Proceedings of the Eleventh Pronghorn Antelope Workshop

April 10-12, 1984 Corpus Christi, Texas

Hosted by the
Texas Parks and Wildlife Department
4200 Smith School Road
Austin, Texas 78744

PROCEEDINGS

OF THE

ELEVENTH PRONGHORN ANTELOPE WORKSHOP

CORPUS CHRISTI, TEXAS

APRIL 10-12, 1984

CHAIRMAN

CHARLES K. WINKLER

FOREWORD

The Pronghorn Antelope Workshop functions as an affiliate of the Western Association of Fish and Wildlife Agencies, with membership open to all states and provinces having pronghorns within their boundaries, regardless of whether or not they are members of the Western Association.

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.

The Workshop began in 1965 as the Antelope States Workshop, held in Santa Fe, New Mexico. From rather modest beginnings (18 employees of 5 state wildlife agencies), the Workshop now welcomes participation by 19 states and provinces, Mexico, Canada, 5 U.S. Federal agencies, the Mexican Wildlife Service, and any universities that are engaged in pronghorn research. The Workshop meets biennially in even-numbered years, with the meeting site rotating among the member states and provinces. Workshops have been held in Alberta, Arizona, Colorado, Idaho, Montana, Nebraska, New Mexico, North Dakota, Texas, Utah, and Wyoming.

The subject matter of the Workshop has always been management oriented with considerable discussion devoted to the most serious problems confronting pronghorns and their habitats. These include, but are not limited to fencing, habitat manipulations, energy development, interactions with domestic livestock, mortality, and harvest management. The Workshop proceedings, which contain most of the papers presented at the Workshop and much of the discussion, are regarded as a primary source of management information about this unique resource. A complete set of the proceedings is available through interlibrary loan from the U.S. Fish and Wildlife Service's Denver Wildlife Research Center Library, Bldg. 16, Federal Center, Denver, CO 80225.

Perhaps the most significant accomplishment of the Workshop to date has been the development and publication of Guidelines for the Management of Pronghorn Antelope, a compendium of the knowledge of some of the foremost pronghorn managers and researchers in the world. Originally published in the Proceedings of the 8th Biennial Pronghorn Antelope Workshop in 1978, copies of the guidelines are available from the Texas Parks and Wildlife Department, Austin, TX 78744.

PREFACE

The 11th Western States Pronghorn Antelope Workshop was held at Corpus Christi, Texas during the period of April 10-12, 1984. The Workshop was hosted by the Texas Parks and Wildlife Department.

Forty-five delegates participated in the Workshop, representing 11 states, 1 province, 8 universities, and 4 Federal agencies. While the attendance was smaller than that of recent workshops, this aspect did not detract from, and in fact may have enhanced, the exchange of information relative to the management of pronghorn antelope.

Reports on the current status of pronghorns were presented for all states and provinces represented by delegates. In addition, status reports for three additional states and one province have been received since the Workshop and are published in these proceedings. Of the 17 technical papers presented at the meeting, 14 are published in their entirety. Three are published as abstracts at the request of the authors, who plan to publish their information elsewhere. The comments and questions that followed each presentation are, to the extent possible, presented at the end of each paper. Poor quality recordings prevented the transcription of some discussion and the Workshop Chairman accepts the blame for any erroneous information that was transcribed. Likewise, all papers were retyped and the Chairman accepts responsibility for any typographical errors or omissions.

The business meeting was conducted on April 11, 1984 and consisted of discussions of the taxonomy of pronghorns, trapping and translocation guidelines, depredation guidelines, guzzlers, fences, and the status of papers published in the proceedings. Details of the meeting are contained in these proceedings.

The Nevada Department of Wildlife has agreed to host the next workshop in 1986.

Charles K. Winkler
Workshop Chairman

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Summary of Pronghorn Workshops held to date.

MEETING DATES AND LOCATIONS	NUMBER ATTENDEES	CHAIRMAN	HOST AGENCY
April 14-15, 1965 Santa Fe, New Mexico	18	W. Huey	New Mexico Department Fish and Game
February 16-17, 1966 Denver, Colorado	32	G. D. Bear	Colorado Game, Fish and Parks Department
February 5-6, 1968 Casper, Wyoming	97	J. L. Newman	Wyoming Game and Fish Commission
January 27-28, 1970 Scottsbluff, Nebraska	85	K. E. Menzel	Nebraska Game and Parks Commission
June 19-22, 1972 Billings, Montana	85	O. V. Compton	Montana Fish and Game Department
February 19-21, 1974 Salt Lake City, Utah	52	D. M. Beale	Utah Division of Wildlife Resources
February 24-26, 1976 Twin Falls, Idaho	68	R. Autenrieth	Idaho Department Fish and Game
May 2-4, 1978 Jasper, Alberta	84	M. W. Barrett	Alberta Fish and Wildlife Division
April 8-10, 1980 Rio Rico, Arizona	64	J. S. Phelps	Arizona Game and Fish Department
April 5-7, 1982 Dickinson, North Dakota	69	J. V. McKenzie	North Dakota Game and Fish Department
April 10-12, 1984 Corpus Christi, Texas	45	C. K. Winkler	Texas Parks and Wildlife Department

PROVINCIAL AND STATE REPORTS

ALBERTA ANTELOPE STATUS REPORT

Leo Gudmundson, Southern Region Wildlife Management Section, Alberta Energy and Natural Resources, Lethbridge, Alberta

POPULATION STATUS

Alberta's antelope population is estimated at 21-22,000 and they inhabit approximately 12,500 square miles of range in the southeastern corner of the province. A number of successive mild winters with resultant high recruitment has allowed the population to increase rapidly to a level similar to previously documented highs. An aerial census program was conducted in late July, 1982, but no attempt was made to monitor the population in 1983.

PRODUCTION AND BUCK RATIOS

Based on classified count data obtained from the 1982 census, provincial kid and buck ratios/100 does were 56 and 55 respectively. Those ratios indicate that the production of kids in 1982 was less than the 10 year average of 67.5 kids/100 does for the period from 1972-1982, while the buck ratio was higher than the long term documented average of 51.6 bucks/100 does.

HARVEST

Antelope harvests in Alberta are regulated through special license draws. There are 2 distinct harvesting programs; one permitting the hunting of trophy animals and the second, providing for a harvest of the female cohort (non-trophy). A trophy antelope is defined as a male pronghorn with horns not less than 5 inches in length, while the non-trophy class includes female pronghorn and males having horns not more than 3 inches in length. Trophy antelope hunting occurs during a 6 day season near the end of October with the non-trophy season running concurrently with the last 3 days of the trophy season.

Numbers of harvest permits for both trophy and non-trophy seasons have been increasing annually in response to an expanding population. In 1982, a total of 2,028 licenses were issued for trophy antelope with an additional 1,443 non-trophy licenses being alloted. A further increase occurred in 1983, when trophy and non-trophy licenses were 2,680 and 1,563 respectively.

A declining response to a voluntary big game (antelope) questionnaire has resulted in a poor indication of hunter success and in turn total annual harvest. During the period from 1970-1979, a high questionnaire return rate of approximately 90% provided a relatively accurate account of annual harvests, but since 1980, response to the questionnaire has declined to approximately 60%. Current success rates are estimated to be approximately 70% for trophy antelope and 65% for non-trophy.

There is no separate archery season for pronghorns in Alberta.

RESEARCH AND MANAGEMENT

During the period 1972-1978, a number of research and management activities were undertaken by the Alberta Fish and Wildlife Division. Current management activities are restricted to population monitoring programs.

Antelope management zones in Alberta are being revised in 1984 and will reflect population management on a winter range basis.

ARIZONA PRONGHORN ANTELOPE STATUS REPORT

Timothy A. Pender, Arizona Game and Fish Department, Seligman, AZ

The current population of pronghorn antelope in the state of Arizona is estimated at nearly 9,000 animals. Population estimates are based primarily on survey results and knowledge of individual game management units by the local wildlife managers.

During the 1983 summer antelope surveys, 6,340 antelope were observed. Buck:doe:fawn ratios were 31 bucks:100 does:39 fawns on a statewide average.

The population of Sonoran antelope in the southwest part of the state may have declined in recent years. At this time there are at least 48 individuals in our state. Hopefully a few more.

There are approximately 22,000 square miles of occupied antelope habitat in Arizona. About 16,000 square miles are open to hunting.

In 1983, 3 types of hunts were available to hunters: archery, muzzleloading and the general firearms hunts. Season dates for archery hunts were from August 26 through September 4 for a 10 day hunt. Muzzleloading and general season firearms hunters had 4 days from September 30 through October 3.

A total of 285 permits was available for archery only hunts in 6 special hunt areas. Ninety-three percent of the permit holders hunted. Hunt success was 8.3% with 24 antelope harvested. Hunters averaged 5 days afield.

One unit was open to muzzleloader hunting with 45 permits available. Ninety-eight percent of the permittees hunted. Hunt success was 29.5% with 13 bucks harvested. Hunters averaged 3.1 days afield.

General season firearms hunters received 833 permits in 21 hunt areas. Hunt success was 62.4% with 520 bucks harvested and a 95% participation rate. Hunters averaged 2.3 days afield. A number of bucks with horns in the 16-18 inch range were harvested.

The only changes in pronghorn range recently have been the result of our transplanting efforts in northwest and southeastern parts of the state.

Antelope research in Arizona is being done on the Sonoran population in the Yuma region. Ten Sonoran antelope were captured by helicopter and net guns, fitted with radio collars and released. Bi-monthly flights have been made since the capture last October and all 10 antelope have been relocated several times. The purpose of this project is to obtain information on basic habitat requirements, distribution, movement, critical use areas and fawning success.

Two other research projects are in the planning stage and should be initiated in the near future. They include an evaluation of the effects of a Savory grazing system on antelope, deer and elk and another evaluation of survey technique by habitat type.

The aerial gunning of coyotes has been evaluated and determined feasible as a result of Dr. Neff's research project on Anderson Mesa near Flagstaff. One control project initiated earlier this year has removed 52 coyotes from locations near Springerville. Another control project will be initiated north of Seligman in Unit 10. The area to be worked in Unit 10 has averaged less than 15 fawns: 100 does over the last 10 years. We are awaiting the results of these 2 projects to see if fawn survival can be improved in other parts of the state as they were on Anderson Mesa.

CALIFORNIA STATE REPORT

Douglas J. Thayer, Dept. of Fish and Game, Altura, CA.

HERD SURVEYS

ANNUAL CENSUS

The northeastern California annual aerial census of antelope was conducted January 9 - 13, 1984. Patchy snow conditions existed on some winter ranges. Fog and snow showers were encountered in some areas. Antelope were fairly well concentrated on winter ranges. Good coverage of all winter ranges was achieved. Counting conditions ranged from poor to excellent. No antelope were found on the California portion of interstate range in Surprise Valley.

Six thousand eight hundred seven (6,807) antelope were counted in the basic California population. The 1984 count was up 9 animals over the 1983 count. The 1984 count is 74 animals or one % lower than the 5-year average of 6,881. The 1984 population is 5,027 animals or 282 percent higher than the low population year of 1960 with 1,780 antelope.

BUCK-DOE RATIO

The annual aerial herd composition survey in northeastern California was conducted July 18 - 22, 1983. Survey techniques were the same as used since 1977 (see 8th Proceedings). In 1982 the reporting system was modified to relate locations and herd compositions to individual herds rather than counties.

Three thousand one hundred ninety-nine (3,199) antelope were classified during the 1983 survey. The buck ratio was 23 bucks per 100 does. This ratio is down 4 bucks per 100 does from the 1982 count and 6 bucks per 100 does from the previous 5-year average.

PRODUCTION

The 1983 kid ratio obtained during the summer herd composition counts was 37 kids per 100 does. This ratio was up 1 kid per 100 does over the 1982 ratio and is the same as the previous 5-year average. The 1983 kid ratio was well below the long-term (30 years) average of 52 kids per 100 does.

HARVEST

The twentieth consecutive hunt was held in northeastern California during the period of August 27 through September 5, 1983. Four hundred thirteen (413) permits for adult bucks were issued for the regular season. Eighty-eight (88) doe permits were issued during the regular season for population control in the Likely Tables zone. One hundred (100) adult buck permits were issued for an archery only season for the period of August 14 through 22, 1983. The fee for all permits was $35. A total of six hundred one (601) permits were issued in 1983.

In 1983 the hunt area for the regular season was divided into the same 6 zones as in 1982. Archery hunters were not restricted to specific zones and could hunt throughout the area.

Thirteen thousand eight hundred sixty-five (13,865) applications were received for the 1983 hunt. Only 88 applications were received for the 100 doe permits authorized.

All hunters were required to report on the success of their hunt through the tag and report card system. Hunters reported taking 448 antelope--383 bucks and 65 does. The 413 regular season permit holders took 367 bucks for 89% success. The 88 doe permit holders reported taking 65 does for a success ratio of 74%. The 100 archery hunters took 16 bucks for 16% success. Overall hunter success was 75%.

The 1983 regular buck season success of 89% is up from the 82% of 1982 and is second only to the 93% of 1981. Regular season hunter success for the previous 5 years averaged 87% and for the previous 19 years 77%. Doe hunter success for the past 4 years has averaged 72%. Hunter success for archery hunters for the past 4 years has averaged 14%.

The percent of yearlings in the kill in 1983 was 10%, down 7% percent from 1982. During the past 16 hunts the percent of yearlings in the kill has ranged from 2 to 36 percent. The percent of 4 years and older age class bucks in the 1983 kill was 45%, down 5% from 1982.

The thirteenth annual hunter orientation session was held the day before the regular season hunt began. There were 154 people in attendance. At least 79 of these were permit holders. The 79 permit holders at the session represented 12% of the regular season and doe hunters. Archery hunters are not included in the orientation as the archery season is held prior to the session. Over the years attendance at these sessions has been good.

During the past 20 years California has issued 7,310 permits (includes regular season, does and archery). During this period hunters have reported taking 5,699 antelope for a success ratio of 78%. Antelope numbers are 160% percent higher in 1984 than in 1964 when the hunts began.

The California Department of Fish and Game has requested a special hunt for 1984 with 600 permits to be issued as follows: 420 regular buck season permits; 100 archery only permits; and 80 doe permits. Doe permits would be good only in 1 specified zone. These permits are being requested for the purpose of regulating herd size.

RANGE SURVEYS

PRECIPITATION

Seasonal precipitation for 1982-83 was above normal. Water supplies for 1983 were considered to be excellent. Seasonal precipitation through February of 1984 is about 3 inches or 25% above normal.

RANGE MODIFICATION

None specifically for antelope.

RANGE CONDITIONS

Forage conditions for 1983 were considered to be good to excellent.

MISCELLANEOUS

DISEASE

No significant outbreaks were noted.

TAGGING AND MARKING

On February 23, 1984, 25 antelope (5 bucks and 20 does) were trapped and relocated from the Likely Tables area of Modoc County to the Adobe Valley area of Mono County. Two of the does shipped to Mono County have died.

During the trapping operations 8 antelope were ear tagged and released on the Likely Tables of which 2 female adults were also equipped with radio transmitter collars. Collars were installed to gain information on the movements of the Likely Tables herd.

SUMMARY

The basic California antelope population as shown by the 1984 census was 6,807 animals. This count is up 9 animals over the 1983 count. California's antelope population is 1% percent lower than the 5-year average of 6,881 animals and is 282% higher than in 1960, the low population year.

The 1983 buck ratio was 23 bucks per 100 does. This was down 4 bucks per 100 does from 1982 and 6 bucks per 100 below the previous 5-year average. This was the lowest buck ratio recorded for California.

The 1983 kid ratio was 37 kids per 100 does. This is up 1 kid per 100 does over the 1982 ratio and the same as the previous 5-year average. The 1983 ratio is well below the long-term average of 52 kids per 100 does.

The twentieth consecutive hunt was held in 1983. Six hundred one (601) permits were issued. Four hundred thirteen (413) regular season hunters took 367 bucks for 89% success. One hundred (100) early season archery hunters took 16 bucks for 16% success. Eighty-eight (88) doe hunters took 65 does for 74% success. Overall hunter success was 75%.

Range conditions for 1983 were considered to be good to excellent.

During February of 1984, 5 buck and 20 does were trapped on the Likely Tables area of Modoc County and relocated to Adobe Valley in Mono County. Two of the does died within a few days of release.

In addition, 8 antelope were ear tagged and released at the trap site on the Likely Tables. Two of these were equipped with transmitter collars.

COLORADO PRONGHORN STATUS REPORT - 1984

Thomas M. Pojar, Colorado Division of Wildlife, Ft. Collins, Co.

The current statewide estimate of pronghorn numbers in Colorado is 57,500. This estimate is based on aerial population trend survey data coupled with computerized population simulations. Recent mild winters (prior to 1983-84) resulted in significant increases in population numbers in some areas of the state. To maintain pronghorn densities at desired levels, post season hunts in selected areas and trapping and transplanting were employed.

This past winter (1983-84) was relatively severe and resulted in higher than normal natural mortality in some areas. Winter feeding of pronghorn was conducted on a limited scale. The ramifications of winter feeding will be discussed in another paper to be presented at this workshop. In general, management personnel believe feeding substantially reduced the amount of natural mortality that would have occurred.

The main harvest season is traditionally held during the last weekend in September. In 1983 the season was held 24-26 September. Legal methods of harvesting pronghorn during this season include: center-fire rifle, muzzle-loading rifle, archery and slug-firing shotgun. There is no separate muzzle-loading and slug-firing shotgun season but a separate archery season was held from 20 August to 22 September. All permits for the regular season are limited and specified. There are generally 3 applicants for every available permit issued. Preference points are issued to unsuccessful applicants. Qualified landowners are allocated 15% of the total limited licenses. One of the conditions a landowner must meet is that a "reasonable" number of hunters be allowed to hunt on his land.

Archery licenses are unlimited; however, our regulations state that a hunter "...may obtain and use only one license per species per year." Regulations for the 1984 season again include unlimited archery licenses. However, because of the relatively high hunter success rate and increased archery hunter density, future regulations may limit the number of pronghorn archery licenses issued.

License fees for both rifle and archery will be increased in 1984 from $13.00 to $17.00 for residents and from $100.00 to $120.00 for non-residents. There is only minor participation in the pronghorn hunt by non-residents.

In the northwest part of the state there is frequent immigration of pronghorn into Colorado from Wyoming. The Wildlife Commission, in an attempt to better balance the number of wintering pronghorn with available range, maintains the option of setting a late season. The decision of whether or not to have the late season is customarily made in mid-November. The late season is limited either sex and is held during the last 2 weeks of December.

In 1982, a total of 9,123 pronghorn was harvested by 11,322 hunters (12,351 licenses, 8% no-shows) for a hunter success rate of 81% (Table 1). An increase of 20% in number of permits issued in 1983 reflects attempts to stabilize or reduce some populations. Early severe weather in 1983 resulted in both lower success and a higher percentage of no-shows (Table 1). The consequence was that the 20% increase in licenses issued increased the total harvest by only 3%.

Table 1. Results of pronghorn harvest in Colorado.

	Harvest				Numbers		
Year	Males	Females	Young	Total	Licenses	Hunters	% Success
1982	5,345	3,428	350	9,123	12,351	11,322	81%
1983	4,936	4,107	352	9,395	14,876	12,632	74%

The research project, Recurrent Estrus and Cycle Length in Pronghorn, was completed and the results will be published in the forthcoming issue of the Journal of Wildlife Management. A manuscript, titled "Diseases and Parasites of Pronghorn: A Review," by Lance and Pojar, will be published as a Colorado Division of Wildlife Special Report. It will be available from the Colorado Division of Wildlife Research Library (317 W. Prospect St.; Ft. Collins, CO 80526) by late summer 1984. A preliminary investigation of the influence of passage through a pronghorn digestive system on the viability of bindweed seeds (Convolvulus arvensis) was completed. The results will be presented at this workshop.

Research is continuing on the comparison of strip vs. quadrat sampling for censusing pronghorn. The sampling systems are being executed in late summer in attempts to find the most efficient and effective method of obtaining both population density and herd structure data during a single fly-over. Thus far, the data show that both sampling systems provide adequate and comparable herd structure data. However, quadrat sampling (using mile square quadrats) generally results in higher population density estimates than strip sampling. Research is continuing to determine which system provides the most accurate estimates of population density.

Researchers at Colorado State University (Torbit and Nagy) have investigated the feasibility of winter feeding of pronghorn. They will report their findings at this workshop. These same researchers have recently initiated an investigation to assess pronghorn use and effect of grazing on winter wheat yields in eastern Colorado.

IDAHO STATE REPORT

Robert Autenrieth, Idaho Department of Fish and Game, Jerome, ID.

Pronghorn numbers in Idaho have generally remained stable or possibly declined during the past 2 years in relation to severe weather, wildfires on winter ranges and disease. The 1981-85 Trophy Species Management Plan provides a population figure between 20,000 and 23,000 based on estimates for individual units. These figures may currently be high due to winter losses experienced in 1981-82 and again this past winter. The southcentral Idaho antelope continue to be impacted by the 238,000-acre wildfire that destroyed their winter range in July, 1981. Sick and dying antelope were reported in southcentral Idaho in August 1982. Symptoms included nasal discharge and staggering. Bluetongue disease was suspected but lab tests were not conclusive. Statewide fawn production dropped to 47 fawns/100 does in 1982, down from the 56 fawns/100 does for the 10 year average. However, bucks/100 does were 42 compared with 37 for the 10 year average. A statewide summary is not available for 1983 but many of the units were down in both fawns and bucks/100 does with some units falling below the minimum level of 30 bucks/100 does called for in the trophy species plan.

Interest in antelope permits has increased since the late 1960's through 1980 when 29,274 applications were received for 1,910 permits (a 7% chance of drawing). The fee was increased from $16.00 to $21.00 in 1981 and to $31.00 in 1982. As a result, applicants dropped to 7,959 for 3,213 permits in 1983 with a 40% chance of drawing. Hunter success was 84% in 1982 and 76% in 1983. Bucks in the harvest were 83% in 1982 and 75% in 1983. As a result of the impact of hunting during the rut study conducted by Gary Copeland, the opening date for controlled hunts was changed in 1983 from September to early October to allow for the orderly completion of breeding. Also, archery seasons are now closed 27 days prior to the controlled hunt opening. In 1983, archery season began with a depredation only hunt in 15 units on August 6. Archers are restricted to within ½ mile of croplands, namely alfalfa. The general archery season opens August 27 and continues to September 11. The general archery season is conducted in 13 units and archers are not restricted to cropland areas. A total of 762 archers hunted antelope in 1982 and harvested 128 for a 16.8% success. The average time spent hunting was 6.45 days with a total of 4,900 archery days expended. The data are not yet available for 1983.

The various controlled hunt seasons in 1982 and 1983 were held on the roughly 23,000 square miles of Idaho open to antelope hunting. Most hunting occurs on Bureau of Land Management administered lands.

	Season	Days	Permits	Units
1982	Sept. 25-Oct. 10	16	1,935	24
	Sept. 25-Oct. 10	16	200	2 (Muzzle loaders only)
	Oct. 30-Nov. 14	16	300	2
			2,435	

	Season	Days	Permits	Units
1983	Oct. 8-Oct. 23	16	1,935	26
	Oct. 8-Oct. 23	16	300	2 (Muzzle loaders only)
	Aug. 27-Sept. 21 (4 hunts)	5 days ea.	7 per hunt	
			28 Total	1
	Oct. 29-Nov. 13	16	850	5
	Oct. 8-Oct. 12	5	50	1 (Muzzle loaders and shotguns only)
	Oct. 22-Oct. 26	5	50	1 (Muzzle loaders and shotguns only)
			3,213	

Preliminary results of an economic survey recently conducted by the co-op unit of the University of Idaho and the Fish and Game Department using the travel cost method showed a net value per antelope permit of $165.00. Net value per hunting day was $86.91 with an average of 1.9 days hunted. The average round trip distance was 614 miles.

Field projects were completed in 1982 and report writing has been emphasized during the past year. The results of the 2-year Little Lost Valley fawn study are reported elsewhere in the Proceedings. Results of the Impact of Hunting Antelope During the Rut were presented at the Western Association of Fish and Wildlife Agencies at Las Vegas, Nevada in 1982 and printed in the Western Proceedings. The following reports are in various states of preparation or review: Antelope Management in Idaho, Antelope-Feral Horse-Livestock Range Relationships and Comparisons of Fawning and Bedding Site Vegetation and Their Relationship to Fawn Survival.

The Department is currently soliciting public comment on a plan to address wildlife depredation. Goals are to minimize conflict, promote harmonious existence between wildlife and people and use non-lethal control techniques where practical. A satisfactory solution to antelope depredation problems is critical to the future management of many Idaho antelope populations where depredations are currently controlling management direction.

KANSAS STATE REPORT

Terry L. Funk, Kansas Fish and Game, Hays, KA

HUNTING SEASONS AND HARVEST

Antelope hunters (Firearms and Archery) harvested a total of 339 animals (175 bucks and 164 does) during the 1983 season. Four hundred eighty nine hunters actually went afield.

ARCHERY SEASON

The eighth archery season was held in Kansas, September 17-25, 1983. Archery pronghorn hunting was open in parts of 6 counties (Wallace, Sherman, Logan, Thomas, Greeley, and Wichita) in extreme western Kansas. A total of 142 applications were received for the 150 available permits. Questionnaires mailed with permits were utilized to obtain archery pronghorn season data. A 96.5% response was obtained.

Of the 142 permittees, 127 archers actually went afield. Archers harvested 18 pronghorns (16 bucks and 2 does) for a hunter success of 14.2%. The 1983 archery season provided 487 mandays of recreation (3.8 days/archery). Six archery hunters hunted all 9 days of the season. Archery hunters in 1982 harvested 11 pronghorns (8 bucks and 3 does) for a hunter success of 15.9%. The 1982 season provided 3.4 days/archer or 233 mandays of recreation.

FIREARM SEASON

Kansas' tenth firearms pronghorn season was held during the fall of 1983. The season dates were October 1 through 3, 1983. Of the 390 permits allowed, 195 went to landowners and 195 to general residents; all had to be legal residents of Kansas. Two mandatory check stations and questionnaires mailed with permits were utilized to obtain antelope season data. Between the 2 reporting methods, a 98.2% response was obtained.

Of the 390 permittees, 362 hunters actually went afield. These sportsmen spent 430 mandays (1.2 days/hunter) hunting and harvested 321 antelope (88.7% hunter success).

Essentially, the antelope season was a one-day affair. Opening day accounted for 69.8% of the harvest and 52.1% of the hunting pressure; this compares with 75.1% and 81.4%, respectively, in 1982. Sixty-seven antelope were taken the second day, and 30 were harvested, the last day of the season. Of the 321 harvested antelope, 159 were bucks, and 162 were does.

Age was determined on 319 antelope by both incisor replacement and by counting incisor annuli. Buck age structure was 86 adults, 53 yearlings, and 21 fawns. Doe ages were 94 adults, 31 yearlings, and 34 fawns.

Antelope teeth sectioning was prepared under a contract with Gary Matson of Montana. The tooth replacement method was accurate for only the first 3 age groups (fawn to 2 1/3 years). Although determining annuli was still difficult on some specimens, by using both methods, good results were obtained.

Age structure was determined by utilizing both methods. One 7 1/3 year old buck and 3 10 1/3 year old does were the oldest antelope harvested for each group.

Yearling bucks made up 38.1% of the over 1 year old buck harvest, compared to 31.7% in 1982 and 39.4% in 1981. Average overall age of firearm harvested antelope was 2.6 years old (2.7 in 1982). Buck average age increased and the yearlings harvested decreased.

POPULATION STATUS

1983 PRODUCTION SURVEY

An aerial survey to classify pronghorns was conducted July 27, 1983, in Wallace and Sherman Counties west of Highway US-27. A Cessna 206 aircraft was used, flying north-south transects at 1/2 mile intervals.

Aerial surveillance accounted for 229 pronghorn antelope. A total of 225 pronghorn antelope was classified according to sex and age compared to 242 in 1982. Table 1 shows the herd sex and age classification based on the total animals classified. The buck:doe:fawn ratio for 1983 was 51:100:57 compared to 22:100:66 for 1982 (Table 1).

Table 1. Kansas Pronghorn Antelope Herd Sex and Age Composition, 1982-83.

Buck		Does		Fawns		Total		Bucks:Does:Fawns	
1982	1983	1982	1983	1982	1983	1982	1983	1982	1983
28	55	129	108	85	62	242	225	22:100:66	51:100:57

The percent of fawns was 28.0% compared to 35.0% in 1982 and the past 3-year average of 29.9%. Bucks accounted for 24.0% of the classified antelope and does accounted for 48.0%. This compares with 12.0% and 53.3%, respectively, in 1982. There were 57 fawns and 51 bucks for every 100 does. This compares with 66 fawns and 22 bucks per 100 does in 1982.

WINTER SURVEY

Aerial surveys were conducted January 10, 1984, and February 2-3, 1984 to obtain winter population data. Surveys were flown over the major range in Sherman, Wallace, Logan Counties, and 2 smaller populations were surveyed in Clark and Hamilton Counties.

The Clark County survey flown on January 10, 1984 accounted for 70 antelope. Ground counts the previous week located an additional 63 head that were unaccounted for in the aerial survey. One hundred three antelope were recorded the same day in the NW 1/4 of Hamilton County.

The February 2-3, 1984 survey of the major range accounted for 765 antelope. This amounts to a 28.5% decrease from the record 1,225 count last year. This years average herd size was 32, while in 1982 it was 25. A herd of 160 was observed this year with 109 being the largest herd in 1982.

MONTANA STATE REPORT

Arnold Dood, Montana Department of Fish, Wildlife and Parks, Glendive, MT.

Winter conditions in Montana since the severe winter of 1978-79 have been normal to very mild. Fawn production and survival have been very good and antelope populations have recovered from the effects of the last severe winter. In fact, some areas are at the highest levels recorded since the initiation of systematic surveys. The current population estimate for Montana is 161,550 antelope or 2.5 antelope for each square mile of antelope habitat in the state (64,600 sq. mi.). This population estimate was generated by using summer densities obtained during aerial surveys conducted each July on a portion (1/3) of the antelope habitat, and applying those densities to the total area of antelope habitat. Summer densities range from less than 1 to more than 5 antelope per square mile on different portions of their range.

Harvests have increased statewide concurrent with the increases in population. In 1982, 26,736 licenses were issued. A total of 22,762 people hunted and they harvested 20,830 antelope, for a success rate of 91.5%. Antelope hunters averaged 2 days of hunting per animal harvested in 1982. Harvest figures and hunter numbers for 1983 are not yet available, however both hunter numbers and harvest were up substantially. All antelope hunting licenses are issued through a computerized drawing system. In 1983, 52,749 people applied for permits and 61% (32,041) were successful. Non-residents may be issued up to 10% of the licenses available and 15% of the licenses in any hunting district are reserved for landowners. This year, the cost of an antelope license for resident hunters in Montana increased from $5.00 to $6.00. Antelope gun seasons start the second weekend in October and run for approximately four weeks. Archers can apply for a general antelope license and hunt during an early archery season (early September to the first week of October).

Antelope habitat in the state continues to be destroyed at an alarming rate. In 1983, Montana made national headlines as a result of the extensive "plowouts" which were occurring. Government programs (PIK, tax incentives, etc.) continue to encourage the destruction of antelope habitat by providing incentives for private landowners to plow fragile rangelands. Antelope habitat on public lands has been fairly stable, however, requests for habitat alterations are becoming more common.

Currently there is no ongoing research on antelope in Montana. However, an antelope working committee has been established and is developing a plan for antelope management and research in the state.

NEW MEXICO STATE REPORT

Bruce Morrison, New Mexico Department of Game and Fish, Santa Fe, NM

New Mexico's pronghorn population is estimated to be close to 30,000 animals. Eighty percent of these inhabit the eastern plains while the remaining 20% occupy scattered habitat throughout the western half of the state.

During the 1982-83 license year there were 3 rifle hunts, 2 archery hunts, 1 muzzleloader hunt, and 1 hunt for the handicapped. The first rifle hunt was in the northeast portion of New Mexico September 3-5. During this hunt 1,459 pronghorn were harvested by 1,920 hunters for a success rate of 76.0%. The southeast quarter of the state hosted the second rifle hunt September 24-25. Success for this hunt reached 79.1% when 1,019 hunters harvested 806 pronghorns. The last rifle hunt was in southwest New Mexico October 1-2. On this hunt 99 hunters took 77 pronghorns for a 77.8% success rate. Total rifle harvest was 2,342 pronghorn by 3,038 hunters for 77.1% success. The first archery hunt was held in north-central New Mexico August 6-14 with 117 hunters taking 0 pronghorn for a success rate of 0%. The September 24-25 archery hunt north of Carlsbad, New Mexico resulted in 36 archers achieving a success rate of 16.7% when they took 6 animals. The muzzleloader hunt was held in south-central New Mexico October 1-2. Seventy-eight hunters harvested 36 pronghorns for a 46% rate. The special hunt for handicapped sportsmen took place October 1-2 north of Roswell, New Mexico. Applicants for this hunt were required to submit, to the Game Department, a doctor's certificate attesting to the fact that the applicant was totally and permanently dependent for mobility on assistive devices. The eight handicapped hunters were 100% successful during this hunt.

The status of New Mexico's pronghorn populations has remained relatively stable the past few years. The oil and gas boom in the southeast quarter of the state was short-lived and did not have a major affect on pronghorn. In February of 1984, we transplanted 210 pronghorns to 4 release sites in northeast New Mexico. These animals were trapped on private land near Wagon Mound at the expense of the landowner. One release was on private land, owned by the same person as the capture site, and three releases were on public land. These releases will provide additional recreational opportunities for the public in the future.

We continue to fly 33%, 100% and fawn survival surveys in several of our pronghorn management units each year. Our 1983 buck:doe ratios ranged from 1:2 to 1:14 with 1:4.2 being the statewide average. Fawn survival rates averaged 41% with a high of 90% and a low of 8.6%. The main reason for reduced fawn survival this year was drought conditions affecting most of our pronghorn range.

After the surveys are completed, landowners are contacted and pronghorn hunt agreements are signed. Permits for each ranch are split between landowner and public licenses, according to the percentages of deeded and public lease land contained within that ranch. The public licenses are issued by lottery from the Santa Fe office, while landowner licenses are issued on a first-come first-served basis from all Department offices. Applicants for landowner licenses are required to obtain pre-issued, numbered applications from the landowner involved.

There are not any pronghorn research projects being conducted in New Mexico at this time. The Roswell Pronghorn Study has been completed and will be reported on by Dr. V. W. Howard later in this workshop.

NORTH DAKOTA STATE REPORT

James V. McKenzie, North Dakota Game and Fish Department, Bismarck, ND

Weather conditions during the 1981-1982 and the 1982-1983 winters were comparatively mild in North Dakota. Specifically, below normal snowfalls and above normal temperatures were recorded. This same general weather picture has continued through the 1983-1984 winter to the present time.

The pronghorn population has responded in a positive way to this reduced winter stress, particularly in the areas of winter mortality and reproduction. Winter mortality, as you would expect, has been minimal since our last workshop at Dickinson, North Dakota, and pronghorn reproduction has been good.

The July aerial survey on portions of the pronghorn range in North Dakota is based on as near a complete count as possible of about one-third of the range each year. Cumulatively, this provides a look at all management units once every 3 years. Population densities and their distribution, sex ratios, and fawn production are obtained through this method.

An overview of the annual pronghorn population status and indicated trend for the years from 1977, through 2 severe winter kills (1977-1978 and 1978-1979), to July 1983, is presented in Table 1.

The pronghorn hunting season was reopened during the fall of 1982 after a 4 year closure. Gun hunting (centerfire rifles - 22 caliber or larger; muzzleloading - 45 caliber or larger; and handguns - cartridge specifications, 1.285 inches or longer and .257 inches or more in diameter) opened October 8, 1982 for 701 permittees (31 other permittees did not hunt) in 14 management units, totaling 6,408 square miles. The 9½ day, any pronghorn season (our big game seasons must open at 12:00 noon on a Friday), resulted in a harvest of 617 pronghorns (475 horned males, 54 does and 88 fawns - 880 M:100 F:163 fawns), for a success ratio of 88.0%.

The 1982 any pronghorn archery season was a split-season affair and involved roughly the western one-half of North Dakota (a total of 33,759 square miles). The first segment opened at noon on September 10 and closed on September 26 (16½ days). The second segment opened on October 18 (after the gun season) and closed on October 31 (13½ days). The harvest was estimated at 104 animals based on past surveys, as a separate harvest survey was not conducted in 1982.

The 1983 gun and archery seasons on pronghorn were on the same basis and on the same management units as in 1982: however, there were more permits issued.

During the 1983 gun season, 1,365 permits were issued for the 14 management units. Of these permits, 1,303 hunters actually were afield and they harvested 1,187 pronghorns (837 horned males, 181 does and 169 fawns - 462 M:100 F:93 fawns) for a success ratio of 91.1%.

A new approach to alleviating crop depredation by pronghorns in North Dakota was tested on 2 management units where 1983 density figures were recorded as 3.0 per square mile (1,934 pronghorns on 645 square miles). The

regulations authorized 750 permits (potential hunting pressure of over 1.16 hunters per square mile) on a "split-time" basis for these 2 units with one half (375) of the permits authorized for each segment. (The 1983 pronghorn gun season opened in all proclaimed hunting units on October 7 and ran for 9½ days before closing on October 16). The early season time frame of the split season was from October 7 through October 13 (6½ days) and the late season from 12:00 noon October 14 through October 23 (9½ days). The harvest results were 664 animals taken (429 horned males, 120 does and 115 fawns - 350 M:100 F:96 fawns) for a success ratio of 92.7%. At this point, the concensus is that not nearly enough females were harvested and it remains to be seen whether any hunter induced dispersal resulted. The July, 1984 survey will indicate whether this dispersal occurred or whether the problem still remains.

The 1983 archery season resulted in 743 licenses being issued for the 2 segment season. The season opened at noon September 2 and ran for 30½ days through October 2 and reopened October 24 for 6½ days until October 30. The harvest was estimated at 119 pronghorn.

On the habitat scene, the pronghorn range continues to be depleted or eliminated. Conversion of diversified range lands with their native species to farmland or to tame pastures with 1 or 2 forage species, intensified energy development with accompanying urban sprawl, and continued over-utilization of the remaining range by domestic livestock are contributing factors. This range depletion and/or destruction is reflected by the limited pronghorn distribution in North Dakota and by the much reduced pronghorn densities following severe winter kills of the recent past.

A recently completed research study, A Study of Pronghorn Antelope Range in North Dakota, by Sarma Jatnieks-Straumanis, will be presented later at this workshop.

Table 1. Overview of Pronghorn Population, Density, Distribution and Reproduction (1977-1983).

	Primary Range			Secondary Range			Tertiary Range		
	Density Per Sq. Mi.	Per 100 F M	Per 100 F F	Density Per Sq. Mi.	Per 100 F M	Per 100 F F	Density Per Sq. Mi.	Per 100 F M	Per 100 F F
1977	.82	43	74	.23	34	59	.18	29	76
Winterkill 1978	.47	39	61	.04	.28	75	.02	.8	85
Winterkill 1979	.32	11	61	.04	24	57	.02	12	59
1980	.22	42	86	.04	33	73	.01	27	107
1981	.39	43	96	.03	22	82	.06	54	78
1982	.77	39	80	.08	32	69	.02	27	100
1983	.78	48	96	.15	44	85	.03	38	64

OREGON PRONGHORN ANTELOPE STATUS REPORT

Rod Ingram, Oregon Department of Fish and Wildlife, Portland, OR

ABSTRACT

Oregon's antelope population is currently estimated at 14,000 animals. A permit type season allows a harvest of nearly 1,000 bucks per year for approximately 2,000 hunters. A severe winter in 1983-84 and poor fawn survival has resulted in a slight population decrease in 1984. A research project on antelope fawn survival revealed 91 percent of the fawn mortality was due to predation and the primary cause was coyote predation. Eighty-seven percent of the mortality occurred in the first three weeks of life.

INTRODUCTION

With the onset of 1984, Oregon's antelope herds continue to struggle a bit. Poor fawn survival in recent years and severe winter weather in 1983-84 has set the population back somewhat this year.

POPULATION STATUS

POPULATION ESTIMATE

The Oregon pronghorn antelope population is currently estimated at approximately 14,000 animals. This figure represents a slight decrease, up to five percent, from the 1983 population and is the result of severe winter conditions in some areas of eastern Oregon during the winter of 1983-84.

POPULATION ESTIMATE METHOD

Population estimates are obtained from a combination of aerial census and herd composition data. Presently, 3,900 miles of aerial census are flown in March before antelope begin leaving wintering areas. This data along with production information is used to estimate antelope populations.

HARVEST DATA

HUNTING SEASONS

Approximately 40,000 square miles of eastern Oregon is open to antelope hunting. The rifle season is generally set for the third week of August and weapons are limited to centerfire rifle and muzzleloaders. One area has been set aside as an archery only area for antelope. Two hunting seasons are scheduled in this area and generally set for the second week of August and the first week of September.

In 1984, a portion of a management unit was set aside as a muzzleloader - only hunt with hunting dates corresponding to the rifle season.

1983 HARVEST

All antelope permits are on a controlled hunt drawing system and successful rifle and muzzleloader applicants are not eligible to apply again for a period of five years. There is no wait period for archers. Permits available in 1983 included 1,650 rifle permits and 450 archery permits. There were 21,300 applications for these permits.

The 1983 antelope harvest was 953 bucks taken by 1,484 hunters for a success rate of 64 percent. The success rate in 1982 was 65 percent. In addition, 100 antlerless permits were available for an agricultural damage hunt and 82 hunters harvested 28 antlerless antelope. Two hundred and seventy-two archers harvested five buck antelope.

DISTRIBUTION

CHANGES IN DISTRIBUTION

Pronghorn antelope are generally found in the southeast quarter of the state. The exception is a small herd of 240 antelope which have resulted from a small transplant about 15 years ago in the Boardman area. This population is not hunted.

A small population of approximately 150 antelope have become established in the John Day Valley which is beyond the normal distribution of antelope in Oregon. Antelope summering in a pine forest habitat in southcentral Oregon continues to expand and now numbers approximately 350 animals.

RESEARCH

PREDATION

A research project was initiated in 1981 to moniter the impacts of predation on fawn survival. Fawns were captured shortly after birth and radio transmitters attached by means of a collar. Two areas near Burns were studied.

The field work on the project is complete and the findings are being prepared for publication. Briefly, fawn losses were extremely high in one area with losses of 94 percent and 100 percent in 1981 and 1982, respectively. The second area displayed losses of 50 percent in 1981 and 36 percent in 1982. Almost 91 percent of the mortality at both study areas was attributed to predation and sixty percent of the mortality was attributed to coyote predation. Bobcats and golden eagles accounted for eight and nine percent, respectively. Eighty-seven percent of the fawn losses occurred during the first three weeks of life.

Published results of this study should be available later in the year.

FUTURE MANAGEMENT

POPULATION STATUS

The Department is very concerned over the downward trend in fawn survival the past 15 years. Average fawn survival in the early 1970's was over 40 fawns per 100 does; but in the past three years, fawn survival has averaged less than 25 fawns per 100 does.

The permit system does allow strict control of harvest and the harvest of bucks at the present time is not heavy, averaging less than a 1,000 bucks per year. There is a heavy demand for an antelope hunting opportunity but maintaining an increased harvest and a quality experience is difficult under present fawn survival rates.

SASKATCHEWAN PROVINCIAL REPORT

Ross Melinchuk - Wildlife Branch. Saskatchewan Parks and Renewable Resources, Regina, Saskatchewan

CURRENT POPULATION ESTIMATES

The 1983 provincial antelope population is estimated at 10,000 and is comparable to that of 1982. Reproductive success was excellent in 1983 based on a kid:doe ratio of 0.85 which represents a 27% increase over the long-term average. The survey was flown during the first week of July and covered 3,107 square miles (20% of available range).

HUNTING SEASONS AND ESTIMATED HARVEST

The 1983 archery seasons for antelope extended from September 5 - October 8. The rifle season was one week long (October 27 - November 2).

In 1983, 2,400 rifle and 248 archery permits were issued with a resulting harvest of 2,144 animals. Hunter success was 14% for archers and 88% for rifle hunters.

The extremely mild winter of 1983-84 should result in low winter pronghorn mortality and good reproductive potential.

NEW AND ONGOING RESEARCH

The Saskatchewan Wildlife Branch is not involved in any research projects at this time.

SOUTH DAKOTA STATE REPORT

Theron Schenck, South Dakota Department of Game, Fish and Parks, Rapid City, SD

In South Dakota, antelope management is based on county management units. Our conservation officers are assigned to districts, usually one officer per county, and are responsible for all survey work and data collecting within their assigned district. Hunting units are based on county boundaries or portions of the counties.

The 1983 pre-season antelope population in South Dakota was estimated to be 67,000. This estimate represents the highest population recorded in recent times. Mild winters and favorable range conditions have contributed to excellent fawn production and recruitment. Spring census flights are used to determine adult sex ratios and early summer flights are used to determine annual reproduction. The surveys are based on a one-third sample of most counties annually.

Archery antelope season begins the third Saturday of August and continues through the last day of September. Resident and non-resident hunting is allowed in all counties west of the Missouri River and two counties east of the Missouri River. Numbers of archery hunters have increased from 420 in 1981 to 508 in 1983. Archers have been fairly successful with 19.2 percent success in 1982 and 24.0 percent in 1983.

The firearm season begins the first Saturday in October and continues through the second Sunday following in most management units. In 1983, there were 18,200 licenses available in 24 hunting units. This represents an increase of 3,300 licenses from 1982. An additional 8 percent non-resident antelope licenses were available for the first time in 1983. A total of 17,000 resident licenses and 451 non-resident licenses were sold. Hunters harvested 14,500 antelope at an 85 percent success rate. Does and fawns made up 47 percent of the harvest.

No major changes in antelope distribution have occurred since the last meeting. We estimate there are 30,800 square miles of occupied antelope range open for hunting. There are presently no plans to do any antelope stocking within the state.

Presently, there are no research projects planned or in progress in South Dakota.

Our present situation involves a different aspect of antelope management than has been previously experienced. Instead of developing strategies to allow a limited harvest, we find ourselves trying to determine the best method of increasing our harvest with a limited number of hunters.

In 1979, the antelope population had bottomed out. South Dakota resident hunters were allowed to hunt once every third year (except landowners) and only 3,100 licenses were issued. By 1982, restrictions on eligibility had relaxed, and hunters could hunt every year if licenses remained after the normal application/drawing period. In an effort to increase harvest in counties where landowner hunter tolerance limited the number of hunters during any given season, we tried a split season method of licensing. This involved

having two back-to-back seasons separated by a short break in between with half the permits available for each season. This strategy proved to be less than a glowing success. Hunters bought all the available first season permits but we sold only 30 percent of the available second season licenses. Even with relaxed eligibility requirements and a good sales effort, we were obliged to have a reduction season in four units which ran concurrently with the deer season to get a limited harvest of antelope. We learned that hunters in South Dakota were traditional thinkers and felt that if they could not hunt the first day, all the antelope would be gone. As a result, they would not buy the available licenses. The attendant difficulties with implementing new regulations, applications, landowner tolerances, etc. helped us decide to try a new tactic. The 1982 season also showed us that we had nearly saturated our antelope hunting market.

The 1983 increase in antelope numbers forced us to rethink licensing/management strategies based on 1982 experiences. We had learned that left to their own choice, our hunters took 2.2 bucks for each doe harvested. It was obvious to all, even the most conservative CO's and landowners, that the does needed to be harvested at a greater rate.

As previously stated, the 1983 season increased the doe-fawn harvest over past years. This was accomplished by allowing non-residents to hunt, eliminating any eligibility requirements and allowing hunters to have two licenses, one of which had to be a doe/fawn. Unfortunately, not even all these changes were enough to result in selling all the available licenses. A total of 1,245 resident and 960 non-resident licenses did not sell.

Prospects for 1984 are good. There are moves underway to expand the number of two antelope units and to facilitate the sale of anticipated record number of licenses.

ANTELOPE STATUS REPORT FOR TEXAS

W. B. Russ, Texas Parks and Wildlife Dept., Sanderson, TX

The Texas antelope population was estimated at 12,011 animals during the fall of 1983 with a herd composition of 1.97 does per buck and 0.27 fawns per doe.

During the 5 year period of 1979 through 1983, the Texas antelope population has fluctuated from a high of 18,207 animals in 1979 to the current low of 12,011 animals. The current figure represents a population decline of 33 percent from the 1982 census. The majority of this population (64%) is found in the Trans-Pecos area with about 25% in the Panhandle and the remaining 11% in the Possum Kingdom District.

Population estimates are obtained from aerial surveys of slightly less than one-half of the occupied antelope range each year. Aerial counts are conducted during the spring and summer. A rotation system allows the inventory of each area at least every third year. Aerial census data concerning herd composition and fawn production are supplemented with ground surveys conducted during June, July, and August.

The antelope hunting 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 equipment and all firearms, except those utilizing rimfire ammunition, are legal for taking antelope. Persons may hunt from a vehicle within the boundaries of private property.

The antelope harvest is controlled by permits, designated as either for buck or doe, which by law are issued to qualified landowners that surveys have shown to have surplus antelope on their property. The hunter must negotiate with the landowner to obtain trespass privileges and a permit.

Buck permit issuance has ranged from 900 to 1,400 permits during the past 5 hunting seasons. An insignificant number of doe permits were issued in unusual instances of high population density in 1979 and 1982. Buck permits are issued on approximately 6 million acres of private antelope range. The buck harvest during the last 5 years has been as follows:

1979 - 897 buck	1981 - 695 buck	1983 - 538 buck
1980 841 buck	1982 - 821 buck	

Utilization of permits had remained above 65% for many years until 1982 when utilization dropped to 58% and declined again in 1983 to 46%. The decline has been attributed to landowner conservatism associated with the current population decline and the continued rise in trespass fees charged to the hunter. In addition, an increasing number of landowners have set management goals for producing trophy bucks.

Hunter demand greatly exceeds the number of surplus buck antelope available for harvest. Present management policy is directed toward the hunter harvest of all bucks considered surplus to breeding requirements. The calculation of buck permit issuance rates incorporates a 25% factor for crippling loss and is aimed at maintaining a post hunting season sex ratio of

at least 1 buck per 4 does. The continued partial utilization of permits by Texas landowners has prevented the maximum harvest of surplus antelope, but has allowed the production of some trophy size bucks.

The Texas Parks and Wildlife Department has had an aggressive program for reintroduction of antelope broodstock into their historic range from which antelope were extirpated. This program has brought two major changes in pronghorn distribution during the past decade, and will be presented in a paper by Departmental personnel later in the workshop.

STATUS OF PRONGHORN ANTELOPE IN UTAH - 1984

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Pronghorn antelope are widely distributed in Utah despite low numbers. They currently exist in small scattered bands on 15 different areas or herd management units within the State. About 40% of these occupy the western desert areas and the remainder are in the northeast corner and in the south-central parts of the State. Populations in some herd units have increased over the past 6 years, largely as a result of improved fawn survival. Total numbers, based on trend counts, are estimated at about 6,000 statewide.

Pronghorn habitat has not changed significantly during this period, but in some areas there has been a shift from winter grazing by sheep to winter grazing by cattle and as a result, there is less diet overlap and competition for forage between pronghorns and livestock in these areas. As a result, some pronghorn populations have responded favorably. Precipitation during the past 2 years has been above average and this has also improved forage quality. In some areas, mining and energy related land use activities are impacting pronghorn habitat. Where this is the case, efforts are made to mitigate habitat losses.

Pronghorn antelope are hunted in Utah in September and early October on a permit basis. Applicants are allowed no more than 1 permit every 3 years. Over the past 10 years, the interest in antelope hunting in Utah has increased significantly. For example, 1,078 persons applied for 152 permits issued in 1968 and harvested 114 bucks. By 1976, the number of applications for permits to hunt pronghorns had increased to over 4,000 per year. In 1983, there were 5,673 applications for 522 permits and these permittees harvested 463 bucks. Seven of these were taken during the 15-day archery season held prior to the regular hunt. Archery permits were available to anyone possessing a valid pronghorn hunting permit. In 1983, the pronghorn hunt was held at a later date (September 24- October 2) than in previous years to avoid hunting during the breeding season. This seemed to work well on the desert ranges, but met with some criticism on other areas, particularly the Awapa Plateau.

Management data obtained annually in Utah include late summer fawn to doe ratio counts, winter trend counts, and harvest information. August fawn to doe ratios have improved on some herd units during the past 4 years. The statewide average ratios in 1982 and 1983 for 13 units were 63 and 73 fawns per 100 does, respectively. Several units had ratios of over 75 fawns per 100 does both years.

Research programs with pronghorn antelope in Utah, which have been active in previous years, have been completed and no additional studies are planned at this time. Some phases of the research have not been published in final form as yet.

The Utah Division of Wildlife Resources, in cooperation with other agencies, is continuing efforts to expand pronghorn populations by trapping and moving animals into new areas where habitat is suitable. In winter of 1982-1983 a total of 371 pronghorns were trapped from Awapa Plateau and Snowville to reduce population numbers. Forty-nine of these were shipped to Arizona and the remainder to 3 different sites in Utah. An additional 340 pronghorns trapped in Colorado were released in Utah. In winter of 1983-1984

a total of 237 pronghorns were trapped from the Awapa Plateau and released at various sites in Utah.

The population on Awapa Plateau has been our most successful and productive introduction to date. It was started in 1965 with 129 pronghorns from Montana and has now expanded to over 1,000 head, and is maintained at about that level by hunting and by trapping for release to other sites. The Awapa Plateau was first opened to hunting in 1968 and to date, a total of 856 bucks have been harvested. In addition, a total of 1,012 animals have been trapped from this area for release into new sites.

Previous research at the Desert Experimental Range indicated that available drinking water was an important factor in pronghorn habitat. It was concluded that pronghorns could not survive without drinking water during hot summer months in the Atriplex-Eurotia vegetation types found at lower elevations on the desert areas of western Utah, even when above average forage succulence occurred. As a result of this work, "guzzlers" or rain catchment systems are considered an important factor in pronghorn management on desert ranges where natural watering sources are absent or limited. Proper placement of these watering systems has improved summer distribution of animals and also improved foraging conditions by enabling pronghorns, particularly does with fawns, to use range they would not otherwise be able to in drought periods.

Another management strategy that has considerable merit in Utah is to adjust class, season and intensity of livestock use to reduce competition with pronghorns. The Division of Wildlife Resources works closely with the Bureau of Land Management and the U.S. Forest to achieve better patterns of livestock use and to maintain and improve pronghorn antelope habitat in Utah.

WASHINGTON STATUS REPORT

Woody Myers, Washington Department of Game, Olympia, WA

Washington's pronghorn population is currently estimated to total between 75 and 100 animals. These estimates are based upon incidental observations by field personnel and private landowners. The four isolated herds which compose the state's population have never been subjected to legal hunting. However, losses due to poaching have been documented in recent times and probably represent a significant limiting factor. No research has been conducted on Washington's pronghorns.

WYOMING STATE REPORT

Craig L. Sax, Wyoming Game and Fish Dept., Mountain View, WY

Pronghorn in Wyoming are managed by objective. Like many states, Wyoming manages around objectives that are based partly on biology and partly on politics. The state's pronghorn are subdivided into herd units (populations), segregated by topography or, more often, political boundaries such as fences and highways. The state-wide objectives for pronghorn are to provide 63,931 pronghorn for harvest at a rate of 89.2 percent success and 2.4 days of hunting per animal taken. This will produce 151,124 days of hunter recreation annually.

CURRENT POPULATION

The 1983 pre-hunt pronghorn antelope population in Wyoming, an estimated 607,936 animals, was high for modern times. The post-hunt population is estimated at 482,011. The population objective is 275,500 animals. The post-hunt population is 75% over the statewide objective, but not all of the herds are over population objectives. In fact, 17 of our 55 herds are within 20% of this objective. Most of the antelope over-population is found in six herd units that are 134,239 animals above the sum of their objectives. These herd units account for about 65% of the 206,511 animals which exceed the statewide objectives for the pronghorn program.

The most recent population estimates were obtained from 1982 Big Game Completion Reports, summarized post-hunt 1982/pre-hunt 1983 population estimates, and population objectives by herd unit. Harvest estimates are based on license sales and past hunter success. Cripple loss is assumed to be 15%.

The cause of what has been a rapidly increasing pronghorn population prior to the winter of 1983-84 has been a series of moderate winters, coupled with consistently high productivity and recruitment and more accurate censusing of pronghorn. There has been a time lag between development of improved pronghorn census and population estimation techniques and their application. There has also been a time lag in the ability of personnel to integrate the available tools into workable systems of prediction. We have made extensive use of population modeling (POP-50) in Wyoming and now have more precise population estimates as a result and estimated trends are significantly higher than previous projections.

As this is being written, major population fluctuations are occurring regionally in Wyoming. These herd unit fluctuations are occurring through population shifts and winter mortality. Habitat incursions have accumulated in recent years, along with moderate winters. These incursions are related to various types of development on antelope range. Accumulation of these untested barriers has, undoubtedly, taken their toll on antelope herds in need of access to critical habitat for the first time in a number of years. The classic example is Red Rim, which will be covered elsewhere in these proceedings.

DISTRIBUTION

Pronghorn occur in all of Wyoming's 23 counties. In general, the herd units are populations, and hunt areas are used to distribute hunters in the right areas to obtain the harvest needed for management. Fifty-five distinct herd units comprise 109 hunt areas. These herds occupy an estimated 68,234 square miles. A total of 46,402 square miles have been identified as yearlong or winter range and 5,110 square miles are critical winter range. The Department's objective is to maintain all existing pronghorn habitat, with maintenance of winter range the top priority.

HARVEST STRATEGIES

The estimated 1983 pronghorn harvest in Wyoming was 98,595 animals. In 1982, 79,515 pronghorn were harvested. Harvest composition in 1983 was 52.8% buck, 41.3% doe, and 5.9% fawn. Residents held 61.5% of the licenses and non-residents held the remaining 38.5%. The resident harvest was 41% bucks, while 70% of the non-resident harvest was bucks.

There are 2 types of licenses available for pronghorn in Wyoming, a limited quota license and a limited quota "additional" license. Both licenses may require the harvest of a specific sex or age class of pronghorn, and/or it may specify the type of weapon to be used. Most limited quota licenses are valid for 1 pronghorn of either sex. Most limited quota "additional" licenses are valid for doe or fawn only. A hunter is usually restricted to purchasing a single license for either sex pronghorn, and most of those hunters take a buck. A person who holds a limited quota license may purchase two limited quota "additional" licenses. The hunter may purchase three limited quota "additional" licenses if no other pronghorn licenses have been purchased. Both types of licenses restrict the hunter to specific hunt areas and hunting between specific dates.

In an effort to reduce herds that were over their population objective, and/or where there were access or trespass problems restricting hunter access, the three license limitation on additional licenses was lifted in 10 hunt areas in 1983. This easing of the regulations permitted purchase of unlimited numbers of additional licenses in these hunt areas. The areas involved are primarily hunted by non-residents. Residents resist hunting these areas due to high access fees demanded by landowners and the availability of alternative hunt areas with free access. An analysis of this permit strategy showed no increase in the number of permits issued in those areas with unlimited licenses per hunter over those areas with a limitation of 3 licenses per hunter (T. Cleveland, pers. comm.). However, in one instance, 30 licenses were issued to 1 resident hunter. In general, it was felt that this liberal license issuance policy was not abused. A very positive aspect of this liberalized permit system is the recognition by landowners that the Game and Fish Department is serious about reducing pronghorn numbers in problem areas. This strategy of unlimited licenses will be tried again this year in 8-10 more hunt areas.

The 1983 hunting seasons for pronghorn varied from nine days to 99 days in length. The earliest seasons, special archery seasons, opened August 1. Some hunt areas permitted rifle hunting until December 31. One hundred-eight hunt areas (all areas with open seasons) permitted rifle hunting and some sort of separate archery season. Large caliber handguns meeting regulations may be used during regular rifle seasons as may muzzle loading rifles and archery

equipment. Separate seasons for muzzle loading were set in two hunt areas. A combined muzzle loading rifle-large caliber handgun season was established in hunt area 66. The longest special archery season offered was seven weeks in length.

Hunter success in 1983 was 92%. The past 5-year trend in pronghorn hunting in Wyoming is seen in Table 1. In 1983, 3,276 archers took 1,501 antelope, for a success rate of 45.8%.

CENSUS AND SAMPLING

Pronghorn trend counts are flown in each herd unit every third year. When necessary, fixed-wing aircraft are used to determine pronghorn distribution and habitat utilization. Pre-season classifications are done annually in each hunt area and herd unit by 4-wheel drive vehicle to determine herd structure and fawn production. Post-season classifications are conducted as necessary. Approximately 20 percent of all antelope hunters are surveyed by mail questionnaire to determine hunters afield, success, hunter effort, harvest structure and recreation days. Hunter field checks are utilized as a check on the mail questionnaire information, and a reporting bias check is also made.

