Proceedings of the Eighth Biennial Pronghorn Antelope Workshop



May 2-4, 1978 Jasper Park Lodge, Jasper, Alberta, Canada

Alberta
RECREATION, PARKS
AND WILDLIFE
Fish and Wildlife Division

PROCEEDINGS

of the

EIGHTH PRONGHORN ANTELOPE WORKSHOP

JASPER, ALBERTA, CANADA

MAY 2-4, 1978

CHAIRMAN

MORLEY W. BARRETT

PREFACE

The Eighth Biennial Pronghorn Antelope Workshop was held in Jasper, Alberta on May 2-4, 1978. The Workshop was hosted by the Fish and Wildlife Division of the Alberta Department of Recreation, Parks and Wildlife.

Eighty-four delegates participated in the Workshop and represented two provinces, 11 states, three federal agencies, two technical schools and nine universities. Each provincial and state delegate reviewed changes in pronghorn populations and management programs. A researcher from Mexico participated in our Workshop for the first time by forwarding a written summary on the status of pronghorn in that country. Some agencies that couldn't be represented at the Workshop forwarded written summaries for inclusion in the provincial and state reports section of the proceedings.

An unusually large number of technical papers were presented. The technical sessions highlighted three main topics, namely, 1) new management techniques, 2) habitat requirements and use of rangelands by pronghorns, and 3) biology and mortality of pronghorn fawns. There was also an extended discussion concerning problems relating to winter severity in northern ranges and potential management approaches to the situation. I thank all participants.

Considerable effort was expended in reviewing and refining the content of the Guidelines for the Management of Pronghorn Antelope. The Guidelines, which have been developed over the past 2 years by Workshop delegates, are published in these proceedings.

The opening remarks, discussion on winter severity, and comments

and questions sections have been transcribed from tapes and have been edited. Similarly, all manuscripts have been retyped and in some cases edited. With the exception of dialogue during the question periods and informal discussions, where necessary, units of measurement used in technical reports have been converted to the metric system. I accept responsibility for all errors or omissions contained in the text of these proceedings.

I wish to extend a special thanks to Tom Drinkwater, Deputy Minister of the Department of Recreation, Parks and Wildlife for his opening remarks, and to Val Geist, Associate Dean, Faculty of Environmental Design, University of Calgary for his comprehensive presentation at our banquet. I also thank Bob Autenrieth, Brent Markham, Bill Samuel and Duane Pyrah for so capably handling the chairmanship of their respective sessions. Many individuals in the Wildlife section of the Fish and Wildlife Division provided much appreciated assistance in the planning and operation of the Workshop and their efforts are herein recognized. Christine Smith and Dave Neave of the Alberta Department of Recreation, Parks and Wildlife are particularly thanked for their continuing support and for securing financial assistance to publish these proceedings. I also thank Harry Vriend for his assistance with editing the manuscripts and Denise Barnard for so capably handling the typing of these proceedings.

The State of Arizona has volunteered to host the Ninth Biennial Pronghorn Antelope Workshop in 1980.

Morley W. Barrett

Workshop Chairman

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Summary of Pronghorn Antelope Workshops held to date.

MEETING DATES AND LOCATIONS	NUMBER ATTENDEES	PROCEEDINGS	CHAIRMAN	HOST AGENCY
April 14-15, 1965 Santa Fe, New Mexico	18	1st Proceedings 103 pages	W. Huey	New Mexico Department Fish and Game
February 16-17, 1966 Denver, Colorado	32	2nd Proceedings 85 pages	G. D. Bear	Colorado Game, Fish and Parks Department
February 5-6, 1968 Casper, Wyoming	97	3rd Proceedings 117 pages	J. L. Newman	Wyoming Game and Fish Commission
January 27-28, 1970 Scottsbluff, Nebraska	85	4th Proceedings 139 pages	K. E. Menzel	Nebraska Game and Parks Commission
June 19-22, 1972 Billings, Montana	85	5th Proceedings 293 pages	O. V. Compton	Montana Fish and Game Department
February 19-21, 1974 Salt Lake City, Utah	52	6th Proceedings 183 pages	D. M. Beale	Utah Division of Wildlife Resources
February 24-26, 1976 Twin Falls, Idaho	68	7th Proceedings 222 pages	R. Autenrieth	Idaho Department Fish and Game
May 2-4, 1978 Jasper, Alberta	84	8th Proceedings 532 pages	M. W. Barrett	Alberta Fish and Wildlife Division

OPENING REMARKS

TOM DRINKWATER, Deputy Minister

Alberta Department of Recreation, Parks and Wildlife

I would first like to extend a good morning to you. I particularly would like to welcome to Alberta our visitors, and we hope that you and your wives will take the opportunity while you are here to see some of Alberta. We are most pleased, certainly, that Alberta Recreation, Parks and Wildlife has been able to host this Workshop for you. I understand that this is the first time it has been held outside of the United States. Jasper certainly may not be antelope country and I can also assure you that Jasper Park Lodge is not where our staff usually stay, but notwithstanding that the attendance here is certainly most encouraging and gratifying. I understand that delegates representing a very wide variety of government agencies and educational institutions have travelled from two Canadian provinces and 15 American states to attend. I think that's just tremendous.

While compared with other natural resource managers we, I guess for the most part, need to understand more about the wildlife resource. But I can also assure you that wildlife is considered a very important resource in this province, with tremendous social and economic benefits to all Albertans. Recent social economic data comparing wildlife values to the coal and forestry industry have strengthened our resolve and bargaining position to protect our resources. While we talk about wildlife and wildlife users being recognized as a prime use of the eastern slopes of the Rocky Mountains, I can assure you also that other

species such as antelope will carry equal consideration in my own thinking and in the Department's resolve with respect to Crown land management in the future. I guess that it can be said, at least I think it can be said, that the adversity faced by the antelope populations this past winter may not be totally negative, for it has certainly focussed the public consciousness on the vulnerability of wildlife in the face of depleting habitats.

The variety of papers offered for your meeting here for the next few days looks most impressive. It appears that there is renewed interest in conducting research on the pronghorn and in refining management approaches to this species. In this regard, I wish particularly to commend this group for your contribution relative to providing a better understanding of the population dynamics and habitat requirements of pronghorns. The management guidelines that your group has been developing for the past 2 years, and that will be finalized at the business meeting here, are particularly welcomed and looked forward to. Hopefully these efforts will lead to improved management and understanding by all agencies engaged in administering lands inhabited by pronghorns.

Lastly, I was most delighted to be able to meet some of you last night; including some of our field staff for the first time. I guess it is regrettable that as time goes on organizations get bigger, and we lose touch with those people that we hear about and read about, and that get us into trouble, and never really have the opportunity to meet them on a face to face basis. I know from my own standpoint that I particularly regret not being associated with the line agency anymore and having a direct involvement with the staff. I say to you that even though you are a small and dedicated group your work is respected by all people.

I would like to wish you every success in meeting your particular objectives, and all the best in the meeting which you are going to be carrying on in the next few days.



Provincial and State Reports

ALBERTA PROVINCIAL REPORT

LEO GUDMUNDSON, Alberta Department of Recreation, Parks and Wildlife
Fish and Wildlife Division, Lethbridge, Alberta

1. The 1977 population estimate: 18,000 antelope.

2. Major changes in habitat or population status.

Rapid population increases in the most northerly ranges have largely been responsible for the increased antelope numbers. In 1977 an overall population density of .79 animals per sq. km (2.05 per sq. mi.) was documented. A number of consecutive mild winters during the mid-1970's in regions with marginal winter habitat has allowed for maximum annual carry-over. It appears that the high population level of 1977 may be short-lived as abnormally harsh conditions during the 1977-78 winter placed extreme hardships on overwintering animals.

3. Hunting season dates and harvest.

A total of 2,705 harvest permits (1,835 trophy and 870 non-trophy) were issued for the 6-day season beginning on October 17. Non-trophy permits were issued for the first time since 1966. Hunter success continued to remain high with 82 percent of the participating trophy licence holders and 80 percent of the non-trophy hunters being able to bag an animal. Trophy licence holders were restricted to bucks bearing horns exceeding 12.5 cm (5 in.) while non-trophy permittees could take any antelope bearing horns less than 7.5 cm (3 in.). Each permit was valid only for a specified antelope management zone or wildlife management unit.

4. No archery season has been established for antelope in Alberta.

5. Research programs.

The Alberta Fish and Wildlife Division continues to direct some effort towards antelope management and research. Some recent publications include:

a. Viruses isolated from captive and free-ranging wild ruminants in Alberta.

b. Hematological values for adult free-ranging pronghorns.

c. Clinico-chemical values for adult free-ranging pronghorns.

d. Capture myopathy in pronghorns.

e. Evaluation of fertilizer on pronghorn winter range.

In addition, research is continuing on the following:

a. Blood profiles of pronghorn fawns.

b. Movement and habitat use by adult and fawn pronghorns.

c. Winter range identification and carrying capacity limitations.

Much of the research is nearing the final stages but extensive data analyses have yet to be conducted.

6. Management strategies.

No major change at present. Based on our research findings we plan to review the management policy and antelope management zones for Alberta.

ARIZONA STATE REPORT

JOHN PHELPS, Arizona Game and Fish Department, Phoenix, Arizona

1. The current population is estimated to be 7,500.

2. No major changes have occurred in habitat. The populations are in decline generally state-wide because of low fawn production. The state-wide average for 1977 was 22.1 fawns:100 does. We will survey production in June and July.

3. The 1977 general hunting season dates were September 17-19 with two game management units having a season September 17-22. The estimated harvest was 586 bucks for a 63.4% hunter success. 1978 hunt structures are similar.

4. Two archery seasons were opened. Two units were open August 26 through 31, 1977 and 45 permits were authorized. Three other units were open September 2-16 and 100 permits were authorized. The estimated harvest was six animals.

5. We have one ongoing antelope research project on Anderson Mesa south of Flagstaff. The purpose of the project is to determine the causes of mortality that have maintained this population in a depressed condition since the winterkill of 1967-68.

6. Surveys in the Arizona Strip have begun to detect an established antelope population. This area has received three transplants between 1961-1971 and the first aerial observations were made in 1974.

CALIFORNIA STATE REPORT

LEO PYSHORA, California Department of Fish and Game, Redding, California

1. Herd surveys.

a. Annual census

The annual aerial census of antelope in northeastern California was conducted January 17, 19, 20 and 21, 1978. Winter ranges for the most part were snow free. Counting conditions were very poor due to cloud cover, fog and snow squalls. Antelope were well concentrated on winter ranges as a result of the previous 6 weeks of stormy weather.

Five thousand eight hundred seventy-two (5,872) animals were counted in the basic California population. No antelope were found on interstate ranges in Surprise Valley. California's population was up 964 animals over 1977. This was the highest count since the present census technique was adopted in 1953. The 1978 count was the second highest count on record. In 1944 the count was 6,147 antelope. California's antelope population has increased by 4,092 animals or 230 percent since the low population year of 1960. The 1978 count is 1,274 animals or 22 percent higher than the previous 5-year average.

b. Buck-doe ratio

The annual aerial herd composition survey in northeastern California was conducted July 25, 26, 27, 28 and 29, 1977. Survey techniques were basically the same as used in past years. The sampling method was modified to conform to the method suggested in the report "Antelope Summer Survey Sampling" prepared by Eugene F. Wittick, Operations Research Branch, California Department of Fish and Game. Wittick suggested the

elimination of specified counting locations which consistently showed low or zero counts. The elimination of the specific areas from the survey was done in the interest of economy.

During the 1977 survey 2,873 antelope were classified. The buck ratio was 29 bucks per 100 does. This ratio is up three bucks per 100 does over the 1976 ratio and equal to the previous 5-year average.

c. Production

The 1977 kid ratio, obtained during the summer herd composition counts, was 38 kids per 100 does.

The count was down ten kids per 100 does from 1976 and nine kids per 100 does below the previous 5-year average of 47. The 1977 kid ratio was the lowest in the 25 years of herd composition surveys conducted in California.

d. Harvest

The fourteenth consecutive antelope hunt was held in northeastern California from August 27 through September 5, 1977. Adult bucks only were legal. Three hundred twenty-five (325) permits were issued on a state-wide drawing basis. Permits cost $15. The hunt area was divided into seven zones. One zone (Zone 7) was enlarged to include an area of antelope range extension. All hunters were required to report on the success of their hunt through the tag and report card system.

Hunters reported taking 271 antelope for an 83 percent success ratio. This was the highest hunter success on record. Hunter success has averaged 75 percent for the previous 13 hunts. Previous years, hunter success has ranged from 59 to 82 percent. For the past 5 years hunter success has averaged 78 percent.

The percent of yearlings in the kill increased from 16 percent in

1976 to 21 percent in 1977. During the past 11 hunts the yearlings kill has ranged from 12 to 36 percent. The percent of 4 years and older age class in the 1977 kill was 38 percent, down from the record high of 48 percent of the kill in 1976. The percent of 4 years and older age class animals in the kill has ranged from 22 to 48 percent during the last 11 hunts.

The seventh annual hunter orientation session was held in Alturas the day before the hunt began. There were 100 people in attendance, of these 62 were permit holders. Many hunters consider this session to be a highlight of their hunt. The percent of permit holders that attend these sessions has ranged from 19 to 31 percent during the past 7 years.

During the past 14 years California has issued 4,325 antelope permits. Hunters have taken 3,233 for an overall success ratio of 75 percent. Antelope numbers have increased 124 percent since 1964 when the current series of hunts began.

The California Department of Fish and Game is requesting a special antelope hunt for 1978. The request calls for 400 permits. Regulations to be basically the same as in 1977. It has been requested that permit fees be increased from $15 to $35 to help defray cost of the management program.

2. Range surveys.

a. Weather conditions

Seasonal precipitation and snowfall have been near normal. Late spring rains provided excellent growth of grasses and forbs in 1977. Summer water sources were very limited.

b. Range modification

None specifically for antelope.

c. Range conditions

While spring and summer forage conditions were improved over the previous season, overall range conditions were considered fair.

3. Miscellaneous.

a. Disease

No disease occurrence was reported in 1977. See letter appended to this report regarding blood sampling.

b. Tagging and marking

On September 15, 1977 seventy-seven (77) antelope were trapped near Willow Ranch (Stearnes Ranch), Modoc County. Seventy of these were released near Skedaddle Ranch, Lassen County. Sixty-nine of these were ear tagged with orange, green or white streamers and numbered ear tags. Of the remaining antelope four were transported to the San Diego Zoo (two of these will eventually be sent to Japan), one was euthanized at the trap site, and two expired en route to the release site.

4. Summary.

The 1978 census showed the basic California antelope population to be 5,872 animals. This count was up 964 animals over the 1977 total. California has had a 230 percent increase in its antelope population since 1960. The 1978 population is 22 percent higher than the previous 5-year average.

The 1977 buck ratio was 29 bucks per 100 does. This was up three bucks per 100 over the 1976 ratio and equal to the previous 5-year average.

The kid ratio for 1976 was 38 kids per 100 does, down ten kids per 100 does from 1976.

The 1977 kid ratio is the lowest on record for California.

The fourteenth consecutive hunt was held in 1977. Three hundred twenty-five (325) permits were issued. Hunters reported killing 271 antelope for a success ratio of 83 percent. The success ratio is the highest on record for California.

Seventy-seven antelope were trapped in the Willow Ranch area of Modoc County. Seventy of these were translocated to the Skedaddle Ranch area of Lassen County. Sixty-nine of these animals were ear tagged and marked with coloured streamers.

Range conditions for 1977 were considered fair.

Table 1. Winter Aerial Census in Northeastern California.

Year	Total Counted	Erratic Winter Population*	Basic California Population
1953	2247	122	2125
1954	2022	172	1850
1955	2137	180	1957
1956	2338	0	2338
1957	2080	107	1973
1958	2165	0	2165
1959	1917	0	1917
1960	1961	181	1780
1961	2068	162	1906
1962	2354	85	2269
1963	2498	123	2375
1964	2618	0	2618
1965	2468	0	2468
1966	2898	163	2735
1967	2665	128	2537
1968	2607	0	2607
1969	2971	101	2870
1970	2999	16	2983
1971	3800	0	3800
1972	3764	0	3764
1973	4357	0	4357
1974	4747	0	4747
1975	4109	0	4109
1976	4987	118	4869
1977	4908	0	4908
1978	5872	0	5872

*Erratic winter populations occupying interstate ranges east of the Warner Mountains subtracted from total, leaves the basic California population.

