and possibly collapse the small diameter fiberglass posts. Although quite simple to install and disassemble, this fence design would need to be installed and removed each year for an application such as ours.

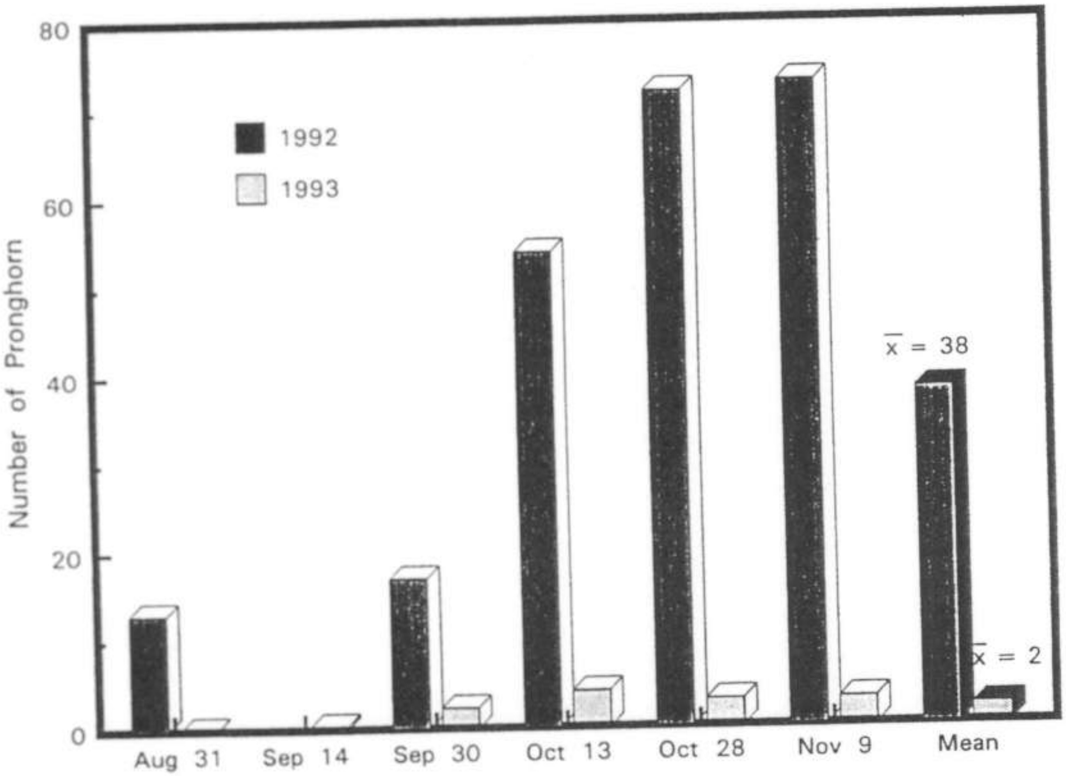

Fig. 4. Number of pronghorn on the irrigated alfalfa field before the electric fence was installed (1992) and after (1993).

Only eight crossings were documented at the track beds, yet 151 observations were made of animals inside the fence. This indicates the animals were entering somewhere besides at the track beds. Although the landowner left a gate open on several occasions, we examined the area for tracks and estimate that the open gate resulted in only one or two entries into the field. Because of evidence in the form of tracks and direct observations, we believe the majority of the entrances were from jumping the net wire (and electric) fence along the northwest boundary of the field. The approach to the fence from the northwest was from higher terrain allowing the animal to see over the fence making it more likely for them to jump (Spillet et al. 1967). An animal attempting to jump into the field would be jumping "downhill" making the 107 cm high much less formidable than if they were jumping it on level ground. When jumping the fence, the animals avoided being grounded, thus, they would not get shocked. The combination of electric fence and net wire seemed to be less of a deterrent than electric fence and 4-strand barbed wire. However, if an animal had at some time experienced a shock from the yellow colored electric twine, there may have been an avoidance response to the fence. Another possible deterrent may have been the visual barrier of having to jump both the electric and net wire fence.

There did seem to be some deterring factor due to the fence (or possibly due to our observation process) given the difference in the number of animals on the field before (1992) and after (1993) the fence was installed. Some unknown portion of this deterrent may simply have been the closing of the gate and repair of the net wire fence.

An unmeasured influence on pronghorn entry into the alfalfa field during our observation period may have been the almost daily visits of project personnel to the area. Although, the group of pronghorn frequenting the vicinity was habituated to vehicles and haying activity in the field. A larger factor, however, may have been our chasing pronghorn out of the field. If left in the field, they may have acted as decoys and enticed more animals into the field, or the fact that they were driven out on an almost daily basis may have made them less likely to re-enter.

The increase in number of pronghorn inside the field beginning in late September (Fig. 5) may have been partially the result of a male's territory inside the field. The animals violating the fence were commonly the same individuals, which included a territorial buck and two to five does. During this period, the buck actively herded the does making it very difficult to drive them out once they were in the field. It is possible the buck was responsible for herding the does onto the field to keep them on his territory or, alternatively, it is possible the does were more highly motivated to enter the field during the breeding season because of the buck's territory.

Our electric fence was 60 cm outside the net wire fence and Palmer et al. (1985) suggested that, for white-tailed deer, a vertical electric fence be placed 2 to 3 m outside net wire or woody fence rows. This, they inferred, would reduce the likelihood that deer would jump the fence rather than attempt to crawl under it and get shocked. With our electric fence being so close (60 cm) to the net wire, pronghorn approaching from the uphill side would almost certainly be focused on jumping both fences rather than attempting to crawl under the electric fence then jump the net fence.

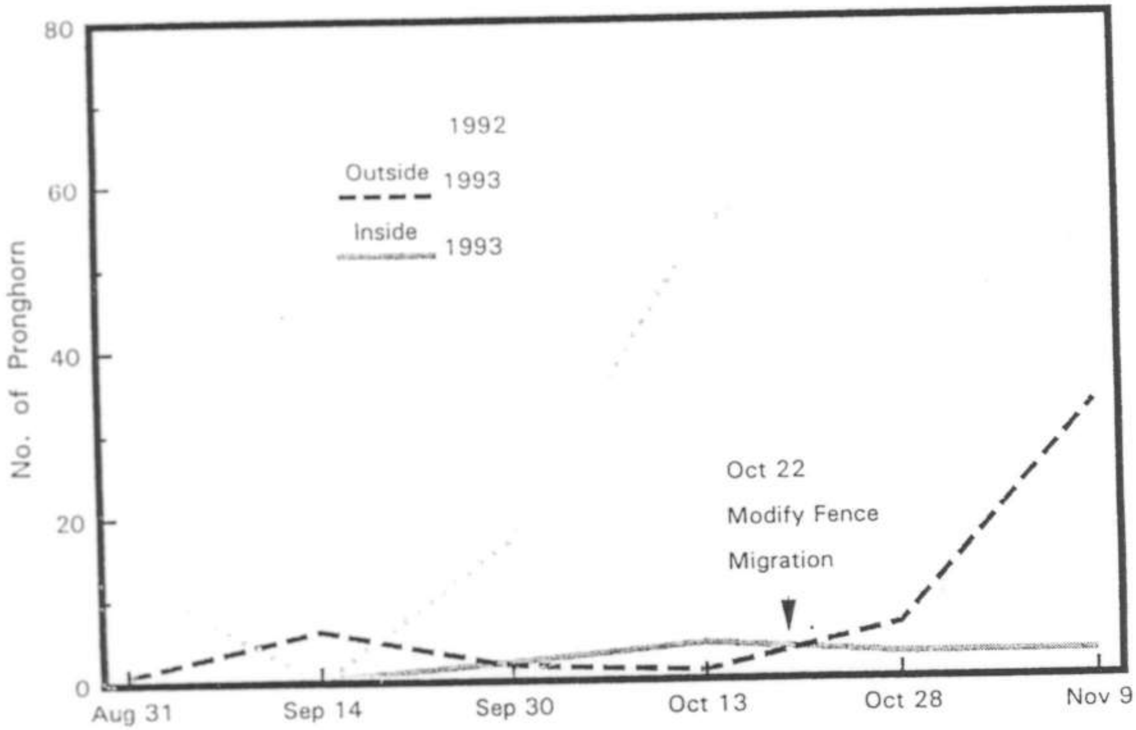

Fig. 5. Number of pronghorn inside and outside the fence in 1993 compared to 1992. The net wire fence was modified to 120 cm high on October 22.

The combination of electric fence and 4-strand barbed wire seemed to be somewhat effective in preventing crossings. We speculate that the electric fence was the main deterrent because the barbed wire fence was not a physical barrier and pronghorn had, in previous years, crossed at will under the barbed wire fence at our track beds. In addition, at times there were tracks 5-10 m outside and parallel to the fence that indicated a concentration of pronghorn activity. We do not know if these animals were repelled by the fence or if they would normally travel along the outside of the fence because we did not monitor tracks when the electric fence was not in place. We can only assume that these animals would have entered the field if the electric fence were not there because of the large number that used the field in 1992 compared to 1993.

MANAGEMENT RECOMMENDATIONS

Three-strand electroplastic twine electric fence may be capable of controlling pronghorn movement. The level of motivation and consequences of fence violations determine how elaborate the fence must be. The 3-strand fence we tested would possibly be adequate for situations with "mild" motivation.

Fence height (either electric or net/barbed wire) of 120-150 cm would probably be necessary to thwart pronghorn movement under "moderate" motivation. On or about October 22, >100 pronghorn migrated into the vicinity of the alfalfa field from the eastern part of Middle Park. A high density of tracks along the northwest boundary net wire fence indicated increased pressure along that portion of fence. On that date, we added a strand of barbed wire to the 107 cm high fence raising it to 120 cm. Even with the increased number of animals in the vicinity, we did not have more animals inside the fence (Fig. 5). From this, we speculate that a fence at least 120-150 cm high fence would be needed to preclude pronghorn passage under the "moderate" motivation such as experienced in our observations. We consided "high" motivation to be animals driven by aircraft as during trapping.

We expected that a 150 cm high 5-strand (or more) electric fence as described by Palmer et al. (1985) for white-tailed deer would be nearly completely effective in controlling pronghorn passage. Their fence (permanently installed) was high tensile wire which would increase fence life and reduce maintenance yet still be less expensive than conventional wire fencing. If there were not an existing fence around the alfalfa field where our observations were made, a permanent high tensile wire electric fence 150 cm high would be an alternative costing 25-60% less than conventional net wire livestock fence (Table 1). However, using seven wires rather than five would be better for pronghorn fencing because the wires would be closer together.

Since there is conventional fencing around the alfalfa field in question, it would be most economical to modify it to preclude pronghorn use (Table 1). Where there is net wire, there are 3 strands of barbed wire attached to the posts below the level of the net wire and these could be used to increase the height to about 150 cm with no cost for materials. Net wire would need to be added to the section of fence that is now only 4-strand barb wire. At 1994 prices, we estimate it would cost about $1,600 for 91 cm net wire to span 1.220 km ($0.40/ft) of this fence. The four barbed wires could be placed at 10 cm spacing above the net wire to raise the height to 150 cm. In Colorado, unless special arrangements are made, the CDOW will provide material to a landowner for fencing to prevent damage (Colorado Division of Wildlife Regulations 1993). In this instance, the cost to the CDOW would be offset in about three years by savings in damage payments.

Table 1. Comparative costs (1994) of materials for four fence configurations with application for fencing pronghorn out of irrigated alfalfa.

Fence Type	Height	Cost/km	Total[a]
3-strand electroplastic twine	56 cm (22")	$775	$2,570
7-strand electric high tensile metal wire	150 cm (5')	$1,525	$5,057
100 cm net wire plus 3 strands barbed wire	150 cm (5')	$2,000+[b]	$6,632+
Modify existing fence net wire + 4 strands barbed	150 cm (5')	$482[c]	$1,598

[a] Cost is for the entire 3.316 km of perimeter fence.
[b] Some quotes were double this amount.
[c] This figure represents cost per km using existing material and purchasing new net wire for that portion of the fence (1.22 km) that is now only 4-strand barbed wire, e.g. $1,600 for net wire for 1.22 km divided by 3.316 km.

CONCLUSIONS

Some possible alternatives for the resolution of damage claim problem would seem to be:

1) remove the segment of the pronghorn population,
2) put protective fencing around the field, or
3) continue to pay damage claims.

Removal of the involved pronghorn would mean eliminating about 25% of the Middle Park population (100-125 animals). This option has two serious faults. First, this segment migrates to eastern areas of Middle Park during summer and is a valued resource to local residents. Second, there would almost certainly be other pronghorn that would move into the area so the removal effort would be an ongoing process that would be expensive and politically indefensible.

Continuing to pay damage claims could be a viable alternative if actual damage were more accurately assessed. The population is approaching the projected carrying capacity (Pojar and Gill 1990), so pronghorn use of the alfalfa field may not increase much beyond the present level.

Protective permanent net wire fencing would be economically feasible if the CDOW were to provide only materials (no labor) to modify the existing fence. Fencing, however, could increase hazards to other wildlife species. A 150 cm high fence, especially one topped with strands of barbed wire, may result in some animals, including mule deer (*O. hemionus*) and elk (*Cervus elaphus*), getting entangled in the fence while attempting to jump it.

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WATER REQUIREMENTS FOR PRONGHORN

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Abstract: A literature search was conducted to assess information regarding the water requirements of pronghorn (*Antilocapra americana*). Pronghorn obtain water for physiological processes from three sources: drinking free water, preformed water in feed, and metabolic water production. Pronghorn drink water from natural sources such as springs, seeps, streams, rivers, lakes, and ephemeral pools; they likewise use man-made structures, i.e., reservoirs, troughs, and precipitation catchments. When deprived of water, they lose weight, decrease forage intake, use shade, limit mobility, reduce activity, and decrease fawn production. With rehydration, animals respond quickly with accelerated vigor. When drinking water is readily available, consumption ranges from 1/4 to 1 gal (.09 to 3.8 l)/day/100 lb (45 kg) animal. When moisture in forage is greater than 75%, pronghorn may cease to drink. During summers, average use of drinking water may increase to 1-1.5 gal (3.8 to 5.7 l) per day. A recommendation for allotting and the development of drinking water facilities for pronghorn accustomed to water availability during summers, is 1 gal (3.8 l)/day/100 lb (45 kg) animal for summer use, and one-quarter this amount for winters when free water or snow are not available. Pronghorn are highly adaptable to varying habitat conditions, exhibiting wide variations for water requirements. Northern herds having abundant water sources often drink daily, especially during summers. Southern herds consume much less water because it is not often available. Some southern populations appear to drink water rarely---often obtaining moisture needs from dew or succulent forage. Apparently, high density populations are associated with abundant, available drinking water; conversely, arid habitats with few permanent drinking water sources support low densities of animals.

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Key words: *Antilocapra americana*, pronghorn, water requirements.