FEEDING PRONGHORN

The Wyoming Game and Fish Department received criticism from out-of-state media and various publics regarding not feeding antelope faced with stress from severe winter conditions. Although this decision was both unpopular and unique, it was based on the agency's experience in previous winters that mortality is not significantly reduced by feeding, and that feeding tends to erode the public awareness of the relationship between wildlife and habitat. It creates the illusion that habitat loss can be tolerated by wildlife and that loss can be mitigated simply by feeding the impacted animals.

NEW RESEARCH

A new investigation has been initiated in Wyoming to identify the effects of leptospirosis in pronghorn. Leptospirosis has been implicated in illness and death of pronghorns in Wyoming in past years.

Table 1. Five Year Trends in the Pronghorn Program in the State of Wyoming.

Fiscal Year	Harvest	Rec. Days	Success	Days/ Animal	Lic. Sold	Lic. Revenue ($)	Mgt. Costs ($)	Hunter ($) Expenditures
FY79	58,132	136,642	87%	2.35	66,461	1,983,571	1,280,290	14,425,807
FY80	44,616	106,144	84%	2.38	53,208	1,371,826	1,233,167	11,618,233
FY81	47,994	95,144	84%	1.98	56,909	2,265,558	1,442,404	12,681,619
FY82	67,801	123,101	88%	1.82	77,327	3,141,674	1,407,200	14,823,181
FY83	79,515	148,266	87%	1.86	91,595	3,703,621	1,845,742	18,538,921

TECHNICAL SESSION

PRONGHORN FAWN MORTALITY ON THE NATIONAL BISON RANGE

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ABSTRACT

The extent and causes of fawn mortality among pronghorns (Antilocapra americana) on the National Bison Range in western Montana were determined from 30 fawns radio-tagged in 1977 and 34 in 1978. High fawn mortality (89%) in 1977 was attributed primarily to coyote (Canis latrans) predation. Bobcat (Lynx rufus) and golden eagles (Aquila chrysaetos) predation was the most important cause of death in 1978, following spring coyote control, when the mortality rate was 71%. During 1978, mortality rates in 2 major fawning areas were significantly different: 93% where bobcat and eagle kills occurred and 27% where coyote-related mortality had been high since 1975 and where most of the coyote control occurred.

INTRODUCTION

Pronghorns, though not indigenous to the National Bison Range (NBR), were successfully introduced in 1951. The original herd of 15 animals increased to 120 by 1962 (Anon. 1956-77), despite the removal of more than 44 animals (Wright, Univ. Mont. Zoologist, pers. comm.). Fawn recruitment remained high until 1970, and transplanting and cropping were necessary to limit population growth (Anon. 1956-77). The fawn mortality rate, which previously had not exceeded 65%, increased to 77% in 1970 and remained high: 83% in 1971, 93% in 1972, 90% in 1973, and 73% in 1974 (Anon. 1956-77, Reichel 1976, Corneli 1980). About 130 pronghorns were on the NBR during the summer of 1978.

An increase in coyote numbers concurrent with increased fawn mortality, apparently a response to the cessation of all predator control (Reichel 1976, Corneli 1980), prompted Reichel's study of coyote-prey relations on the NBR in 1974 and 1975. Although he determined that Microtus spp. were the most important food item in coyote scats throughout the year, pronghorn fawns were important during the fawning season. Coyote predation was apparently the most important cause of death among fawns fitted with transmitters in 1975, when the mortality rate was 69% (Reichel 1976).

Because of transmitter failures, Reichel (1976) was able to obtain cause-of-death data for only 7 fawns; apparently 5 were coyote kills and 2 resulted from weak calf syndrome. Using more reliable telemetry equipment, Von Gunten (1978) studied pronghorn fawn mortality on the NBR during the summer of

[1]The U.S. Fish and Wildlife Service; Montana Department of Fish, Wildlife and Parks; University of Montana; and Wildlife Management Institute cooperating.

1977. Corneli (1980) continued the study in 1978 and controlled coyotes during the spring to determine if compensatory mortality would replace coyote predation.

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STUDY AREA

The 7,700-ha NBR, located at the southern end of the Flathead Valley in western Montana, is primarily a Palouse Prairie grassland with timbered areas at higher elevations and along Mission Creek. Elevation ranges from 696 m to 1,361 m. The southern half of the Range is steep, rocky, and dissected by canyons. These studies were restricted primarily to the flatter northern and southeastern grasslands, where pronghorns congregate during spring and summer (Figure 1). The study area was described in detail by Kitchen (1974).

METHODS AND MATERIALS

Von Gunten (1978) and Corneli (1980) list details of the methods and materials.

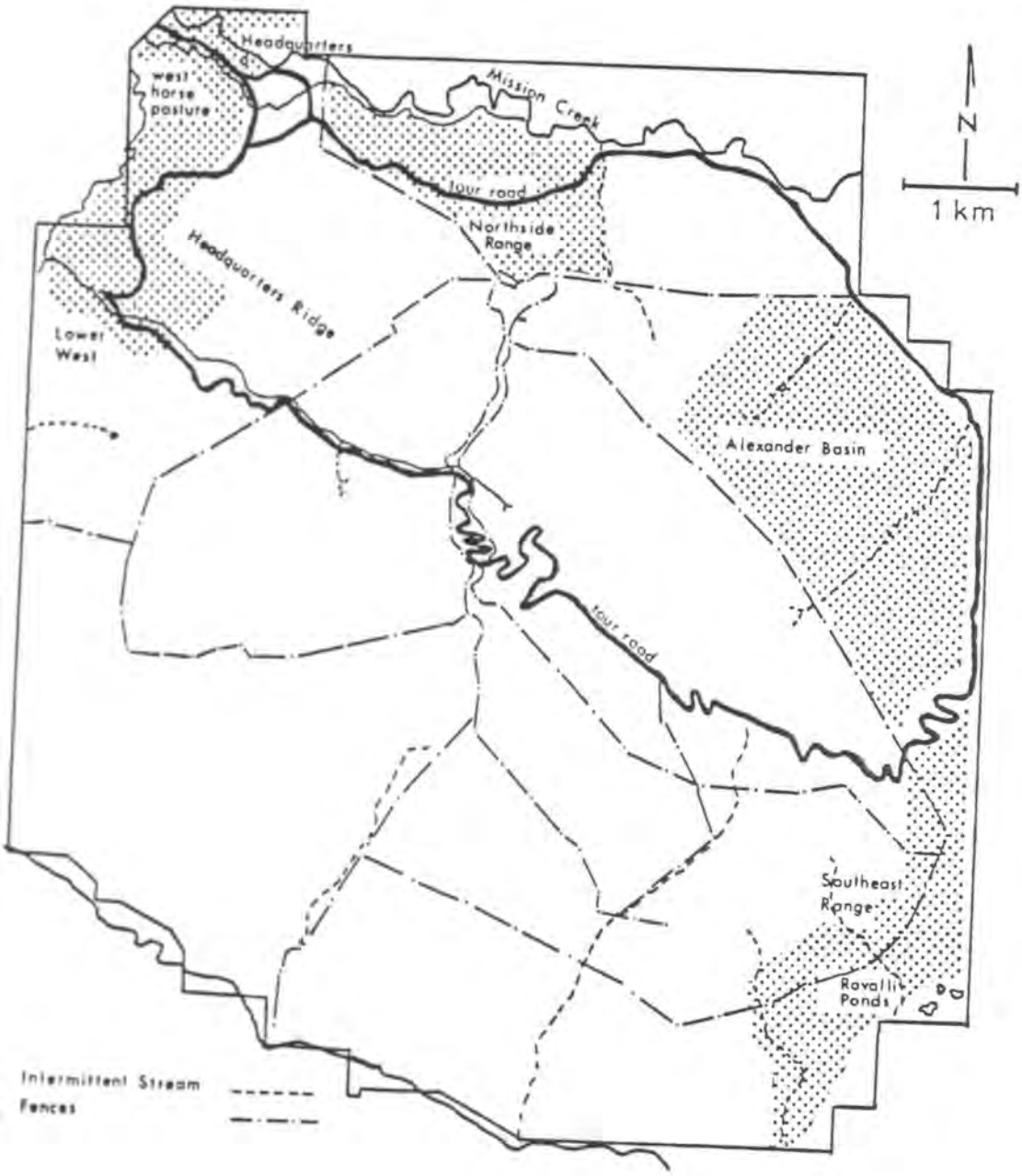
Fawns were captured after at least a 4-hour imprinting period (Autenreith and Fichter 1975) and before 3 days of age. They were harnessed with 110-g lithium-powered transmitter backpacks. No backpack weighed more than 5% of the smallest fawn's weight (2.5 kg). Data recorded included capture time, physical characteristics, and age which was estimated using Bromley's (1977) criteria.

Fawns were located 4-5 times weekly. Dead fawns were photographed and pertinent data recorded. We determined the cause of death by characteristic killing and feeding patterns of predators (O'Gara 1978). A fawn was listed as "predator killed" if the proximate cause of death was clearly an attack, resulting in wounds typical of a given predatory species accompanied by subcutaneous hemorrhages that indicated the fawn was alive when the wounds were inflicted. A fawn was listed as "predator involved" if circumstantial evidence linking it to predators existed. For example, fawns were often observed in apparently good health, and the next morning only a few bloodstained fragments could be found with the radio. If the fragments and radio were at a coyote den, the death became "coyote involved."

Over 95% of NBR does ordinarily have twins (O'Gara 1968), so each fawn crop was estimated by counting pregnant does in early May. Fawn death rates were determined by comparing the estimated fawn crop with the number counted in early August and September (1977) or October (1978).

Coyote control began on 8 May 1978, 2 weeks before fawning began, and continued through 9 June. Steel traps, M-44s, and snares proved inadequate during the short control period. One coyote was poisoned, 4 were killed in snares, and 14 were shot from a helicopter by O' Gara.

Figure 1. The National Bison Range, Moiese, Montana. Stippling depicts areas where does congregate during summer.



We used scent stations (Linhart and Knowlton 1975) and direct observation to determine coyote abundance (Von Gunten 1978, Corneli 1980).

RESULTS

We captured and radio-tagged 30 fawns in 1977 and 34 in 1978. All captured fawns appeared healthy except one with a dislocated cannon bone in 1977 and a small fawn captured in 1978 that was thin and weak.

In 1977, 95 fawns were estimated born, and 85 (89%) had died by late September; in 1978, 65 of 92 (71%) had died by mid-October. Among the radio-equipped fawns that died, most were dead within 3 weeks after birth: 70% of 30 in 1977 and 82% of 34 in 1978.

Twenty radio-tagged fawns died in 1977, and 7 others presumably did because they were not seen during the fall inventory (Table 1). The 20 known deaths included 5 fawns killed by coyotes, 3 by bobcats, and 1 by a golden eagle. All that remained of 11 fawns were bits of bone, hair, chewed elastic, and transmitters; 9 were found near the dens of coyotes that probably consumed them. The fawns had been seen recently and appeared healthy, so coyote involvement was suspected. Because of transmitter failures, information on causes of mortality was lost from the remaining 7 fawns. Three fawns, including 1 killed by a coyote, were not seen with a doe following capture; rejection may have predisposed them to death.

Twenty-two (65%) of the radio-tagged fawns died in 1978 (Table 1). Eight were killed by predators: 3 by bobcats, 2 by golden eagles, and 3 by unidentified predators. Coyotes probably consumed at least 3 fawns, but did not necessarily kill them. The remains of 2 of the 3 were found near active coyote dens and all 3 were almost completely consumed, a feeding pattern characteristic of coyotes. Bobcats rarely eat an entire fawn at one feeding but coyotes often do (O'Gara 1978). Because of transmitter failures (3), or scant remains (7), the cause of death could not be determined for 10 fawns. However, 7 of the 10 appeared healthy less than 48 hours before death and their rapid disappearance suggested predator involvement. The sibling of a fawn killed by an eagle apparently succumbed to capture myopathy (Chalmers and Barrett 1977). Bruises on the carcass, tracks of a running doe, and eagle feathers indicated a long chase in which the doe repulsed the eagle (Corneli 1980). In addition, carcasses of 2 untagged fawns were recovered after students watched an eagle kill them.

Table 1. Fates of 66 NBR fawns born in 1977 and 1978.

	Pre-control 1977	Post-control 1978
Survived	3	12
Predator killed		
Coyote	5	0
Bobcat	3	3
Golden eagle	1	4
Unidentified predator	0	3

Predator involved		
Coyote consumption probable	9	3
Unidentified predator		7
Eagle-induced capture myopathy		1
Unknown		
Transmitter failure	7	3
Nearly completely consumed	2	
Total	30	36

Both years, a fawn's fate was related to its location. Fawns born on the northside range in Alexander Basin during 1977 died at significantly earlier ages than those born on the southeastern range (Kolomorov-Smirnov 2-sample test, $T = 0.69$, $p < 0.005$). Two fawns born on the southeastern range moved to Alexander Basin when they were 33 and 35 days old, and died 2 and 5 days later. Both were "coyote involved" deaths. During 1978, among 14 fawns tagged in the southeast, 13 (93%) died, whereas in Alexander Basin (where coyote control was centered) only 3 (27%) of 11 tagged fawns died. The difference was highly significant ($X^2 = 11.27$, $p < 0.001$, 1 d.f.). The 1 southeastern survivor moved to Alexander Basin when she was 10 days old. Of 4 fawns radio-tagged on the northside, near Alexander Basin, 50% died., 80% of 5 fawns radio-tagged in the lower western pasture died.

The mean capture weights of surviving fawns (3.7 kg) were not significantly different than those of fawns that died (3.4 kg).

Coyotes occupied at least 6 dens each year in Alexander Basin, the northside range, and the northwestern part of the Range, but no active dens were found in the southeastern pasture. Adult coyotes inhabiting or frequenting the Range numbered at least 16 in 1977 and 21 in 1978 before control.

From 8 May to 9 June 1978, we killed 19 coyotes, including 7 females (5 lactating) and 12 males. Except for an adult pair in the western horse pasture that survived control, coyotes were rarely seen during the summer after control. The July 1977 scent line index was 80, compared to 4 in July 1978. By November 1978, NBR personnel reported sighting about the usual number of coyotes for that time of year (Magadinno, NBR biologist, pers. comm.) and the index increased to 69 in October, compared to 132 in September 1977.

DISCUSSION

Predation remained the most important cause of death among pronghorn fawns in 1978 following coyote control, as it had been in 1975 and 1977, years of no control. More fawns survived in 1978 (29%) than in 1977 (10%), but survival was comparable to the 31% recorded in 1975 (Reichel 1976).

Although the 1978 fawn mortality rate remained high, a large difference existed between rates in the 2 major fawning areas: 27% in Alexander Basin, where most of the coyote control occurred, and 93% in the southeastern pasture. In Alexander Basin, 90% fawn mortality in 1975 (Reichel 1976) and

93% in 1977 was attributed primarily to coyote predation. The dramatically improved survival apparently was a result of removing the resident coyotes. However, control was not extensive enough to affect the whole NBR, and did not affect predation other than that caused by coyotes. Alexander Basin had been the site of dens occupied by at least 1 breeding pair since 1974 (Reichel 1976, Von Gunten 1978), and traditionally has also been a major pronghorn fawning area (Kitchen 1974, Reichel 1976, Swanger 1977). Each consecutive year that does fawned there may have provided resident coyotes with experience, improving their fawn hunting efficiency. In Alexander Basin, other mortality factors did not compensate for the absence of coyote predation in 1978. Neither year did we find evidence that other factors (disease, abandonment by dams, precipitation, or food supply) significantly affected fawn mortality (Von Gunten 1978, Corneli 1980).

The 1978 fawn mortality rate remained high in the southeastern pasture, where predation was the most important cause of death. The concentration of bobcat and eagle kills there was probably related to the terrain, characterized by ridges dissected by draws and intermittent streams. Bobcats hunt by stalking (Bailey 1972) and the numerous brushy draws and rocky ridges provided the cover essential to a successful stalk. Such cover was relatively unavailable on the open, flat terrain of Alexander Basin. The 4 eagle kills were restricted to the southeast, probably because the air currents associated with the ridges facilitated hunting. An eagle that was observed carrying sibling fawns on separate occasions glided from a 1,200 m ridgetop and did not lift the fawns above the altitude where they were caught. The observation is similar to those of Carnie (1954) and Bodie (1978), who observed golden eagles carrying fawns from ridges and noted the apparent importance of ridges as an aid to carrying fawns.

Compared to pronghorns on open range, those on the fenced NBR had a limited choice of fawning locations. Some locations were probably better suited than others because of higher quality forage. Since 1969, the major concentrations of pregnant does shifted from the northern portion of the Range to the southeast near Ravalli Ponds (Figure 1; Reichel 1976, Von Gunten 1978). During the same period, northside vegetation changed to a near climax state, resulting in a decline of forbs (yarrow, Achillea lanulosa and aster, Aster falcatus) that were important components of NBR pronghorn diets (O'Gara and Greer 1970). Such a change did not occur in the southeastern range, and parturient does may have been attracted to the greater abundance of forbs there. In 1978, 38% of the pregnant does fawned in the southeast. Comparable data are not available before changes in range condition, but only 1 doe had fawns in the southeast during spring 1966 and two does during spring 1967 (O'Gara pers. observ.). Also, Kitchen (1974) did not indicate pronghorn groups in the southeast. The proximity of this fawning area and bobcat habitat apparently contributed to the high mortality caused by bobcats.

The high reproductive potential of pronghorn does (Buechner 1950, Ellis 1972, Yoakum 1978) apparently permits populations to remain stable despite high fawn mortality if losses from the adult population are low. An Oregon population maintained numbers for 17 years with an annual recruitment of only 26 fawns:100 does (Yoakum 1978). However, successive years of low recruitment in isolated populations, such as the NBR herd, may cause population declines as the breeding-age animals grow old, die, and are replaced by fewer young animals.

During the 1978 breeding season, Kitchen (pers. comm.), who had learned to recognize each individual born before 1972 (Kitchen 1974), observed that at least 65% of the adults on the NBR were older than 7. He believed a major population decline might occur in 2-3 years. Supporting his observation were the results of the March 1979 NBR Big Game Census, which revealed a loss of 33% of the herd during the previous winter. Among 25 adult carcasses recovered and aged during spring 1979, 23 were older than 7 (Corneli 1980).

A natural stability of predator-prey interactions seems unlikely on the NBR. The coyotes do not depend on pronghorns for survival (Reichel 1976); thus, their numbers would not be checked by declining pronghorn numbers. Recovery from a decline would be further hampered because fences preclude repopulation from nearby herds and confine the pronghorns with experienced predators. The level of fawn survival needed to maintain a stable population has not been determined. However, 10-20% survival is apparently sufficient, and such survival precludes the need to otherwise control the population.

If successive years of high predator-caused mortality do threaten the breeding population, predator control may become necessary if maintenance of the pronghorn herd on the NBR is deemed desirable. Improving postnatal survival should result in increased numbers of adult pronghorns unless some factor, other than predation, has changed dramatically on the NBR since the early 1970's when coyotes increased substantially. Before that time, the herd nearly doubled (and half of it had to be removed) every 2 years (Anon. 1956-77). Beale and Smith (1973) believed that even a low density of bobcats could inflict high mortality on pronghorn fawns, and a severe reduction would be necessary to significantly increase survival in the southeastern pasture. Reduction of NBR bobcats might be unacceptable, and unnecessary, because considerable fawn mortality can be endured by the herd. The dramatically decreased mortality in Alexander Basin indicates that removal of coyotes, especially older, experienced ones, could improve pronghorn survival enough to prevent a serious population decline. Coyote populations are resilient (Knowlton 1972, Connolly and Longhurst 1975), so periodic control should not threaten the NBR population.

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LITTLE LOST PRONGHORN FAWN STUDY - CONDITION, HABITAT USE AND MORTALITY

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ABSTRACT

A total of 67 pronghorn fawns (Antilocapra americana) was transmittered in the Little Lost Valley during 1981 and 1982 to document physiological condition, habitat use and mortality.

Measurements taken shortly after birth indicated fawns were generally vigorous and in good condition. Vegetation was measured at 21 birth sites and 278 fawn bed sites. Mortality was 52% in 1981 with hypothermia/starvation being the primary cause. A 31% mortality was documented in 1982 with the greatest cause of death due to predation. Comparisons with other study areas provide insight into the relationship between birth sites, bedding cover and fawn survival.

INTRODUCTION

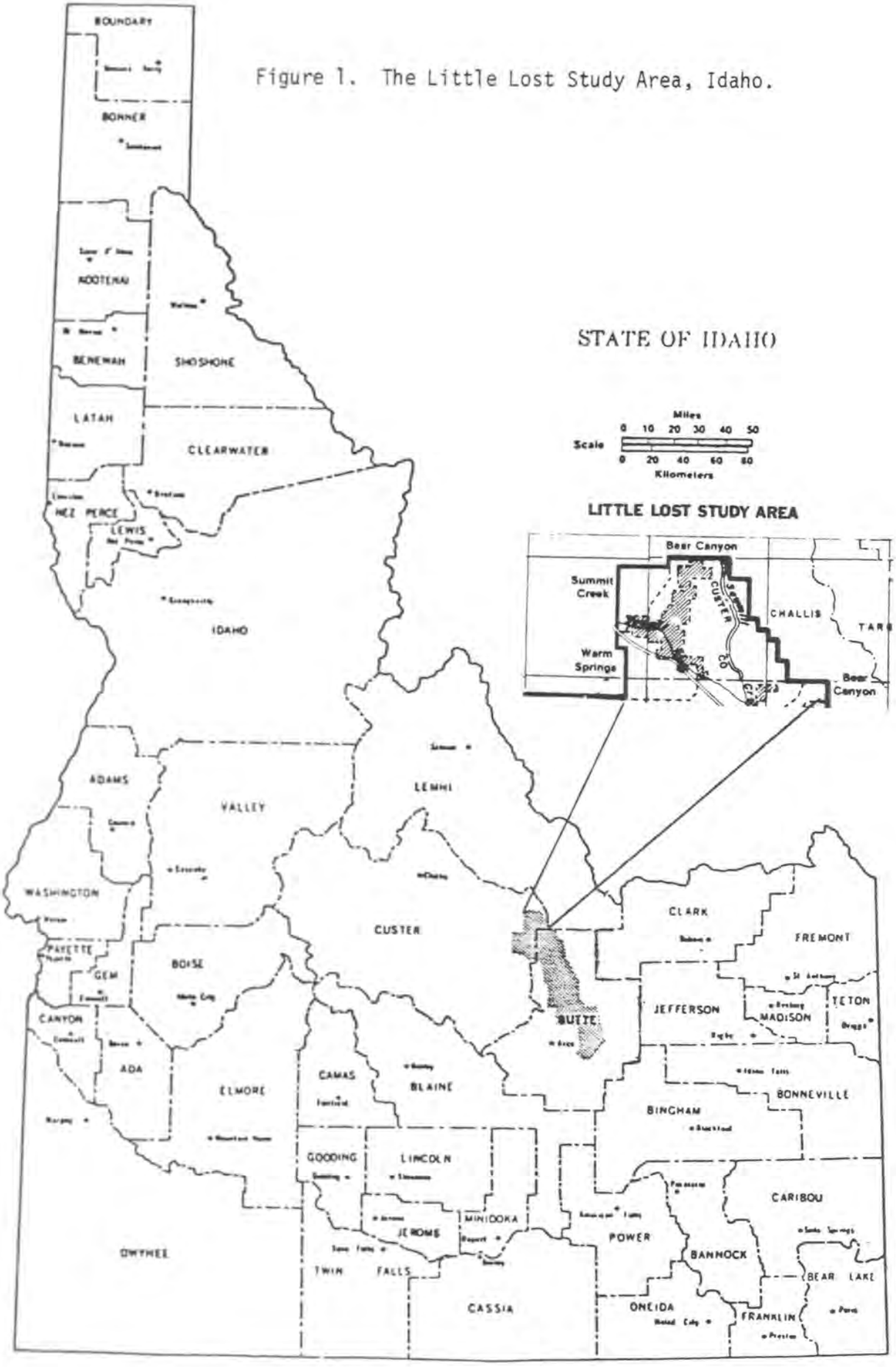
The Little Lost pronghorn fawn study was a continuation of data collection begun in 1973 to quantify the selected vegetation at birth sites and fawn bed sites. This information was collected to test the hypothesis of habitat imprinting (Fichter 1971). Based on early results, the studies subsequently focused on comparing vegetation used in both high and low production areas and documenting fawn mortality. The Little Lost study was the last of 5 to be conducted. Results and comparisons with the other studies are discussed.

Funds for the study were provided by the Idaho Department of Fish and Game and Pittman-Robertson Project W-160-R. Gratitude is expressed to the following individuals who helped with data collection: Gary Copeland, Bob Griswold, Tim Smallwood, Von Pope, Mark Davis, Jay May and my wife Doris. Bob McCarty (Idaho Falls BLM) also provided project assistance.

STUDY AREA

The Little Lost Valley is a sagebrush dominated land that ranges from an elevation of 1,433 m (4,778 ft) ASL at the Lost River sinks to 2,926 m (9,752 ft) ASL on Hawley Mountain (Figure 1). Commonly found plants include: Wyoming big sage (Artemisia tridentata wyomingensis), mountain big sage (Artemisia tridentata vaseyana), low sage (Artemisia arbuscula), rabbitbrush (Chrysothamnus viscidiflorus), blue bunch wheatgrass (Agropyron spicatum), prairie June grass (Koeleria cristata), bottlebrush squirreltail (Sitanion hystrix), buckwheat (Eriogonum spp.), lupine (Lupinus spp.), arrowleaf balsamroot (Balsamorhiza sagittata) and tapertip hawksbeard (Crepis acuminata). Range condition is rated: 715 ha (1,787 acres) excellent, 31,223 ha (78,057 acres) fair, 25,098 ha (62,746 acres) poor. Range trend is listed as 61,111 ha (152,777 acres) up, 0 ha down and 44,515 ha (11,287 acres) stable (U S.D.I. 1979).

Figure 1. The Little Lost Study Area, Idaho.



Weather records at Howe indicate the mean average precipitation ranges from 16.3 cm to 27 cm (6.4 in to 10.5 in) with an average of 22 cm (8.7 in). However, precipitation on the north end of the unit may be higher.

"The Little Lost River Valley was grazed by domestic sheep since 1882 when the area was settled. Some bands used the unit year-round while others only grazed during the winter. Large trail herds also traversed the valley in the early days.

Local historians indicate that around the turn of the century, the Little Lost and Birch Creek valleys were overgrazed by about 3,000 horses. Cattle were introduced in the 1880's, but not in the intensity of the sheep and horses.

During the range adjudications of the 1950's and 60's, BLM reduced the licensed AUMs by 839, but damage inflicted by the historic use still shows on about half of the unit." (U.S.D.I. 1980)

Antelope have historically inhabited the Little Lost Valley with population declines recorded in the 1920's and again in the mid 1950's when a severe winter decimated the herd (U.S.D.I. 1982). Recent surveys indicate between 2,000 and 3,000 antelope inhabit the valley.

Other wildlife species in the Little Lost include mule deer (Odocoileus hemionus), elk (Cervus elaphus), and sage grouse (Centrocercus urophasianus). Predators include coyotes (Canis latrans), bobcats (Felis rufus) and golden eagles (Aquila chrysaetos).

Data collection was emphasized in the upper valley near the Pahsimeroi Valley divide in the area of Summit Creek. Seasonal grazing occurs on the Summit Creek and Bear Canyon BLM allotments. A July 1 turn-out occurs on the Summit Creek Allotment where most fawning takes place. An early May turn-out occurs on the adjacent (more xeric habitat) Warm Springs Allotment and the Bear Canyon Allotment.

METHODS

Binoculars and spotting scopes were used from vantage points to locate and monitor parturient does through birth. Parturiency was determined based on descriptions in Autenrieth and Fichter (1975). After imprinting occurred (3 hrs after birth) walkie talkies were used to direct the capture crew of 1 or 2 individuals to the birth scene. In addition to attaching a solar powered transmitter (Wildlife Materials, Carbondale, IL) sex was determined and weight, length, heart rate, respiration rate and temperature were taken. Handling time was usually less than 15 minutes and care was taken to minimize contaminating fawns with human scent. Rubber gloves were worn and transmitters were carried in a sack with sagebrush leaves for several days prior to use. The birth site was flagged for subsequent vegetation analysis.

Transmittered fawns were monitored at least once daily using a Telonics receiver (Mesa, AZ) until 3 weeks of age, then at least 2-3 times a week through July. Bed sites of relocated fawns were flagged for subsequent vegetation analysis.

Mortalities were photographed and cause of death was determined where possible. Carcasses were frozen and shipped to Dr. Ted P. Kistner, D.V.M. at Oregon State University for necropsy.

A Daubenmire 2x5 decimeter plot frame was used to measure vegetation on 25 sites in each quadrant of a 1/100 acre circular plot centered on the birth or bed site. Number of brush plants per quadrant and maximum brush height and canopy in each quadrant were also recorded. In areas where the vegetation was not homogenous, another 1/100 acre plot was established and the 2x5 decimeter plot frame was used to characterize the non-use site (Daubenmire 1959).

Simultaneous temperatures (°C) were recorded at bed site level and 150 cm (60 in) above the site using the Rustrak (Gulton Industries, Manchester, NH) dual temperature recorder with pressure sensitive chart paper printed with hourly and 15 minute intervals.

A wind recording system (Model 2360, Weathertronics, Sacramento, CA) was used at bed sites in 1982 to continuously monitor wind speed. The device was positioned in the proximity of the bed site and measured wind speed at 38 cm (15 in) above the bed.

RESULTS

A total of 25 fawns was transmittered in 1981 and 42 in 1982 with 54% being 4 hours old or less (Appendix Tables 1 and 2). Maximum age was 7 days. Composition was 23 males and 44 females. Most fawns were vigorous at birth and newborns (not more than 4 hours old) weighed an average of 3.9 kg (8.6 lb). The average weight for all fawns handled was 4.1 kg (9.1 lb). Average rectal temperature for fawns handled in 1981 was 37.5°C (99.5°F) and 38°C (100.4°F) in 1982. Respiration rate averages were similar with 34 in 1981 and 36 in 1982. Heart rate averages were 132 in 1981 and 146 in 1982. All fawns appeared healthy and exhibited the lie-low posture characteristic when imprinting has occurred

Causes of fawn mortality were determined in the field and through a carcass study by Dr. Ted Kistner (D.V.M. at Oregon State University). These data are summarized in Tables 1-3. In 1981, 13 (52%) of the 25 fawns died of various causes. Seven fawns (28%) died from hypothermia and/or starvation, 5 (20%) died from predation (2 golden eagle, 2 bobcat and 1 coyote) and 1 (4%) from trauma-related shock. Analysis indicated the fawn was stepped on by an adult antelope or larger animal which ruptured the abomasum and the trauma led to shock. The fawn had nursed shortly before death. In 1982, 13 (31%) of 42 fawns died. The reduced mortality from 1981 related mostly to only 1 hypothermia loss and 2 abandonments. In 1982, bobcats accounted for 5 (12%) deaths, coyotes 2 (5%) and golden eagles 1 (2%). Predator losses were similar in both years with 20% in 1981 and 24% in 1982.

Maternal defense of fawns from predators is understood but seldom observed. The following extracts from field notes provide insights into this behavior.

6/4/83 -- Observed doe making move to locate fawn. 0925-30 fawn (est. age 3-5 days) got up, nursed, ran vigorously with doe. 0931 from east, another doe is chasing a coyote in the direction of the doe and fawn. Doe pressures

the coyote, overruns it as it zig-zags. The doe with fawn sees activity and fawn drops down, but not before spotted by coyote, who makes pass on fawn as it gets up and runs. Both does chase coyote and overrun it. Coyote gets up and goes for fawn again with same sequence as before. Fawn tries to run away and coyote comes for it again. Action moves out of view under hill (0933). 0936 moved vehicle in view of the doe. The doe that initially chased the coyote is walking back east. Coyote not in view. 0936-1000 doe is circling an area of dense big sage, frequently horns brush, watches toward sage, rushes through area she was watching. No coyote observed. I suspect coyote is laying in the dense sage consuming the fawn. Doe makes no effort to physically contact the coyote or run it off. (Past observations have helped me understand how tenacious a coyote is once prey is located. However, up to now, I have thought does were relatively effective in defending fawns.) 1001 doe again horns brush but circles less. 1010 doe paws the ground several times first right front foot, then left, again horns brush. 1013 doe appears to browse, raises up and watches then feeds again. Continues to walk back and forth but with less determination. Rump patches no longer flared. 1018 doe begins walking away toward southwest 27 m (30 yds), turns facing site, horns brush and walks back toward site, feeds. 1021 again walks in to the edge of the brush and stands watching, takes 2 or 3 steps into brush, rump patches flare, turns, walks back out, feeds, rump patches return to normal. 1030 doe again walks to edge of brush, horns brush, turns and walks 18 m (20 yds) east, turns, walks back, horns brush, paws ground and horns brush. 1036 magpie flys in and lands nearby. 1040 doe walks 9 m (10 yds) up hill from site, again paws and horns brush. 1045 doe again walks to sage edge and stands. No rump patch flaring. 1048 doe horns bush.

Table 1. 1981 Little Lost antelope study fawn mortalities.

Fawn#	Age At Capture (hrs.)	Wt. (kg)	Age at Death (Days)	Cause of Death	Wt. At Death (kg)
1	46	4 4	6	Hypothermia/starvation	3.4
3	3	4.5	3	Predator related trama	4.3
7	3	4.9	5	Predation-golden eagle	-
9	3	3.6	4	Hypothermia/starvation	3.1
11	3	3.8	8	Predation-bobcat	-
13	3	3.8	4	Hypothermia/starvation	3.2
15	3	4.6	4	Hypothermia/starvation	3.6
16	3	4.3	4	Hypothermia/starvation	3.6
17	3	4.1	3	Shock secondary to trama	4.4
21	72	4.7	5-7	Hypothermia/starvation	4.1
23	3	4.3	7	Predation-eagle	-
24	3	4.0	3	Predation-bobcat	3.6
25	72	5.0	9	Hypothermia/starvation	4.5

Table 2. Comparison of milk in gastrointestinal tract and physical condition scores from trauma and hypothermia fawn cases, 1981

	Fawn No.	Milk[a] Rumen	Abdomasum	Small Intestine	Large Intestine	Kistner Index[b] Phys. Cond. Score (points 0-100)
TRAUMA	I	+	+	+	+	25
	17	+	+	+	+	45
	45	+	+	+	+	45
	Mean physical condition score					38
HYPOTHERMIA						
	25	-	-	-	-	10
	21	-	-	-	+	5
	15	-	-	-	+	10
	VII	-	-	-	+	5
	13	-	-	-	+	5
	16	-	-	-	+	10
	9	-	-	-	+	10
1	Mean physical condition score					8

a + milk present
- milk absent
b Kistner, et al. 1980

Table 3. 1982 Little Lost Antelope Study fawn mortalities.

Fawn #	Age at Capture (hrs)	Wt. (kg)	Age at Death (days)	Cause of Death	Wt. at Death (kg)
1	48	4.5	4-5	Predation - bobcat	-
3	24	3.8	4-6	Predation - eagle	-
4	24	4.0	4-6	Predation - coyote	4.2
5	48	3.8	11-13	Predation (no carcass)	-
15	48	4.7	13	Predation - bobcat	-
16	24	3.8	2-3	Abandonment-Hypothermia	3.5 -
18	4	3.3	44	Predation - bobcat	-
21	24	3.7	14	Predation (no carcass)	-
30	96	4.7	9-10	Predation - coyote	5.4
32	3	3.5	2	Pedation - bobcat	-
37	48	3.3	11-14	Predation - bobcat	-
38	1	4.0	2	Abandonment-Hypothermia	3.6
41	8	3.8	3	Hypothermia	3.4

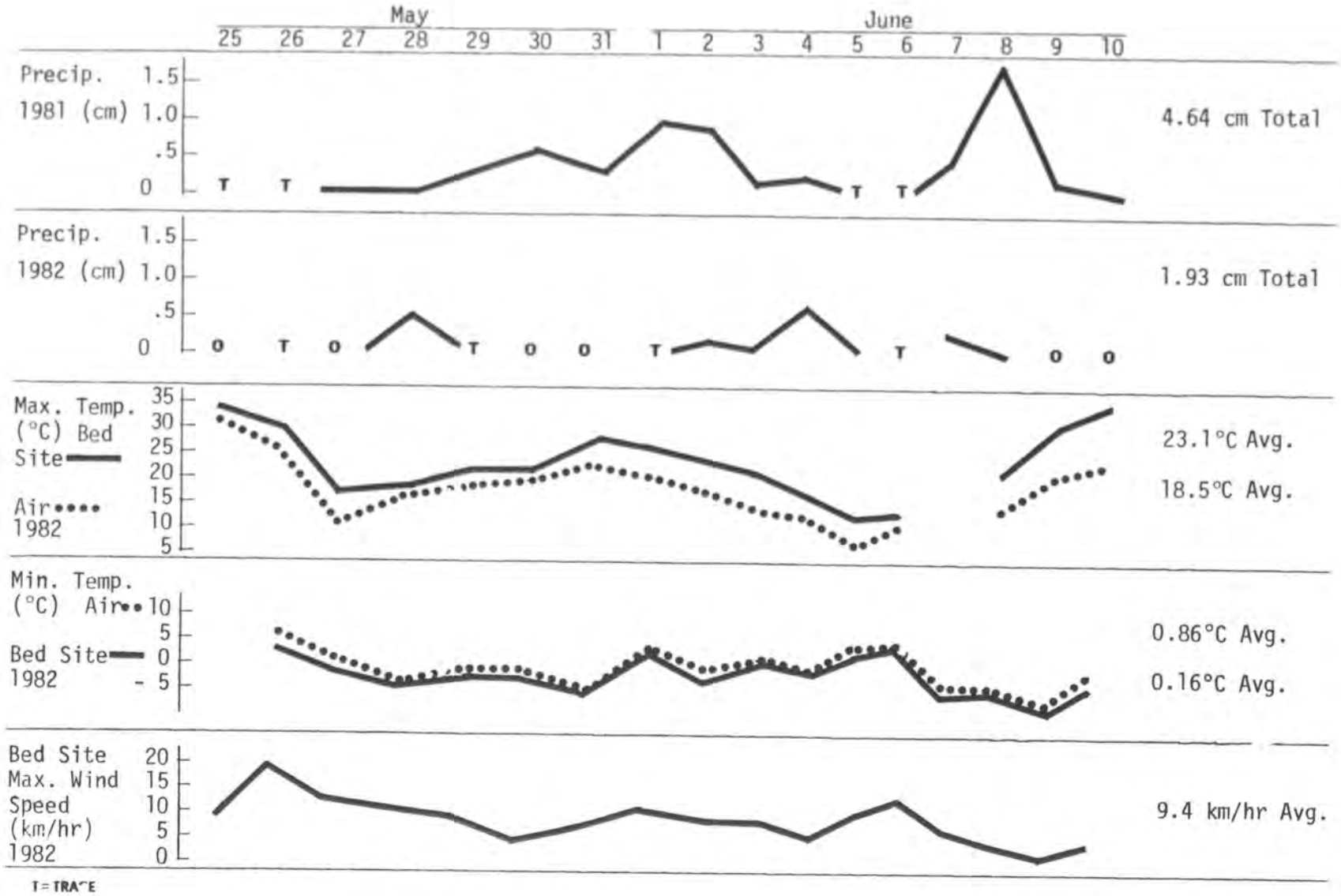
1101 doe continues to walk near brush site. 1106 doe walks into brush, partially flares rump patches, horns bush, turns, walks out. 1122 doe stands facing into brush, walks 9 m (10 yds) W, turns and horns brush. 1130 doe turns from watching site and begins trotting east. She had not gone more than 68 m (75 yds) when coyote walks from brush site heading west. Doe turns and sees coyote and runs back toward it. Coyote trots then runs over hill to

west. 1135 doe trots back to 180 m (200 yds) E. of site, feeds. 1144 doe returns to site, walks into brush, looks, stands, turns, stands, no aggressive behavior. 1147 begins feeding and walks away. 1149 again returns to site, extends muzzle as if sniffing, again walks away and feeds on forbs. 1155 doe walks to kill site in brush, stands there 14 min. and walks out. 1209 doe trots S. from area toward vehicle. 1215 gets her second fawn up 360 m (400 yds) N. of us. 1244 fawn beds down not more than 180 m (200 yds) N. of where twin was killed. Doe returns to kill location, stands there a minute and begins feeding in vicinity. 1315 doe again returns to kill site. 1440 hiked to mortality site and found female fawn intact, not consumed. Only external marks were a cut near left eye and a mark (cut) on left front leg. Apparently the coyote had lain near the dead fawn for the nearly 2 hours waiting to break away from the doe. He was using the protection of the 60 cm (2 ft) high dense mountain big sage. This observation aided in understanding the many instances in past years of finding unconsumed predator kills.

6/7/83--0900 from Battle Hill. Observed 72 does distributed across Big Flat from the boundary fence to Charolais field fence. Observed that dog Sand has followed us from camp and is located about 450 m (500 yds) W. of Charolaisfield cattle guard. He is under attack by 3 does. They are chasing him exactly as they do a coyote and he is responding in a similar fashion but not as quickly. He "holes up" in a patch of big sage. 1030 the 3 does keep the pressure on and Sand stays put. Interestingly, the most aggressive doe also behaves aggressively toward the other 2 does, periodically herding them away then returning to Sand's location. The aggressiveness displayed by the doe toward the other does may have been displaced behavior. She also spent a lot of time horning bushes. The survival value of does fawning in the same area is dramatically illustrated here. Any ground predator on the flat would come under attack by 1 or several does spaced out across the area. 1040 1 of the 3 does begins walking away and feeding. 1100 Sand stays put with 2 does continuing to stand, watch, walk around. Overrunning the dog is not now occurring, I guess since he is not attempting to move away. 1101 aggressive doe chases second doe away several meters. 1103 third doe is back now with other 2. 1330 during the past 2 hours we slowly moved the vehicle to within 135 m (150 yds) from where the does had Sand pinned. Sand made no attempt to run even when he saw our vehicle. Does were aware of us but did not leave. At 1315 I called to Sand. He slowly began movement toward truck. He fast walked half way to vehicle when does ran him down not more than 45 m (50 yds) from us. He ducked down, does were within a few centimeters but did not make contact. He then came on to truck, does came within 18 m (20 yds) and watched him. Sand made mistake walking out behind truck a few meters. One of the does ran within 2 m (5 ft) of the truck and ran over top of Sand as he ducked. She made contact with at least 2 hoofs. Dog ran back for cover of truck, does stood at 9 m (10 yds) and 1 horned the brush. 1450 one of the does had a fawn within 180 m (200 yds) of where Sand was pinned down. She got it up in front of us at 45 m (50 yds) as she and other doe finally gave up on Sand at 1430 and began to leave area.

Weather during 1982 fawning was less severe than in 1981 (Figure 2). Precipitation was 1.9 cm (.59 in) from May 25 through June 10, 1982 and 4.6 cm (1.8 in) for the same period in 1981. The national weather station at Howe (elevation 1,446 m [4,820 ft] ASL) reported the average maximum temperature was 21.1°C (70.0°F) for the fawning period in 1982 and 20.4°C (68°.7°F) in 1981. The average minimum was 5.3°C (41.6°F) in 1982 and 7.7°C (45.9 F) in

Figure 2. Weather data at Little Lost Study Area, 1981-82.



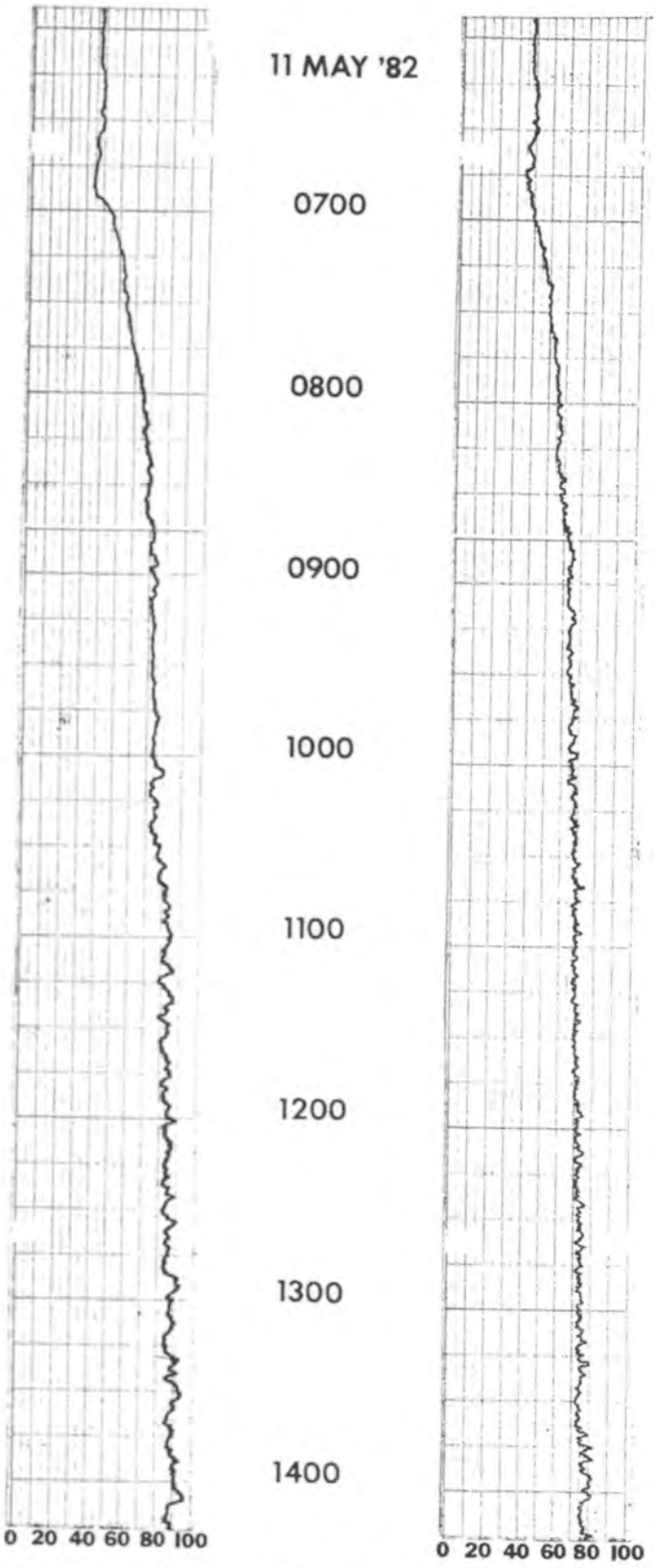


Figure 3. Temperature monitoring (°F)-bedsite (on left) and ambient air temperature at 150 cm (on right).

1981. Temperatures at camp (elevation 1,950 m [6,500 ft] ASL) averaged 5°F lower. Even though temperatures between years were not greatly different, the 2.7 cm (1.1 in) greater precipitation appeared to be key in increased hypothermia losses.

Temperatures were simultaneously measured at fawn bed sites and 150 cm (60 in) above the bed (Figure 3). Temperature rises usually paralleled one another during the morning with bed site temperatures rising as much as 15° F above the 150 cm air temperature by mid-afternoon. This was particularly true on calm sunny days. Dramatic fluctuations in bed site temperatures were noted on sunny days with gusty winds. On overcast days, bed site temperatures were little greater than the air temperature. With afternoon temperature decline came a delayed bed site temperature decline compared with the 150 cm monitor. However, the bed site temperature fell lower than air temperature with an average of 0.16°C (32.3°F) compared with 0.86°C (33.5°F).

Wind data were not recorded in 1981 but this equipment was included with the temperature recorder in 1982. Moderate wind speeds ranging from 0 to 19 km/hr (11.4 mi/hr) were monitored.

The upper Little Lost range was highly productive in 1981 and 1982 even though spring precipitation was less in 1982. The reduced precipitation is expressed in the lower mean total coverage value for birth and bed sites (Tables 4 and 5). This value is an expression of shrub coverage (which changed little from 1981 to 1982) and the grasses and forbs production. The 3 year vegetation averages for Little Lost birth sites and 4 year averages for bed sites are virtually the same, indicating fawns are selecting similar cover for bedding as the does selected for giving birth.

Table 4. Little Lost birth site vegetation summary.

Year	Sample Size	Avg. % Cover	Avg. % Cover of Shrubs	Avg. Height of Tallest Shrub (cm)	Avg Diameter of Largest Shrub (cm)	Shrubs Per 1/100 Acre
1977	1	53.6	12.7	59.5	46.3	68
1981	10	45.3	16.2	44.8	73.5	63
1982	10	40.2	19.8	53.8	75.8	72
Total	21					
AVG.		43.3	17.7	49.8	73.3	68

Table 5. Little Lost bed site vegetation summary.

Year	Sample Size	Avg. % Cover	Avg. % Cover of Shrubs	Avg. Height of Tallest Shrub (cm)	Avg Diameter of Largest Shrub (cm)	Shrubs Per 1/100 Acre
1977	11	56.4	18.3	59.0	49.8	129
1978	10	46.3	16.9	45.0 (9*)	-	39 (9*)
1981	116	47.4	18.1	50.3	73.3	63
1982	141	38.9	17.0	50.8	70.3	60
Total	278					
AVG.		43.4	17.5	50.8 (277*)	70.8 (268*)	64 (277*)

* Sample size.

DISCUSSION

Arrival of does on the upper valley spring-summer range was not documented but, barring later than usual snow melt, most does apparently arrive from the lower valley by mid-May. (An aerial survey on May 20, 1982 located 525 antelope in the upper valley in group sizes from 2 to 29.) The area of greatest fawning density occurred on the relatively flat terrain north of Summit Creek and south of Bear Mountain called "Big Flat". The area is characterized by a near homogenous stand of Wyoming big sage with a good understory of bluebunch wheatgrass and a great diversity of forbs. Range is classed in good condition.

The first fawn was observed on May 18 in 1981 and on May 22 in 1982. Fawning peaked on May 26 and 27 in 1981 and May 31 in 1982 although a pregnant doe was observed as late as June 8. Bodie (1979) noted fawning occurred in the nearby Pahsimeroi Valley from 24 May to 9 June, which agreed with our observations in that area that fawning occurred between May 20-June 10 (Autenrieth and Fichter 1975). By June 12, 1981 204 does and 62 bucks were located on the Big Flat area. Another 28 does and 5 bucks were on East Big Flat where cattle turn-out is mid-May. The Warm Springs Allotment also has a May livestock turn-out and 78 does and 42 bucks were located there on June 14, 1981. By July 1, 228 does and 101 bucks were on Big Flat, 80 does and 42 bucks on East Big Flat and 261 does and 165 bucks on the Warm Springs Allotment. Antelope not initially migrating to the upper valley during early spring appeared to do so as the lower range dried. The Lower Warm Springs Allotment had only 183 does and 122 bucks on July 13 while Big Flat (on the Summit Creek and Bear Canyon allotments) increased to 424 does and 291 bucks. East Big Flat also increased, but less dramatically, to 94 does and 38 bucks. It appears that the does were initially seeking relative seclusion for giving birth and later sought the highest quality succulent vegetation which was provided by the Big Flat area where livestock grazing did not begin until July 1. Data vary on whether antelope avoid cattle (Buechner 1950, Becker 1972, Campbell 1972 and Pyrah 1971). However, it is not surprising that does

mostly fawned in the one pasture with a July 1 cattle turn-out date. Parturient does seek seclusion even from other antelope.

As in the other antelope study areas, fawn weight at birth was not determined to be a survival problem. The average newborn fawn weight of 3.9 kg (8.6 lb) was similar to 4.0 kg on the Road Creek study (Autenrieth draft); 3.6 kg (7.9 lb) for Pahsimeroi fawns (Bodie 1979); 3.7 kg (8.1 lbs) for Nevada fawns (McNay 1980) and a 4.0 kg (8.9 lbs) for Oregon fawns (C. F. Trainer personal communication). Little Lost fawns were not born in a weakened condition and thus were not predisposed to mortality. Bodie (1979) felt that low weight, less vigorous fawns were probably less vulnerable to predation due to remaining motionless more than stronger fawns. Documented mortalities on the Little Lost study related to factors that healthy fawns must deal with to a greater or lesser degree in all populations depending on weather, habitat quality and predator density.

Fawn weights did not vary during 3 fawning seasons in the Little Lost to the degree noted in the Pahsimeroi (Bodie 1979) or the Road Creek study (Autenrieth draft) but average body temperature did differ. While the difference between the 1981 temperature average of 37.5°C (99.5°C) and the 1982 average of 38°C (100.4°F) was not great, the fact that this information was gathered only during the fawning period may reflect the degree of environmental stress in a particular year. A similar relationship was noted on the Road Creek study (Autenrieth draft) where the greatest fawn success was documented in 1979 in association with high maximum and minimum temperatures during the fawning period and low precipitation. Average fawn temperature was 38.2°C (100.8°F) compared to 37.6°C (99.7°F) in 1980 when rain and/or snow occurred most days during fawning. Barrett (1981) found a correlation between fawn rectal temperatures and bed site air temperatures.

The 1981 loss of 28% of transmittered fawns to hypothermia and/or starvation suggests that significant reduction in annual production may be expected as a result of harsh weather during the period of fawning and lying secluded. Dr. Kistner's analysis of the non-predator related mortalities he surveyed indicated "abandonment/starvation/hypothermia/shock as the probable cause(s) of death, either singly or in combination. Since all but 1 fawn had milk in the gastrointestinal tract, these were not the classical abandonments seen when fawns are captured before establishment of a firm maternal/fawn bond. Fawns that succumb (of the classical abandonment) seldom have milk in the gut. The size and age of the fawn without milk in the gut would argue against abandonment in this case. It is felt the doe of this fawn had died or been killed, otherwise, this fawn would never have lived a week or more to achieve the size when it died. A second factor is that in all cases of classical abandonment examined by this investigator, fawns had a watery diarrhea with fecal soaking of the hair of the perineum, and the intestines were invariably congested or much more red in color than normal. One of the fawns had a slight diarrhea, but the intestines were normal in all carcasses.

The remaining fawns had not eaten for an interval from several hours to a day or more prior to death, based on absence of milk in the rumen, abomasum and small intestine and the very poor physical condition. The question is then posed, was the weather so bad the does did not attempt to nurse the fawns or were the fawns hypothermic and too weak or too disinterested to nurse? It is possible that an occasional uniparous (first time of fawning) doe would ignore her fawn under severe weather conditions, but improbable that several

multiparous does would do the same, particularly after the maternal bond is established. It is much more probable that these fawns were stressed by the inclement weather, became hypothermic, failed to nurse at regular intervals, exhausted their energy reserves, were unable to maintain body temperature and finally succumbed to hypothermia.

The condition of the thymus and thyroid glands in the fawns would argue for the stress/hypothermia/starvation diagnosis. Ozoga and Verme (1978) noted that the thymus glands of penned fawns dying from disease or malnutrition within a month of birth were one-sixth as large as normal fawns that died from accidents. Subsequently, Dr. Terry Spraker of Colorado State University has worked on the phenomenon of small thymus glands in newborn deer fawns, but has not yet published the results (1981 pers. comm.) Dr. Spraker stated that severe stress, induced by either malnutrition or weather, will result in the atrophy (involution or disappearance) of the thymus in 2-3 days in neo-natal fawns. The atrophy results from high corticosteroid levels produced by the adrenal glands in response to the stress. Although he has not found grossly abnormal thyroid glands, he felt the thyroids could be involved."

While the importance of trace mineral levels in fawns is poorly understood, (Stoszek et al. 1978) liver selenium values were collected and are listed in Appendix Table 4.

Temperature monitoring data from bed sites support the contention that quality cover reduces the effect of harsh weather and wind chill. It follows that lower fawn success should be expected in areas where vegetative cover provides little protection from harsh weather. As Bodie (1979) noted, increased starvation and abandonment might also be expected when spring weather is severe and does are nutritionally stressed. Langenou and Lerg (1976) reported that whitetail deer (Odocoileus virginianus) fawns born to nutritionally stressed does evoked a fear and aggression response rather than the normal licking and grooming response. Only 2 (4.5%) abandonments were documented during the Little Lost study, 1 of which related to my stumbling onto a birth scene within minutes after birth. The doe did not return for the fawn. Predator related mortalities command attention due to their rather obvious impacts, but in some years, predation may be secondary to the more subtle environmentally related mortalities. The above information on hypothermia becomes significant when related to the fact that predation losses were similar for 1981 and 1982 with 20% and 24% loss of transmittered fawns.

Bobcats were the chief fawn predators (7 transmittered fawn kills) with coyotes and golden eagles each taking 3. Level of transmittered fawn predation was below that of the 35.7% reported by Bodie (1979), and the 42% recorded on the Road Creek study (Autenrieth, draft). However, only a 4% transmittered fawn loss was reported on the Birch Creek study (Hoskinson 1977) where mean percent vegetative cover at bed sites was highest.

The fact that maternal does defend their fawns from predation is common knowledge but seldom is the process observed. The 2 field observations in the Little Lost helped to understand does' responses to mammalian predators and the fact that even though the defense is effective, it is often after the fawn is mortally wounded or killed. It appears that even though fawns enjoy the immediate protection from predators while up with the doe, their vulnerability while up and active is also greatly increased.

Evidence that fawns are sometimes abused and killed by yearling and/or adult antelope has been noted by Autenrieth and Fichter (1975), Bodie (1979) and Autenrieth (draft) where an observation was reported of a buck hooking his horn on the elastic radio collar and lifting the fawn off the ground. The trauma-related death documented in 1981 was diagnosed as internal injury from being stepped on. Antelope inflicted injury on fawns occurs both on transmittered and untransmittered fawns, seemingly through a form of investigative play mostly by yearling does and bucks. This behavior would not seem adaptive but occurrence is infrequent and probably not significant.

Production success based on transmittered fawn survival understimated survival in 1981 (transmitter data=63 fawns/100 does, August survey data=74 fawns/100 does) and overestimated survival in 1982 (transmitter data=92 fawns/100 does, August survey data=59 fawns/100 does). This information may help to alleviate fears that handling fawns contributes a significant mortality factor but also indicates the small sample size and the relatively small study area may not totally reflect the overall population.

Few data are available on the relationship between cover and air temperature. Barrett (1981) and Autenrieth (draft) documented temperatures warmer at the bed level than 150 cm (60 in) above. While sufficient data are yet to be collected for comparing vegetative cover with thermal values, the implication is that hypothermia may be reduced in fawns occupying microclimates located in high percentage cover.

Range condition appeared similar in 1981 and 1982 but weather data indicated the May-June period was wetter in 1981. The result was a higher grass-forb production in 1981 that is reflected in the higher average percent cover (Tables 4 & 5) measured at birth and bed sites than in 1982. Since big sage cover varied little, the increase relates to the grass-forb component. While high spring precipitation can be a cause of hypothermia, it can also indirectly increase fawn survival through increased concealment and thermal cover. The impact is a function of timing.

Statistical tests are currently being conducted for birth (84) and bed site (760) vegetation data on 5 study areas to determine if the contention that fawns imprint on birth site cover and select similar cover at subsequent sites (Fichter 1971) is supported. Results will soon be reported in another paper, but Little Lost data support the hypothesis and indicate fawns select sites with somewhat greater coverage values. This conclusion must be tempered however with the knowledge that several days often elapsed prior to measuring sites and grass-forb phenology was somewhat advanced from the time of fawn use.

Comparisons for bed site cover and August fawns/100 does ratios for 5 study areas are given in Table 6. Productivity for the 5 populations appears related to total average canopy coverage at bed sites (Autenrieth 1982). While it is oversimplistic to assume only cover relates to fawn survival, the data on 760 bed sites collected since 1973 strongly suggests this is a key factor and providing improved cover in poor habitats used for fawning may be more of a long term solution to increasing production than attempts to control predators.