Table 2. Antelope Herd Composition Summary.

Year	Population	Ratio			Number Classified
		Bucks	Does	Kids	
1954	1850	58	100	84	689
1955	1957	52	100	77	1020
1956	2338	51	100	57	927
1957	1973	58	100	66	861
1958	2165	59	100	70	1390
1959	1917	46	100	53	1496
1960	1780	32	100	39	1079
1961	1906	44	100	64	1042
1962	2269	39	100	42	1493
1963	2375	44	100	62	1721
1964	2618	47	100	57	1918
1965	2468	44	100	52	1592
1966	2735	35	100	40	1718
1967	2537	40	100	58	1963
1968	2607	39	100	61	2025
1969	2870	37	100	69	2336
1970	2983	35	100	63	2779
1971	3800	41	100	40	3089
1972	3764	33	100	55	3289
1973	4357	34	100	42	2769
1974	4747	26	100	41	2711
1975	4109	28	100	51	2844
1976	4869	26	100	48	2886
1977	4908	29	100	38	2873

Table 3. Buck Antelope Kill by Season.

Year	Permits Issued	Reported Kill	Hunter Success Ratio
1942	500	405	.81
1943	500	362	.72
1944	500	322	.64
1945	500	307	.61
1949	500	349	.70
1951	416	280	.67
1959	171	120	.70
1964	240	183	.76
1965	240	141	.59
1966	265	179	.68
1967	250	159	.64
1968	260	189	.73
1969	270	204	.76
1970	300	241	.80
1971	400	303	.76
1972	380	301	.79
1973	385	305	.79
1974	410	284	.69
1975	225	70	.76
1976	375	306	.82
1977	325	271	.83

COLORADO STATE REPORT

CHARLIE BROWN, Colorado Division of Wildlife, Craig, Colorado

Colorado's antelope population is estimated at 40-50,000 and inhabit various habitat types ranging from desert in southern Colorado to prairie in eastern Colorado to aspen-spruce timber in certain portions of Colorado. My area, 38,850 sq. km (15,000 sq. mi.) in size, is generally sagebrush dominant prairie habitat and supports approximately 7,000 antelope.

Annual surveys record buck:doe:kid ratios and computer programs combined with landowner input determine appropriate harvest levels. In 1977, kids/100 does ranged from 80 in northern Colorado to 20-25 on the eastern prairies. High predator populations appear responsible for depressed kid production.

In 1977, 17,144 applicants applied for 5,600 antelope licences issued for a 3-day rifle season. Archers may hunt antelope during separately scheduled seasons provided they purchase an archery licence. Supervised damage control hunts also take place in areas where landowners request assistance to eliminate depredation problems.

During the early part of this winter poor range conditions in the northwest part of the state, as a result of severe drought, forced some large herds of antelope onto irrigated fields. Depredation complaints forced the relocation of approximately 300 antelope to the southern part of the state. The remainder of the winter has been extremely mild with adequate precipitation. Pronghorn survival appears good and the population trends continue upwards.

IDAHO STATE REPORT

ROBERT AUTENRIETH, Idaho Department of Fish and Game, Jerome, Idaho

An estimated 13,000 to 15,000 pronghorns are distributed across southern Idaho extending as far north as the city of Salmon. The largest populations are associated with the mountain valleys northwest of Idaho Falls.

An August fawn-doe aerial census has been conducted on most of the 29 harvest units for the past 5 years. Average production ranges from 12 to 86 fawns per 100 does. August buck-doe ratios range from 27 to 53 bucks per 100 does.

Our 5-year management plan calls for increasing most of our pronghorn populations through conservative harvest and a transplanting program.

The rifle season generally runs for 2 weeks, opening the fourth weekend in September. A total of 21,877 applications were received for the 1,735 either-sex permits in 1977. Harvest success for the 1,536 individuals that hunted was 70 percent. Bucks accounted for 75 percent of the harvest. Archery tags sold in 1977 totalled 841. Twenty-seven males and 15 females were harvested for a success of 5 percent. A 75 permit, muzzle loaders only, hunt provided 47 percent success for those who hunted with 87 percent bucks taken.

The impact of the 1977 drought will not be evident until the 1978 fawn-doe ratios are determined. Improved habitat conditions have followed the general downward trend in sheep numbers on the range. A total of 6,000 acres of winter range will be lost to agriculture on the Upper

Snake River Plain. The 1976 Teton flood victims will be given the opportunity to farm this critical antelope and sage grouse winter range.

Several Idaho BLM districts are altering their fences on antelope range to meet the 16 inch smooth bottom wire requirement. However, much remains to be done on this project.

Research in Idaho continues along several fronts. The Departmental antelope ecology study was made a 12-month project in July 1977. We now have 2 to 5 years of production data for most populations. A big part of the study involves population analysis in terms of trends, current harvest levels, habitat and future management. The fawning and bedding cover selection study continues to compare differences in habitat use between populations. There can be little doubt that does and fawns are selecting for cover types in Idaho. This study will be moved to the Challis unit this year and combined with fawn mortality and wild horse competition research.

The southeastern Idaho migration and seasonal range use study continues with a second graduate student continuing the work. This research is supported by the U. S. Department of Energy and supervised by Dr. Doyle Markham. The first phase of the study produced two papers for publication -- "Metabolic indicators of habitat differences in three pronghorn antelope populations" and "Migration behaviour of pronghorn antelope in southeastern Idaho".

Graduate student Gary Copeland is in his second of three seasons on the buck breeding behaviour, habitat selection and hunting impact study. Walt Bodie is in the third year of a pronghorn fawn mortality study and will give a report later in the program.

A cooperative study between Dr. Doyle Markham (U. S. Department of

Energy) and Idaho Fish and Game since 1972 has produced three papers currently pending for publication: "Plutonium in pronghorn antelope lungs near a nuclear fuel reprocessing plant", "Iodine-131 concentrations in air, milk and antelope thyroids in southeastern Idaho" and "Strontium-90 concentrations in pronghorn antelope bones near a nuclear fuel reprocessing plant".

Computer modelling is being initiated in Idaho. One pronghorn population has been modelled to date with what we feel is good success in mimicking the real world data. The model indicates that while the overall population has been increasing the past few years, the buck-doe ratio continues to decline -- an interesting consideration where maintaining trophy class bucks is a goal.

COMMENTS AND QUESTIONS

CLEMENTS: You mentioned barbed wire and smooth bottom wires. Would you comment on this, please?

AUTENRIETH: Yes. In the Fencing Workshop which was held in Wyoming, in 1972 I believe, where our representatives and the Federal agencies got together, fencing guidelines were established regarding what should be and should not be used on antelope ranges. On the cattle range we have established a guideline where the bottom wire is to be no lower than 16 inches and that it will be smooth. This has been incorporated into BLM's manual and by law they are required to reevaluate all their fences on the pronghorn ranges. This is taking place in Idaho, and in some cases they are leaving it to us to show them where we have a problem, which is fine. We have an ongoing program in most districts now to alter those bottom wires where they

are a problem.

HELMS: We ran into a snag on this regulation; apparently BLM somewhere along the line interprets that fencing policy as applying only to allotment type fences. Fences along highways, they say, don't apply to them; and that, of course, is one of the most important problems in a lot of areas. So I don't think we are over the hurdle yet.

AUTENRIETH: Yes, I'm sure we are not. We are making some progress and we have a long way to go. I think we probably have more problems with state lands in Idaho now. We have quite good cooperation with BLM in Idaho.

MARKHAM: You have already mentioned transplanting antelope to historic ranges, do you know why they aren't there anymore?

AUTENRIETH: The areas I have in mind were severely overused during the mining periods in the early history of the state. Since then the grazing situation has improved considerably. Certainly we don't have ideal range in this state, but with improved precipitation which we have had the last few years and less livestock use, we feel that in at least two or three of these areas we can improve things. I probably misrepresented things a little bit. We have a small remnant population so we are just going to try to stimulate it. We feel we have the habitat and the BLM seems to be willing to go along on it so we're going to try.

WISHART: I have a note from our newspaper that you have a coyote proof fence to help you down there. Do you have anything more on that?

AUTENRIETH: Are you talking about the sheep experiment station?

WISHART: It looks like a dandy for keeping antelope in or out.

AUTENRIETH: I'm not fully aware of what all their plans are there. I know they are getting into a sagebrush control burning study as well. Whether they can improve or finish off their sagebrush we are not sure. I really can't expand on that very much. Maybe Dr. Fichter could give you more information later on.

KANSAS STATE REPORT

TERRY FUNK, Kansas Fish and Game, Hays, Kansas

1. Current population estimate is 1,200 antelope located in four different areas of state.

    a. Wallace and Logan counties - 1,100 antelope

    b. Clark and Comanche counties - 100 antelope

    c. Barber county - 30 antelope

    d. Chase county - 40 antelope

2. Changes in population and habitat in Kansas are slight; however, there is some concern about the amount of rangeland being broken out in Wallace and Logan counties.

    Two new herds were established in January 1978. One is in Clark county and the other is in Chase county.

3. Kansas firearms antelope season will be from the 7th of October through the 9th of October with 100 permits being issued. The projected hunter success will be approximately 90 percent.

4. Antelope archery season will be September 30th through October 4th with 60 permits being issued. Harvest will be between four and ten animals.

5. New programs consist of establishment of three additional antelope herds in Kansas.

6. Kansas has terminated no antelope research programs and is presently doing a food preference study.

7. LANDSAT has been used to assist in locating release sites for new herds.

COLE: If your numbers are so low and you're looking for transplants, why do you have seasons?

FUNK: In the Wallace-Logan area there is prime antelope range that has reached its carrying capacity, and the landowners in that area became quite violent and threatened to kill anybody that came in there 5 or 6 years ago when we suggested that we would trap from those herds and move them to other sites. So it's a public relations problem there. They absolutely refused to let us go in and trap any of their antelope and move them to other sites. But they will allow some limited hunting in there, so it is our only means of controlling that population right now. We are getting some movement out of the area through the drainages into other questionable areas that have the same problems that the range has, mainly agriculture encroachment. So we hope through this population pressure and movement that it will establish some isolated herds in the surrounding areas. But that is the reason we can't just go in and move them. The state of Kansas has very little public land and the public land we have is not in the antelope range; we have no public lands there at all. It's all private ownership and it's large tracts of land, thousands of acres per ranch, and we have several ranchers in the area that absolutely refuse any hunting at all. As a matter of fact, Fish and Game employees are not allowed on their property during the season. They actually have men on horseback riding the range on the perimeter. We can't go in and the hunters can't go in. They get quite violent out there.

MEXICO REPORT[1]

JOSE C. TREVINO, Arquitectura #919, Chihuahua, Chihuahua, Mexico

A total of 561 pronghorn antelope were counted in Chihuahua last year. The population's sex and age ratios were: 50 bucks, 100 does, 17 fawns. Reproduction and survival rates were low as indicated by the 17 fawns per 100 does.

Coyotes were seen frequently on antelope ranges; however, no attacks were witnessed. Golden eagles were scarce but two attacks were observed. One report of bobcat predation on antelope was recorded.

Within the state of Chihuahua antelope mainly inhabit low rolling hills or flat rangelands with a primary vegetative cover of grasses and scattered yucca. One smaller habitat is characterized as sandy soils supporting predominantly sagebrush and yucca.

The population appears to remain relatively stable with small isolated herds increasing in some areas and decreasing in others. It is postulated that poaching, livestock competition and droughts are all contributing factors to stabilizing the population. Herds that are increasing are on rangelands given some kind of protection from poaching by the landowners.

The pronghorns transplanted from New Mexico to San Luis Potosi are increasing slowly. From the original 52 transplanted the population decreased to 24, but then increased to 39 during 1977. The 1977 census included nine fawns.

The Department of Wildlife for Mexico provided information on estimated antelope numbers for the states of Sonora and Baja California

[1]Report presented by Jim Yoakum, BLM, Nevada

(see summary table below). These counts represent estimated numbers and lack census inventories in the field.

In summary, it appears through field inventories and estimates that the pronghorn antelope population for Mexico for 1977 was about:

Chihuahua	560
San Luis Potosi	40
Sonora	70
Baja California	200
Total	870

Editor's Note: Jose Trevino is currently working on one of the first in-depth pronghorn antelope research projects for Mexico. The above report for Mexico is the first status report that country has presented to the Pronghorn Antelope Workshop. Members of the Workshop received Mexico's participation enthusiastically and look forward to that country's continuing participation at future Workshops.

COMMENTS AND QUESTIONS

QUESTION: Has this work been published yet?

YOAKUM: No, Trevino's work will not be finished until, I think, the summer after this coming one, I believe. And then there will be his thesis and following that will be whatever he deems appropriate from that standpoint. One thing that I did find is that Trevino's study started as a particular individual's interest but is now being sanctioned and sponsored by the Fish and Wildlife Service of Mexico.

WISHART: Have you any idea of the size of the pronghorns there?

YOAKUM: The size of the animals themselves? No, there are no collections being accomplished during the study and there will not be any unfortunately. This was a recommendation by Trevino and I hope this will be done in the future but it is not scheduled at the present time.

MONTANA STATE REPORT

DUANE PYRAH, Montana Fish and Game Department, Lewistown, Montana

Pronghorn antelope management in Montana today has changed very little from the summary presented in the 1976 workshop transactions. All legal hunting is by either sex permit with hunting seasons from September 10 to October 8 for archery hunters and October 9 to October 30 for gun hunters. Some districts have a split season to limit hunter density as a technique to reduce landowner resistance to hunting access. So far the season length has not been changed. Thus, hunters in each split have only one-half of the hunting time. Some ranchers object to the 2 opening days. And some hunters object to the poor quality of horns near the end of the second split. A landowner preference is given in permit drawings.

Regional efforts vary, depending upon problem priorities. Periodic surveys of antelope distribution and population trends are state-wide efforts. In addition, extra effort in solving hunter access problems on private lands is being pushed from the state level.

A state-wide survey of antelope distribution and density estimate was coordinated by the planning division. From these data, goals for 1980 hunting were established.

In central Montana we anticipate summer aerial surveys in nearly all antelope hunting districts following the apparently large winter losses during winter 1977-78.

Fish and Game Department research on antelope is limited to mining areas in southern Montana. The annual aerial survey of the Yellow Water

Triangle is a continuing study of population dynamics.

The final report on the ecological effects of sagebrush control should be out before long since most of the rough draft writing has been done.

COMMENTS AND QUESTIONS

BARRETT: Could you elaborate on the mechanics of your preferential landowner permits?

PYRAH: The landowner has to be a bona fide landowner and own at least 160 acres in the area that he applies for a permit, and I think up to 10 percent of the total permits can be given to preference landowners. I don't think we have that many that are taken yet.

NEBRASKA STATE REPORT

KARL MENZEL, Nebraska Game Commission, Bassett, Nebraska

Summer aerial surveys normally cover about 3,885 km^2 (1,500 mi.^{2}) in a sample area of 19,425 km^2 (7,500 mi.^{2}). Population estimates are derived for 25 to 30 percent of the antelope range which contains 70 to 80 percent of the antelope in the state. The estimated 1977 population in the primary range was slightly over 7,000, which was 4 percent below the preceding 5-year average and 14 percent below 1974, which was the highest year on record.

Rifle season opens the last Saturday in September and lasts 9 days. Harvest data are obtained from compulsory check stations. All seasons are either sex (two units bucks only in 1964) and success has averaged 79 percent. Harvest in 1977 was 1,325 of which 56 percent were adult (1 1/3 and older) males. The preceding 5 years' harvests ranged from 848 to 1,463 and averaged 1,220. A 2-month archery season attracts minor attention with averages of about 140 hunters and 12 antelope harvested.

Management is currently limited to census, harvest and some non-hunting depredation control.