Whether pronghorn need drinking water to sustain viable populations is an equivocal issue. Some authors refer to the continued need for drinking water in order to maintain healthy herds (Einarsen 1948, Buechner 1950, Sundstrom 1968, Beale and Holmgren 1975, Hailey 1979, Yoakum 1978, Kindschy et al. 1982, Allen et al. 1984) and others. Still other reports maintain that pronghorn rarely, if ever, drink water and that the animals can obtain moisture needs from succulent forage (Skinner 1922, Hoover et al. 1959, Monson 1968, Phelps 1978, Sheldon 1979, Arizona Game and Fish Department 1981, Cancino 1994).

Consequently, there has been polarization---one camp inferring pronghorn need drinking water available to maintain healthy, abundant populations---while a second camp continues to report some herds apparently live with little or no permanent drinking water available.

The objectives of my study are to report and assess field and laboratory findings regarding water requirements for pronghorn, and to document when and where water is required, and limit extrapolation of these findings in habitats of similar biomes. Also, management recommendations are provided for allotting and developing drinking water for pronghorn.

Appreciation is extended to Marshall White, Don Spalinger, and Bart W. O'Gara, for suggestions and review of a previous draft of the manuscript.

METHODS

A literature search was conducted to assess reports documenting the positive or negative needs of pronghorn for water intake. Three bibliographies (Prenzlow 1965, Yoakum 1967, 1991)and two compendia (Yoakum and Spalinger 1979, O'Gara and Yoakum 1992) were most helpful.

A total of 41 reports containing information specific to pronghorn use and needs for water were reviewed. Most were anecdotal. However, two studies quantified water intake under controlled field conditions (Sundstrom 1968, Beale and Holmgren 1975), and two under laboratory conditions (Wesley et al. 1970, Whisler 1984). Of these four major studies, three provided findings regarding experiments with water deprivations and rehydration (Wesley et al. 1970, Beale and Holmgren 1975, Whisler 1984).

FINDINGS

Water is one of the most important nutrients to mammals because of its variety of functions and magnitude of requirements(Maynard and Looshi 1969). Water is required within a mammal's body as a solvent and is involved in hydrolytic reactions, temperature control, transport of metabolic products, excretion, lubrication of skeletal joints, and sound and light transport within the ear and eye (Robinson 1957). Water comprises 99% of all molecules within the body (MacFarlane and Howard 1972). Between 71 and 85% of the body weight is water, with higher quantities found in younger animals (Moulton 1923). According to Robbins (1983:17-18) "Water requirements are affected by ambient air temperatures, solar and thermal radiation, vapor pressure deficits, metabolic rates, feed intake, productive processes, amount and temporal distribution of activity, and physiological, behavioral, and anatomical water conservation adaptations."

In recognition of the above biological functions and processes for pronghorn, it is apparent that water nutrients are required in adequate quantities to sustain healthy pronghorn, and to provide for the production and lactation of fawns.

Water Nutrient Sources

More than 60 years ago, Leopold (1933:287) provided basic information regarding water sources for wildlife. He stated they obtain water from: drinking water, dew, succulence, and metabolic water. He further provided these findings and suggestions:

> "The watering habits or preferences of game when water is plentiful, and its real requirements when water is scarce, are two different things. To see a species drinking is not enough proof that it must drink. To prove that it must drink under one condition of food and weather is not proof that it must drink under any and all conditions. The test of its minimum requirements is the maximum deprivation which it will survive without injury. Game managers, in order to select and develop land for refuges, preserves, plantings, and other management ventures, need two kinds of information about water: 1. The kind and distribution of water-sources necessary for survival under various conditions. 2. The minimum kind and distribution of water-sources necessary for survival under various conditions. 3. The environmental controls necessary to meet the second, and if possible the first, criterion."

Leopold stated that reliable information differentiating the first two points for various wildlife under various conditions is scarce, hard to interpret, and generally not available. Most authors confuse point 1 and 2. His final assessment for pronghorn was that these ungulates drink regularly when they can, especially adult females at fawning time, but pronghorn can subsist and reproduce on succulence from vegetation alone where circumstances require.

Robbins (1983) in his monograph on wildlife feeding and nutrition, concurred with Leopold (1933) that water for wildlife requirements is obtained from:

(1) free water, such as streams, lakes, puddles, rain, snow or dew,
(2) preformed water contained in forage, and
(3) oxidative or metabolic water produced as a product of oxidation of organic compounds containing hydrogen.

According to Taylor (1975) preformed water may be less than 10% weight of air-dried forage to 70% or more for succulent vegetation.

Measurements of free water intake underestimate total water requirements because of the omission of preformed water (Robbins 1983). Free-ranging pronghorn have been able to meet their water requirements from preformed water (Beale and Smith 1970). Estimates of preformed water can be made from detailed knowledge of food intake, although such measurements are often confined to experiments of captive animals where feed and water intake can be measured with accuracy (Wesley et al. 1970, Whisler 1984).

The four major pronghorn/water field studies and laboratory experiments conducted to date are:

Wamsutter Field Study

Sundstrom (1968) measured drinking water consumption for 25-35 pronghorn in a 2 mi (5 km) fenced native habitat enclosure near Wamsutter in southcentral Wyoming. He reported precipitation, evaporation, temperature, succulent vegetation, and lactation in does, were factors affecting average daily drinking water intake rates. These rates varied from 0.09 gal (0.3 l)/day/animal in May, to 1.19 gal (4.5 l)/day/animal in August, with an average summer use of 1 gal (3.8 l)/day/animal (Table 1). As new growth succulent vegetation became available, pronghorn decreased drinking water ingestion. Spring rains provided additional available water in the form of ephemeral pools. Water intake rates accelerated in July when precipitation decreased and vegetation started to become desiccated. During August, water intake was greatest, averaging 1.12 gal (4.2 l)/day/animal.

Pronghorn distribution on surrounding unfenced habitat changed during the early part of July until October. In some areas where pronghorn were commonly seen in June, they were rarely observed by July. While Sundstrom conducted a census in the surrounding Red Desert Area the latter half of July, he observed 95% of pronghorn were within 3-4 mi (4.8-6.4 km) of drinking water sources. Single bucks were seen up to 7 mi (11.3 km) from water supplies.

In an adjacent area of similar habitat characteristics, 3,291 pronghorn were counted, of which 2,334 (71%) were located in areas of abundant water supplies compared to 954 (29%) in areas with scarce water sources.

Subsequent field studies in southcentral Wyoming by Deblinger and Alldredge (1991) investigated the effects of pronghorn summer distribution by manipulating drinking water sources. Their conclusions were: (1) pronghorn distribution did not significantly change with changes in free water availability, and (2) that pronghorn densities remained highest in areas with free water available for drinking.

Table 1. Summer water intake for pronghorn based on field and laboratory investigations.

Reference Source	Study Site	Study Animals	Calculated Water Intake
Sundstrom (1968)	Natural habitat enclosure, Wamsutter, WY	Mixed herd of adults and fawns	1 gal/day/adult (3.8 l/day/adult)
Beale and Smith (1970)	Natural habitat enclosure, Desert Range Exp. Sta., UT	Mixed herd of adults and fawns	0.75 gal/day/100 lb (2.8 l/day/45 kg)
Wesley et al. (1970)	Indoor lab cages, Colorado State Univ., Fort. Collins, CO	4 short yearlings (2 males, 2 females)	0.9 gal/day/100 lb (3.5 l/day/45 kg)
Whisler (1984)	Outdoor lab pens, Sybille Exp. Unit, WY	Adult females	0.95gal/day/100 lb (3.6 l/day/45 kg)

Desert Range Experiment Station Field Study

Beale and Smith (1970) studied pronghorn/forage/water relationships for four years on the Desert Experiment Range in western Utah (Fig. 1). Annual precipitation ranged from 4.25 to 11.3" (10.8-28.7 cm). During summers of above average precipitation, forbs provided 90% of the diet--conversely, years of below-average summer rainfall contributed less than 20%. When forb moisture content was >75%, pronghorn ceased to drink water even though it was readily available. As vegetation lost moisture content, drinking water intake accelerated, reaching 3 qts (2.8 l)/day/animal during extremely dry periods (Table 1). The results of this study indicated that water intake was closely related to succulence of forage that was correlated with amounts of precipitation received.

Beale and Holmgren (1975) also quantified the consumption of drinking water for pronghorn in western Utah. Drinking water intake increased as moisture in forage decreased. Water use was highest during hot summer periods. The amount of drinking water ingested ranged from 0.66-1.72 gal (2.5-6.5 l)/100 lb (45 kg)/day with an average of 0.75 gal (2.8 l)/day/animal during summer.

Experiments were conducted by restricting the availability of drinking water for some animals. Adult females with fawns were most affected by dehydration. Adult animals lost weight, appeared thin and dehydrated, were less active, spent less time feeding and more time lying down, and feces moisture content decreased. When animals rehydrated, their recovery was observable within hours as the weak and inactive became strong and active. Beale and Holmgren (1975:25) reported three important points developed from this study:

> "(1) Pronghorn antelope does and fawns can do well with regard to physical condition and growth on *Atriplex-Eurotia* vegetation types found at lower elevations on the desert areas of western Utah during summers of average forage production if drinking water is readily available.
> (2) Without drinking water, pronghorns cannot live during hot summer months on these rangelands for extended periods of time, even when above average forage succulence occurs.
> (3) The amount of drinking water required for pronghorns is related both to maximum air temperatures and the amount of moisture in the feed they are utilizing. An increase of 25 degrees F in daily maximum air temperatures (when in the 70-100 degree range) increases water intake of pronghorns approximately one gallon per 100 lb of animal weight."

Colorado State University Laboratory Experiments

Wesley et al. (1970) conducted studies on four short yearlings (two males and two females). They measured food and water intake under laboratory controls at Colorado State University, Fort Collins, Colorado. Tested animals were reported having a slightly higher content of body water than ruminants examined in other studies, possibly because pronghorn have a lower fat content than most domestic or laboratory animals. Water flux in pronghorn is similar to that of deer (*Odocoileus* spp.). Water kinetics was noticeable different for females and males.

Water consumption was 1.0 and 1.27 gal/day/100 lb animal for two females, while these values for two males were 0.76 gal and 0.62 gal with an average of 0.9 gal for both sexes (Table 1). According to the authors, pronghorn are possibly energetically expensive ruminants to maintain because of their high metabolic rate.

The authors cautioned the interpretation of these findings to include uncontrolled animals, because confined animals have increased water flux compared to wild, free-roaming pronghorn.

University of Wyoming Laboratory Experiments

Whisler (1984) conducted laboratory experiments with adult female pronghorn at the Sybille Experimental Unit in southcentral Wyoming relative to:

(1) quantifying daily water intake obtained from drinking water, preformed water in forage, and metabolic water production,

(2) measuring daily water losses through feces, urine, and evaporation from the respiratory tract and skin in both hydrated and dehydrated animals, and

(3) investigating possible behavioral, morphological, and physiological adaptations pronghorn possess to survive periods of water shortages.

Water intake rates were measured for drinking water, preformed water, and metabolic water production (Table 1 and Table 2). The average water intake was 0.95 gal/day/100 lb animal(3.6 l/day/45 kg animal). This rate was slightly higher (Table 1) than Wesley et al. (1970) and may have been related to the presence of solar radiation and higher activity levels when compared to Wesley's animals, which were more confined in indoor laboratory cages.

When pronghorn were deprived of water, Whisler (1984)noted the following responses contributed to water conservation:

(1) Physiological--- decrease in body moisture by 23%, reduced exhaled air temperature, increase in urine urea concentration, decline in respiratory rate by 50%, and cessation of panting.

(2) Behavioral---decreases in activities, increased time spent under shade (that diminishes need for evaporative cooling), and decreased forage consumption (to lower feces and urea production). Evaporation accounted for nearly 50% of total water losses, urine 33%, and feces 17%.

Pronghorn apparently have adapted to survive periods of water deprivation. However, after periods of dehydration and the return of water availability, these mammals rapidly rehydrate and regain vigor. No deleterious effects were observed upon rehydration. Their adaptive abilities allow them to maintain plasma volume when dehydrated, and they posses counter-cooling structures allowing for maintenance of relatively cool brain temperatures during fast mobility in high ambient temperatures--a survival mobility adaptation for escape from enemies during warm seasons. Whisler (1984:56) summed up pronghorn water requirements by stating, "Without water conserving mechanisms, pronghorn would rapidly loose water, become severely dehydrated, and die."

Table 2. Calculated mean water intake for three hydrated and three dehydrated adult pronghorn during summer in Wyoming (modified from Whisler 1984).

Water Intake	Gains for Hydrated Animals		Gains for Dehydrated Animals	
	liters	gals.	liters	gals.
Drinking	2.847	0.75	0.530	0.14
Preformed	0.31	0.08	0.075	0.01
Metabolic	0.091	0.02	0.026	0.00
TOTAL	3.248	0.85	0.631	0.15

Sonoran and Peninsular Pronghorn Water Relationships

The distribution of Sonoran pronghorn (*Antilocapra americana sonorensis*) is currently limited to the Sonoran Desert in Arizona, USA, and Sonora, Mexico (US Fish & Wildlife 1982). There are few sources providing permanent drinking water. There are no reports that any one has seen a free-roaming Sonoran pronghorn drink water at any time (Monson 1968, Phelps 1978).

Sources of drinking water are almost nonexistent within Sonoran pronghorn habitat (Arizona Game and Fish Department 1981). Water at the time of European settlement was available when the Gila River and Rio Sonoyta were flowing permanently. However, these rivers have been developed for agriculture and no longer flow permanently, thus pronghorn habitat has deteriorated with contemporary human activities. Permanent springs or water holes also are limited in pronghorn habitat, although they exist in adjacent mountains. Water from ephemeral pools may be available depending on rains, which annually average <5" (<13 cm). Several wells and water catchments (guzzlers) have been developed, but their use by pronghorn appears to be minimal (Arizona Game and Fish Department 1981).

During the late 1980's, Hughes and Smith (1990) conducted 166 observation hours at water sources in pronghorn use areas. They hypothesized that average distances to water would be less in the dry season than the wet, if Sonoran pronghorn relied on drinking water to help meet metabolic requirements. However, they found no significant differences in distances to water between the dry and wet season. In conclusion Hughes and Smith (1990:33) stated "we found no confirmed evidence (pronghorn sightings, tracks, feces) near water sources in pronghorn use areas to suggest that Sonoran pronghorn drink water." The authors reported high use of succulent forbs (including cacti) and indicated that Sonoran pronghorn may meet water needs from moisture in food.

The peninsular pronghorn (*Antilocapra americana peninsularis*) now is limited to a portion of the Vizcaino Desert in South Lower California, Mexico (Cancino 1994). Cancino reports that there are no permanent drinking water sources known to be available for pronghorn. He noted these animals consume large quantities of succulent forage, may obtain water from vegetation containing dew and fog, and may use pools of water caught during infrequent rains (averaging 3.6" -- 9.24 cm annually) (J. Cancino, person. comm. 11/93).

Both the Sonoran and peninsular pronghorn are classified as endangered subspecies (Simon 1966)---the only subspecies so classified for this genus. Population densities of <1/m (<2.6 km) exist for these subspecies inhabiting environments with low available water sources compared to populations in Wyoming and Montana where drinking water is more available and herds range from 5-10 animals/mi (2.6 km) (Yoakum 1968).