Doe-fawn groups began forming by June 10 each year in relation to the completion of the 3 week lying secluded period. However, distribution of the

Table 6. Antelope bed site vegetation and production comparisons

Area	$\bar{X}$ Coverage(%)	$\bar{X}$ Coverage Shrubs (%)	$\bar{X}$ Tallest Shrub Ht (cm)	$\bar{X}$ Greatest Brush Dia(cm)	Brush Plants/ 100th Acre
Birch Creek	59.1 ($^{N}_{89}$)	27.0 ($^{N}_{89}$)	51.1 ($^{N}_{89}$)	44.2 ($^{N}_{87}$)	61 ($^{N}_{87}$)
	1973-82 Fawns/100 does - 73				
Little Lost	43.4 ($^{N}_{278}$)	17.5 ($^{N}_{278}$)	50.8 ($^{N}_{277}$)	70.8 ($^{N}_{268}$)	64 ($^{N}_{277}$)
	1973-82 Fawns/100 Does = 60				
Upper Pahsimeroi	48.5 ($^{N}_{125}$)	24.3 ($^{N}_{125}$)	32.8 ($^{N}_{125}$)	39.4 ($^{N}_{73}$)	57 ($^{N}_{23}$)
	1973-82 Fawns/100 Does = 41				
Big Lost	35.9 ($^{N}_{56}$)	23.9 ($^{N}_{52}$)	39.4 ($^{N}_{56}$)	-	-
	1973-82 Fawns/100 Does = 46				
Road Creek	33.9 ($^{N}_{212}$)	12.7 ($^{N}_{212}$)	65.6 ($^{N}_{212}$)	99.8 ($^{N}_{212}$)	48 ($^{N}_{212}$)
	1973-82 Fawns/100 Does = 23				

groups (as the summer progressed) appeared related to the availability of succulent vegetation. The total number of antelope on the Big Flat study area was 401 on June 12, 1981 and increased to 1,173 by July 14, 1981. Antelope numbers on nearby ranges that were more xeric sites and grazed early were reduced in July. In 1982 it was noted the doe fawn groups grew from just a few individuals per group on June 11 to, in one case, 100 antelope which included 11 transmittered fawns on July 1. The large groups seemed to peak in early July and by late July the largest group was 45 and included 6 fawns. The increase and decline in group sizes appeared to coincide with the peak in grass-forb production and, as the range dessicated in mid-to late summer, groups fragmented and more efficiently sought out the mesic areas and pockets of succulent vegetation. This behavior may also relate to the smaller doe-fawn groups beginning to utilize resources found within buck territories where they were relatively free from buck harassment as the rut approaches (Copeland 1980).

SUMMARY

The Little Lost antelope population enjoys a long term annual productivity classed as good in Idaho. The habitat used for birth and fawn bedding provided sufficient cover to conceal fawns during the lying secluded period. It was also sufficient to provide a microclimate warmer than the 150 cm air temperature thus providing some protection from weather related stress. As was demonstrated in 1981; however, severe spring weather may significantly impact fawn survival even when fawns are vigorous at birth and bedding cover is sufficient. While loss to predation was similar both years of the study, and low when compared with most other populations, the addition of unexpected hypothermia losses resulted in significantly reduced 1981 fawn success. While dealing with hypothermia losses is outside the management realm, understanding its importance, predicting its occurrence and comprehending the relationships of protective bed site cover are basic to managing.

That fawns bed in habitat similar to their birth site is no longer speculative. In that data show fawns best survive the vulnerability period when utilizing habitat providing greater than 40% mean canopy coverage, management efforts should be oriented toward that goal once the fawning areas are known for each population. While fawning areas seem traditional in many areas, caution should be used when tempted to identify a particular location as a "fawning ground". Fawning locations are selected by pregnant does and relate to concealment during parturition. Site selection relates to seeking seclusion, vegetation cover, freedom from snow, lack of disturbance including livestock, and probably good range forb production. The combination of these elements and fawning locations may change in a particular area over time. Management should be oriented to generally providing habitat and cover needs on spring-summer range and not just to managing for specific locations identified as "fawning grounds".

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Appendix Table 1. 1981 Little Lost Study fawn measurements.

	Sex	Age (hrs)	Wt. (lb)	Rect. Temp.(°F)	Heart	Resp.	T. L. (in)	H. Ft. L. (in)	Ear (in)
1	F	46	9.7	99	144	40	24.5	11.0	3.4
2	F	48	9.3	100	160	60	21.0	10.0	3.3
3	F	3	10.0	99	160	32	23.5	11.3	4.2
4	F	3	9.8	92	128	32	20.0	9.8	3.6
5	F	3	8.3	98	88	28	23.5	9.9	3.8
6	F	3	9.3	99	184	36	22.0	10.0	3.8
7	M	3	10.9	100	138	20	24.5	10.9	3.4
8	F	3	9.5	102	144	24	23.5	11.0	3.4
9	M	3	8.0	97	124	44	25.5	10.0	3.4
10	F	3	7.5	100	140	40	22.0	10.1	3.3
11	F	3	8.5	98	136	36	23.0	9.3	4.1
12	M	3	8.0	99	144	32	22.0	9.9	4.0
13	F	3	8.5	100	104	28	23.8	10.1	3.8
14	M	3	9.3	100	84	24	23.0	10.8	3.5
15	F	3	10.3	102	144	44	24.0	10.6	3.3
16	F	3	9.5	100	160	36	24.0	10.5	3.5
17	M	3	9.0	100	120	48	24.0	10.3	4.1
18	M	3	9.0	100	128	44	24.3	10.3	4.3
19	F	3	7.8	100	136	32	23.0	10.3	3.3
20	F	3	7.5	99	124	24	23.5	10.3	3.5
21	M	72	10.5	102	84	20	24.5	11.0	3.6
22	F	48	7.5	100	124	32	22.5	9.9	3.6
23	F	3	9.5	100	178	38	24.0	9.8	4.1
24	F	3	9.0	101	148	32	22.5	9.5	4.0
25	M	72	11.0	100	76	28	24.5	9.5	4.1
Avg.			9.1	99.5	132	34	23.3	10.2	3.7

Appendix Table 2. 1982 Little Lost Study fawn measurements.

#	Sex	Age (hrs)	Wt. (lbs)	Rect. Temp. (0°F)	Heart	Resp.	T. L. H. (in)	Ft. L. (in)	Ear (in)	Head (in)	Neck Circum. (in)
1	M	48	10.0	102.5	100	48	21.5	10.3	3.4	9.5	6.8
2	M	3	9.5	101.0	136	36	22.5	10.1	3.4	9.5	6.5
3	M	24	8.5	100.0	180	17	22.3	9.8	3.3	9.1	6.0
4	F	24	8.8	98.0	100	24	27.0	10.6	3.3	9.8	5.8
5	M	48	8.5	100.0	120	30	21.0	11.0	3.1	9.3	6.5
6	M	48	9.5	100.0	208	56	24.0	10.3	3.4	9.4	7.0
7	F	48	8.5	98.0	128	43	25.0	10.1	3.3	8.8	5.5
8	F	36	9.5	100.5	208	32	22.5	10.3	3.3	8.8	6.5
9	F	36	10.0	101.8	164	36	22.8	10.4	3.6	9.1	6.8
10	M	48	8.8	103.0	148	32	24.0	10.3	3.5	9.3	6.3
11	F	60	8.8	102.0	152	36	24.5	10.3	3.1	9.3	6.5
12	F	3	8.0	100.0	172	29	22.0	10.5	3.3	9.1	5.8
13	F	72	10.0	101.2	172	36	23.3	10.0	3.6	9.4	6.6
14	M	48	8.5	101.0	160	42	22.0	10.0	3.1	9.3	6.8
15	F	48	8.5	100.0	196	68	21.5	10.5	3.4	10.0	7.0
16	M	24	8.5	101.0	160	45	23.0	10.3	3.1	10.0	6.0
17	F	3	9.5	100.0	84	24	23.6	10.9	3.8	8.8	6.3
18	M	4	7.4	96.2	88	36	21.6	9.4	3.4	8.5	6.3
19	F	3	9.3	100.0	76	35	24.5	10.5	3.3	9.8	6.0
20	M	3	9.5	102.0	104	28	22.5	10.6	3.5	9.5	6.8
21	F	24	8.3	97.8	144	28	21.9	10.3	3.5	8.8	6.6
22	M	96	11.7	98.0	194	32	24.3	11.1	3.4	10.3	7.1
23	F	3	8.8	101.5	144	46	21.5	9.9	3.8	9.5	5.9
24	F	3	8.0	99.5	140	33	22.5	9.8	3.3	9.5	6.5
25	F	120	12.3	100.8	200	40	24.5	10.8	3.4	9.0	6.5
26	M	72	8.5	100.5	140	32	22.8	10.3	3.0	9.5	6.5
27	F	24	10.3	102.0	96	40	25.0	10.5	3.5	9.8	7.0
28	F	72	9.3	100.0	112	28	23.0	10.3	3.6	8.6	6.6
29	M	24	8.5	99.5	144	32	22.3	10.3	3.8	8.6	6.6
30	F	96	10.5	101.0	156	28	23.5	10.8	3.8	9.3	7.3
31	F	3	7.0	100.0	144	24	22.5	9.3	3.3	9.0	6.0

Appendix Table 2. Continued

#	Sex	Age (hrs)	Wt. (lbs)	Rect. Temp. (0°F)	Heart	Resp.	T. L. H. (in)	Ft. L. (in)	Ear (in)	Head (in)	Neck Circum. (in)
32	M	3	7.8	101.0	124	21	24.0	9.5	3.3	8.5	6.0
33	M	3	9.1	100.0	168	43	22.5	10.4	3.3	10.0	6.8
34	F	4	8.5	103.0	136	44	23.5	10.4	3.3	9.3	6.0
35	F	3	8.5	101.0	160	52	22.0	10.3	3.3	8.8	6.9
36	F	168	11.5	103.0	256	31	26.5	10.5	3.4	10.0	6.5
37	F	48	7.3	97.0	84	24	22.8	10.1	3.5	8.5	5.6
38	F	1	8.8	101.0	108	36	23.0	10.1	3.5	9.5	6.0
39	F	4	10.5	100.5	76	26	23.5	10.1	3.6	9.8	6.0
40	F	4	8.3	98.0	84	23	24.0	10.5	3.1	9.3	6.0
41	F	8	8.5	100.0	120	29	22.5	10.3	3.5	9.0	6.0
42	F	72	11.3	102.0	240	38	23.5	10.6	3.5	9.3	6.6
Average		35	9.1	100.4	146	36	23.8	10.3	3.4	9.3	6.4

Appendix Table 3. 1983 Little Lost Study fawn measurements.

	Sex	Age (hrs)	Wt. (lb)	Rect. Temp.(°F)	Heart	Resp.	T. L. (in)	H. Ft. L. (in)	Ear (in)
1	F	24-48	9.0	103	190	42	22.0	10.6	3.5
2	F	72-120	10.5				25.5	10.8	3.8
3	F	48-72	10.5	104	260	66	21.5	10.5	3.6
4	M	3	8.5	102	156	42	23.0	10.4	3.4
5	M	3	8.0	102	154	27	22.3	10.1	3.5
6	F	48-72	10.0	102	156	34	24.0	10.9	3.4
7	M	4	8.0	104	120	40	24.0	10.4	3.6
8	M	4	7.5	102	132	48	22.5	9.9	3.1
9	M	72	9.5	103	116	58	25.4	10.9	3.3
10	F	48-72	7.8	105*	108	80*	22.3	9.9	3.5
Avg.			8.9	103	155	49	23.3	10.4	3.5

* Elevated after running.

Appendix Table 4. Liver selenium values of pronghorns, cattle, and domestic sheep.

	Deficient	Marginal	Adequate	High
Cattle[a]	.02-.17	.12-.25	.25-.50	.75-1.25
Dom. Sheep	.005-.10	.15-.25	.25-1.0	2.0-10.0

Pronghorn

Little Lost, ID 1981	n=9	$\bar{X}$=.69 (range .24-1.23)	fawns
Little Lost, ID 1982	n=5	$\bar{X}$=.47 (range .39-.62)	fawns
Bear Valley, OR 1982	n=9	$\bar{X}$-.10 (range .04-.15)	does

a Cattle and sheep values from Puls, R. 1980. Veterinary Mineral Deficiency and Toxicity Information: Preliminary. Version. Veterinary Laboratory, Province of British Columbia, Ministry of Agriculture, Box 100, Abbotsford, B.C. V52 4N8.

HOME RANGE AND DIEL MOVEMENTS OF PRONGHORN ANTELOPE FAWNS IN BREWSTER COUNTY, TEXAS

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ABSTRACT

Average home range size for 10 pronghorn antelope (Antilocapra americana) fawns increased geometrically with increasing age. Mean weekly home range size increased from 57.9 ha at 2 weeks of age to 1,031.8 ha at 16 weeks of age. Fawns 4 weeks of age or less used the igneous hill and mountain range site more than the gravelly, loamy or draw sites. Reasons for this use are believed to be related to the availability of bedsites providing concealment for young fawns. Fawns 4 to 16 weeks of age utilized the gravelly range site more than other sites. This preference is believed due to the formation of fawn/doe groups, with fawn movements closely resembling those of the mother. Diel movements averaged 1,435 m at 1 week of age and 4,375 m at 12 weeks of age.

INTRODUCTION

Early studies of pronghorn antelope have relied upon resightings of marked individuals for estimating movements and home range size (Bayless 1967, Bromley 1967). The development of radio-telemetry equipment has made home range and movement data more readily obtainable (Cochran and Lord 1963, Tester et al. 1964) and has proven to be an indispensable tool in studying the ecology of young ungulate species which exhibit cryptic behavior (Cook et al. 1967, Garner et al. 1976, Dickinson 1978).

Little information concerning home range in home range development of antelope fawns is available. A study of antelope fawn mortality in the Trans-Pecos region of Texas (Tucker and Garner 1980a) provided daily radio-locations used to describe the home range and diel movements of 10 fawns 1 to 16 weeks of age.

METHODS AND MATERIALS

The study was conducted in a 6,100 ha pasture located 1 km east of Alpine, Brewster County, Texas (Figure 1). Buechner (1950), while studying the life history and ecology of pronghorn antelope in this area, described the general region as a desert grassland. Topography of this area ranges from nearly level, open prairie rangelands to gently rolling hills. The climate is a warm, temperate, semi-desert type with mild winters and warm summers. Annual

[1]Current Address: Bureau of Land Management, Cedar City, Utah 84720
[2]Current Address: Arctic National Wildlife Refuge, U.S. Fish and Wildlife Service, Fairbanks, Alaska 99701

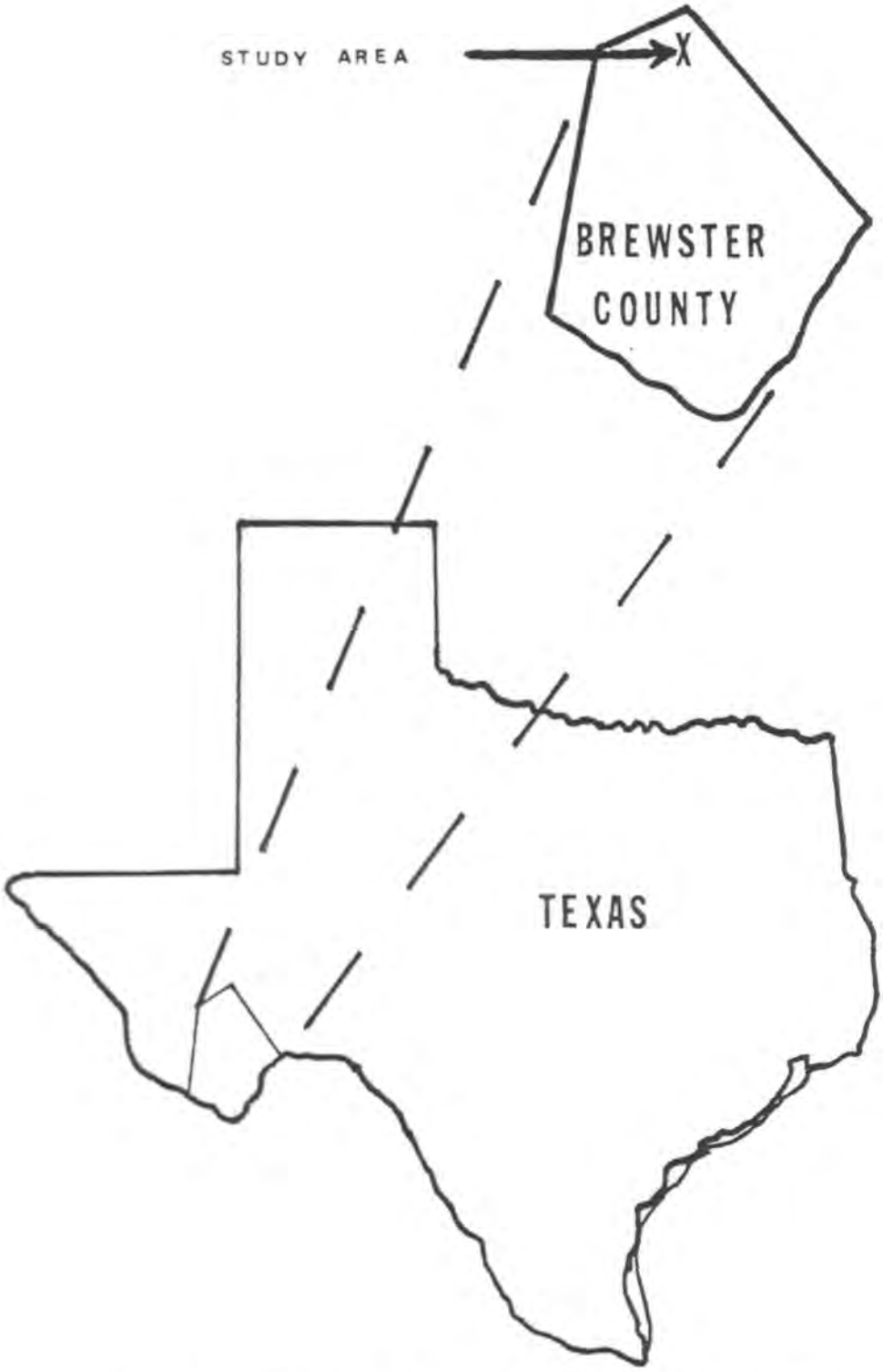


Figure 1. Location of pronghorn fawn study area in Brewster County, Texas.

precipitation averages 35 cm, most of which occurs between July and September (Soil Conservation Service 1978, Alpine, Texas, unpublished data). The study area is used for a cow-calf operation with livestock grazing during the late summer. There are no agricultural developments in the study pasture. Surface water is available throughout the area, and did not inhibit antelope from dispersing over the entire pasture. Public access and hunting are restricted and there is an annual harvest of 2-6 adult males.

There are 4 major range sites present on the study area. They are the gravelly, igneous hill and mountain, loamy, and draw range sites (Figure 2). Gravelly range sites are approximately 75% of the study area and have level to gently rolling terrain that is dominated by short and mid-grasses, with mid-grasses being found in areas of higher moisture content. Species such as tobosa grass (Hilaria mutica), blue grama (Bouteloua gracilis), and black grama (Bouteloua eropoda) presently occur. In areas where this site is in excellent ecological condition, major grass species include sideoats grama (Bouteloua curtipendula), cane bluestem (Bothriochloa barbinodes), and green sprangletop (Leptochloa dubia). Soils are shallow to moderately deep, gravelly loams (Soil Conservation Service 1978, Alpine, Texas, unpublished data).

Igneous hill and mountain range sites occur on approximately 15% of the area, with topography consisting of rolling to steep hills and mountains. Slopes vary from 8 to 15%. Vegetation is comprised of species found in a mixed grass prairie such as sideoats grama, cane bluestem, blue grama and black grama. Soils are shallow, stony loams intermixed with coarse, igneous gravel and rocks with frequent boulders and outcrops (Soil Conservation Service 1978, Alpine, Texas, unpublished data).

Loamy range sites occur on approximately 5% of the study area. Sideoats grama, cane bluestem, and green sprangletop are the dominant species on areas where the site is in excellent range condition. Tobosa grass, blue grama, and black grama, however, are predominant on this range site in the study area. Soils are deep, fine textured loams, (Soil Conservation Service 1978, Alpine Texas, unpublished data).

Draw range sites consist of narrow, frequently overflowed areas, and are approximately 5% of the study area. Soils are deep, sometimes stony loam. The relatively high water holding capacity of these soils enhances the growth of the bunch grass alkali sacaton (Sporobolis airoides). Trees and shrubs found on this range site include walnut (Juglans microcarpa), cottonwood (Populus sargentii), Apacheplume (Fallugia paradoxa), and mesquite (Prosopis glandulosa) (Soil Conservation Service 1978, Alpine, Texas, unpublished data).

Aerial census data (11 June 1978) indicated that 95 adult antelope inhabited the study area. Herd movements are restricted by a woven-wire fence 1 m in height which surrounds approximately two-thirds of the study area. The remainder of the area is fenced with 5-strand barbed wire which may allow occasional movements to an adjacent ranch. At no time during the study were antelope observed crossing these fences.

During May and early June 1978, fawns were captured using a nighttime capture technique described by Brownlee and Hailey (1970). Fawns were aged,

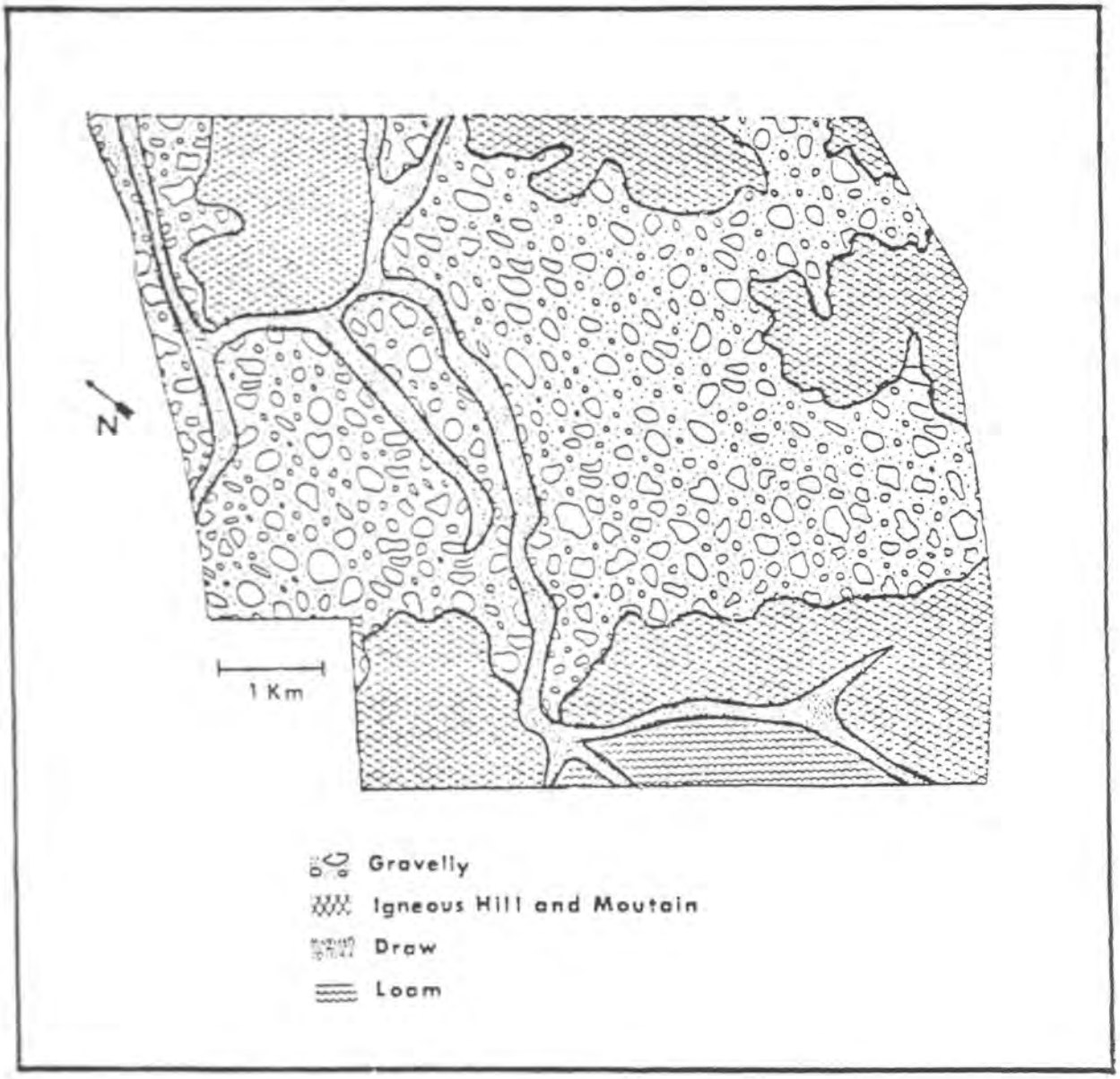


Figure 2. Range site locations on pronghorn fawn study area, Brewster County, Texas.

measured, sexed, weighed, marked, and released at the capture site. Fawns were aged based on new hoof length (Tucker and Garner 1980b) and other physical characteristics.

Radio-telemetry equipment (Telonics, Telemetry-Electronics Consultants, Mesa, Arizona) was used to relocate marked fawns. Fawns were radio-located daily by triangulation and subsequent observation (Cochran and Lord 1963) from the date of capture until early September 1978. Fawn location, activity, health status and vegetation type were recorded daily. Fawn locations were monitored at approximately the same time of day and an attempt was made to minimize the disturbance to the fawn and other antelope that might be nearby. Locations were transferred from field maps to overlays of large scale (1:24,000) contour maps. Home range and diel movements were determined using these overlays.

Cumulative home range sizes were constructed for each fawn at weekly age intervals. The minimum area method was used to determine home range boundaries (Dalke 1942, Mohr 1947). A compensating polar plainimeter was used to measure home range size.

Chi-square tests (Steel and Torrie 1960) were used to test expansion of home range between weeks and to compare the home range of males to that of females. Home ranges of fawns up to 4 weeks of age and of fawns 4 to 16 weeks of age were plotted on maps to determine the range sites most used by fawns during these age intervals.

Diel movements were measured as near to the end of each 24-hr period as possible. Distances were measured from locations plotted on topographical maps and were measured to within 15 m. A Chi-square test was used to test for significant increases in mean weekly diel movements.

RESULTS AND DISCUSSION

Ten fawns survived for an adequate length of time to provide data for determining home range size and diel movements.

HOME RANGE

Individual and mean home range size increased with age. At 2 weeks of age, fawn home range sizes averaged 57.9 ha, and increased to 1,031.8 ha at 16 weeks of age (Figure 3). A significant expansion of fawn home range occurred between the second and third weeks of age (X^2=37.8, 1df, P< 0.05). This increase in home range is believed to represent increased activity of young fawns. A significant increase in home range also occurred between the fifth and sixth weeks (X^2=79.8, 1df, P< 0.0005), and continuous increases for weeks 9 through 13 (X^2=41.4, 1df, P< 0.0005,). Home range size was stable between 13 and 16 weeks of age. Home range size beginning at 5 to 6 weeks of age began to closely resemble the doe's home range (Figures 4, 5, 6, 7, 8 and 9) and at this age fawn/doe groups were formed (Autenreith and Fichter 1975).

The average home range at 16 weeks of age was used to compare the home ranges of males to females. Males had a significantly larger average home range size than females (X^2=71.3, 1df, P< 0.0005). In Montana, Bayless

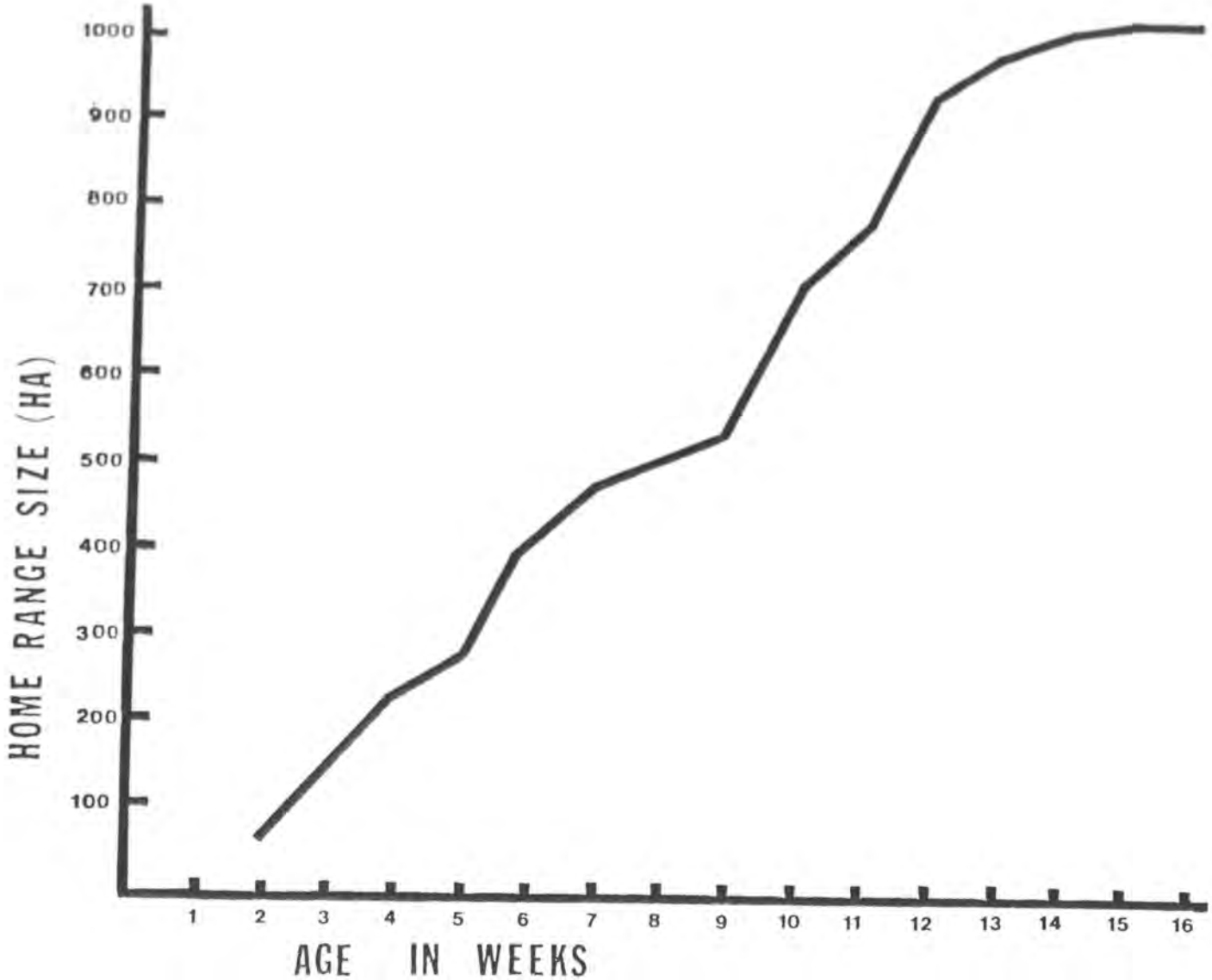


Figure 3. Average home range size at weekly age intervals.

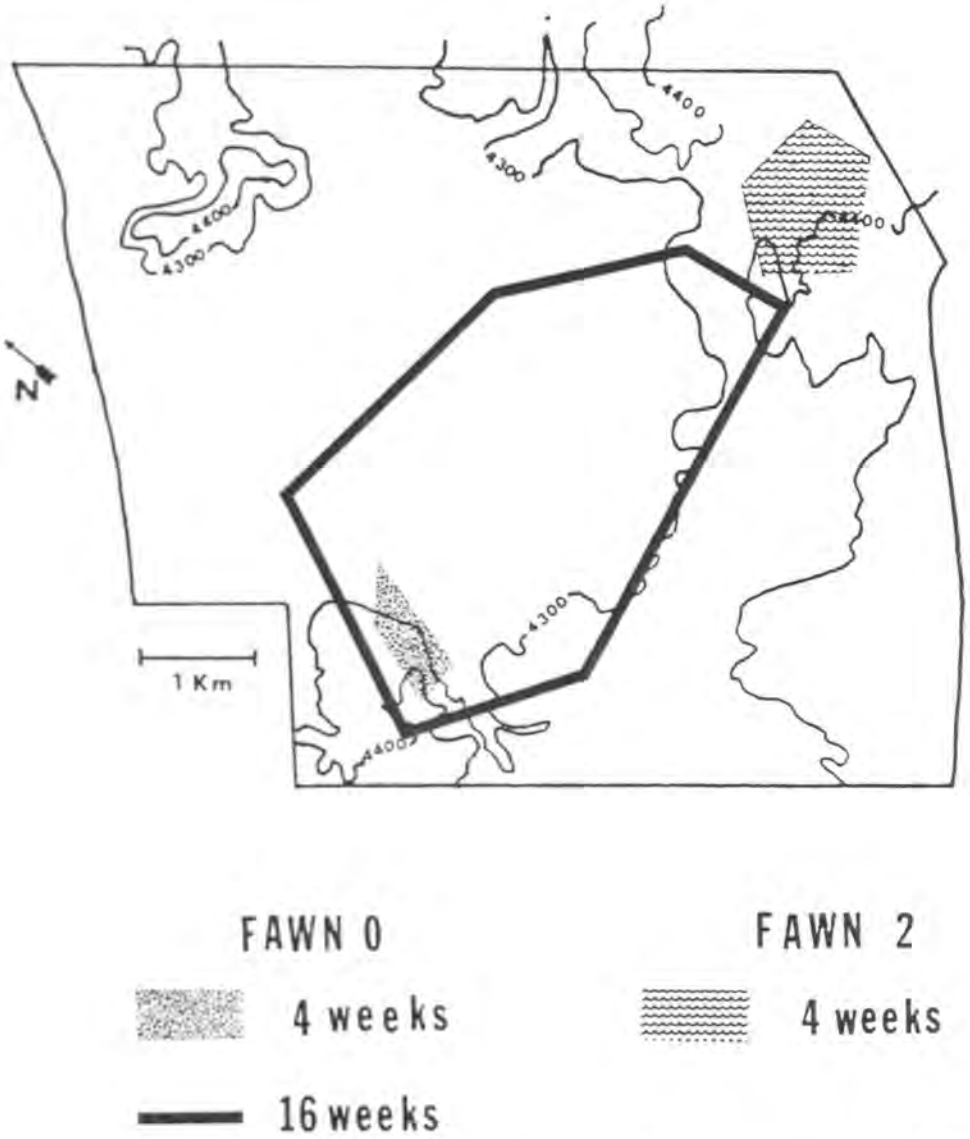
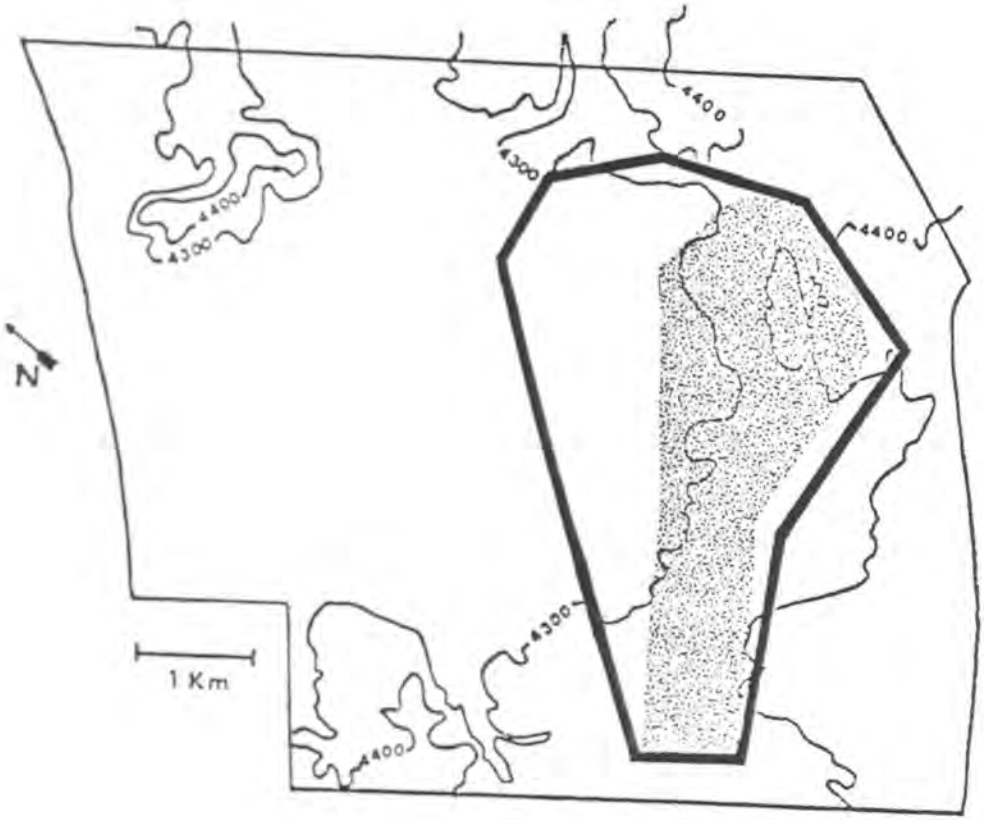


Figure 4. Cumulative home range of fawn 0 at 4 and 16 weeks of age and the cumulative home range of fawn 2 and 4 weeks of age.

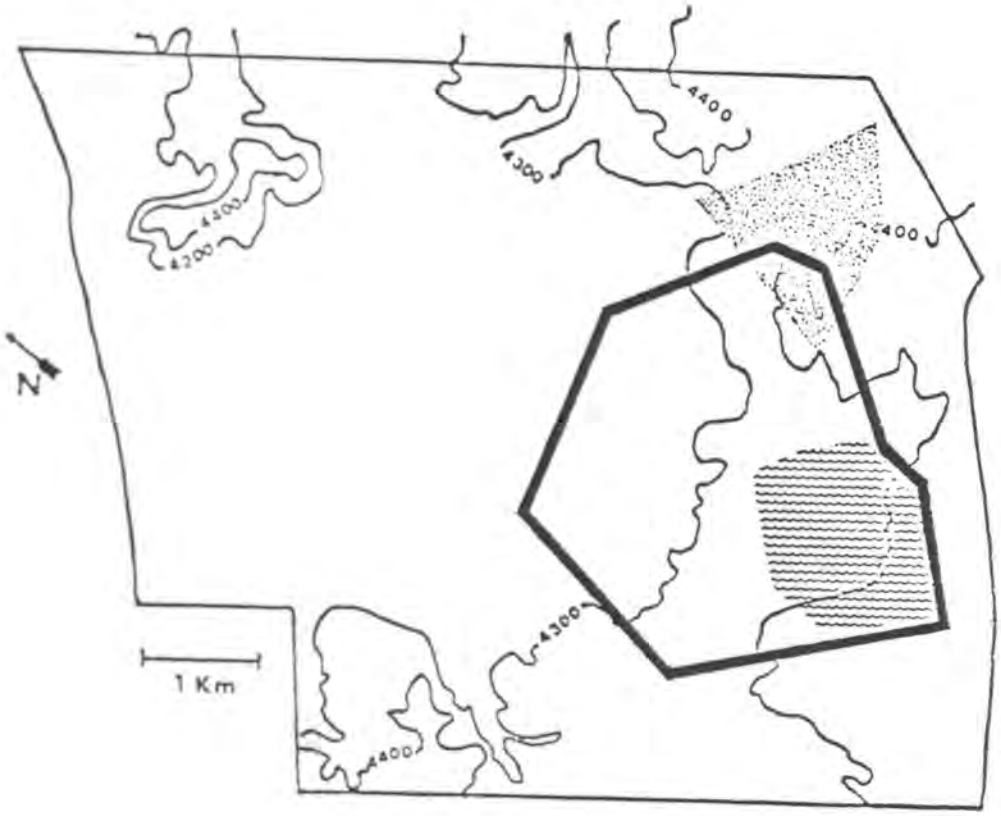


FAWN 3

4 weeks

16 weeks

Figure 5. Cumulative home range of fawn 3 at 4 and 16 weeks of age.



FAWN 24

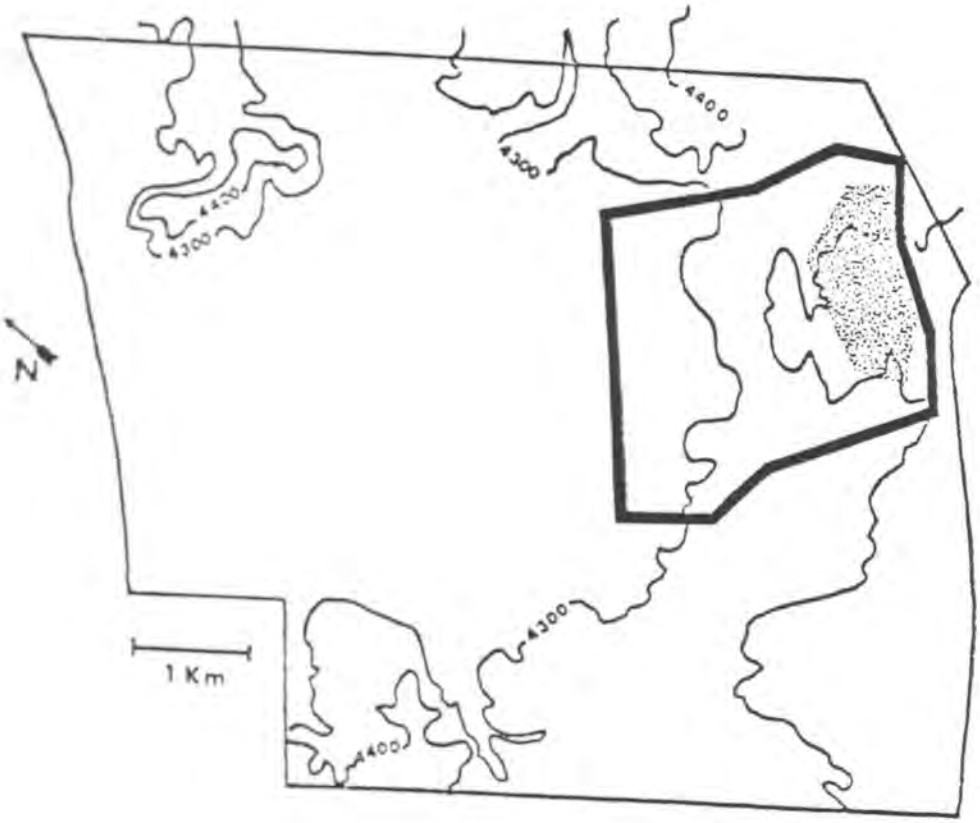
4 weeks

16 weeks

FAWN 19

4 weeks

Figure 6. Cumulative home range of fawn 24 at 4 and 16 weeks of age and the cumulative home range of fawn 2 at 4 weeks of age.

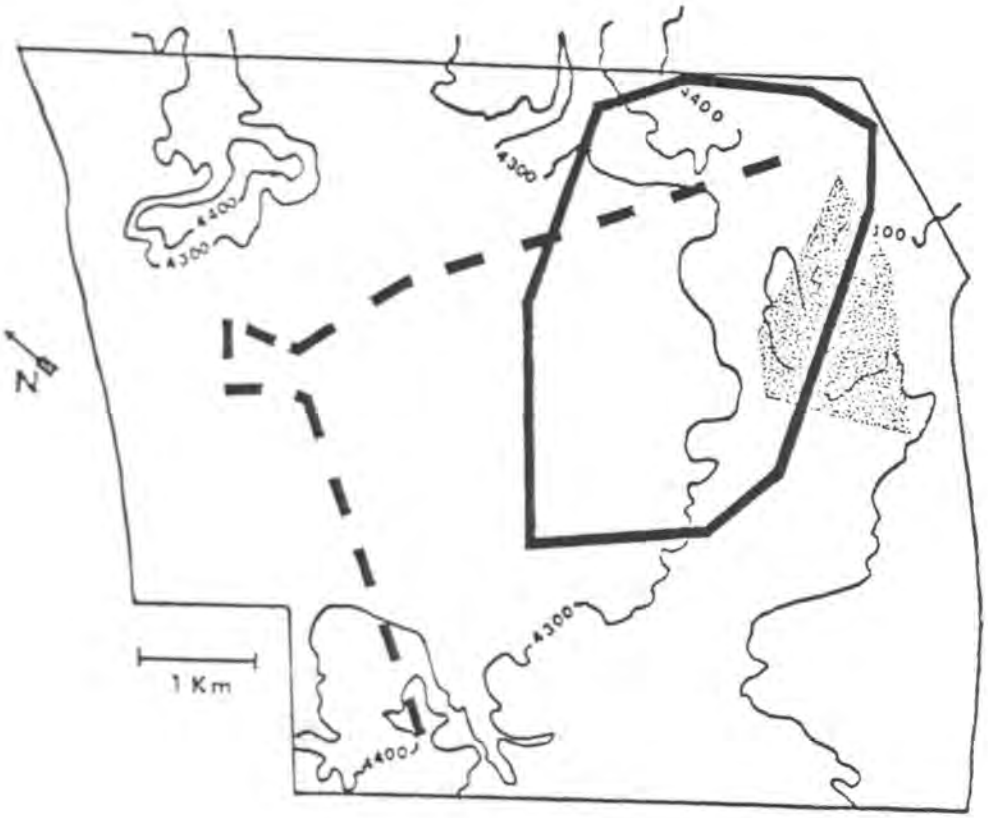


FAWN 8

4 weeks

16 weeks

Figure 7. Cumulative home range of fawn 8 at 4 and 16 weeks of age.



FAWN 11

shift

16 weeks

FAWN 26

4 weeks

Figure 8. Shifted and cumulative home range of fawn 11 and the cumulative home range of fawn 26 at 4 weeks of age.

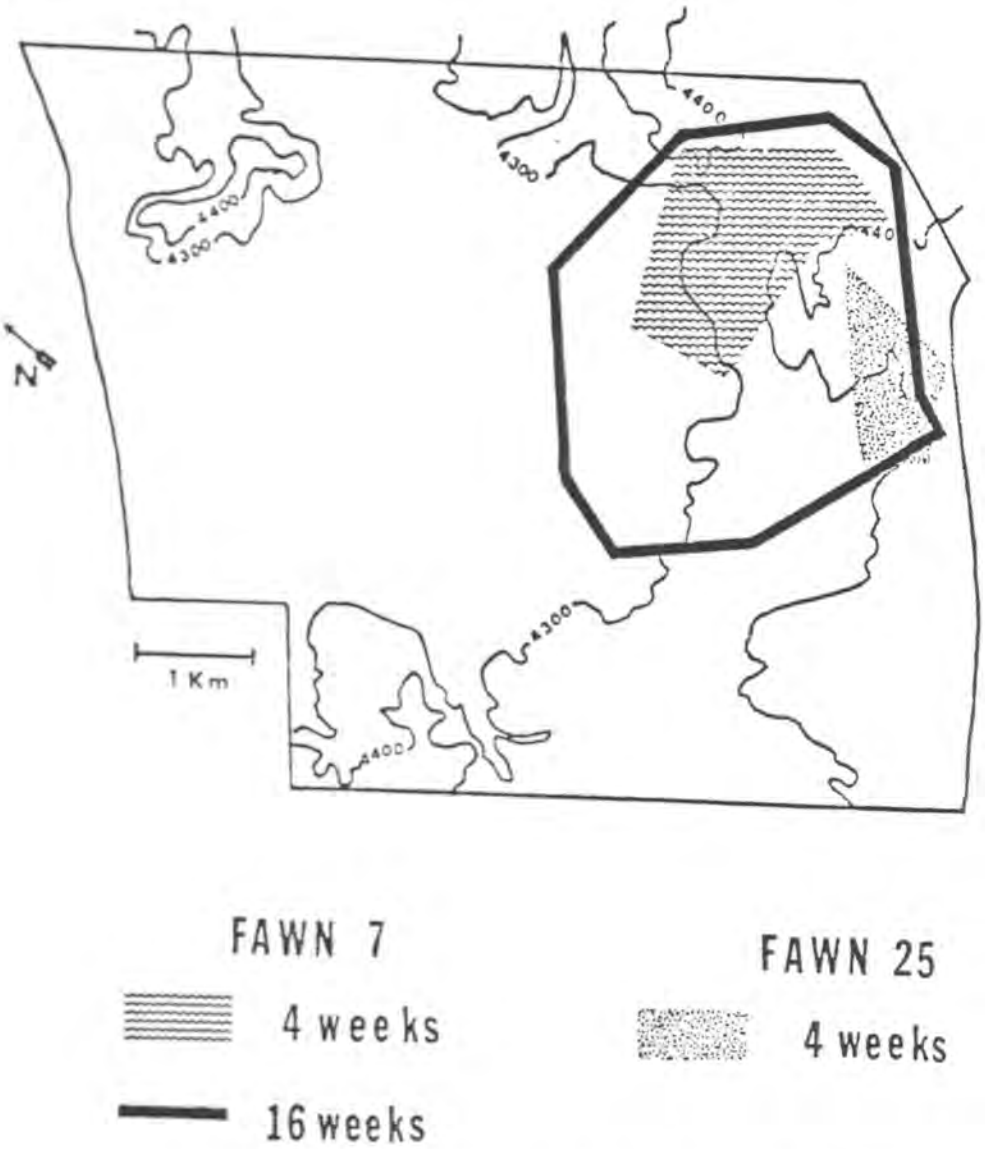


Figure 9. Cumulative home range of fawn 7 at 4 and 16 weeks of age and the cumulative home range of fawn 25 at 4 weeks of age.

(1967) reported a larger average home range for females (978.9 ha) than males (639.6 ha) during the winter months (from data on 6 fawns of approximately 6 months of age). Using the data of Bayless (1967) no significant difference was found between the home range size of females in Texas and that of females in Montana (X^2=2.3, 1df, P< 0.10). A significant difference was found between the home range size of male fawns in Texas and that of male fawns in Montana (X^2=281.4, 1df, P< 0.05). Reasons for this difference in home range size are unknown.

RANGE SITE PREFERENCES

Cumulative 4-week home ranges of 9 fawns (fawn 11 was excluded due to a shift in home range) are presented in Figure 10 and show home ranges in relation to range sites on the study area. Home ranges for fawns 2, 7, 8, 19, 25, and 26 were combined due to their close association in one portion of the study area. The igneous hill and mountain range site was preferred by fawns up to 4 weeks of age (65.7% percent igneous hill and mountain vs 32.2% gravelly, loamy and draw, $X^2$17.1, 1df, P< 0.0005). Fawns 2, 3, and 24 were found on the igneous hill and mountain sites on approximately 50% of their locations. Their use of this site was not significant over their use of the gravelly, loamy, and draw range sites (Table 1). The reasons for most fawns having preference for the igneous hill and mountain range site over other areas are unclear; however, young fawns showed a preference for bedsites which had cover 19 cm or taller and were often found bedded in areas which had scattered clumps of cane bluestem, sideoats grama, and black grama. (Tucker and Garner 1983.)

The range site most utilized by fawns 4 to 16 weeks of age was also determined in the same manner (Table 2). Fawns 2, 19, 25, and 26 succumbed to predation and did not survive long enough during this time period to identify any range site preference. The remaining 6 fawns exhibited a significant use of the gravelly range site over the igneous hill and mountain site (X^2=31.5, 1df, P<0.005). Fawns of this age tend to form fawn/doe groups, resulting in the fawns utilizing essentially the same habitat as adult does.

SHIFTS IN HOME RANGE

A shift in home range was exhibited by fawns 3 and 11. Fawn 3 moved approximately 4.5 km during the third week and returned to its original area during the fourth week. The causes for this shift are unknown; however, fawn 15 was killed by a coyote (Canis latrans) while the fawns were bedded approximately 75 m apart. During the next 2-week period, fawn 3 avoided that area.

Fawn 11 (Figure 8) was captured on 23 May at approximately 15 days of age. During the next 32-hr. period, the fawn moved 2.6 km north, northeast. The fawn did not return to the area in which it was captured. These movements were not included in calculating the average home range size. They were; however, included in diel movement calculations.

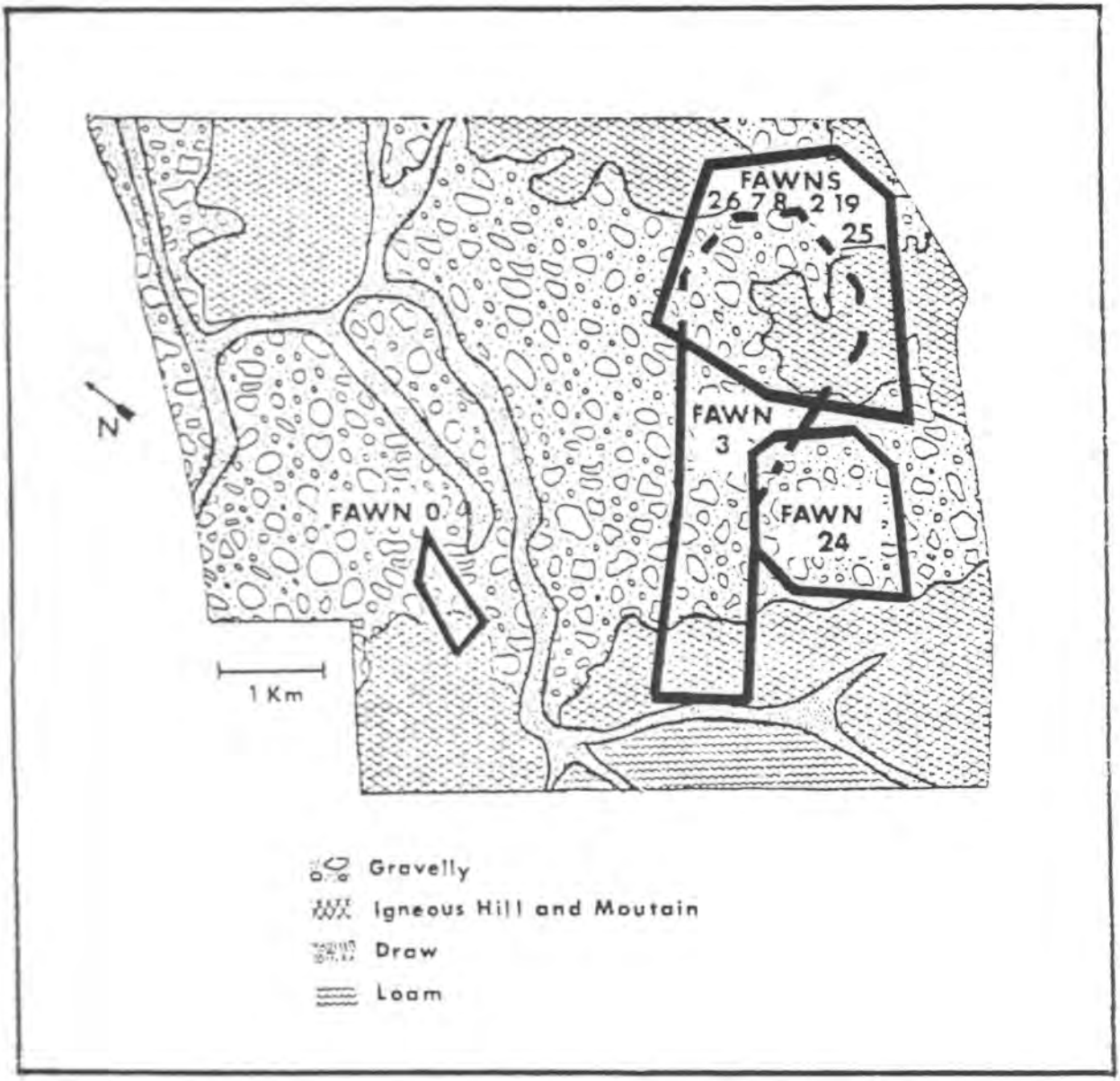


Figure 10. Cumulative 4 week home ranges of fawns 0, 2, 3, 7, 8, 19, 24, 25, and 26 in relation to the range sites. Fawns 2, 7, 8, 19, 25, and 26 are combined to illustrate their close association with one portion of the study area.

Table 1. Range site usage (%) by 10 fawns 1 to 4 weeks of age in Brewster County, Texas, 1978.

Fawn Number	Range Site				
	Igneous Hill and Mountain	Gravelly	Loamy	Draw	Chi Squared
0	88.8			11.2	67.8[a]
2	52.6	47.4			0.5[b]
3	50.0	41.7	8.3		0.3[b]
7	58.3	41.7			4.7[c]
9	78.2	21.8			40.6[a]
11	57.1	42.9			3.5[c]
19	71.4	28.6			25.6[c]
24	50.0	50.0			0.0
25	81.8	18.2			49.4[a]
26	57.1	42.9			3.5[c]

[a]P<0005.

[b]Not significant at 0.05 level of significance.

[c]P<0.05.

Table 2. Range site utilization (%) by 6 fawns 4 to 16 weeks of age in Brewster County, Texas, 1978.

Fawn Number	Range Site				
	Igneous Hill and Mountain	Gravelly	Loamy	Draw	Chi Squared[a]
0	88.8			11.2	67.8
3	18.4	81.5			48.8
7	28.7	71.2			25.3
8	36.3	63.6			11.7
11	24.0	75.9			35.4
24	11.5	88.4			66.9

[a]$P<0.005$.

Table 3. Weekly mean diel movements (m) for 10 fawns 1 to 16 weeks of age in Brewster County, Texas, 1978.

	Diel Movements			
Age in Weeks[a]	Minimum Movement	Maximum Movement	Mean	Standard Deviation
1	15.2	1128.5	437.6	318.1
2	45.7	1906.2	544.1	410.0
3	91.5	2714.5	748.7	587.9
4	15.2	3400.7	793.0	598.2
5	15.2	2760.2	759.4	500.4
6	167.7	3873.5	969.2	663.2
7	30.5	2135.0	736.3	624.7
8	152.5	2302.7	1034.3	652.6
9	137.2	2729.7	847.5	532.6
10	61.0	4422.5	1206.5	500.6
11	167.7	1952.0	626.7	927.4
12	30.5	3019.5	1333.6	715.7
13	30.5	2180.7	732.7	595.1
14	45.7	2165.5	744.0	550.1
15	137.2	2089.2	896.7	540.0
16	76.2	1875.7	821.9	493.9

[a]Includes only fawns surviving in that age interval.

DIEL MOVEMENTS

Diel movements were examined within each weekly age interval (Table 3). Movements ranged from 1,435.7 m at 1 week of age to 4,375.6 m at 12 weeks of age. The mean diel movement at 1 week of age was 437.6 m, while at 13 weeks of age, diel movement averaged 133.6 m. A significant increase was observed between the mean distances moved at 1 and 2 weeks of age (X^2=20.8, 1df, P<0.0005), and weeks 2 and 3 (X^2=55.9, 1df, P<0.0005). These increases in movements also correspond to increased home range size in these age intervals. Mean diel movements increased weekly until 4 weeks of age. At this point, mean distances became sporadic and, as with home range, tended to reflect the activity of the mother.

In summary, causes of large home ranges exhibited by antelope fawns in the Trans-Pecos region of Texas are unclear. Fawns less than 4 weeks of age utilized the igeneous hill and mountain range site as their primary use areas. These areas provided adequate vegetation and cover characteristics needed for bedsites. The home range and diel movements of these fawns gradually increased until 4 weeks of age, at which time home range size continued to increase while diel movements remained the same. Fawns 4 to 16 weeks of age primarily used the gravelly range site as these fawns became more physically active and were able to remain with the mother.

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MIGRATORY PATTERNS OF PRONGHORN IN THE RED DESERT, WYOMING

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ABSTRACT

A study of pronghorn (Antilocapra americana) migration, habitat use, and uranium strip mine impacts was conducted in southcentral Wyoming during 1980 and 1984. One thousand, two hundred and forty-six pronghorn in the Red Desert herd unit (10,000 animals) were captured each November of 1980 through 1983. Pronghorn were marked and released with 776 individually recognizeable neckbands and 57 radio collars. Seasonal migration, habitat use, and other ecological parameters were studied through reobservation of marked animals and their associates. Over 6,600 aerial and ground observations of marked animals (approximately 2,100 radios, 4,500 color collars) were recorded during the study period. In addition, standarized aerial transects were surveyed each month as an index of seasonal distributions.

The Red Desert is a semi-arid, intermountain basin dominated by sagebrush steppe vegetation. Mean, annual precipitation ranges from 14 cm to 24 cm. The winter of 1980-1981 was extremely mild with virtually no snow cover and above normal temperatures. The winters of 1981-1982, and 1982-1983 were subnormal and normal, respectively, with <15 cm of nondrifted snow accumulation and normal temperatures. The 1983-1984 winter was severe with area-wide snow accumulation >25 cm, deep drifts in some areas, and temperatures -16°C to -25°C for the two weeks of mid-January. Pronghorn winter mortality was rarely observed from 1980-1983, but was estimated at 60% in 1984 based on marked pronghorn mortality and a spring population census.

Pronghorn migratory patterns were relatively constant on summer ranges but showed great variation in winter distributions. Telemetered mature males showed strong affinity to spring-summer-fall home ranges, while females tended to return only to general summer areas. Winter distributions appeared to be dependent on weather, forage availability (primarily Artemsia tridentata wyomingensis), and individual behavior. Some individuals were sedentary residents in small areas while others immigrated far from their trapsite without returning. The majority of marked animals migrated between summer and winter ranges.

The variation in winter pronghorn distributions was reflective of winter weather and snowfall patterns. Marked pronghorn travelled an average of 18 km from their respective trapsites throughout the 1980-1981 winter. Their movements were in a southerly direction from their summer range and further south than the previous year. During the normal 1982-1983 winter, pronghorn traveled approximately 30 km in a south and southwesterly direction far from their summer ranges. During the 1983-1984 severe winter, pronghorn traveled approximately 80 km.. Their movements were variable but mostly southerly and southwesterly until reaching the interstate highway fence; the southern border of the study area. The highway with the fence was the most formidable barrier

observed in the study area. Pronghorn traveled east or west along the fence until mid-January where they remained in wintering areas until May. The majority of marked pronghorn wintered in different areas during the 1983-1984 winter as compared to the previous three winters.