COMMENTS AND QUESTIONS

QUESTION: Your harvest was 1,325?

MENZEL: Yes. I don't recall the exact permit numbers but hunter success is 80 percent. Most of our seasons have run about 80 percent but it was 74 percent last year.

PHELPS: I read a report, and I don't know whether you turned it out or if somebody else in Nebraska turned it out, that evaluated a hunter questionnaire type program as opposed to a check station where they came up with differences around the order of harvest of 8 percent higher, say, on the questionnaire than they did with the check station information. The end result of the study was that they rejected utilizing a hunter questionnaire program in favour of a check station. In terms of 8 percent it's rather a small amount the way we look at the difference, in terms of the expense of running a check station. And could you fill me in on what sort of information you feel you get out of the check station that makes it worthwhile?

MENZEL: I have to scratch a little bit on the memory as this was in 1967, and I did write the report, but it's digging back in the grey cells a little bit. But the primary thing as far as the total harvest is concerned is dependent on the response rate. If you get a very high response or if you sample the nonrespondents there is no particular problem coming up with the harvest. But let's say if you are running 80 percent success you don't have that many to be unsuccessful obviously and your estimate wouldn't be that far off if you assumed they were all successful, but if you are running a low rate your successful hunters respond much more rapidly than nonsuccessful. Now I don't recall the figures exactly but the primary problem was in the reporting accuracy in what the hunters had taken. If that is a factor in the management or the determination of the harvest then we didn't feel that you could get it from the questionnaire. For one thing, fawns are not reported. I believe that it was way less than half of the actual, probably a quarter of the actual, and buck kills are over-reported. It's probably economically not worth it.

NEVADA STATE REPORT

GEORGE TSUKAMOTO, Nevada Department of Fish and Game, Reno, Nevada

It is currently estimated that there are approximately 6,500 pronghorn inhabiting some 51,463 km^2 (19,870 $mi.^2$) of habitat in Nevada. The highest densities occur in northwestern Nevada; however, scattered and isolated populations are found throughout the state.

The current population status has been on a slight increase based on information collected from aerial summer production surveys and winter trend and buck ratio counts.

Hunting seasons have traditionally been held during the last week of August through the Labour Day weekend in September. Archery season precedes the rifle hunt and continues for approximately 3 to 4 weeks.

The pronghorn hunts are strictly regulated through a quota system based on the management objective of maintaining a minimum of one buck for every five does following the hunting season. For the past 10 years an average of 332 rifle tags have been issued annually. During the 1977 season 412 tags were issued of which 409 hunted and harvested 354 pronghorn bucks for 87 percent success. The past 10-year average hunter success is 79 percent.

Archery antelope hunts have been held annually on a quota basis since 1967. Reported harvest has been very small but increasing with the advent of the compound bow. In 1977, 44 of the 50 tag holders reported eight animals harvested for 18 percent success.

At the present time no pronghorn research programs are in progress

in the state. Some work is contemplated by the U. S. Fish and Wildlife Service for the very near future to investigate the cause(s) of the low productivity rate of pronghorns on the Sheldon National Wildlife Refuge.

A pronghorn species management plan is being written and is approximately 40 percent complete. The completed document will be available during the 1979 fiscal year.

NEW MEXICO STATE REPORT

JACK HERRING, New Mexico Department of Game and Fish, Raton, New Mexico

New Mexico's yearly cycle of antelope management begins in April or May with the population surveys. These surveys are flown 33 1/3 percent of 100 percent on a 3 year rotational basis with each herd unit being flown once every 3 years. These surveys provide a population base for management purposes.

The next step in the cycle is the July fawn survival surveys during which a representative sample of the population is classified. Through this determination of the annual increase of certain herds, a determination of that year's management plans can be made.

After the surveys a determination of which herds to hunt can be made. Further considerations at this point are: the number of permits to be allotted by hunt area and the bag limit for that particular hunt. After the total number of permits for the hunt area has been decided, this number is further broken down to determine the number of permits for individual ranches. At this point landowner contacts are made and hunt agreements are signed.

The hunts start in the north central part of the state with a 9 day either sex bow hunt in mid to late August. This hunt has an unlimited number of licences and is on Bureau of Land Management and U. S. Forest Service lands. Last year there was a 2.3 percent hunter success with 169 hunters taking four antelope.

The regular season hunts start in the northeast quarter of the state with a 3 day hunt in early September followed by the northwest,

southwest and southeast area hunts in late September or early October. The total number of hunters state-wide last year was 3,438 with a combined harvest of 2,380 antelope for a hunter success of 69.2 percent.

Overall, New Mexico's antelope herds have been increasing as the past 3 springs have been generally favourable. The spring is our most critical period as we seldom have harsh enough winters to cause a die off. The availability of spring moisture to provide green forage during the fawning season determines the fawn survival.

COMMENTS AND QUESTIONS

GJERSING: You mentioned that you had a sort of trade-off between hunters wanting to hunt on private land, and you approached the landowner and you got a permit for a hunter to hunt on the private land. In return, his people were allowed to hunt on public land or something like this. Could you elaborate on this trade-off, because right now in Montana we're involved in a program trying to open up closed private land to people and we ran into the same thing that apparently you have, that they want something in return for that -- an economic return or something of an incentive. And could you also elaborate on this incentive for a minute?

HERRING: Yes, the way it works is, take for an example a guy with a ranch that is 70 percent deeded and 30 percent public. In this example, say for that ranch you had decided he would get ten permits. Of the ten permits, seven of them would be what we call landowner permits; in other words, of the ten he would have seven that he could designate who the hunter is, and give this hunter authorization to go buy a landowner antelope licence. The other

three would go into a public drawing for the 30 percent public land. Now, when they do this, the rancher actually signs an agreement, and in this agreement it states that he understands that the movements of antelope would make it necessary for the hunters to follow the antelope. Therefore, he agrees to allow those three public hunters on to his deeded land in return for the favour of his private land hunters going on to the public land.

AUTENRIETH: Jack, didn't the Secretary of Interior support the fencing guidelines of BLM and indicate it should be implemented in New Mexico?

HERRING: If he did, he didn't support it very strongly because the fact is the BLM was running scared and they thought the whole thing was going to fall through, and that's why they called Game and Fish in as a kind of moderator. I don't know exactly what happened in D.C. I think BLM got sort of a 'yes, you guys are right' but they never did really back them.

AUTENRIETH: It sounds like you're involved in a compromise where we're going to end up with something less than what we'd hoped for in terms of antelope movement. Do you think your Department will buy off on this and, in effect, is the BLM going to get off the hook on what's in their guidelines?

HERRING: At the present time it looks like there's going to have to be a compromise or the whole thing's going to fall through on them, because the ranchers raised such a big stink that it didn't look like they were going to get anything done for awhile.

YOAKUM: Maybe I can help answer some of the questions that are being raised here. Maybe I can help you a little bit on that. We did go to court 2 weeks ago with ranchers on this issue, in which certain

fences are referred to as "wolf proof". They are made with net wire fence, part of it's buried, and then it has three or four strands of barbwire above that. Some of those fences are 50 and 60 inches high and are formidable barriers. Most of these fences were built 20 to 30 years ago on state, federal and private lands. Those fences that were on public land were modified in the last couple of years in relationship to the guidelines put out at the Regional Fencing Workshop and the guidelines of this Workshop right here. When those fences were modified the ranchers took BLM to court, saying BLM was arbitrary and capricious in allowing antelope to go from one pasture to the other and was affecting their economic base. The Bureau of Land Management was not in accord with that because with the passage of the Multiple Use Act 2 years ago we deem it a requirement by law that antelope should have the right to travel from pasture to pasture. We presented our case, and it will be 6 months or thereabouts before the judge will make his decision, but that is a test case. It's an item that I would like to bring up more at our business meeting because I think our guidelines should address that subject and other similar subjects; there are going to be many, many cases held in court relative to the future of our antelope and this, I think, is the real value of our guidelines which were used in this particular test case.

HERRING: How did it look in court, did it look good?

YOAKUM: We presented everything we had, and our lawyer said that if we lost it there he was going to appeal it right on up. But I would say it looks very good. Of course I'm not biased or prejudiced, but I think it looks very, very good.

HERRING: If the landowners win that one it could have some pretty far-reaching consequences.

YOAKUM: Oh, it would have major consequences, that is right.

HERRING: Also, since this thing came up and we got into the fencing, the same bunch of ranchers that started raising all the concern about the fences being changed have since contacted Australia, as I understand it. At least that's where they tell me they get the idea. They are putting in electric predator proof fences that are supposed to be developed in Australia to keep dingos out of sheep.

OKLAHOMA STATE REPORT

G. B. WINT, Department of Wildlife Conservation, Oklahoma City, Oklahoma

Our primary vehicle in determining antelope populations is an annual aircraft survey during early March, supplemented by ground reports. The population during the winter of 1977-78 was estimated at 150 animals. Population trends over the past several years have been downward. This is due to changed land use practices which include conversion of native pastures to farm land and severe overgrazing during a generally dry period.

We have held no antelope seasons since 1968.

No past or present antelope research programs have been initiated. This is due, partially, to a lack of interest by the general public and low hunter interest.

Suitable habitat is limited and future prospects in this area of large, privately owned ranches are poor.

Other than protection and an annual census, we have no present projects on antelope in this state.

In closing, prospects for the antelope in Oklahoma are not promising. This situation will continue and antelope populations will probably decline unless there is a major change in land use and human attitudes.

OREGON STATE REPORT

PAUL EBERT, Oregon Department of Fish and Wildlife, Portland, Oregon

1. 1977 population estimate: 13,800 antelope.

2. Major changes in habitat or population status.

August kid/doe ratios have continued a gradual decline since 1950. The current 5-year average of 33 kids per 100 does is 20 percent below the previous 5-year average of 41 fawns per 100 does. The 1977 ratio of 30 kids is the second lowest ratio on record. Buck ratios show a similar decline and average 26 bucks per 100 does during the last 5 years.

Antelope populations declined from .89 antelope per sq. km (2.3 antelope per sq. mi.) in 1950 to .42 antelope per sq. km (1.1 antelope per sq. mi.) in 1961. The populations increased to a peak of .93 (2.4) in 1971 and have averaged .81 (2.1) since. Since hunters have been mainly restricted to the taking of buck antelope with horns longer than the ears, population changes have been largely a product of kid survival.

Massive sagebrush spraying operations tapered off by 1970 and habitat changes since have been minor. Water development by the Bureau of Land Management has allowed better distribution of the herds. The severe drought of 1977 severely reduced forage and water supplies and competition for water between wildlife, cattle and wild horses was critical on many areas. A considerable number of wild horses were removed and supplemental water was trucked to critical areas.

3. Hunting season dates and harvest.

A 5-day buck antelope season was allowed in 1977 starting on August 27 with 1,400 permits allowed in 19 areas. An estimated total of

1,349 hunters participated in the season, taking 890 buck antelope and averaged 66 percent success. The taking of doe antelope was allowed in two areas where landowner conflicts existed. An estimated 115 hunters took 85 doe antelope and averaged 74 percent success. The 1977 harvest of buck antelope is the highest on record.

4. Bowhunting antelope season.

A 16-day buck season starting August 13 was allowed 200 permit holders in one area. An estimated 150 bowhunters participated, taking only one antelope. Reporting hunters averaged 5 days of hunting per individual.

5. Research programs.

There are no ongoing antelope research studies and none have been completed recently. Although no new studies are scheduled there is concern over the low survival rate of kids during the first 4 months of life and this is being considered in future research plans.

6. Management strategies.

Oregon's antelope herds are managed to provide the buck hunter with 50 percent chance of success and a reasonable chance to hunt a medium-sized buck. The objective is to maintain a pre-season buck ratio of at least 25 bucks per 100 does. Since management does not have adequate data to substantiate maximum range carrying capacities, doe harvest has only been recommended when a landowner conflict arises. Trapping and transplanting is also being used to resolve landowner problems. A limited amount of helicopter time to hunt coyotes prior and during the kidding period has been allowed in these areas where kid ratios are low and where numerous coyotes have been observed during this period.

SASKATCHEWAN PROVINCIAL REPORT

EARL WILTSE, Department of Tourism and Natural Resources
Regina, Saskatchewan

Since 1974 resident antelope populations have increased substantially in the northern portions of the antelope range. Last year we estimated 5,500 antelope in Saskatchewan. This year we are anticipating sizeable reductions in our migratory populations. Severe winter conditions were experienced in the southwestern corner of our range, southeast Alberta and northern Montana winter ranges. Winter losses could result in significant hunting restrictions as the area hardest hit normally supports 30 to 40 percent of Saskatchewan's antelope population.

The northern portion of the range appears to have escaped the winter elements experienced along the Montana-Saskatchewan border. Our investigations have revealed only small losses in the northern areas. We collected some animals during February and found them to be in reasonably good condition.

One interesting note was 24 antelope found in close association with a cattle wintering feedlot north of Leader, Saskatchewan. Examination of the animals revealed foot rot (Necrobacillosis). In 1974 the disease was discovered in mule deer and white-tailed deer found in close association with a cattle feedlot in the Cabri Sandhills. Also, Morley Barrett and Gordon Chalmers reported a case of foot rot in one pronghorn antelope in southern Alberta.

Saskatchewan has issued hunting licences through the big game computer draw. In 1977 we issued 1,556 licences. Hunting success was 84.7

percent. The 1 week season is normally held during the last week of October. Bag limit is one antelope, either sex. We also have a special antelope archery season. We issued 150 licences last year. Archers harvested 23 animals for 15.4 percent hunter success.

Currently we have no active antelope research program. An antelope research study was conducted from 1968 to 1974, which I will elaborate on this afternoon.

SOUTH DAKOTA STATE REPORT

BOB BROWN, Department of Game, Fish and Parks, Faith, South Dakota

It is estimated that prior to 1800 over 700,000 antelope roamed the prairies of South Dakota. By 1909 antelope were considered extinct east of the Missouri River. In 1924 it was estimated that there were only 680 antelope in western South Dakota. By 1937 antelope numbers had begun to increase. In 1941 the first aerial count of antelope was conducted and the population was estimated at 10,000. Through the aerial census and determination of annual productivity, the 1977 summer antelope population was estimated at over 40,000.

Annual aerial census data form a basis for recommendations of hunting season unit boundaries and harvest quotas. The hunting season is the most important tool for management of antelope in South Dakota. Ultimate objectives of an antelope hunting season are to keep the population well distributed within landowner tolerance levels and range carrying capacity and to provide optimum recreational opportunity. Hunting units are established on a flexible unit and permit quota system. The permit quota system enables managers to increase, stabilize or reduce the populations independently of each other and has been effective in South Dakota since 1941.

South Dakota's aerial census begins about May 1 and consists of a one-third sample of all hunting units. Units are surveyed using belted transects one-half mile wide on a mile and one-half center line. A doe:kid count is made in late June. These data are then evaluated to determine harvest quotas.

Our best antelope habitat occurs in the northwestern corner of the state and Fall River county in the extreme southwestern corner of the state. Our summer population in 1977 was 40,000.

In 1977 we issued 9,300 permits for a 9-day rifle season. Our antelope season always begins on the first Saturday in October. Hunters harvested 7,600 antelope for a success rate of 82 percent. Better than 60 percent of our annual harvest is bucks. Rifle permits are limited to residents by state law. Landowners receive preference for 50 percent of licences. Few landowner permits are taken.

Archery antelope season is held from September 1 to October 31 but is closed during the rifle season. Last year 600 licences were sold with an estimated success of 30 percent. Archery permits are unlimited and available to both residents and non-residents.

Very little antelope research has been conducted in South Dakota. Currently we have no antelope research projects.

We just came through the worst winter on record since they began keeping records before 1900. We had a substantial movement of antelope out of the northwest corner of the state. We have also had a heavy winterkill. Management must now respond to the effects of this past winter.

TEXAS STATE REPORT

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At present the Texas antelope population is estimated at 14,700 animals. The bulk of the population, approximately 8,300 animals, is in the Trans-Pecos ecological region west of the Pecos River. Another concentration of about 4,700 occurs in the Panhandle region, and one ranch in the southern Rolling Plains carries a population of about 1,200. The remainder occur in relatively small bands scattered through the Rolling Plains and High Plains.