DISCUSSION AND MANAGEMENT RECOMMENDATIONS

Pronghorn primarily obtain water by drinking free water and from succulent forage (Einarsen 1948, Sundstrom 1968, Wesley et al. 1970, Beale and Smith 1970 , Whisler 1984, O'Gara and Yoakum 1992). Snow may be ingested as a moisture substitute (Skinner 1922, Rouse 1941, Hoover et al. 1959, Bruns 1977, Taylor 1975). Water is also obtained through metabolic processes, but this is minor (Table 2) compared with quantities obtained by free and preformed water (Whisler 1984). Herds at sea level along the Pacific Ocean coast in South Lower California, Mexico, where permanent free water is not available, are believed to obtain water mainly from dew on vegetation and from succulent forage (J. Cancino, person. comm., 11/93).

When available, pronghorn drink free water from natural sources, i.e., springs, seeps, streams, rivers, lakes, and ephemeral pools of rainwater. They likewise consume water from man-made structures such as reservoirs, troughs, and precipitation catchments (Yoakum 1978) (Fig. 1 and Fig. 2).

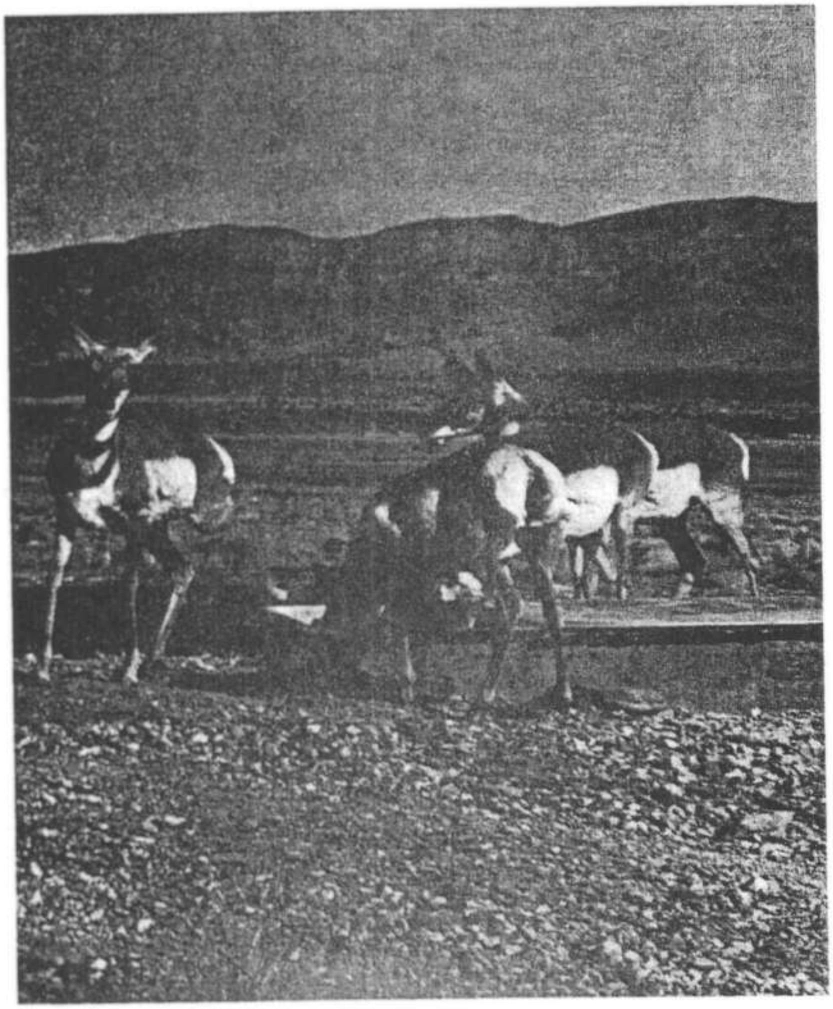

Fig. 1. Pronghorn drinking water from troughs installed at the Desert Range Experiment Station, Utah. (Photo by Donald M. Beale, Utah Division of Wildlife Resources).

Fig. 2. Pronghorn drinking at a stock pond in Wyoming (photo by George Dern, US Soil Conservation Service).

The quantity of water consumed varies with body size, age, sex, health, lactation, and physical activity of the animal, as well as with humidity and ambient temperature of the environment, and availability of succulent forage. The use of water decreases with lower temperatures, snow cover, succulent forage, and dew or rain. Conversely it increases with drier atmospheric conditions, lack of snow, dry forage, and higher temperatures. In Wyoming, pronghorn were adversely stressed when snow or free water were not available during winters (Guenzel et al. 1982, Cook 1984).

Water requirements for pronghorn have not been well documented or understood. Two studies (Sundstrom 1968, Beale and Smith 1970) reported the quantity of drinking water consumed for free-roaming animals. Wesley et al. (1970) reported water turn-over rates for yearlings confined in laboratory cages. Whisler (1984) investigated water intake of all three forms (free water, preformed water from feed, and metabolic water production).

Pronghorn in northern environments drink water frequently when it is available. When they are deprived of this nutrient, they exhibit dehydration stress, affecting both health and reproduction. However, pronghorn in southern hot deserts have evolved with little or no permanent drinking water; consequently, they have adapted to living with low quantities and infrequent access to free water.

According to Whisler (1984), summer water requirements for an adult pronghorn in Wyoming were 0.95 gal/day/100 lb (3.6 l/day/45 kg) animal (Table 1). This water requirement was based on studies of laboratory animals, and the water needs for free-roaming animals accustomed to drinking water may be greater. Managers responsible for developing free water sources would do well to consider pronghorn water requirements (for animals accustomed to drinking)for summer use to average l gal (3.8l)/day/per adult animal. Drinking water in quantities of approximately 1/4 of summer rates, should be available for pronghorn during winters when free water (including snow) is not available for herds accustomed to drinking.

Three studies (Beale and Smith 1970, Wesley et al. 1970, Whisler 1983) reported the physiological changes in pronghorn deprived of drinking water. When animals were dehydrated, they lost weight, changed activity patterns, and lost vigor. When rehydrated, they immediately drank copiously and regained weight and vigor immediately.

The availability of free water appears to be related to pronghorn production, survival, and population densities. Herds inhabiting northern rangelands where drinking water often is available, maintain densities of 5-10 animals/mi, whereas populations in hot deserts have densities of <1/mi (<2.6 km)(Yoakum 1968).

It appears pronghorn have existed for millions of years in habitats experiencing periodic water deficiencies. Pronghorn have developed physiological mechanisms and behavioral characteristics to conserve water for survival. Apparently, the pronghorn is a highly adaptable native ungulate capable of surviving and reproducing on free and preformed water while occupying arid and semiarid western rangelands.

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COPPER DEFICIENCY IN CAPTIVE PRONGHORN FAWNS

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Abstract: In 1989, copper deficiency was diagnosed in hand-reared captive pronghorn (*Antilocapra americana*) fawns at the Los Angeles Zoo, Los Angeles, California. Clinical signs were manifested in unweaned fawns and included anemia, anorexia, progressive paresis/recumbency and acute aortic rupture. Blood serum copper levels in fawns born during the 1989 season (0.08-0.67 ppm, n=12) were below levels considered normal for domestic sheep and goats (0.7-2.0 ppm). Copper supplementation of the hand-rearing formula was initiated and resulted in an increase in mean serum copper levels (from 0.45 ppm before supplementation to 0.68 ppm after supplementation). This difference was found to be statistically significant ($P<0.05$). Fawns born in subsequent seasons (1990-1993) supplemented with copper had similar mean serum copper levels (0.68 ppm) and no objective clinical signs of deficiency.

PROC. PRONGHORN ANTELOPE WORKSHOP 16:158-167

Key words: *Antilocapra americana*, copper, minerals, nutrition, pronghorn.

Copper deficiency is considered one of the most common mineral deficiencies in livestock worldwide (McDowell 1985a, Maas et al. 1992). It has also been reported in nondomestic species including red deer (*Cervus elaphus*), Tule elk, (*C. e. nannodes*) blesbok (*Damaliscus dorcas phillipsi*), impala (*Aepyceros melampus*) and waterbuck (*Kobus defassa*) (Blood et al. 1983, Dierenfeld et al. 1988, Maskall and Thornton 1989, Jessup 1993). The importance of copper in hemoglobin production, iron absorption and mobilization, nervous system development, bone metabolism, and heart function is made apparent in the spectrum of clinical signs associated with its deficiency (McDowell 1985a, Smart and Cymbaluk 1991). Disorders attributed to copper deficiency include anemia, diarrhea, depressed growth, change of hair color, neonatal ataxia, infertility, heart failure, and skeletal defects (Smart and Cymbaluk 1991). Since the copper requirements for young and growing animals are higher than for adults, young animals often exhibit a higher incidence and severity of signs (Miller 1974, Blood et al. 1983, McDowell 1985a).

Although the National Research Council of the National Academy of Sciences

(NRC) publishes guidelines for dietary copper requirements in domestic species, actual copper metabolism is complicated by a complex array of interrelated factors including age, physiological state, (e.g., gestation), interactions among other dietary factors, especially molybdenum and sulfate, and individual species differences (Miller 1974, McDowell 1985b, Dierenfeld et al. 1988, Smart and Cymbaluk 1991). Since imbalances in many of these related factors, (e.g., excess molybdenum, etc.), may result in a secondary copper deficiency, the presence of adequate dietary copper or normal serum levels is not sufficient to rule-out a deficiency. Consequently, deficiencies are often diagnosed on the basis of a combination of clinical signs, supporting laboratory analyses and response to treatment.

Animals and Clinical History

The Los Angeles Zoo has maintained a pronghorn herd since 1975. In 1984, a 76 day-old female fawn collapsed and died suddenly after a week-long course of supportive therapy for severe weakness and lameness. Necropsy showed that she had a massive dissecting aneurism of the aorta. In 1989, a set of twins was delivered by Cesarian section to a nulliparous female who had been described as a "poor doer". The dam died during surgery. At approximately 56 days of age, the female twin began exhibiting weakness that progressed to posterior paresis, lethargy, diarrhea, decreased appetite, and anemia. The animal deteriorated clinically despite ongoing supportive therapy including antibiotics, vitamin E/selenium, and subcutaneous fluids and was euthanized at 65 days of age. Necropsy findings included bony nodules on two ribs, and serous atrophy of body fat stores. She was diagnosed with suspected copper deficiency. Thus, the objective of our study was to describe the diagnosis and treatment of copper deficiency in captive hand-reared pronghorn fawns.

METHODS

Dietary Supplementation, Sample Collection and Analyses

Due to the death of the fawn with suspected copper deficiency, all remaining fawns born during 1989 were manually restrained and bled for trace mineral analysis. The fawns were 3-4 months of age at that time.

In November 1989 a copper supplementation program was instituted for all fawns. A 5% solution of copper sulfate, providing 18 mg copper per ml, was administered orally once daily at a rate of 0.5 ml per 20 kg of body weight.

Fawns born in subsequent seasons (1990-1993) were bled within one week of birth and then again opportunistically when they were between three and eight months of age. Serum was separated and frozen until analysis could be performed. All samples were submitted to the California Veterinary Diagnostic Laboratory (Davis, California) for trace mineral analysis including zinc, iron, copper, and magnesium. Laboratory values derived from sheep were used for comparison of "normals" and statistical analysis of the various sample groups was performed using the Student's t test and Chi-square analysis. Sample groups included serum values obtained from some of the same fawns at different ages.

RESULTS

The serum copper values from the 1989 fawns are shown in Fig. 1. Twelve samples obtained from nine fawns. All the samples from the 3-4 month-old fawns were below the minimum serum copper value established for sheep by this laboratory (normal range = 0.7-2.0 ppm) (Table 1). A wide range in copper levels was seen among the fawns, which had been hand-reared by the same protocol (Table 2). The serum copper level in the male twin of the female that had died with suspected copper deficiency was 0.08 ppm (sample #3, Fig. 1). The mean serum copper value of 0.45 ppm for the fawns was substantially lower than the minimum value used to diagnose marginal/deficient states (0.7 ppm) (Table 2).

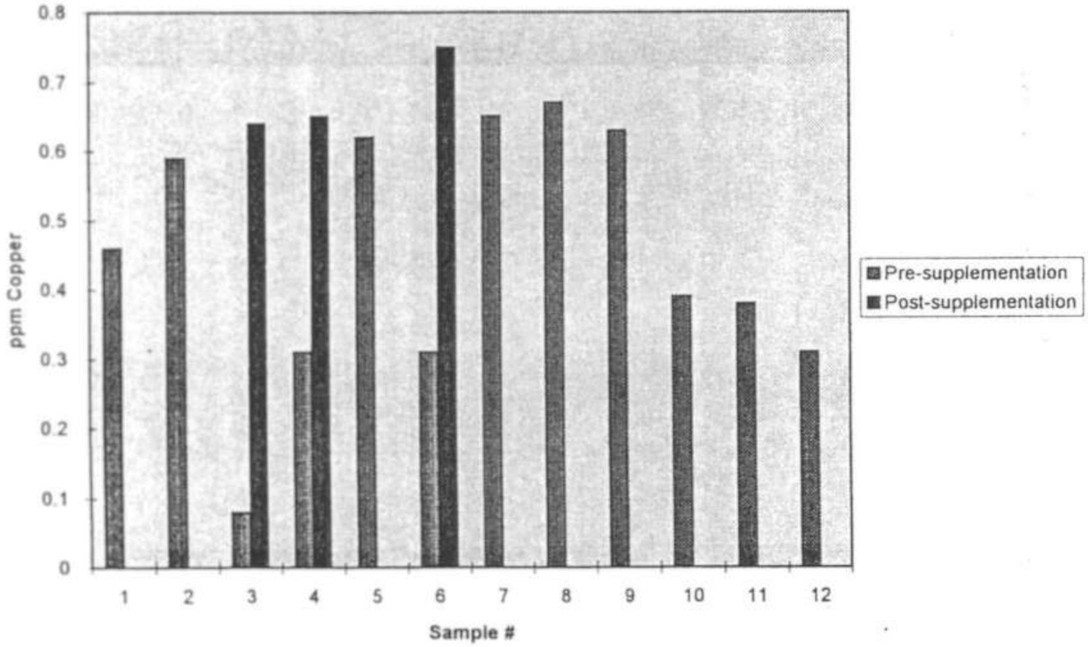

Fig. 1. Serum samples from pronghorn fawns born during the 1989 season are identified on the X axis (12 samples obtained from 9 fawns). Serum copper values (measured in ppm) are shown on the Y axis either before (pre-supplementation) or after (post-supplementation) copper supplementation was initiated. Paired samples are identified by the same sample ID number.

Table 1. Number of serum copper values in deficient, marginal, and adequate categories.