COMMENTS AND QUESTIONS

QUESTION - Are there any barriers other than the Interstate?

DEBLINGER - The study is pretty flat. There aren't that many terrain features. There are a lot of woven wire fences, but they haven't really caused much problem. Most of the die-off had occurred after they crossed the fences. Most of animals died of exposure or starvation.

QUESTION - How much snow pack do you have over those fences?

DEBLINGER - We got most of our storms very early and we had no wind early on, which was unusual. What we had was powdery snow which didn't crust until they were past these fences. In several instances, gates were left open, which helped a lot, but I observed lots of antelope jumping fences.

QUESTION - Did you get buck-doe-fawn ratios in mortality?

DEBLINGER - Not yet; we're still doing mortality searching. It appears that there's a lot fewer bucks and does and fawns are about even, but that's just off the top of my head.

THE HISTORY OF ANTELOPE MANAGEMENT IN SOUTHEASTERN MONTANA

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ABSTRACT

A general summary of the history of pronghorn antelope (Antilocapra americana) management in southeastern Montana is presented. Various historic events and practices such as livestock grazing, homesteading and farming and their effect on antelope are examined. The story of antelope recovery in southeastern Montana is documented. Past trapping and transplant efforts along with protective measures which were enacted are discussed. Populations, harvests, and hunter numbers during the period are examined and a variety of "management" techniques, including bucks only seasons, either-sex seasons, manipulating season dates, doe/fawn tags, second tags valid for doe/fawn and permit number adjustments are evaluated. In addition, a discussion of hunter and/or landowner problems, response and attitudes to these management techniques is included. A brief look is taken at survey procedures and problems. The paper concludes with a summary of pronghorn management to date and speculates on the future of the species and its management in southeastern Montana.

INTRODUCTION

In the early 1800's, antelope were distributed nearly statewide in Montana with the exception of the forested and mountainous areas of the western portion of the state. Lewis and Clark reported seeing and shooting numerous antelope during their journey through what is now Montana (Mussehl and Howell 1971). The history of antelope management in Montana is one associated with the white settlers that came to this area. Prior to settlement, antelope were used only minimally by Indians and fur trappers and they were numerous as late as 1896. The southeastern part of Montana has been and continues to be one of the most important antelope producing areas in this state.

The art and science of game management is directed toward continuing opportunities for an annual harvest of game birds and animals in a sporting manner. The purpose of this paper is to pause and look back at the history of pronghorn antelope management in the southeastern part of Montana. The history and management of antelope in Montana follows that of this species in other states, although some of the "techniques" used may vary. Many management practices have pitfalls and/or limitations. Management of antelope in Montana has definitely had its ups and downs, and no one answer or technique has proved adequate for all situations. I will attempt to follow antelope populations through their highs and lows and document the antics of game managers who were along for the ride. The paper will also attempt to point out some of the public and professional attitudes which prevailed at different times in the history of antelope management in southeastern Montana. The material presented is not intended to be extremely technical in nature but an overview embellished with many opinions and biases of the author. I hope to at least stimulate some thought as to what antelope management is and what it could be in the future.

This paper was assembled by putting together bits and pieces of information on file at the Miles City office of the Montana Department of Fish, Wildlife and Parks. I would like to express my appreciation to all those individuals whose notes and data sheets proved helpful, especially N. Martin, J. Egan, C. Eustace, H. Wentland, and the late H.O. Compton.

METHODS

The thrust of antelope management in Montana is decided through aerial population survey flights conducted during July. Surveys are flown on clear, calm mornings and evenings by flying at one mile intervals along north-south section lines. All antelope observed are classified and their location recorded. Harvest data are obtained from annual surveys of a sample of hunters who are contacted by mail or by phone. This is supplemented by information obtained from check stations operated during the hunting season. Much of the remaining information presented in this paper is from notes and data sheets on file at the Miles City office of the Montana Department of Fish, Wildlife and Parks.

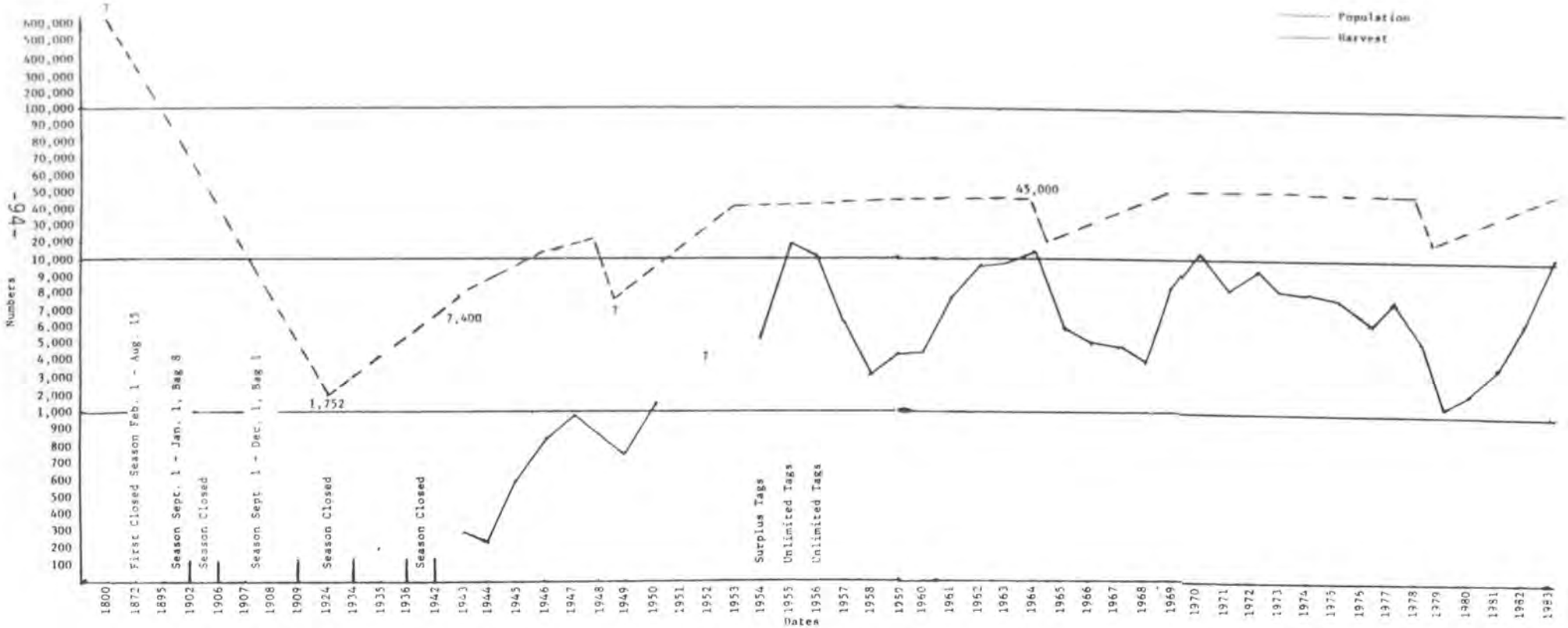
STUDY AREA

The 30,000 square mile area is located in the southeastern part of Montana known as the Montana Department of Fish, Wildlife and Parks Region 7. The area includes gently rolling areas, badlands, and timbered breaks. Major vegetation types are grassland, sage-grassland, pine hills, and cultivated crops, mainly dryland wheat. Major land uses are farming and livestock grazing by cattle and sheep. Antelope occur in 57% of the area and private land accounts for 80% of all the antelope habitat available. Land ownership is 5% state school lands, 14% public lands (BLM and Forest Service), and 81% private. Climate of the area can be described as semi-arid with hot summers and cold winters. Temperature and year-round weather conditions are highly variable and can be extreme.

POPULATION AND HARVEST

A description of population and harvest trends over the years appears in Figure 1. Antelope originally were very common in southeastern Montana. Populations have followed a cycle where supply exceeded demand followed by a period where demand exceeded supply. Hunting seasons have been set accordingly with generous seasons when supply exceeds demand and restrictive seasons when demand exceeded supply. Prior to 1940, the potential of southeastern Montana had seldom been recognized and little game survey work was done. Scientific management was initiated in the early 1940's and the first antelope seasons held then were to alleviate local crop damage. After the declines in the early part of the century, antelope numbers increased with only temporary setbacks in the severe winters of 1948-49, 1964-65 and 1978-79. During the severe winter of 1978-79, antelope populations were reduced by 58%. The following year, permit numbers were cut by an average of 67% (range 0-94%) with the eastern-most hunting districts showing the greatest declines. During the period from 1967-77, 42% of the statewide harvest occurred in southeastern Montana and most of this was from private lands. Landowner reaction to increased hunter numbers resulted in an increase in land closures during the mid-70's from 14 to over 50% (Eustace 1976).

Figure 1. Antelope population and harvest in southeastern Montana, 1800-1983.



RESULTS

PRISTINE SITUATIONS (. -1870)

Originally antelope were widespread on our continent and numbers were great. This was also the case for Montana with an estimated population of 2,500,000 for the state before settlement (Beer 1944). In all probability a great many of these antelope were found in the southeast corner of the state. Use of antelope by Indians and early explorers was light. The demise of the bison (Bison bison) and Indian, and the influx of domestic livestock brought many changes and antelope were no longer abundant after 1896-97.

LIVESTOCK ERA (1870-1900)

In the latter part of the 1800's, white men and their livestock began to invade the antelope habitat of southeastern Montana in a big way. Vast numbers of cattle, horses and sheep were grazed on the land. Attitudes of producers were that of a limitless resource (i.e. grass) waiting to be grazed. As a result, rangelands were severely overgrazed. In addition, antelope were being exploited year-round for food and predator control (animals were shot and laced with poison). A series of severe winters brought a rapid end to open-range livestock grazing. Fences started going up and antelope could no longer move at will across parts of their habitat. Now a new era was being ushered in: the homestead era.

HOMESTEAD ERA (1900-1930)

Human populations on southeastern Montana antelope habitat rose dramatically. In some areas there was a family on every quarter section. Many antelope ended up in the stomachs of early homesteaders. This, along with the fact that thousands of acres of original antelope habitat were destroyed during the first 2 decades of this century by overgrazing and cultivation, resulted in dramatic declines in antelope numbers. Antelope herds were reduced to small herds in small concentration areas. Nelson (1925) estimated there were only 1,752 antelope left in southeastern Montana by 1924, and herds were still decreasing in most areas. He also stated that the antelope situation in this area was precarious and in need of prompt attention if they were to survive. It is interesting to note that even at this time the people of southeastern Montana gave themselves very little credit for being part of the problem. Thomas N. Marlowe, Chairman of the State Fish and Game Commission, wrote as follows: "The matter of further protection and propogation of the antelope is, to my mind, a very difficult one. In spite of what we have tried to do in this state, they seem to be, as stated in your letter, on the decrease and practically threatened with extinction. The only possible solution of this matter appears to be the creation of an antelope preserve somewhere in eastern Montana.....I am satisfied after having been a member of the State Fish and Game Commission for more than 5 years that the greatest problem confronting us in this state in the protection of game is the control of predatory animals. If we could exterminate them there would be plenty of game in the state for all demands as there is no doubt that predatory animals destroy more than all hunters put together" (Nelson 1925). Nelson also reported that in 1 district, bootleggers in high-powered automobiles passing through the area had a practice of pursuing and killing antelope on the open plains. And finally, it is also interesting to note that even at these extremely low population levels there were still complaints

received about antelope damage to crops, particularly alfalfa. It was during this era that antelope numbers reached their low point, however a new era was being ushered in that would turn things around for antelope: the dust bowl.

DUST BOWL ERA (1930's)

The droughts and dust bowls of the 30's drove many homesteaders from southeastern Montana. Human populations dropped dramatically and abandonment of homesteads restored more favorable conditions for antelope. A change in land use patterns and regrowth on cultivated fields resulted in improved range conditions for antelope. The history of land abuse during the early period of settlement was past and although they left their scars, the land was in a condition where recovery was possible. In addition, a new field, wildlife management, was developing and beginning to have an effect on the resource. Antelope recovery was underway.

ANTELOPE RECOVERY (1930-)

Early wildlife managers identified protection and reestablishment of antelope populations as the top priority. Seasons remained closed or severely restricted and trap and transplant programs were begun in earnest. Southeastern Montana served as a reservoir of antelope that provided animals for other parts of the state. Only a few hundred antelope were trapped and released in this part of the state Most of the animals trapped went to other parts of the state and to North Dakota, Nevada, Kansas, Utah, Arizona and even Hawaii. In addition, approximately 100 antelope from this area were sent to zoos, including 4 that went to France. The trap and transplant program succeeded in restocking the empty but suitable habitat areas in Montana. This leads us into the 1940's and the age of "modern" antelope management.

ANTELOPE MANAGEMENT

To manage as defined in the Merriam-Webster dictionary means to achieve one's purpose. The purpose of antelope management, as practiced in southeastern Montana, along with the programs employed is a product of resource management evolution. Management of antelope is still evolving and like the animals it deals with, it must continue to evolve to meet the challenge of changing times and conditions. Early management activities were aimed at protection and perpetuation while later activities have been aimed at providing a maximum sustained annual harvest, along with minimizing the population fluctuations which occur. In addition, it has been stated that antelope management should be consistent with other range uses and provide the greatest sport without being a detriment to succeeding populations (Mussehl and Howell 1971). The majority of management to date has dealt with regulating season and harvest factors according to antelope population and landowner tolerance. All of the management "techniques" which have been employed in southeastern Montana are interrelated and all have been directed at this stated goal. A brief description of some of the techniques we have employed is presented below:

Bucks Only Seasons

The earliest seasons in southeastern Montana after the low population levels of the 20's and 30's, were generally bucks only. Seasons were scheduled after the rut and the males could be harvested at this time without

influencing population growth. The bucks only seasons for antelope and other species did instill the general public with a "don't kill the mothers complex" for a period of time. Because of habitat changes and concurrent population changes which are occurring in this part of Montana at the present, it is conceivable that bucks only seasons may be a management tool again in the future. This may be necessitated by widespread habitat changes (i.e. plowing) which result in limiting herds of antelope to widely spaced small "islands" of habitat. Antelope distribution during July flights suggests that antelope are slow to repopulate these areas once the herd has been lost.

Either-Sex Seasons

Either-sex seasons have been the norm in southeastern Montana and have since 1958. With increasing antelope numbers and a situation where supply exceeded demand, the public accepted either-sex seasons for antelope. It is interesting to note there are quite a few "old timers" who wouldn't hesitate to shoot doe antelope and yet refuse to harvest female deer. The idea of either-sex hunting of antelope is now very well accepted by the public even at low antelope population levels. It should be noted that the harvest under single either-sex permits tends to be mostly yearling and older males (60-70+%). As a result of this, it is difficult to achieve much population control under this system.

Doe/Fawn Only Tags

When people are given a choice of applying for either-sex <u>or</u> doe/fawn tags, we have found substantially less demand for doe/fawn tags with less than 50% issued through the drawing. Most of these tags end up being sold as surplus tags after the regular drawings for permits; however, the tags are generally all sold by the opening day of the season. By issuing 1/3 of the permits in an area as doe/fawn only, the harvest of females and fawns can be expected to increase by 15% over what would occur with all either-sex permits.

A Second Tag Good For Doe/Fawn

In 13 of the hunting districts (54% of the total area) in southeastern Montana, we have gone to a system where successful applicants in the drawing for an either-sex tag may purchase a second tag valid for a doe or fawn in the same unit. The use of multiple tags was originally proposed in 1965 because there were so many antelope available and not enough people to harvest them. The second doe/fawn tag is used now as a means of increasing the harvest in an area while keeping hunter numbers within landowner tolerance levels. The use of second tags has been well accepted by landowners and by most hunters as long as the reason behind them is fully explained. There are a few hunters who object to the fact that someone can harvest 2 animals while they weren't allowed to hunt. The use of second tags increases the total harvest (40-60%) and also the percentage of females and fawns in the harvest by approximately 20%. Usually 60% percent of the people given the option of purchasing the second tag usually do so (range 37-77%) and people have shown that they are willing to travel to remote areas if they can harvest 2 animals. The use of this technique is currently being expanded in southeastern Montana; however, we still are unable to reach our harvest objectives with it in some areas. For an individual to take more than 2 antelope is unfeasible as it would meet with considerable public resistance.

Adjusting Season Dates

The length of the antelope season in southeastern Montana has been adjusted many times throughout the years and has varied from 7-72 days with the longest season in 1954. The first seasons in the late 1800's were quite liberal and then became more and more restrictive as antelope numbers declined. They were lengthened again once antelope numbers rebounded. Presently the season in Montana appears to be fairly well established beginning the second week of October on a Sunday and running for 4 weeks into the first part of November. There is a two week overlap of deer and antelope seasons. The reason that the season is shorter than in the 50's and 60's is to accommodate landowner's requests for relief from hunters. Our season occurs after the rut so breeding activities of antelope are not interrupted. The timing of the season creates a small problem with males shedding horn sheaths near season's end in November. A system whereby the season would open on a "fixed date" was tried in 1983. This results in opening day falling on different weekdays in different years, but the date remaining the same. The weekday opening in 1983 was generally well accepted by landowners who felt it reduced opening day pressure. There were a few sportsmen, however, that felt a weekday opening gave an unfair advantage to non-resident hunters who could hunt while residents had to work.

Split Seasons

Under this system, ½ of the hunters are allowed to hunt during the first half of the season and ½ during the second half of the season. Split seasons were tried in the early 1970's in an effort to reduce opening day pressure on landowners and to distribute hunter pressure over the entire season. At first the split seasons were accepted; however, landowners began to object because they felt that they ended up putting up with 2 opening days. Also, hunters who hunted the second half objected because they felt they didn't get a fair chance to hunt antelope - particularly the bucks. However, harvest data showed that total harvest and sex and age statistics were very similar for both halves of the season.

Change Hunting District Boundaries

The hunt areas in southeastern Montana changed from several large areas to 34 small districts in 1983. This change was an attempt to distribute hunters and harvests to more precisely coincide with antelope distribution and availability on private lands. A problem with this approach resulted from landowners in some areas getting together and charging those with a permit in that area to hunt. Another difficulty is that antelope move freely between hunting districts and may not be available in the district intended when the season opens. The current trend is back toward larger areas.

Hunter Response and Attitudes

Currently the demand for antelope exceeds the supply and this situation is likely to continue into the foreseeable future (statewide 52,750 people applied for 32,041 available permits). We have found that hunters are cooperative with the different management strategies as long as the reasoning behind them is explained. We have also noted an improvement in hunter attitudes as the majority now ask permission before hunting (required by law). Antelope hunting techniques are getting better and the days of a truck,

gun, and fence cutter appear to be over. There is still plenty of room for improvement; however, since an improvement in hunter behavior will keep lands open to the public.

Landowner Response and Attitudes

Through the years we have observed that landowners don't tolerate antelope hunters as well as deer hunters. This is probably a result of some hunter behavior in the past (for example cutting fences) and the fact that antelope hunting is still more vehicle oriented. Landowners in southeastern Montana prefer shorter seasons with bigger and bigger harvests and fewer hunters afield. Landowner tolerance to hunter numbers also changes dramatically. Many landowners only allow hunters on their property when antelope populations are high. At this point, there is little hope of controlling the population. Landowners also are very good at informing us of the greater availability of their antelope after the fact (i.e. seasons). During the past few years antelope damage problems have been severe in some areas, particularly on seed alfalfa. We have tried to balance hunter numbers, antelope numbers and landowner tolerance by issuing multiple tags (Table 1) to keep hunter densities low and increase harvest. Land closures have been a severe problem in the past as a result of allowing too many hunters afield and exceeding landowner tolerance levels. Also, when one ranch closes, the pressure on surrounding open ranches increases accordingly and the closure tends to feed itself. In addition, large blocks of land have been closed by landowners who have blamed the department for unfavorable political decisions (i.e., the ban on Compound 1080).

Miscellaneous

An archery season on antelope prior to the gun season has been held since 1959; however, hunters must still apply in the drawing to obtain a permit. The harvest is negligible (100-120).

Also, an ex-officio warden program was developed whereby all field biologists received enforcement training in an effort to open more private lands through increased enforcement during the hunting season. It has been observed that the overall impact of this program has been small, although it can be effective on a specific area if enough manpower is available.

Problems With Management To Date

Results from 1 hunting district, which is flown for population counts, in both July and November, are presented in Table 2. It is apparent that population estimates and, therefore, permit levels based on July flights are erroneous. The highly variable results of these surveys demonstrate a need to better understand survey efficiency if we are to harvest the annual surpluses of the antelope population. Throughout the history of antelope management in southeastern Montana, the goal has been to maintain population levels at a stable, relatively high point to provide maximum sustainable yields for the sportsmen of the state. Previous attempts to stabilize antelope populations within the current management systems has proven futile. Eustace and Wentland (1972) stated that issuing permits equal to 1/3 of the annual antelope count (as has been the practice) will not insure a harvest equal to annual recruitment. They also stated that management based largely on aerial surveys does not satisfy the needs of an intensive management program. It is apparent

that we need to know a great deal more about antelope populations and population dynamics if we are to effectively manage them.

Table 1. Permit numbers and hunter densities from 1972-1983.[1]

Year	Permits	Hunter Density/ Sq. Mi.	
1972	13,825	.64	
1973	12,770	.60	
1974	13,145	.60	Period of Extensive
1975	12,130	.60	Land Closures
1976	10,845	.51	
1977	11,060	.51	
1978	8,755	.40	
1979	2,778	.10	
1980	3,308	.15	
1981	5,715	.26	
1982	7,071	.33	
1983	4,595	.45[2]	

[1]Based on 21,503 square miles of antelope habitat.

[2]Demonstrates effect of multiple tags.

CONCLUSIONS

Management of pronghorn antelope in southeastern Montana to date has been basically a "brushfire" approach with solutions being applied to immediate problems rather than the long-term ones. All of the management we have applied is interconnected: what we do for the landowners affects the sportsmen; what we do for the sportsmen affects the landowner; and what we have done for antelope has regretfully had little effect. To date, we have just attempted to monitor population fluctuations and set harvest levels accordingly and even at this we have been fairly ineffective. If we are ever to ready manage antelope we will need to do the following:

BIOLOGICAL

We need to understand survey efficiency so that we can take advantage of surpluses when and where they exist. In conjunction, we need a more thorough understanding of antelope population dynamics. While it is unlikely antelope will ever become extinct in southeastern Montana, we will need to maintain population levels high enough to provide a substantial harvest. It is obvious that with the manpower and data currently available, an intensive management program is not feasible. In addition, there is a pressing need for more management oriented antelope studies, such as conditions which affect hunter distribution, harvest, and actual effects of different management practices on populations, etc.

Table 2. Population survey data for summer and fall in hunting district 710 for 1981, 1982, and 1983.

1981	Males	Females	Fawns[1]	Total	Density
Summer	667	1,007	992	2,666	3.8
Fall	744	3,405		4,149	5.9
1982	**Males**	**Females**	**Fawns**	**Total**	**Density**
Summer	1,108	1,700	1,782	4,590	6.6
Fall	744	1,596	1,641	4,011	5.7
1983	**Males**	**Females**	**Fawns**	**Total**	**Density**
Summer	1,182	1,776	1,721	4,679	6.7
Fall	1,238	5,707		6,945	9.9

[1] Fawns and females combined during fall 1981 and 1983 flights.

ECOLOGICAL

There is a pressing need to define what constitutes antelope habitat and to understand the limitations of such habitats. In addition, we need to be able to accurately monitor antelope habitat and any changes which are occurring. Consistently in the planning process, the access of hunters to antelope has been the top priority while habitat understanding or work has come in second. Access becomes a very minor issue once the habitat and antelope associated with it are lost.

SOCIAL

The social aspects of antelope management have long been overlooked and are in need of more attention. The basic social problem in antelope management is that of a public commodity (wildlife) which lives on private land. To solve this problem I see only 2 viable solutions. One is to make the private commodity (land) public and manage for antelope. This solution would be impossible in our society. The second solution would be to make the public commodity (wildlife) private. Although there are some states which are headed along these lines through issuing landowners permits for animals on their lands, this solution has been and will continue to be met with a great deal of opposition in southeastern Montana. Our only hope, therefore, is to moderate this public-private conflict.

In addition, society needs to change so that those who practice sound stewardship of the land are rewarded for it and those who abuse the land are not. All too often the programs of our government have rewarded those who have practiced the poorest land stewardship (i.e., PIK and tax incentives that

reward those who plow fragile rangelands). We need to encourage the government to institute programs and practices which promote the long-term benefits (public and private) of sound land management versus the short-term profit. To bring this about will take an abrupt change in the attitudes and philosophies of most Americans and their government. It will be our responsibility as game managers to facilitate this change by obtaining the knowledge and understanding of antelope populations and their needs in order to teach the public. Only through informing the public of the long-term benefits of those systems and/or programs which promote sound land stewardship and therefore meet the needs of antelope, will they be able to make an informed decision that will benefit themselves and antelope, now and in the future. The future rests in their hands.

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COMMENTS AND QUESTIONS

QUESTION - How successful was that dry land farming?

DOOD - Economically it's very successful. If you're asking how much wheat they grow, they never do. These people are not trying to grow a crop on that land. It's economically feasible because of tax incentives, disaster payments, etc.

PRONGHORN SUMMER DISTRIBUTION AND WATER AVAILABILITY IN THE RED DESERT, WYOMING 1/

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ABSTRACT

Studies conducted in 1979-1980 in sagebrush/grassland of south-central Wyoming determined locations of important summer habitats of pronghorn (Antilocapra americana), and examined relationships of water and related environmental characteristics to pronghorn seasonal movements and summer distributions. Biweekly flights in a fixed-wing aircraft on transects covering about 20% of the 9200-km^2 Red Desert Herd Unit revealed areas of pronghorn summer concentrations and timing of seasonal movements. In 1980, pronghorn began dispersing from winter ranges (Basin area) as snow cover diminished in spring, and by the end of June were concentrated on adjacent summer ranges (Foothills area), where available drinking water was more abundant and dependable. Percent of pronghorn groups observed within 6.4 km of known water sources increased through late spring and summer to a maximum of at least 92% in August, just after measurements of forage moisture content were lowest in both areas. Negligible precipitation was measured in either area in June and July, and mean monthly temperature peaked in July in both areas.

While available water is an important and necessary component of pronghorn summer habitat, other factors also appear to affect summer distribution of pronghorn in the Red Desert. Seasonal movement of pronghorn onto summer ranges began in April and May, presumably before water demands were great and while many water sources were still available in the Basin area. Preliminary measurements made in summer 1980 suggested that shrub height, stand conformation, and understory structure in the Foothills area offered potentially superior fawning cover. Initial movements onto summer ranges in late spring just before fawning may be in response to these factors. Cooler and wetter conditions allowed later drying of forage plants in the Foothills area later in summer. Pronghorn selection of the Foothills area as summer habitat was probably influenced by their reduced demands for drinking water because of forage moisture content and water availability.

Further studies of the influences of other factors on water and range requirements of pronghorn in summer in the Red Desert might include analysis of fawning cover and nutritional quality of spring and summer forage, effects of forage succulence on food and water intake of pronghorn, and pysiological responses of pronghorn to water stress and heat loading.

1/ Financed by Union 76-Minerals Exploration Company and the U.S. Bureau of Land Management, Rawlins, Wyo., and conducted as partial fulfillment of requirements for the degree of Master of Science for the senior author.
2/ Present address: U.S. Fish and Wildlife Service, 1300 Blue Spruce Drive, Fort Collins, CO 80524

COMMENTS AND QUESTIONS

QUESTION - Did you see a lot of mortality associated with poor water conditions?

BOYLE - No, we've seen very little fawn mortality.

QUESTION - Did you identify any critical summer habitat?

BOYLE - I would say the northern end of the study area (indicated on map with pointer).

AGE COMPOSITION AND HORN DEVELOPMENT OF TEXAS PRONGHORNS

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ABSTRACT

From 1978 through 1982 age composition and horn development data were taken from a total of 1,075 buck pronghorn antelope (Antilocapra americana). Age composition varied between years and districts, but was similar for all districts when averaged over the 5-year study. With 2 exceptions, maximum average horn measurements for all years and districts were recorded in the 5.3 yr.+ age class. Measurements for horn length and basal circumference by age class were similar for the 3 districts.

INTRODUCTION

In recent years an increasing number of landowners have become interested in the economic value of the wildlife resources available to them. Many have come to the conclusion that it is to their advantage to offer hunters a quality hunting opportunity, where the client's prospects of bagging a trophy antelope are high.

As with other big game species, knowledge of the age structure of a pronghorn antelope herd is one of the necessary segments of information needed to develop a management program. An absence of older animals in the harvest may indicate that the population is subject to excessive hunting pressure. An abundance of older animals in the harvest may indicate increased hunting recreation is available.

In Texas, the pronghorn harvest is controlled by permits issued by the Texas Parks and Wildlife Department to landowners. One of the current harvest objectives is to maintain a minimum adult sex ratio of 1 buck per 4 does in the post-hunting season population. In order to evaluate any adverse impact this level of harvest may have on age composition and horn development, the Texas Parks and Wildlife Department undertook a 5-year effort, to collect data from pronghorn antelope harvested in the state. This study was funded by the Federal Aid in Wildlife Restoration Act as part of Texas Project W-109-R, Big Game Investigations.

METHODS

Age and horn measurement data were obtained from hunter killed animals in 3 districts (Trans-Pecos, Panhandle, and Possum Kingdom) encompassing the state's antelope population. Data were collected during each hunting season from 1978 through 1982.

Age of harvested pronghorn bucks was determined by observing tooth wear and replacement as described by Dow and Wright (1962) with slight modification by Hailey (1979). Additionally, animals classified as 2.3 and 3.3 years of age were combined into 1 age class (2.3 & 3.3) to compensate for variance in tooth replacement. For analysis, data were arrayed in 4 age classes: 1.3 yr., 2.3 & 3.3 yr., 4.3 yr., and 5.3 yr.+. Fawns (0.3 yr.) were not included the study.

Horn measurements, recorded in millimeters, consisted of length (from the outside base up over the curl to the tip) and basal circumference.

RESULTS

AGE COMPOSITION

Approximately 70% of the pronghorn antelope in Texas are found in the Trans-Pecos District. The Panhandle District contains about 20%, and the Possum Kingdom District holds the remaining 10%. Of the 1,075 animals sampled during the study, 796 were examined in the Trans-Pecos, 153 were checked in the Possum Kingdom, and 126 came from the Panhandle. Due to persistent drought and poor reproduction, hunting was limited in the Possum Kingdom in 1978 and 1980 and in the Panhandle in 1981. Because of extremely low sample sizes, age and horn measurement data were not reported during these hunting seasons. Data were submitted from the Trans-Pecos District every year.

Age composition of antelope harvested in the Trans-Pecos (Table 1) remained much more constant year to year than in the other districts (Tables 2 and 3). The year to year variation in age composition found in the Possum Kingdom and Panhandle Districts may be attributed to drought and in some cases small sample sizes.

The Trans-Pecos District yielded the highest proportion of animals in the older age classes. Over the course of the study, 51.0% of the Trans-Pecos sample was in the 4.3 yr. and 5.3 yr.+ age classes. The Possum Kingdom District followed closely with 48.3% in the 2 oldest age classes. The Panhandle District reported 40.4% of its sample in the 2 oldest age classes.

Over half (54.8%) of the Panhandle sample was represented in the 2.3 and 3.3 yr. age class. The Panhandle also reported the highest percentage of yearlings (4.8%) in the harvest. The Possum Kingdom reported 4.6% of the sample in the 1.3 yr. age class. Yearlings made up 3.0% of the Trans-Pecos sample.

HORN DEVELOPMENT

With the exception of 1978, the Trans-Pecos District consistently yielded the longest average horn length over all age classes (Tables 4, 5, and 6). Average horn length in the Trans-Pecos ranged from a low of 310 mm recorded in 1981 to a high of 345 mm in 1982. Average horn length in the Possum Kingdom ranged from 279 mm in 1981 to 322 mm in 1982. Average horn length in the Panhandle ranged from 317 mm in 1979 to 344 mm in 1982.

The longest average horn length by age class, each year and in each district, was found in the 5.3 yr.+ age class, except in 2 years (Panhandle, 1979 and Trans-Pecos, 1980) when the 4.3 yr. age class had the longest average horn length. In several instances the average horn length of the 4.3 yr. age class was equal to or within a few millimeters of the 5.3 yr.+ age class. The maximum horn length measurement from each district was found in the 5.3 yr.+ age class. The maximum horn lengths were as follows: Trans-Pecos, 445 mm in 1980; Possum Kingdom, 422 mm in 1982; and Panhandle, 450 mm in 1982.

Table 1. Age composition (%) of the buck antelope harvest in the Trans-Pecos District, Texas, 1978 through 1982.

Year	Sample Size	1.3 Years	2.3 & 3.3 Years	4.3 Years	5.3+ Years
1978	183	2.8	49.1	27.9	20.2
1979	117	0.9	57.2	31.7	10.2
1980	139	4.3	39.6	29.5	26.6
1981	164	2.4	59.2	23.8	14.6
1982	193	4.2	29.5	44.0	22.3
Total	796	3.0	46.0	31.8	19.2

Table 2. Age composition (%) of the buck antelope harvest in the Possum Kingdom District, Texas, 1979, 1981, and 1982.

Year	Sample Size	1.3 Years	2.3 & 3.3 Years	4.3 Years	5.3+ Years
1979	50	6.0	64.0	28.0	2.0
1981	2	0.0	100.0	0.0	0.0
1982	101	4.0	37.6	42.6	15.8
Total	153	4.6	47.1	37.2	11.1

Table 3. Age Composition (%) of the buck antelope harvest in the Panhandle District, Texas, 1978, 1979, 1980, and 1982.

Year	Sample Size	1.3 Years	2.3 & 3.3 Years	4.3 Years	5.3+ Years
1978	50	4.0	44.0	24.0	28.0
1979	35	11.4	82.8	2.9	2.9
1980	22	0.0	50.0	40.9	9.1
1982	19	0.0	36.8	31.6	31.6
Total	126	4.8	54.8	22.2	18.2

Table 4. Buck pronghorn antelope average horn length (mm) by age class, Trans-Pecos District, Texas, 1978 through 1982.

	1.3 Years		2.3 & 3.3 Years		4.3 Years		5.3+ Years		Totals	
Year	Sample Size	Avg.	Sample Size	Avg.	Sample Size	Avg.	Sample Size	Avg.	Sample Size	Avg.
1978	5	230	90	320	51	356	37	362	183	336
1979	1	248	67	319	37	356	12	369	117	335
1980	6	225	55	325	41	345	37	340	139	331
1981	4	201	97	298	39	335	24	335	164	310
1982	8	245	57	332	85	356	43	357	193	345

Table 5. Buck pronghorn antelope average horn length (mm) by age class, Possum Kingdom District, Texas, 1979, 1981, and 1982.

	1.3 Years		2.3 & 3.3 Years		4.3 Years		5.3+ Years		Totals	
Year	Sample Size	Avg.	Sample Size	Avg.	Sample Size	Avg.	Sample Size	Avg.	Sample Size	Avg.
1979	3	275	32	309	14	321	1	374	50	312
1981	0	---	2	279	0	---	0	---	2	279
1982	4	216	38	306	43	336	16	350	101	322

Table 6. Buck pronghorn antelope average horn length (mm) by age class, Panhandle District, Texas, 1978, 1979, 1980, and 1982.

	1.3 Years		2.3 & 3.3 Years		4.3 Years		5.3+ Years		Totals	
Year	Sample Size	Avg.	Sample Size	Avg.	Sample Size	Avg.	Sample Size	Avg.	Sample Size	Avg.
1978	2	297	22	330	12	356	14	370	50	342
1979	4	195	29	330	1	380	1	362	35	317
1980	0	---	11	290	9	354	2	360	22	322
1982	0	---	7	314	6	358	6	363	19	344

The largest overall average basal circumference each year was spread among the 3 districts (Tables 7, 8, and 9). Overall average basal circumference ranged from a low of 138 mm in the 1980 Trans-Pecos sample to a high of 146 mm in the 1982 Panhandle sample. Most overall average basal circumferences were clustered around 143 mm.

With the exception of the Panhandle District, the largest average basal circumference was found in the 5.3 yr.+ age class each year. The 4.3 yr. age class yielded the largest average basal circumference in the 1979 and 1980 Panhandle samples. However, in both instances the sample sizes were quite small. In each district, the maximum basal circumference measured each year was evenly distributed between the 4.3 yr. age class and the 5.3 yr.+ age class. The largest basal circumference measurements in both the Trans-Pecos and Possum Kingdom Districts were found in 4.3 yr. antelope, 179 mm in 1978 and 162 mm in 1982 respectively. The Panhandle District sample contained a maximum basal circumference of 170 mm. This measurement was recorded twice, once on a 5.3 yr.+ antelope in 1978 and again on a 4.3 yr. antelope in 1982.

CONCLUSION

Maximum pronghorn antelope horn development was generally achieved in the 5.3 yr.+ age class. However, average horn measurements recorded in the 4.3 yr. age class sometimes exceeded and often were within a few millimeters of the averages shown in the oldest age class category.

The Trans-Pecos District exhibited the highest proportion of pronghorn bucks in the 2 oldest trophy producing age classes with 51.0% of the sample occurring in the 4.3 yr. and 5.3 yr.+ age classes. The Possum Kingdom District harvest followed closely with 48.3% of the sample in the 2 oldest categories. The Panhandle District reflected a younger average pronghorn harvest with the 2 oldest categories comprising 40.4% of the sample.

With about half of the harvested antelope occurring in the quality producing 4.3 yr. and 5.3 yr.+ age classes, the objective of maintaining a minimum post harvest adult sex ratio of 1 buck per 4 does is not adversely affecting the pronghorn resource.

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Table 7. Buck pronghorn antelope average base circumference(mm) by age class, Trans-Pecos District, Texas, 1978 through 1982.

	1.3 Years		2.3 & 3.3 Years		4.3 Years		5.3+ Years		Totals	
Year	Sample Size	Avg.	Sample Size	Avg.	Sample Size	Avg.	Sample Size	Avg.	Sample Size	Avg.
1978	5	125	90	138	51	145	37	150	183	142
1979	1	120	67	142	37	150	12	150	117	145
1980	6	121	55	135	41	141	37	141	139	138
1981	4	118	97	141	39	148	24	149	164	143
1982	8	125	57	141	85	148	43	148	193	145

Table 8. Buck pronghorn antelope average base circumference (mm) by age class, Possum Kingdom District, Texas, 1979, 1981, and 1982.

	1.3 Years		2.3 & 3.3 Years		4.3 Years		5.3+ Years		Totals	
Year	Sample Size	Avg.	Sample Size	Avg.	Sample Size	Avg.	Sample Size	Avg.	Sample Size	Avg.
1979	3	130	32	141	14	139	1	155	50	140
1981	0	---	2	144	0	---	0	---	2	144
1982	4	119	38	136	43	144	16	147	101	141

Table 9. Buck pronghorn antelope average base circumference (mm) by age class, Panhandle District, Texas, 1978, 1979, 1980, and 1982.

	1.3 Years		2.3 & 3.3 Years		4.3 Years		5.3+ Years		Totals	
Year	Sample Size	Avg.	Sample Size	Avg.	Sample Size	Avg.	Sample Size	Avg.	Sample Size	Avg.
1978	2	118	22	139	12	145	14	151	50	143
1979	4	129	29	145	1	151	1	142	35	143
1980	0	---	11	143	9	148	2	136	22	144
1982	0	---	7	141	6	145	6	153	19	146

DEVELOPMENT OF AN EMERGENCY FEEDING SYSTEM FOR PRONGHORN ANTELOPE

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ABSTRACT

A series of investigations was undertaken to develop an emergency ration and test a delivery system for use by pronghorn antelope (Antilocapra americana) during severe winters. Initial studies included ration evaluation by conducting feeding trials with hand-reared pronghorn. Results of feeding trials revealed that a nutritionally complete, digestively safe ration for pronghorn could be developed. Subsequent investigations were designed to determine: 1) time required for wild pronghorn to recognize ration as food; 2) effectiveness of olfactory attractants in enticing pronghorn to stations, 3) suitability of 2 prototype feeders; 4) effects of feeding on pronghorn behavior.

INTRODUCTION

There are occasionally severe winters in parts of the western U.S. and Canada. In many of these areas, pronghorn antelope (Antilocapra americana), suffer heavy losses during such periods due to exposure to cold, malnutrition and starvation (Compton 1970, Martinka 1967, McKenzie 1970, Mitchell 1965, Mitchell 1980, West 1970, Wishart 1970). During such times the carrying capacity of a winter range may decrease to almost zero due to heavy snow cover on the vegetation. Several of the above mentioned authors elaborated on the patterns of winter-kills. Fawns of both sexes seem to be most susceptible, followed by males and finally females. On several occasions mummification and desiccation of unborn fetuses have also been reported. Although such losses may be acceptable on a purely ecological basis, they are difficult to justify in case of a species which is managed for recreational purposes. Severe winter-kills result in drastically lower numbers of pronghorn for several years, depriving the public from recreational hunting and viewing.

Wildlife biologists have been discussing the possibility of feeding pronghorn during such stress periods (Gjersing 1978, Helms 1978, Pyrah 1978). Indeed, attempts have already been made in the past by interested sportsmen groups and game departments to prevent starvation by supplying feed to pronghorn. Most of these attempts failed to save pronghorn in significant numbers. Part of the reason that previous feeding operations were not successful may be that pronghorn were fed low energy, low digestible rations, e.g., various hays from a variety of sources, and feeding strategies were not planned ahead of time. In summary there has been no real scientific effort to investigate what kind of emergency ration pronghorn need and when and how these rations should be delivered.

There are at least 3 circumstances under which a feeding program might be attempted: 1) feeding during unusually severe winters; 2) feeding at key winter ranges which may be temporarily disturbed due to man's activities, e.g., mining (in this case such feeding could be a part of mitigation measures), and 3) feeding (baiting) pronghorn away from an area which is under rehabilitation due to previous habitat disturbances.

It is apparent that many important questions, such as type of ration, timing, duration and level of feeding, and type of delivery systems, must be answered before such a program can be initiated.

The authors wish to acknowledge the financial support for these studies provided by Rocky Mountain Energy Company and the contributions of company environmental specialist, Elroy Taylor. We also wish to thank the Colorado Division of Wildlife for its logistical support and contributions of Keane Callahan and Bill Gardiner.

OBJECTIVES

The initial objective of our studies was the development of a nutritionally complete, digestively safe pelleted ration which was acceptable to pronghorn. Objectives in the second phase of our studies were to field test prototype feeders and olfactory attractants, and to evaluate pronghorn response to our feed and delivery system.

METHODS

PHASE I - FEEDING TRIALS

Six hand-reared pronghorn were fed 2 experimental rations which differed in digestibility and fiber (Table 1). Daily intake for each animal was measured and all animals were weighed before and after each feeding trial. Fecal material was collected each day and qualitatively described as a check for digestive distress.

PHASE 2 - FIELD TRIALS

Feeding stations were established on pronghorn winter ranges in North Park, Colorado (Figure 1). This area was chosen because it is characterized by winters of significant snowfall and low temperatures. North Park is the northernmost of Colorado's 4 large intermontane parks and is located immediately west of the front range. It lies within townships 5 to 11 north, ranges 77 to 82 west, sixth principal meridian. The park is entirely enclosed by mountains. The west boundary is formed by the Park Range which is parallel north-south to the east boundary formed by the Medicine Bow Range 80 km distant. The south end of the park is enclosed by the Rabbit Ears Range and the north boundary 90 km away is formed by Independence Mountain.

The topography of North Park is flat compared to the surrounding mountains. It consists of low, undulating benches and ridges separated by drainages. The main streams form a meandering pattern on low alluvial flood plains up to 1 km wide. Elevation of most of the sagebrush communities is between 2,400 and 2,585 m. The main exception is Owl Ridge-Peterson Ridge, 2

Table 1. Nutritional characteristics and ingredient list for 2 experimental rations fed to pronghorn. Ration 1 was employed in field trials with wild pronghorn.

Analysis (Dry Matter Basis)

	Percent	
	Ration 1	Ration 2
Dry Matter	90.59	93.00
Crude Protein	19.34	18.54
Acid-Detergent Fiber	13.58	
Crude Fiber		20.00
Apparent *in vivo* Dry Matter Digestibility	72.07	
In vitro Dry Matter Digestibility		61.94

Ingredients

Ration 1	Ration 2
Bentonite	Bentonite
Barley	Barley
Corn	Corn
Milo	
Oats	
Wheat Mids	Wheat Mids
Beet Pulp	
Dry. Brewer's Grain	Dry Brewer's Grain
Molasses	Molasses
Trace Mineral Package	Trace Mineral Package
Vitamin Package	Vitamin Package
	Soy Bean Meal
	Corn Gluten Meal
	Wheat
	Dehydrated Alfalfa

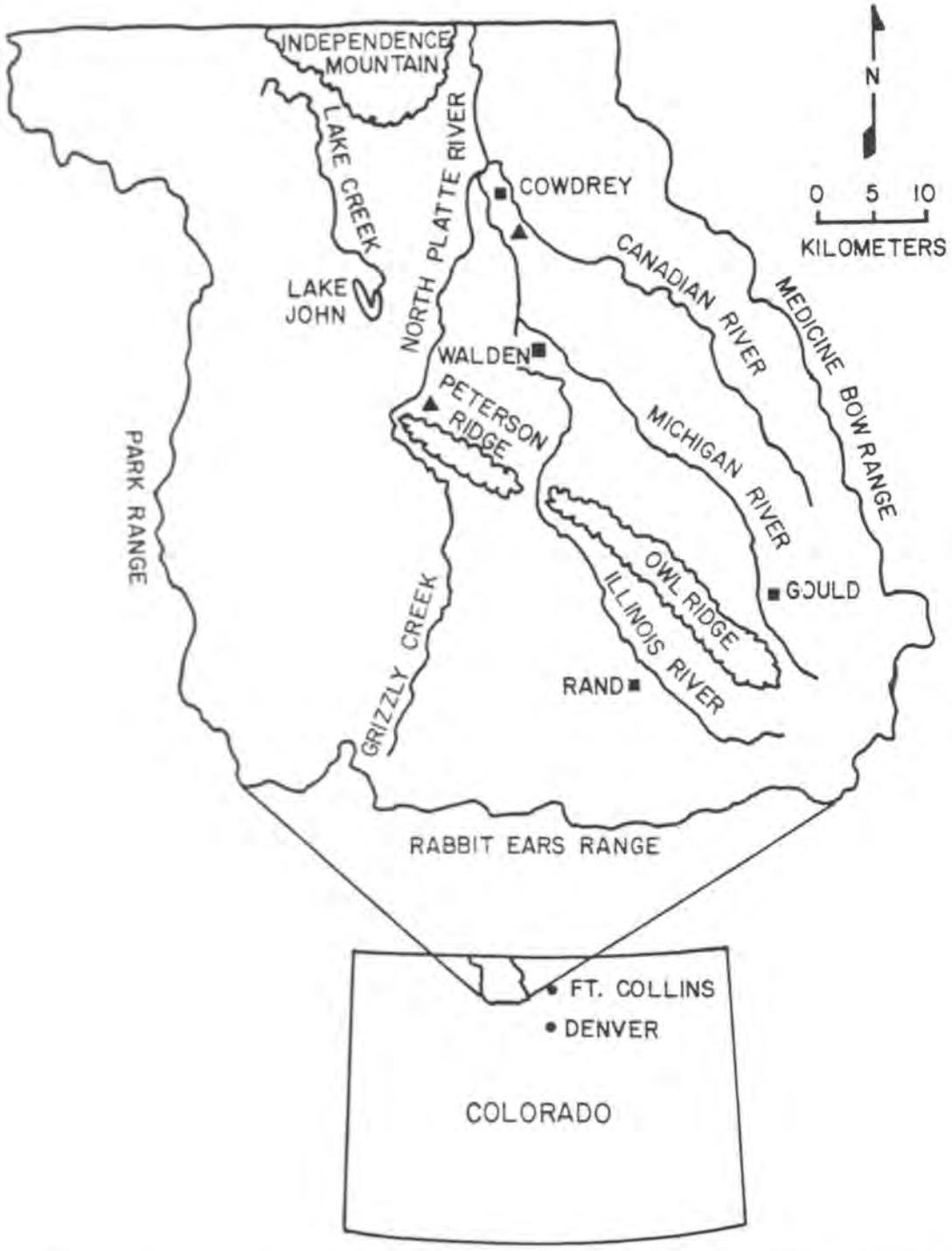

Figure 1. Location of pronghorn feeding trials North Park, Colorado 1983, triangles mark specific locations of feeding stations.

end-to-end ridges extending northwest from Owl Mountain on the east to Delaney Butte on the west and rising 61.5-154 m above the floor of the park. The mountains encircling this park are drained to the north by the North Platte River, major tributaries include the Roaring Fork, North Fork, Canadian, Michigan and Illinois Rivers and Grizzly Creek.

Feeding stations were established at 2 locations in North Park. The first was established on the west side of the Arapahoe National Wildlife Refuge (ANWR), approximately 1 km east of Colorado Highway 14. Station 2 was established 3 km south of Cowdrey along a ridge west of the Canadian River approximately 0.5 km east of Colorado Highway 125. Stations were established after ground surveys revealed that the following conditions were met:

1) Sites were occupied by pronghorn during winter.
2) Sites allowed ease of observation and servicing with minimal disturbance.
3) Sites were similar in slope and aspect.
4) Sites were near preferred habitat and leeward of ridge tops.

Stations were established in early January 1983. Pronghorn abandoned ANWR in late January and those feeders were moved to the Canadian River site. All stations were removed from North Park on 1 March 1983.

Three feeding stations, comprised of 6 feeders (3 tire and 3 metal feeders) were placed in an area frequented by wintering pronghorn. Feeders were randomly ordered in linear fashion. Each attractant was randomly applied to both a metal and a tire feeder. Attractants used were (1) anise powder (ani-mol-aid), (2) iso-butyric acid, and (3) apple juice concentrate. Anise powder was added to the feed and sprinkled around the feeder on the ground. Apple juice concentrate and butyric acid were sprayed on cotton swabs attached to feeders and on feed. Attractants were applied to feeders biweekly or less frequently if pronghorn were near feeders. Application rates for attractants averaged 0.07 kg anise powder, 30 ml apple juice concentrate and 30 ml butyric acid per feeder.

Two types of feeders were tested: (1) a commercially available self-feeding metal pig feeder, and (2) an inverted automobile tire feeder with a plywood floor. Each feeder held approximately 22 kg of pelleted feed. The feed was Ration 1 (Table 1) developed in our first phase of experiments. Feed was placed ad-libitum in feeders and all feeders were treated with an olfactory attractant to lure animals to feeders.

Initially, feeders were spaced at 25 m intervals. After monitoring agonistic behavior at that spacing distance, feeders at 2 stations were compressed to 10 m spacing and enlarged to 50 m spacing at the 3rd station.

Behavioral aggression was measured at individual feeders by observing pronghorn through a 15-40X spotting scope. Distance of observation was 150-200 m at Station I and 300-500 m at Stations II and III. Aggression was measured at individual feeders as number of agonistic encounters per animal minute. The rates were adjusted for number of pronghorn within 5 m of a feeder.

RESULTS

PHASE 1 - FEEDING TRIALS

Both experimental rations were consumed by pronghorn, although mean daily intakes of Ration 2 were significantly greater than Ration 1 (Table 2). Experimental animals showed no symptoms of digestive distress and their weights did not significantly change during trials (Table 3). There were also significant differences in the amount of time required for pronghorn to recognize and consume either ration.

PHASE 2 - FIELD TRIALS

Although we desired to test our feeding system under severe winter conditions, unusually mild conditions persisted during the experimental period. Snowfall was not sufficient to restrict pronghorn movements nor reduce forage availability. Additionally, unusually mild temperatures further reduced snow cover resulting in an open winter. However, in spite of these conditions, pronghorn were successfully enticed to feed from both prototype feeders.

USE OF FEEDERS

Feeding stations were established on ANWR on 11 January 1983 and on BLM land near the Canadian River 14 January 1983 (Figure 1). Pronghorn were often observed near stations, obviously in visual contact with feeders. Pronghorn appeared to fear feeders and when approaching exhibited alarm postures including pilo-erection of the rump patch. Pronghorn did not use feeders, apparently because the form was unfamiliar. Pronghorn abandoned ANWR in late January and that station was moved to the Canadian River site. Pronghorn were again observed near feeders but did not utilize them. On 31 January, several truckloads of big sagebrush (*Artemsia tridentata*) were cut and placed around individual feeders to break their unnatural outline.

Initial observations of pronghorn use of feeders occurred on 5 February. Pronghorn used feeders for all but 3 days during the remainder of the study. An estimated 400 pronghorn used the feeders at least occasionally during February. On 26 February approximately 300 pronghorn were within 100 m of feeders on Stations II and III and approximately 140 pronghorn were within 10 m of a feeder. Numbers of pronghorn using a feeding station ranged from 1 to 75, those within 5 m of a feeder ranged from 1 to 20. Pronghorn were usually at feeders by dawn, left during mid-day and returned in the afternoon to feed at least until dark. Pronghorn probably fed during the night, but we were not equipped for night observations.

Although pronghorn utilized feeders only during February, a total of 268 feeding bouts were observed. Of this total, 44% occurred at metal feeders while 56% occurred at tire feeders. Mean number of pronghorn per feeding bout was 2.9 at metal feeders and 3.3 at tire feeders. (These means are biased because feeding bouts of single animals were not included and large groups were often not counted before they were disrupted.) Age-sex composition at feeders was: 11% adult males, 25% adult females, 38% juvenile males and 25% juvenile females (Table 4).

Table 2. Mean intake (g/day) of 2 commercial rations fed to tame pronghorn.

Group/ Animal #	Intake (g/day) Ration 1	Intake (g/day) Ration 2
Group 1		
201	627.4	1045.5
203	570.6	1058.3
225	664.5	1167.8
Group 1 x ± S. D.	620.8 ± 38.6	1090.5 ± 54.9
Group 2		
224	667.0	887 0
211	656.3	847 0
202	883.0	843.1
Group 2 x ± S. D.	735.4 ± 104.4	859.8 ± 19.8
Overall Mean ± S. D.	678.1 ± 97.4	974.8 ± 122.9

Table 3. Weights (kg) of 6 tame pronghorn before and after feeding trials of 2 commercial rations.

	Ration 1		Ration 2	
Group/ Animal #	Pretrial Wt. (kg)	Posttrial Wt. (kg)	Pretrial Wt. (kg)	Posttrial Wt. (kg)
Group 1				
201	43.7	41.3	41.3	41.2
203	35.6	32.7	32.7	35.1
225	56.7	51.3	51.3	51.0
x±S.D.	45.3 ± 8.7	41.8 ± 7.6	41.8 ± 7.6	42.4 ± 6.5
Group 2				
224	41.7	39.5	39.5	39.0
211	34.5	34.0	34.0	33.3
202	40.0	39.5	39.5	38.3
x±S.D.	38.7 ± 3.1	37.7 ± 2.6	37.7 ± 2.6	36.9 ± 2.5
Overall Mean ± S. D.	42.03 ± 7.03	39.72 ± 6.03	39.72 ± 6.03	39.65 ± 5.69

Table 4. Composition of agonistic encounters among pronghorn by age-sex class during tests of emergency feeding program during January and February, 1983 in North Park, Colorado.

Age-Sex Class	% at Feeders	Initiation of Agonistic Encount.	Recipient of Agonistic Encounters (%)
Adult Male	11%	16%	8% - Adult Males 17% - Adult Females 32% - Juvenile Males 43% - Juvenile Females
Adult Female	26%	16%	0% - Adult Males 47% - Adult Females 0% - Juvenile Males 53% - Juvenile Females
Juvenile Male	38%	59%	0% - Adult Males 18% - Adult Females 62% - Juvenile Males 20% - Juvenile Females
Juvenile Female	25%	9%	0% - Adult Males 23% - Adult Females 4% - Juvenile Males 73% - Juvenile Females

Approximately 950 kg of feed was consumed during the field season. Some feed was consumed by white-tailed jack rabbits (Lepus townsendii), but these losses were very difficult to estimate. Jackrabbits were able to jump into feeders and both fed and defecated in feeders, resulting in loss of feed. All jackrabbit use was apparently nocturnal since no jackrabbits were observed at feeders during daylight hours.

OLFACTORY ATTRACTANTS

None of the olfactory attractants were able to entice pronghorn to feed during the early stages of the experiment. Apparently, attractants were not able to overcome the visual problems that the feeders elicited in pronghorn. After use of feeders began, none of the attractants appeared to be preferred by pronghorn. Of 268 feeding observations 25% were at feeders with anise powder, 42% with apple juice, and 32% with butyric acid. First use of feeders appeared to be a function of first feeder intercepted rather than applied attractant since feeders containing each attractant were initially approached on different occasions. The short sampling period precluded testing attractants against a control of no attractant.

RATES OF AGONISTIC ENCOUNTERS

Agonistic encounters at feeders ranged from lowered head threats to butts and clashes. Initiation of agonistic encounters at feeders was dominated by juvenile males (59%). The majority of these encounters were with other juvenile males (52%, Table 4). Adult males (16%) and adult females (16%) initiated 32% of agonistic encounters and juvenile females 9% (Table 4).

Mean rates of agonistic encounters were positively correlated with increased numbers of pronghorn for 2-4 pronghorn per feeder (Figure 2). Mean rates increased from 0.24 per animal minute with 2 pronghorn per feeder to 0.67 per animal minute with 4 pronghorn per feeder for all spacings. Mean rates of agonism were inversely correlated with distance between feeders (Figure 3). Mean rates were greatest for 10 m spacing with 2-4 pronghorn per feeder. Mean rates were lowest for 50 m spacing with 2-4 pronghorn per feeder, however lowest mean rates with 3-4 pronghorn per feeder were observed with 25 m spacing (Figure 3).

Mean length of feeding bouts was inversely correlated with number of pronghorn per feeder (Figure 4). Mean feeding bout length ranged from 48 sec with 4 pronghorn per feeder to 98 sec with 2 pronghorn per feeder for all spacings (Figure 5). Mean feeding bout length was positively correlated with increased spacing of feeders (Figure 4). This parameter ranged from 55 sec for 10 m spacing to 80 sec for 50 m spacing with 2-4 pronghorn per feeder (Figure 5).

EFFECTS OF FEEDING STATIONS ON PRONGHORN HERD DISTRIBUTION

Prior to utilizing feeders, pronghorn on the Canadian River winter range moved north and south along the Canadian River. These movements, first upstream and then downstream along the river, brought the herd in contact with the feeding station every 7-10 days. Once pronghorn began consuming the experimental ration, however, the herd no longer ranged over the river drainage, but stayed in the vicinity of the feeding stations. Rather than move laterally along the river, pronghorn crossed the river and bedded

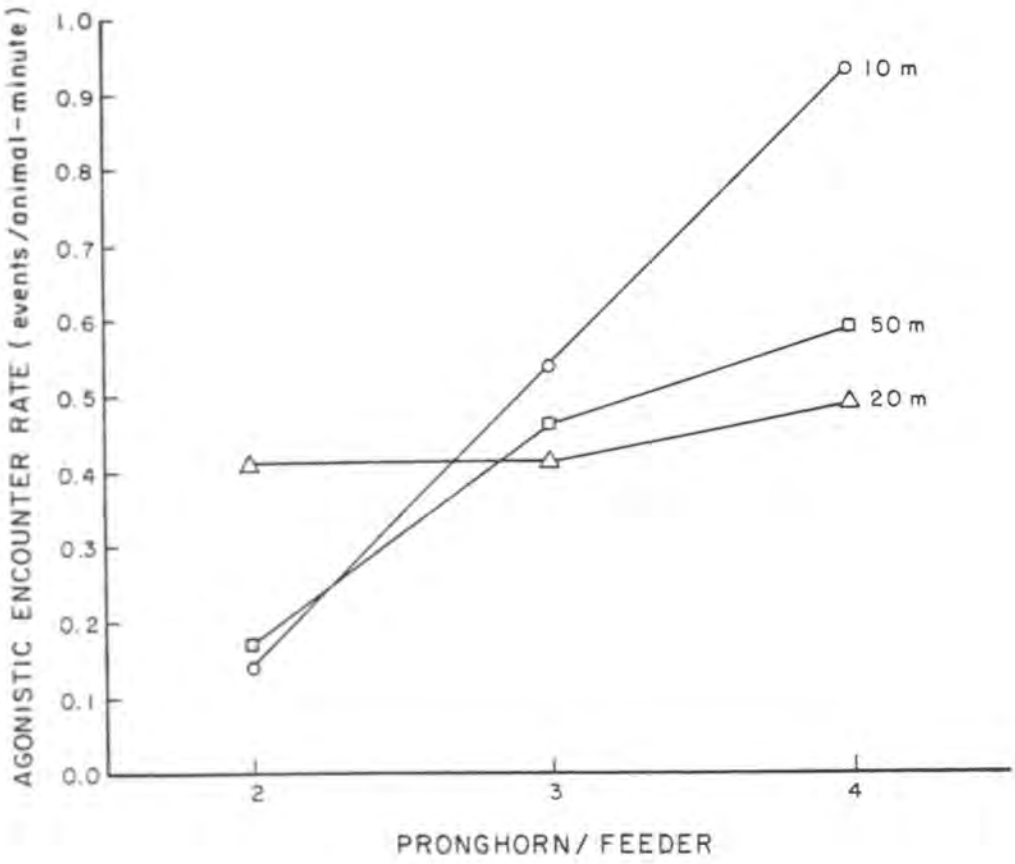

Figure 2. Relationship between agonistic encounter rate and number of pronghorn per feeder for 10, 25 and 50 m feeder spacing.