In 1973 our population reached a peak of about 18,000 antelope, but the following year the population declined to approximately 8,200 as a result of drouth and a hard winter. Since that time the population has shown substantial recovery, with a 16 percent increase in the population indicated between 1976 and 1977.

Our adult population is estimated by aerial surveys conducted during the spring and summer. At the present time approximately 40 percent of the antelope range is censused annually with a portion of the range being sampled in successive years to provide data on population trends.

Fawn production is determined from ground observations in the summer and from aerial observations in the Panhandle where the census is conducted late enough to provide valid production data.

The antelope harvest in Texas is controlled by permits which by law must be issued to qualifying landowners, i.e. landowners with huntable surpluses on their property, who in turn distribute the permits

to their hunters. Hunting is largely on a fee system with hunters paying the landowner for trespass rights for the purpose of hunting. We have a 9-day hunting season in early October with a bag limit of one antelope per hunter. In 1977 a total of 1,373 hunting permits was issued, which resulted in a harvest of 918 antelope. Hunter success was 93 percent.

The last major restocking effort involving antelope occurred in 1972 and 1973, when 1,100 antelope were stocked on 62 ranches in the Trans-Pecos and Rolling Plains. Last year limited hunting was permitted on eight of these ranches in the Rolling Plains and many of the other transplanted herds are holding their original numbers or increasing slightly. Approximately 20 percent are considered failures.

The Texas Parks and Wildlife Department is not conducting any antelope research at this time. Several universities are conducting studies concerned with population ecology of the pronghorn.

UTAH STATE REPORT

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At present there are roughly 3,000 pronghorn antelope in small scattered bands on 16 different areas or herd units over the state of Utah. About one-half of these occupy the western desert areas and the remainder are in the northeast corner and in the south central part of the state. Hunting of male antelope is allowed on permit basis. During the last 4 years some herds have declined but others have increased and the numbers of permits issued have remained about the same. In 1976 and 1977, 230 and 250 permits were issued and 180 and 208 bucks were killed these years respectively. This was slightly below the number of permits issued in 1974 and 1975 and a slight decrease in harvest. This was a substantial increase in harvest over earlier years such as 1956 when 51 bucks were taken on 85 permits. The increase in harvest in the past few years results largely from established new herds.

The Utah Division of Wildlife Resources is attempting to expand the present pronghorn antelope range by introducing animals into new areas where there is suitable habitat. In 1965 an introduction was made on Parker Mountain, a plateau ranging from 2,134 to 2,743 m (7,000 to 9,000 ft.) in elevation. This herd has increased about 20 percent annually since the introduction and by 1975 there were over 600 animals present. In 1975 this area was trapped and 145 moved to two new sites. Six additional introductions into different areas have been made in the past 4 years. Most of these herds are doing well and hunting seasons

have been held on two of them.

The Utah Division of Wildlife Resources has been active in pronghorn antelope research for the past 15 years. Research to date indicates that considerable pronghorn antelope range exists in western Utah and that much of this range will support several times the number of antelope that are now present. Fawn birth rates are usually high (1.6 to 1.8 fawns per mature doe) but fawn mortality is often excessive. In some years over 80 percent of the fawns born in May are lost by September.

High fawn mortality during summer months continues to be the main reason for the static population trends of many of the herds. Predation on fawns during summer is the major cause of mortality. Current research is intended to determine the relationships of mortality among pronghorn antelope fawns with other ecological factors.

Management data obtained in Utah on an annual basis consist of late summer fawn/doe ratio counts and winter trend counts. In 1976 and 1977 fawn/doe ratios on the individual herd units ranged from a high of 84 fawns per 100 does to a low of 8 fawns per 100 does. Most herd units had less than 50 fawns per 100 does.

We feel if management techniques can be developed which, directly or indirectly, reduce the high fawn mortality rate that occurs with many pronghorn antelope herds, the total population in the state of Utah could be increased considerably.

WASHINGTON STATE REPORT

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Historically there have been no substantial accounts of pronghorns in Washington. Prehistoric pronghorns inhabited the Columbia Plateau on the east side. Archeological investigations have found antelope bones at Indian house pits near Nespelem, Ritzville and Wallula, but pronghorns probably were extirpated from Washington about 1700, prior to European settlement. Change in climatic conditions over the past 4,000 years is probably the reason for the demise of the antelope in this state.

In 1938 and 1939, 50 pronghorn fawns were obtained from the Charles Sheldon Refuge in Nevada. Twenty-two were raised to maturity. In 1940, 100 fawns were obtained from the Hart Mountain Antelope Range in Oregon of which 16 were raised to maturity. The 3-year program provided the state 38 bottle-reared, mature pronghorns. These were released in the Squaw Creek area of Kittitas County in 1940 on 4,087 ha (10,100 acres) of newly purchased Department land. The first year after they were released the population produced six new fawns.

The U. S. Army took over this area as the "Yakima Firing Center" between 1943 and 1946, returning it to the Department in 1946. The population had increased to 100 by 1950 when the Army again took over the land permanently. In 1950 ten pronghorns were herded into a trap by helicopter and transplanted to the Carl Harder Ranch near Ritzville in Adams County. By 1956 about 80 antelope roamed the channelled scablands between Sprague Lake and Washtucna. Presently, only ten animals

each are left at both the Yakima Firing Center and the Washtucna area.

In 1968, 22 pronghorns were obtained from the Oregon Game Commission in the vicinity of Burns, Oregon. Plants of 11 animals each were made on the Colockum Wildlife Recreation Area in Kittitas County and on the Sam Gross Ranch near Summer Falls in Grant County. Presently, about 20 animals survive in the Colockum; a like number in Grant County.

While some initial success was achieved with all four pronghorn plants, currently only 60 antelope have maintained a precarious position in four different locations within the state. As to why this species has had difficulty establishing itself in Washington, we can only state a hypothesis. Antelope are only endemic to the higher prairies of the west and the lower prairies of the Columbia Basin differ in some significant, unrecognizable way from adequate pronghorn habitat. This situation is not uncommon in the introduction of other exotic species to new habitat and we should learn to accept it with relation to pronghorn antelope in Washington.

WYOMING STATE REPORT

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Wyoming is in a development stage and this is probably our biggest problem right now, the energy development in Wyoming. It hasn't really affected the overall state population of antelope so far. Our estimate population is 206,000 antelope. The whole state is divided up in antelope areas and each one is managed as a separate unit, with permits allotted to each unit. The doe/fawn ratios run between 60 up to 100 fawns per 100 does, with good production in most of the areas. We had a good winter last year and didn't suffer the extreme weather to the degree South Dakota and some of the other provinces did. Antelope are coming out in good shape this spring.

In 1977, 70,000 antelope permits were issued. Of the 70,000 permits, 50,000 of them went to non-resident hunters and only 20,000 to the resident hunters. For many years Wyoming hasn't had enough resident hunters to take the number of permits that were being allocated. On some of the public land areas there is a high demand by the residents for permits but on private lands residents are unwilling to pay trespass fees.

Our hunting seasons are varied. We start many of our pre-season archery hunts in August, middle of August, and these will run up to a month before the rifle season starts. Our general rifle season will start in Wyoming about the first week of September and it will carry on through, depending on how many damage complaints we have, into December.

Wyoming has gone to a second licence for doe or fawn, and this can

be purchased in addition to the original licence. These licences are only issued for areas where we need to reduce the population.

We do not have any current research programs going on in Wyoming. It's not that we feel we know everything about antelope but there are other areas that need to be investigated a little more thoroughly; antelope have been one of our real points of interest for many years, but now we are shifting to some of the other problems we have. There is one study that is in the hopper and that is a food habit study. This has been okayed by our commission and it will involve the food habits of pronghorns on private land in four different habitat types.

In 1976 we had a blue tongue epidemic in portions of our antelope range. We lost in the neighbourhood of 3,000 head of antelope. Hunting seasons were adjusted to compensate for this loss but we had some movement into this area in the winter of 1976 and today pronghorn populations are much the same as they were before the epidemic.

We also have a program to establish a computer model for each big game species.



Technical Session

IS TROPHY HUNTING FOSTERING "UNNATURAL" SELECTION FOR SMALLER, LESS VIGOROUS AND NONTERRITORIAL PRONGHORN BUCKS?

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Abstract: Two kinds of social organization that result from agonistic behaviour (aggression and response to aggression) among pronghorn (*Antilocapra americana*) bucks are a dominance hierarchy and territoriality. The hierarchy is linear and said to be based primarily on age and weight, with large, dominant males (an estimated 20 to 30 percent of a male population) each defending a specific geographic area against intrusion by all other male pronghorns about half the year. Territorial bucks do most of the breeding; thereby, the function of the dominance hierarchy is that of determining which males breed the females. Body size of bucks may be an expression, not only of age and condition of forage but also of genetically based, individual variation. Of particular importance to our consideration here are the facts that behaviour is also genetically influenced and variable and, therefore, subject to selection. A buck's social rank may depend, in part, upon the relative level of his aggressiveness which may, in turn, be functionally related to vigor. If these two features are, to any extent, genetically controlled traits that show individual variation, selection for smaller, less vigorous and nonterritorial pronghorn bucks seems to be a possibility under the pressure of trophy hunting.

At the Thirtieth North American Wildlife Conference, Stokes and Balph (1965:410) predicted "that in 25 years animal behaviour will be as much a part of wildlife management as population ecology is today". Five years later, at the 11th Symposium of The British Ecological Society, Geist (1971:421) said: "If we are to conserve and manage all ungulate species in the wild state", we must have knowledge, not only of each species' habitat requirements but also its total biology, "including its diverse behavioural adaptations". In 1971 an International Symposium on the Behaviour of Ungulates and its Relation to Management was held at Calgary; the scope of the symposium substantiated the statement, made at that meeting, that application of "behavioural knowledge to management of wild species" was under way: the resulting publication -- two volumes totalling 940 pages -- presents 56 papers by 59 behaviourists from 17 countries. Among those contributions are reports of evidence that, in some ungulates, there are correlations between dominance ranking and territoriality, on the one hand, and quality of breeding stock and selection for vigor, on the other. In light of this background it seems reasonable to consider some possible genetic effects of trophy hunting on the quality of pronghorn populations because of the species' social organization. For the purposes of this paper quality refers to size, vigor and aggressiveness of males as these factors relate to social rank and the expression of territoriality.

The social behaviour of the pronghorn, like that of many other kinds of animals, includes aggression -- or, more appropriately stated, agonistic behaviour. The latter term takes into account both aggression and the immediate response (or responses) to aggression, such as escape, avoidance, submissive displays, "fighting back", etc. Agonistic inter-

actions are most clearly thought of in the one-to-one context. Typically in such encounters one individual is dominant over the other which is called the subordinate.

Two kinds of social organization that result from agonistic behaviour -- and with which we are concerned here -- are the dominance hierarchy and territoriality.

A dominance hierarchy is the arrangement of the individuals of a social group into a ranking or order of social status in which domination and subordination become organized by way of learning, recognition and habit into a regular and customary relationship. The simplest and perhaps commonest hierarchical organization is linear, i.e. individual A may dominate all other members of the group, B all but A, C all but A and B and so on.

Territoriality exists when an animal actively defends all or a part of its home range against intraspecific intruders of the same sex. What an animal does in defending its territory is called territorial behaviour. Such behaviour is said to be "the most familiar manifestation of aggressive tendencies" (Marler 1972:32).

In the pronghorn a territory is "a specific geographic area" that is "consistently defended by one male against all other male pronghorns" (Kitchen 1974:49).

Studies in Montana (Bromley 1967, 1969; Bromley and Kitchen 1974; Kitchen and Bromley 1974; Kitchen 1974) and Wyoming (Ingold 1969) and our observations in Idaho have shown that pronghorn bucks form dominance hierarchies and that the territorial individuals are high in the hierarchy. Kitchen (1974:52, 91) states that the hierarchy is linear and "based primarily on age and weight"; on the National Bison Range in Montana

"large, dominant males defended nonoverlapping territories" about 6 months out of the year (see also Bromley 1969).

However, it is estimated that only 20 to 30 percent of the bucks in a population are territorial at any given time. Nonterritorial males form all-male ("bachelor") groups or, as "lone" individuals, "restrict their activities to well-defined areas" but do not defend them. "Occasionally older bachelor males wandered alone and were seen on all parts of the range" (Kitchen 1974:50-51).

That dominance relationships among the pronghorns on the National Bison Range "were well established.....would be expected in [such] a small, isolated population" is pointed out by Kitchen (1974:22); he suggests, however, that the same is "probably.....typical of most populations, since larger pronghorn populations are made up of a series of sub-populations with specific home ranges (Pyrah 1970)".

Prompting, if not justifying, the question under consideration here is the fact that the territorial bucks do most of the breeding. "A male with a territory was almost certain to breed, and a buck without one was virtually certain not to breed", according to Kitchen (1974:76). "Territorial males accounted for 92.6 percent of all copulations and large bachelors for only 7.4 percent" (Kitchen 1974:92). Abundantly clear is the significance of Kitchen's (1974:91) conclusion that the ultimate function of the dominance hierarchy among pronghorn bucks "is that of determining which males eventually breed females".

Of particular interest here is the ethological principle that behaviour is variable. Scott (1972:31) asserts: "Every individual [animal] behaves differently from every other one, partly because of heredity and partly because of differences in previous experience.....the

social environment depends upon interaction between the animals making up a group, all of whom show individual differences". Hinde (1970:217) says that individual differences in behavioural traits are known to exist; for example: "Rats which explore vigorously also respond intensively in a number of other situations (feeding, defence, sexual activity, grooming, etc.). A common factor to all these activities can be presumed. This factor is subject to genetic influences".

Because behaviour is genetically variable it is subject to selection. The following statements by Alcock (1975:14) are relevant (original sequence of the two excerpted passages reversed here):

> Individuals within a species differ in the exact nature of the physiological mechanisms they happen to possess because their genotypes differ. Some are capable of behavioural responses that others lack altogether or possess in different form. These individual differences may contribute to variation in reproductive success.
>
> The genes that animals have are present by reason of natural selection. They have been maintained in populations because they contribute to the development of animals with a high probability of reproducing successfully in competition with other animals with different genes. A successful genotype contains instructions that translate into a competent animal that will behave in ways that promote the production of offspring that will also reproduce. Animals that fail to do this fail to transmit their genes to subsequent generations.

It has become apparent that the behaviour of pronghorns shows geographic differences, or perhaps more appropriately, ecologic differences. David Kitchen (personal communication 21 April 1976) has stated, for example, that "pronghorn social systems vary with habitat quality". Explicit in such circumstances is the possible danger of uncritically extrapolating research findings on this species in one part of the country to management practices in another. Even more hazardous would be the indiscriminate extrapolation of behavioural information about one species to another, and particularly to the formulation of management techniques for the latter on the basis of such information. However, questions which arise in the study of one species can often point to potential problems regarding another species. For example:

Studies on the territoriality and population regulation in the Uganda Defassa waterbuck (*Kobus defassa ugandae*), in which territorial behaviour is "confined to the male", have led Spinage (1974) to state that a "plausible function of territoriality is offered by the Neo-Darwinian view that it maintains a prime breeding stock. Territoriality ensures that breeding is denied to the young, and therefore untried, and to the old and to the weak. This could lead to selection for vigour".

The rutting behaviour of the Newfoundland caribou (*Rangifer tarandus*) has been studied by Bergerud (1974); he reports as follows: (p. 425) "A ranking or social order of stags was indicated by several observations.

.....

The large antlered animals were near the top of the hierarchy while the young and smaller antlered animals were subordinate". (p. 428). "I believe a dominance ranking between [among] males provides the best stud stock, through competitive selection, and reduces disturbances during

breeding". (p. 434) "As a planned management program the proportion of males in the Newfoundland population was reduced by legal hunting of stags only from 1957 to 1967. The decline in the ratio between mature males (4 to 9 years) and females was from 1:3 to 1:5. This change may have accounted for: .....an increase in the percentages of medium-size stags that bred does".