Group sampled	Cu <0.4 ppm*	Cu 0.4-0.7 ppm*	Cu >0.7 ppm*
1989 - presupplementation	6/12 (50%)	6/12 (50%)	0/12 (0%)[a]
1989 - postsupplementation	0/3 (0%)	2/3 (67%)	1/3 (33%)[b]
1990 - 1993	2/11 (18%)	3/11 (27%)	6/11 (55%)[c]

*Categories: Cu < 0.4 ppm - deficient; Cu 0.4-0.7 ppm - marginal; Cu > 0.7 ppm - normal. Statistical significance: a vs b ($P<0.05$); a vs c ($P<0.01$); b vs c (not significant, $P>0.05$); Chi-square test.

Table 2. Means and ranges in serum copper values of captive pronghorn fawns.

Group sampled	n	Mean (ppm)	Range (ppm)
1989 - presupplementation	12	0.45[a]	0.08-0.67
1989 - postsupplementation	3	0.68[b]	0.64-0.75
1990 - 1993	11	0.68[c]	0.36-1.10

Statistical significance: a vs c ($P<0.05$); b vs c (not significant, $P>0.05$); Student's t test. Paired samples from a and b significantly different at $P<0.05$.

Based on the high incidence of marginal/deficient serum copper values (Table 1), a program to supplement the hand-rearing formula with copper sulfate was instituted. Approximately two months after initiation of the program, the remaining three fawns from the herd were rebled. Results are shown in Fig. 1 and Tables 1 and 2. Oral supplementation with copper sulfate solution on a daily basis resulted in a statistically significant increase in mean serum copper values compared to samples from the same individuals prior to supplementation (0.23 ppm pre-supplementation and 0.68 ppm post-supplementation; $P<0.01$, paired t test). The animals that remained in the herd were also those individuals with the lowest initial copper values; supplementation increased serum values from the deficient range into the marginal-low normal range (Table 1). This was a statistically significant decrease in the number of hypocupremic animals ($P<0.05$). In addition to increased serum copper values, no additional clinical cases occurred after supplementation began.

Due to the apparent clinical improvement of the fawns that were supplemented with copper sulfate, the supplementation program has continued during subsequent hand-rearing seasons. Copper sulfate is added to the hand-rearing formula that was feed to the fawns daily from the birth of the fawn until it is weaned. Serum copper results from fawns born during the 1990-1993 seasons are shown in Fig. 2. There was no statistically significant difference between copper values obtained from fawns less than one month of age and those obtained from fawns between one and eight months of age (P>0.1). These two data sets, therefore, were subsequently combined to increase the sample population for further analysis (11 samples obtained from 6 fawns). The mean serum copper value of all supplemented fawns born in 1989 was similar to that of all supplemented fawns born in subsequent seasons (Table 2). However, the percentage of supplemented fawns born after 1989 with normal serum copper was higher than the percentage of supplemented fawns born in 1989, although the difference was not statistically significant (Table 1).

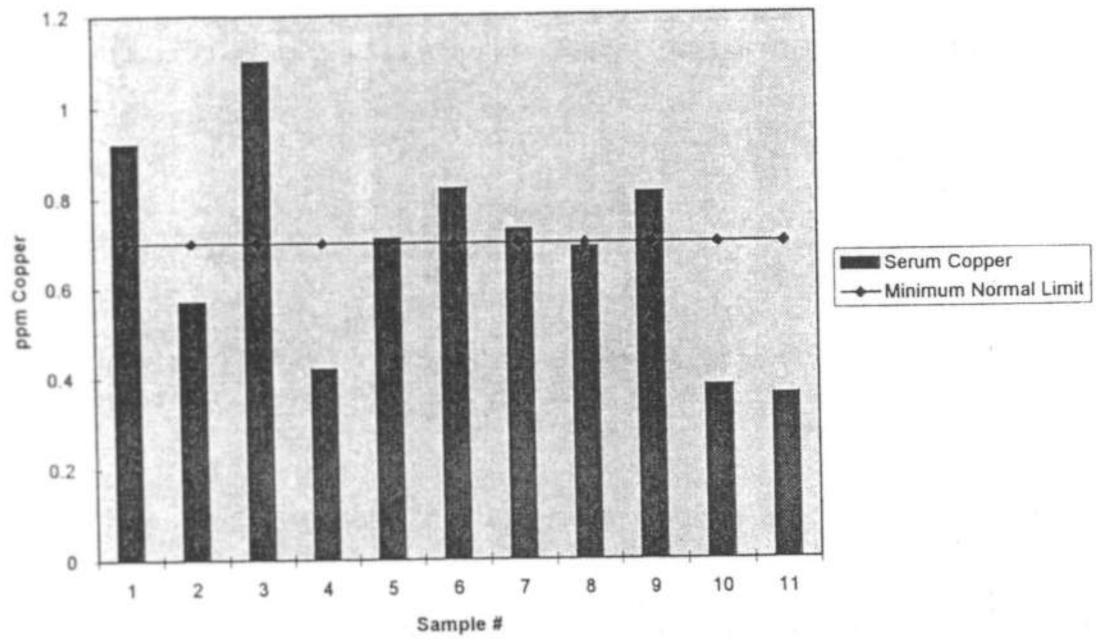

Fig. 2. Serum samples from pronghorn fawns born between 1990 and 1993 are identified on the X axis. Serum copper values (measured in ppm) are shown on the Y axis. A horizontal line set at 0.7 ppm copper represents the value used to assign the minimum normal limit.

The comparison between serum copper values of non-supplemented fawns (born in 1989) and supplemented fawns (born 1990-1993) is shown in Fig. 3. As expected, oral copper sulfate supplementation resulted in a statistically significant

($P<0.025$) increase in serum copper levels and a cessation of any further clinical cases of copper deficiency. Therefore, although the mean value was still considered below normal, there was apparent clinical improvement in the herd.

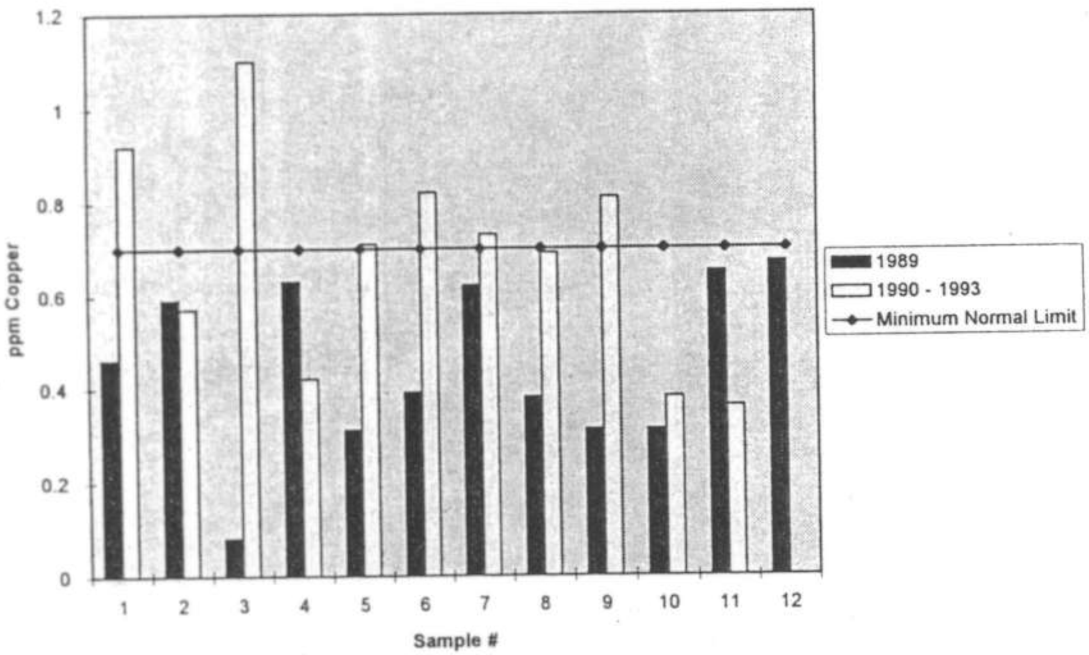

Fig. 3. A comparison of serum copper values from fawns that were not supplemented with copper sulfate (1989) is made with fawns that received copper sulfate supplementation (1990 - 1993). A horizontal line set at 0.7 ppm copper represents the value used to assign the minimum normal limit.

DISCUSSION

Most neonatal ruminants are susceptible to trace mineral deficiencies due to the low mineral content of milk (Jurgens 1982, Blood et al. 1983). However, the fetus normally can cope with this due to *in utero* placental transfer of copper and its storage in the liver. Calves may be born with higher liver copper values than their dams, especially if the dams are on a marginal diet (McCaughan 1992, Viejo and Casaro 1993, Xin et al. 1993). Neonatal calves may be protected from deficiency through utilization of hepatic copper stores for up to four months (McCaughan 1992). Often, the most severe clinical signs are exhibited in animals two-three months of age through weaning. The timing of the clinical syndrome points to the role of hepatic copper and inadequacy of milk to provide sufficient copper intake (Blood et al. 1983). The two pronghorn fawns (at the Los Angeles Zoo) that died with clinical and pathological signs consistent with copper deficiency were two-three months of age.

Copper levels in the central nervous system of the fetus are also influenced by copper nutrition of the dam during perinatal development and may result in persistent changes of the central nervous system (Blood et al. 1983, Prohaska and Bailey 1993, Rietcorrea et al. 1993). Enzootic ataxia is a disease of suckling lambs born to ewes that have inadequate dietary intake of copper.

Subclinical copper deficiency is difficult to diagnose due to the lack of specific clinical signs. Since the liver is the primary storage organ for copper, serum copper levels may be maintained in the normal range through release into general circulation until the hepatic copper levels drop significantly (<40 ppm) even though dietary levels are inadequate (Maas et al. 1992, Wikse et al. 1992). Consequently, at such time that serum copper levels decline to an abnormally low level a presumption of declined liver stores may be made and copper deficiency diagnosed.

Due to the presence of clinical signs and deaths consistent with copper deficiency, a survey of serum copper levels was conducted in pronghorn fawns born in 1989. Since the fawns were three-four months of age, the low serum copper levels probably reflected depletion of hepatic stores. Although the dams' serum or hepatic copper levels were not measured at that time, studies are currently underway to assess potential subclinical copper deficiency in the adult pronghorn herd. Inadequate dietary copper intake or the presence of interfering dietary substances in the dams may have contributed to lower hepatic stores in the fawns. Secondary copper deficiency is a common occurrence in California livestock (Morris 1991, Maas et al. 1992).

Since dietary copper requirements are often complicated by multiple physiological interactions (as previously discussed) often the best diagnostic criterion is response to supplementation (McDowell 1985, Dierenfeld et al. 1988, Suttle 1988, Smart and Cymbaluk 1991, Blincoe 1993, Littledike and Young 1993, Xin et al. 1993). This is especially true with exotic species in which the nutritional requirements have not been established. We chose to supplement with copper sulfate because it is commonly used in domestic livestock to treat deficiency, it provides bioavailable copper, and it can be administered orally, thus avoiding local tissue reactions and potential toxicity of parenteral forms (Blood et al. 1983, McDowell 1985, Morris 1991). Based on the resolution of clinical signs and increase in serum copper values, the fawns showed a positive response to supplementation. Although mean serum values for supplemented fawns were considered below normal compared to domestic ruminants, it is unclear whether this indicates a subclinical deficiency state or a species-specific difference. Further studies are needed to address these questions.

MANAGEMENT IMPLICATIONS

Nutritional requirements for exotic species play an important role not only in the health of each individual, but in the overall reproductive health of the herd as well. Free-ranging animals have been shown to select forages to balance mineral requirements (McNaughton 1990). However, captive animals are usually offered a limited array of feeds, and regional differences may result in nutritional imbalances in forages and water provided. The pronghorn herd at the Los Angeles Zoo experienced two fawn deaths that could be attributed to copper deficiency. Although objective clinical signs in the adults were not detected, serum copper levels in unweaned fawns indicated inadequate hepatic stores that probably resulted from subclinical secondary copper deficiency in their dams. At the Los Angeles Zoo, oral copper sulfate supplementation has proven to significantly increase serum copper levels in pronghorn antelope fawns. However, until species-specific dietary copper requirements are established, resolution of clinical signs will remain the most practical diagnostic and health maintenance indicator.

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1993 CENSUS OF THE PENINSULAR PRONGHORN

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Abstract: A census of the peninsular pronghorn (*Antilocapra americana peninsularis*) was conducted in April, July, and November 1993 in the "El Vizcaino" Biosphere Reserve in South Lower California, Mexico. Aerial and ground searches were done simultaneously and compared to avoid double counting. Apparently there is a population increase over previous years, with 175 pronghorn counted. The April census showed a healthy fawn to doe ratio of 66:100. Total animals seen were: April 135, July 82, and November 175. The low number in July reflects wide dispersion during that time of year. The aid of radio collars would assist in location of widely dispersed herds in future surveys.

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Key words: Pronghorn, census, *Antilocapra americana peninsularis*, Mexico.

Nelson (1925) stated: "... it is rather surprising that they have continued to survive" referring to the peninsular pronghorn. Nelson (1925) estimated a total of 500 animals for the subspecies (Fig. 1) located in 3 separate populations in Lower California, México. Huey (1964) remarked: "Today the subspecies totters on the verge of extinction with a few reputedly living on the arid remote desert llanos... It is safe to predict that within the next 20 years this race will have disappeared from Baja California." Presently, 70 and 20 years respectively, following the preceeding authors assessments, there are apparently 200 or more peninsular pronghorn. Today, peninsular pronghorn are limited to only one of the former habitats (Hall, 1981), i.e. the Vizcaino Desert located in the northwest corner of the state of South Lower California, México.

Peninsular pronghorn are classified as an endangered subspecies according to the Diario Oficial (1991) and the International Union for Conservation of Nature and Natural Resources (1988). In order to protect all pronghorn in Mexico, hunting has been prohibited by federal law since 1922. The area currently occupied is dedicated to the perpetuation of this endemic subspecies has been declared the Biosphere Reserve "El Vizcaino" (Diario Oficial 1988).