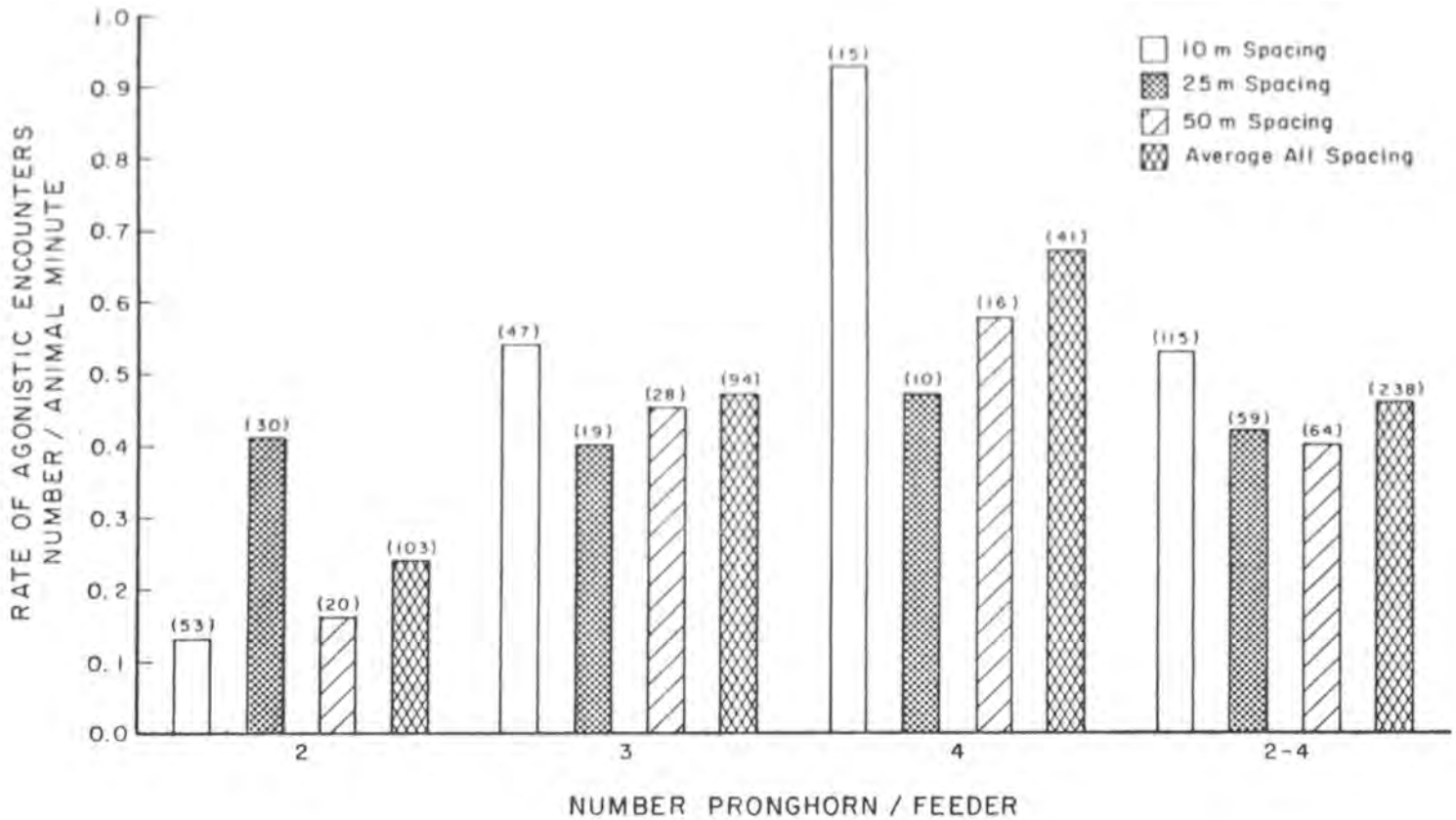

Figure 3. Histogram of agnostic encounter rate and number of pronghorn per feeder for 10, 25 and 50 m feeder spacing. (Numbers in parenthesis are sample sizes.)

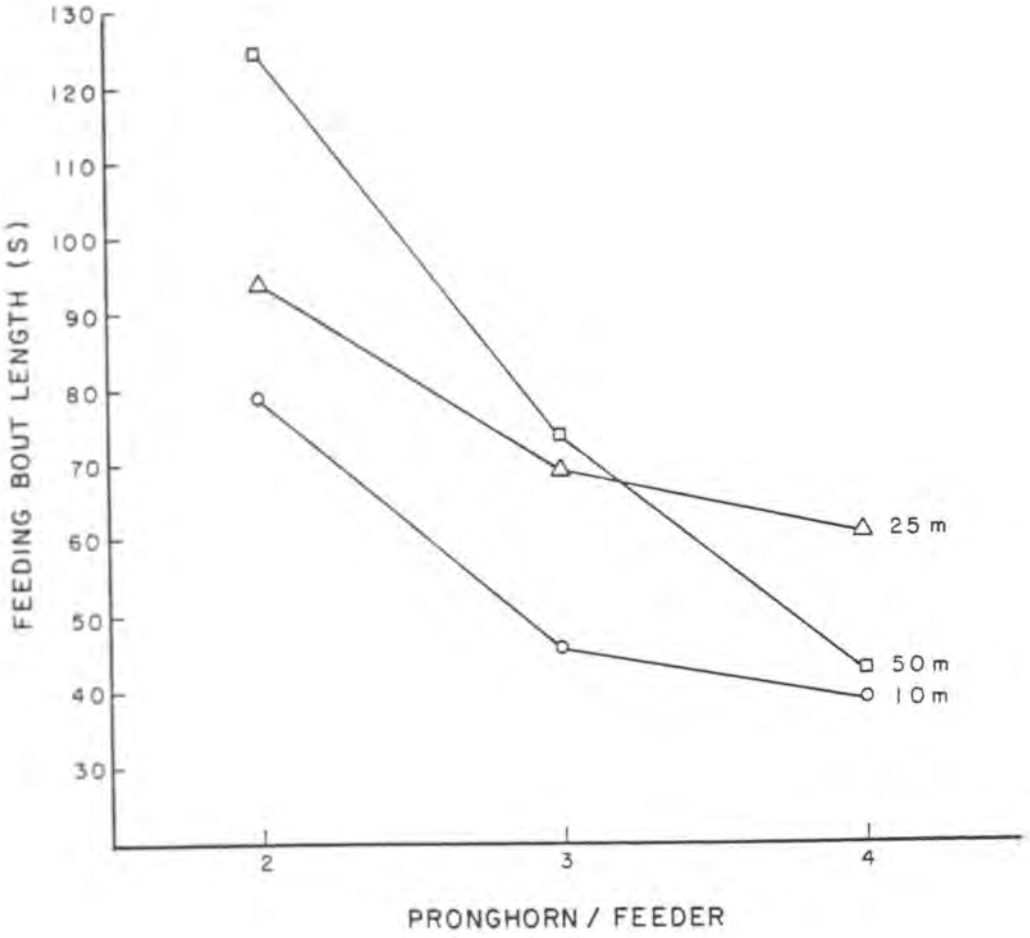

Figure 4. Relationship between feeding bout length and number of pronghorn per feeder for 10, 25 and 50 m feeder spacing.

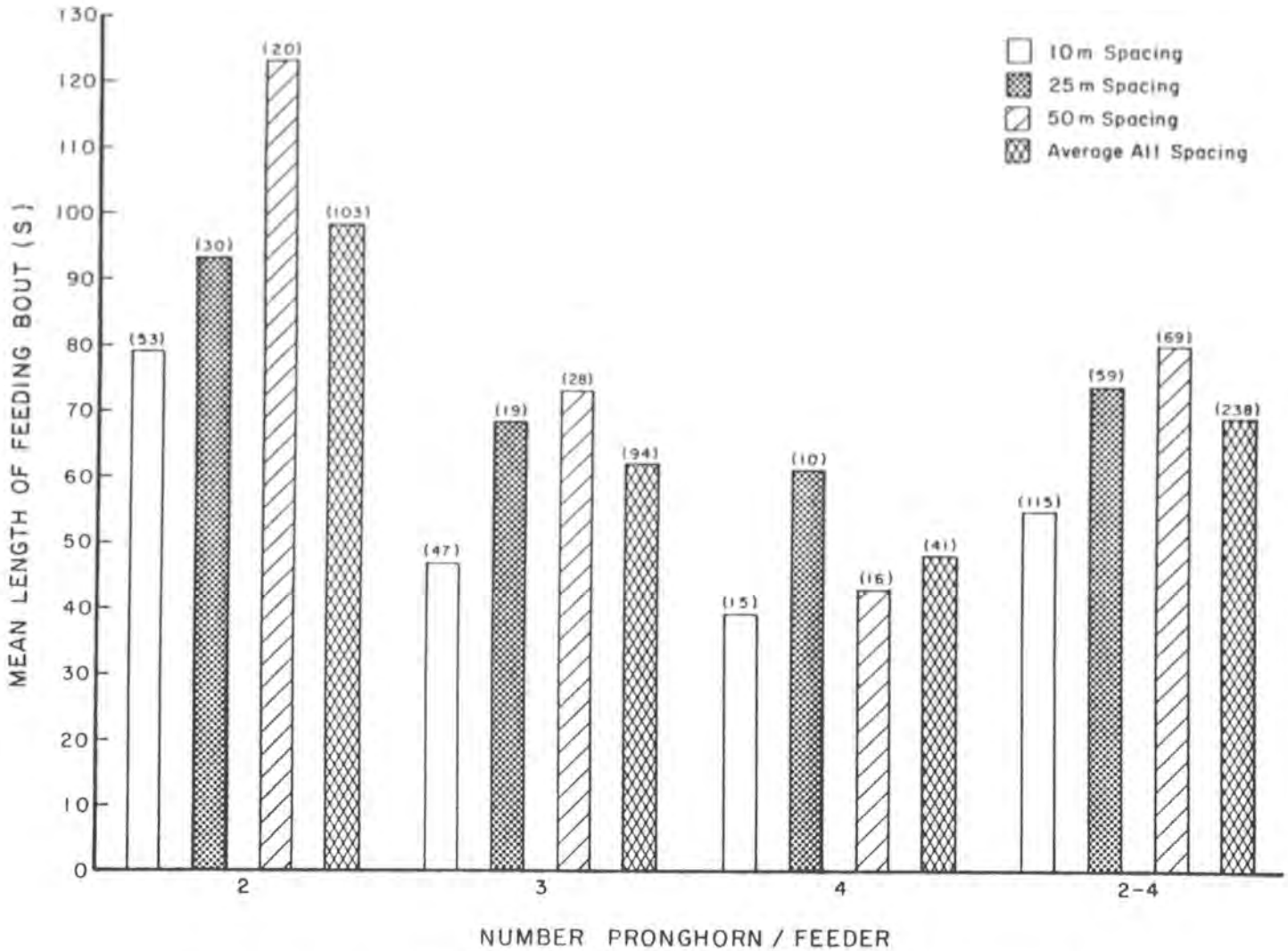

Figure 5. Histogram of mean feeding bout length versus number of pronghorn per feeder for 10, 25 and 50 m feeder spacing. (Numbers in parenthesis are sample sizes.)

opposite the stations on the east side of the Canadian. The pronghorn remained within approximately 3 km of the station until the cessation of the experiment. After feeder retrieval, pronghorn immediately abandoned the site and once again dispersed throughout the Canadian River winter range.

DISCUSSION

PHASE 1 - FEEDING TRIALS

Results of feeding trials showed that a nutritionally complete, digestively safe ration could be formulated for pronghorn. Since animals showed no significant changes in weight and no symptoms of digestive distress, we believe either ration suitable for pronghorn.

Ration 2 was consumed in greater quantities than Ration 1, but we believe that higher consumption was due to the greater fiber content of Ration 2. We do not interpret these data to indicate preference of Ration 2 over Ration 1.

Since winter feeding would be employed at those times when pronghorn would be most severely nutritionally stressed, the more digestible ration would be more immediately valuable to pronghorn. While either feed could be used, we believe that Ration 1 (Table 1) would be the better emergency ration for pronghorn since it would be digested more rapidly.

PHASE 2 - FIELD TRIALS

In spite of the mild winter conditions in North Park during January and February 1983, we were completely successful in enticing pronghorn to feed at our stations. This winter offered less than optimal conditions for testing our system, yet we are completely confident that pronghorn will respond to well designed feeding programs.

We were unable to discern any preference by pronghorn for our prototype feeders. Animals fed equally at both types, however tire feeders may offer access to more animals per unit time and may be preferred by mature males since their horns do not interfere with access to feed. The lack of snow did not allow us to test snow shedding capabilities of either feeder; we hope to test this system's adequacy in snow in future work. We were also unable to demonstrate any pronghorn preference for olfactory attractants.

Our data on agonistic encounters among pronghorn is very preliminary, but some general trends can be noted and used to design future studies. In general, it appears that rates of agonistic encounters increase with number of pronghorn up to a maximum number of pronghorn. Additionally, the 25 m spacing between feeders appears to be optimal for reducing agonism and increasing length of time spent feeding. At 10 m the feeders are probably so close that pronghorn are too crowded to feed efficiently. The 50 m spacing also appears to concentrate pronghorn around an individual feeder while an adjacent feeder remains unnoticed.

Evidently, pronghorn used visual clues to investigate feeders since they did not use feeders until cut sagebrush was used to conceal feeders. These visual clues were not overridden by the olfactory stimulation of attractants, therefore, further work is needed to elucidate the roles of visual and

olfactory stimuli in enticing pronghorn to feed from man-made structures. The observation of pronghorn abandonment of the study area after feeder removal raises many questions for both pronghorn researchers and managers. If, as we postulate, pronghorn visually "key" on the feeders, then it may be possible to manipulate pronghorn distribution on winter ranges by simply moving feeders to desired sites. However, pronghorn would have to first imprint on feeders before their distribution could be modified.

An obvious concern to pronghorn biologists, after reviewing our work, is the time lag required for pronghorn to begin feeding from our stations. We believe this time lag can be attributed to the abundance of forage during our trials. In Colorado, as in neighboring states, the 1983-84 winter was characterized by unusually low temperatures and heavy snowfall. The Colorado Division of Wildlife initiated pronghorn feeding programs in 3 areas; southeast of Greeley, North Park and near Craig (T. Pojar pers. comm.). A pelleted ration was spread on scattered alfalfa hay. Within 2-3 days pronghorn began consuming this ration at Greeley and North Park. However, pronghorn were not successfully fed at the Craig site. We believe that the time lag observed in our study was an artifact of the mild 1982-83 winter, since this lag was not observed with 2 of the feeding operations conducted by the Colorado Division of Wildlife during 1983-84.

Based on our research results and information obtained from the Colorado Division of Wildlife, our opinion is that pronghorn can be successfully fed. Obviously, much more data are needed to evaluate delivery systems, locations, duration of supplemental feeding, etc. We also believe that any pronghorn feeding program should be researched and prepared in advance taking into consideration the biological, financial and political constraints.

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COMMENTS AND QUESTIONS

QUESTION - What was the cost of the feeding operation?

TORBIT - We figured it was less than 30 cents per animal per day, based on the consumption rates we observed.

QUESTION - What happended to the animals at the Craig site; did they move on or die?

TORBIT - They died.

QUESTION - As a rule of thumb, how many pounds of ration per day were required?

TORBIT - Based on the consumption rates in the feeding trials, we estimated a pound per day per animal was sufficient for their needs. Hopefully there would also be some native vegetation available the pronghorns could use.

QUESTION - Are the ingredients in the ration readily available?

TORBIT - Yes. The ration is commercially available from feed mills in the Ft. Collins area.

QUESTION - Have you been able to evaluate the system in terms of reducing winter mortality?

TORBIT - No. There's an evaluation team going around the state looking at feeding programs but they're mostly interested in deer and elk.

QUESTION - How was your study funded?

TORBIT - Rocky Mountain Energy provided funds for the research and Colorado Division of Wildlife provided a lot of logistical support.

QUESTION - Do you feel it would be desirable to provide a water source with the feeders?

TORBIT - I don't feel that an open water source is necessary during cold winters as long as they have something to eat.

RUMEN OVERLOAD AND POLIOENCEPHALOMALACIA: DISEASES ASSOCIATED WITH CONSUMPTION OF GRAIN BY PRONGHORNS

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ABSTRACT

Cases of rumen overload and polioencephalomalacia are described in pronghorns (Antilocapra americana) from Saskatchewan. Both diseases are associated with carbohydrate rich (grain) diets and may result from deranged rumen microflora. The occurrence of the diseases is discussed in relation to the use of cropland by pronghorns.

INTRODUCTION

The pronghorn is an animal of the prairie grasslands of western North America. Much of its historic range has been modified and residual areas of native grassland are often interspersed with cropland. Although pronghorns utilize cropland to some extent, there is little information on the use of agriculture crops other than alfalfa and winter wheat (Cole 1956, Cole and Wilkins 1958). We find cereal grains commonly in the rumen of pronghorns examined in Saskatchewan and have observed 2 disease conditions that are associated in other ruminants with carbohydrate-rich grain diets.

Rumen overload (RO) is a metabolic disease that occurs when ruminants consume a large quantity of readily fermented carbohydrate. The disease is common in livestock (Blood et al. 1979) and also occurs in deer (Wobeser and Runge 1975). Following ingestion of suitable carbohydrates there is rapid proliferation of certain microorganisms in the rumen with fermentation and production of lactic acid. The acidity kills other microflora in the rumen, causes rumen stasis, increases osmolarity of the rumen fluid so that water is drawn from the blood and other tissues into the rumen causing dehydration, and damages the rumen wall allowing bacteria and fungi to invade. If sufficient acid is absorbed from the rumen to overcome the body's buffering system the animal will become acidotic, blood pressure falls, kidney function ceases and the animal may die of shock. Animals that survive the acute stage may die several days later of fungal infection of the damaged rumen wall.

Polioencephalomalacia (PEM) is a degenerative disease of the brain of domestic and wild ruminants. The pathogenesis of the disease is not understood completely, but appears to be related to a deficiency of vitamin B_1, thiamine. Thiamine is normally produced in the rumen, but enzymes (thiaminases) that inactivate or destroy thiamine have also been found in the rumen of some animals. Animals changed from a low to a high concentrate diet have high levels of thiaminase and low levels of thiamine in their rumen (Brent 1976, Sapienza 1981) and it is thought this is caused by proliferation of certain bacteria that produce thiaminases. Thiamine is essential for enzymes involved in intermediate metabolism. The brain has a very high demand for energy, and it is thought that a deficiency in carbohydrate metabolism results in the changes seen in PEM, which translates literally to softening of the grey matter of the brain.

Funding for this and other studies of disease in Saskatchewan wildlife has been provided by the Department of Parks and Renewable Resources. Staff of the Department are also thanked for their help.

METHODS

The pronghorns reported here were found sick or dead in southwestern Saskatchewan between 1970 and 1984. They were submitted for necropsy to the Western College of Veterinary Medicine by personnel of the Department of Parks and Renewable Resources. A necropsy was performed in each case and ancillary techniques (microbiology, histopathology, toxicology, etc.) were used as appropriate.

RESULTS

RUMEN OVERLOAD

During the 14 year period 3 instances involving RO or rumenitis (inflammation of the rumen) have been investigated. The first of these occurred during the severe winter of 1973-74 and involved a herd of pronghorns near Corval. This herd had contained 30-40 animals earlier in the winter, but when a problem was reported in mid-January only 23 animals were present. On January 14 the herd was seen eating at a pile of wheat stored on the ground the previous autumn by the landowner. There was deep snow in the area (up to 80 cm) and little other food was available. On January 15 a freshly dead adult female, and a female kid that was unable to stand, were found near the grain pile. The farmer was advised to fence the pile. The area was searched on January 17 and 4 additional animals were found dead within a kilometer of the pile. Two of these had been scavenged and were not submitted. The 4 animals submitted (2 from each of January 15 and 17) were in good body condition with abundant fat. The adult doe from January 15, and an adult male from January 17, had bite wounds on the neck and throat, but no other signs of predation. The other 2 animals were kids and had no wounds. In all animals the skin was tightly adherent, the underlying tissues were dry and the blood was dark and "tarry", suggesting dehydration. One kid had free blood clots in the trachea, and the doe had hemorrhage in the wall of the abomasum. The rumen content in all consisted of wheat, wheat chaff, a small amount of straw, and fluid. The pH varied between 5 and 6. The rumen mucosa was tightly adherent, particularly in the ventral sac. The abomasum contained undigested wheat, the intestines contained bile-stained fluid with kernels of wheat throughout the intestine in 2 animals. Microscopically, the rumen epithelium was parakeratotic with vacuolar degeneration and separation of the superficial layers. The diagnosis made was acute RO, with 2 of the animals having been killed by an unknown predator. The lack of lesions other than on the neck suggested that these animals may have been down when attacked.

In March, 1982, 11 pronghorn carcasses were submitted from near the town of Lawson. The herd from which these came had been provided alfalfa hay for approximately 3 weeks because of deep snow in the area. Some animals had entered the town and were observed eating spilled wheat about a grain elevator. Five of the animals had been struck by a train; most of the remainder appeared to have died of starvation, although the cause of death could not be determined with certainty as some carcasses were incomplete. One

2-year old doe was found dead in an abandoned building. She was emaciated and the femur marrow contained only 6.1% residue after oven drying (Hunt 1979). Two partially mummified fetuses were in the uterus. The rumen contained alfalfa hay and several nails and bits of wire. The mucosa was tightly adherent and microscopically there was severe vacuolation and inflammation of the mucosa. The diagnosis was emaciation and subacute rumenitis. The "hardware" was thought to have been picked up while eating spilled grain from the ground.

In January 1979, a yearling male pronghorn that was part of a herd of 37 near Cabri was observed to be "shivering" by a farmer. The animal was found dead the next day. At necropsy the animal was in fair body condition. The perineal region was pasted with feces indicating the animal had diarrhea. A portion of the serosal surface of the ventral sac of the rumen and the serosa of the reticulum were hemorrhagic. The mucosa in these areas was dark red-black and firmly adherent. The rumen contained a small amount of wheat and fluid, the intestines contained only fluid. Microscopically, the affected areas of the rumen and reticulum were hemorrhagic and necrotic with many fungal hyphae invading both the wall and arteries. Many of the vessels in the wall were thrombosed. A diagnosis of necrotizing mycotic rumenitis, probably as a sequel to earlier RO, was made.

POLIOENCEPHALOMALACIA

We have described 4 cases of a PEM-like disease in pronghorns previously (Wobeser et al. 1983); since that publication we have examined 3 additional animals with similar lesions. Six of the 7 pronghorns had signs of nervous system derangement prior to their death, the other animal was found dead. Two could stand, but staggered, fell and got up repeatedly; the other 4 were unable to stand, lay in lateral recumbency and threshed or paddled with their legs. Four of the animals were adult females, the others were kids (a male, a female and 1 animal whose sex was not recorded). Two animals were found in each of January and September, 1 was found in each of December, February and March. The animals were in fair to excellent body condition and only one had grossly visible lesions in tissues other than the brain. That animal was found down and paddling in a stubble field. It was part of a herd of 20-25 animals that had fed in the field throughout the winter. At necropsy, there was extensive hemorrhage under the skin and in the muscles of the back, and a lumbar vertebral body was fractured. It appeared that the animal had been struck by a vehicle on a nearby road and dragged itself into the field. However, the brain had focal symmetrical areas of hemorrhage and necrosis in the thalamus as seen in pronghorns with PEM (Wobeser et al. 1983) and the animal may have had nervous disease at the time it was struck.

Four of the other pronghorns had grossly visible lesions in the brain consisting of varying degrees of brain swelling and herniation, focal symmetrical hemorrhage in the thalamus and brainstem, and malacia (softening) of the grey matter of the cerebral cortex. The other 2 animals did not have gross lesions, but there were microscopic changes in the thalamus and cerebral cortex. Wheat was present in the rumen of 6 of the animals; the rumen of the seventh animal contained only a small amount of fluid and material suggestive of winter wheat.

DISCUSSION

The lesions in pronghorns are similar to those in domestic ruminants and deer with PEM and RO (Thomson 1967, Jubb and Kennedy 1970, Wobeser and Runge 1975, 1979). Because the changes may be subtle, the diseases could be overlooked without careful attention to the brain and rumen during necropsy. Rumen pH is useful for diagnosing RO in the living animal (Thomson 1967), but the usefulness of pH measurement of rumen content in animals that have been dead for some time and which have been frozen is unknown. Animals with these diseases may be killed by other agents such as predators or vehicles, indicating the need for a thorough necropsy.

Both of the conditions are associated with diets rich in carbohydrates and seem to result from deranged rumen microflora. The amount of grain required to produce acute RO is influenced by several factors including the type of grain, the body condition, and prior diet of the animal. In sheep and cattle the toxic dose may range from 25-80 g of ground grain/kg body weight (Blood et al. 1979). The rumen content of 1 of the pronghorns from Corval was dried, weighed and found to contain 3.06 kg of wheat. This represented 54.6 g of grain/kg of body weight. Rumen overload is only likely to occur when animals eat a large volume of grain, perhaps when other food is made unavailable by deep snow. The 3 cases we have seen appear to represent different stages of the disease: acute RO with death related to systemic effects of acidosis; subacute rumenitis that may have followed consumption of grain; and secondary fungal infection of the rumen wall.

Polioencephalomalacia is often associated with a change to a more concentrated diet in domestic animals, or with other factors that alter the rumen microflora (Haven et al. 1983). The cases that we have seen in pronghorns suggest that the disease occurs sporadically among individuals within herds feeding in cropland. The recognition of 7 cases in the past 5 years indicates that PEM may not be a rare disease of pronghorns in Saskatchewan.

Unfortunately, we have not recorded the type of food present in the rumen of all of the pronghorns examined in our laboratory; however, information was available for 62 animals necropsied during September-March between 1970 and 1984. This information was based on visual examination of the rumen content at the time of necropsy. Grain was present in 33 (53%) of the animals, with the grain being wheat in 31 cases, and barley and mustard or rape (Brassica sp.) in 1 each. This frequency of occurrence of grain is probably not indicative of the diet of pronghorns throughout the province (Dirschl 1963), because most of the animals submitted for necropsy came from marginal areas of pronghorn range where cropland is prevalent, but it does indicate that many pronghorns in the province utilize cereal grains.

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COMMENTS AND QUESTIONS

QUESTION - How much time does it take for the polio symptoms to appear?

WOBESER - We don't know. The sick pronghorns are brought to us in the lab but we don't have any information on when the symptoms first appeared, or when they consumed the grain.

QUESTION - Have you seen any problems with pronghorns that consume the vegetative (green foliage) portion of the grain?

WOBESER - We haven't seen either of these problems in pronghorns eating the green parts of winter wheat.

AN INTERAGENCY APPROACH TO EVALUATING PRONGHORN TRANSPLANT SITES IN MONO COUNTY, CALIFORNIA

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ABSTRACT

An interagency team involving 9 wildlife biologists evaluated 5 sites for pronghorn transplant feasibility in Mono County, California.

Objectives for a pronghorn release were developed by the team. Habitat evaluation criteria were developed from these objectives and used as a basis for comparing sites. Consequences of a release in each of these sites were evaluated in terms of impacts on pronghorn.

A habitat suitability rating developed by Yoakum (1980) was used to evaluate habitat quality. Other criteria considered important were: snow depth, presence of natural physical barriers, area size, fence type, predation potential, depredation potential on agricultural crops, potential for competition with other herbivores and the potential of a release area to function as a complete biological unit.

The site with the highest transplant potential was subjected to 2 further alternatives: 1) recommend for transplant or 2) delay action until certain criteria were met. The alternative that best provided for pronghorn requirements was recommended.

The approach used for evaluating these sites may have applicability in assessing other potential release sites. Relocations of pronghorn, or any other wildlife species should be preceded by an evaluation which analyzes the suitability of habitats for introductions. Implementing this evaluation approach is useful for establishing transplant site priorities and providing insight into the feasiblity of transplants.

INTRODUCTION

In historic times, there were an estimated 40 to 60 million pronghorns (Yoakum 1980). By 1924, the population had declined to 24,000 due to heavy resource exploitation (Nelson 1925). Conservation efforts since the early 1900's have resulted in a present day pronghorn population of 750,000. A major reason for the re-establishment of pronghorns on historic ranges is the translocation of animals from core populations to adjacent areas with suitable habitat (Yoakum 1980).

The evaluation of release sites should be an important phase in transplant endeavors, due to cost, decreasing availability of suitable historic habitats, and the need to recognize possible conflicts with other resource uses.

Transplant evaluations should: 1) determine the feasibility of introducing pronghorns to transplant sites and 2) prioritize sites on the basis of areas which have the highest likelihood of resulting in a successful transplant. Haphazard evaluations will result in the inability to predict the outcome of a transplant and may end in a transplant failure.

Although several authors have dealt with pronghorn habitat requirements (Kindschy et. al. 1982, Salwasser 1980, Yoakum 1980 and Autenrieth 1978), there are a lack of specific transplant evaluation methods. In 1981, an interagency team developed an evaluation method for assessing transplant sites in Mono County, California which shows promise for use in other areas. This team was comprised of 9 wildlife biologists from 5 different agencies. Using an interagency team in the evaluation process provided greater familiarity with the areas, availability of different types of expertise, the ability to assess several areas at one time, and greater support when a conclusion was derived.

The interagency team developed 3 major objectives for evaluating potential transplant sites:

1) Manage for a pronghorn herd in and adjacent to a release site with a goal of 200 animals.
2) Provide a sustained pronghorn population which would increase wildlife aesthetic and harvest values.
3) Maintain and enhance ecological conditions in and adjacent to a release site to provide for pronghorn habitat requirements.

In light of the objectives, 4 questions were framed relative to the feasibility of a pronghorn transplant. These were:

1) Should pronghorns be transplanted into Mono County?
2) If pronghorns are transplanted, where should they be released?
3) What habitat improvements are required prior to a release?
4) What habitat improvements are required following a release?

The remainder of the analysis was directed by the objectives and feasibility questions.

The authors wish to thank the following individuals for assisting in the implementation of this evaluation method: J. Capodice, D. Delaney, W. Harvey, R. Hubbell, V. Koontz, F. Smith and R. Thomas.

METHODS

Five sites in southern Mono County, California were evaluated for pronghorn transplant feasibility in the spring and summer of 1981 (Figure 1). These sites were located 250 km (155 miles) south of Reno, Nevada and 50 km (30 miles) north of Bishop, California (37°50'N, 118°30'W). All sites except one, Hammil Valley, were Great Basin sagebrush (Artemisia tridentata) communities. Hammil Valley was considered a high desert shrub community.

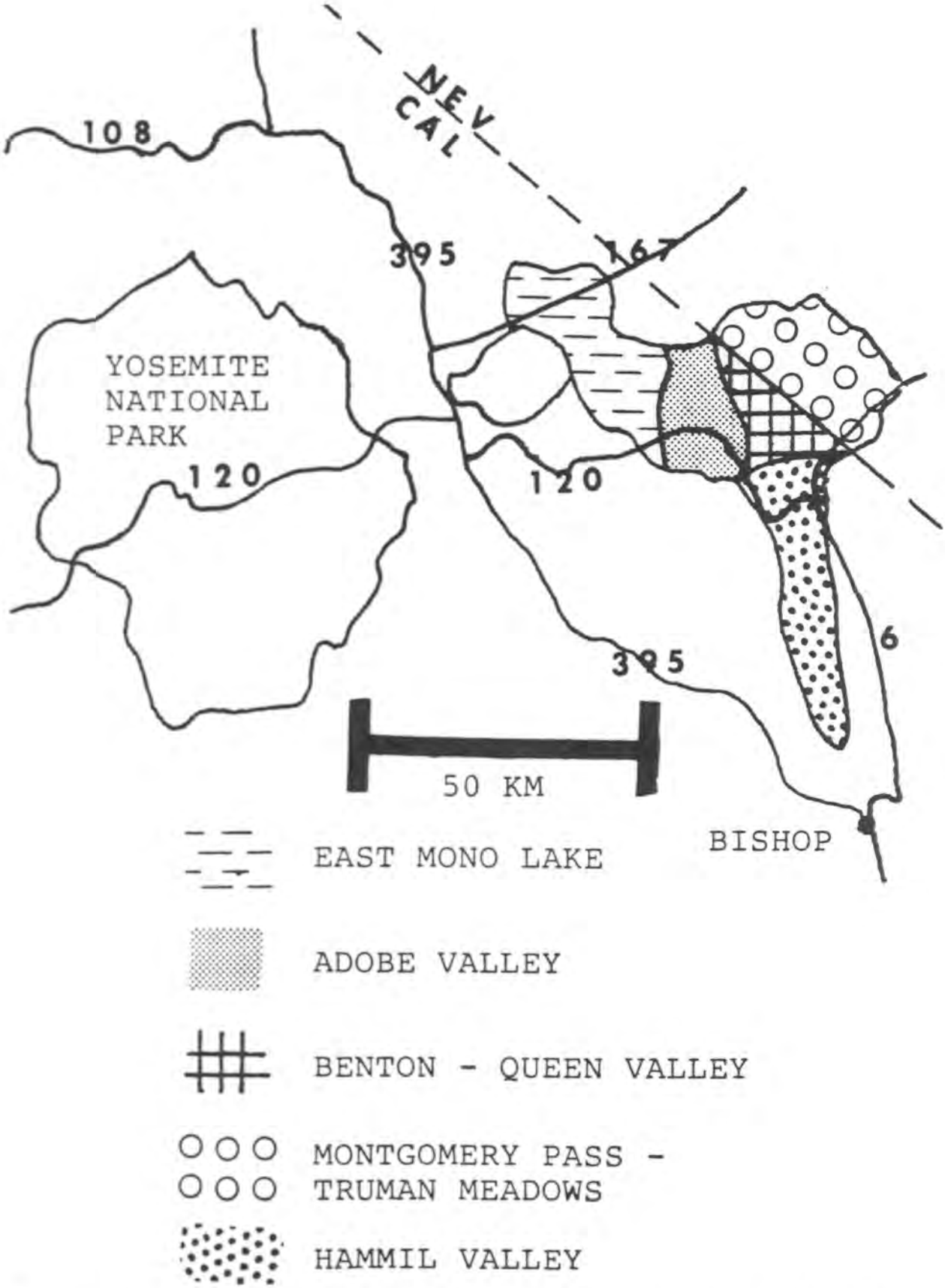

Figure 1. Five potential transplant sites evaluated for pronghorn in Mono County, California.

Nine criteria were assessed for each site. These were: 1) habitat suitability, 2) mean snow depth, 3) natural physical barriers, 4) size of area, 5) fences 6) predation potential, 7) depredation potential, 8) seasonal suitability and 9) herbivore competition potential. For purposes of this evaluation, parameters for each criteria were taken from Salwasser (1980), Yoakum (1980), Autenrieth (1978), Yoakum (1978), Schwartz et al. (1977), Yoakum (1974), Beale and Smith (1970), Olsen and Hansen (1970) and Severson et al. (1968).

Habitat suitability was divided into 4 criteria. These were water distribution, forage quality, forage quantity, and vegetation height. Yoakum (1980) developed a system which numerically rates these criteria. Ratings were determined for each of the criteria, added, and a resulting habitat suitablity score, between 0 and 100, was assigned to each site. Water availability was considered optimum if water sources were less than 3.2 km (2 miles) and unsuitable if greater than 8.0 km (5 miles) apart. Forage quality was considered optimum if forbs comprised 10-30% ground cover, grasses comprised 20-50% and shrubs comprised 10-30%. Forage quantity was considered optimum if forage production exceeded 455 kg (1,000 pounds) per acre. Vegetation height was considered optimum between 25 cm (10 inches) and 64 cm (25 inches) and unsuitable if greater than 64 cm (25 inches) or less than 13 cm (5 inches). Vegetation data for these criteria were based on Soil Conservation Service, Forest Service and Bureau of Land Management vegetation surveys. Water distribution data were compiled using aerial photos, 7.5 minute USGS quad maps, and field reconnaissance.

Mean winter snow depths were interpolated using data from weather stations nearest to the sites being evaluated. Areas were considered suitable for winter use if snow depths were less than 25 cm (10 inches).

Natural physical barriers were evaluated to determine potential for restriction to pronghorn movements. Major physical barriers include large rivers, mountain ranges, and dense timbered areas.

Area size was determined by using a polar planimeter and 7.5 minute USGS quad maps. Optimum area size was considered 256 km^2 (100 mi^2).

Fences were evaluated in relation to pronghorn passability. A fence was considered passable if the bottom wire was at least 41 cm (16 in) from the ground.

Predation potential was subjectively rated in terms of high, moderate or low. Predator abundance information was obtained from various agency personnel, ranchers, and individuals familiar with the sites.

Depredation potential was evaluated on the basis of agricultural crop location in relationship to each site. Distances were determined from each site to the nearest alfalfa field, and a depredation potential rating of high, moderate, or low assigned to each area.

Seasonal suitability of a site was evaluated on the basis of whether or not an area could support pronghorn on a year round basis.

Potential for competition with domestic livestock was evaluated on the basis of class of livestock, animal unit months, and grazing systems. Each

site was rated as having high, moderate, or low potential for livestock/pronghorn conflicts.

Following the evaluation of each site, limiting factors were addressed on the basis of the aforementioned criteria. The sites were compared against each other and prioritized in terms of the site(s) which had the greatest potential for a successful pronghorn transplant.

RESULTS

Adobe Valley is selected as an example of how each site was evaluated. Five major vegetation communities were delineated in Adobe Valley. These include: 1) Basin sagebrush/Douglas rabbitbrush (Chrysothamnus viscidiflorus), which is endemic, 2) Basin sagebrush/Indian ricegrass (Oryzopsis hymenoides), a mid-successional plant community resulting from herbicide spraying, 3) Indian ricegrass/Basin sagebrush, an early successional plant community resulting from herbicide spraying, 4) gray rabbitbrush (Chrysothamnus nauseosus)/saltgrass (Distichlis spicata), a meadow to upland shrub ecotone and 5) salt grass/sedge (Carex spp.) meadows dominating riparian areas.

Table 1 summarizes the habitat suitability ratings for Adobe Valley. Each vegetation community was rated separately and the averages weighted to obtain the final score. Water was abundant, mainly in the form of water developments for livestock. These needed modification to accommodate pronghorn use. Forbs were poorly represented in all vegetation types. This was considered a major limiting factor for pronghorn use in Adobe Valley. In general, composition of grasses and shrubs in Adobe Valley were not considered limiting. All vegetation types show low herbaceous vegetation productivity. Seeded areas, comprised mainly of graminoids, had the highest herbaceous forage production, varying from 227 kg (500 pounds) to 455 kg (1,000 pounds) per acre. Vegetation height was another major limiting factor. On 59% of the area, vegetation height was greater than 64 cm (25 in) in height, and not conducive to pronghorn use.

Mean winter snow depths were 25 cm (10 in). Snow depth was not considered a limiting factor.

Natural physical barriers affecting pronghorn mobility were not present within Adobe Valley. Adobe Valley is ringed by several mountainous areas containing dense single-leaf pinyon (Pinus monophylla) and western juniper (Juniperus occidentalis). These areas were considered barriers to pronghorn. However, there were areas which allowed pronghorn emigration from Adobe Valley.

Adobe Valley is 153 km^2 (60 mi^2). The small size of the area was considered limiting in terms of pronghorn home range movements.

Fences were another major limiting factor. There was .34 km per km^2 (.54 mi per mi^2) of fence. All fences were considered a barrier to pronghorn movements.

Predation potential was estimated as moderate.

Table 1. Habitat suitability rating for Adobe Valley by vegetation type.[1]

Type[2]	Water	Vegetation Quality Forb	Vegetation Quality Grass	Vegetation Quality Shrub	Vegetation Quantity	Vegetation Height	Total Rating
Artr/Orhy	10	1	17	5	5	0	38
Orhy/Artr	10	1	16	5	5	5	42
Artr/Chvi	10	1	2	5	3	0	21
Disp/CAR	10	1	10	10	2	7	40
Dist/Chna	10	1	16	5	2	8	42
Total	10	1	14	5	3	5	38

1 Ratings are based on data applied to Yoakum's (1980) habitat criteria and rating procedure for pronghorn habitats.

2 Vegetation Symbols

Artr *Artemisia tridentata* - big sagebrush

Orhy *Oryzopsis hymenoides* - Indian ricegrass

Chvi *Chrysothamnus viscidiflorus* - green rabbitbrush

CAR *Carex spp.* - sedge

Disp *Distichlis spicata stricta* - saltgrass

Chna *Chrysothamnus nauseosus* - gray rabbitbrush

Depredation potential was estimated as low. The nearest agricultural croplands were in the Benton-Queen Valley area, located 8 km (5 miles) southeast.

Adobe Valley was considered a complete biological unit. Based on mean winter snow depths and vegetation availability, the area was considered suitable for pronghorns for all seasons.

Adobe Valley is grazed by cattle (1,686 AUM's) and sheep (556 AUM's) during summer. One rest-rotation grazing system was implemented while the remaining areas were grazed season long. If livestock management was not integrated with pronghorn habitat requirements, then grazing could be a limiting factor on pronghorn establishment. Potential for competition with herbivores was considered moderate.

Table 2 provides a comparison of the 5 sites using the 9 evaluation criteria. Adobe Valley had the highest habitat suitability rating and was considered the best site for a pronghorn transplant. Even though Adobe Valley ranked more favorably than the other sites, the interagency team identified several factors which would limit the possibility of a successful transplant. These included:

1) a low habitat suitability rating. The combination of poor forb representation, poor vegetation quantity, and unsuitable vegetation height on much of the area resulted in conditions generally not conducive to pronghorn use.
2) fences were a barrier to pronghorn movements.
3) water sources needed to be modified to accomodate for pronghorn utilization.

Based primarily on these factors, the interagency team recommended that a transplant be postponed until the following conditions were met:

1) Modify all fences to provide pronghorn passage.
2) Modify all livestock watering sources to accomodate use by pronghorn.
3) Develop and implement a large scale vegetation improvement project to enhance forage quantity and quality.
4) Modify livestock grazing systems to manage for forb species important to pronghorn.
5) Develop a long term pronghorn herd management plan.
6) Initiate monitoring studies to determine pronghorn movements and success of the transplant program.

Instead of following the interagency recommendations, a decision was made to translocate pronghorns into Adobe Valley. Fences were modified to permit pronghorn passage and some water sources were modified to accomodate for pronghorn use. None of the other recommendations were followed.

In March 1983, 43 pronghorns were translocated to Adobe Valley. These were animals causing depredation problems in northern California. Currently (April 1984), 6 of these animals remain at the release site. These pronghorn use Adobe Valley in the summer and Hammil Valley in the winter. The remaining pronghorns dispersed out of Adobe Valley (Goldsmith pers. comm.). There has been no fawn recruitment into the adult population from the remaining animals (Goldsmith pers. comm.).

Table 2. Comparison of 5 transplant sites using 9 evaluation criteria [1]

Criteria	East Mono Lake	Adobe Valley	Benton - Queen Valley	Montgomery Pass- Truman Meadows	Hammil Valley
Habitat Suitablity Rating	13	38	11	26	14
Mean Snow Depth cm(in)	30(12)	25(10)	0(0)	30(12)	0(0)
Physical 1 Barriers	low	low	low	moderate	low
Release Area Size $km^2(mi^2)$	289(113)	154(60)	120(47)	276(108)	141(55)
Fences km/km^2 (mi/mi^2)	.13(.21)	.34(.54)	.12(.19)	0(0)	.02(.03)
Predation[1] Anticipated	moderate	moderate	moderate	moderate	moderate
Depredation[1] Anticipated	low	low	high	low	high
Complete Biological Unit	no	yes	yes	no	yes
Competition[1] with Herbivores	low	moderate	low	high	low

[1] Evaluated subjectively in terms of high, moderate, and low potential.

The results of this transplant indicate the habitat was marginal as determined by the interagency team's evaluation system. The outcome of the transplant if the interagency recommendations were followed, is open to speculation. However, overall habitat suitability would have been higher and thus more conducive to pronghorn establishment and fawn recruitment in Adobe Valley.

CONCLUSIONS

As an aid for future pronghorn translocations, the following management guides are recommended:

Transplant sites must be evaluated for habitat suitability prior to release of animals. Sites considered feasible should have a habitat suitability rating of good or better, and meet the other criteria discussed in this paper. Areas which do not meet these specifications should not be considered feasible, or they should be improved to meet these criteria prior to a pronghorn release.

Multiple transplant sites need to be prioritized on the basis of those areas having the highest biological potential for success. Ideally, this should be done on a statewide or regional level, thereby assuring transplants are accomplished on high quality sites.

Criteria discussed in this paper need to be fine tuned for other biomes. Ratings for vegetation derived in Yoakum (1980) were adapted for sagebrush/grasslands in the Great Basin, and should be modified to reflect conditions in other vegetation regions.

Transplants should include monitoring studies to determine the success of the translocation. This is a valuable step in developing and modifying transplant guidelines and to insuring accountability in transplant endeavors.

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COMMENTS AND QUESTIONS

QUESTION - What type of grazing management was being practiced in Adobe Valley and what did you recommend?

McCARTHY - It was under a rest-rotation system, primarily cattle grazing. My big push was for more deferred rotation systems to get more forb production.

EXPLORATION, DISPERSAL AND HOME RANGE ESTABLISHMENT OF PRONGHORN FOLLOWING RELOCATION

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ABSTRACT

The purpose of this study was to understand how pronghorn (Antilocapra americana) adapt after relocation and to evaluate the reasons for success or failure of the transplant. The behavior and ecology of 43 pronghorn were studied after relocation from an agricultural region of northern California to a sagebrush-grassland in eastern California. Pronghorn were located by radio-telemetry and scanning with binoculars or a spotting scope. They were observed 4-5 times each week after release, during spring, summer and fall of 1982 and 1983, and occasionally during 2 winters. Two years after release 6 pronghorn remained in the transplant area, 7 were known mortalities, 8 emigrated to another established population, 1 was nomadic and the fate of the remaining 21 animals was unknown. After release, pronghorn dispersed in all directions but mainly northwest in the direction of their pre-transplant range. Some made long exploratory movements (up to 80 km) then returned to the release site. Animals traveled in groups as large as 13 and as solitary individuals; roads were used as travel routes. Five months after the transplant, 5 adult females and 1 2-year-old male remained in the study area. They established their home range during the first year and selected the same habitats during the second year. Their summer and fall ranges were in the valley where they were released. In winter and spring they moved to a lower elevation area that had been explored by one of the does during the first month after release. Although fawns were born in both years, none survived past 2 months. A viable population has not been established by this relocation. Management implications are discussed.

COMMENTS AND QUESTIONS

QUESTION - Do you know if breeding occurred and fawns were dropped?

GOLDSMITH - Yes, they bred both years and fawns were born. Most of them died by two months of age.

QUESTION - What were the ages of the animals that were transplanted?

GOLDSMITH - Various. There was a wide variety of older to young animals.

QUESTION - Does the failure of the transplant relate to habitat or to behavior?

GOLDSMITH - I think it may be an interaction of behavior and habitat. It may be a failure of the animals to adapt to a different habitat.

QUESTION - Do you have any knowledge at all of the reasons for the fawn losses?

GOLDSMITH - I don't have any direct evidence of predation-nutrition factors but I'm going to be looking at some indirect evidence during the next year.

Coyotes were present on the area and there's no reason to believe they didn't take some fawns, but I also observed some behavior of fawns that might have indicated problems other than predation.

QUESTION - Could water have been a problem?

GOLDSMITH - Water may have been a problem. There was good potential for water but it would be turned on and off at random.

EVALUATION OF TEXAS ANTELOPE TRANSPLANTS

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ABSTRACT

Texas pronghorn antelope (Antilocapra americana) suffered significant population declines during the period 1880 to 1925. In 1924, it was estimated that only 2,407 pronghorns remained from a statewide population once estimated at several million head. Small isolated antelope herds set the basis for a restoration program initiated in 1939. From 1939 to 1982, 5,658 pronghorns were trapped and transplanted to previously inspected sites within the historic range of antelope in Texas. Several limiting factors that have prevented pronghorn antelope from reaching their full potential in Texas are discussed.

HISTORICAL BACKGROUND

The historic range of pronghorn antelope in Texas was established by Bailey (1905) who reported that in 1900 antelope occurred as far east as Henrietta in northern Texas, Rocksprings in the southwestern part of the State, and Alice in the southern part. This information was apparently used by Nelson (1925) in establishing the former range of antelope as being west of the 97th meridian. Buechner (1950) concluded that pronghorns were extremely abundant in the Trans-Pecos prior to 1880 and occurred in smaller numbers in other parts of the State. Leftwich and Simpson (1977) felt that pre-settlement (pre-1880) pronghorn populations were higher in the Panhandle and Permian Basin regions than in the Trans-Pecos.

The settling of West Texas during the late 1800's resulted in a significant decline in the antelope population. This decrease was noted by Mearns (1907) who described antelope as being rare in the southwestern United States by 1890 in areas where they had occurred by the thousands 25 years previously. Excessive hunting was the primary reason responsible for the initial decline in pronghorn numbers during this period (Buechner 1950). Overgrazing by domestic livestock and net wire fences further increased the decline in pronghorn numbers during this period and in following years. The antelope population was considered at a very low point when the first comprehensive census was conducted in 1924 (Nelson 1925). A total of 2,407 pronghorns was recorded for the State. Buechner (1950) noted that a few ranchers had protected antelope from an early date resulting in scattered isolated populations. From this nucleus, pronghorn numbers gradually began to increase. Based on game warden reports, the population in the Trans-Pecos had reached 3,888 antelope by 1938 (Fisher 1938). In 1941, Fisher (1941) determined by aerial survey that a minimum of 4,742 antelope occurred in the region.

EARLY TRANSPLANTS

Trapping and transplanting pronghorn antelope in Texas was initiated in 1939 with an objective of statewide restoration of the species to suitable

habitats within its historic range (Jones 1949, Uzzell 1973). The initial trapping was preceded by a one year period of gathering information pertinent to transplant operations.

The earliest trappings were accomplished by riders on horseback herding antelope through diversion lanes of net wire into a net corral. In 1941, a fixed-wing aircraft was utilized for herding and was found to be more efficient and economical. Eventually, a helicopter was employed for herding pronghorns to the trap.

Initial trapping efforts were aimed at removing antelope from overstocked sheep range due to the incompatibility of these animals as demonstrated by a history of die-offs (Buechner 1950). Trapping efforts were also directed towards antelope populations on enclosed areas where surpluses existed. Transplants were then made to previously inspected and approved sites within the historic range of pronghorns as established by Bailey (1905).

Jones (1949) noted several factors that limited the success of the transplant program and expansion of remnant antelope herds. These factors included coyote (Canis latrans) predation on both fawns and adults, natural and artificial barriers (especially net wire fencing) which restrict natural ranging, competition with livestock (notably sheep), reluctance to occupy adjacent vacant range, oil field development, agricultural development, illegal hunting, brush invasion, severe weather conditions (especially drought), and injury inflicted to antelope during trapping and transplanting operations.

During the period 1939 to 1956, approximately 4,000 antelope were restocked on areas of suitable habitat in West Texas. By 1953, many herds, both native and restocked, had increased to the point that closely regulated hunting was initiated. Hunting season on antelope had previously been closed for fifty years.

RECENT TRANSPLANTS
(1972 - 1982)

An intensive restoration effort was initiated in 1972 when surplus broodstock became available on a large non-hunted ranch located in the lower Rolling Plains. During a 2-year period, 1,105 head of antelope were transplanted to approximately 1.5 million acres of vacant range on 59 ranches in the Trans-Pecos and lower plains (Hailey, 1979). In 1977, 1 release was made involving 25 antelope in the lower plains. During the period 1979-1982, 528 pronghorns were released on 18 separate sites utilizing broodstock from Texas, Wyoming and Colorado.

During this 11-year period (1972 - 1982), a total of 1,658 antelope were released on 78 sites in 29 counties representing 3 geographic regions of western Texas. A total of 714 bucks (43%) and 944 does (57%) was stocked for a sex ratio of 1.3 does per buck. An average of 21.3 antelope was stocked at each site. Sources of pronghorn broodstock for the transplant effort include: Texas - 1,224 (74%); Colorado - 350 (21%); and Wyoming - 84 (5%).

The status of the restocked herds was evaluated at 5 or more years after the stocking. Sixty-six of the 78 sites have been evaluated at this time,

with the evaluation of the remaining 12 sites pending the elapse of 5 years following the release of broodstock.

Presently, 12 (18.2%) of the transplanted herds are rated as successes with sustained population increases. Twenty-three (34.8%) of the herds are rated as undetermined at this time with a decreased number of broodstock still surviving. Failures account for 31 (47%) of the remaining herds with loss of broodstock. It should be noted that at some period, 23 (34.8%) of these transplanted herds were rated as successes which translates to 11 herds being down-graded to either undetermined or failure by 1984.

Two formerly successful herds were lost to illegal hunting. Both herds were on secluded ranches and thought to be well protected. Limited buck hunting had been allowed during the 1978 hunting season. The following year, only 4 does remained on one site and it is reported that few pronghorns remain on the other.

The severe drought during 1983 claimed 6 herds once considered successful in the Trans-Pecos region. Two of the herds experienced a total loss of all antelope.

The remaining 3 herds once considered successful have been rated as undetermined in 1984. It is thought that a combination of illegal hunting and coyote predation may be responsible.

DISCUSSION

Not surprisingly, today's antelope managers face many of the same problems which were found to be limiting factors over 40 years ago. In recent times, predation and oil field development have intensified and may be considered significant limiting factors concerning antelope restoration in Texas (Kothmann 1982).

Loss of antelope habitat to agricultural development may be stabilizing as the cost of farming and irrigation water soars. Chemical and mechanical control of brush has reopened new ranges for pronghorns, but at the cost of reducing habitat for other desired wildlife. Net wire fencing and livestock competition are less serious factors due to the decrease in sheep ranches and the use of improved grazing techniques by better educated ranchers. Illegal hunting, considered by recent investigators (Uzzell 1973, Hailey 1979) to generally be a minor limiting factor, may cause problems in isolated cases. Severe cold weather is not considered a major problem to antelope in Texas; however, periodic droughts often cause high mortality as noted by Hailey (1979). The use of tranquilizers, antibiotics, and improved trailers and loading techniques have combined to significantly lower trapping and transplanting related injuries (Kothmann 1982).

Coyote predation on fawns in the lower Rolling Plains is considered as the most serious limiting factor to antelope restoration in the opinion of this writer. Recent conversations with wildlife district leaders Jack Kilpatric (Trans-Pecos) and David Dvorak (Pannandle) also express the seriousness of coyote predation on young fawns. Hailey (1979) stated that control of the coyote population in the Trans-Pecos will have to be practiced if the full potential of the antelope as a game animal is to be realized. Kothmann (1982)

refers to several years of low fawn survival in the Panhandle when stating that coyote predation is a significant factor limiting fawning success.

Coyote predation on young fawns appears to be most limiting on small numbers of antelope such as transplanted herds. Concerning fawning success, Udy (1953) noted that the coyote can be an important factor retarding the increase in small antelope herds. Evidence of this is indicated by recent transplant records which show that 6 of 11 (55%) antelope releases made on sheep ranches are considered successes. Only 6 of 55 (10.1%) releases made on cattle ranches are now considered successful. Intensive predator control is the rule on most sheep ranches in West Texas while little to no control is exercised on cattle ranches. Though many cattle ranchers recognize the coyote as a serious threat to antelope, few are willing to control coyotes until predation starts occurring on calves.

The antelope restoration program in Texas has faced more failures than successes in terms of numbers and percentages. Encouragement to continue; however, is offered by the once vacant ranges now occupied by productive herds and by the tenacity of many small herds that survive despite the odds.

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COMMENTS AND QUESTIONS

QUESTION - How many animals do you consider necessary to make a successful transplant?

DEL MONTE - Around 40 animals. One thing we've observed on small remnant herds is that around 40 or 50 antelope can hold their own against coyotes. Below that it's critical. On the transplants I've inspected it's hard to find a landowner that doesn't point the finger squarely on the coyote as the major problem.

COMMENT - On many transplants farther north they wouldn't transplant less than 100 antelope. If less than that they wouldn't set up herding patterns and didn't have the behavior for it.

DEL MONTE - We have many herds that have stayed around 50 animals for many years, but if it drops much below that, predation becomes a major factor.

QUESTION - You speak of these 5 km^2 pastures. Are they fenced to the point that animals can't get out? That's a pretty small area.

DEL MONTE - Most of them have net wire fences but that's a minimum area. We try to go to the bigger ranches when we can.

ROSWELL PRONGHORN STUDY

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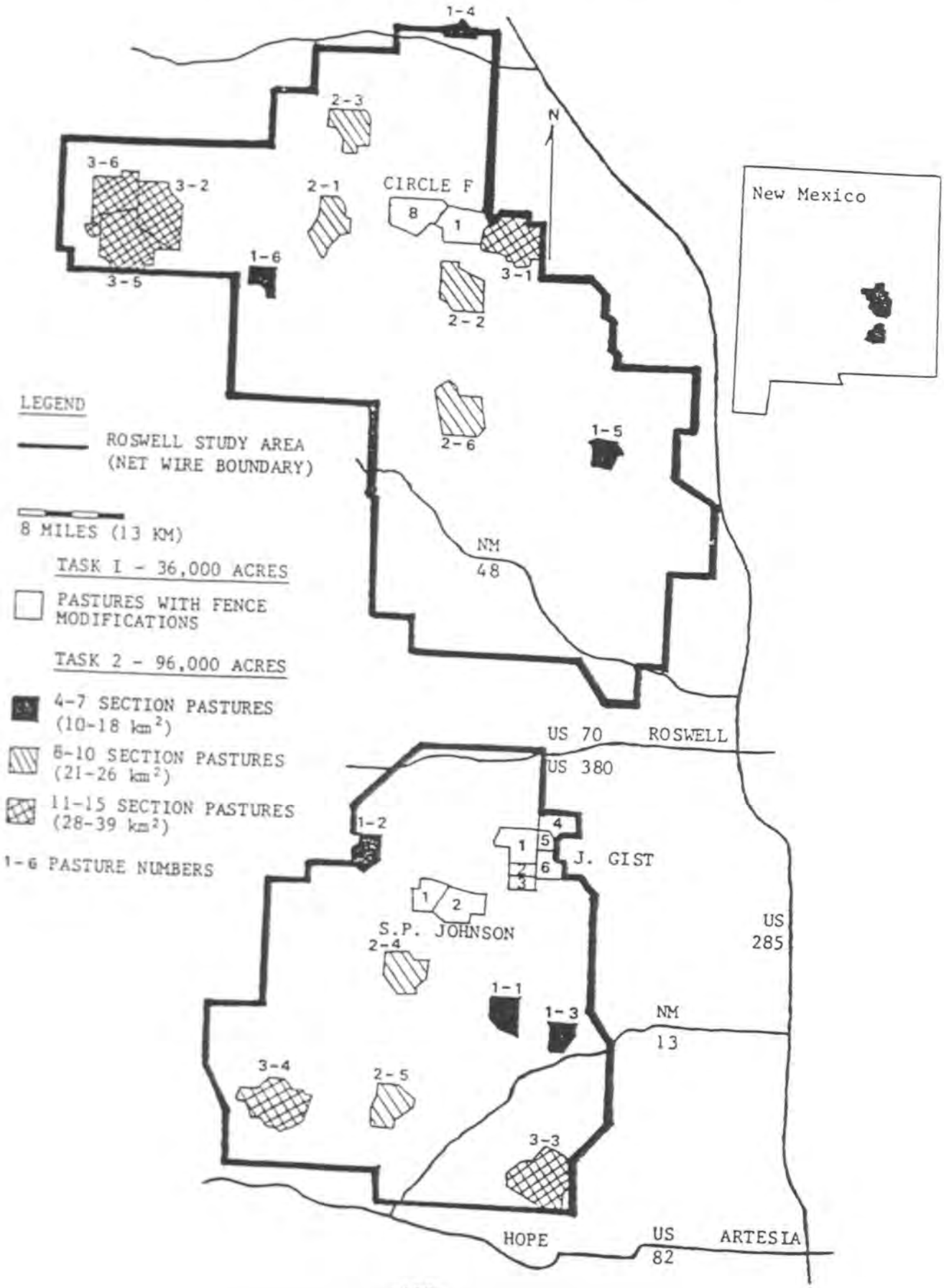
ABSTRACT

Pronghorns (Antilocapra americana) were stocked in 18 study pastures enclosed by net wire in southcentral New Mexico during January and February, 1979. Pastures were grouped as small (4-6 sections), medium (7-10 sections), and large (11-14 sections). All pastures were stocked at 2 animals/section with 1 male:3 females. Field data were collected during specific months or periods from June, 1979 though September, 1982 and included number, sex and age of pronghorns in each pasture; numbers and classes of livestock; precipitation; fecal collections for each ruminant present; and vegetation productivity and availability. Analyses of data indicated sizes of the pastures were not important to pronghorn viability. Density and class of domestic livestock affecting availability and production of selected forb species were the determinant factors for maintaining or increasing pronghorn numbers within individual pastures. Pastures with sheep densities greater than 10-12 AU's/section (50-60 sheep/section) on a yearlong basis did not have viable pronghorn herds. Greatest increases in pronghorn densities occurred in pastures with largest standing crops of fall-winter forbs which generally occurred where only cattle were grazed.