The Uganda kob (*Adenota kob thomasi*) "has a highly evolved system of territorial behaviour" (Buechner and Schloeth 1965:209) largely expressed by "the defense of small, fixed territories within a central area of concentrated territorial activity [conventional territorial breeding ground]. This area is surrounded by a zone of more widely spaced territories. Females enter the territorial ground throughout the year for the purpose of breeding" (Buechner 1961:698). "Undoubtedly, one consequence" of this "highly developed system of territorial behaviour on conventional leks" is the "maintenance of a high quality of genetic variability in the population, since natural selection of those males that are morphologically, physiologically and behaviourally fittest is accomplished through territorial behaviour.....most of the transfer of genetic information is accomplished by a relatively small number of highly selected males" (Buechner 1974:863-864). "Clearly, the shooting of those territorial males that breed in the most active territories of a given TG [conventional territorial breeding ground] can adversely affect the genetic composition of the population" (Buechner 1974:865). "To preserve genetic viability and the social organization of the population requires a pattern of harvest that protects territorial males, [and] concentrates on young males in bachelor herds" (Buechner 1974:853).

Buechner's hypothesis is rejected by Kitchen (personal communication

21 April 1976): "Regarding behaviour and harvesting [of pronghorns] I don't see any problems and feel that harvests per se will not have much effect on the social system. Younger males will have settled dominance positions and breeding will still be done by the best available males in a given population. Therefore, there will be no change in the direction that natural intrapopulation selection will take". However, there appears to be a flaw in this argument: extraction of older and, therefore, some territorial males from the breeding process by hunting is explicit in Kitchen's reliance on "younger males". But note particularly: "breeding will still be done by the best available males in a given population". (Emphasis ours.) Should we be satisfied with the "best available" which might be less fit genetically than the best possible at this moment in the phylogeny of the species and as a consequence of enlightened management? It must be remembered that dominance is established over a continuum and that, to the best of our knowledge, positions in a given hierarchy shift through time. Therefore, while a particular 3-year-old buck, for example, might be well advanced in the dominance hierarchy and successfully copulate (if accepted by an estrous doe), he might not become territorial at 7 years of age; i.e. he might not be among the "best" bucks at maturity. Needing further attention in this connection is the maturation of the courting repertoire of the pronghorn buck. There is reason to suspect that young bucks may not always be accepted by estrous does because of inadequacies, both quantitative and qualitative, in the males' courtship behaviour.

In the light of these views we are faced with at least three possibilities which should be of interest to us here: (1) that body size of pronghorn bucks -- and even length of horns (a feature especially fancied

by trophy hunters) -- may be expressions, not only of age and condition of forage but also of genetically based, individual variation; (2) that a buck's social rank within his own age and size category may depend, in part, upon the relative level of his aggressiveness; and, more to the point, (3) that vigour and aggressiveness (which may be functionally related) may, to some extent, be genetically controlled traits that show individual variation and are therefore subject to selection.

The data presented in Table 1 quantify (for the state of Idaho) two well-known phenomena: (1) the tendency of pronghorn hunters to favour the taking of bucks, and (2) the consequent and substantial reduction of the buck-doe ratio from the essentially one-to-one of neonates. The ratios also suggest an increasing percentage of the buck population being annually killed by hunters over the last 25 years or so. Furthermore, data not set apart in the table suggest that the number of bucks per 100 does has decreased by about 30 percent in some areas in the last 10 to 15 years. The fact that disproportionately high harvests of male pronghorns occur (probably annually) is, of course, well-known. For example, Martinka (1966) reported that, for the period 1959 through 1965 in Montana, "selection for adult males appeared related to actual hunter preference rather than a fall herd social structure which would permit inadvertent selection for adult males". His conclusion was based on a sample of 1,774 pronghorns one and one-half years old and older, examination of which at check stations revealed a ratio of 198 bucks per 100 does taken by hunters.

Possible weaknesses in our data should be mentioned: (1) The inclusion of fawns in hunters' card returns for 1962 through 1965 might be thought to account for what appears to be an unusually high ratio of

Table 1. Data[1] indicating selection for males by pronghorn hunters in Idaho.

Sources of Information	Numbers on Which Buck-Doe Ratios Based: Individuals	Numbers on Which Buck-Doe Ratios Based: Sightings[2]	Bucks Per 100 Does
FAWNS (neonates and very young)[3]			
1957-1976 inclusive	236	--	98
HARVEST (long-yearlings and older)			
1950-1956: state-wide, card returns	6,643	--	156
1957-1961: part of state, checking station records and card returns	1,644	--	169
1962-1974: state-wide, card returns (includes fawns)	15,248	--	193
1975: state-wide, card returns and checking station records (includes fawns)	1,257	--	242
FIELD COUNTS (yearlings and older)			
1956-1975	--	16,140[4,5]	59
1973[6]	1,283	--	34
1974	1,327	--	37
1975	1,735	--	33
1976	2,318	--	37
1977	3,012	--	39

[1]From Idaho Fish and Game Department records and personal field notes.
[2]Annual counts over a period of 2 or more years result in repeated sightings of some individuals.
[3]Seen at close range (Autenrieth and Fichter 1975:15; also current study on cover at birth sites and fawn bedding sites by Autenrieth).
[4]Composition counts on 2,244 groups from ground and helicopter (omit lone pronghorns and "lone" does with one or two fawns each).
[5]Data will furnish partial basis for a paper on pronghorn groups in preparation.
[6]Counts from helicopter: resumed in 1973, ending 9 year hiatus.

bucks per does in the harvest. Note, however, that a sample of 1,190 "adults" taken by pronghorn hunters in Nebraska in 1974 yielded a ratio of 235 bucks per 100 does (Suetsugu 1975). (2) In aerial searches, even from a helicopter, it is possible that some lone bucks, territorial or

not, are missed because they are less readily seen than are groups of pronghorns. If these two circumstances indeed bias the data, the marked and consistent differences in buck-doe ratios among the three "classes" of data still appear collectively to furnish verification of selectivity favouring bucks among Idaho's pronghorn hunters. The discrepancies are further validated by way of contrast with Kitchen's (1974:11) report that he could identify as individuals "56 of 58 yearling and adult males and 44 of 50 yearling and adult females", suggesting a sex ratio of 116 bucks per 100 does at the time of his study (1969-1971) on the National Bison Range where, we have been informed by B. W. O'Gara (personal communication 27 January 1976), there is no hunting. This ratio approaches expectations for an unhunted population.

Some intriguing questions emerge: Do pronghorn bucks show individual and heritable differences in vigour and aggressiveness -- features which appear to contribute to acquiring high status in the dominance hierarchy, and thereby to establishing and holding territories? Recall that Kitchen (1974:51) observed "lone mature bucks" that were not territorial; "they restricted their activities to well-defined areas but did not defend them". Such individuals have also been observed in central Idaho. Are they less vigourous and/or aggressive than those mature bucks that defend territories? If the harvest by hunters who prefer to take bucks -- and especially trophy bucks -- actually decreases the component of territorial bucks (regardless of the rate), will an increasing proportion of the does be bred by mature but nonterritorial bucks and by smaller bucks of varying levels of vigour and aggressiveness? If so, selection for smaller, less vigourous and nonterritorial bucks seems to be a possibility.

Here is one so-called pragmatic response: All these data and ideas

have a nice academic ring to them; but, if, indeed, trophy hunting is fostering such selection, the effects will probably not be measurable for some hundreds of years, so why worry?

Unfortunately, we have no measurements revealing the percentage of the territorial buck component taken in the harvest -- or what percentage of the total buck harvest is made up of territorial bucks. Whether the heritable traits we are considering here are also carried by females is another unknown; this question must also deal with the probable relation between the expression of genetic information and hormones.

When territorial bucks are removed by hunting, nonterritorial males may fill the breach. If all bucks carry the same genetic destiny of size, vigour and aggressiveness we have nothing to be concerned about as regards genetic viability. The evidence suggests they do not.

Finally, we would emphasize three points: (1) We are not saying that the genetic response to trophy hunting considered here is a "clear and present danger". The question nevertheless remains. (2) Testing the hypothesis, i.e. measuring, will call for long term studies using highly sophisticated techniques. (3) Support of such research will be evidence of administrative recognition that knowledge of the behaviour and social organization of the pronghorn is needed to intelligently manage this species. A study relevant to the question posed by this paper is under way in Idaho.

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COMMENTS AND QUESTIONS

SIMPSON: Good morning, Edson. I agree with you strictly that behaviour is a vehicle by which an animal interacts in its environment to survive. I don't think that we have any real disagreement along these lines. The one thing that I would really query though is you have built a very strong case, which may be valid, that selection is concomitant with removal, or in the case of hunter removal, of trophy animals. But, as you pointed out, we don't know that horn size, per se, is one of the factors that determines territoriality in pronghorns. We know it in cervids and it is of some possibility in bovids, not directly as in cervids display, but during fighting solutions in bovids. So I think we do need to do a lot of work on whether or not the horn of a pronghorn is important to the establishment of a territory. There's another thing that I think we need to look at, and I think this is something that is pretty important if we're looking at the academics of pronghorn management. These things have been subjected to hunting pressure for 20 years and they have survived. Now maybe the value of the trophy has dropped but we, as people interested in wildlife, surely are interested in pronghorn

survival per se. It would be very nice if we could breed super bucks but if the selection process is going on then genetically the behaviour, the capability of survival must be retained by the individual to survive, and certainly those that get away and breed are the ones that have survived under the new selective pressure. Would you care to discuss that as a possibility in terms of the overall survival of the species?

FICHTER: My response would be to commend you for raising further problems that need research, and if I am wrong please correct me, but I caught a tinge of the pragmatic here that I have mentioned in the paper.

SIMPSON: No, it wasn't pragmatic.

FICHTER: Okay. Yes, you have simply, or not simply at all, but you've very complexly increased the complexity of the problem, of the total problem. I'm not criticising the practical manager, I have been one myself, or tried to be, in Nebraska and I know the point of view. I think we are going to have to broaden our viewpoint as we go along and the major stumbling block is the one implied in my final statement -- administrative recognition of the need for that kind of knowledge, by way of support.

O'GARA: I agree that this is a question that really needs investigating. Edson's going to have a lot of discussion, I can see, in the next couple of days, so I'm going to throw out a few observations that will be useful to both sides probably. Having worked on the bison range through the same time that Dave Kitchen did I might observe that the sex ratios he was looking at were after I just shot 24 does. I did find that usually 3-year-olds started trying to establish

territories and 4-year-olds easily had territories. Usually his animals were off the territory by the time they were 7 or 8. And these nonterritorial bucks he talks about, I've collected a lot of them, too, and I've never gotten one under 7 years. Most of these are off their territories. Horn size. The one time I was collecting some bucks and Dave was there I went to him to be sure I didn't interfere with his studies and he said, let's look at something. I've got one buck that did almost all the breeding, seems to have the best territory, he doesn't seem to have very good horns. And I have a buck with tremendous horns that isn't having any luck. So the next two bucks I collected were those two, and the one with the little horns weighed 160 pounds and the one with the big horns weighed 124 pounds. So maybe body size is a little more important than horns in these animals.

FICHTER: I'm certainly in agreement with you there, all the evidence points in that direction. But I think it is a valid point that, like our species, the individuals help keep their egos up with long horns of one kind or another; they have to be taken into consideration. You have emphasized, re-emphasized, one of my points, I think, if I read you loud and clear, and that is that there is variation from place to place. As a matter of fact I think we're going to find that management practices in one of our Idaho valleys may not be entirely appropriate in the next one, and there are two or three people in this audience that I think will agree with me. The universal phenomena of change, variability, that's really the basis of what Bob and I are trying to talk about here, and we tend, I think, to forget it. Well, not entirely, because every report we've had this morning

was talking about change in the weather, change in the forage, change in numbers of animals from more to less and what have you. But some of the more obscure changes, I think we're going to have to become more aware of them or, and/or, make the people who hold the purse strings more aware of the need to know more about them.

BEALE: My question's in regard to hunter harvest in relation to the season of hunt. In other words, when they're hunting during the rut, are we taking a greater proportion of territorial bucks than if we select our hunting periods either prior to or following rut periods?

FICHTER: Yes, I think when we hunt is relative to the thesis of our paper here, and in Idaho traditionally we've been hunting during the rut, and I have reason to believe that a buck with a breeding group of does, whether it's one doe, which is sometimes the case, or half a dozen, is somewhat more vulnerable to the gun. Gary Copeland's going to know a lot more about that in a couple of years because he's been watching hunter behaviour. It wasn't in the game plan but it was forced on him, and I might say that some of the things he's seen have not been too encouraging about our species. Very definitely a part of the picture.

SONORAN PRONGHORN HABITAT IN ARIZONA

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Abstract: The endangered Sonoran pronghorn (*Antilocapra americana sonoriensis*) (Goldman 1945) occupy a large area of Sonoran Desert in southwestern Arizona. Their habitat includes portions of a National Monument, National Wildlife Refuge and an active Military Gunnery Range.

The habitat of the Sonoran pronghorn in Arizona encompasses an area of approximately 607,500 hectares (1.5 million acres) in the extreme southwestern portion of the state. The social, physical and biological aspects of the habitat combine to make it as unique and interesting as the pronghorn which inhabit it.

Administrative responsibility for Sonoran pronghorn habitat is shared by the United States Fish and Wildlife Service, the United States Park Service, the United States Air Force and the United States Marine Corps. This unique administrative responsibility was established approximately 40 years ago with the creation of the Cabeza Prieta Wildlife Refuge, Organ Pipe Cactus National Monument and the Luke-Williams Gunnery Range. While the management objectives of the agencies are quite different, they have collectively eliminated human habitation and commercial endeavour from Sonoran pronghorn habitat. This has been the single most important management step taken, to date, to ensure the survival of the Sonoran pronghorn in Arizona.

Geologically, southwestern Arizona is characterized by block faulted mountain ranges separated by broad alluvial valleys. These valleys are the true habitat of the Sonoran pronghorn. The valleys are very flat and range in elevation from 122 to 488 meters above sea level. In some instances, the valleys contain numerous closed drainages which result in the formation of playas (normally dry lake beds) up to one mile in diameter. Large areas of sand dunes in varying stages of stabilization are also characteristic of Sonoran pronghorn habitat.

Sonoran pronghorn habitat is one of the driest areas in North America. Table 1 (Sellers and Hill 1974) illustrates the magnitude of the aridity.

Table 1. Precipitation (mm) at weather stations adjacent to Sonoran pronghorn habitat.

Station	Elevation (meters)	Average Precipitation	Lowest Yearly Precipitation on Record
Ajo	537	231.14	84.58
Gila Bend	225	144.53	54.10
Sentinel	210	114.54	35.81
Mohawk	138	105.16	34.29
Wellton	79	104.39	11.18
Yuma	42	85.85	6.35

The rainfall pattern is normally biseasonal, occurring in mid-winter and late summer.

Temperature becomes an important factor in Sonoran pronghorn habitat during the summer. From mid-May through mid-September daily temperatures exceed 38 degrees (C) with maximums often exceeding 44 degrees (C). Soil surface temperatures may reach 73 degrees (C) on the hottest days (Ives 1964).

Climatically, the habitat of the Sonoran pronghorn is part of the

Sonoran Desert. The vegetation and flora of the Sonoran Desert have been very well described by Shreve and Wiggins (1964). Two of Shreve's Sonoran Desert subdivisions constitute Sonoran pronghorn habitat in Arizona. The Arizona upland subdivision is characteristically composed of a paloverde (*Cercidium* sp) - cactus (*Opuntia* sp) association containing the sahuaro (*Carnegia gigantea*) as a minor, but very obvious, member of the association. The Arizona upland association is normally found on the upper slopes of the valleys and along the abraided drainages within the valley bottoms.

The Lower Colorado Valley subdivision is the more xeric of the two subdivisions and constitutes the majority of the Sonoran pronghorn habitat in Arizona. Creosote bush (*Larrea tridentata*) and bursage (*Franseria dumosa*) are the major perennials of the Lower Colorado Valley region. The sand dunes and playas present in the Lower Colorado Valley subdivision do not support large quantities of perennial vegetation, an exception is big galleta (*Hilaria rigida*) a coarse unpalatable perennial grass which grows in abundance on the semi-stabilized dunes. These areas are very important, as they produce large quantities of annual and ephemeral plants following any measurable precipitation.