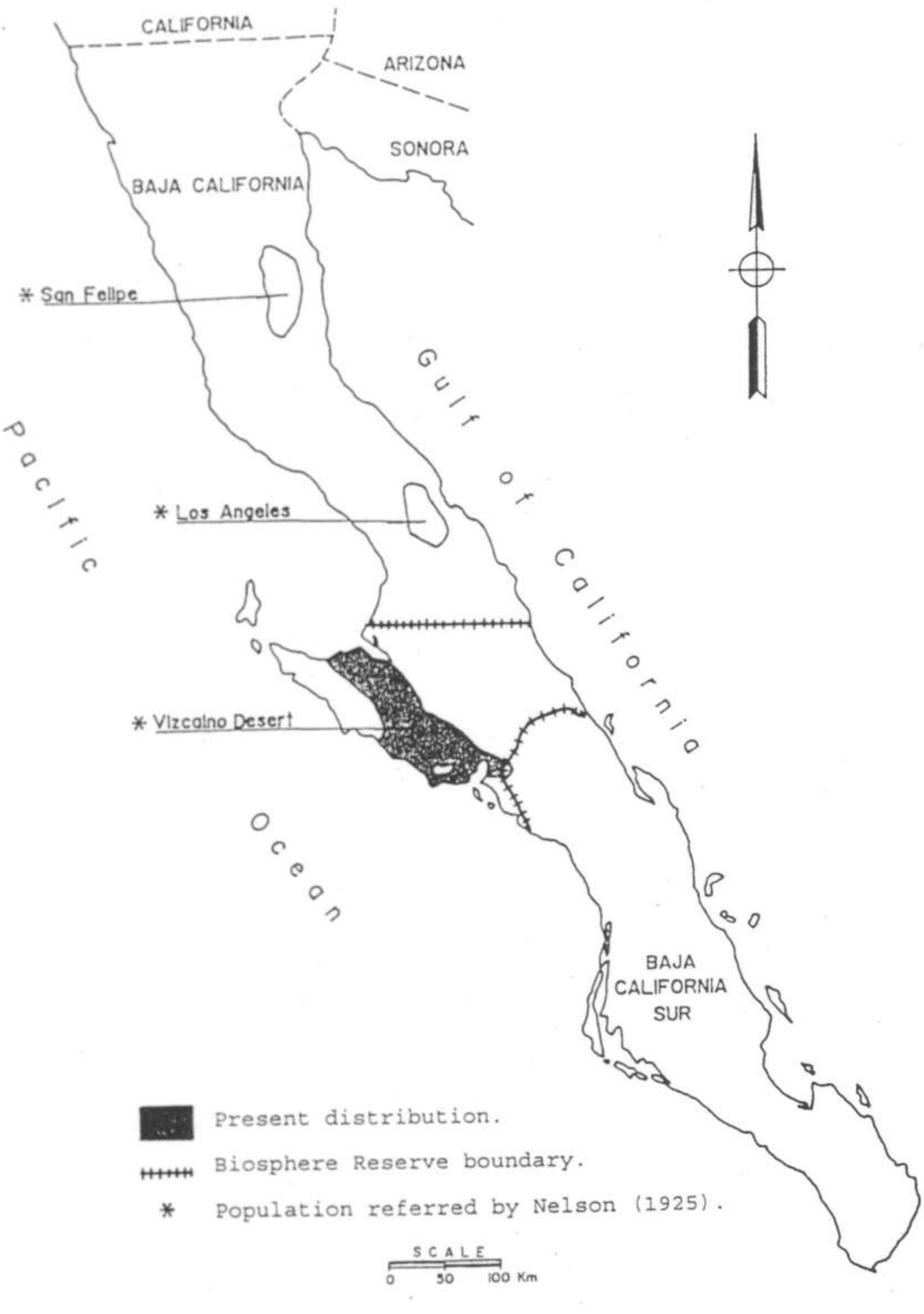

Fig. 1. Present distribution of the peninsular pronghorn.

Jaramillo (1989) presents a summary of the status of peninsular pronghorn stating they were "few", "small groups", and "abundant". Most of the citations referred to populations in the Vizcaino Desert. Perhaps for this reason, census efforts since 1977 have been carried out in the Vizcaino Desert. Surveys have been conducted almost annually until now (Cancino et al. In prep.).

The Centro de Investigaciones Biologicas del Noroeste S.C. - Northwest Biological Research Center (CIBNOR), Secretaria de Desarrollo Social (SEDESOL), Cia. Exportadora de Sal (ESSA) and CONACyT (No. 0639 N9110) conducted three surveys in 1993 to obtain biological data relative to changes in the population. The objective of our paper is to present the results of the censuses conducted in the Vizcaino Desert during 1993.

Sandra Lanham (Environmental Flying Services) assisted by piloting her airplane. Jim D. Yoakum encouraged and reviewed previous drafts of our paper.

STUDY AREA

The present habitat of all peninsular pronghorn (Fig. 1) is within the Vizcaino Reserve which is part of the Sonoran Desert (Shreve and Wiggins 1964). León de la Luz et al. (1991) described nine vegetative associations within the Biosphere Reserve. Pronghorn use mainly three of these plant communities: halophilous shrub, dune shrub and spineless shrub (Cancino 1988). Topographic characteristics include undulating plains, low hills, small plateaus, sand dunes and dry watershed courses. These habitat characteristics are similar to certain other historical pronghorn habitats, however, contemporary peninsular pronghorn habitat has one factor that differs: herds occupy rangelands from sea level to 250 m.

Salinas-Zavala et al. (1991) described the climate as dry, semi-hot with annual temperature ranges 18-22°C, and annual precipitation of 9.24 cm received during winters. There is a strong influence of fog and dew from the ocean that is not recorded by the weather stations.

METHODS

Several reports document procedures for conducting pronghorn surveys (Firchow et al. 1990, Johnson et al. 1991, O'Gara and Yoakum 1992). Also, procedures to correct biases are suggested by O'Gara and Yoakum (1992). But because of the number and distribution of the peninsular pronghorn, we modified these techniques. The surveys were conducted as follows: intensive searches were conducted in an area of approximately 5,000 km^2 divided into seven zones. Two ground vehicles and one airplane (Cessna 182) were used in each census with at least four ground and two aerial observers. Each census included five days by ground and 30 hours of flight. The aerial searches were conducted in east-west transects at an average altitude of 100 m with average distance between transects of 1,000 m. In addition, dry stream courses were specifically checked. Each aerial sighting was located with a Global Positioning System instrument. Ground observers used 10x50 binoculars or a 10-40x spotting scope to locate and observe pronghorn from vantage points. Both ground and aerial surveys reported time of day, herd size, age and sex composition, and flight direction.

A search summary containing observations from ground and aerial surveys was plotted and contrasted on 1:50,000 maps. The records were analyzed separately to avoid double counts.

RESULTS

Table 1 and Fig. 2 depict the results of the surveys conducted during April 15-19, July 17-21 and November 16-20, 1993. The highest number of pronghorn observed for this and all previous annual surveys was 175 individuals in November. The birth season for the peninsular pronghorn begins in January and extends into early March. The April census was timed to determine fawn production and 35 were observed. During the July census, it was not possible to estimate fawn survival because of two difficulties in determining age: fawns and yearlings were difficult to distinguish, and the shedding of horns sheaths by males was hard to determine at a distance. Seasonal results of these censuses are in agreement with O'Gara and Yoakum (1992): "...choice of survey time have a profound effect on survey results..." Thus, April was the right time to observe fawns, and July was not the best time to estimate herd numbers. Surveys conducted during November provided the highest total population number; just as it has in previous years of surveys.

Table 1 shows the males:100 females and fawns:100 females ratios. The April census provided both ratios (88:100 and 66:100 respectively), while July and November depicted the males:100 females ratio because of the aforementioned aging difficulties. The 88FF:100DD ratio is considered good for the study area. Jaramillo (1989) presented fawn:female ratios for several years and several times in certain years. The 1993 ratio (88:100) was the same as October 1979, but there were some years with "poor" ratios, for example 12:100 in June 1983 (Jaramillo 1989). We hope to continue the surveys as a means of obtaining more data relative to annual fawn recruitment.

Fewer pronghorn were observed during July and some sightings were noted in areas where animals had not been seen during the last 10 years. Results from our 1993 surveys indicate high summer dispersal and possibly an increase in population.

Table 1. Results of 1993 census for peninsular pronghorn in the Vizcaino Desert, South Lower California, Mexico. (A = Aerial census; G = Ground census)

Date	Type survey	Total Counted	Male: female	Fawn: female
April	G	51	23:100	37:100
April	A	121	80:100	82:100
May	G	13	43:100	43:100
Summary		**135**	**88:100**	**66:100**
July	G	35	145:100	27:100
July	A	55	160:100	---------
Summary		**82**	**170:100**	**5:100**
November	G	117	66:100	---------
November	A	151	140:100	---------
Summary		**175**	**85:100**	

CONCLUSION

Based on our 1993 surveys, the occupied range reported previously for the peninsular pronghorn (Gonzalez-Romero et al. 1991) will be remapped to indicate habitat currently occupied. In order to assess population dynamics of the peninsular pronghorn, it is recommended that three seasonal surveys be conducted annually. However, the time for each census should be further evaluated: it is suggested that April and November be maintained, but starting dates could be adjusted. The summer census should be accomplished at least one month earlier, with the starting date also adjusted. It is recommended that radiotelemetry and vegetation studies be accomplished in the future in order to help obtain needed information for this endangered subspecies.

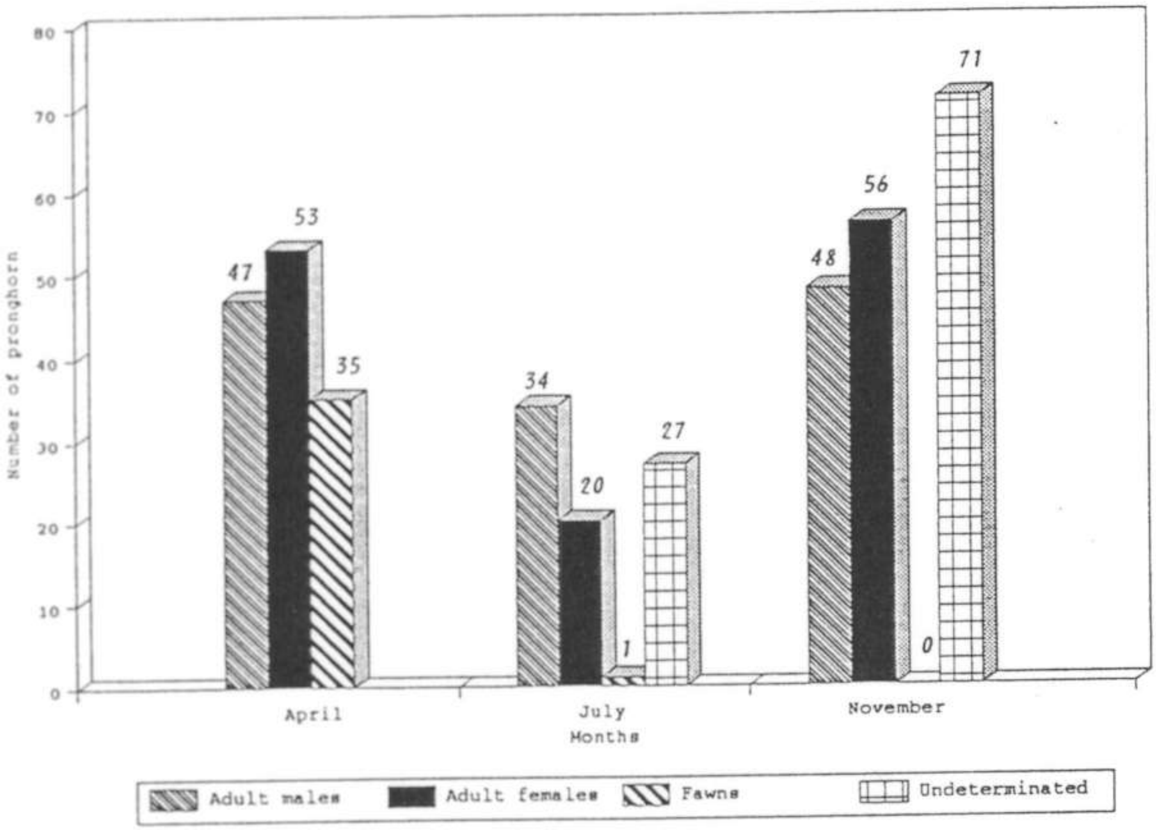

Fig. 2. Sex and age of peninsular pronghorn in the 1993 census.

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FOOD HABITS OF THE PENINSULAR PRONGHORN

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Abstract: The current population of peninsular pronghorn (*Antilocapra americana peninsularis*) is within the Biosphere Reserve in the Vizcaino Desert of South Lower California, Mexico. There are nine vegetative associations in this area of which pronghorn use three: halophilous shrub, dune shrub and spineless shrub. Plant succulence and dew are crucial because no permanent drinking water is available. Feeding habits of the subspecies were studied by microhistologic analysis of fecal samples, together with direct and indirect observations. Diet selection averaged 44% shrubs, 22% forbs, 4% grasses, and 30% unidentified.

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Key words: Food habits, *Antilocapra americana peninsularis*, Vizcaino Desert, succulence, water.

The peninsular pronghorn is an endangered subspecies (International Union for Conservation of Nature and Natural Resources 1988, Diario Oficial 1991). For some 20 years its distribution and population has been limited to the Vizcaino Desert in the state of South Lower California, Mexico (González-Romero et al. 1991). There is currently little information available on this subspecies.

In order to protect all pronghorn in Mexico, federal law prohibited hunting since 1922. The present distribution of the entire peninsular pronghorn is within the Biosphere Reserve "El Vizcaino" (Diario Oficial 1988).

Although surveys have been conducted for some 20 years, most other aspects of management have been neglected. Knowledge of the species biology and condition of habitat are needed to develop a creditable recovery plan.

Microhistological analysis of fecal samples is one of the most appropriate techniques for studying the peninsular pronghorn's food habits because many samples can be obtained and animals need not be sacrificed (Smith and Shandruk 1979). This is especially true for Mexico where hunting of pronghorn is prohibited by law, therefore, there is little opportunity to obtain stomach samples. Fecal samples can be readily preserved (Fitzgerald and Waddington 1979) and results are reliable when compared with other food habit techniques (Todd and Hansen 1973, Anthony and Smith 1974, Kessler et al. 1981). The objective of my study was to determine major food plants consumed year-long by pronghorn in the Vizcaino Desert.

My study was accomplished in a partial fulfillment of course requirements for a Bachelor degree at the University Autonoma of Chapingo, Mexico (Cancino 1988). Financial support was obtained from SEDUE (Secretaria de Desarrollo Urbano y Ecologia). Dr. Bart O'Gara and Jo Meeker provided valuable assistance to develop the study, and Jim D. Yoakum encouraged publication and reviewed the manuscript.

STUDY AREA

The Vizcaino Desert is within the Sonoran Desert (Shreve and Wiggins 1964) in the northwest corner of the state of South Lower California, Mexico (Fig. 1). Nine vegetative associations are described for the Reserve (León de la Luz et al. 1991), but pronghorn generally use three: halophilous shrub, dune shrub, and spineless shrub. *Frankenia palmeri, Chaenactis lacera* and *Encelia californica* are the dominant species in each association. Topography consist of plains, low hills, sand dunes and dry water courses, with the latter being extensively used during the dry season. Elevation ranges from sea level to 250 m. Climate was dry, semi-hot, with an average annual temperature range between 18-22°C. Precipitation was predominately obtained during winter and averaged 9 cm (Salinas-Zavala et al. 1991). Despite the importance of relative humidity and dew, these factors were not recorded.