INTRODUCTION

In 1940 the New Mexico Department of Game and Fish (NMDG&F) estimated pronghorn numbers at 3,000 in an area west of Roswell, New Mexico, lying between the Pecos River (east) and the foothills of the Sacramento Mountains (west) and extending approximately 80 km to the north and south of US 70-380 (Figure 1) (Walt Snyder, pers. comm.). Pronghorns were so plentiful that in 1938 several hundred were trapped in east-central New Mexico and transplanted in other areas of the state and to the Wichita Mountains National Wildlife Refuge in Oklahoma. During the 1920's and early 1930's the area west of Roswell, approximately 607,042 ha (1.5 million ac), was cross-fenced with net wire (Russel 1964) in order to facilitate an expanding sheep industry. By 1977 it was estimated that pronghorn numbers had declined to approximately 300 (NMDG&F population estimate) in the area enclosed by net wire fences. Bear (1969) in Colorado, Hailey et al. (1966) in West Texas, and Russell (1951) in New Mexico have described similar declines in pronghorn populations due to

Figure 1. Roswell study area, showing location and size of pastures.



restrictions imposed by net wire fences on movement of pronghorns to areas providing adequate food.

Because pronghorn numbers were declining on public lands enclosed by net wire fences in east-central New Mexico, the Bureau of Land Management's (BLM) Roswell District began plans to alleviate the effects of the net wire fences located west of Roswell. In 1975 pronghorn fencing directives were issued by the Roswell District, and fence modifications were initiated. Livestock ranchers, especially those situated in east-central New Mexico, objected to the federal government's policy of altering fences for pronghorns. In addition, the BLM announced that pronghorns would be reestablished in historic habitat areas west of Roswell in order to comply with federal regulations which require multiple use management on public lands.

On 21 October 1976, the Federal Land Policy and Management Act (FLPMA) became law. Section 102. (a) (8) states that public land will be managed to provide food and habitat for fish, wildlife, and domestic animals. Section 103 (c) defines multiple use as the management of public lands and their resources so that they are utilized in a combination that will best meet the present and future needs of the American people.

Ranchers in the area remained opposed to fencing modifications. In 1976 the BLM held several public meetings to obtain the views and recommendations of local interest groups. In the summer of 1977 a pronghorn "task force" was formed, consisting of 2 area ranchers and 2 representatives each from the BLM, NMDG&F and the U.S. Fish and Wildlife Service. The "task force" then developed a study proposal to provide the information required to determine accurately the effects of increasing the pronghorn habitat and study any alternative means of achieving this objective.

A study was proposed by the "task force" to: 1.) study the movement of livestock and pronghorns through different sizes and types of fence modifications, and 2.) determine the botanical composition of sheep, cattle and pronghorn diets and relative preference for different plant species by these herbivores, and to develop models to characterize and predict pronghorn habitat qualities and minimum area needed to support viable pronghorn herds. A viable herd was defined as a herd where recruitment equals mortality. Only Task 2 is discussed in this paper.

Task 2 included 4 subtasks: 1) conduct vegetational analysis of 18 study pastures that had pronghorns transplanted into them; 2) develop a computer model to determine variables necessary to establish minimum requirements to support a viable pronghorn herd; 3) conduct monthly censuses of pronghorns and livestock within the study pastures; and 4) make fecal collections for pronghorns, and cattle and sheep when appropriate, to determine seasonal food preference. It was anticipated that the performance period for the research would take approximately 4 years. The study was to begin no earlier than 1 December 1978, and be completed by 30 September 1982. The study contract was awarded to New Mexico State University, Agricultural Experiment Station in April 1979.

The authors would like to express their gratitude to many individuals, ranchers and agency personnel who cooperated or assisted with data collections and provided information on livestock numbers for the 28 study pastures.

Graduate student Jeffrey Bradybaugh provided data on pronghorn behavior.

Personnel from the New Mexico Department of Game and Fish and the Roswell District, BLM assisted with data collections and necropsy of pronghorns which were sacrificed during die-offs in 3 study pastures

Several individuals at Texas Tech University including Leslie Krysl and Brigid Hickey assisted with the cattle, sheep, and pronghorn microhistological diet analyses. Luke J. Celantano provided statistical analyses of these data.

A special thanks is extended to Alex Lara, Wildlife Technician, and to Don Ellsworth and James Freudenberger, Range Technicians, for their efforts in collecting most of the field data and doing many of the mundane jobs associated with a research project of this magnitude. Their efforts were invaluable to the success of the project.

STUDY AREA

TOPOGRAPHY

The 4-year study was conducted in 18 study pastures approximately 20 to 70 km northwest and southwest of Roswell, New Mexico (Figure 1). This area is generally characterized as a short grass prairie with topography varying from flat prairies to rolling hills progressing to rugged limestone hills and canyons.

VEGETATION

Principal grass species consist of dropseed (Sporobolus spp.), gramas (Bouteloua spp.), muhly (Muhlenbergia spp.), threeawns (Aristida spp.), windmill grasses (Chloris spp.), buffalograss (Buchloe dactyloides), and tobosa (Hilaria mutica). Primary perennial woody species found in the area, which ranges from between 1 to 10% cover on any particular pasture, includes catclaw (Acacia greggi), cholla (Opuntia imbricata), mesquite (Prosopis glandulosa), oaks (Quercus spp.), broom snakeweed (Gutierrezia sarothrae), Louisiana sagewort (Artemisia ludoviciana), and Apache plume (Fallugia parodoxa).

CLIMATE

The climate is semiarid with abundant sunshine and wide ranges of daily and seasonal temperatures. Winter temperatures seldom reach -18°C (22°F) while summer temperatures rarely go above 38°C (100°F). The average yearly precipitation is approximately 30.5 cm (12 in) and generally falls between July and September (Maker et al. 1971).

RANCHING INDUSTRY

Cattle and sheep ranching are the primary land uses for the area with most pastures being grazed year round. Some pastures were rested from livestock use at various times of the year throughout the study. Both cattle and sheep were grazed in 12 of the pastures, cattle only in 3 pastures, and sheep only in 3 pastures. Stocking rates for cattle and sheep varied from 7 to 84 ha (17 to 207 ac) per animal unit year (3.1-35.9 AUs/sect) whenever livestock were in the pastures.

METHODS

GENERAL JOB DESCRIPTION

Capture and Transplanting Pronghorns

Pastures used in the study varied in size from about 1,000 to 3,900 ha (4 to 15 sections) all enclosed with netwire. Twenty-seven grazing allotments containing 81 pastures within the study area were considered for the study after receiving the ranchers' verbal agreements to cooperate in supplying water, maintaining fences, and furnishing actual livestock use records. All 81 pastures then were evaluated for production and variety of grasses, forbs, and browse; and diversity and suitability of topography. The 18 pastures in the study were chosen by a random selection. These pastures were divided into 3 size classes ranging from approximately 1,000 to 3,900 ha (4 to 15 sections) with 6 replications of each size (Fig 1).

The NMDG&F, along with the BLM, captured a total of 309 pronghorns using techniques described by Russell (1964). Trapping operations began on 15 January 1979, and the last animals were released on 10 March 1979. Nine of the total 309 pronghorns were replacements for those that died during transit or shortly after release. All pastures were flown within 1 week after the release to locate the dead or injured animals for replacement purposes. State and BLM biologists examined all dead animals to determine the probable cause of death. Some of the detrimental causes were found to be stress and shock, pneumonia and 1 possible bald eagle (Haliaetus leucocephalus) kill.

Pronghorns were stocked in each pasture at a density of 1 per 130 ha (2 per section) and at a sex ratio of 1 male per 3 females. All animals to be released into the study area were fitted with vinyl-coated nylon collars. Males received blue collars, and females received orange collars. Red, yellow, and black numbers identified the pasture and size class designation.

Aerial Censuses

Monthly inventories of pronghorn populations were conducted via aerial censuses. Total herd numbers, natality, mortality, survival, immigration, and emigration were assessed. During April and May of each year no aerial surveys were taken to avoid disturbing the ewes or does while lambing and fawning were in progress.

Several types of airplanes were used throughout the study including a Piper Archer, Warrior Super Cub, and Cessna Cuttlass and Skyhawk. Each pasture was flown early in the morning on a north to south grid pattern with transects approximately 400-800 m apart and in an altitude of 50-100 m and airspeed of about 140 km/hr. If the total count appeared low when compared to the previous census the pasture was regridded on an east to west pattern and the higher count was recorded. After an animal had been missing for 4 months it was omitted from the population. The highest number of fawns recorded during any month for that year was accepted as being a minimum estimate of total fawns born in that pasture.

Vegetational Studies

Procedures used in the vegetation sampling followed closely the procedures for the Soil-Vegetation - Inventory Methods (SVIM) outlined by the Bureau of Land Management. Initially all the study pastures were mapped into range sites following descriptions presented by the Soil Conservation Service (1967). The size of each range site was utilized to determine the allocation of sampling units to each pasture.

Basal cover was determined by the step-point method (Evans and Love 1957). Each transect consisted of 100 points. If the basal portion of a plant fell directly beneath a small point on the tip of the observer's boot, the species was recorded. Ground cover conditions including bare ground, litter, and rock were also recorded. The step-point transects were sampled once in each pasture in the fall of 1979 or early winter of 1980 in the same general location as the herbage standing crop transects.

Herbage standing crop was determined by the weight estimate method (Pechanec and Pickford 1937, Wilm et al. 1944) with (0.25 m^2) circular quadrats. There were 10 quadrats in each transect, but the length of the quadrat varied depending upon the size, shape, and topography of the range site. Double sampling was not used, but periodic clipping was utilized to keep weight estimates as accurate as possible. Herbage standing crop was estimated in all pastures during January, March, June, and September of each year during the study.

Fecal Collections and Diet Analysis

Fecal samples were collected for dietary studies on a seasonal basis (January, March, June, and September). A sample of 12 fecal groups per species for all pastures was attempted each season. This sampling scheme resulted in total sample sizes of 2,340 for cattle; 2,184 for sheep; and 1,894 for pronghorns. Pronghorn pellets were collected only after observing animals defecating except in pastures where there were no sheep. No difficulty was encountered in identifying cattle dung. Sheep pellets were collected at watering tanks and from bedding areas. All fecal samples were collected as fresh as possible for that month. Approximately 20-30 pellets were collected for sheep and pronghorns and about 20 ml of sample was collected from individual cattle fecal passages. All samples were placed in individually marked (species, collection date, and pasture) plastic bags and soaked with 90% ethanol until analyses were performed.

Microhistological examinations (Baumgartner and Martin 1939, Dusi 1949) were conducted on each fecal group at the Wildlife Food Habits Analysis Laboratory, Texas Tech University, Lubbock to determine the vegetative diet. Fifty percent of each fecal group was emulsified in a commercial food-mixing blender, a sample transferred to 2 microscope slides, and a cover slip affixed. Systematically-located microscope fields were examined on each slide, and all plant fragments in each field were identified, based on characteristics of epidermal tissues (Croker 1959, Davis 1959), or categorized as "unknown". A reference collection of microscope slides and corresponding microphotographs was developed to facilitate this procedure. Data for each animal were recorded as relative frequencies by dividing the number of "hits" for a given plant species by the number of hits for all species.

Diet similarities, comparing species rather than general forage classes, were made using Kulczinski's Similarity Index (Oosting 1956). The resulting indices were tested for pasture and season effects. Initial data inspection indicated that the variation about the average index was symmetric and that the sizes of the seasonal ranges were similar within each comparison; therefore, the assumption that the average similarity indices were normally distributed appeared justified. The variation across season appeared homogeneous (R. King 1981, pers. comm.).

Pronghorn Data Set Compilation

Data collected from overflights on numbers of pronghorns in each study pasture were organized over time by dividing years into 3-month seasons beginning in March, June, September, and December. Numbers of collared males and females, uncollared males and females, and fawns at the beginning of each season in each pasture were determined from the maximum number of individuals in each category seen during the season and in subsequent months. Data from a series of flights were considered for each seasonal data point since not all animals were seen on every flight. Pronghorns which jumped out of a pasture and then returned were considered to have remained in the pasture for the purpose of enumerating surviving animals in the pasture.

Seasonal data for pronghorns were grouped into years, with each year beginning in the June-August season, the first season in which new fawns could be observed. Maximum observed fawn production for each pasture each year was the maximum number of fawns seen on an individual flight during that year. Fawns per female were calculated as the maximum number of observed fawns divided by the number of adult females alive at the end of the March - May season when fawns were born. For the first fawn crop, the number of females stocked in the pasture was used as the divisor. Yearling and adult females alive at the end of the next spring season were old enough to have produced fawns, since the yearlings were almost 2 years old during that season.

Seasonal survival rates for fawns, adult females, and adult males were calculated by dividing the number of animals alive at the end of a season by the number of animals alive at the beginning of that season.

Environmental Data Set Compilation

Descriptive information for each study pasture was tabulated and included pasture size, an index to latitude (Township designation), ruggedness index (a multiplicative function of total relief and the total length of all contour lines traversing an area, Beasom et al. 1983), vegetation type, percent of climax vegetation, SCS and SVIM estimates of annual forb, grass, and shrub production, and a dummy variate based on a BLM designation of suitability for pronghorns (good or poor).

Data for environmental variables which did vary over the course of the study were organized into 3-month seasons corresponding to those used for pronghorn population data. Stocking rates (average animal units per section for cattle and sheep were calculated for each season based on 1 cow or 5 sheep per animal unit. The fraction of cattle and sheep that was calves and lambs also was recorded for each season. Total standing crop of grasses, forbs, and shrubs was recorded from measurements for each season. The number of forb species and the combined standing crop of preferred forbs(those with highest

importance values in pronghorns' diets) also were recorded. The percentges of grasses, forbs, and shrubs in the diets of cattle, sheep, and pronghorns were tabulated for each pasture and season. Rain gauge readings were summarized to provide totals for 4 periods: 1) March through May, 2) June and July, 3) August, and 4) September through November, for each pasture each year. No precipitation data were collected for December through February.

DATA ANALYSIS

The original study design was structured for analysis of variance, with pastures grouped into 3 size ranges and divided between 2 suitability types within each size group. However, pastures within each size group were not of a uniform size, the 2 suitability types (good or poor) proved unreliable, and 3 pastures were dropped during the course of the study so that sample sizes within size groups varied. Therefore, multiple regression analysis was more suitable than the more structured analysis of variance. A dummy variate was used for suitability types and actual pasture sizes replaced the pasture size groups in the analysis. Simple correlation coefficients were calculated between pronghorn population data and environmental data, and among environmental variables. Some calculations used seasonal data, and some used averages over several seasons, as appropriate. Dependent variables for multiple linear regressions were chosen from pronghorn population data for examining associations with environmental parameters from the same and preceding seasons.

Because of the range of environmental variables measured during this study, there were frequently more variables than observations for any given class of regressions. Consequently, independent variables to be examined were chosen on the basis of study objectives, pronghorn life history information, and correlations with the dependent variable. Forward addition stepwise regression techniques were used to select the best subset of independent variables (Steel and Torrie 1980).

Two sets of analyses were performed with the study data. The first included only those environmental variables that did not change throughout the study and those that could reasonably have been estimated beforehand. The second included all of the seasonally varying environmental data.

RESULTS

AERIAL CENSUS

Populations of pronghorns in the 18 study pastures fluctuated throughout the study (Table 1). Most pastures showed considerable increase in numbers of pronghorns at the beginning of 1980, thus indicating high reproduction and fawn survival during the summer of 1979. The populations continued to increase in 4 pastures in 1980; but 3 pastures had very dramatic declines and were withdrawn from future studies in November 1980, thus leaving 15 pastures for the remainder of the study.

Reproduction and fawn survival was moderately high during the summer of 1981, and 10 of the 15 remaining pastures had a net increase in pronghorn populations when compared to the previous year. During the summer of 1982 fawn production and survival was highly variable. Only 3 pastures showed

Table 1. Populations of pronghorns in the 18 study pastures, as determined by aerial censuses, 1979-82.

Pasture Number	Year				
	1979 (Feb)	1980 (Jan)	1981 (Jan)	1982 (Jan)	1982 (Sept)
1-1	12	23	30	38	52
1-2	8	13	11	14	11
1-3	8	14	8	13	19
1-4[a]	8	8	4	--	--
1-5	8	10	10	12	13
1-6	8	15	12	14	8
2-1	18	26	18	16	14
2-2	16	22	18	15	15
2-3	16	25	15	11	14
2-4[a]	16	13	6	--	--
2-5	16	17	15	7	2
2-6	18	22	23	38	39
3-1[a]	22	31	0	--	--
3-2	26	35	29	49	37
3-3	22	39	45	65	78
3-4[b]	20	40	30	10	0
3-5	21	36	32	35	19
3-6	22	43	46	49	32

[a]Pasture eliminated from study November 1980.

[b]Unknown numbers of pronghorns present in pasture at release.

substantial increases in total pronghorn numbers. An additional pasture (3-4) had a major decline in pronghorn numbers during December 1981 and January 1982. The pronghorns in this pasture continued to decline until the June aerial census indicated the entire population had died. Subsequent flights during the remainder of the study failed to locate any pronghorns in this pasture.

At the culmination of the flights in September 1982 only 4 pastures showed substantial increases when compared to previous years of the study. All others either were stabilizing or declining in total numbers of pronghorns.

VEGETATIONAL STUDIES

The vegetation of the study area was primarily grassland with shrubs occuring mainly in pastures along the western side at higher elevations. Blue grama (Bouteloua gracilis) was the most abundant grass species, occurring in all pastures (Table 2). Three awns, mat muhly (Muhlenbergia richardsonii), slim tridens (Tridens muticus), sideoats grama (B. curtipendula), sand dropseed (Sporobolus crytandrus), and hairy grama (B. hirsuta) also were important in most of the pastures. Tobosa was locally abundant, occurring mostly in low-lying areas.

Forbs were not very abundant in the fall of 1979 following a growing season which received very low precipitation.

Broom snakeweed (Gutierrezia sarothrae) was the most widespread shrubby species. Other shrubby species were scattered throughout the pastures.

The pastures were divided into 4 groups based on vegetational similarity, topography, and elevational position (Table 3). The number of species in each group of pastures varied from 44 to 64 during the initial sampling. The lowland sites apparently were more diverse than those in the foothills. Frequency was determined from the 0.25 m^2 quadrats used for standing crop determinations. Again, several species were abundant in all areas: blue grama, sand dropseed, mat muhly, three awns, and broom snakeweed (Table 4). Tobosa was confined mostly to the lowland pastures while galleta (Hilaria jamesii), and New Mexico feathergrass (Stipa neomexicana) were most abundant on the upland pastures. There seemed to be no discernable pattern from north to south.

DIET ANALYSIS

The diet of pronghorns was dominated by forbs (66-76% average relative frequency throughout all pastures, seasons, and years) (Table 5). Most of the values for individual pasture ranged from 60-80%, although extremes of 40-92% were observed. No individual pastures consistently stood out as having relatively high or low values. The relative frequency of grass in the seasonal diet of pronghorns averaged approximately 1-5% with a range of 0-19% for individual pasture-season combinations (Table 5). Browse use by pronghorns was intermediate to forbs and grass. Average relative frequency values indicated their diet was comprised of approximately 30% browse in the winter and spring seasons (Table 5).

Cattle diets were dominated by grasses in all pastures during all sample periods. The average dietary composition of grass ranged from approximately

Table 2. Basal cover (%) of plant species in study pastures at time of initial sampling (Fall 1979).

	Pasture Number																	
	1-4	1-6	2-1	2-2	2-3	2-6	3-1	3-2	3-5	3-6	1-2	2-4	2-5	3-4	1-1	1-3	1-5	3-3
Bareground	47.6	47.0	29.0	26.7	37.0	42.8	40.7	36.0	34.0	42.0	23.0	31.0	22.5	38.5	27.0	35.4	25.5	46.6
Litter -Persistent	0.3	Tr	1.0	1.0	0.3	1.3	0.3	0.5	0.2	Tr	Tr	0.3	1.0	1.3	0.3	0.2	0.8	Tr
-Nonpersistent	22.6	9.0	4.0	10.5	21.0	6.0	10.2	7.2	8.0	9.0	2.0	11.0	7.0	14.0	9.3	12.5	3.8	12.0
Gravel	4.6	4.6	6.0	12.8	3.6	6.0	8.7	3.5	7.0	4.0	17.5	8.0	8.0	5.0	16.8	10.0	7.8	8.2
Cobble	3.3	4.0	12.0	12.0	3.0	2.5	4.5	8.5	8.0	5.0	9.0	7.0	8.5	11.3	8.3	5.1	6.5	1.8
Stone	1.6	Tr	4.0	2.0	2.6	2.3	0.3	0.8	1.0	0.5	4.0	1.6	2.5	5.0	1.8	1.6	2.5	Tr
Bedrock	1.6	1.3	1.0	1.0	1.0	1.5	0.8	1.0	1.0	0.8	6.5	6.3	5.0	2.5	4.5	4.5	2.5	4.0
SPECIES																		
Grasses																		
Bouteloua gracilis	4.6	18.3	14.0	5.3	6.3	12.8	3.0	22.0	19.0	25.0	4.5	5.0	4.5	2.0	1.3	0.8	2.8	1.3
Hilaria mutica						1.8	1.8				1.5	8.3	3.0	0.8	3.5	10.5	0.8	2.2
Scleropogon brevifolius	Tr		2.0	0.8		3.3	3.5						0.5	Tr	7.3	8.1	1.5	5.8
Erioneuron pilosum	0.6	Tr	6.0	2.5		1.5	1.8	Tr	0.6		2.5	4.0	8.0	1.0	7.5	2.0	3.0	1.3
Lycurus phleoides	1.3	0.6		0.5		Tr	0.3	0.5	0.2	0.3	2.5		1.5	0.8	0.5		1.0	
Muhlenbergia repens	Tr			0.3	0.3	0.3	0.8	4.0	1.4	2.5	Tr		2.5	3.8				Tr
Muhlenbergia richardsonii	3.3	2.6	2.0	0.3	1.0	0.8	0.8	3.0	1.0	2.5	Tr		Tr	2.3	Tr	Tr	1.0	
Muhlenbergia porteri	Tr		1.0	Tr		1.5	0.8	0.3					5.5		1.8	1.7		1.2
Muhlenbergia montana								1.0	1.8		0.5		3.5	1.0				
Aristida spp.	2.3	0.6	4.0	1.5	4.3	1.0	4.0	2.0	2.6	0.3	3.5	1.3	3.0	2.0	2.0	0.7	2.8	1.3
Eragrostis intermedia			Tr								Tr	0.3	1.0	0.3				
Bouteloua eriopoda		1.0	2.0	1.3	4.3	1.8	3.0	1.3			2.5	2.0	3.0		1.5	0.7	2.5	1.3
Sporobolus cryptandrus	Tr	1.3		2.8	0.6	2.3	4.0	0.8	1.0	Tr	0.5		1.5	2.0	Tr	Tr	1.3	0.5
Sporobolus giganteus				9.3														
Stipa neomexicana	Tr	1.0	1.0	1.5	1.3	0.5		4.0	6.2	4.0							Tr	
Bouteloua hirsuta	1.6	1.0	1.0	0.5	1.6		0.5		0.4	0.3	1.0	1.0	1.5	1.3	0.5		0.8	Tr
Hilaria jamesii	0.3	0.3	1.0	0.5	0.3	4.3	1.0	3.5	2.6	4.0								
Bouteloua curtipendula	Tr	1.0	1.0	1.3	1.6		0.3	1.8	1.8	0.8	3.5	2.3	2.5	0.3	0.8	1.0	Tr	0.2
Leptochloa dubia											0.5	0.3		0.3	Tr			
Tridens muticus				0.8			Tr					Tr	Tr		1.5	0.7	0.3	0.2
Muhlenbergia torreyi	Tr	0.3		0.5	Tr	1.3	2.5				Tr				0.5	0.3	0.8	1.2
Panicum virgatum				Tr							0.5		2.0	0.3	0.3		Tr	Tr
Enneapogon desvauxii											Tr							
Bothriochloa barbinodis													1.0			0.5		
Panicum obtusum					Tr		0.3							0.5				Tr
Setaria leucophila											Tr							
Erioneuron pulchellum			Tr	0.5		Tr			Tr	Tr		Tr	1.0	0.8	Tr	0.5	0.3	Tr
Sitanion hystrix														0.3				
Blepharoneuron tricholepis														0.3				
Andropogon scoparium					0.3													
Total Grasses	14.0	28.0	35.0	30.2	21.9	33.2	28.4	44.2	38.6	39.7	28.5	24.5	45.5	20.1	29.0	27.5	18.9	21.5

Table 2 continued.

	Pasture Number																	
	1-4	1-6	2-1	2-2	2-3	2-4	3-1	3-2	3-3	1-6	1-2	2-4	2-5	3-4	1-1	1-3	1-5	3-3
Forbs																		
Croton pottsii						Tr								Tr	Tr	Tr		
Evax verna															Tr	Tr		
Conyza couleteri															Tr	0.3		
Aster spp.	Tr																	
Lesquerella fendleri		0.3			0.3													
Sphaeralcea coccinea		Tr		0.3														
Sphaeralcea angustifolia				Tr														
Astragalus mollissimus					1.0													
Dyssodia pentachaeta														0.3				
Portulacca spp.														0.3				
Total Forbs	Tr	0.3	0.0	0.3	1.3	Tr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	Tr	0.3	0.0	0.0
Shrubs																		
Gutierrezia sarothrae	2.0	1.0	3.0	2.8	5.3	3.8	3.0	Tr	0.6	0.8	0.5	Tr		0.3	1.0	0.3		1.3
Dalea formosa									Tr	Tr	Tr	Tr	0.5	Tr	Tr	Tr		
Nolina microcarpa			Tr	0.3	1.0	Tr	Tr				Tr			0.3	0.3	0.5		
Opuntia acanthocarpa					Tr						Tr	Tr						
Fallugia paradoxa											Tr							Tr
Acacia greggii				0.3										0.3	0.3			
Yucca glauca					0.3						Tr							
Opuntia engelmannii													Tr		Tr	Tr		
Eurotia lanata		Tr							Tr	Tr								
Yucca elata					Tr				Tr	Tr								
Parthenium incanum														0.3				
Krameria lanceolata																		Tr
Rhus aromatica														0.3				
Artemisia frigida									Tr	Tr								
Total Shrubs	2.0	1.0	3.0	3.4	6.6	3.8	3.0	Tr	0.6	0.8	0.5	Tr	0.5	1.2	1.6	0.8	0.0	1.3
OVERALL TOTAL	16.0	29.3	38.0	33.9	29.8	37.0	31.4	44.2	39.2	40.6	29.0	24.5	46.0	21.8	30.6	28.6	18.9	22.8

Table 3. Pasture grouping, sample sizes and numbers of species sampled during 1979-80 inventory.

Geographical Region	Pastures Included	Number Quadrats	Number Species
South Hills	1-2, 2-4, 2-5, 3-4 S.P. Johnson	140	51
South Plains	1-1, 1-3, 3-3, Gist	290	64
North Hills	1-5, 2-1, 2-2, 2-6, 3-1, Circle F	210	44
North Plains	1-4, 1-6, 3-6, 3-2, 3-5, 2-3	170	60

Table 4. Frequency (%) of species from different geographic areas in the West Roswell area, 1979-80.

Species	South Hills	South Plains	North Hills	North Plains
Grasses				
Bouteloua gracilis	23	14	78	48
Bouteloua curtipendula	9	3	17	6
Bouteloua hirsuta	6	2	12	5
Bouteloua eriopoda	11	17	16	26
Scleropogon brevifolius	9	42	1	13
Sporobolus cryptandrus	17	10	26	27
Sporobolus giganteus	0	0	0	5
Muhlenbergia repens	9	1	8	5
Muhlenbergia richardsonis	12	8	24	8
Muhlenbergia torreyi	1	8	1	17
Muhlenbergia porteri	9	26	2	11
Muhlenbergia montana	0	0	5	0

Table 4. (Continued)

Hilaria mutica	26	37	0	7
Hilaria jamesii	0	2	24	8
Erioneuron puchellum	17	13	0	14
Erioneuron pilosum	46	37	8	32
Tridens muticus	9	8	0	5
Aristida spp.	35	12	29	33
Panicum virgatum	14	5	1	3
Lycurus phleoides	14	0	14	13
Stipa neomexicana	0	0	18	5
Forbs				
Croton corymbulosus	8	0	1	0
Croton spp.	1	0	0	5
Conyza coulteri	0	5	0	0
Lesquerella fendleri	0	1	41	0
Chamaesarcha conoides	1	0	0	6
Evax verna	0	17	0	0
Aster spp.	0	0	12	1
Shrubs				
Gutierrezia sarothrae	39	48	61	70
Acacia gregii	12	7	0	7
Dalea formosa	7	0	0	2
Nolina microcarpa	11	0	2	9
Opuntia acanthocarpa	17	8	1	5
Opuntia engelmannii	4	7	1	4
Eurotia lanata	0	0	6	0

Table 5. Average (and range) of relative frequencies (%) of grasses, forbs and browse in the seasonal diets of cattle (C), pronghorns (P) and sheep (S) on 15 study areas in east-central New Mexico, as determined by fecal analysis, from fall 1979 through fall 1982.

	Fall			Winter			Spring			Summer		
Forage	C	P	S	C	P	S	C	P	S	C	P	S
Grass	67.2 (53-83)	5.3 (1-20)	33.2 (18-55)	72.6 (57-97)	1.4 (0-9)	38.9 (23-61)	69.9 (47-89)	3.4 (1-10)	43.7 (32-54)	77.5 (62-93)	2.6 (0-6)	41.2 (27-52)
Forbs	28.3 (12-44)	73.8 (67-86)	52.2 (36-64)	12.9 (3-33)	65.8 (40-92)	40.7 (22-59)	14.7 (4-47)	65.8 (45-85)	42.6 (28-62)	18.9 (6-34)	75.8 (47-91)	45.9 (32-64)
Browse	3.4 (1-9)	20.9 (9-31)	14.5 (6-24)	14.5 (4-27)	32.8 (3-58)	20.1 (2-38)	15.4 (2-38)	29.8 (4-53)	13.7 (2-32)	4.6 (1-14)	21.6 (7-50)	12.8 (6-19)

67-77%, and all values for individual pastures were within 20% of these averages (Table 10). There was an apparent inverse relationship between the relative amounts of forbs and browse consumed by cattle. The seasons of highest forb use, summer (19%) and fall (28%), corresponded with the lowest use of browse, approximately 3-5% (Table 5). Conversely, browse use by cattle was highest (15%) and forb use lowest (13-15%) in winter and spring.

The diet of sheep was comprised of approximately equal amounts of grass and forbs (39-45%) in winter, spring, and summer, although in fall the average dietary composition of grass declined to 33% and that of forbs increased to 52% (Table 5). The percent composition of browse in the diet of sheep ranged from approximately 2-38% for individual pastures in certain seasons, but the average values across all pastures ranged from only about 13-15% for spring, summer, and fall and 20% for winter (Table 5).

Selectivity Indices further attested to the importance of forbs, and to a lesser extent browse, in the diet of pronghorns in this area (Table 6). Some species, such as Artemisia ludoviciana, Croton spp., Sphaeralcea coccinea, S. angustifolia, and Opuntia spp. had relatively high indices in all seasons. Other species represented by relatively high index values in at least 2 seasons were: Verbena spp., Eriogonum spp., Dalea formosa, Gutierrezia sarothrae, Euphorbia spp., Abutilon incanum, Rhus microphylla, Sida spp. and Krameria lanceolata. Ambrosia psilostachya, which had the highest overall ranking, was represented by an extremely high average selectivity value in the summer seasons and relatively low values in the other seasons. Similar seasonally disproportionate use was indicated by the relatively high indices in the spring season for Astragalus spp., Marrubium vulgare, Leucelene spp., Eurotia lanata, and Lithospermum spp., and in the winter season for Zinnia grandiflora, Conyza coulteri, and Erodium spp.

Some plants had relatively high relative frequency values, at least in certain seasons, for the diet of cattle, pronghorns, and sheep. Although the values were higher for cattle and sheep, grasses in this category were Bouteloua gracilis, Sporobolus spp. and Stipa spp. Five forb species (Croton spp., Abutilon incanum, Sphaeralcea coccinea, S. angustifolia, and Verbena spp.) apparently were eaten in approximately equal amounts by the 3 herbivores. Other forbs in this category, although with disproportionate use by the 3 herbivores, were Ambrosia psilostachya, Lesquerella fendleri, and Sida spp. Of the browse, only Opuntia spp. was represented with consistently high relative frequencies for these animals.

Grasses utilized in relatively large amounts by cattle and sheep but not pronghorns were Bouteloua curtipendula, B. eriopoda, Erioneuron pilosum, Lycurus phleoides, Muhlenbergia spp., Aristida spp., and Setaria leucopila. No forb or browse species were consistently utilized by either class of livestock in greater amounts than pronghorns. Pronghorns and sheep utilized Artemisia ludoviciana, Cassia spp., Berlandiera lyrata, Calylophus serrulatus, Conyza coulteri, Eriogonum spp., Lesquerella spp., Brickellia brachyphylla, Dalea formosa, Rhus aromatica, and R. microphylla disproportionately more than cattle.

The only plants consistently utilized by cattle disproportionately more than by the other 2 herbivores were Andropogon spp. and Sorghastrum avenaceum. Similarly Eurotia lanate was the only plant consistently represented by higher relative frequency values for sheep than for cattle or

Table 6. Average Selectivity Indices (relative frequency in diet/relative biomass available on respective study pastures) for dietary items of pronghorns, as determined from winter 1980 through fall 1982.

Species	Fall	Winter	Spring	Summer	Overall[1] Rank
Ambrosia psilostachya	475	300	399	18,165	1
Artemisia ludoviciana	1,736	1,476	1,340	7,555	2
Croton spp.	1,841	1,570	6,222	2,417	3
Sphaeralcea coccinea	4,800	574	1,464	2,830	4
Opuntia spp.	1,758	1,835	2,950	1,291	5
Eriogonum spp.	2,128	531	32	4,430	6
Dalea formosa	2,130	27	29	3,352	7
Solanum elaegnifolium	261	219	277	4,661	8
Sphaeralcea angustifolia	1,745	1,167	1,138	1,035	9
Verbena spp.	1,021	31	1,173	2,267	10
Gutierrezia sarothrae	57	1,928	2,664	264	11
Euphorbia spp.	999	215	426	2,894	12
Abutilon incanum	3,076	20	234	924	13
Rhus microphylla	293	919	1,472	1,097	14
Sida spp.	959	0	0	2,719	15
Astragalus spp.	343	31	2,103	337	16
Krameria lanceolata	1,215	84	955	503	17
Ratibida columnaris	857	179	1,407	313	18
Quercus undulata	270	70	780	1,354	19
Marrubium vulgare	753	13	1,294	284	20
Lesquerella fendleri	305	370	1,535	35	21
Leucelene spp.	292	166	1,173	182	22
Zinnia grandiflora	1,302	80	32	825	23

Table 6. (Continued)

Polygala spp.	811	286	565	438	24
Eurotia lanata	154	27	1,758	60	25
Plantago patagonica	491	89	432	590	26
Artemisia filifolia	889	0	53	660	27
Dalea jamesii	483	27	140	1,043	28
Conyza coulteri	1,227	14	277	75	29
Evax verna	719	112	212	75	30
Lithospermum spp.	295	13	1,231	122	31
Erodium spp.	1,162	0	112	218	32
Calylophus serrulatus	402	0	188	438	33
Heterotheca spp.	225	57	611	131	34

Table 7. Average (and range) of Similarity Indices for the comparative diets of cattle, pronghorns and sheep on 15 study pastures in east-central New Mexico from fall 1979 through fall 1982.

Season	Animal Comparison		
	Cattle-pronghorn	Pronghorn-sheep	Cattle-sheep
Fall	20.1	44.1	42.4
	(9-34)	(26-60)	(26-51)
Winter	13.9	38.2	43.9
	(3-27)	(23-60)	(24-68)
Spring	17.5	38.5	47.0
	(7-33)	(24-61)	(41-54)
Summer	13.0	35.1	51.6
	(6-27)	(24-43)	(28-98)

pronghorns. In contrast, pronghorns consistently utilized Euphorbia spp., Evax verna, Galium microphyllum, Linum rigidum, Melampodium leucanthum, Plantago patagonica, Polygala spp., Salvia spp., Juniperus monosperma, and Prosopis glandulosa disproportionately more than did cattle or sheep.

The results of the Similarity Index comparisons suggested that the diets of cattle and pronghorns are more dissimilar than are those of either pronghorns or cattle compared to sheep (Table 7) The average indices for the cattle-pronghorn comparison ranged from approximately 13 to 17 during winter, spring and summer, and increased to 20.1 in the fall. The pronghorn-sheep comparison followed a similar pattern with the average value in the fall being higher than that for the other seasons. In contrast, the Similarity Index for the cattle-sheep comparison was lower in the fall than in the other 3 seasons.

FAWN PRODUCTION AND SURVIVAL

Maximum fawn production per female and seasonal survival varied among pastures and among years during the study. Yearling pronghorns could be distinguished from adults only during the summer 1980 through spring 1981. At this time all collared animals were adults, since they had been brought to the study as adults or yearlings in spring 1979, and all uncollared animals not fawns were yearlings and survivors from the first fawn crop of the study, born in 1979. Beginning the summer of 1981, uncollared animals distinguishable from fawns included both yearlings and older animals. For the time that yearlings were identifiable, the survival rates of yearlings and adults of the same sex were almost identical, so yearlings and adults (both collared and uncollared) were lumped into the same age category for analyzing and reporting pronghorn population data. During the study, the pattern of fawn survival was most similar to that of older animals in the fall and most different in the spring.

VIABILITY INDEX

One of the objectives of this study was the evaluation of the suitability of the study pastures for stocking pronghorns. To apply these results to other pastures in New Mexico, some index of suitability is needed. Those conditions favoring increasing pronghorn populations were of interest, and increasing populations depended on increasing the pool of breeding females, so the change in the number of potential mothers was chosen as an inappropriate index of suitability of the pasture habitats for pronghorns. The selected index for this study was the ratio of potential breeding females at the end of the study to initally stocked breeding females, and is called the Viability Index.

Clearly the number of actual and potential recruits to the female breeding population varies throughout the year, being greatest in the early summer when fawn numbers are highest, and least in the spring after annual mortality but before new births have occurred. Females are considered as recruited into the breeding population when they are mature enough to conceive, namely in the fall of their yearling year. The number of fawns that are potential recruits depends on the probability of their survival through the fall of their yearling year, and the fraction of survivors that is female. The fall season was chosen as the time for calculating the Viability Index for the study since the last pronghorn observations were made in the fall. All of the surviving collared and uncollared females other than fawns at the end of the study can

be considered as recruited into the pool of breeding females, and thus contribute to the totals of actual and potential mothers. The number of female fawns expected to become breeding females then remains to be determined.

The number of recruited mothers expected from the fall fawns depends on the probability of their survival until the following fall and on the fraction of females among the survivors. For the study pastures, over the 3 complete years of the study, the average survival rate for fawns from September through the following June was 0.65, and of those fawns that survived to be yearlings, 60% were female. For the 4 summer seasons of the study, the survival rate over the summer for yearling and adult females averaged 0.90. Thus, the expected number of females eventually recruited into the breeding population from fall fawns can be calculated as (fall fawns) x (0.65) x (0.60) x (0.90), or (fall fawns) x (0.35).

The Viability Indices for the antelope herds in the study pastures was calculated as follows:

$$\text{Viability Index} = \frac{(\text{fall \# fawns} \times .35) + (\text{Fall \# adult + yrlng females})}{(\text{initial number of stocked animals})}$$

The number of stocked females, the final number of females and fawns, and the calculated Viability Index shows that 5 study pastures were suitable for pronghorns (Table 8). A Viability Index of less than 1 indicates a declining population, and an index of 1 indicates no population growth after 3 years. Those pastures with indices of 1.3 and up have shown increasing pronghorn populations.

YEAR-TO-YEAR DIFFERENCES FOR ALL PASTURES

The study area as a whole experienced both favorable and unfavorable environmental conditions during the time that the pronghorn stocking experiment was in progress. The variety of environmental conditions, closely tied to rainfall patterns, was fortunate from the point of view of the study, since it enabled us to distinguish the influence of weather from that of intrinsic pasture characteristics such as vegetational characteristics, ruggedness, and size. Data for rainfall, forb standing crop, fawn production and survival, and adult survival averaged over all pastures at each season for the duration of the study show these variations (Tables 9 through 12).

There were 2 dry periods during the course of the study, the first from the fall 1979 through the summer of 1980 (33% of the wettest corresponding period during the study), and the second from the fall of 1981 through the spring of 1982 (57% of the wettest corresponding period during the study). In between, the fall of 1980 was rather wet throughout the study area. Temperatures were well correlated with rainfall, with cooler temperatures occuring during wet seasons.

The general pattern of forb abundance is related to rainfall patterns, with forb standing crop during relatively dry winter and spring seasons being approximately 50% of forb standing crop during wet winter and spring seasons. The highest average summer forb standing crop occurred in 1981 which was the wettest summer. Fall forbs in 1981 were lower than that in 1980, reflecting fall but not summer rainfall. This is an indication of the

Table 8. Viability Indices for pronghorns on the 18 study pastures in east-central New Mexico, 1979-82

Pasture Number	Numbers Stocked (females)	Numbers at end of study		Viability Index
		females	fawns	
1-1	9	17	14	2.43
1-2	7	5	4	0.91
1-3	6	11	6	2.18
1-4	5	0	0	0.00
1-5	6	11	3	2.01
1-6	6	7	0	1.17
2-1	14	6	0	0.43
2-2	12	7	1	0.61
2-3	11	7	5	0.80
2-4	12	0	0	0.00
2-5	11	0	0	0.00
2-6	13	22	9	1.93
3-1	17	0	0	0.00
3-2	19	22	7	1.29
3-3	17	31	22	2.28
3-4	19	0	0	0.00
3-5	20	10	5	0.59
3-6	17	17	2	1.04

Table 9. Average rainfall in inches (cm) for 18 study pastures, 1979-82.[a]

Year	March - May	June - July	August	September - November
1979	2.69	1.99	2.49	0.88
	(6.83)	(5.05)	(6.32)	(2.24)
1980	1.17	1.06	2.72	2.66
	(2.97)	(2.69)	(6.91)	(6.76)
1981	2.08	4.69	4.56	1.61
	(5.28)	(11.91)	(11.58)	(4.09)
1982	1.10	2.33	2.78	3.68
	(2.79)	(5.92)	(7.06)	(9.35)

[a]Data not collected for December through February

Table 10. Average forb standing crop in lbs/acre (ka/ha) by season for 18 study pastures, 1979-82.

Dates	Spring	Summer	Fall	Winter
12/79-2/80	--	--	--	8.9
				(10.0)
3/80-2/81	10.9	26.1	100.5	26.1
	(12.2)	(29.2)	(112.6)	(29.2)
3/81-2/82	34.3	59.9	77.1	15.9
	(38.4)	(67.1)	(86.4)	(17.8)
3/82-9/82	21.7	31.8	65.1	--
	(24.3)	(35.6)	(72.9)	

Table 11. Annual fawn production and seasonal fawn survival averaged for 18 study pastures, 1979-82.

Dates	Max fawns/ female	Fawn Survival Rate			
		Summer	Fall	Winter	Spring
6/79-5/80	0.97	0.94	0.92	0.86	0.47
6/80-5/81	0.50	0.72	0.70	0.86	0.89
6/81-5/82	0.84	0.89	0.77	0.91	0.80
6/82-9/82	0.47	1.00	--	--	--

Table 12. Seasonal survival for yearlings and adults combined, for females and males, averaged for 18 study pastures, 1979-82.

Dates	Summer		Fall		Winter		Spring	
	f	m	f	m	f	m	f	m
6/79-5/80	.96	.97	.93	1.00	.91	.88	.95	.86
6/80-5/81	.89	.86	.79	.85	.94	1.00	.94	.98
6/81-5/82	.93	.92	.88	.91	.92	.99	.81	.90
6/82-9/82	.81	.79	--	--	--	--	--	--

importance of the timing of rainfall as well as the annual total.

DISCUSSION

FAWN PRODUCTION AND SURVIVAL

Several authors have documented the effects of predation upon production and survival of pronghorn fawns and upon increases or decreases of pronghorn herds (Einarsen 1948, Buechner 1950, Arrington and Edwards 1951, Udy 1953, Hailey 1979, and Neff 1979). These authors report that significant impacts can be made on fawn survival by coyotes and golden eagles, particularly when herds are relatively small in number. Coyotes should not have been responsible for many fawn losses in the study area as intensive predator control was carried out by U.S. Fish and Wildlife Service, Animal Damage Control personnel throughout the area during all years of the study. No attempt was made to estimate pronghorn losses to golden eagles although eagles were common in the area. One attack by a golden eagle on a yearling pronghorn was observed during a spring aerial survey in 1981.

Buechner (1950) and Hailey (1966) both reported on the effects of netwire fencing restricting movements of pronghorns to areas containing more favorable forage conditions in West Texas. These authors stated that restricted movement, particularly during periods of limited forage, would cause pronghorn herds to either decline in numbers or die off completely if poor forage conditions prevailed for several weeks. Drought, deep snow and over-grazing by livestock could contribute to the paucity of forage for pronghorns.

The 2 lowest average values for maximum observed fawn production occurred in 1980 and 1982 following the 2 dry winters. Fawn production in 1981 was almost double that in either 1980 or 1982, and followed the highest rainfall for the September through March periods. Interestingly, the largest observed value of fawns per female was the first year of the study, from stocked females pregnant when captured away from the study area. This may indicate that capturing, transporting and releasing operations were not detrimental to pregnant females.

Average fawn survival was reduced during the dry periods of the study. Survival of older animals also was slightly depressed during these same times, but fawns were more affected by poor conditions than adults. It should be noted that mortality of very young fawns was not observed in this study because the first overflight after fawning was in June. Thus, it is possible that actual fawn production was less variable than indicated by our data, and that differences in observed maximum fawns per female were due to increased mortality of newborn fawns during the 2 driest springs. However, young fawns were observed during June and July in all years of the study.

No single season was consistently critical for the survival of any population category. Instead, both plant production and pronghorn population trends in general were tied to variations in the amount and timing of rainfall for the study area as a whole.

VIABILITY INDEX

Pronghorn population trends across pastures over time were related to rainfall, as were differences among pastures in any one time. That result poses something of a problem with respect to selecting pastures for pronghorn

stocking, since advice to choose pastures that will have good rainfall would be accurate but not easily accomplished. Analyses were done using the Viabiltiy Index for each pasture as the dependent variable with a selection of independent variables that could reasonably be known before a pasture is stocked, such as pasture characteristics that remain constant over time, or other factors subject to planning, such as stocking rates.

The Viability Index indicates how pronghorn herds in the study pastures had fared after a series of favorable and unfavorable years, so it is a useful index to the suitability of the study pastures for pronghorns. Before the study began, half of the pastures were considered to be good habitat, and half poor. Using a dummy variate of 1 for pastures designated as good (group A) and 0 for those considered to be poor before the study started (group B), the correlation of assumed suitablility grouping with the viability indices at the end of the study was 0.27, indicating there was still something to be learned about suitable habitat for pronghorns.

The independent variables considered in regressions with the Viability Index for this first part of the data analyses for the study included such pasture characteristics as size, ruggedness index, and latitude. Additional factors from vegetation surveys were considered, namely general vegetation type, range site types, percent of climax species, basal cover of grasses, forbs, and shrubs, and estimated annual production under average conditions from SCS and the SVIM surveys. Of these factors, the ruggedness index was the most useful, with a correlation with Viability Index of -0.58, indicating that more rugged terrain is less suitable. All of the pastures with resource areas classified as Southern Desert had Viability Indices of at least 2.0, but also had low ruggedness indices. No relationship between viability and range site types was apparent. None of the other parameters from early vegetation surveys were useful predictors of viability.

There was 1 parameter measured in the later vegetation studies that was a useful predictor of viability in combination with ruggedness, namely the average number of forb species present during the fall. The number of forb species was greater in the fall than in other seasons, as was the forb standing crop. The number of fall forbs was closely associated with latitude for our study pastures, with more southerly pastures having greater forb diversity. The number of fall forbs is a parameter that could reasonably be determined before selecting pastures for future antelope stocking through a vegetation survey. The maximum potential number of forbs would follow appreciable late summer rains. A regresssion of Viability Index against ruggedness, pasture size, and fall number of forbs accounted for 63.6% of the variation observed in viability.

Anticipated stocking rates for cattle and sheep is another factor that could reasonably be estimated before deciding whether to stock pronghorn in a given pasture. Throughout our study, increasing antelope herds were not found to be compatible with sheep stocking rates greater than 10 animal units or 50 sheep per section. Sheep and cattle stocking rates for each season, averaged over the study, were all considered as variables for improving the regression of viability against ruggedness, size, and forb diversity in pastures. The addition into the model of average sheep densities in the fall increased the explained variation to 75.7%, resulting in the best regression found for evaluating pasture suitability for pronghorn stocking from a priori variables.

In the regression (Table 13), the variable for fall number of forbs enters with a positive coefficient, and the other variables for ruggedness index, fall sheep density, and pasture size, all have negative coefficients. In our study pastures, sheep densities tended to be higher on the more rugged pastures, compounding the unsuitability of rugged terrain for pronghorns. Large pasture size appears to be a disadvantage as well, but only after forb diversity, livestock, and ruggedness are taken into consideration. Larger pastures tended to have greater forb diversity, if only because they encompass a greater variety of range sites, and the increased diversity tends to offset the disadvantage of size per se.

Pasture size was a variable of great interest when this study was designed. The coefficient of pasture size (Table 13) indicates a slight disadvantage with increasing pasture size. However, the interpretation of the effect of pasture size is not straightforward for this study, since the medium-sized pastures were considerably more rugged on average than either the small or large pastures, and had lower average numbers of fall forbs and lower winter forb production than the other 2 size groups (Table 14). Large pastures tend to have greater forb diversity, which enhances suitability for stocking with pronghorn.

As noted previously, rainfall patterns were closely related to success of pronghorn populations in the study pastures. Adding the total rainfall from August through November to the regression of viability against a priori variables adds almost 10% to the percentage of variability explained by the regression. Table 15 shows the ranges and average values of the a priori variates and fall rainfall for pastures grouped according to Viability Index.

SEASONAL DIFFERENCES AMONG PASTURES

Vegetation and Physical Factors

Clear trends emerged from the first part of the analyses, namely consideration of the study data averaged over all pastures for each season, and averaged over all seasons for each pasture. The second part of the data analyses examined differences among pastures over the duration of the study, without any lumping or averaging of data points. Pronghorn production and survival were considered with respect to environmental factors associated with the observed changes in the study herds. The resulting picture was somewhat more complicated than the general trends

The importance of rainfall patterns to pronghorn population trends has been indicated previously. The impact of rainfall is expressed through the relationship between rainfall and vegetation, or food availability for pronghorns. Analysis of vegetation data will concentrate on forbs, since fecal analysis studies clearly have shown the dominance of forbs in pronghorn diets. The particular forb species with the highest importance values from the fecal analysis are called preferred forbs. The preferred forb list can be separated into 2 groups, with the first group having the highest importance values and referred to as Preferred Forbs I. Total Preferred Forbs refers to both groups combined.

The sampling design for the study allowed the analysis of several variables related to forbs for each season, including total forb standing crop, Preferred Forbs 1, Total Preferred Forbs standing crop, and number of

Table 13. Results of the best regression of Viability Index for pronghorns against *a priori* variables for 18 study pastures

Dependent variable: Viability Index	
Independent variable	Coefficient
Ruggedness index	-0.00562
Pasture size in sections	-0.06751
Ave. fall number of forb species	0.10642
Ave. fall sheep, animal units/section	-0.05931
Intercept	1.08170
Regression	
Degrees of freedom	4
Sum of squares	9.66675
Mean	2.41668
Error	
Degrees of freedom	13
Sum of squares	3.09569
Mean	0.23813
Standard error of estimate	0.43986
F-value	10.14
Multiple R squared	75.7

Table 14. Comparison of the pasture size-groups with respect to other selected parameters.

Variable	Average for pastures in size groups		
	Small	Medium	Large
Size (sections)	4.8	8.6	12.3
Ruggedness index	48.5	83.7	51.7
Fall number of forbs	12.2	9.2	14
Winter total Forbs in lbs/acre (kg/ha)	21 (23.5)	11 (12.3)	17 (19.0)

Table 15. Average values and ranges of selected parameters for 18 study pastures grouped according to suitability for pronghorns.

Average (range)	Pasture group		
	Herd increased	Herd Stable	Herd declined
Viability	2.02	0.98	0.20
Index	(1.29 - 2.43)	(0.80 - 1.17)	(0 - 0.61)
Size in	7.9	7.2	9.8
sections	(3.9 - 13.3)	(3.9 - 12)	(6 - 14.9)
Ruggedness	42.3	48.3	82.0
index	(28 - 65)	(31 - 80)	(38 - 131)
Fall forb	15.3	10.5	9.8
numbers	(10.3 - 20.3)	(8 - 12)	(5.3 - 16)
Fall sheep	2.3	7.7	10.9
AU/section[a]	(0 - 7.6)	(3.4 - 9.4)	(3.4 - 24.2)
Fall rain	5.28	5.65	4.62
in inches	(3.99 - 6.73)	(4.67 - 6.68)	(1.78 - 6.20)
Spring total preferred			
Forbs	17.50	10.45	4.80
lbs/acre	(4.40 - 33.17)	(6.47 - 20.67)	(0.20 - 9.70)
kg/ha	(4.93 - 37.15)	(7.25 - 23.15)	(0.22 - 10.86)

[a]One animal unit = 5 sheep.

forb species, a simple measure of diversity. Data on these parameters were available from each pasture in the study for each season during the study, beginning with the winter of 1979-80. Rainfall, especially in late summer and fall, was associated with higher total forbs, Total Preferred Forbs, and number of forb species. In addition to rainfall, ruggedness (negative coefficient, or lower plant standing crop for more rugged terrain), and latitude (higher plant standing crop toward the south) were consistently important variables in regressions with vegetation parameters as the dependent variable. Pasture size was usually a significant variable as well and generally entered with a positive coefficient. The tendency for larger pastures to have higher average plant standing crop may be related to the likelihood of greater diversity in the larger areas with an increased chance of a more productive site. Physical factors alone generally accounted for 25 - 55% of the variation observed in forb standing crop between pastures in each season.

In examining vegetation data from each pasture for each season, using observations from all years for that season, the various forb parameters did not vary in the same way. Standing crop of Total Preferred Forbs and total forbs were similar in the spring and summer, but less so in the fall and winter. Ice cream forbs and Total Preferred Forbs were most similar in the fall and least similar in the spring. The numbers of forb species and total forb standing crop were unrelated in the fall, but similar in other seasons. It is apparent that the forb parameters provide different information at different times during the year, and that no single forb parameter consistently represents any of the others throughout the year.

Livestock and Vegetation

The vegetation data for this study were measurements of standing crop, but did not account for growth, consumption, and other physical losses between sampling periods. The total amount of plant material actually available to livestock and pronghorns differed from the measured standing crop. Thus, it was not surprising that livestock, particularly sheep, density sometimes entered as a significant variable in predicting vegetation crops measured in the various pastures. For regressions with winter Total Preferred Forbs as the dependent variable, winter sheep density was the first variable to enter in a forward stepwise regression procedure. This indication of the impact of livestock on vegetation was reinforced by the fecal analysis results which showed overlap in use between livestock, particularly sheep, and pronghorns for forbs.

Another useful perspective on the competition for food between pronghorns and livestock is comparison of the food requirements for cattle and sheep in the different pastures at specific times with the availability of food as indicated by vegetation standing crop for the same season. Forbs were chosen for the comparison because of their importance in pronghorn diets.

Average daily forb intake for young and adult cattle, sheep, and pronghorns for each season was calculated (Table 16). The seasonal weight estimate for adults are based on information for range animals in New Mexico for each month (based on conversations with J. Sachse, J. Knight, and L. Foster, Extension Service, New Mexico State University) (see Table 16). Daily dry matter consumption as a percentage of body weight was based on information from range animals for cattle and sheep, and on information for goats of sizes

Table 16. Calculated seasonal forb consumption by cattle, sheep, and pronghorns.

	Cows				Calves			
	Sum	Fall	Win	Spr	Sum	Fall	Win	Spr
Weight (lbs)	875	925	975	900	140	350	500	700
(kg)	(398)	(420)	(443)	(409)	(64)	(159)	(227)	(318)
Daily intake %	2.2	2.0	1.8	2.0	2.4	2.2	2.0	2.2
% of forbs	21	31	14	17	21	31	14	17
Forbs consumed lbs/day	4.04	5.74	2.46	3.06	0.71	2.39	1.40	2.62
(kg)	(1.84)	(2.61)	(1.12)	(1.39)	(0.32)	(1.09)	(0.64)	(1.19)
	Ewes				Lambs			
Weight (lbs)	128	133	136	140	30	70	100	120
(kg)	(58)	(60)	(62)	(64)	(14)	(32)	(45)	(56)
Daily intake %	2.4	2.4	2.4	2.4	2.6	2.6	2.6	2.6
% forbs	48	58	44	44	48	58	44	44
Forbs consumed lbs/day	1.47	1.85	1.44	1.48	0.37	1.06	1.14	1.37
(kg)	(0.67)	(0.84)	(0.65)	(0.67)	(0.17)	(0.48)	(0.52)	(0.62)
	Pronghorn				Fawns			
Weight (lbs)	97	100	102	105	22	52	75	90
(kg)	(44)	(45)	(46)	(48)	(10)	(24)	(34)	(41)
Daily intake %	2.6	2.6	2.6	2.6	2.8	2.8	2.8	2.8
% forbs	82	75	69	70	82	75	69	70
Forbs consumed lbs/day	2.07	1.95	1.83	1.91	0.51	1.09	1.45	1.76
(kg)	(0.94)	(0.89)	(0.83)	(0.87)	(0.23)	(0.50)	(0.66)	(0.80)

similar to pronghorn (estimates provided by J. Holechek, Range Ecology, New Mexico State University). The percentage of forbs in the diet of each species was based on data from the fecal analysis portion of this study. For young animals, the same seasonal percentage of forbs in the diet as for adults was used, but weights were lower while daily intake as a percentage of body weight was higher than for adults. The results are considered to be a working estimate of demand on forbs by livestock for the study pastures.

For each pasture in each season of our study, the total forb demand by cattle and sheep combined for the whole season was calculated from stocking rates for that season, partitioned into young and adult animals, daily consumption of forbs for 91 days per season, and pasture size. The resulting forb demand by livestock in lbs/acre/season was compared to measure forb standing crop in lbs/acre/season. The resulting surplus of available forbs over forb demand by livestock (Table 17) shows that forb surplus was largest in the fall when forb production was greatest. Demand for forbs was sometimes greater than forb availability, particularly during the winter and spring of the dry periods of 1979-80 and 1981-82.