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COMMENTS AND QUESTIONS

MITCHELL: I've noticed in your photographs that the bucks look pretty black through the eyes. Is this characteristic of the subspecies?

PHELPS: I don't believe so. My inclination is that taxonomically there's probably no difference in any characters that have been used so far. What I think they are, and somebody mentioned it earlier, is they're an ecological race or ecotype, and that is probably about the only difference. We have three subspecies of antelope and if you put them all side by side it would be pretty hard for us to pick one from the other.

MITCHELL: Do any of the subspecies overlap in Arizona?

PHELPS: No, they are spread now primarily because they've been eliminated from a large portion of the former area of intergradation.

QUESTION: What about the horn sheath drop? Does that occur in early November?

PHELPS: No. Breeding behaviour has somewhat to do with the physiology and apparently is considerably different than it is in the northern races. They drop fawns as early as February and apparently their fawn drop is timed to take advantage of the winter range which is more dependable than the summer range. Fawn drop is not instantaneous like it is in most of our northern antelope herds. It's most spread out, but it also does start much earlier. It's usually over by May.

QUESTION: There must be differences in the rut period as well?

PHELPS: Well, yes, it's of course offset to the same degree that fawn drop is; in other words, they are apparently in rut in July and they'll drop their horns in August.

BARRETT: John, is there any suggestion that there's any difference in natality rate of the Sonorans in this very harsh environment?

PHELPS: We have observed twins. You can't tell whether it's survival or what the factor is, but single young are normal. But we have observed twins. My guess would be it's probably very similar to the other antelope. Like you say, the environment is so much harder that they don't realize anywhere near the production that northern races are capable of.

WISHART: How about the weights?

PHELPS: Size-wise I haven't been able to weigh any, of course, so the best that I can determine from what few specimens are available the measurements don't differ greatly from the other races. Weights, I don't know. I haven't had occasion to weigh any.

QUESTION: I didn't quite understand your statement on free water.

PHELPS: That's a bad term. People use that. I don't know what free water is, myself. It turns out to be a dependable water supply where they could go and drink from an open trough or a dependable water supply -- there is none.

QUESTION: Do they have water available at all times?

PHELPS: No, they do not. At least a large portion of the population apparently has not.

QUESTION: Do Sonoran pronghorns frequent the water holes periodically?

PHELPS: Not very often. There are two water supplies on the game refuge that are accessible to antelope. They check these things every

year and have for the last 30 years. Based on available accounts nobody today, anywhere, has ever seen a Sonoran antelope drink water. Now that's negative information but it's overwhelming. They've been seen at the junction with water twice and I personally have seen tracks at water once.

QUESTION: But don't they drink water?

PHELPS: No. That's rather shocking. Someone said something similar in the transactions of the Bighorn Sheep Council Meeting about 1965 or something like that, and I didn't believe it, but I do now. I still don't believe it but I have to.

BEALE: They must get water in the intense spring rainstorms?

PHELPS: Oh, yes, they get water then. I'm sure they've taken it during this opportunity, but from the beginning of May to whenever they are on summer range, which may be as late as August, there is no water available and that's the time of year when it's critical. Now they could get by. They take the fruit on these chain cholla which are fairly high in water content. But they also get into a problem with oxalic acid; cactus is very high in oxalic acid. There is only one animal, one mammal, that I know of that's capable of metabolizing oxalic acid. It will kill a javelina in three months, a cactus diet. So it's another mystery.

QUESTION: You were saying that rutting season was rather well spread out?

PHELPS: It apparently is somewhat spread out, but apparently the peak occurs sometime the first part of July.

QUESTION: Do you ever have fawns born in May?

PHELPS: May, yes. We have had occasional fawns observed in May, the

first part of May, and it's difficult to tell how old they are because you don't get that close to get a good look at them. In a lot of this country it's hard to get a good look at them. From what we can determine they are often born in March or April sometime.

YOAKUM: What would you estimate the total Sonoran antelope population to be in Arizona and Mexico?

PHELPS: From what we saw down there I can make an estimate. We classified 50-some head, 54 or 52, I believe, in Mexico, and I would guess we saw about 20 percent of the population, so my estimate for Mexico would be about 250 animals. In Arizona I would estimate about 100 animals. There is apparently a total of about 350 animals.

QUESTION: Are there problems with Sonoran pronghorns and the Indian population in Arizona?

PHELPS: An Indian Reservation borders this area on the east, and was excellent Sonoran antelope habitat. They were primarily a farming, nomadic type people and when the government settled them they got an extremely large Reservation, but they gave them cows. You can go out, and I've got some pictures of this -- I've seen over 100 dead cows around a water hole in the middle of the summer. What's happened is, they've overstocked the range so badly that the cows can't get far enough away from water to eat, or they can't eat and get to water. That's what's happened to the Indian Reservation, they've destroyed habitat.

QUESTION: Do the natives have the right to shoot them?

PHELPS: They can shoot them on sight but there're none there on the Reservation. There're none there because they've eliminated them through grazing.

BROMLEY: John, I've noticed in some of your pictures that bucks, does, fawns are all running together. Do you ever see separation of all bucks?

PHELPS: This is one of the unique behavioural aspects of these animals. If you want to call it a herd size, -- it's much smaller than anything you guys would probably even anticipate. It probably approaches three animals, I haven't finalized the data and taken mean herd size or anything. Down there the behaviour is not oriented towards bachelor groups or territorial bucks or anything of this nonsense. It's oriented towards surviving through the summer; the optimum is survival through the summer. What they do is, they scatter out, they break out into unit herds, one, two, three animals. You may lose half the population of individuals but the species, or the subspecies, will survive. And I'm sure that's the reason.

BOTANICAL COMPOSITION OF FECES FROM PRONGHORN ANTELOPE GRAZING THE OREGON HIGH DESERT[1]

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M. VAVRA, Eastern Oregon Agricultural Research Center, Union Station Union, Oregon

Abstract: Microhistological examination of pronghorn antelope (*Antilocapra americana oregona*) feces were conducted over a 2 year period to determine botanical composition. On this juniper-sagebrush-bunchgrass community the mean annual botanical composition was 62.2, 21.0, 13.1 and 4 percent browse, grass, forb and unidentified, respectively. Sandberg's bluegrass (*Poa secunda*) was the principal grass taken in the spring and downy brome-grass (*Bromus tectorum*) taken following green-up in the fall. Bitterbrush (*Purshia tridentata*) was more important in the summer than in the winter while sagebrush was a component year around. Juniper was an important constituent during one winter. Forbs, primarily blue mustard (*Streptanthus cordatus*) was selected during the spring and summer months.

The data base from which the current knowledge of food habits of the pronghorn antelope is derived is extremely limited. Yoakum (1958) summarized the existing data which included Einarsen (1948), Mason (1952), and Ferrell and Leach (1952). Tsukamota and Deibert (1968) presented the composition of 115 samples and Richardson (1972) reported composition of 52 samples. All of the above estimates were based on composition of rumen

[1]Cooperative investigations of the Science and Education Administration, U. S. Department of Agriculture and the Oregon Agricultural Experiment Station, Squaw Butte Experiment Station, Burns, Oregon, OAES Technical Paper No. 4785.

contents. Seventy-one percent of the total samples (356) were from hunter kills; thus, information of diet composition in other seasons of the year is from low sample numbers.

There is need for more seasonal dietary information for the pronghorn antelope if range and wildlife managers are to manipulate, protect or conserve habitats to assure continuation of acceptable levels of pronghorn antelope numbers in the sagebrush-bunchgrass regions.

Recent advances in methodology utilize microscopic determination of plant species in the feces of grazing animals for an estimate of dietary selection. The opportunity provided by this technique to examine a larger number of animals throughout the season without sacrificing the animal should markedly add to our knowledge of grazing animals' dietary habits.

This report presents the botanical composition of pronghorn antelope feces on 17 sample dates seasonally distributed over a 2 year period.[1] The report discusses those results and compares them with results in the published record.

DESCRIPTION OF THE STUDY AREA

The study area, located 40 km west of Burns, Oregon, is a 166 km^2 unit of a larger area wintering approximately 5-7,000 mule deer (*Odocoileus hemionus*). Most deer are common from December to May, but some deer are resident to the area yearlong. About 30 wild horses and 2-300 antelope are yearlong residents. Cattle and sheep graze portions of the area each year under Bureau of Land Management permit from April 1 to January 1, according to allotment management plans.

[1]Acknowledgment is made to the support given by the Oregon Fish and Wildlife Commission.

The study area is a typical desert-forest fringe area of the cold desert. It lies about 1,370 m above sea level with local elevation variations of 60 to 90 m. The vegetation is a complex mosaic dominated by an overstory of juniper (*Juniperus occidentalis*), big and low sagebrush (*Artemisia tridentata* and *A. arbuscula*) and an understory of bluebunch wheatgrass (*Agropyron spicatum*) and Idaho fescue (*Festuca idahoensis*). Associated species include antelope bitterbrush, Thurber's needlegrass (*Stipa thurberiana*), Junegrass (*Koeleria cristata*) and Sandberg bluegrass. Broadleaf succulents are many, but comprise less than 15 percent of the total herbaceous production. Blue mustard was a forb important to the study.

Average annual precipitation is 29.2 cm, with the majority occurring as snow in the winter or as spring and fall rains. Summers are characteristically dry.

METHODS

Fresh samples of antelope fecal material were collected periodically from May 1975 to April 1977. Locations of animals were observed in the field and then searched for fresh pellets. Five or six pellet groups were collected each date except for June 29, 1976 and September 24, 1976 when only one antelope was observed and November 5, 1976 when three samples were obtained.

Samples were stored frozen until analyzed. Sample preparation and analysis followed the procedure of Sparks and Malechek (1968). Twenty microscope fields were observed on each of three slides for each sample.

RESULTS AND DISCUSSION

Approximately 4 percent of botanical composition was unidentified.

Averaged across all dates the mean botanical composition of antelope feces was 62.2, 21.0 and 13.1 percent browse, grasses and forbs, respectively. Yoakum's summary (1958) reported comparable values of 68.8, 7.0 and 20.9 percent, respectively. However, the latter means are unevenly weighted because most of the samples are from hunter kills that were taken in late summer or early fall. Yoakum's results differ in that he observed more forbs and less grass in antelope diets than we observed.

Seasonal means of dietary composition observed in this study and results reported by Yoakum (1958) are shown in Table 1. Browse composition is alike except for the spring period during which we found less browse in the feces. The decrease in browse was compensated mainly by an increase of the grass component. Grass composition was least important during the summer period, whereas forb composition during the winter months was extremely low (< 2 percent).

Table 1. Seasonal dietary composition of the pronghorn antelope.

	Winter[1]		Spring		Summer		Fall	
	Y[2]	SV[3]	Y	SV	Y	SV	Y	SV
	- - - - - - - - - - - - percent - - - - - - - - - - - -							
Grass	5.7	11.8	9.2	36.0	Trace	6.6	13.2	29.6
Forb	7.2	1.8	23.3	21.0	32.4	21.5	21.0	8.2
Browse	85.3	83.9	65.6	37.1	64.9	68.4	59.1	59.6

[1]Winter (December to February, inclusive); Spring (March to May, inclusive); Summer (June to August, inclusive); Fall (September to November, inclusive).

[2]After Yoakum (1958).

[3]Study results.

Yearly, or even seasonal, dietary composition means will rarely provide sufficient information for the range or wildlife manager to properly execute his responsibility of good resource stewardship. This is partic-

ularly true in semi- and arid regions where annual climatic fluctuations are great and when seasonal climatic incidents can significantly alter vegetation characteristics temporarily. The latter becomes extremely important in interpreting research, particularly when the study is of short duration.

Figure 1 presents the botanical composition by grass, forb and browse components for each sampling date. Grass was an important dietary constituent in the spring of each year, more so in 1976 than in 1977 and again in the late summer-fall period but more important in 1976 than in 1975. In the spring period, Sandberg's bluegrass was the principal grass selected but in 1977 greater amounts of the larger, later-growing perennial grasses were taken. In the late summer-fall period, Sandberg's bluegrass was again the principal grass but in 1976 downy bromegrass constituted from 13 to 51 percent of the total diet with Idaho fescue and Thurber's needlegrass contributing 20 and 9 percent, respectively. Precipitation from July through June for 1975 and 1976 was 23.4 and 24.9 cm, respectively; both amounts are below the long time normal of about 30.5 cm. However, over 5.1 cm of rain fell in August and September 1976, causing a flush of new grass growth that was reflected by the increase of grass in diets of antelope on October 5. In 1975, precipitation sufficient to cause new growth did not occur until the month of October and diets of antelope reflected this in the November samples. The spring of 1977 followed an extremely dry winter and it was observed that many Sandberg's bluegrass plants failed to initiate new growth. Grass composition in 1977 diets was only 22 and 39 percent for March and April compared with 80 and 57 percent for the same months in 1976. In addition, particularly in the month of April 1976, more use of grasses other than Sandberg's bluegrass

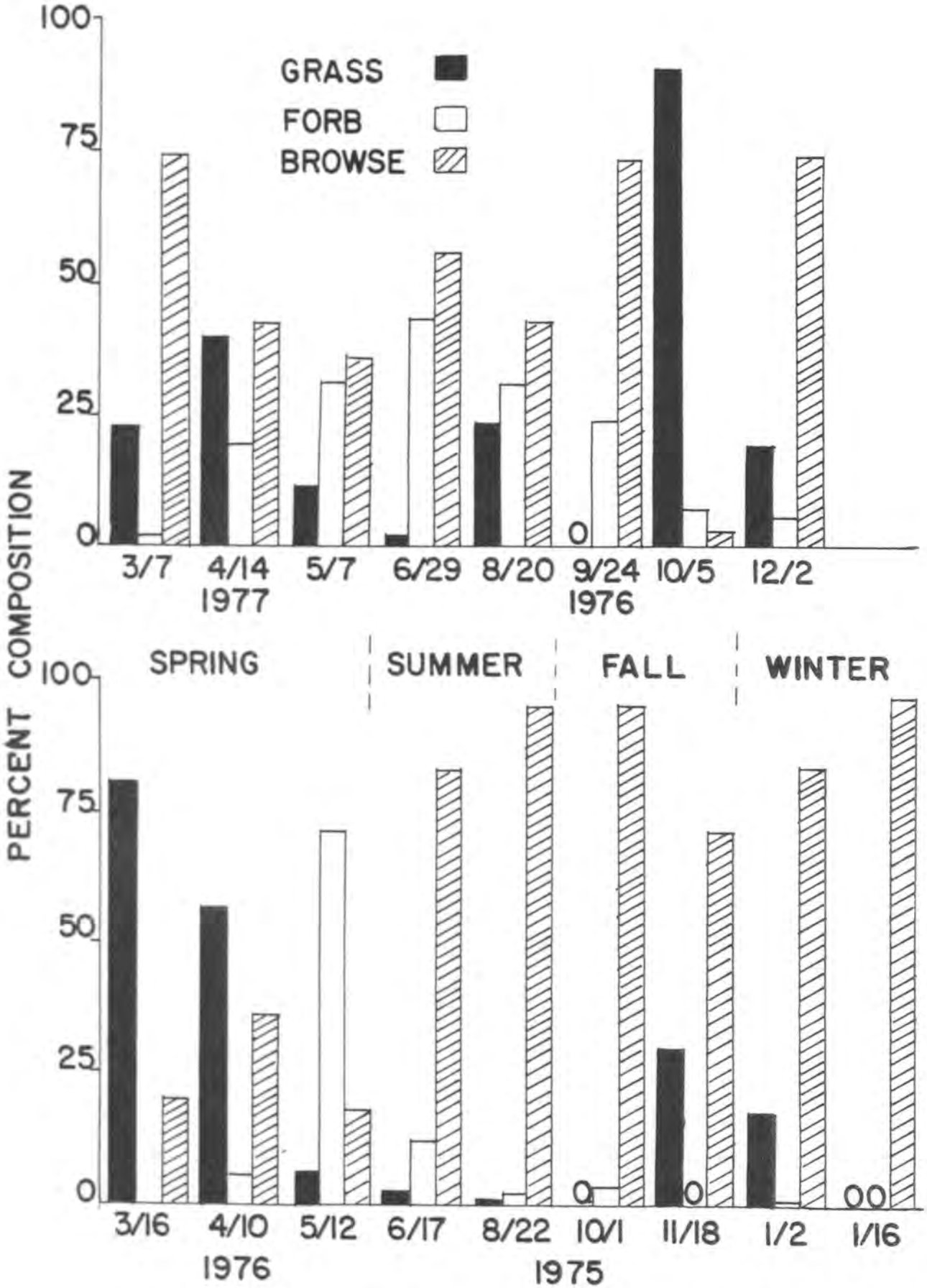

Figure 1. Diet composition of antelope as estimated from fecal analysis.

was noted.