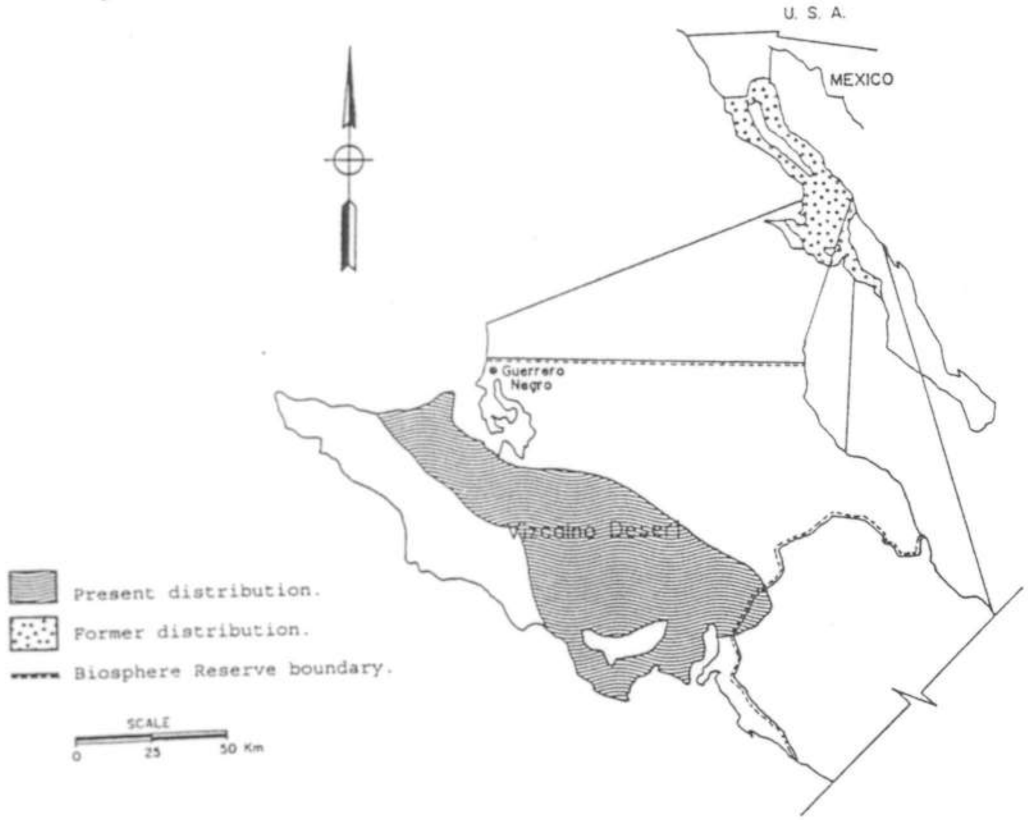

Fig. 1. Historic and present distribution of the peninsular pronghorn in Lower California peninsula, Mexico.

Two environmental factors are noteworthy: there are no known sources of permanent fresh water for drinking except rain pools lasting one-two days following infrequent rains, and domestic cattle graze the area throughout the year.

METHODS

Vegetation samples were collected and later identified for reference slides by the Biology Institute of the Universidad Nacional Autonoma de Mexico, Mexico City, Mexico. These were then compared to slides of fecal samples from pronghorn, which were collected from January 1984 to March 1986. Samples were obtained during other activities at the Reserve, so there was no specific schedule for collection. Samples were collected from the areas most frequented by pronghorn. No other wild ungulate such as mule deer (*Odocoileus* sp.) or bighorn (*Ovis* sp.) inhabit the area. Several additional plant species were recorded in accordance with direct and indirect methods described by Hlavachick (1968).

Microhistological analysis of feces, as described by Hansen et al. (1978) was the main technique used. Records of the microscope field examination were grouped into four categories: shrubs, forbs, grasses, and unidentified. Cacti were grouped with forbs, and trees were included in the shrub class, as suggested by Yoakum (1990). Most plants were identified to species; however, some could be keyed only to genus. From the preliminary review of reference slides, flower fragments were easily identifiable, e.g. for instance stamens, petals, and pollen grains, and were recorded into the unidentified category.

RESULTS AND DISCUSSION

Table 1 lists 38 plant species identified from 114 fecal samples. These fecal samples were collected on frequently used rangelands that represented approximately 20% of the pronghorn habitat. The average consumption by forage class (Figure 2) indicates shrubs represented 44%, forbs 22%, grasses 4%, and the remaining percent was unidentified. Most of the unidentified percentage was flowering parts, primarily forbs and shrubs, however positive species identification was not accomplished.

Yoakum (1990) pointed out few reports were published regarding pronghorn food habits in the desert biome. One of these studies was conducted for Sonoran pronghorn (*A. a. sonoriensis*) in Arizona and Mexico where consumption was highest for forbs and shrubs with minor use of grasses (Edwards and Ohmart 1981). Peninsular pronghorn likewise ingest mainly forbs and shrubs.

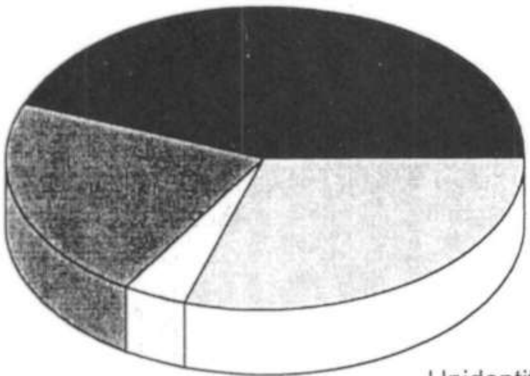

Fig. 2. Year average of food habits of the peninsular pronghorn.

Table 2 is a list of 62 plants used by pronghorn as noted by feces analysis and observations. Of this total, 27 were forbs (including 3 cacti and 3 lichens), 26 were shrubs, and the remaining three were grasses.

Slides of lichens were not made because the clearing solutions (both Hertwing and bleach) dissolved the plant. Perhaps that is why lichens were not found in the fecal samples. Lichens, however, could be important because of their ability to store water (B. O'Gara pers. comm.). Lichens have been reported as pronghorn forage by Yoakum (1958) and Thomas and Rosentreter (1992).

Cholla cactus (*Opuntia cholla*) was listed because fruits of this plant were found in the rumen of a dead pronghorn. Edwards and Ohmart (1981) noted the consumption of cholla flowers and fruit by Sonoran pronghorn.

Unfortunately data regarding the composition of available forage classes was not obtained during my study, nor were samples of cattle feces collected and analyzed. If these data were available, it would have been possible to determine preference ratios and degree of dietary overlap. More quantitative data are needed for future management decisions, enhancement of pronghorn habitat, and development of a recovery plan.

CONCLUSION

A more comprehensive food habitat study for the entire peninsular pronghorn habitat along with diet selection of cattle, is needed. Plant composition of available forage also is needed for areas where feces collections are obtained. Several important aspects need evaluation for the desert biome: vegetation condition, pronghorn carrying capacity, and availability and quality of forage. Knowledge of nutritional requirements for pronghorn is limited, and whether these requirements are different for the desert is unknown.

Table 1. Percent composition of forage plants consumed monthly by pronghorn in the Vizcaino Desert, Mexico, from 1984-1986.

Category Species*	Jan'84	May'85	Jun'85	Jul'85	Sep'85	Dec'85	Feb'86	Mar'86
Acacal								0.35
Ambcam	1.63	0.75	2.4	2.16	4.08	1.74	0.89	
Arispp							0.58	0.35
Ascsub	1.74	5.63	3.19	2.93	7.54	2.45	1.91	0.79
Astspp	1.0	3.93		0.85		1.73	2.24	0.79
Atrspp	0.35	1.54	2.8	6.93	4.08	2.82	3.53	1.85
Bacsar		3.53	3.19	3.45	5.36		3.89	
Boubar							0.58	
Burfas		1.54	0.58	0.85			1.54	11.67
Carcor	1.35					3.16		0.35
Cenpal	0.35			0.58			0.35	2.17
Chalac		1.54	7.2	5.16	4.48	1.74		
Ditcal	3.63					0.34		
Dysant							0.35	
Encspp	3.65	11.8	22.3	12.16	12.68	16.03	0.89	
Errben	17.4	14.5	14.2	13.5	16.54	6.62	11.8	13.69
Eupleu							0.89	1.0
Eupmis			2.78		4.97			
Fouspp			0.35					
Fraspp			0.58	2.16			0.35	
Hapspi	1.35					8.34		1.0
Lotrig		0.75	3.6					
Lupspp	6.73	2.75			0.36	2.04	4.62	1.48
Lycspp			1.0					
Marpar	0.35						0.35	
Nictri	1.35					2.43	2.91	
Oenspp	4.35	6.14		5.85	3.25	6.62	6.5	1.0
Pacdis	4.75	4.35	3.59	1.85	3.25	3.53	2.48	4.08
Perspp	14.71	3.14		1.53		4.34	1.54	1.85
Phafil	6.33	3.82	4.0	3.73	0.36	1.0	6.7	8.86
Plains			0.58	0.28			1.91	2.59
Rhulen							0.35	
Solhin							0.35	
Sphspp		1.14	0.29	0.82		0.34	1.54	0.35
Stilin				0.26				
Tripal							0.58	2.17
Sp.1			0.58					1.49
Sp.2	3.9	4.35	1.0	4.0	3.25	1.34	5.28	3.78
Flower	23.7	25.5	24.28	26.83	23.25	24.7	29.8	34.35
Other	1.34	3.15	1.39	3.73	1.97	8.34	5.28	2.96
Total	99.96	99.85	99.88	99.61	95.42	99.65	99.98	98.97

* Note: Abbreviations in Table 2.

Table 2. List of plant species consumed by pronghorn in the Vizcaino Desert, South Lower California, Mexico.

Family Genus-Species	Forage Class	Botanical abbreviation
ANACARDIACEAE		
Pachycormus discolor	Shrub	Pacdis
Rhuss lenti	Shrub	Rhulen
ASCLEPIADACEAE		
Asclepias subulata	Shrub	Ascsub
BRASSICACEAE		
Dithyrea californica	Forb	Ditcal
CACTACEAE		
Ferocactus sp.	Forb	Fersp
Mammilaria sp.	Forb	Mamsp
Opuntia cholla	Forb	Opucho
CHENOPODIACEAE		
Atriplex canescens	Shrub	Atrcan
Atriplex julacea	Shrub	Atrjul
Atriplex policarpa	Shrub	Atrpol
Suaeda sp.	Shrub	Suasp
COMPOSITAE		
Ambrosia camphorata	Shrub	Ambcam
Baccharis saratrhoides	Shrub	Bacsar
Dyssodia anthemidifolia	Forb	Dysant
Encelia californica	Shrub	Enccal
Encelia farinosa	Shrub	Encfar
Haplopapus spinulosus	Forb	Hapspi
Nicolletia trifida	Forb	Nictri
Perityle spp.	Forb	Perspp
EUPHORBIACEAE		
Acalipha calicornica	Shrub	Acacal
Chamacyce sp.	Shrub	Chasp
Euphorbia leucophila	Forb	Eupleu
Euphorbia misera	Shrub	Eupmis
Stillingia linearifolia	Shrub	Stilin
FOUQUIERIACEAE		
Fouquieria diguetii	Shrub	Foudig
FRANKENIACEAE		
Frankenia palmeri	Shrub	Frapal
Frankenia grandifolia	Shrub	Fragra

LEGUMINOSAE		
Astragalus spp.	Forb	Asyspp
Calliandra californica	Shrub	Calcal
Errazurizia benthami	Shrub	Errben
Lotus rigidus	Shrub	Lotrig
Lupinus spp.	Forb	Lupspp
Marina parryi	Forb	Marpar
Phaseolus filiformis	Forb	Phafil
LOASACEAE		
Petalonix linearis	Forb	Petlin
MALVACEAE		
Sphaeralcea spp.	Forb	Spaspp
NYCTAGINACEAE		
Abronia villosa	Forb	Abrvil
ONAGRACEAE		
Oenothera crassifolia	Forb	Oencra
Oenothera primiveris	Forb	Oenpri
OROBANCHEACEAE		
Orobanche sp.	Forb	Orosp
PLANTAGINACEAE		
Plantago insularis	Forb	Plains
SAPINDACEAE		
Cariospermum corindum	Forb	Carcor
SCRPHULARIACEAE		
Russelia casseinea	Shrub	Ruscas
SOLANACEAE		
Lycium spp.	Shrub	Lycspp
Solanum hindsiaanum	Shrub	Solhin
VERBENACEAE		
Burroughsia fastigata	Shrub	Burfas
AMARYLLIDACEAE		
Triteleiopsis palmeri	Shrub	Tripal
GRAMINEAE		
Aristida spp.	Grass	Arispp
Bouteloua barbata	Grass	Boubar
Cenchrus palmeri	Grass	Cenpal
UNIDENTIFIED		
Three species of lichens.		
Two species of forb.		

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CAPTURING PRONGHORN BY NETGUNNING FROM THE GROUND VERSUS THE AIR

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Abstract: The high cost of using helicopters to net gun pronghorn (*Antilocapra americana*) in Yellowstone National Park encouraged me to develop a method of netgunning pronghorn from the ground. I compared ground versus aerial netgunning in terms of logistics, costs, pronghorn mortality, and public relations. A shooter riding in the bed of a pickup truck was able to net 21 adult pronghorn along park roadsides. I modified the net canister and net to make deployment of the net, and release of captured animals, easier. Standard helicopter operations netted 17 animals. The ground team of two members caught about one animal per day at a cost of $167.00 each. The aerial netgunning team of 15 people and two helicopters caught 17 pronghorns in 3.5 hr. The cost of aerial netgunning was $403.00 per animal. Ground netgunning required less training, had fewer logistic difficulties, and caused less public relations problems, than did aerial netgunning. However, ground netgunning was much slower at capturing animals than aerial netgunning. Two weeks after capture, significantly fewer pronghorn netgunned from the ground had died (14.3%) than those netgunned from the air (47.1%). Also, 50% of the pronghorn that had been hog-tied died, whereas only 8.7% of the non-hog-tied animals died. Limited efforts to capture pronghorn from blinds were unsuccessful, but recent results of archery hunters suggest use of pit blinds could be very productive.

PROC. PRONGHORN ANTELOPE WORKSHOP 16:186-197

Key words: Pronghorn, netgunning, costs, mortality, nets.

Early in my study of Yellowstone National Park pronghorn I decided to instrument a few animals with radiotelemetry equipment to determine movements of the herd in and out of the park. Because any animal handling in Yellowstone is liable to receive close public scrutiny, I elected not to capture animals with immobilizing drugs because of possible animal injuries from darts and narrow pronghorn tolerance to drugs (O'Gara and Yoakum 1990). Net guns may be useful tools for capturing pronghorn (Barrett et al. 1982, Firchow et al. 1986), particularly if small numbers of captured animals are desired (O'Gara and Yoakum 1990), and this method was selected.

Biologists use a helicopter to facilitate netgunning of pronghorn (O'Gara and Yoakum 1990), and the manual for the Coda$_{TM}$ net gun contains extensive instructions on deploying nets safely from helicopters (C. R. Gray, Coda Enterprises Inc., Mesa, Ariz., 1990). Although I only had radio transmitters for 20 animals, I had no funds to pay $450.00 to $650.00 per hour to rent a helicopter for pronghorn capture, let alone pay for safety training, ground crews, and per diem. Thus, I was required to try something new - use a net gun from the ground to capture pronghorn. Two years later, I was able to do limited helicopter flying to compare ground and aerial netgunning. The objectives of this work were to: a) develop ground netgunning methodology, b) develop modifications to net gun equipment if needed, and c) compare ground versus aerial netgunning in terms of logistics, costs, pronghorn mortality, and public relations.