The surplus of forb availability over demand by cattle and sheep was correlated with total forb standing crop for each season. When the average seasonal forb surplus over all years for each pasture was examined with respect to the Viability Index for each pasture, the correlation between viability and average spring forb surplus was 0.62, of larger magnitude than the correlation between viability and ruggedness. The data indicate that the amount of available forbs is a significant factor in explaining the population trends for pronghorns in the study pastures

The impact of the availability of forbs on pronghorn viability was illustrated by the different trends on the 3 adjacent pastures in the study, pastures 3-2, 3-5, and 3-6. All are large pastures located in the northwest portion of the study area and are similar in terms of ruggedness index, rainfall patterns, and general vegetation type. However, pronghorns in pasture 3-2 almost doubled the pool of breeding females, while populations in the other 2 pastures declined or stayed the same. While total forb production was not very different in the 3 pastures, the average number of fall forbs in pasture 3-2 was 17, compared to 12 and 11 for the other pastures. Additionally, average fall sheep stocking rate was only 3.8 animal units (19 sheep per section in pasture 3-2 with the increasing pronghorn herd, in comparison with 12.3 and 9.3 animal units (62 and 47 sheep per section in pastures 3-5 and 3-6.

Fawn Production by Pasture

The pattern of fawn production by pasture for each year was similar to that averaged over all pastures because of the importance of rainfall. Considering fawn production for each pasture for each of the 4 fawn crops of the study, spring rain alone accounted for about 15% of the observed variation. Inclusion of the variables for ruggedness and latitude increased the fraction of variation accounted for to 32%. Only those variables were available for analyses of data including the 1979 fawn crop, since vegetation studies did not begin until the winter of 1979-80. More detailed information was available on environmental conditions before and during the birth of the later 3 fawn crops produced during the study. Data on forbs, livestock, forb surplus, and pronghorn diets were examined. Single factors with correlation

Table 17. Seasonal forb surplus calculated as forb standing crop minus seasonal forb demand by cattle and sheep (lbs/acre).

Pas-ture	Win 79-80	Spr 80	Sum 80	Fal 80	Win 80-81	Spr 81	Sum 81	Fal 81	Win 81-82	Spr 82	Sum 82	Fal 82
1-1	5	6	29	38	19	41	75	109	36	58	62	126
1-2	-10	-9	10	86	10	24	50	162	-8	-8	37	29
1-3	8	15	18	43	52	66	169	65	20	16	30	44
1-4	25	-1	12	70	--[a]	--	--	--	--	--	--	--
1-5	-10	-1	24	82	3	7	61	28	0	4	24	22
1-6	23	3	12	38	-6	-2	16	32	-8	-6	-6	1
2-1	-11	-1	10	5	-3	2	6	176	-10	3	-7	102
2-2	-11	-2	0	85	14	11	22	31	-14	-6	24	55
2-3	11	-7	10	73	33	43	24	90	21	27	13	155
2-4	-12	1	38	172	--a	--	--	--	--	--	--	--
2-5	-12	-1	11	102	0	3	9	64	1	-7	15	27
2-6	-3	5	10	77	27	43	51	17	12	8	27	44
3-1	-3	0	-3	68	--[a]	--	--	--	--	--	--	--
3-2	-7	5	41	52	21	-2	12	38	-5	20	8	32
3-3	-3	13	13	279	85	103	130	62	37	42	33	76
3-4	25	-5	23	163	1	14	82	81	9	-6	--	--
3-5	-8	2	13	38	1	9	30	8	6	21	44	24
3-6	-2	7	-7	83	4	11	26	8	-7	6	19	24

[a]Dropped from study due to low pronghorn numbers in the pasture.

coefficients with maximum observed fawns per female of absolute value greater than 0.35 (Table 18) were useful indicators of fawn production for fall, winter, and spring. The standing crop of Preferred Forbs I, and Total Preferred Forbs were related to fawn production. However, the number of forb species in a pasture was more closely related to fawn production than the availability of preferred forbs. Several vegetation parameters were better than rainfall alone in indicating fawn production. Sheep density and forb surplus in the winter and spring also were important. Note that spring variables may be significant for newborn fawn survival as well as fawn production. Since fawns were not observed until June in this study, our measurement of fawn production actually represents a combination of fawn production and early survival. Fawns dying before the June overflight would not have been included in our production estimate.

The factors of ruggedness, pasture size, and latitude together account for approximately 30% of the variation in fawn production among pastures over the last 3 years of the study. The addition of fall and spring rainfall increases the fraction of explainable variation to 44%, and the addition of sheep density during the fall, winter, and spring increases it to 56%. Vegetation information was not available for the fall prior to the birth of the 1980 fawn crop, but that information is probably picked up adequately by fall rainfall which was closely related to fall plant production in the years when both was measured. Rainfall data produced better regressions for fawn production than vegetation parameters alone, and addition of sheep stocking rates improved both sets of regressions. In general, higher fall and spring rainfall has been associated with higher fawn production, and higher sheep densities with lower fawn production. The addition of winter and spring forb surplus (available forbs minus livestock forb requirements), resulted in the regression presented in Table 19, in which coefficients for rainfall and forb surplus were positive, coefficients for sheep density were negative, and a substantial amount of the observed variation was explained.

Seasonal Survival Rates by Pasture

The pattern of seasonal pronghorn survival rates by pasture was not as closely related to the pattern averaged over all pastures as was the case for fawn production. The analysis of survival with respect to environmental variables focused on the fawn segment of each population, since fawn seasonal survival pattern was similar to that of adults, but with a greater variation in survival rates at any given time. No single factor was very closely related to fawn survival in the summer, fall or winter, but in the spring the correlation between fawn survival and sheep density was -0.46, and the correlation with percentage of forbs in pronghorn diets was 0.36. Correlations were run on data from each pasture each year for a given season.

Using the variables for ruggedness, rainfall, seasonal forbs, preferred forbs, numbers of forbs, livestock densities and forb surplus, it was possible to account for only 40% of the variation in fawn survival for each season. Again, analysis was based not on averages over years, but on data from all pastures and all years for each season. Fall variables were better predictors of winter fawn survival than were winter variables, again indicating the importance of fall rains and plant production for successful pronghorn herds. Ruggedness of the pasture was a consistently negative factor, as was sheep density. Inclusion of the variable for seasonal forb surplus was a significant improvement over either livestock rates or forb parameters alone.

Table 18. Largest correlation coefficients of single parameters for pastures with pronghorn fawn production for 1979-82.

Fall parameters:

0.43 Total Preferred Forbs

0.36 Preferred Forbs I

0.37 Rainfall

Winter parameters:

0.39 Forb Surplus

0.41 Total Preferred Forbs

-0.44 Sheep Density

0.43 Number of Forb Species

0.36 Preferred Forbs I

Spring parameters:

0.41 Forb Surplus

0.38 Total Preferred Forbs

0.47 Number of Forb Species

Table 19. Results of best regression of maximum observed fawns per female against environmental parameters from the fall, winter and spring before and during fawning, 1980-82.

Dependent variable: fawn production	
Intercept: -0.00389	
Independent variables:	Coefficients
ruggedness index	-0.00070
pasture size in sections	0.03623
latitude index	0.05170
rainfall Sept. - Nov.	0.12423
rainfall March - May	0.06956
fall sheep density	-0 01436
winter sheep density	-0.00775
winter forb surplus	0.00328
spring forb surplus	-0.00881
Regression	
Degrees of freedom	10
Sum of squares	5.49887
Mean	0.54983
Error	
Degrees of freedom	35
Sum of squares	3.62521
Mean	0.10357
Standard error of estimate	0.28703
F-value	5.30
Multiple R squared	60.2

Population Declines

During the course of the study, pronghorn herds abandoned or died out in 5 of the study pastures. An examination of the environmental conditions in each of those pastures during the times of rapid population decline serves to reinforce the importance of ruggedness, rainfall, and sheep densities to fenced pronghorn herds.

The pronghorn herd in pasture 3-1 declined very abruptly during the winter of 1979-80, and the herd in pasture 1-4 declined during the following spring and summer. The period from fall 1979 through early summer 1980 was dry throughout the study area, but rainfall was even lower for these pastures than for the rest of the study area The population in pasture 2-4, the most rugged pasture in the study, was lost when the animals jumped a cattle guard to enter an adjoining less-rugged pasture. The second most rugged pasture in the study group was pasture 2-5, where the pronghorn population declined slowly beginning in the summer of 1981 and was lost entirely during the second dry period in the spring of 1982. The population in pasture 3-4 declined rather rapidly in the winter and spring of 1982, coinciding with almost doubled sheep stocking rates. Through the summer of 1981, sheep stocking rates in pasture 3-4 varied from 10 to 20 AUs/sect (50 to 100 sheep/sect) (26 to 13 ha/AU), but by winter 1982 had been increased to 35 or 36 AUs/sect (7.4 to 7.2 ha/U) or 165 to 170 sheep per section. During the winter or spring before the decline of each of these populations, forb demand by livestock exceeded forb availability.

Stocking Density

In examining the data from this study, the question of optimal stocking densities for starting new pronghorn herds has arisen. This study was not designed to answer that question, since all pastures were initially stocked at the same density of approximately 2 pronghorns/section (130 ha/pronghorn. However, some partial conclusions can be drawn. First, 2 pronghorns/section (130 ha/pronghorn) is certainly a sufficient stocking density, since some of the herds in the study pastures increased very well from that starting point. Second, this study has not produced any evidence that higher stocking rates would be detrimental, since those herds that have done well have continued to increase in density. The herds that have declined can be explained without invoking density dependent declines. An initial stocking rate of 2 pronghorns/section (130 ha/pronghorn) certainly seems adequate; a higher initial pronghorn stocking rate would be acceptable biologically, but possibly not economically, since transplanting pronghorns is not a trivial procedure. However, results of this study indicate that anticipated sheep density, particularly stocking rates greater than 10 to 12 AUs/section (50 to 60 sheep/sect) (26 to 22 ha/AU), is a far more significant factor for pronghorn herd viability than is initial pronghorn density.

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COMMENTS AND QUESTIONS

QUESTION - What's the distance of the transplants?

HOWARD - About 300 to 350 miles. What I would like to inquire about in your transplant is, you did it in March. Isn't that late, putting a lot of stress on pregnant females?

RESPONSE - Yes, I would agree. There was quite a bit of capture myopathy on that transplant.

HOWARD - On these transplants we lost only 7 head of 300 moved.

QUESTION - In the book, The Elk of North America, there are some pretty good models for optimizing stocking ratios for herbivores. What kind of potential do you think they have for optimizing ratios of pronghorns and cattle or sheep?

HOWARD - It depends on the rainfall regime. One that would apply in one place may not work at all in other. The model that Dr. Hammond built is totally different from one she built for Wyoming.

QUESTION - While the factors in the model would be different, would the model itself be different?

HOWARD - Probably not. The weights of the factors would be different but the factors themselves would be similar.

COMMENT - In our transplant, two of the does that were injured the most in the transplant had fawns the following year.

HOWARD - In our transplant the highest reproduction was on the pure grassland. The ones handled and stressed in February did better that year than the succeeding year. Of course, when you're handling them fairly early in pregnancy you don't have stress problems you might have with animals handled later.

A STUDY OF PRONGHORN RANGE IN SOUTHWESTERN NORTH DAKOTA

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ABSTRACT

The location and extent of pronghorn (Antilocapra americana) habitat in southwestern North Dakota was mapped with the use of remote sensing techniques. Vegetative composition of the study area was characterized and compared to pronghorn range in other areas of the United States and Canada.

INTRODUCTION

This study was initiated for 2 main reasons:

1. North Dakota's pronghorn population has been undergoing a considerable state of flux in the past 2 decades and its future appears uncertain (Samuelson 1982).

2. With 1 exception (McKean 1953), there has been no research conducted on pronghorn habitat in North Dakota.

The area chosen for study was one of North Dakota's 3 pronghorn management units (Badlands Pronghorn Management Unit), which contains about 65% of the state's pronghorn population (Samuelson 1981). The vegetation of the area has been classified as mixed prairie in which wheatgrass (Agropyron) and needlegrass (Stipa) are the most prevalent.

METHODS

A multi-stage approach, incorporating remotely sensed data (aerial photography, Landsat imagery, Landsat digital data) and ground-truth data, was used in analysis of pronghorn habitat (grassland). Spectral characteristics corresponding to study site coordinates were analyzed. Remote sensing analyses were conducted at the University of North Dakota's (UND) Institute of Remote Sensing using the UND mainframe computer and various software packages. Vegetative data (ground-truthing) were gathered using the microplot method (Daubenmire 1959) and the Braun-Blanquet releve technique (Mueller-Dombois and Ellenberg 1974). Data for percent ground cover types were collected in 1981. Releve data were collected in 1981 and 1982. Vegetative data were analyzed using a statistical package (SAS 1982), an ordination technique (Hill 1979), and an analysis of variance program (Nie et al. 1975).

RESULTS

GRASSLAND MAPPING

A computer-generated grassland cover map was produced that depicted the location and extent of grassland in the study area. Although the map is too large to be shown here, amounts of grassland identified on the map are

displayed in Table 1. An initial intention of this study was to distinguish grassland quality as well as quantity. Three types of grassland recognized by visual assessment of study sites (native prairie, native prairie with 5-25% scattered sagebrush, and tame grass pasture), however, were not found to differ significantly enough on the basis of their spectral characteristics. Therefore, all three types were combined under the general term "grassland."

VEGETATIVE GROUND COVER PERCENTAGES

The percentage of biotic ground cover for study sites ranged from 22% to 55% (figures revised from Jatnieks-Straumanis 1983), with the average value being 37%. Percentages for the various vegetative ground cover types for the study area are compared to pronghorn range in other parts of the United States and Canada (Table 2). As mentioned above, these values represent native prairie (NP) and native prairie with 5-25% scattered sagebrush (SS) sites combined.

PLANT SPECIES DIVERSITY

Species diversity for study sites is compared to pronghorn range in other parts of the United States and Canada (Table 3). Although analysis of 1981 releve data (total of 68 samples) by an ordination technique indicated a significant difference between species composition of NP sites and SS sites (Jatnieks 1982), this was not the case with 1982 releve data. Analysis of 1982 releve data (total of 136 samples) yielded no significant differences between NP sites, SS sites and tame grass pasture (TP) sites. One reason for these results could be the disproportionate numbers of the 3 grassland types used in the analysis; 101 NP, 12 SS, and 23 TP sites. Although sample numbers were skewed in favor of NP sites, they reflected proportions of the 3 grassland types as they appeared on the grassland cover map. The ordination technique revealed somewhat of a segregation between NP and SS sites, but this could not be attributed to species presence or abundance. The factors responsible for this slight segregation (perhaps differences in soil characteristics between sites) were not determined. Analysis of species diversity implies that the presence, absence, or abundance of certain species (i.e., native grasses, sagebrush, and tame grasses) on a particular site is not a good indicator of the overall species composition found on that site.

DISCUSSION

When the grassland cover map is compared to Landsat images it becomes apparent that the remote sensing techniques used underestimate the amount of grassland in the study area. Reasons for this phenomenon include the following:

1. Topography - the terrain of the study area, although containing gently rolling grassland, is interrupted by a variety of features whose spectral characteristics differ from those of grassland. These features include drainage systems, rocky outcrops, and areas of bare ground.

2. Resolution of the remote sensing system used in this study was approximately 0.44 hectares. This large data cell size, combined with the phenomenon of interrupted terrain, caused miscalculation of grassland.

Table 1. Extent of grassland cover in the Badlands Pronghorn Management Unit, ND.

County	Total Area* of County (km^2)	Total Area in Grassland (km^2)	Percent of Area in Grassland
McKenzie	4,262	525.8	12.3
Dunn	819	66.4	8.1
Golden Valley	2,599	242.1	9.3
Billings	2,458	332.7	13.5
Stark	123	9.1	7.4
Slope	2,048	397.3	19.4
Bowman	1,843	203.0	11.0
TOTAL	14,152	1,776.0	12.5

* Total area of county located within the study area boundary.

Table 2. A comparison of vegetative ground cover between Badlands Pronghorn Management Unit (BPMU) and mixed grassland and sagebrush-grassland communities.

Cover Type	(BPMU)*	Mixed Grassland	Sagebrush-Grassland
Shrubs	0-22%	1-19%	5-30%
Forbs	4-27%	1-19%	10-30%
Grasses	54-96%	26-88%	30-40%

Mixed Grassland = results from Wetland 1968, Campbell 1970, Mitchell and Smoliak 1971 and Mitchell 1980.

Sagebrush-Grassland = results from Yoakum 1974, 1980.

* Figures revised from Jatnieks-Staumanis 1983.

Table 3. A comparison of plant species diversity between Badlands Pronghorn Management Unit (BPMU) and mixed grassland and sagebrush-grassland communities.

Cover Type	(BPMU)	Mixed Grassland	Sagebrush-Grassland
Shrubs	7	2-7	5-10
Forbs	54	10-34	10-50
Grasses	15	10-16	5-10

Mixed Grassland - Wentland 1968, Campbell 1970, Mitchell and Smoliak 1971 and Mitchell 1980.

Sagebrush-Grassland = Yoakum 1974, 1980.

This problem of underestimation may be diminished in future studies due to the fact that more recently launched satellites have a resolution of 0.11 hectares.

The diversity of plant species in the study area is within or above preferred values for pronghorn range elsewhere. Considering percentages of ground cover types, values for the study area are comparable to those for mixed-grass range in neighboring areas of Montana and Alberta. Compared to range in the sagebrush-grassland biome, however, the study area contains less shrub cover and considerably more grass cover. This paucity of shrub cover may be a limiting factor in determining the number of pronghorn North Dakota's range can support.

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WYOMING'S RED RIM PRONGHORN CONTROVERSY: HISTORY AND CURRENT STATUS

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ABSTRACT

The Red Rim area, a crucial pronghorn (Antilocapra americana) winter range in south-central Wyoming, has been the focal point of one of the state's most controversial wildlife issues for the past 7 years. The complex biopolitical issues surrounding this controversy can be separated into 6 general categories including: (1) crucial pronghorn winter range, (2) fencing, (3) application of mining suitability criteria to Federally-controlled surface through the Surface Mine Control and Reclamation Act (SMCRA), (4) decisions concerning privately-owned coal through the petition process, (5) leasing of coal, and (6) mineral extraction and reclamation technologies. This paper describes pronghorn numbers and distributions on Red Rim from 1977 to 1984. Discussions of the winter range's importance to pronghorn and important areas within the winter range are presented. Criterion 15 of SMCRA, which examines the suitability of leasing minerals on critical wildlife areas, is discussed as it applies to Red Rim.

INTRODUCTION

In Wyoming and other western states, viable pronghorn antelope populations have been re-established and maintained primarily because of the widespread availability of suitable habitats (Einarsen 1948, Russell 1964, Sundstrom et al. 1973, Mitchell 1980, and Smith and Beale 1980). Recent increases in energy exploration and surface mineral extraction threaten to alter or progressively remove larger portions of these habitats if wise resource management policies are ignored. When massive development projects occur on crucial habitats, especially traditional winter ranges, the future maintenance of free-ranging pronghorn populations will be difficult to achieve.

The Red Rim area in south-central Wyoming contains approximately 69.3 million tons of recoverable bituminous coal (Wyoming Department of Environmental Quality and U.S. Office of Surface Mining 1983), but has also been designated as crucial pronghorn winter range (Wyoming Game and Fish Department 1981). A major controversy surrounds the land use decision which would either lease Red Rim for coal development or preserve it as crucial winter habitat for pronghorns. The biopolitical issues involved in this controversy are complex, but can be divided into 6 general categories. These include: (1) crucial pronghorn winter range, (2) fencing, (3) application of criteria to Federally-controlled surface through the Surface Mine Control and Reclamation Act (SMCSA), (4) decisions concerning privately-owned coal through the petition process, (5) leasing of coal; and (6) mineral extraction and reclamation technologies.

Because several of those 6 categories are extremely involved and would require great length to adequately explain, we will limit our discussion to 3 major topics. First, we present data showing the most valuable parts of the winter range complex, including results of intensive monitoring of pronghorn numbers and distributions in the Red Rim area from 1977 through 1984. Second, a new 150 cm-tall woven wire fence surrounding the area is related to pronghorn distributions and mortality during the present winter. Also, Federal Criterion 15, which examines the suitability of leasing minerals on critical wildlife habitats, is discussed as it applies to the Red Rim situation.

STUDY AREA

The 10,240 ha Red Rim winter range lies approximately 19 km southwest of Rawlins, Wyoming, in Carbon and Sweetwater Counties. The area is within the Wyoming Game and Fish Department's Antelope Hunt Area 55 and Baggs Antelope Data Analysis Unit (DAU). All of the winter range consists of alternating square mile sections of public and private land.

Red Rim is part of the semi-arid Red Desert with mean daily temperatures ranging from -5.6 C in January to 20.0 C in July (U.S. Bureau of Land Management 1976). Average annual precipitation is 22.5 cm, most of which occurs as snow during February and March.

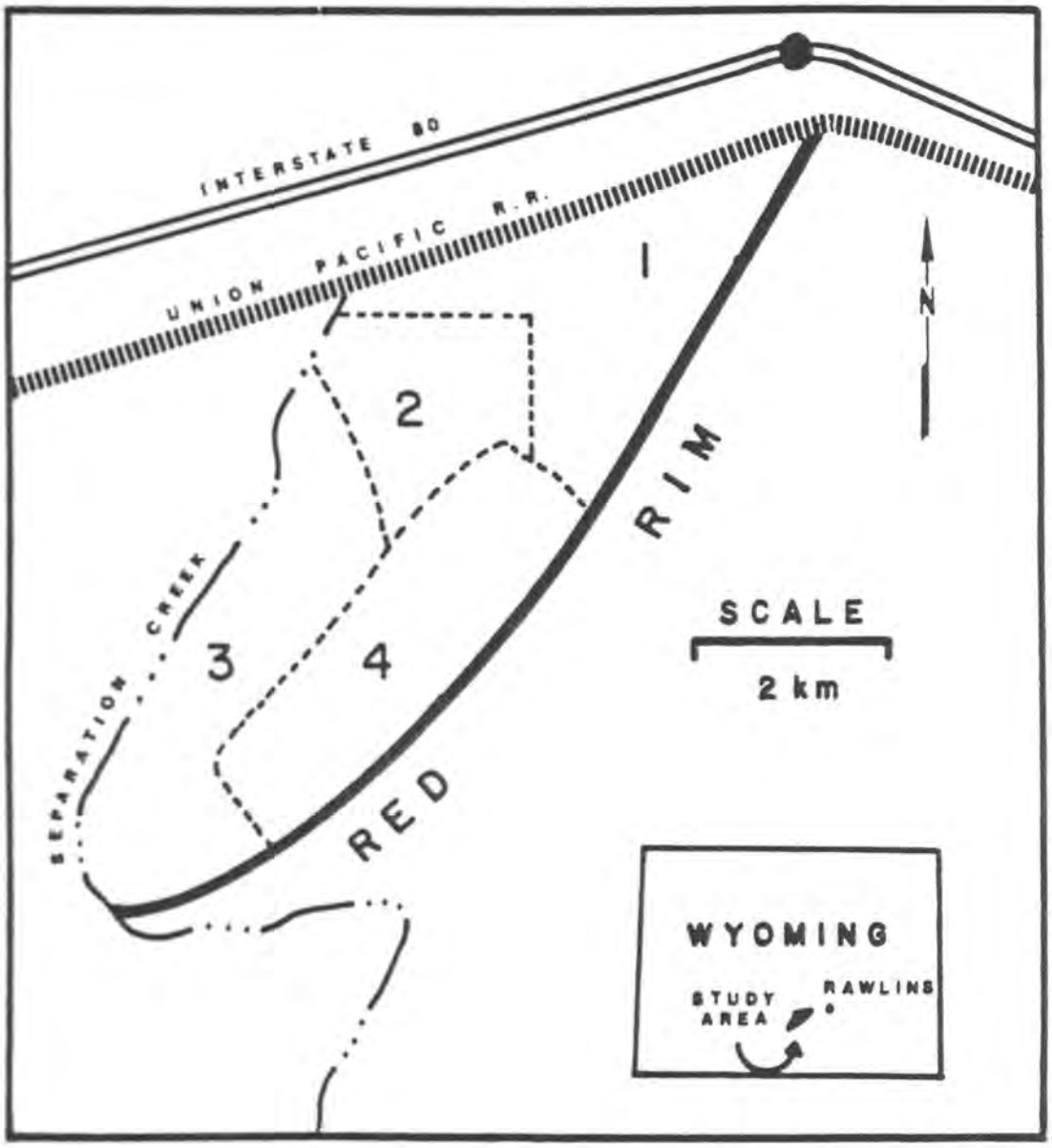
The area's value as pronghorn winter range arises from the uplifted geologic formations exclusive to Red Rim. The crest of Red Rim, the most prominant topographic feature, is a northeast-southwest escarpment averaging 30 m in relief and forming the eastern border of the winter range. Elevations range from 2,099 m in the north to 2,286 m in the south.

Four distinct habitat associations occur within the winter range (Figure 1). Northeastern portions of Red Rim (Area 1) consist of rolling topography and a mixture of big sagebrush (Artemisia tridentata) - wheatgrass (Agropyron sp.) and black greasewood (Sarcobatus vermiculatus) - saltbush (Atriplex sp.) habitats. Northwest of Red Rim (Area 2) the terrain becomes relatively flat. Vegetation in this area consists of greasewood - saltbush - big sagebrush associations. A major draw along Separation Creek, an ephemeral stream, constitutes Area 3. Sides of the draw contain big sagebrush - rabbitbrush (Chrysosthamnus sp.) - wheatgrass habitats. Vegetation along the creek is primarily a greasewood - big sagebrush mixture with scattered willows (Salix sp.). Elevated portions of Red Rim (Area 4) consist of numerous ridges and benches dissected by steep draws. Draws are predominantly big sagebrush - grass while ridges and benches contain scattered stands of various mountain shrubs including Saskatoon serviceberry (Amelanchier alnifolia), antelope bitterbrush (Purshia tridentata) and true mountain mahogany (Cercocarpus montanus).

METHODS

Pronghorn numbers and distributions within the Baggs Antelope DAU were determined by Wyoming Game and Fish Department and U.S. Bureau of Land Management aerial counts during the winters of 1977-78, 1978-79, 1979-80, 1982-83 and 1983-84. All groups observed that were too large to accurately

Figure 1. The Red Rim crucial pronghorn winter range in southcentral Wyoming showing 4 distinct habitat associations occurring in the area. 1 = Northeast portion of Red Rim, 2 = Greasewood-saltbush Flat, 3 = Separation Creek Area, 4 = Crest of Red Rim. See text for descriptions of each habitat association.



count from the air were photographed for later assessment. Observer visibility biases were calculated and pronghorn estimates were adjusted accordingly (Moody 1983).

During the winters of 1980-81 and 1981-82, pronghorns were observed from the ground within the Red Rim winter range as part of a 3-year graduate research project by the senior author. Weekly counts were conducted along a 90 km route. The presence of 20-25 marked animals on the winter range (Irwin et al. 1984) helped reduce duplicate pronghorn observations. To test the compatibility of air and ground counts, simultaneous surveys were conducted on 11 February 1982. Also several ground counts and monthly aerial surveys were very similar, often within 25 animals. Because all results were similar, we used data from both techniques.

Pronghorn distributions determined from ground counts were mapped in relation to the 4 distinct habitat associations within the winter range to evaluate important concentration areas. In addition, total numbers and distributions of pronghorns observed during the 7 winter periods were related to overall winter severity each year to determine changes in abundance on Red Rim and distributions within the Baggs DAU during varying climatic conditions.

RESULTS

Weather severity varied widely among the 7 winters we compared. The winter of 1980-81 was extremely mild with low snowfall and above normal temperatures (Ryder 1983). In contrast, the winter of 1983-84 has been one of the harshest on record. Deep, widespread snow cover and sub-freezing temperatures have persisted across the Baggs DAU since late-November. Of the 7 winters examined, 2 (1980-81 and 1981-82) were considered mild, 3 (1977-78, 1979-80 and 1982-83) were average and 2 (1978-79 and 1983-84) were severe.

During mild or average winters, pronghorns within the DAU were distributed among 4 major winter ranges: the Red Rim area, the China Butte area, the Creston Junction - Cherokee Hill area and the Rawlins - Hogback Lake area (Figure 2). Snow cover was less extensive in these winters, but a wide "snow belt" developed and separated northern and southern segments of the herd, restricting major north-south movements.

Pronghorn were restricted to the Red Rim and China Butte crucial winter ranges during the severe winter of 1978-79 (Figure 3). Again, the "snow belt" barred major north-south movements between wintering areas after mid-December 1978.

Numbers of pronghorns utilizing the Red Rim winter range have varied with winter severity. During the 5 mild or average winters, 1,000-1,600 animals were observed on the winter range (Table 1). During the severe 1978-79 winter, 2,000 - 2,800 pronghorn inhabited the area. Large numbers observed during the average winter of 1982-83 probably resulted from a high pronghorn population in the entire Baggs DAU.

Pronghorns within the Red Rim winter range were not randomly distributed. Separation Creek and the Crest of Red Rim (areas 3 and 4) constituted approximately 50% of the winter range, but contained 75-80% of the pronghorns observed during the winters of 1978-79 through 1981-82 (Irwin et

Figure 2. Winter pronghorn distributions in the Baggs Pronghorn Data Analysis Unit during mild or average winter conditions. 1 = Creston Junction - Cherokee Hill Area, 2 = Red Rim Area, 3 = Rawlins - Hogback Lake Area, 4 = China Butte Area.

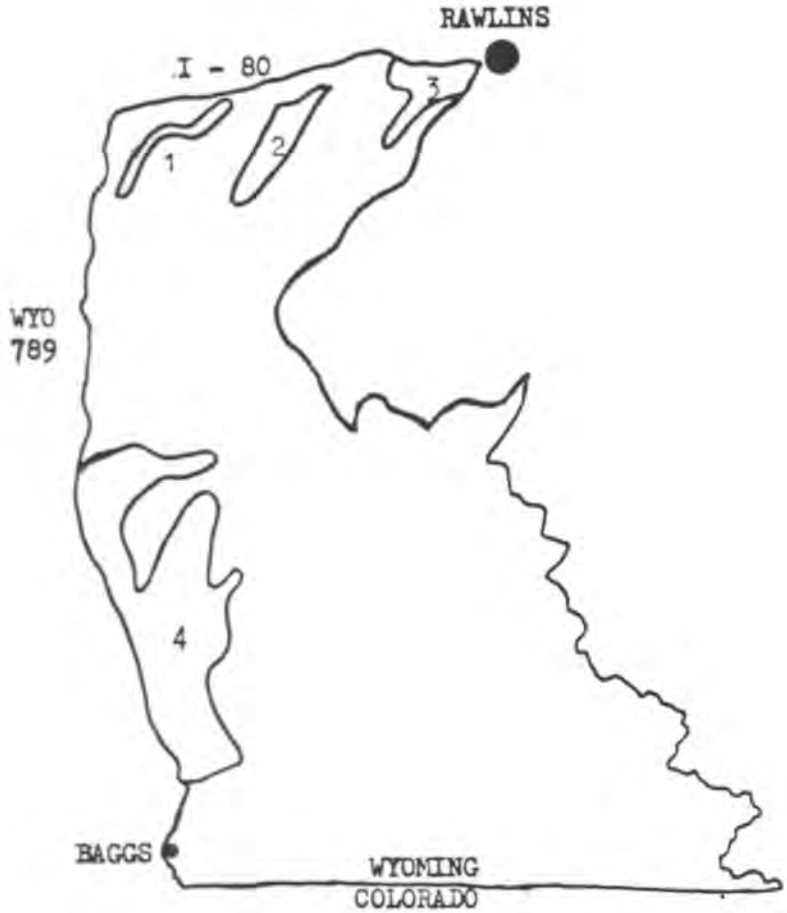


Figure 3. Winter pronghorn distributions in the Baggs Pronghorn Data Analysis Unit during severe winter conditions. 1 = Red Rim Area, 2 = China Butte Area.

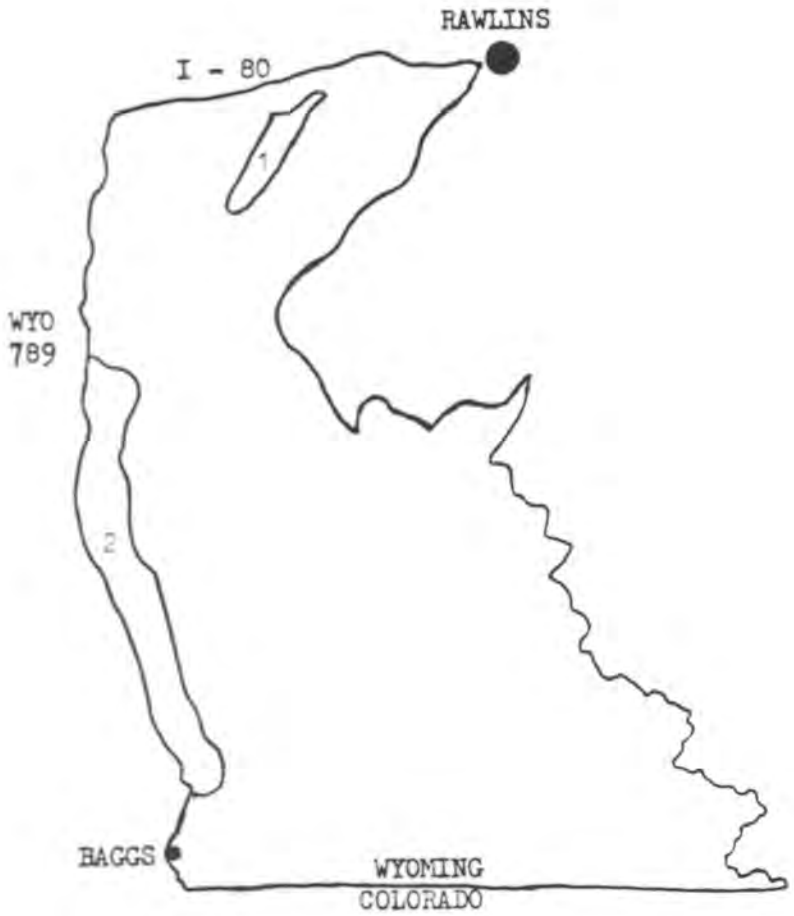


Table 1. Estimated numbers of pronghorn observed on the Red Rim Crucial Winter Range from 1977 through 1984.

Winter	Estimated Number of Pronghorn	Winter Severity Determination[a]	Source[b]
1977-78	1,000-1,200	Average	WGFD
1978-79	2,000-2,800	Severe	WGFD,BLM
1879-80	1,000-1,300	Average	WGFD,BLM,UW
1980-81	1,000-1,200	Mild	WGFD,UW
1981-82	1,100-1,600	Mild	WGFD,UW
1982-83	2,100-2,500	Average	WGFD
1983-84	50-1,000[c]	Severe	WGFD

a -Based on approximate depth and duration of snow cover, coupled with extreme low temperatures.
b - WGFD =Wyoming Game and Fish Department
BLM = U. S. Bureau of Land Management
UW = University of Wyoming
c - See text for explanation of these low numbers

al. 1984). The remaining 15-20% were distributed throughout northeastern and northwestern portions of the area.

Normal winter pronghorn distributional patterns within the Baggs DAU have been altered during the present severe winter. During late-summer 1983, a 150 cm-tall woven wire fence was completed around the Red Rim winter range by landowner, Taylor Lawrence. The fence encloses a federal cattle allotment leased by Mr. Lawrence, but all portions of the fence lie on private sections of the checkerboard land ownership system. In mid-November, massive early-winter snow storms hit the Red Rim area and approximately 2,500 pronghorns began congregating around the fence. On 1 December, local press coverage exposed the growing problem and the situation soon received national attention. Observations of pronghorns along the fence indicated many animals were weakening from prolonged exposure to deep snows, sub-zero temperatures and high winds. In response to the crisis, Wyoming Governor Hershler and members of his staff met on 9 December with representatives of the Wyoming Wildlife Federation, Wyoming Game and Fish Department, U.S. Bureau of Land Management and Mr. Lawrence, attempting to reach a compromise concerning the fence. An agreement was reached that day and 400 m segments of the fence were taken down that afternoon and the next morning.

However, by this time, most of the pronghorns had died or left the area, in an apparent effort to find alternate wintering locations. As a result, only 1,000 animals were observed on the winter range during mid-December aerial counts. The total estimate of the Baggs antelope population after this flight was approximately 8,400 animals.

Weather conditions remained very harsh during January and February and several major storms moved through the area. Mid-January snow depths averaged 70 - 90 cm across the DAU. Flights conducted in March yielded counts for the DAU of only 1,200 pronghorns, only 50 of which were observed on the Red Rim winter range. Thus, current mortality estimates for Hunt Area 55 range from 35-70%.

DISCUSSION

After reviewing trends in numbers and distributions of pronghorns in the Baggs DAU from 1977 to 1984, there is no question that the Red Rim area is traditional and crucial winter range. Each winter, increases of 400 - 2,200 animals above summer estimates of 600 (Ryder 1983) were observed. During most winters, wide expanses of deep snow south of Red Rim generally limit major movements to the China Butte winter range after mid-December. Thus in severe winters when deep snow restricts the availability of alternate wintering areas, Red Rim provides the only refuge for pronghorns in northern portions of the Herd Unit. Construction of a 150 cm woven wire fence around Red Rim effectively removed this necessary habitat during the current, very severe winter. Although mortality rates may have been high even without the fence, it seems likely that mortality would have been lower based on the low mortality observed following the severe 1978-79 winter.

If Red Rim is crucial pronghorn winter range, why is the area still being considered for coal development? The answer is complex and is still being debated. Federal Unsuitability Criterion 15 (U.S. Bureau of Land Management 1979) states:

"Federal lands which the surface management agency and the state jointly agree are fish and wildlife habitat for resident species of high interest to the state and which are essential for maintaining these high priority wildlife species shall be considered unsuitable. Examples of such lands which serve a critical function for the species involved include: (i) active dancing and strutting grounds for sage grouse, sharp-tailed grouse, and prairie chicken; (ii) winter ranges most critical for deer, antelope, and elk and (iii) migration corridors for elk."

However. mining of critical habitats may be allowed under certain circumstances:

"A lease may be issued if, after consultation with the state, the surface management agency determines that all or certain stipulated methods of coal mining will not have a significant long-term impact on the species being protected."

In other words, leases may be granted if it can be demonstrated that an area containing crucial wildlife habitat can be restored as crucial wildlife habitat following mining.

However, existing topography on Red Rim is extremely diverse, especially in the Separation Creek and Crest of Red Rim areas. Many small draws and secondary ridges in these areas provide micro-climatic differences which allow pronghorn to avoid long-term exposure to high winds and blowing snow. Reestablishment of secondary ridges is apparently not technologically feasible (Wyoming Department of Environmental Quality and U.S Office of Surface Mining 1983). Permanent loss of these ridges will reduce the value of Red Rim to pronghorns during severe winter conditions.

Loss of secondary ridges will also affect post-mining revegetation efforts. Snow accumulations are expected to decrease without the existing micro-topographic features to hold wind-blown snow (Wyoming Department of Environmental Quality and U.S. Office of Surface Mining 1983). Lower snow accumulations will reduce soil moisture needed to support the current vegetation associations. Poor, shallow soils found in the area will compound the problem. We believe that mining cannot proceed without causing significant long-term impacts to the ability of the Red Rim winter range to support antelope.

Thus, it appears there is more at issue than the loss of one crucial wildlife habitat. Federal Unsuitability Criteria are being tested. If Criterion 15 is not enforced and mining is allowed in the Red Rim area, a dangerous precedent will be established. Wisely-enacted regulations, designed to allow energy development while protecting crucial wildlife habitats, will be seriously reduced in strength.

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COMMENTS AND QUESTIONS

Editor's Note - This paper was presented by Larry Irwin.

QUESTION - Recently a lawsuit was lost by BLM regarding the use of right-of-ways going through section corners of the checkerboard. Property within private land ownership was deemed to be private and no access was permitted unless granted by the landowner or with some type of lease. This is a checkerboard pattern where the fence is located. Why didn't that precedent hold with the fence since it has to cross, at least minutely, public land?

IRWIN - Two things happened. One is that, as I understand, the fence is entirely on private land. The second is that Wyoming is still an ultra-conservative agricultural state and they protect the landowner's rights.

QUESTION - As I understand it, the fence is back up now or will be put back up. Will we have to go through this again or what's going to happen?

IRWIN - I believe this will be a negotiable issue which the rancher is using to gain confirmation of whether the area will be ruled suitable for mining. I might also mention that he has bid on coal leases south of the area and is definitely interested in mining coal.

QUESTION - How much impact would a mine on that rim have on the pronghorn population?

IRWIN - While no one really knows about that. Very likely it would greatly reduce critical winter range.

QUESTION - Have you seen a mine plan?

IRWIN - No. I've seen some old ones; they seem to change.

QUESTION - How long a time are we talking about for a mining period? Would it all be disturbed at once or would it be in segments?

IRWIN - I'm not sure. Somebody said 25 years.

QUESTION - That's from a 1977 pre-law mine plan. There is no mine plan for that area right now. You said steep slopes cannot be restored. How steep a slope is important to antelope and in what ratio?

IRWIN - The slopes that seem to be important are in excess of 20 percent on the south end of Red Rim. South and west facing slopes.

QUESTION - If you could design a winter range topography for antelope in that area, what would it look like?

IRWIN - Exactly like Red Rim.

QUESTION - How do you feel about the copper mine proposed for the north half?

IRWIN - Based on the fact that about 80 percent of the animals were using the south half, that would be a reasonable alternative. There still would be some losses but I suspect them not to be highly significant.

QUESTION - Is there a basis for any lawsuits?

IRWIN - The Wyoming Wildlife Federation has filed a petition to have the area declared unsuitable for mining. Regardless of which way the decision goes it looks like it may end up in court anyway unless a compromise can be developed.

QUESTION - Is the landowner the one that wants to start a mine or is it some company?

IRWIN - Elroy (Taylor) can answer that better than me. There's some decisions that have to be made. One is, can mining be allowed on state lands or private lands and that is up to the Wyoming Department of Environmental Quality. The decision on Federal lands is up to the Office of Surface Mining. The reclamation criteria on state lands are not as strong as those for Federal lands, so an area could be declared suitable on private land but not on Federal land. If so, it's very difficult, logistically, to mine those alternate sections of land.

QUESTION - I wonder why a coal company would want to mine an area like that when there's already coal on the market from different areas. Is it an extremely profitable seam?

IRWIN - I think the coal isn't really that valuable. The real issue is probably trying to find a way to circumvent Criteria 15 of the Surface Mining Control and Reclamation Act. That appears to us to be the real issue.

COMMENT - The coal on the private sections belongs to the railroad. They're trying to preserve their options to mine that coal. There are no plans to mine that coal. The coal in the alternate sections is owned by the public; BLM is administering that now, so that would be leasable coal, depending on the outcome of the petition. If anyboby has a plan to mine it, it's the landowner right now. The coal is 10,000 BTU; it's not shabby.

FIELD TEST OF A WINTER PRONGHORN HABITAT SUITABILITY INDEX MODEL

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ABSTRACT

In evaluating a winter pronghorn (Antilocapra americana) Habitat Suitability Index (HSI) model, regression analysis was used to directly evaluate model performance and indicate improvements to the model. Data were collected from 29 wintering areas in Montana, Idaho, Colorado, and Wyoming. Data required for model assessment included shrub canopy cover, height, and diversity, percent of winter range planted to winter wheat, topographic diversity, and type and density of fences. Additional information was collected concerning other vegetation attributes, climate, human developments, pronghorn population, and other miscellaneous characteristics. Data analysis indicated the HSI model addressed important variables that, when incorporated into the model, explained 39% ($P < 0.001$) of the variation in wintering pronghorn densities. Modifying the model to be more sensitive to shrub canopy cover, altering the topographic diversity variable, and including a variable to reflect canopy cover of herbaceous species resulted in a better model which explained 50% ($P < 0.001$) of the variation in pronghorn densities. Examination of residual and normal probability plots indicated moderate violation of normality and constant variance assumptions. A logarithmic transformation of the dependent variable alleviated violation of these assumptions and improved variance explained to 70% ($P < 0.001$). Incorporating a variable to reflect availability of unfrozen water sources in winter should be useful; however, data were insufficient to evaluate such a variable in this test.

INTRODUCTION

Recent legislation, particularly the National Environmental Policy Act of 1969, mandated wildlife responses to be evaluated and described in relation to U.S. goverment-sponsored alterations in habitat. Thus, it is now essential that biologists be able to relate species to habitat conditions and predict species response to habitat alterations (Thomas 1982).

Many methodologies have been created to assess the ability of various habitats to provide life requisites of wildlife species or groups of species (Seitz et al. 1982). Many of these are undergoing field testing (e.g., Ellis et al. 1979, Mule 1982, Seitz et al. 1982). Because HSI models are generally derived using non-empirical techniques (Mule 1982) and often created from a

paucity of information (Van Horne 1983), stringent field tests are mandatory to produce truly dependable, robust models.

Many pronghorn ranges overlay vast, recoverable coal deposits in the western U.S., (Amstrup 1978), and substantial habitat loss also has occurred due to intensifying agriculture, housing development, and oil/gas activity. Thus, the HSI model for pronghorn developed by Allen and Armbruster (1982) is a timely and useful tool to aid decision-making concerning crucial pronghorn ranges if, indeed, it incorporates pronghorn habitat requirements into a functional, accurate model. Ultimately, however, this model will be of value only if it is accepted by field personnel.

This paper presents preliminary results of a relatively extensive field test of the winter pronghorn HSI model.

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METHODS

The HSI model of Allen and Armbruster (1982) assumed 5 important variables on antelope winter ranges: shrub canopy cover (V1), shrub height (V2), shrub diversity (V3), topographic diversity (V4), and availability of winter wheat (V5). Model output may also be altered to reflect amount and type of fences. These variables are listed in Figure 1.

To test this model, data were collected on vegetation, topography, climate, development activities, and pronghorn population characteristics. This information was used in 2 ways to evaluate the model. First, simple and multiple regression techniques were used to evaluate relative importance of habitat vs. nonhabitat variables to determine if the HSI model addressed variables that are substantially related to pronghorn densities on winter ranges and fawn productivity of each herd. Second, vegetation and topographic data were used to calulate various HSI model variables. Model outputs were regressed against pronghorn density on winter ranges to directly access model performance. This paper reports primarily the results of this second approach. Lengthy descriptions of methods and results associated with the first approach were presented by Cook (1984).

Vegetation data collection required 2 phases. First, the relative amount of each plant community present on each study site was estimated. At 100 m intervals along random transects, the sampler identified the plant community. Communities were identified based upon dominant shrub species. At least 4 stops/km^2 were sampled on each wintering area. Relative proportions of each plant community were calculated by dividing the number of stops in each community by the total number of stops obtained throughout the wintering area.

Figure 1. Suitability index graphs for variables contained in the pronghorn winter Habitat Suitability Index model.

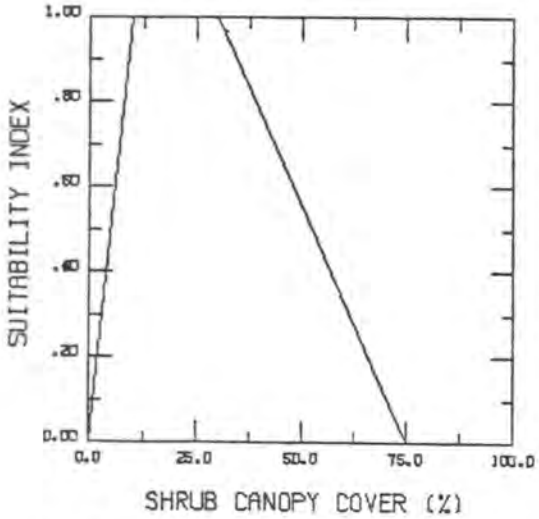
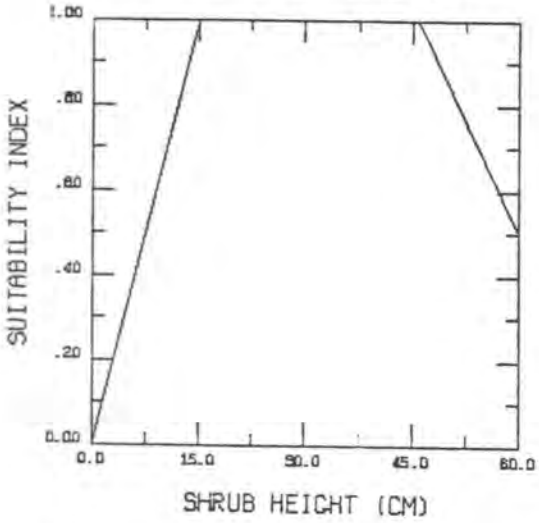
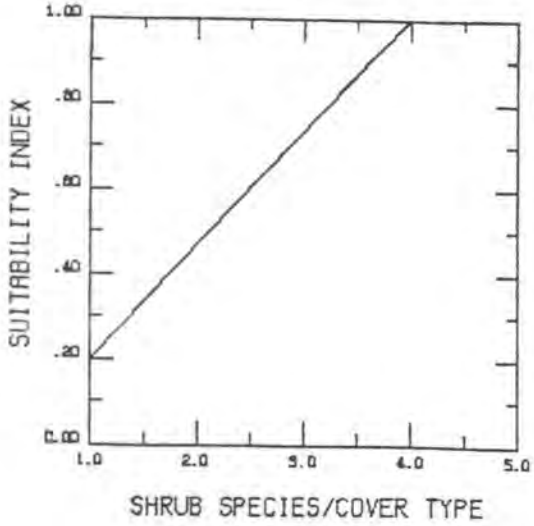
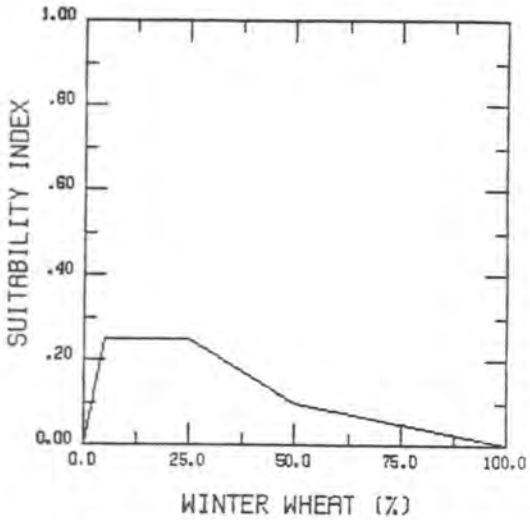
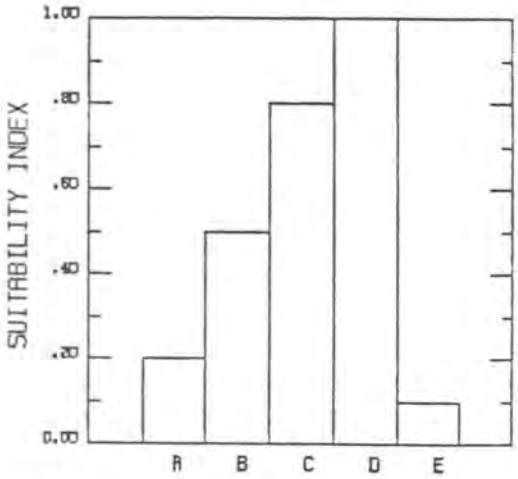
Variable	Variable Description	Suitability Graph
V1	Percent shrub canopy cover.	
V2	Average height of shrub canopy.	
V3	Number of shrub species per cover type.	

Figure 1. (cont.)

Variable	Variable Description	Suitability Graph
V4	Percent of available pronghorn habitat in winter wheat.	
V5	Topographic diversity. A) 0-5% slope; little to no physical relief. B) 0-5% slope; area broken by drainages. C) 5-25% slope; rolling. D) 5-25% slope; ridges, rims, and/or drainages present. E) >25% slope; mountainous.	

Second, canopy cover of vegetation classes in each plant community was estimated. These classes were annual grass, perennial grass, annual forb, perennial forb, mat forb, cactus, yucca (Yucca glauca), half shrubs, and each species of shrub. The line-intercept method was used to estimate canopy coverage. Height of each shrub intercepted by the line was also measured. Preliminary sampling just prior to the field season indicated that 25 line-intercept transects sampled in each plant community would usually be adequate to estimate within ±15 percent of the mean with 95% confidence.

Topographic diversity was estimated using U.S.G.S. topographic maps with scales of 1:24,000. Each wintering area was stratified into 1 or more of the topographic types shown in Figure 1 and a planimeter was used to estimate area of each type as well as size of the entire winter range. From this, percent of area in each topo type was calculated. Unfortunately, no suitable topographic maps existed for the study sites in Montana. However, an approximate suitability index for them was estimated.

Estimates of pronghorn numbers and size of winter ranges were obtained from various state wildlife agencies, and, for the Idaho study sites, from the Bureau of Land Management and the U.S. Department of Energy. Density estimates were calculated from these data.

HSI model evaluation depended primarily on simple regression techniques. Pronghorn winter densities were used as the dependent variable, and various HSI model output were used as independent variables. Residual plots were generated to evaluate violations of regression analysis, namely heterscedasticity of variance and nonlinearity (Zar 1974, Neter and Wasserman 1974). Non-normality was evaluated by inspection of normality plots (Neter and Wasserman 1974). SPSS (Nie et al. 1975) and BMDP (Dixon et al. 1981) statistical computer packages were used for data analysis.

RESULTS

Data were collected from 29 wintering areas (Figure 2). A wide variety of environmental conditions was represented in this regional sample, especially in terms of vegetation and topographic characteristics. Samples were located in 5 different vegetational ecoregions (Bailey 1980). These included areas on the short grass prairie with essentially no shrubs to intermountain sagebrush areas with a markedly depauperate herbaceous component. (Most shrub-supporting plant communities on nearly all study sites were dominated by various sagebrush taxa, usually Wyoming big sagebrush (Artemisia tridentata wyomingensis). Variation in topographic diversity ranged from flat areas to areas which were essentially mountainous. Populations that support annual harvest rates of about 9% and others with over 20% and populations that produced as few as 43 fawns/100 does and others with nearly 90 fawns/100 does were included. A wide range of conditions were also represented in climatic patterns, livestock grazing rates, and development activities.

Tables 1 and 2 present summaries of vegetation and pronghorn population characteristics, respectively. Densities shown in Table 2 suggest most winter ranges support less than 20 pronghorn/km^2, except for the Little Snake River Corridor, which supports nearly 40/km^2. This density seems unreasonably high (>6 times higher than the average density of the other winter ranges), and no census data existed to support it; consequently it was considered unreliable

Figure 2. Location of pronghorn winter range study sites. Medicine Bow, Red Rim, and Muddy Creek were each divided into 2 subranges; thus, total sample size was 29. LSRC stands for Little Snake River Corridor.

Table 1. Percent vegetation canopy cover by major plant life form averaged for each wintering area.

Pronghorn Wintering Area	Grass Cover	Forb Cover	Half Shrub Cover	Shrub Cover	Shrub Height (cm)	Total Cover
Montana: Petroleum Co.						
Yellow Water-Area 2	28.7	3.5	1.1	8.6	22.1	41.8
Yellow Water-Area 5	31.7	3.5	1.2	7.5	24.2	43.8
Yellow Water-Area 6	26.7	3.5	1.1	10.3	21.6	41.5
Idaho: Butte and Clark Co.						
Birch Creek	9.8	0.4	0.3	17.3	33.2	28.2
Little Lost R.	9.3	0.9	0.2	18.8	19.1	28.9
Howe	5.6	1.4	0.6	17.3	37.3	24.8
Colorado: Moffat Co.						
Four Mile Creek	14.9	1.6	4.2	21.1	35.3	41.6
Big Gulch	28.9	2.4	0.4	18.8	42.2	49.6
Sandwash Basin	2.7	1.0	1.9	13.9	29.1	19.2
Urie's Pasture	22.8	1.6	1.0	22.0	45.9	48.5
Little Snake River Corridor	13.0	1.1	0.6	12.2	24.0	26.9
Colorado: Weld Co.						
Pawnee Buttes	78.9	2.4	1.6	0.1	4.0	82.9
Willow Creek	77.3	2.5	0.3	0.0	0.0	80.4
Crow Creek	72.7	3.4	0.2	0.0	0.0	76.0
Winter Wheat	72.2	2.2	1.5	0.4	22.5	76.2
Porter Creek	71.8	8.2	2.3	2.3	23.3	85.2
Wyoming: Uinta Co.						
Albert Creek	10.9	3.1	2.4	15.4	32.7	31.9
Wyoming: Park, Bighorn, and Hot Springs Co.						
Worland-Area 2	7.5	0.8	4.9	1.8	36.6	15.1
Worland-Area 1	14.4	1.6	4.6	8.6	31.7	29.1
Worland-Area 6	18.9	3.5	0.6	16.5	37.1	38.7
Wyoming: Fremont Co.						
Koehler Draw	16.8	4.2	0.1	11.0	15.2	32.2
Mazett Flats	18.3	6.5	0.2	11.1	17.1	36.7
Logan Gulch	17.1	3.7	4.5	9.0	16.9	34.5
Wyoming: Carbon Co.						
Muddy Creek-South	12.0	2.5	1.2	20.2	27.5	35.7
Muddy Creek-North	12.6	1.9	2.1	18.4	27.4	35.1
Red Rim-North	15.0	1.1	4.9	11.3	32.7	32.1
Red Rim-South	14.9	3.7	1.8	17.3	25.3	37.6
Medicine Bow-West	19.9	2.6	1.0	20.3	22.8	43.7
Medicine Bow-East	19.7	2.7	6.1	11.2	22.7	39.5

Table 2. Population characteristics for pronghorn populations occupying winter range study sites.

Pronghorn Wintering Area	Pronghorn Density (No./km^2)	Fawn-Doe Ratios	Harvest[a]	Doe[b] Harvest
Montana: Petroleum Co.				
Yellow Water-Area 2	4.6	64	20	6.0
Yellow Water-Area 5	5.8	63	20	6.0
Yellow Water-Area 6	5.4	67	20	6.0
Idaho: Butte and Clark Co.				
Birch Creek	4.2	74	9	1.6
Little Lost R	8.8	55	9	1.6
Howe	9.7	65	9	1.6
Colorado: Moffat Co.				
Four Mile Creek	8.1	84	17	7.1
Big Gulch	5.4	84	17	7.1
Sandwash Basin	4.6	43	13	3.5
Urie's Pasture	6.0	77	20	9.0
Little Snake River Corridor	38.6	84	17	7.1
Colorado: Weld Co.				
Pawnee Buttes	0.5	59	9	3.1
Willow Creek	0.3	59	9	3.1
Crow Creek	0.4	59	9	3.1
Winter Wheat	0.0	59	9	3.1
Porter Creek	2.0	59	9	3.1
Wyoming: Uinta Co.				
Albert Creek	6.9	87	15	3.9
Wyoming: Park, Bighorn and Hot Springs Co.				
Worland-Area 2	1.6	60	10	2.5
Worland-Area 1	4.2	73	19	5.0
Worland-Area 6	4.6	75	9	2.3
Wyoming: Fremont Co.				
Koehler Draw	3.9	88	10	3.6
Mazett Flats	6.9	84	14	7.0
Logan Gulch	3.9	81	10	3.9
Wyoming: Carbon Co.				
Muddy Creek-South	19.8	85	13	4.6
Muddy Creek-North	4.6	85	13	4.6
Red Rim-North	5.0	76	11	2.7
Red Rim-South	15.1	76	11	2.7
Medicine Bow-West	19.3	86	13	3.6
Medicine Bow-East	12.0	86	13	3.6

[a]Harvest is the number harvested ÷ population size x 100.

[b]Doe harvest is the number of does harvested ÷ population size x 100.

and was excluded from the data analysis.

For each HSI variable in Figure 1, suitability indices (SI) were calculated and from these life requisite values for food (LRfd), topographic cover (LRcov), and the overall HSI were derived using the following equations:

$$LRfd = ((\sqrt{SIV1 \times SIV2}) \times SIV3) + SIV4 \qquad (1)$$

$$LRcov = SIV5$$

$$HSI = \text{the lower of LRfd or LRcov} \qquad (2)$$

Each of the SI's, LR's, and the HSI were regressed against pronghorn winter densities. In addition, several modifications were incorporated:
1. The SI for shrub cover (V1) was modified so that optimal shrub cover was 15 to 30% rather than 10 to 30%. This change seemed appropriate given the data presented in Figure 3. The scatter in points is minimal when shrub cover was < 15%, but extreme when shrub cover > 15%, suggesting shrubs strongly limit pronghorn density when relatively sparse, but when abundant, other variables become important in regulating density.

2. To calculate LRfd, the formula

$$LRfd = (SIV1 \times \sqrt{SIV2 \times SIV3})) + SIV4 \qquad (3)$$

was substituted in place of 1. This alternate equation increased the influence of shrub canopy cover (V1) on LRfd and subsequently the overall HSI compared to the original equation.

3. LRfd and LRcov were combined using an arithmetic mean rather than using the lower LR value as in the original model. The approach in the original model assumed the lowest LR is limiting the population. However, our data suggested compensations exist between LRfd and LRcov, indicating an arithmetic mean is more appropriate.