Forbs were selected primarily in the spring and summer periods. Blue mustard provided the bulk of the forb diet and on May 12, 1975 comprised about 71 percent of the total diet. Other forbs taken included buckwheat (*Eriogonum*), yarrow (*Achillia*), arnica (*Arnica*) and granite gilia (*Leptodactylon*). The small proportion of forbs in antelope diets is probably due to the small percentage of forbs in the particular plant community of the study area.

Previous reported research documents sagebrush, bitterbrush and rabbitbrush as the primary species contributing to the diet of the pronghorn antelope. Sagebrush was the major browse contributor in our study but use of it by antelope varied throughout the season (Figure 2). Diet composition of sagebrush was greatest in the winter periods; however, in 1976 from 39 to 67 percent of the diet was comprised of this species in late August to late September. Yet, in 1975 sagebrush in the late summer-fall period was less than 20 percent of the diet.

Bitterbrush was more important in the summer period than in the winter period. In the summer of 1975 bitterbrush in the diet ranged from 71 to 89 percent and in late June 1976, composition was 54 percent bitterbrush. Bitterbrush in the remaining seasons constituted less than 10 percent of the total diet. This selectivity of bitterbrush by antelope in the summer season compares well with that reported by Mason (1952).

Surprisingly, juniper was a substantial contributor to the winter diet of antelope during the winter of 1975-76 (Figure 2). From October 1 to mid-January this tree furnished 37 percent or more to the antelope diet. In the winter of 1976-77 juniper in the diet did not exceed 20 percent.

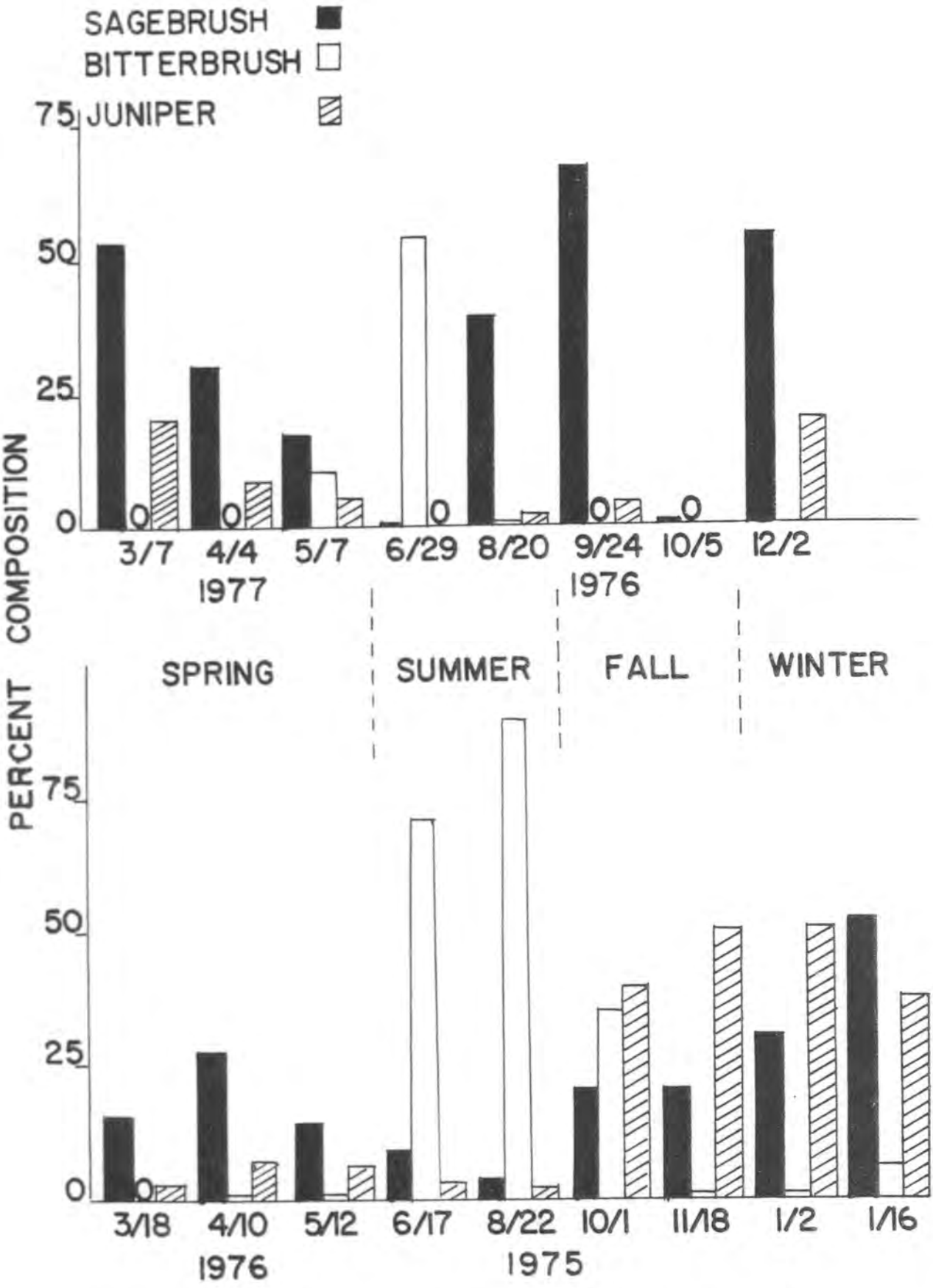

Figure 2. Browse components in the diets of antelope as estimated by fecal analysis.

In other periods of the year juniper diet composition ranged from 0 to 8 percent. Though juniper has been reported as a forage contributor to antelope diets these results suggest that in some years it may represent a substantial portion of their diet.

Rabbitbrush was locally abundant on some habitats of the study area. Only on a few isolated sample dates did antelope browse this species in this study.

Only in the winter of 1975-76 was snow depth sufficiently deep (about 25.4 to 38.1 cm) over an extended period of time to cause a feeding problem in this study. The January 2, 1976 samples were obtained immediately before a storm system; samples collected 14 days later represent a sample taken following about 10 days of restricted food availability. Snow depth of about 30 cm remained throughout the month of January and most of February. In February 1976 we were unsuccessful in locating the antelope and assumed that they had moved to some other area. During the winter of 1976-77 snow depth seldom limited even grass availability and if so, availability was restricted only for a very short duration.

Differing diet composition between years has been discussed only in respect to the year's influence on forage availability. Because the area was also grazed by cattle and sheep in the summer period and is a primary deer winter range, their activities may have also influenced which plant species the antelope had available to them. Similar dietary information for the 2 year period was also obtained for those ungulates as well as for wild horses that are, like the antelope, year round residents. An initial summary of dietary composition of all ungulates for this study has been prepared (Vavra and Sneva 1978).

The microhistological method for determining botanical composition of animal feces as an index to diet composition is not without some weaknesses, errors or bias. Though the method estimates diet composition for the most part or undigested portions of the plant cuticle, the relative frequency of those fragments occurring in the feces is influenced by the digestibility of the plant species, which varies seasonally and by ungulate species. In this study blue mustard shattered more readily in the grinding process and is believed to have caused a higher frequency of "hits" during microscopic analysis, resulting in an overestimation of this species contribution to the diet. We were unable to differentiate among the sagebrush subspecies, if such were present in the diet. Despite these drawbacks the technique has shown good reliability in ranking forage components in their importance in the diet as compared with that determined from esophageal or stomach analysis, Vavra et al. (1978). Our plans include a continuation of this study to provide for *in vitro* digestion coefficients of forages selected seasonally in 1978 and 1979.

Domestic and wild animals grazing on rangelands are extremely mobile. Feces of some of these species can be quite similar and thus difficult to differentiate. In this study we operated under a guideline of visual sighting and then sampling. We also recorded the general vegetation of the sampling site. However, because the time required for passage of forage in the gut of ungulates is in the order of 24 to 96 hours, it is unlikely or at least questionable if the vegetation in the locale of sampling would be a good representation of that found in the feces.

The high proportion of juniper and sagebrush browse intake during the fall and winter is of some concern. Nagy and Tengerdy (1967) suggested that essential oils in deer diets containing more than 50 percent sagebrush

may depress bacterial action in the rumen. However, Smith et al. (1965) did not indicate any visible nutritional impacts on antelope sustained on a diet of 75 percent sagebrush and 21 percent juniper. They suggested that antelope may have different digestive attributes than deer. Perhaps the essential oil components in sagebrush or those in juniper are not all inhibitory; some may stimulate digestion, as has been shown by Oh et al. (1967) for essential oils in Douglas fir (*Pseudotsuga menziesii*) needles.

SUMMARY

Botanical composition of pronghorn antelope feces were determined on 17 dates over a 2 year period from a juniper-sagebrush-bunchgrass rangeland. Sagebrush was a major dietary constituent in the fall-winter period but differences between years were evident. Bitterbrush was important as a summer-fall component to the diet. Sandberg's bluegrass and downy bromegrass were the principal grasses selected and blue mustard was the only forb that was taken in large quantities during the spring-summer period.

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BEALE: You mentioned 40 or 50 percent use in their diet of juniper. What are your other browse plants like? Do you have a shortage, then, of sagebrush or something?

SNEVA: No, there was no shortage. At least there was no shortage on the total plant. Now whether they are specific towards current growths and not willing to accept old growths, leafage, this may be a situation. But as far as availability of sagebrush in general, no, there was no shortage here.

HELMS: What composition did your bitterbrush make up in this area?

SNEVA: I don't have a good handle on it. We are still continuing in this area and we will get vegetative estimates in terms of area and possibly some productivity. I would say that it is rather small, but again, what bitterbrush plants we have are not hedged clear back, so that I don't think we would classify them, the bitterbrush plants, as being severely overgrazed, despite the limitations that there is not too much of it.

HELMS: This was interesting because of the utilization by cattle of the bitterbrush in Wyoming. Generally if you have cattle on bitterbrush range you have utilization there.

SNEVA: The cattle are here during the late fall, but again we see no bitterbrush in the fecal material and this may be due to the fact that there is plenty grass available. I think the cow is herbaceous, preferably, and I think if the availability is there I don't think they'll go to browse unless they're lacking the grass end of it, probably.

HELMS: They're not in there then til late fall?

SNEVA: Well, the cattle are in there actually from April, beginning of April, to the first of December, but again it's under allotment management plan. Some areas are being grazed early, some are being grazed late, some are being rested clear around the year. So there are areas that an antelope can move to that would not be grazed in any particular year.

YOAKUM: Were any of your samples taken on crested wheat seedings?

SNEVA: No, there is no crested wheat grass seeded in that area. Close by there is one, about two or three miles to the south of this particular area I was sampling, but I never did sample them off of it.

YOAKUM: So crested wheat never showed up in any of your samples?

SNEVA: No.

PYRAH: One thing, did you measure any plant composition in your study area?

SNEVA: Not yet, it's in the plans. We are actually going ahead with this study. I'm collecting vegetation samples this year on the basis of what we see occurring in the diet. We're going to *in vitro* digestion next year on the samples so that we can correct the fecal estimate with digestion coefficients and attempt to get a better handle on composition.

PYRAH: Did you try to collect any rumen samples to correlate with your fecal samples?

SNEVA: No, we haven't here. We may do that next year when we go into some sacrifice kills with the *in vitro* digestion because we work with the rumen contents of antelope and with deer. But generally the work

being done elsewhere in this area of rumen versus fecal correlation shows that while the exact level of percentage composition is not in total agreement nevertheless when they rank species in importance both methods rank the same species.

PYRAH: There's usually quite a large difference between forbs and shrubs, and since forbs are particularly important for antelope during the summer it looks like the method itself may underestimate something that has high importance for antelope.

SNEVA: This is possibly true. There is more problem with this method with forbs than with the grass species and the browse species. In this particular case the blue mustard fragmentated very badly under milling. We feel we're overestimating the forbs, but I think part of our problem here, our low forb situation here, is probably attributed to the fact that this is not a strong forb community. It never has been. The best we can ever do is 10-15 percent total composition by weight on forbs.

MITCHELL: I think you said that the cattle were not grazing the *Poa secunda*. Is that correct?

SNEVA: That's right. They weren't taking it here.

MITCHELL: What is the basis for this conclusion; was it direct observation?

SNEVA: No, we're not seeing any samples of blue grass coming through in the fecal material.

MITCHELL: So your technique is such that you can differentiate the species, can you? Is this on the basis of the heads or the vegetative parts?

SNEVA: This is on vegetative parts.

MITCHELL: I see; using auricles and this sort of thing?

SNEVA: No, this is basically what they call the histological features of the grass. It's based on the cellular structure of these grasses.

MITCHELL: So you're analyzing cow pats as well as fecal groups from pronghorns, are you?

SNEVA: Yes. We sampled all five animals actually; I presented only the data for antelope here.

MITCHELL: Do you offer any reason why perhaps they may not be grazing *Poa*, what appears to be here a very succulent grass?

SNEVA: Well, in part the cattle aren't coming on there til April 1st, for one thing. The *Poa secunda* of course in our country is generally composed of low bunches, maybe an inch up to an inch and a half in diameter. Leaf height at that particular time is only an inch and a half or so, and I think they'd much rather graze the bigger bunch grasses even though they have old growths in them.

TRANQUILLIZING PRONGHORNS WITH M-99 FROM A HELICOPTER[1]

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Abstract: Pronghorn antelope bucks (*Antilocapra americana*) were captured in the Birch Creek drainage, east central Idaho, using a helicopter, Cap-Chur gun, M-99 and acepromazine. Available drug concentration of one mg/cc made it impossible to deliver an adequate dose with a dart. Four bucks were successfully captured and transmittered. Three bucks died as a result of dart penetration. Two bucks died 36 hours after handling due to handling shock precipitated by insufficient drug dosage. No mortality resulted from the drugs. Problems of drug dosages, dart delivery and animal handling are discussed. This technique holds promise for capturing selected individuals if M-99 becomes available in higher concentrations.

In order to successfully conduct a behaviour study on territorial pronghorn antelope bucks it was necessary to put radios on selected individuals. The standard technique of driving pronghorns into a hidden trap was unsatisfactory. We could not afford to place transmitters on bucks in a "potluck" manner hoping to end up with marked territorial bucks. The only feasible method appeared to be locating obviously territorial bucks within the study area and in an expedient manner tranquillize, pro-

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cess and release the selected individuals.

The technique of choice seemed to be the use of a helicopter, a Cap-Chur gun and the drug M-99.

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STUDY AREA

Birch Creek is located in east central Idaho approximately 85 km northwest of Idaho Falls. Birch Creek valley lies between the Lemhi Range to the southwest and the Beaverhead Range to the northeast. The Continental Divide runs along the summit of the Beaverhead Range, forming the Idaho-Montana border.

The soils are shallow, well-drained and gravelly on nearly level to gently sloping mixed alluvium on alluvial plains and fans. The valley lies in the sagebrush-grass vegetation zone and upper Sonoran life zone. Plant communities rapidly change as one goes from higher altitude and moister regimes to low-lying zeric regions. The upper valley is primarily big sage (*Artemisia tridentata vaseyana*) and Idaho fescue (*Festuca idahoensis*). Big sage (*Artemisia tridentata tridentata*) and bluebunch wheat grass (*Agropyron spicatum*) characterize the vegetation at intermediate elevations. The lower valley has shallow soils and supports low sage (*Artemisia arbuscula*) with sparse growths of Sandberg bluegrass (*Poa secunda*).