My research was partly funded by the National Park Service, Yellowstone National Park, but would not have been possible without considerable volunteer labor. The volunteer help of J. G. Scannell is particularly acknowledged.

STUDY AREA

Pronghorn were captured in rangeland habitat in Yellowstone between Mammoth and the northern park boundary at Reese Creek, some 10 km to the northwest. Big sage (*Artemisia tridentata*) was the dominant shrub, and bluebunch wheatgrass (*Agropyron spicatum*) and needle-and-thread (*Stipa comata*) were common grasses. Vegetation was described in detail by Despain (1990). This area was part of the permanent (winter and summer) pronghorn range in Yellowstone, and covered about 5,000 ha (Fig. 1).

METHODS

Ground Netgunning

My assistants and I carefully studied the net gun manual and followed all safety instructions. As recommended by the manufacturer and O'Gara and Yoakum (1990), I used factory-assembled 3.7x3.7 m nets with 17.9x17.9 cm mesh, with a tensile strength of 170.1 kg. We each test-fired the tool 20 times at plastic garbage can targets, and found the maximum ground-to-ground range of the net under calm wind conditions was about 14 m.

Many Yellowstone pronghorn were habituated to humans and vehicles. They seldom allowed a person to approach on foot closer than about 20 m, but they did permit a slow-moving vehicle to pass by as close as 5 m. Thus, we developed a "drive-by shooting" technique, using a pickup truck. The gunner crouched in the bed of the truck while a driver cruised roads in pronghorn habitat at about 24 km/hr. If the animal remained in range as the vehicle passed, the gunner fired the net. If the animal were netted, the truck was quickly, but not violently, stopped. The gunner immediately jumped out and held the pronghorn down, while the driver pulled the vehicle off the road and then brought the equipment and blindfold-blanket. While the driver installed the pronghorn's radio collar or drew a blood sample, the shooter began disentangling the animal from the net. We never attempted to net a pronghorn if another vehicle was in sight on the road, and we avoided capturing animals where we could not see at least 0.5 km in both directions. As recommended by O'Gara and Yoakum (1990), I never captured more than one pronghorn in a net, to prevent animals from injuring each other.

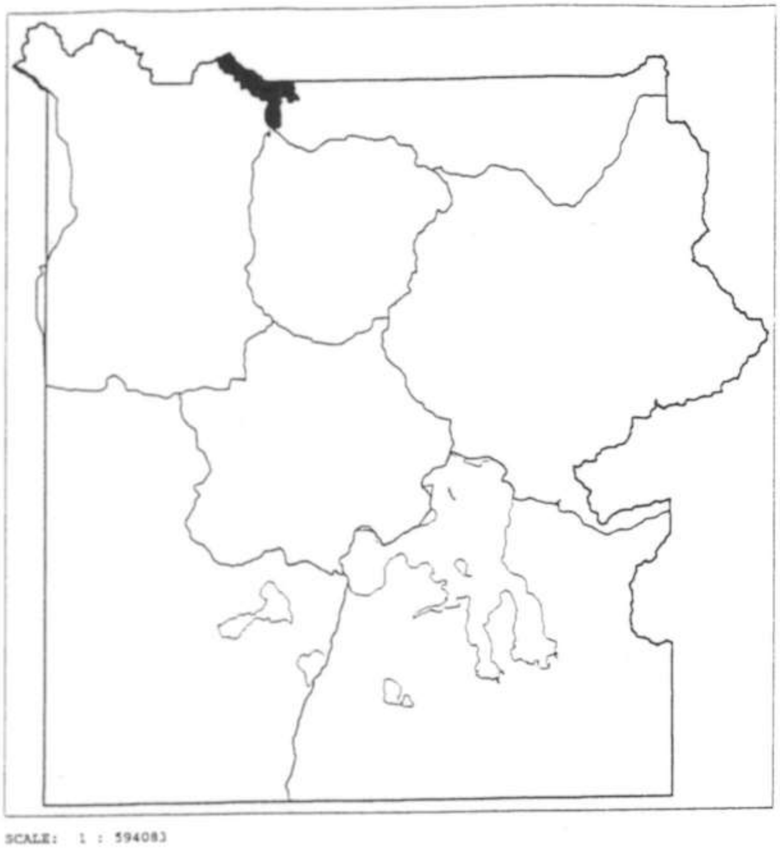

Fig. 1. Portion of Yellowstone National Park where pronghorn netgunning was done.

Pronghorn gradually became wary of our truck, so we built three blinds from which to net the animals. We baited the area around one below-ground blind with dried alfalfa hay pellets, and tried waving white flags to toll pronghorn into netting range at two above-ground blinds. All ground netgunning was done in January through March 1992 when pronghorn were concentrated at low elevations near roads.

Aerial Netgunning

Aerial netgunning of Yellowstone pronghorn was done on 26 and 27 February 1993, and was incidental to a mule deer (*Odocoileus hemionus*) capture effort. During the planning stage, it was not even known if there would be any extra time to capture pronghorn, so I was not given the opportunity to assemble or train a pronghorn handling crew in advance. The entire capture operation tried to follow established U.S. Department of Interior procedures, and details were summarized by the coordinator (P. J. P. Gogan, Natl. Park Serv., unpublished data, 1993).

Federal regulations required that 2 days of helicopter safety training be provided by two instructors. Nine people who would be handling or netting animals took the training. Additionally, there was a National Park Service flight dispatcher, two pilots, and a factory observer, for a total of 15 people involved in the operation.

One helicopter carried the gunner and net gun factory observer. After they netted a pronghorn, a second, circling "mugger" helicopter carried three handlers to the animal. They then restrained it, installed the radio collar, drew blood, and released it. There were two teams of three handlers each because the gunner caught pronghorn much faster than they could be processed. Pronghorn were captured for 2.5 hr the first afternoon and for about 1.0 hr the next morning. Total helicopter time was 7.1 hr for the two aircrafts.

RESULTS

Ground Netgunning

I netgunned 21 adult pronghorn from the ground, and averaged 1 animal caught per 8-hr day. About 1/4 of the shots caught a pronghorn. If the net passed over the animal's head, it invariably became tangled in the front feet and the animal was caught. If the net only reached the back of an animal's neck, the pronghorn always was able to run out from under it. I was never successful in tolling or baiting pronghorn even to within 100 m of a blind.

Training.--It took two days to train ourselves to use the netgun safely and accurately.

Logistics.--Only two people and a truck were required. We were easily able to schedule trapping days simply by notifying park rangers when we would be working.

Public Relations.--We had absolutely no problems. On only one occasion did a park visitor see us handle a pronghorn. Reaction was favorable when we explained the purpose. No rangers saw us handle animals.

Cost.--Our cost per captured pronghorn was approximately $167.00. No hazardous duty pay was required.

Mortality.--One pronghorn broke a femur when netted, and two more died <1 week after they were released (Table 1). I suspected aspiration of rumen contents or capture myopathy in the delayed-mortality cases. Early in the study, one of these animals was hog-tied, and the other was tangled in a net so badly that she was essentially hog-tied. Both animals belched when being handled. Although remains of both were consumed by coyotes, making necropsy impossible, I elected to discontinue hog-tying. We suffered no more quick losses among the 17 remaining pronghorn we captured (Table 2).

Table 1. Pronghorn deaths due to animal injuring itself, or suspected capture myopathy, for ground versus aerial netgunning. The proportion dead for ground capture was significantly less than for aerial capture ($P = 0.058$).

	Dead	Alive	Total	% dead
Ground	3	18	21	14.3
Aerial	8	9	17	47.1
Total	11	27	38	29.0

Table 2. Relationship between pronghorn deaths and hog-tying versus not hog-tying. The proportion dead for hog-tying was significantly greater than for not hog-tying ($P = 0.028$). G = ground, A = aerial, T = total. Five pronghorn that suffered known physical injuries likely to cause death are not included in this table.

	Dead			Alive			Total			% dead
	G	A	T	G	A	T	G	A	T	
Hog-tied	1	4	5	0	5	5	1	9	10	50.0
Not hog-tied	1	1	2	17	4	21	18	5	23	8.7
Total	2	5	7	17	9	26	19	14	33	21.2

Without hog-tying, we restrained a netted pronghorn by gathering its legs beneath its body, and letting it stay in a position similar to that of a normally-bedded pronghorn - with its head and neck erect. Many animals kicked and struggled in this position, but they certainly were not uncontrollable if handlers were determined and experienced. Standard blindfolds were not acceptable because struggling pronghorn knocked them off. I found that a light cotton blanket, thrown over the head and shoulders of the captive, stayed in place better. It was also useful to wrap part of the blanket around sharp horn tips for safety. Capture was in winter so overheating was not a factor.

Modifications to Equipment

I wanted to get animals back on their feet in less than 15 min. The biggest impediment to this was that the four steel net weights tended to gather beneath the feet of the pronghorn, intertwine in a terrible tangle, and virtually enclose the pronghorn in a knotted bag. I largely resolved this by cutting in half four cords in a straight line in the middle of the net (Fig. 2). The base of a 5.1-cm metal spring clip with a swivel (Fig. 3) was then tied with an improved clinch knot to half of each cord, and the clip was snapped over a bowline loop knot in the other cord half. With this modification, I could open a hole in the center of a net enclosing an animal, and let it out. I often cut release times in half this way, and the clips had no effect on net gun performance.

The recommended way to hold the net inside the fiberglass canister on the net gun was with several strips of masking tape. The process was slow, wasted tape, and scattered broken tape when the gun was fired. In cold weather, the tape would not stick to the fiberglass. I solved this by riveting one end of a 1.9-cm wide strip of $\text{Velcro}_{\text{TM}}$ on the outside of each of the four sides of the canister (Fig. 4). The smooth, flush head of each rivet was on the inside of the box. Each strip was long enough so that it crossed over the packed net about half way and meshed with its complementary, opposite strip for <u>only</u> 1.0 cm. More overlap might overly restrict net escape from the canister when the gun is fired. I fired nets held in canisters this way dozens of times and never broke a $\text{Velcro}_{\text{TM}}$ strip.

A common problem with netgunning is that weights may be loaded in the four barrels in the wrong sequence, so that when the net is fired, it does not deploy in a square, but rather in some sort of triangular shape, due to crossed corners. Such a simple mistake can be costly if it takes most of a day to get a good shot from the ground. This problem may be largely solved by using a permanent ink marker to number the four corners of each net, and also place the same number sequence on each corner of each net canister, and on each barrel of the gun. This kept me from ever having a crossed net when trying to capture a pronghorn.

The Coda$_{TM}$ net gun comes without a safety switch. The manufacturer advised me that a safety can be obtained on special order (C. R. Gray, Coda Enterprises, pers. comm.), but I was unable to obtain one during the study. Mr. Gray inspected the minor net and canister modifications described above and expressed no concerns.

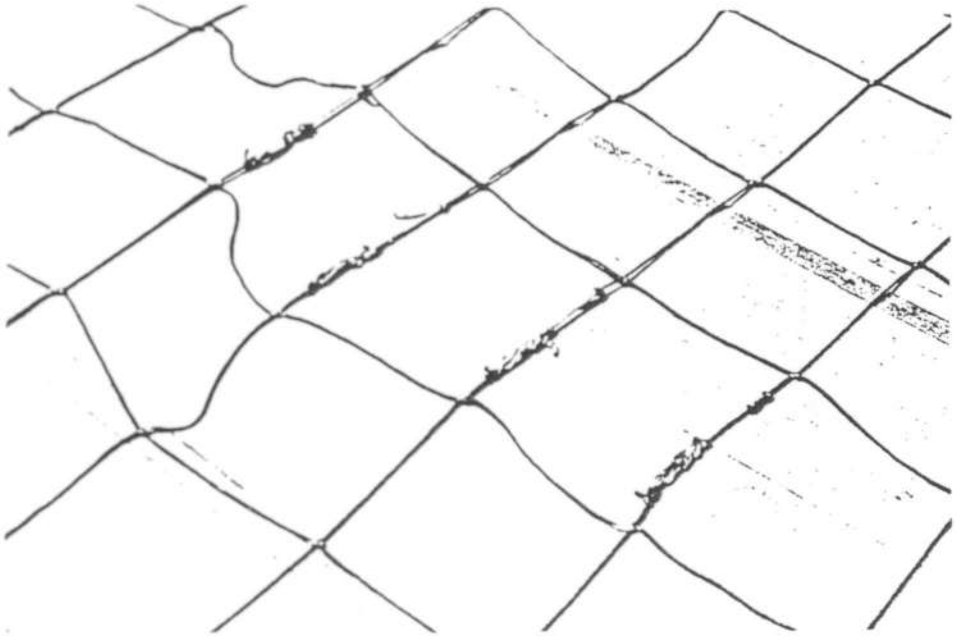

Fig. 2. Netgun net with four spring clips installed in a row in the center of the net, for easier release of entangled animals.

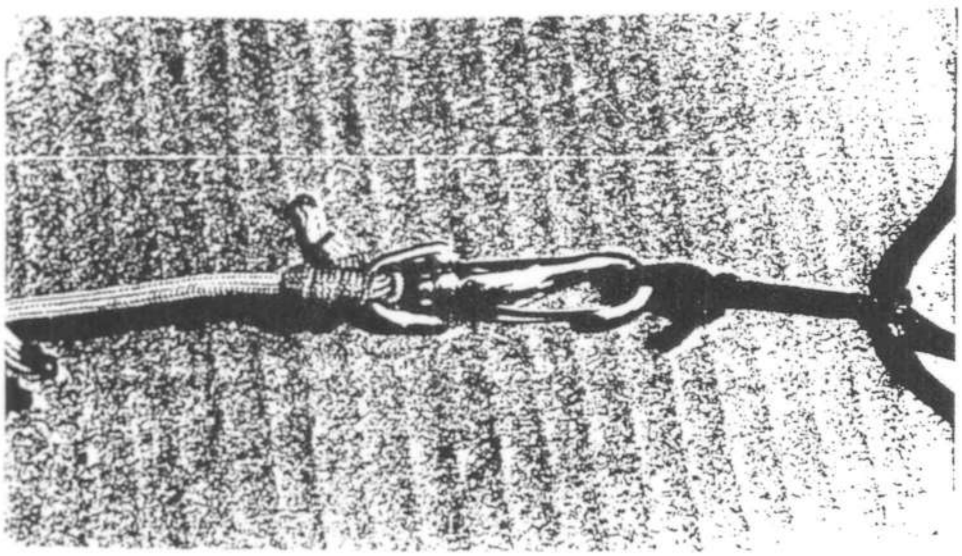

Fig. 3. Closeup of the spring clip with swivel installed in netgun nets.