4. Kindschy et al. (1982) noted the importance of herbaceous species. A SI function (V6) was derived to reflect herbaceous canopy cover. This function assumed herbaceous canopy cover of 10 to 40% is optimal and was included in the model using the formula:

$$LRfd = (SIV1 \times (\sqrt[3]{SIV2 \times SIV3 \times SIV6})) + SIV4 \qquad (4)$$

The original HSI model explained 39% ($R^2 = 0.39$, $P < 0.001$) of the variation in winter pronghorn density. Each of the individual alterations increased variation explained 2 to 8%. When all alterations were incorporated into a "best" model, it explained 11% more variation ($R^2 = 0.50$, $P<0.001$) than the original model.

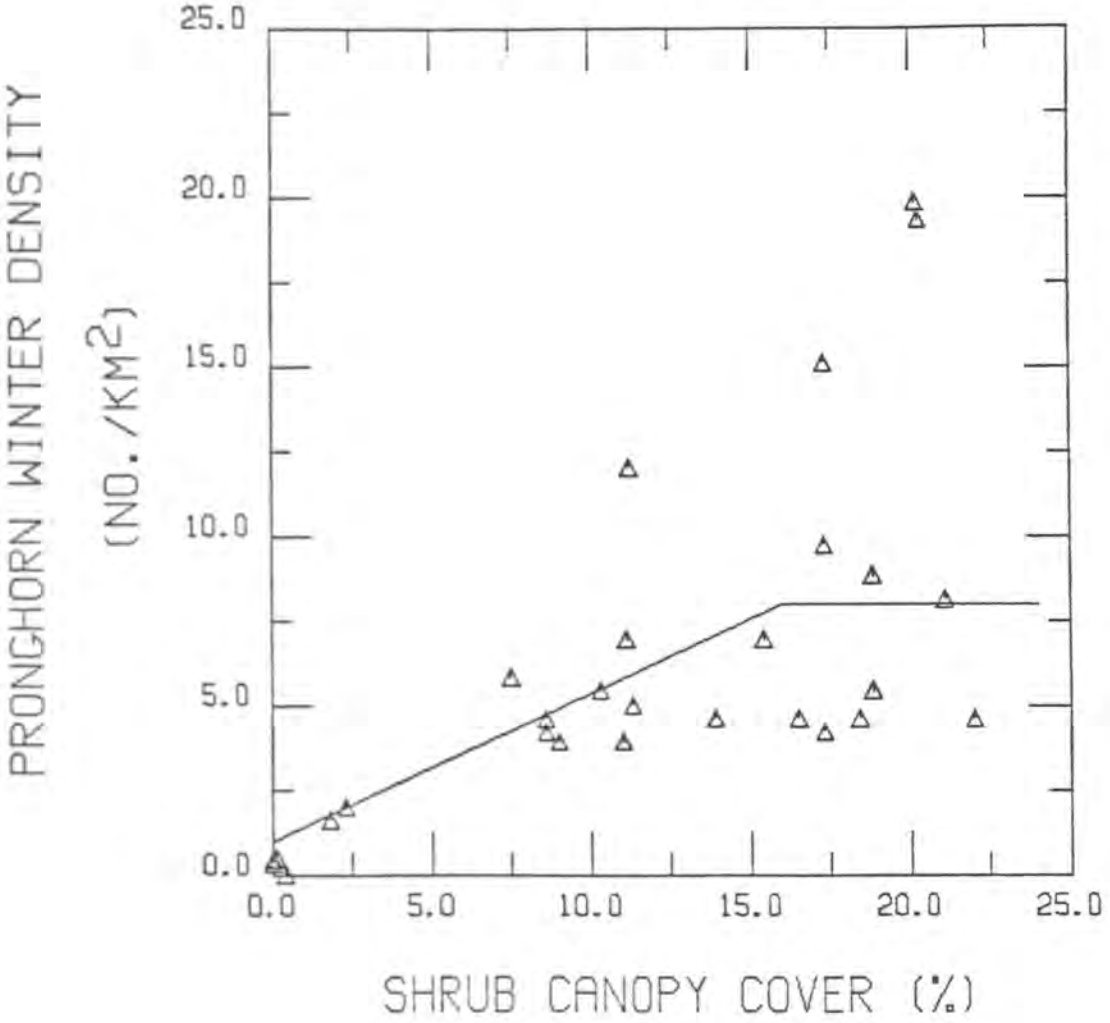


Figure 3. Bivariate plot of pronghorn density and shrub canopy cover on 28 winter range study sites. The scatter in points is comparatively minimal when shrub cover is less than 15 percent suggesting a strong limiting effect on pronghorn density by relatively sparse shrub cover.

However, plots of standardized residuals and normal probability plots indicated regression assumptions of constant variance and normality were moderately violated. A logarithmic (base 10) transformation of the dependent variable alleviated both problems. The amount of variation in pronghorn densities explained by the modified model increased to 70% (R^2 = 0.70, $P<0.001$).

DISCUSSION

The unaltered HSI model functions relatively well, given the inherent problems of using density as a measure of habitat quality (Lancia et al. 1983). However, this model nor the improved version could explain more than 50% of the variation in pronghorn density. This suggested the model was not accurate or that nonhabitat variables such as harvest or climate patterns may be important. However, multiple regression analysis which included nonhabitat variables such as harvest intensity, winter weather severity, total annual precipitation, amount and type of fencing, livestock grazing severity, and other miscellaneous variables strongly support the contention that habitat variables were the primary factors significantly affecting density on pronghorn winter ranges (Cook 1984). This suggested unexplained variation is at least partly due to errors in estimating pronghorn numbers and/or boundaries of winter ranges, thus introducing error into pronghorn density estiamtes. Violation of regression assumptions likely also contributed to some of this unexplained variation.

This model, especially the modified version, is designed so that shrub canopy cover has greatest influence in determining the overall HSI rating for a winter range. Substantial literature supports the contention that shrub availability strongly influences winter distribution and, during more severe winters, survival. Martinka (1967) reported mortality in severe winters was substantially reduced in areas with larger amounts and availabilty of shrub cover. Dirschl (1963) noted winter distribution was restricted to areas containing shrub forage resources. He indicated abundance of shrubs was a primary factor regulating carrying capacity of winter ranges. Studies by Bayless (1969) and Barrett and Vriend (1980) also support this hypothesis.

Final model output is also designed to weight topographic diversity as a substantial, though secondary influence (compared to shrubs). But the value of topographic diversity is less clear in the literature. Kindschy et al. (1982) indicated that areas with >10% slope were much less than optimum. Clary and Beale (1983) noted the reputation of pronghorns to avoid rough country, but found that slopes >33% were used in greater proportion than available in Utah. Bruns (1977) noted use of microhabitats in Alberta with favorable climatic conditions provided by topographic features. Mitchell (1980) also reported use of relatively rough topography after the arrival of inclement weather in Alberta. Moreover, he noted roving herds become sedentary in microhabitats which provided food and shelter. However, the singular role of topographic cover was not indicated. Martinka (1967) indicated the importance of shrubby vegetation, southern exposures and wind blown ridges. Ryder (1983) reported the value of high topographic diversity associated with high winds to maintain snow-free areas, even in relatively severe winters. Cook (1984) reported areas with unusually high pronghorn densities had both high shrub canopy cover and relatively high topographic diversity.

Thus, we conclude winter ranges that provide high shrub cover (>15%) and high topographic diversity provide greatest opportunity to pronghorn to acquire adequate forage and find microhabitats which provide shelter. Further, the HSI model seems to quantify these important characteristics and combine them into a realistic rating of wintering areas.

The inclusion of a variable that reflects the availability of unfrozen water sources may further increase the utility of this model. It is often assumed that water requirements are met by snow in the winter (Kindschy et al. 1982). However, Guenzel et al. (1982) noted that pronghorn distributions were strongly affected by a free water source during a mild, relatively snow-free winter. Further, Wyoming Game and Fish personnel (C. Thompson, pers. comm. 1983) have noted indications of water stress in pronghorn wintering on or adjacent to Worland Area 2 and Area 1 (Figure 2). This area is extremely dry (<20 cm of precipitation/year and < 1 cm/month of winter precipitation), with commonly long snow-free periods in winter. We feel that unfrozen water sources can be important, and a variable reflecting availability of open water should be included in the HSI model. We assumed at least 3 open water sources/100 km^2 would be adequate based on pronghorn home range sizes (Bayless 1969) and pragmatic considerations.

Figure 4 presents suitability indices for the modified model. (The topographic diversity variable is altered slightly from the original variable (Figure 1) to reduce subjectivity concerning application of this variable). Time to collect field data to implement this model should require about 10 man-days for an average-sized wintering area (65-120 km^2), and about 5 man-days to collect topographic data from maps, calculate an overall HSI, and conduct other office work. We recommend use of the line-intercept method to estimate vegetation canopy cover because it is relatively accurate (Pieper 1978), and this model is calibrated based on it. Data from other methods, which can produce markedly different cover estimates (Pieper 1978), may produce misleading results when incorporated into this model.

Model users should recognize 2 potential limitations. First, because, the model does not include a variable reflecting snow deposition, the user must have some knowledge of this potentially limiting factor. Second, the model was field tested using data from normal winters; thus, its reliability for rating habitat quality during severe winters is unknown. Areas that are suitable for pronghorns during severe winters likely result from a complex interaction of climatic, topographic, vegetation, and other characteristics. Such relationships are currently poorly understood (Cook 1984).

A key benefit of the pronghorn HSI model is the ability to obtain a precise, quantitative description of habitat conditions, thereby decreasing the dependence upon subjective, verbal descriptions of habitat and perceived quality. Model output can provide a reference point from which changes in habitat conditions can be predicted and compared by contrasting the relative value of different areas at the same point in time or the relative value of the same area at future points in time given various habitat alterations. The quantitative characterization of habitat, combined with data on pronghorn use and the biologist's knowledge of the area, can permit the manager to more fully and accurately justify the decisions and recommendations made pertaining to the management of the area.

Figure 4. Suitability index graphs for variables either modified or added to the orginal pronghorn Habitat Suitability Index model.

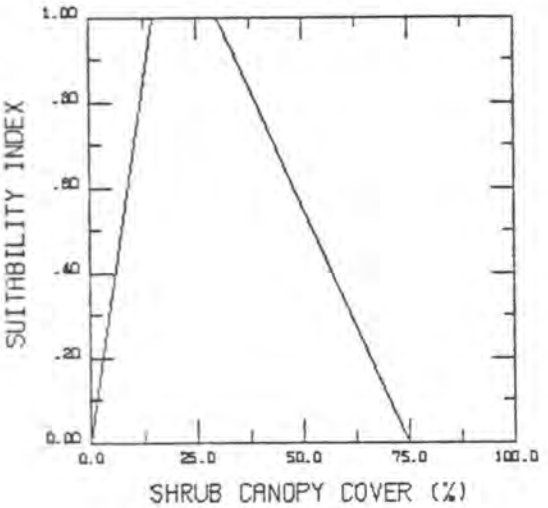
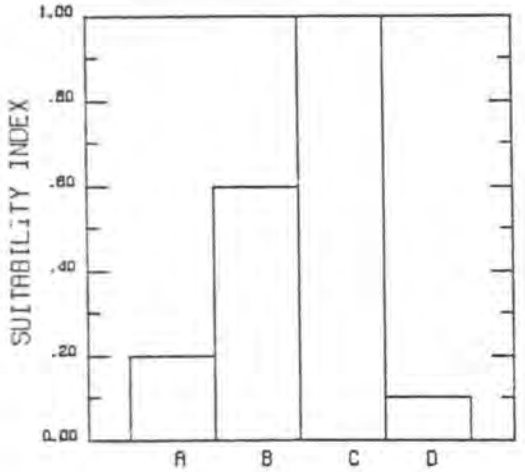
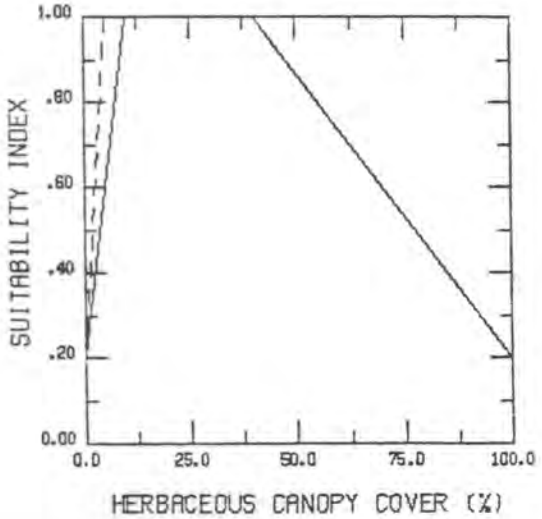
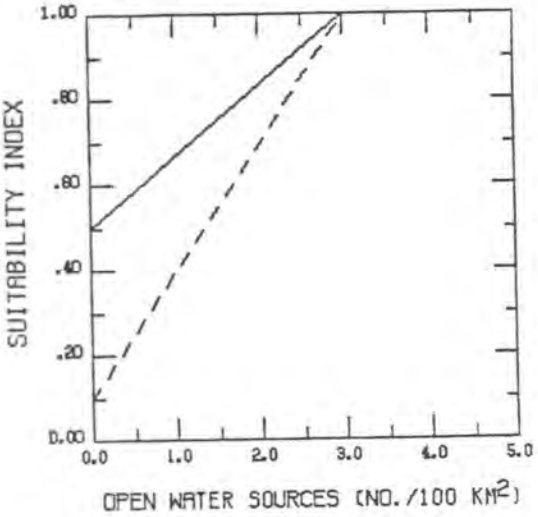
Variable	Variable Description	Suitability Graph
V1	Percent shrub canopy cover.	
V5	Topographic diversity. A) 0-3% slope; flat or nearly so. B) 3-8% slope; gently rolling. C) 8-25% slope; substantial drainages, ridges, and/or rims present. D) >25% slope; mountainous.	
V6	Percent canopy cover of herbaceous species.	

Figure 4. (cont.)

Variable	Variable Description	Suitability Graph
V7	Density of unfrozen water sources. The dotted line is appropriate if average monthly winter precipitation is < 1.0 cm. This graph assumes a relatively uniform distribution of open water sources.	

For example, we applied the model to a coal-bearing, controversial winter range in south central Wyoming called Red Rim. Wyoming Game and Fish Department biologists and University of Wyoming researchers have noted the high quality and critical importance of this area to pronghorn. Moreover, research indicated the south half was apparently superior to the north half. Application of this model supported both contentions; the south half rated as one of the best wintering areas included in this study whereas the north half received only a moderate score. Further, HSI models have been used for comparison of habitat values resulting from various mine reclamation alternatives (Rhodes et al. 1983), and to evaluate the effect of various management options on habitat potential (Urich and Graham 1983). Possibly a test of the ultimate value of HSI models, the reduction of personal opinion by presentation of HSI values were found to be a strong point in favor of the use of HEP and HSI models when used as court testimony concerning habitat quality and illustrating potential impacts (Banner 1984, pers. comm.).

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COMMENTS AND QUESTIONS

QUESTION - I've seen some formulations where you combine different factors in the mathematical equation. How were those combined? A lot of those were simple products of the various parameters. Is that how these were put together?

COOK - Originally yes. We changed a little bit. Some HSI Models combine those variables based on geometric means rather than arithmetic means. The idea behind geometric means is it reflects the limiting characteristic of any one variable. If you use a geometric mean on an area that has flat winter range but has tremendous food, it's going to rate out extremely low because topographic diversity is low. We feel that shrub availability or shrub production is much more important than topographic diversity, so we use an averaging, a mathematical average, rather than a geometric average, to combine those two life references.

QUESTION - Is that the only way you can choose between relative importance? If you combine all those averages one or two particular entities that tend toward zero become the most important no matter what the rest of them are.

COOK - I agree. That's why we use the arithmetic mean. The rest of the model is calibrated so that variables such as herbaceous cover or availability of water will have very little effect on the model output unless it's just not there. In that case it will have a strong effect on HSI Model output but it won't take it down to zero.

QUESTION - What were your density estimates on winter ranges and how would snow depth affect them?

COOK - The density data for winter ranges were all collected in winter time and ranged from about .1 per square mile to 51 or so. Red Rim had densities as high as any area. This model is not set up to directly assess snow depth but does so indirectly by giving an area a high rating if it has a high shrub canopy coverage combined with a high topographic diversity.

QUESTION - You said slopes from 5 to 25 percent were best. Do you have any feel within that broad range or is 5 percent as good as 25 percent?

COOK - No, I don't. On this type of study I didn't collect habitat use information.

QUESTION - Do you have any feel for length of slopes or aspects?

COOK - My data indicate that northeast slopes are valuable in mild winters. However, if snow depth gets a little higher those places are inaccessible. Beale and others found that southwest aspects are most important. What may be optimum is the juxtaposition of northeast and southwest slopes.

QUESTION - How about the length of slopes? Are 3 short ones as good as one long one?

COOK - I don't know. In terms of mine reclamation these HSI Models are not designed to measure winter range so exactly that it takes 2 years to collect the data. They're designed as a tool to aid the biologist in his knowledge of the area. The 2 together give a better indication of what you've got out there and what various management activities may do to change an area.

VIABILITY OF BINDWEED SEEDS AFTER PASSAGE THROUGH A PRONGHORN DIGESTIVE SYSTEM

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ABSTRACT

Pronghorn (Antilocapra americana) are suspected of being a factor in the spread of bindweed (Convolvulus arvensis) seeds into private range and farmlands. Pronghorn may eat bindweed when they are grazing in wheat stubble fields in the late summer and early fall and spread the seeds in their feces. A tame pronghorn was fed 2,000 bindweed seeds and feces were collected for the next 7 days. Of the 2,000 seeds, 369 were recovered. Germination of the recovered seeds was 6.8 percent. The remaining ungerminated seeds were mechanically scarified and 94.4 percent (303 of 321) germinated. Of 389 control seeds, 2.1 percent germinated before scarification and 93.2 percent germinated after scarification. There was a significantly higher percentage of germinating seeds after passage through the pronghorn digestive system (X^2 = 11.15, P = .0008). Acid or mechanical scarification of seeds in the rumen may result in a higher germination percentage. After scarification, control and test seeds had equally high germination percentages (X^2 = 0.42, P = 0.5170).

INTRODUCTION

There is concern by landowners that pronghorn may be a major factor in the spread of bindweed. Pronghorn may eat bindweed seed when they are grazing in stubble fields in the late summer and early fall. Food habit studies in Colorado (Hoover et al. 1959) and California (Ferrel and Leach 1950, Ferrel and Leach 1952) show that pronghorn eat bindweed in minute quantities (although plant parts consumed were not specified). However, bindweed was not found as a pronghorn food item in Oklahoma (Buechner 1950), Oregon (Mason, 1952), Montana (Cole and Wilkens 1956), Saskatchewan (Dirschl 1963), New Mexico (Russel 1964), Wyoming (Severson et al. 1968), or Texas (Hailey 1979). If soil moisture is adequate, bindweed will remain green in wheatfields through the summer, flower and produce seed until the first frost. According to Eugene Heikes (extension weed specialist, Colorado State University), bindweed seed remains in the capsule until the capsule is shattered by the plant drying or from some disturbance.

Bindweed seeds are extremely durable. In soil, bindweed seeds can remain viable for more than 30 years (Phillips 1961). The seed is very hard and germination percentages at any one time are usually quite low unless the seed coat is weakened (scarified) mechanically or with acid.

A study in Nebraska (Harmon and Keim 1934) showed that viable bindweed seed passes through the digestive system of calves, horses, sheep and hogs. One thousand bindweed seeds were fed to various animals and the seeds

recovered from the droppings for the next 4 days. Germination of unscarified seed was increased by passage through the animals' digestive tracts. Acid-scarified seeds also had a higher germination percentage than controls. The recovery period (4 days) in this study was probably a little short considering that in an Idaho study (Leherer and Tisdale 1956) viable seeds of other plant species remained in the digestive tracts of sheep for as long as 9 days. Viable seeds of other plant species will pass through the digestive system of sheep and rabbits (Leherer and Tisdale 1956) and sheep and deer (Heady 1954). Since pronghorn would be expected to be much like sheep or deer, it is probable that bindweed seeds ingested by pronghorn would be viable after passage through the digestive system. This study addresses the question of whether or not passage through the pronghorn digestive system effects the viability of bindweed seeds.

We thank the following persons from the Colorado Division of Wildlife: Paul Neil for care of the experimental animal; Andre Duvall and Gene Schoonveld for their support and contributions during the planning stages; Allen Anderson for bringing to our attention several useful publications, Bruce Gill for his administrative support and Tom Beck, Dave Freddy, and Tom Hobbs for reviewing the manuscript. Dr. D. Bowden of the Statistics Department, Colorado State University, assisted in the design. Drs. W. Laycock and A. Wilson of the U. S. D. A. Agricultural Research Service contributed to the original study plan. We offer special thanks to Sylvia Greenspan for her many hours of diligent data collection.

This study was supported by the Colorado Federal Aid in Wildlife Restoration Project 45-01-503-15050 and the U. S. D. A. Agricultural Research Service.

METHODS

Bindweed seeds were obtained from a vacant lot near the Colorado Division of Wildlife, Wildlife Research Center in Fort Collins and from a field at Hughes Stadium, Fort Collins. The seeds had been allowed to ripen and dry naturally and were collected after the first frost. This ensured that the seed coat had developed to its maximum hardness.

A portion of this collection was used as control and germinated to determine germination percentage. They were treated with thiram to reduce contamination, and placed on moist blotters in 6 in. square covered plastic dishes. The dishes were put in a controlled environment germinator in total darkness with an alternating temperature of 30°C for 8 hours and 20°C for 16 hours for 7 days. The percentage of seeds that germinated was recorded daily. A seed was considered germinated if the root was at least 10 mm long. After the first germination trial, the remaining ungerminated seeds were mechanically scarified by making a small incision in the seed coat with a razor blade. The seeds were again placed in the germinator for 7 days under the same conditions recorded earlier and germination counts were recorded daily. Some seeds were lost during the scarification procedure.

Seeds from the same lot as the controls were used in the pronghorn feeding trial. Prior to the feeding trial a tame pronghorn (a 3-year-old doe) was trained to stay comfortably in a wire-mesh-bottomed digestive cage. During the study, she was left in the cage for 7 days. A collecting tray underneath

the wire-mesh flooring caught the feces. A ration of 100 g of grain mixture, 1,000 bindweed seeds and a small quantity of maple syrup was prepared and fed to the pronghorn twice-once in the afternoon of the first day and again in the morning of the 2nd day of the trial. Feces collections began on the morning of the 2nd day and were collected from the tray once a day every afternoon throughout the trial. Each day's feces were put in individual paper bags, marked with the date, and air dried for several days. Seeds were separated from the pellets by carefully crushing each pellet with a mortar and pestle and searching the material for seeds. Number of seeds recovered from each day's feces was recorded. They were germinated in the same manner described previously for control seeds.

RESULTS AND DISCUSSION

The germination of the control seeds demonstrated that the coat of bindweed seed is hard and impervious to water. Our sample of seeds showed characteristically low germination but high viability. Only 2.1 percent of the seeds germinated before scarification (Table 1), however, 93.2 percent germinated rapidly after they were scarified with a razor blade (Table 2).

Of the 2,000 seeds ingested, 369 or 18.5 percent were recovered in the feces (Table 3). No seeds were recovered until the 3rd day of the feeding trial. The greatest number of seeds (62 percent) were recovered on the 3rd day. By the 7th day, only one seed was recovered which indicated that the 7-day period following feeding was sufficient to permit the passage of most, if not all, of the bindweed seeds through the digestive tract of the pronghorn. We assumed that the other 1,631 seeds or 81.5 percent of those ingested, were digested or mechanically destroyed. Of the seeds that survived the digestive system, only 6.8 percent (25 of 369) germinated. However, germination percentage of these seeds was significantly higher than for control seeds ($X^2 = 11.15$, $P = 0.0008$). This may have been due to mechanical or acid scarification in the pronghorn digestive system. After the recovered seeds were scarified with a razor blade, they had a germination of 94.4 percent (Table 4). The control and test seeds had equally high germination percentages ($X^2 = 0.42$, $P = 0.5170$) after scarification. This showed that most of the seeds were viable even though most did not germinate without being scarified.

CONCLUSIONS

Viable bindweed seeds pass through the pronghorn digestive system; however, over 80 percent of the ingested seeds are destroyed in the digestive process. Of the 2,000 seeds fed the pronghorn, only 1.2 percent survived digestion and germinated without being scarified and 15.2 percent of the 2,000 germinated after scarification. Under field conditions and without being scarified it is unknown how many of these hard-coated seeds would actually germinate.

Although pronghorn may consume small quantities of bindweed, it is not known if pronghorn eat bindweed seeds when seeds are ripe enough to be viable or have developed a hard seed coat. Further studies of pronghorn foraging under field conditions would be necessary to determine if pronghorn eat bindweed seed pods when seeds are viable and have a hard seed coat.

Table 1. Germination of control bindweed seeds before scarification.

Sample no.[a]	No. Seeds	No. (%) Germinated	No. (%) Hard[b]	No. (%) Contaminated[c]
1	190	1 (0.5)	188 (99.0)	1 (0.5)
2	199	7 (3.5)	188 (94.5)	4 (2.0)
Total	389	8 (2.1)	376 (96.6)	5 (1.3)

[a] Sample no. 1 included seeds from a vacant lot near the Division of Wildlife building, Fort Collins, CO. Sample no. 2 included seeds from a field at Hughes Stadium, Fort Collins, CO.

[b]Seeds that did not imbibe water.

[c]Seeds with a fungal growth which made them nonviable.

Table 2. Germination of control bindweed seeds after scarification of the seed coat.

Sample no.[a]	No. Seeds	No. (%) Germinated	No. (%) Hard[b]	No. (%) Contaminated[c]
1	178	171 (96.1)	1 (0.6)	6 (3.4)
2	175	158 (90.3)	0 (0.0)	17 (9.7)
Total	353	329 (93.2)	1 (0.3)	23 (6.5)

[a] Sample no. 1 included seeds from a vacant lot near the Division of Wildlife building, Fort Collins, CO. Sample no. 2 included seeds from a field at Hughes Stadium, Fort Collins, CO.

[b]Seeds that did not imbibe water.

[c] Seeds that were damaged during the scarification process to the point that they could not germinate. Contaminated seeds had a fungal growth which made them nonviable.

Table 3. Recovery and germination of bindweed seeds after passage through the pronghorn digestive system.

Day[a]	No. (%) Seeds Recovered	No. (%) Germinated	No. (%) Hard[b]	No. (%) Contaminated[c]
1	fed 2,000 seeds	-	-	-
2	0	-	-	-
3	230 (11.5)	19 (8.3)	196 (85.2)	15 (6.5)
4	96 (4.8)	2 (2.1)	86 (89.6)	8 (8.3)
5	35 (1.7)	4 (11.4)	31 (88.6)	0 (0.0)
6	7 (0.4)	0 (0.0)	7 (100.0)	0 (0.0)
7	1 (0.1)	0 (0.0)	1 (100.0)	0 (0.0)
Total	369 (18.5)	25 (6.8)	321 (87.0)	23 (6.2)

[a]Day from initial feeding of seeds. Feces were collected for 7 days.

[b]Seeds that did not imbibe water.

[c]Seeds with a fungal growth which made them nonviable.

Table 4. Germination of scarified bindweed seeds after passage through the pronghorn digestive system.

Day[a]	No. (%) Seeds Scarified	No. (%) Germinated	No. (%) Hard[b]	No. (%) Contaminated[c]
1	-	-	-	-
2	-	-	-	-
3	196	184 (93.9)	2 (1.0)	10 (5.1)
4	86	82 (95.3)	0 (0.0)	4 (4.7)
5	31	29 (93.5)	0 (0.0)	2 (6.5)
6	7	7 (100.0)	0 (0.0)	0 (0.0)
7	1	1 (100.0)	0 (0.0)	0 (0.0)
Total	321	303 (94.4)	2 (0.6%)	16 (5.0)

[a]Seeds that did not imbibe water.

[b]Seeds with a fungal growth which made them nonviable.

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COMMENTS AND QUESTIONS

QUESTION - You said you separated the seeds from the pellets with a mortar and pestle?

RYAN - Yes. We took each pellet individually, crushed it, and extracted the seeds.

QUESTION - How would that compare to scarification? Would that affect germination?

RYAN - Possibly. We did it as carefully as we could. What we did with the razor was actually cut the seed coat. It would have to be damaged sufficiently to let water get to the seed.

QUESTION - The results you got are about what I'd expect. I've collected approximately 200 samples under field conditions where bindweed was present by observing antelope feeding on the green vegetation, and used the same procedure to identify the seed. I was unable to find any bindweed seed in the samples.

RYAN - It's possible that pronghorns eat it and it won't pass through. We fed a concentrated amount and only found 369 of 2,000 seeds. In a normal feeding it might not come through at all.

COMMENT - The digestive process destroys 75 percent of the seed, so instead of having 2,000 bindweed seeds out there, you only have 369.

RYAN - Yes, and those are the only ones that came through. And of those, only 2.1 percent germinated on their own without scarification.

COMMENT - Also, there was higher germination in those that passed through the pronghorn than those that did not go through the system.

BUSINESS MEETING

MINUTES OF BUSINESS MEETING
11TH PRONGHORN ANTELOPE WORKSHOP
CORPUS CHRISTI, TEXAS
APRIL 11, 1984

The business meeting of the 11th Pronghorn Antelope Workshop was called to order by Workshop Chairman, Charles Winkler, at approximately 3:30 p.m.

Delegates were present from the following states: Arizona, Colorado, Idaho, Kansas, Montana, New Mexico, North Dakota, South Dakota, Texas, Utah, and Wyoming. Other delegates present were Jim Yoakum, Bureau of Land Management; Frank Sprague, Soil Conservation Service; Bart O'Gara, University of Montana; Gary Wobeser, University of Saskatchewan; and Volney Howard, New Mexico State University.

No delegates attended from Alberta, California, Mexico, Nebraska, Nevada, Oklahoma, Oregon, Saskatchewan, or Washington. Although employees of the U.S. Fish and Wildlife Service, U.S. Forest Service, and National Park Service attended the Workshop, they were not designated as delegates by their respective agencies.

OLD BUSINESS

I. Trapping and Translocation Guidelines:

Jim McKenzie (North Dakota) reviewed the trapping and translocation guidelines developed after the discussion at the 1982 Workshop. He requested the delegates review the guidelines and forward their comments to him by July 1, 1984. If acceptable, the guidelines would be published in these proceedings.

II. Depredation Guidelines:

Guidelines for handling pronghorn depredation of agricultural crops submitted by Bruce Morrison (New Mexico) at the 1980 Workshop were briefly discussed, but no action was taken relative to adoption. However, several delegates reported current problems with pronghorn depredation (see state reports for Idaho and North Dakota) and others anticipated such problems if current trends in habitat alterations continued.

Bob Autenrieth (Idaho) moved that at the next workshop each state should be prepared to comment on their methods of handling complaints of pronghorn depredation. McKenzie seconded and the motion carried.

Bart O'Gara moved that a committee be appointed to follow up on the preceding motion. This motion was seconded by Jim Yoakum (BLM) and passed. Autenrieth was appointed chairman of the committee with Arnold Dood (Montana) and Craig Sax (Wyoming) as members.

III. Classification of Pronghorns:

Tom Pojar (Colorado) reviewed the history of the taxonomy of pronghorns, providing insight into the long-standing confusion by the scientific community regarding its classification. After considerable discussion which produced no conclusions, Volney Howard (NMSU) moved, seconded by Dood, to let taxonomists settle the issue. This motion was amended by Autenrieth, seconded by Pojar, to contact the International Commission of Zoological Nomenclature (ICZN) and request an official ruling as to the classification of pronghorns with regard to family. Motion carried and Pojar volunteered to contact the ICZN.

IV. Status of Papers Published in the Workshop Proceedings:

Jim McKenzie informed the group that he had prepared a letter to the editor of the Journal of Wildlife Management and requested a ruling as to whether papers published in the Workshop proceedings were eligible for future publication in the JWM. No response had been received.

Audrey Goldsmith commented that she had made a similar inquiry to JWM regarding her paper and had been advised that the proceedings were considered a valid publication and papers contained therein would not be eligible for publication in JWM; however, an abstract was not considered to be a publication.

Winkler advised the group that anyone who desired to have only their abstract published in the proceedings should advise him accordingly.

NEW BUSINESS

I. Guzzlers and Fences:

Bob Autenrieth presented a short slide show on construction of a guzzler (water catchment) and gave a favorable evaluation of a fence wire fastener that permits easy movement of the bottom wire to allow passage of pronghorns. He reported no fence related mortality had occurred on his study areas in the 2 years that the devices had been in use and recommended their use on new fences and existing fences as they are refurbished.

Bob Autenrieth inquired about electric fences. Winkler observed that there weren't many electric fences in Texas' pronghorn range but they were becoming common in some major white-tailed deer areas. He had recently observed 5 white-tailed deer pass through an electric fence designed specifically to enclose deer in less than 30 seconds.

Don Beale (Utah) stated there was a real need to develop a fence that would allow the passage of antelope but restrain domestic sheep.

Beale also suggested that a section on water development for pronghorns be included in the management guidelines. He was requested to prepare such a section for presentation at the next meeting.

II. Host for 1986 Meeting:

Jim Yoakum reported that the Interstate Antelope Conference had extended an invitation to hold the next workshop at Reno, Nevada. No other bids were offered and Winkler advised the group that he would contact the Nevada Department of Wildlife and request confirmation of this offer. (The Director of the Nevada Department has responded that his agency would be delighted to host the workshop and that George Tsukamoto would serve as chairman.)

The meeting was adjourned at approximately 5:00 p.m.

Respectfully submitted,

Charles Winkler
Workshop Chairman
June 12, 1984

MANAGEMENT GUIDELINES

(Trapping and Translocation)

In 1978 the Pronghorn Antelope Workshop published "Guidelines for the Management of Pronghorn Antelope" as part of the proceedings of the 8th Workshop. The objective of the guidelines was to provide the pronghorn manager with the best information currently available for managing and perpetuating pronghorn habitats.

The need to revise and incorporate new information into the guidelines was recognized at the outset. This supplement on trapping and translocation represents the first modification of the guidelines since their original publication.

Copies of the guidelines and this supplement are available from Charles K. Winkler, Texas Parks and Wildlife Dept., 4200 Smith School Road, Austin, TX 78744.

III. MANAGEMENT GUIDELINES

D. Translocation

1. Trapping

Pronghorns are live-captured by a wide variety of nets, traps, drugs, and under certain conditions, without the aid of either mechanical or chemical means. Each method is designed to reduce a pronghorn (or a group of pronghorns) to a restrained condition as a requisite management goal or a research need.

Amstrup, et al. (1980) suggests parameters to consider when selecting a capture method. They are: ".....; number, age and sex of animals needed; density of animals in the trapping area; terrain and proximity to roads; whether pronghorns are accustomed to fences; how wary the animals are; the possibility and acceptability of mortalities; and the cost (in time as well as money) per captured or marked animal."

a. Live Capture

A review of methods for live-capturing large game animals reveals that two basic trap designs are favored for the capture of pronghorns. They are: 1) the corral-type drive trap as described by Fisher (1942) and credited to T. Paul Russell and Elliot S. Barker (two workers in New Mexico) for its development; and Moody, et al. (1982) as an updating of the technique; and 2) the linear tangle net [Amstrup et al. (op. cit.)]. A modified combination of these two capture methods is reported by Reeves (1982).

The corral-type drive trap (Figure 1) is favored when the capture of a large number of pronghorns is the goal while the linear tangle net and the corral-tangle net modification is best suited for the capture of fewer, but more select, target animals. The worker will select the method best suited to his research or management needs.

b. Trap Placement

Correct trap placement (Figure 1) is vital for the success of any pronghorn trapping attempt. Additionally, safety precautions (for both the workers and the target animals) should be strictly adhered to.

The entire trap or net should be hidden by some vegetative or geomorphic feature along known or suspected pronghorn travel routes.

The mouth and wings of a corral trap and the axis of a tangle net should be positioned within 30 degrees of the prevailing wind direction and should be a safe distance from flight hazards (powerlines, trees, etc.). Other flight precautions should depend on the pilot's judgement.

Natural and manmade barriers, steep terrains or tall vegetation, should be avoided near the mouth or within the wings of a corral trap unless pronghorns are actually observed routinely using such areas as travel lanes.

Finally, existing fences near the trap site should be carefully evaluated. Their use may either aid or hinder a successful trapping operation depending upon the observed reaction of the target group of pronghorns to that fence.

c. Trap Modifications

Every trap type has, at one time or another, been modified to meet some capture strategy. The corral trap (and wing) and the linear tangle net design have also been modified to increase pronghorn capture efficiency. Significantly, these two trap design concepts appear to have been combined and modified in an innovative way by Reeves (op. cit.).

The woven wire wings of the corral trap are usually a straight-legged "Y" funneling into the trap mouth. Workers in Wyoming [Moody et al. (op. cit.)] narrowed the distance between these wings near the trap, but gradually flaired them until at 300-400 meters (984-1312 feet) the ends were

about .5 kilometer (1584 feet or .3 mile) apart. This eased the problem of target pronghorns attempting to go over (or through) the trap wings. Another modification they used was a cargo netting fence (the same used in the trap proper) as a trap wing for the first 100 meters (350-400 feet) from the trap mouth to ease this problem and to reduce injury of target pronghorns.

Yet another modification involves a burlap containment curtain extending across the trap wing funnel to facilitate moving pronghorn groups the final distance (approximately 200 meters or 650 feet) into the corral trap. This burlap curtain is folded in place on the ground across the trap wing at or near the blinds on each side of the trap funnel. As the target animals cross the folded curtain, workers emerge from the blinds and form a line across the funnel. When the line has formed, these people raise the curtain to establish a visual barrier to discourage escape attempts back out of the trap funnel.

The visual barrier curtain (Figure 2) is also recommended for the top 2/3 of the trap proper. This burlap or canvas curtain is for the purpose of reducing escape attempts (and injury to pronghorns) through the sides of the trap and its suspension from the top of the trap walls discourages escape attempts (and injuries) over the top. Most importantly, the curtain is lowered simultaneously with the trap gate when the pronghorns enter the trap. It is rolled up and secured at the top of the net with a "quick-release" string-washer-cotter pin assembly until that time.

A final modification of the corral trap technique used in some states, is a "back-up" fence laid out across the trap funnel which is raised after the target pronghorns have crossed it. It allows for the storage of animals in the funnel while another group is worked into and through the trap.

The only modification of the tangle net is reported by Amstrup et al. (op. cit.). It involved concealing the tangle net as either a single or a double cul-de-sac rather than a linear placement.

d. Temperature

Because of thermal stress, corral trapping for translocation is not recommended when ambient temperature is over 21°C (70°F) and preferably in the 4°-10°C (40°-50°F) range.

During a catch and release operation, the temperature limit may not be as critical because of short duration of captivity. Reeves (op. cit.) and Amstrup et al. (op. cit.) successfully trapped for this purpose in August when ambient temperatures are normally high.

e. Season

Because of obvious hunter-related problems and the thermal limitations, live capture of pronghorns for translocation is recommended for the months of December, January, and the first one-half of February. The avoidance of capture and handling of mammals, including pronghorns, during the last half of gestation is suggested by both Selye (1976) and Archer (1979). They agreed that elevated serum corticosteroid levels due to trapping stress may trigger abortion.

Live capture for other purposes is accomplished prior to, during, and after the annual hunting season and is possible during spring and summer as well. This time frame may depend more on management or research goals than anything else.

f. Time of Day

The recommended time to corral trap pronghorns for translocation is prior to 11:00 a.m. This facilitates getting the animals worked, loaded and on the road and even released during daylight hours the same day; however,

pronghorns have been successfully released at night or have even been held overnight and released the following day.

g. Type of Aircraft

An experienced pilot can move pronghorns to a trapping site efficiently with either a fixed-wing or a rotary-winged aircraft; however, because of maneuverability, a helicopter may be more effective when the pronghorns approach or enter the wings of a corral trap or the tangle net cul-de-sac. This is not without costs because the constant pressure applied by a helicopter appears to stress the pronghorns more than the alternating pressure applied by a fixed-wing aircraft. This caution is included with the recommendation that a rotary winged aircraft be used to drive the target pronghorns into the trap wings and to hold them there until the line of workers form across the trap funnel and the burlap containment curtain is raised. As a safety precaution, it is recommended, at that point in time, the helicopter retreat to, and hover at, a safe distance behind the workers with the containment curtain.

When using a tangle net, it is recommended that the helicopter push the target pronghorns into the linear net of the cul-de-sac.

h. Use of Containment Curtain

It is recommended that the line of people with the burlap containment curtain advance toward the trap mouth when the pronghorns move in that direction; when they stop, the people stop; when they move, the people move. It is also recommended that unnecessary noise be kept to a minimum. It is not a rodeo! It is gentle, but constant pressure until the animals enter the corral trap, the gate is closed and the visual barrier curtain is released.

i. Cooling Down Period

It is recommended that the captured pronghorns be allowed to settle down in the trap without human harassment for 10 to 40 minutes (or a reasonable period of time). This is a judgement call depending on how far and how long the pronghorns have been moved and the ambient temperature.

2. Handling and Loading

Within the trap proper, a canvas curtain is recommended that can be drawn across a portion of the corral, hiding the workers from the animals.

a. Hand Capture

A net seine or fence (catchment net) is recommended for the purpose of segregating small groups (6-10 animals) from the main body of trapped pronghorns during this hand capturing phase. Segregating these small groups of animals reduces the chance of injury (to both the workers and the pronghorn) and expedites handling.

Secondly, it is recommended that for each pronghorn segregated by the catchment net, at least one person (but preferably two people) be made available to hand capture and restrain that animal as quickly and effectively as possible.

Further, it is critically important that a restrained or carried pronghorn be positioned on its sternum with its head well above the level of the rumen to prevent aspiration of regurgitated rumen content. Pistey and Wright (1960) cautions, "an excellently immobilized animal can become a fatality immediately from asphyxiation by obstruction or later from aspiration pneumonia."

At this point, the period of restraint is dependent upon the number of short term procedures (tagging, injecting, measuring, etc.) deemed

necessary and whether tranquilizing drugs have been used; nevertheless, during a translocation effort, these procedures should be kept to a minimum.

It would also seem appropriate to make this holding procedure as routine and uneventful as possible, contingent upon minimizing the chance of injury to both the subject and those in attendance.

b. Group Loading

When groups of pronghorns are to be translocated and individual handling for marking is not required, the use of a cattle type loading chute (Figure 3) can reduce stress to the animals and expedite the loading process. The chute should be one constructed specifically for pronghorns with solid wooden sides and runway, canvas top and a width of approximately .5 meters (22½ inches).

c. Tranquilizing Drugs

These are drugs that alter behavior; they promote tameness and ease of handling, and they act slowly but for a long duration. Two such drugs, Valium (5 mg/cc) and Acepromazine (50 mg/cc) are routinely used by some during all pronghorn translocations. Dosages are 1 cc for adults and .5 cc for young of the year.

3. Transporting

Thomas and Allred (1943) described the conversion of one-half to three-quarter ton trucks with stake bodies to haul Wyoming antelope. They stressed ventilation, light exclusion, and covering with a canvas top. These requirements remain valid.

The type of vehicle recommended for hauling pronghorns must meet the following minimum specifications. It must be: 1) well ventilated; 2) dark; 3) compartmentized (to segregate horned males); and 4) easy to load

by hand. Additionally, the space requirement for each pronghorn during transportation is about .288 m^2 (3.2 $ft.^2$).

It may be advisable to blindfold the horned males during transportation even when they are segregated from the other pronghorns. Blindfolds are an alternative to removing the horn tips and likely serve the same purpose.

It is strongly recommended that the vehicle start the trip to the release site immediately when loading is complete. The vehicular motion has a definite calming effect on the pronghorns during transit.

Finally, it is recommended that the pronghorns in transit be periodically hosed down with water when ambient temperatures are above 21°C (70°F).

4. The Release

Recommendations are for a gentle release (open the gates and walk away) as soon as possible after arriving at the release site or as soon as research needs are met.

ADDENDUM

IV. References Cited

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Figure 1. Schematic placement of pronghorn trap.

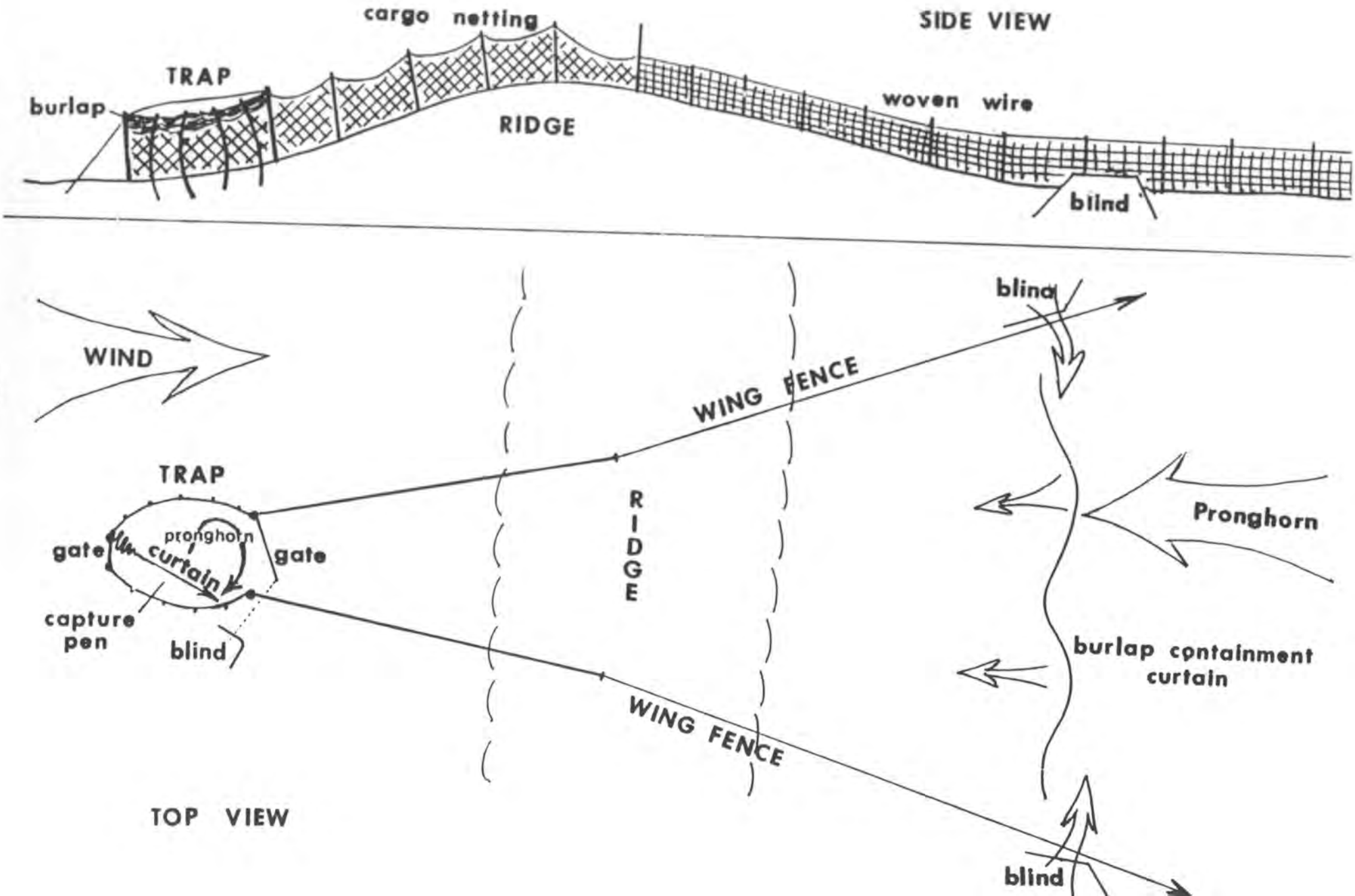

Figure 2. Detail of trigger assembly and placement of pronghorn trap drop curtain.

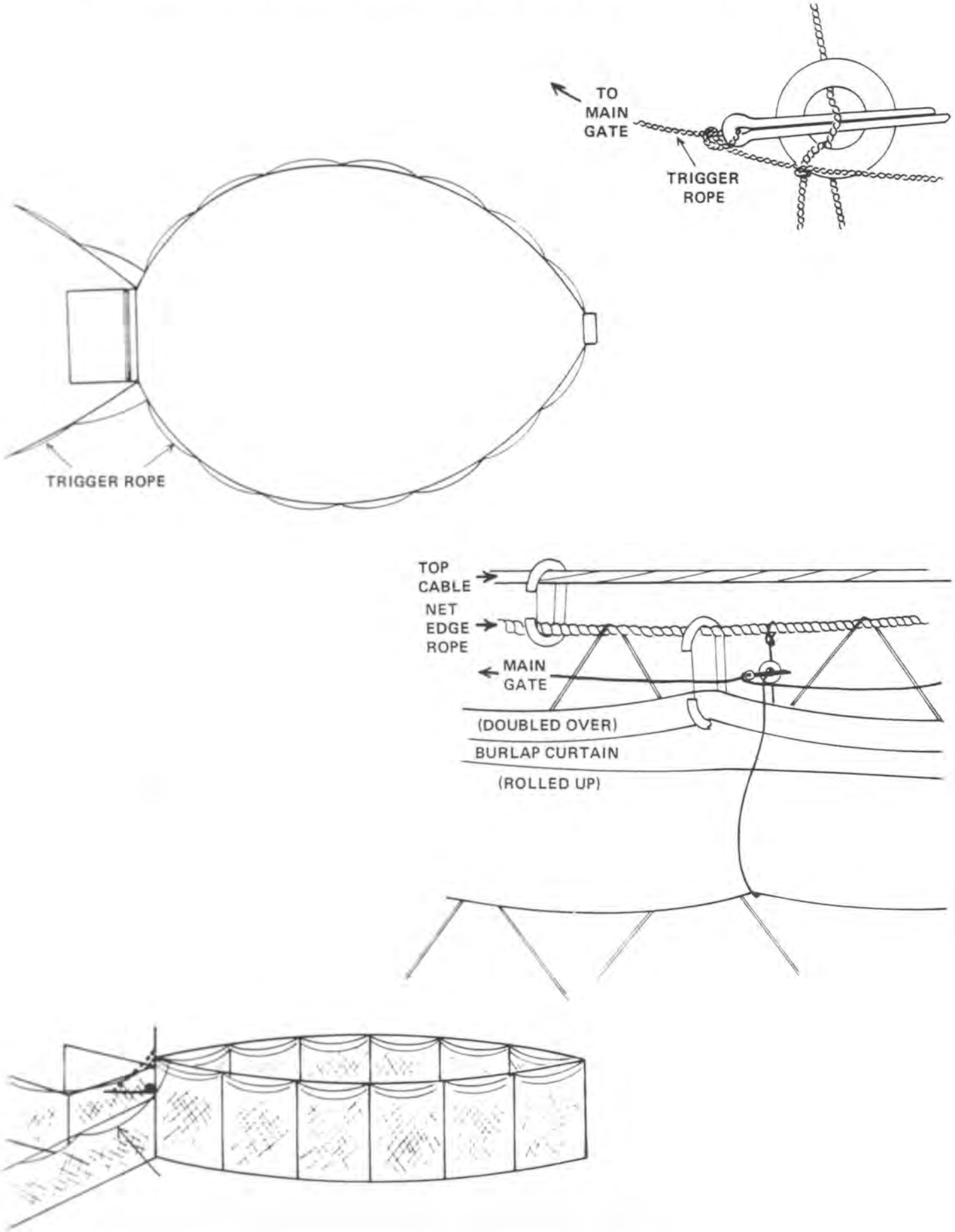

Figure 3. Construction details of pronghorn loading chute.

Figure 3a. Side View of Pronghorn Loading Chute

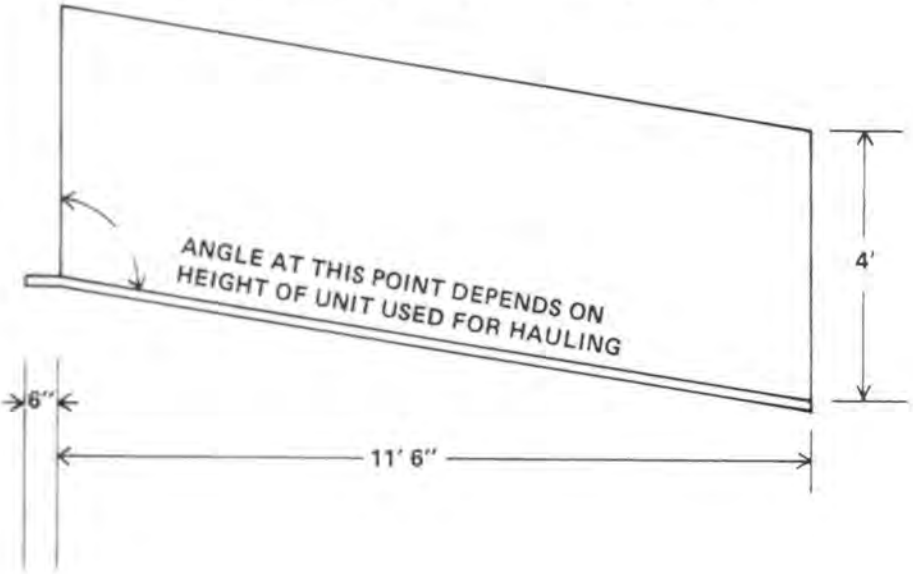

Figure 3b. Detail of End View of Pronghorn Loading Chute

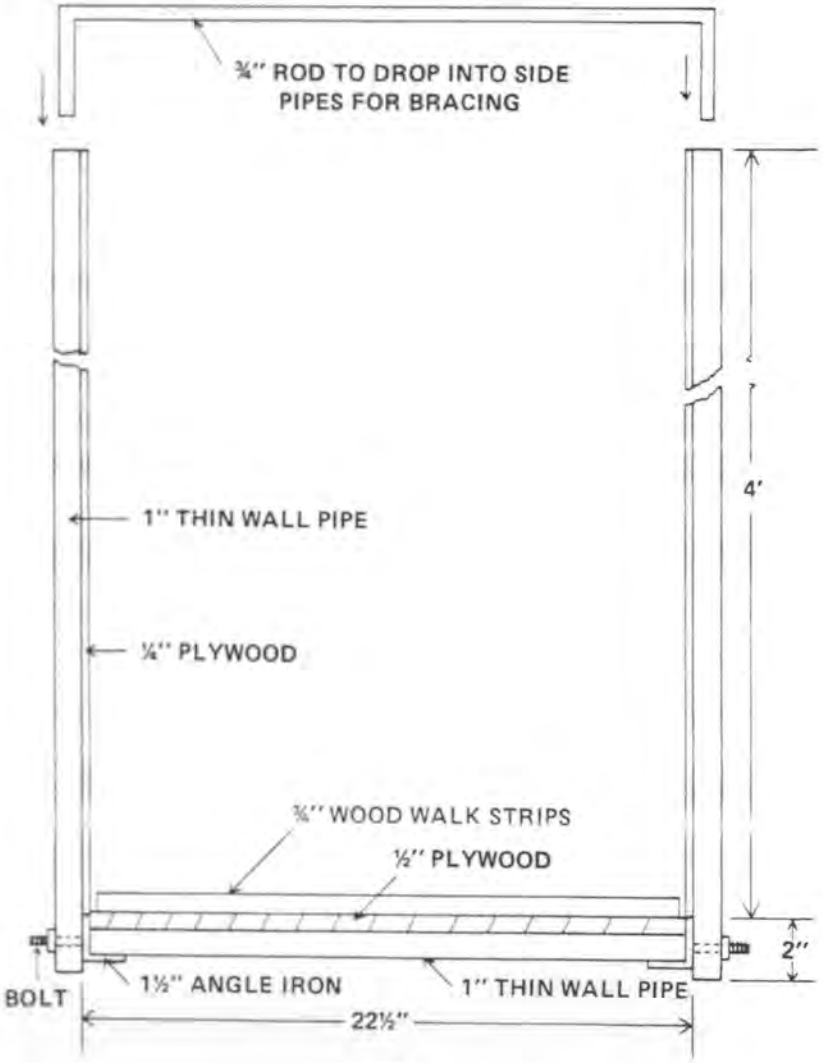

Figure 3 (Cont.)

Figure 3c. Detail of Bottom Frame of Pronghorn Loading Chute

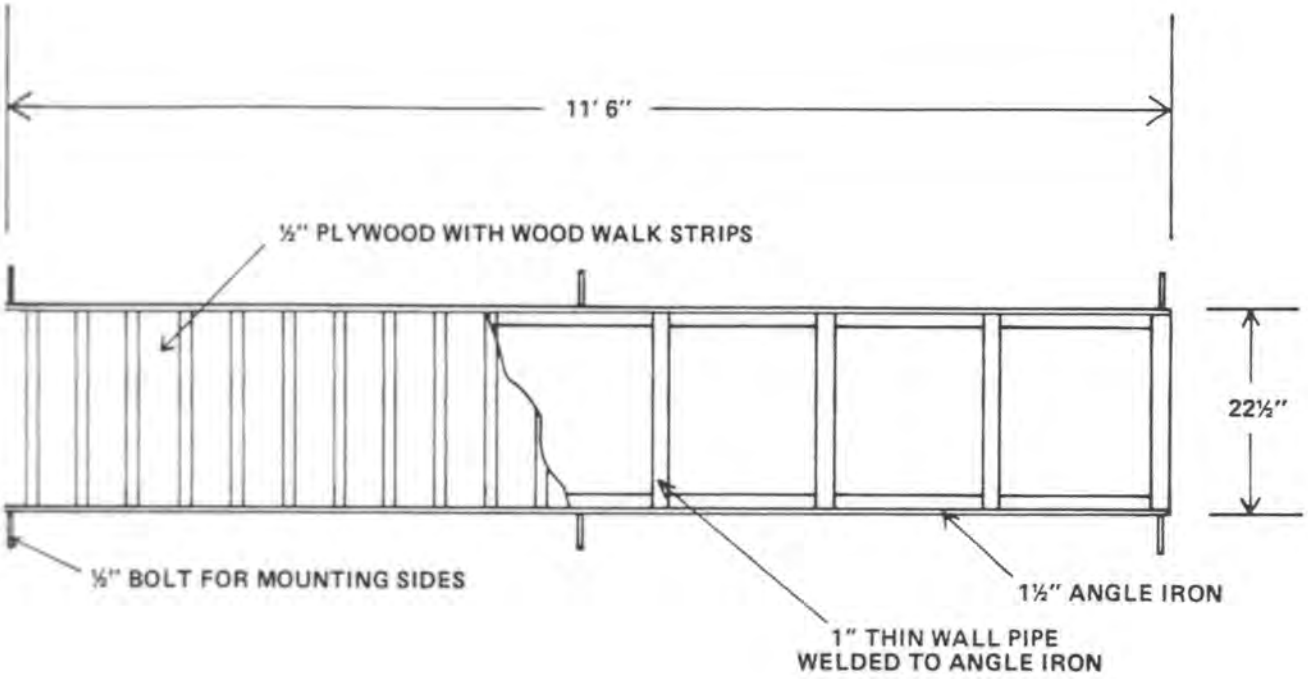
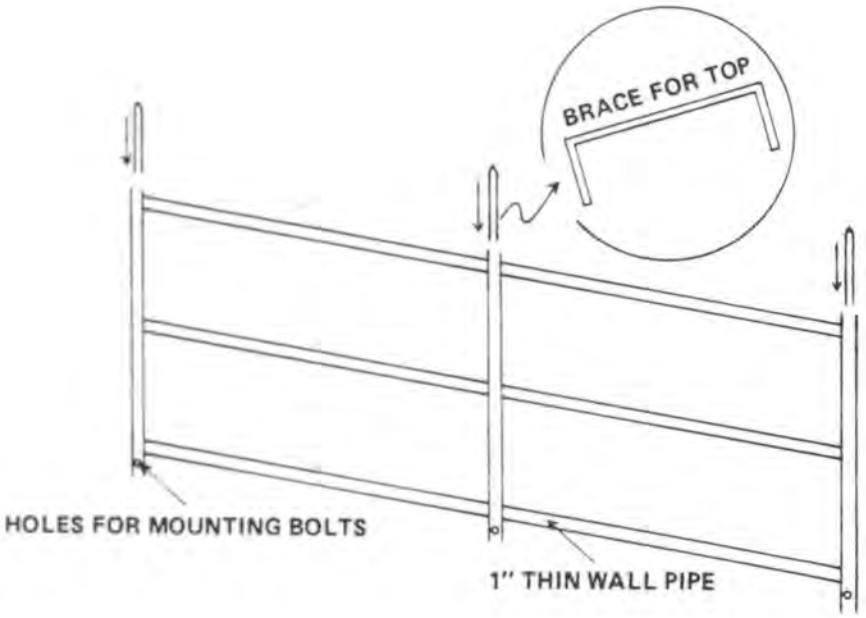
Figure 3d. Detail of Side Frame of Pronghorn Loading Chute