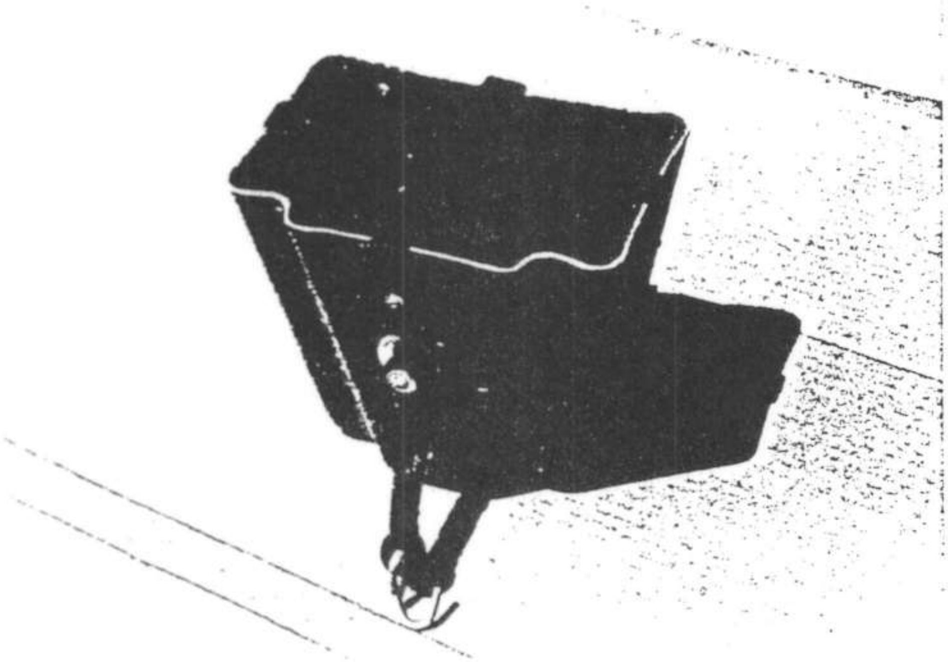

Fig. 4. Netgun canister with Velcro$_{TM}$ strips installed. Strips are in the closed position, as if a net were underneath them.

Aerial Netgunning

I netgunned 17 pronghorn with the aid of a helicopter. With 3.5 hr flying time for the gunning helicopter, this equaled a capture rate of 4.9 animals/hr, with two double captures.

Training.--It took two days to train nine of us to safely get in and out of a helicopter, regardless of how much previous experience some of us had doing this. The net gunner received training elsewhere.

Logistics.--Fifteen people were used full time for the pronghorn capture. Scheduling of the helicopters, crews, and training took days to set up and had to be done weeks in advance. Availability of helicopter time to capture pronghorn was doubtful, so handling crews were not trained except for a last-minute briefing.

Public Relations.--The two helicopters operated out of the Gardiner, Montana airport and frequently flew over or near the town. This attracted considerable attention. When 1 pronghorn had to be destroyed due to an injury, I advised the pilot to carry it back inside the cargo space to the airport for necropsy. The pilot felt otherwise and, without my knowledge, carried the dead pronghorn in a sling directly over the town at about 1730 hr - when everyone was coming home from work. Public reaction was very negative and I received complaints from citizens and rangers for a week.

Cost.--The coordinator of the helicopter capture effort calculated it cost $6,856 to capture the 17 pronghorn, averaging about $403.00 per animal. Helicopter time was $614.10/hr, including pilot expenses. All capture personnel also received extra hazardous duty pay (P. J. P. Gogan, Natl. Park Serv., unpubl. data, 1993).

Mortality.--On the first day, two pronghorn were caught in one net. The ensuing struggle broke the back of one and it had to be destroyed. A second pronghorn was chased excessively through belly-deep snow so that safety trainers could get photos - a scheme that was not shared with me. When the animal was finally netted I landed with my mugger crew and found it bleeding from the nostrils and anus. It was released without a radio collar and was assumed to have died later. On the second day, two more pronghorn (both bucks) were caught in the same net. As a result, a horn from one destroyed one eye in the other. The injured male was released and assumed to have died, due to intense coyote pressure on Yellowstone pronghorn.

Besides the initial three losses, 5 of 14 collared animals were dead within 16 days, and I suspected capture myopathy was the cause. The result was a total aerial netgunning loss of 47.1% (Table 1). This was significantly greater than ground netgunning losses.

Because of my previous ground-netting experience with hog-tying, I did not let my mugging crew hog-tie any animals, and we had one of five animals die later (Table 2). The netgunner and the other mugging crew ignored my request, and hog-tied all nine animals that they collared and released. Four of the animals died within the next 16 days.

Combining both ground and aerial captures, hog-tied pronghorn suffered 50.0% mortality, while non-hog-tied animals had 8.7% mortality (Table 2). The difference was significant (P=0.028, 2x2 contingency table, Snedecor and Cochran 1967:217).

DISCUSSION AND MANAGEMENT IMPLICATIONS

With Yellowstone pronghorn, ground netgunning was simpler, safer, and cheaper than aerial netgunning. Additionally, capture caused much less public disturbance and caused significantly less mortality to animals. It seemed to me however, that pronghorn netted from the ground became more entangled in the net than pronghorn netted from the air - possibly because animals chased from the air were more exhausted and did not fight the net as much. One large buck I netted from the ground did a complete flip and landed so hard that a femur was broken. This happened only once, but shows that it is important to carefully inspect each animal for broken bones before releasing it from the net.

Netgunning pronghorn from the ground may not be for everyone. Yellowstone pronghorn were habituated to close approaches by vehicles, but in most places where pronghorn are hunted and are more wary, close-range netting from a truck would not be possible. In such conditions, blinds set up at watering sites, travel corridors through fences, or bait stations might prove effective. We had no luck with blinds, but they were not in especially good places and we only spent six days using them. Adams (1994) reported that Colorado bowhunters had high success using pit blinds to help them take pronghorn near watering areas. Average shot distances were under 22.9 m, which is close to net gun range.

Even when ground netgunning works, it is a slow process at one animal per day for a 2-person team. Some researchers may feel this takes too long to get an adequate sample. Helicopter netgunning cost 2.4 times as much per animal caught than did ground capture. Thus, given similar expenses, if a ground team required > 2.4 days to capture each pronghorn, it would be cheaper to do it with helicopters and a large team.

If helicopter-assisted capture is planned, it is imperative that the biologist decide how the operation is going to be done, within safety constraints. Netgunners and pilots should not dictate how animals are handled. In particular, as O'Gara and Yoakum (1990) noted, gunners <u>must</u> avoid capturing > 1 animal in a net. As in all other shooting - when in doubt, do not fire.

I found significantly higher pronghorn mortality with aerial versus ground netgunning, but this may have been because one of the aerial mugging crews hog-tied all of their animals. However, the net gun manufacturer (C. R. Gray, Coda Enterprises, pers. comm.) noted that pronghorn losses had been about 30% during previous helicopter capture operations. Combined data from ground and aerial netgunning suggest that hog-tying is strongly associated with pronghorn mortality. A hog-tied pronghorn lies flat on its side, and a handler must elevate the animal's head to inhibit aspiration of rumen contents. Possibly this amount or type of elevation is not enough. Also, an animal with tied legs may pull against the restraint too much, and contribute to organ or muscle injury.

Another drawback to hog-tying is that it simply takes more time to do the tying versus not doing it. When early attempts at weighing, measuring, aging, instrumenting, and drawing blood from captured pronghorn seemed to be taking too much time and causing undue stress on animals, I elected to drop most of the optional data gathering and try to keep handling time below 15 min. Usually, the primary objective of capturing pronghorn is to radiocollar healthy, free roaming animals for ecological studies, and I suggest that wildlife biologists should resist requests by veterinarians, pathologists, and anatomists to gather data from a struggling netgunned animal that would be more easily collected from necropsied animals from various other sources.

Pronghorn that are not hog-tied require more handler exertion to restrain them (somewhat like corral-trap operations), and it is important that suitable handlers be obtained in advance. I had one inexperienced handler that was frightened by fighting, struggling animals, and thus hampered the efficiency of the rest of the crew.

The minor Velcro$_{TM}$ modification I made to the net canister, as well as the numbering system, will help in properly loading nets for both ground and aerial netgunning. Likewise, clips in the middle of the net are useful for quickly freeing pronghorn, regardless of the method of deployment. Another option is to cut the net in several places to remove it from an animal. However, at $150 or more per net, the cost soon becomes prohibitive.

I feel a net gun should have a safety switch. Safeties may be misused, but their obvious value is recognized by every firearms manufacturer in the world. When preparing to shoot horizontally or even slightly uphill from the ground, my gun's bolt often slid backward, ejecting the blank cartridge when the handle was left in the raised, "safe" position. Presence of a safety would have allowed us to safely keep the bolt closed. In a helicopter, the loaded gun is usually pointed downward, so the bolt stays forward even when the handle is in the raised "safe" position. A helicopter gunner can still use the highly-visible raised bolt handle as a safety if desired, and omit use of the standard safety.

There is another application of the ground-deployed net gun that biologists may want to try. After pronghorn fawns are a few days old, they often will not allow an approach to within 2-3 m for capture by a long-handled net. Many will, however, allow approach to within 14 m - the range of a net gun. We used a 3.7x3.7 m net with 7.7x7.7 cm mesh, and captured two during limited testing. This tool may almost double the time period that pronghorn fawns may be caught with nets.

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BUSINESS MEETING

ORGANIZATION and FUNCTION

of the

PRONGHORN ANTELOPE WORKSHOP

BY-LAWS

I. Designation

This organization shall be known as the "Pronghorn Antelope Workshop". The official publication of the Workshop shall be known as the Pronghorn Antelope Workshop Proceedings.

II. Goal

The goal of the Workshop is to provide information relative to and encourage the perpetuation of sustainable wild stocks of pronghorn antelope as an ecological, aesthetic, and recreational natural resource on western rangelands, both public and private, at their most productive levels consistent with other proper land uses.

III. Objectives

A. To provide an opportunity for all persons interested in pronghorn antelope to meet and discuss current research and management of the species and its habitat.

B. To provide a vehicle for disseminating research and management findings to the various agencies and organizations concerned with pronghorn antelope management.

C. To promote species-oriented research for development of new information on all aspects of pronghorn antelope ecology, life, history, and management on western ranges.

D. To identify particular problems associated with pronghorn antelope management and to formulate recommendations and resolutions directed to the appropriate agency or organization including the Western Association of State Game and Fish Commissioners.

E. To promote cooperation among all agencies and organizations concerned with pronghorn antelope management and research, particularly among the various provincial, state, and federal agencies with the primary responsibilities of managing this species and its habitat.

IV. Organization

A. The Pronghorn Antelope Workshop shall be open to any person interested in pronghorn antelope and its management.

B. Voting

Voting members shall consist of one representative of each of the following:

1. State, provinces and countries.

Alberta, Arizona, California, Colorado, Idaho, Kansas, Montana, Mexico, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, Saskatchewan, South Dakota, Texas, Utah, Washington, Wyoming.

2. Federal Agencies.

Bureau of Land Management, Forest Service, Soil Conservation Service, U.S. Fish and Wildlife Service, Parks Canada, and the Director General de Fauna Silvestre.

3. Universities and Colleges.

The chairman may appoint up to three people to represent colleges and universities. This appointee shall come from any college or university actively engaged in antelope research.

Voting representatives for the state, provinces and countries shall be appointed by the agency directly responsible for wildlife management within the above named states, provinces, and countries.

The chairman shall request that each of the above named federal agencies appoint one voting member. This request shall be directed to one of the regional offices or service centers in the western United States, Canada, and Mexico.

Voting shall be accomplished only by those authorized representatives in attendance at the business meeting of the Workshop.

C. The Pronghorn Antelope Workshop will be scheduled biennially on even numbered years. The host state, province, or country shall select the time and place of the meeting. The host shall appoint one of its representatives who will act as Chairman. The duties of the chairman shall be:

1. To serve as chairman for the two year period following his appointment.

2. To call for papers and prepare an agenda for the Workshop and assemble and distribute any recommendations or resolutions made or passed at the Workshop.

3. To prepare and distribute the transactions of the Pronghorn Antelope Workshop for which he has been responsible.

4. To organize and conduct the meeting and business of the Workshop.

5. To appoint committees as necessary.

6. To maintain the goals and objectives of the Workshop.

7. To prepare and make a formal report to the Western Association of State Game and Fish Commissioners.

D. The new host state, province, or country shall be selected and announced at the business meeting of the Workshop. It is the intent of the Workshop that host state, province, or country will be volunteered on a rotating basis among the actively participating member states, provinces, and countries.

E. The mailing list of the Pronghorn Antelope Workshop shall be:

1. The Western Association of State Game and Fish Commissioners.

2. The Director and Game Chief of every member state, province, and country.

3. All biologists known to be conducting antelope research.

4. All state BLM offices and BLM Regional Service Centers in the western United States.

5. All regional Forest Offices of the western United States.

6. All regional offices of the U.S.F.&W.S. in the western United States.

7. All regional offices of the S.C.S. in the Western United States.

8. All Cooperative Wildlife Research Units in the western United States.

9. All persons attending the Workshop.

10. Any person or organization requesting a copy of the Proceedings.

F. The chairman shall forward the mailing list and any other pertinent material to the new Workshop chairman upon completion of his responsibilities as chairman of the current Workshop.

As amended April 10, 1980 at Rio Rico, Arizona.

BUSINESS MEETING
16TH PRONGHORN WORKSHOP

Emporia, Kansas
April 21, 1994

The business meeting was called to order by Chairman Keith Sexson at 8:30 a.m. Delegates were present from Arizona, California, Colorado, Kansas, Montana, Nebraska, New Mexico, Nevada, Texas, Utah, and Wyoming. A complete list of participants and their affiliations is presented in the list of attendees on page vii of this proceeding.

Old Business

Information Network.

Laurie Colton discusses the need to develop an information network where PR reports and general publications on pronghorn could be housed and made available. Robb Hitchcock indicated that the North American Pronghorn Foundation could be a repository for items like the workshop proceedings and state reports. Richard Ockenfels indicated that he had three complete sets of the proceedings. Jim Yoakum indicated that he had two complete sets of proceedings (one set for loan) plus 1,200 reprints. Tom Pojar indicated that he had the 3-ring copy of Yoakum's literature listings. Yoakum is working on having this bibliography published.

Trapping and Translocation Guidelines.

Tom Pojar suggested that we should update our information on new and improved trapping techniques and the variations used among states. Robb Hitchcock indicated he would be sending out survey on trapping techniques. Jim Yoakum suggested that trapping and fawn capture could be panel topics for one of our meetings.

New Business

Host state for the 17th Workshop (1996).

Laurie Colton extended an invitation to host the next workshop in California. Kim Brinkley suggested that we publish a copy of the abstracts prior to the meeting. Robb Hitchcock suggested that the state status reports be ready for distribution by the time of the meeting. Laurie requested lists of names, addresses and telephone numbers of people who should be contacted for the meeting. Kim offered to send a list of information to Laurie on people dealing with pronghorn at zoos.

Concern was expressed over the length of time it had been taking to get the proceedings published. It was suggested that we should strive to have the proceedings in the hands of participants within six months.

The meeting was adjoined at 10:30 p. m.