TECHNIQUES AND MATERIALS

Extensive ground observations during April and May of 1977 resulted in location of 28 territorial pronghorn bucks.

From May 31 through June 3, a Hughes 500 helicopter was utilized to dart nine of these individuals. This aircraft allowed one individual to shoot while another tracked the dart's path. Darting distance was within 10-30 meters with most darting occurring at 20 meters. Locating a specific buck was accomplished by flying the animal's territory until he was spotted and identified. Once the animal was located the helicopter would follow the running buck to allow the dart to be shot. The pilot attempted to follow the buck so that the gunner could shoot 20^0 forward at a distance of 20 meters. The hip was considered the target area. The drug was administered using a Cap-Chur gun (Palmer Chemical and Equipment Co., Inc., Douglasville, Georgia). A four cc automatic syringe with 1.9 cm semi-barbed needle was used. Needles were sharpened and plugged with petroleum jelly. Tests indicated that green coded 22 calibre charges were most suitable for our distance requirements and projectile weight. The Palmer gun was sighted for 20 meters.

The immobilizing drug M-99 (Etorphine hydrochloride, American Cyanamide Company, Princeton, New Jersey) was obtained in aqueous solution of 1 mg/cc. Darts were pre-loaded with 3 mg M-99. One cc of the tranquillizer Acepromazine (Ayerst Co.) in 10 mg/cc concentration, was used in conjunction with the M-99.

After the shot was made the helicopter crew attempted to conclude if a "hit" was made. Rarely was the dart visible on the animal. Generally the spotter could follow the flight of the dart and judging from a "puff" of fur or spot of blood determine if indeed the dart had arrived on target. If the hit was uncertain or confirmed, the helicopter pulled away from the buck which was then observed from a distance for signs of narcosis. If no signs of drug induction had occurred after 10 minutes,

a re-darting was attempted.

When a buck started to show signs of impeded motor control the standby ground crew was notified via walkie-talkie of the animal's condition and location. The ground crew consisted of five to six persons with necessary processing equipment in a 4-wheel-drive Chevrolet Suburban. The helicopter hovered at a distance of .8 to 1.6 km from the animal to minimize stress. The ground crew would arrive at the animal's site when the buck lost motor control. Bucks were not completely sedated and had to be manually restrained while being processed.

Data collection included: 1) taking animal weight with suspended scales, 2) measuring horns by Boone and Crockett method, 3) measuring neck diameter and shoulder height, 4) monitoring heart and respiratory rate with stethoscope, 5) taking rectal temperature, 6) treating all wounds with Topazone (Eaton Vet. Lab., Norwich, New York), a topical antibacterial, 7) taking frontal and ventral reference photographs, 8) drawing a 10 cc blood sample with a 20 cc large bore syringe, 9) attaching 65-mm-square, colour-coded, plastic ear tags (Ritchey Co., Briton, Colorado), 10) fitting solar-powered radio transmitters (Wildlife Materials, Carbondale, Illinois), and 11) administering the M-99 antagonist M-50-50 (Diprenorphine, American Cyanamide Co., Princeton, New Jersey). M-50-50 in a concentration of 2 mg/cc was administered at twice the dosage of M-99. This was given 2/3 intramuscularly and 1/3 intravenously.

Animals were observed until they had regained coordination. All bucks were radio monitored to ascertain their post-handling condition. Necropsies were performed on three of the fatalities to determine cause and time of death as well as the condition of the animals.

The advantage of darting from a helicopter is that it allows a researcher to obtain specific animals. Since our study deals with territorial buck behaviour the helicopter technique allowed the marking of preselected territorial bucks on the study area. If a researcher did not have these constraints it would no doubt be more economical and energy-efficient to wing trap (Hoover et al. 1959, Spillett and Zobel 1967).

A turbo charged helicopter was critical for this operation. This is due to our study area being located at an elevation of 2,111 - 2,250 m above sea level which reduces effective horsepower by 30 percent, and the need for quick maneuvering and hovering capabilities. The helicopter was flown 14.8 hours at a cost of $130 per hour. Various other helicopters have been used including a Hiller 12-E and a Bell series "B", (Arizona Game and Fish Dept. 1971) both having less load capabilities but supercharged engines.

A pilot experienced in big game survey work is recommended. It was found in New Mexico that an inexperienced pilot needs at least 4 hours training time in surveys and several practice runs before becoming effective at helicopter darting (Wilson 1975). Our pilot had experience in helicopter coyote control.

No capture attempts should be made when wind velocities exceed 15 knots and gross weight of the helicopter should be kept at a minimum. The Hughes 500 performed adequately with three people weighing a total of 252 kg. The helicopter must be modified to allow the gunner(s) to freely aim the tranquillizer gun. The door may be removed which reduces the aerodynamic performance or doors may have zippered vinyl windows. The craft we used had the vinyl window in front and the door removed in

the rear.

A total of 52 darts were shot at 13 animals with 27 hits. Modified darts were used. Half the barb was removed and the needle sharpened. Modified darts resulted in less tissue damage and less probability of partial injection due to tissue plugging the needle bore (Day 1969). Loaded darts were plugged with petroleum jelly to "seal" the unit and prevent premature loss of the drug. Frequently the shooter could not determine if he had hit the target but the spotter would follow the dart path. Darts with irridescent fletchings were easier to see.

Variable darting distances posed a problem of which charge load to use. Green charges are too powerful for a range of 10 m and ineffective in propelling syringes accurately beyond 30 m. Other researchers have reported problems with erratic velocities using Palmer equipment (Bart O'Gara and Harry Gorman, pers. comm. March 1, 1978). While sighting our Palmer 32 gauge Cap-Chur guns we found as much as 36 cm of vertical drift at 25 m with the same lot of green coded charges. This variability can result in darts that lack the velocity to reach targets while others may break a femur or penetrate deeply into tissues. In an attempt to obtain more uniform results new tail fletchings were used with each shot, the gas ports of the follower were cleaned and the rifle barrel cleaned and lubricated daily. Some researchers have chosen the Palmer CO_2 gun. Its maximum range is only 18 m from a helicopter but has been used successfully to capture bighorn in Arizona, Utah, Nevada, New Mexico and Mexico (Wilson 1975).

Deflection of 4 cc darts resulting from rotor wash was a problem when shooting beyond 25 m. Smaller darts had less surface area for deflection. Other dart delivery problems included glancing hits and partial

injections. Glancing hits occurred when the dart hit high on a hip. Partial injections can occur when the internal plunger charge fails to fire or the plunger thrusts at an angle in the dart bore. These problems are not always easy to document or correct.

The majority of bucks darted were solitary during our early June operation. When pursued with the helicopter these animals would frequently turn 180° under the helicopter when approached to within 30 m. This constant maneuvering of animal and helicopter made dart placement difficult at best. This type of complication can quickly turn a flank shot into a fatality due to thoracic penetration.

The evasive behaviour may be largely due to whether the animal is alone or with a group. Similar bucks observed from the helicopter in August, November and December "lined out" in a group and allowed a closer and easier target. Time of year may be of importance to the overall success of the operation.

Little helicopter time was spent locating and darting specific animals ($\overline{X}$ = 4 and 7 minutes respectively). The majority of the time and cost investment was involved in waiting for animals to become immobile. This took an average of 19.3 minutes and is indicative of insufficient drug dosage. When dart dosage was inadequate to immobilize an animal additional time had to be spent re-darting and waiting for ataxia.

The ground crew should approach the darted buck as soon as it is recumbent. The walkie-talkie system could have been improved by use of headsets as the helicopter noise often made transmissions inaudible. However, the system allowed the crew to arrive promptly. Thus, the animal was processed in a minimum amount of time ($\overline{X}$ = 25 minutes). It was felt that in shortening the handling time we could reduce the potential

for shock.

Shock is an important complication when handling pronghorns. The symptoms of stress are accelerated heart rate, salivation and nystagmus. In the future, blindfolds and a 50 mg I-M injection of the corticosteroid, dexamethizone (Azium, Shearing Lab., Bloomfield, J. D.) will be administered prior to handling every animal. Both Thorne and Gorman have observed elevated blood pressure as a side effect of M-99. However, it is reversed by the injection of the antagonist M-50-50 and no mortality was attributed to the problem.

The pre-immobilization period was defined as the time from darting to recumbency and ranged from 4.5 minutes to 45 minutes. Factors accounting for this spread include distance a buck was run before being darted, whether or not the buck received a full injection, redarting attempts and location of injection. It is worth noting that buck number 2 was shot before he had run 50 meters. Table 1 shows this animal was satisfactorily immobilized in 4.5 minutes with little physiological stress.

After a successfully placed dart injected into an animal, an average of 6 minutes lapsed before the first evidence of ataxia was noted. Many ungulate species are immobilized within 5 minutes using M-99 at our dosage rate.

M-99 affects both autonomic and voluntary nervous systems. The first visible sign of drug effect was ataxia. In the pronghorn this was first evident as a slumping of the hindquarters and forward progression of paralysis. The last stage before the animal lies down is a combination "goose-stepping" and action that suggests stotting.

Information accompanying the drug states immobilization time to be 5 to 15 minutes. This is supported by researchers (Smeller and Bush 1976,

Table 1. Observational data, vital statistics and dosages of immobilizing drugs used on pronghorn bucks.

Antelope Number	Pre-immobilization Period (minutes)	Respiratory Rate (inspirations/minute)	Heart Rate (beats/minute)	Rectal Temperature °C	Body Weight (kg)	Dosage of Etorphine: M-99 (mg/kg)	Dosage of Acepromazine (mg/kg)	Dosage of Diprenorphine: M-50-50 (mg/kg)	Recovery Time: gain feet (minutes)	Results
1	21	-	180	-	54.0	.056	.185	.222	3.5	Recovered
2	4.5	104	108	40.5	51.7	.058	.193	.095	4	Recovered
3	7	92	188	40.5	52.6	.114[a]	.380[a]	.152	10	Death by shock 30-36 hours
4	14	116	228	38	57.15	.052	.175	.122	10	Death: Penetration of spleen by dart
5	23	156	224	40.5	51.7	.116[a]	.580[ab]	.116	6	Recovered
6	23	120	204	41	49.9	.060	.200	.120	2	Death by shock 30-36 hours
7	17	68	208	40.5	51.7	.116[a]	.386[a]	.154	-	Death: Vena cava penetrated by dart
8[c]	45	100	211	40.5	51.7	.116[a]	.387[a]	.212[d]	17	Recovered
	$\bar{X}$ = 19.3	$\bar{X}$ = 108	$\bar{X}$ = 193.9	$\bar{X}$ = 40.2	$\bar{X}$ = 52.6	Range .052-.116	Range .175-.580	Range .095-.222	$\bar{X}$ = 7.5	

[a]More than one dart hit (may not have been a full injection).
[b]1 cc 1 im injection of 10 mg Acepromazine (animal not sufficiently sedated).
[c]Additional 1 im injection of 5 cc of Dexamethizone.
[d]Additional 4 mg given 1 im 12 minutes after first injection.

Heck and Rivenburg 1972) who reported immobilization of various ungulates at approximately 5 to 7 minutes.

Dosages of M-99 are expressed as a function of the animal's body weight divided into the number of mg of M-99. Animal weights were closely grouped between 57.15 and 49.9 kg with an average weight of 52.6 kg. Our range was .052 to .116 mg/kg. It is important to note that all dosages greater than .060 mg/kg were a result of more than one dart being used. A lapse of about 10 minutes occurred between redarting attempts. It cannot be stated whether a full dosage was injected from any dart.

The role of the tranquillizer in combination with M-99 is twofold. It sedates the animal while the M-99 is being induced and it counters the hyperexcitability and convulsions some species exhibit (Harthoorn 1965). The tranquillizer used is generally Rompun or Acepromazine. The choice tends to be one of individual preference. Good results have been reported using the two drugs in combination (McKean, Stock and Magonigle 1978).

Buck #5 was injected with an additional 10 mg of Acepromazine after capture to put it in a satisfactory level of sedation. Acepromazine expressed as a ratio of mg/kg ranged from .175 through .580. The range of M-50-50 used was .095 through .222 mg/kg. This dosage should be increased to three times the M-99 dosage. This should decrease average recovery time from 7.5 minutes to less than 4 minutes.

Physiological parameters were monitored on eight pronghorns. Baseline references to respiratory rate and heart rate were not available. Respiration rates collected from our antelope ranged from 68 through 156 respirations per minute ($\bar{X}$ = 108). It is not known how much of a heart and respiratory rate increase is the result of exercise and stress and how much relates to drug effect. Heart rates ranged from 108 through

228 with a mean of 193.9 beats per minute.

Rectal temperature ranged from 38° C to 41° C. The mean value of 40.2° C does not sharply deviate from levels reported by Bear et al. (1973) who gave a $\overline{X}$ = 38.4° C on temperatures of 49 collected animals. Bear shot unexcited animals and took temperatures soon after death. Lonsdale et al. (1971) recorded an average body temperature of 38.5° C on live pronghorns with temperature telemetry units. Body temperatures rose 2° C when the animals were handled or while the attendant cleaned the corral.

Difficulty was encountered while trying to handle and process semi-sedated animals. Frequently an animal had to be caught on foot and manually restrained.

Three fatalities occurred as a result of dart penetration. In the first buck the dart penetrated the lungs and aorta resulting in death from bleeding within a few seconds. The second buck was killed by a dart penetration through the flank and into the spleen with resultant bleeding. The third buck died as a result of a dart penetrating on the left side of the anus and severing the vena cava.

The animals were necropsied at the death site using fat deposit analysis. It was determined that their overall condition was good to excellent.

Other deaths included two bucks which were radio-collared and released. Death occurred 30 to 36 hours after release. Subcutaneous blood vessels were engorged with blood indicating shock. One of the two bucks was observed from the air 25 hours after release. This animal was up and moving although noticeably stiff in the hindquarters. It is thought these fatalities were the result of shock from an insufficient dose of M-99. Both of these bucks were only minimally sedated during handling.

Four bucks were never captured even after multiple dartings. It is not known how much of the drug was actually injected.

DISCUSSION AND RESULTS OF IMMOBILIZING DRUGS

The problems of immobilizing free-ranging pronghorns have only recently been investigated.

Succinylcholine Chloride has been commonly used as an immobilizing agent but has a narrow dose-safety range. Even though it was successfully used on captive pronghorn by Beale and Smith (1967) its use on antelope has been discouraged (Tom Thorne, pers. comm. February 11, 1977, Harry Gorman, pers. comm. March 1, 1978). Using a full dose on a stressed pronghorn could result in death from respiratory collapse. The depressant effects of this drug on the respiratory system might be compounded by the high elevation of our study area. Other detrimental effects have been described by Burris (1965).

Several researchers have had successful results using M-99 on wild ruminants (Drevemo and Karstad 1974, Presnell et al. 1973, Leege and Schlegel 1974). In making the decision on which drug to use we contacted various individuals who had experience with M-99. It became evident that there was a broad difference in recommended dosages. All agreed that M-99 is the best of currently available drugs.

There is a problem with extrapolating dosage rates from other species or captive animals. Suggestions ranged from 3-4 mg M-99 with 50-100 mg Rompun or 5-10 mg Acepromazine in place of Rompun (Tom Thorne, pers. comm. February 11, 1977) -- three mg M-99 was considered to be a lethal dose (Boever 1974). It would appear, based on the results of Harry Gorman (pers. comm. March 1, 1978) who has immobilized 25 captive antelope with M-99, that the best dosage is 8-9 mg M-99 in conjunction with 10 mg

Acepromazine or 50 mg Rompun. A similar dosage was used successfully on six captive antelope by Kistner at Oregon State University. Since the objective of any immobilizing drug is rapid capture and up to 9 mg of M-99 is required on pronghorns, current availability in only 1 mg/cc concentration renders it unsatisfactory for dart delivery under field conditions.

If M-99 becomes available in a higher concentration it is felt it would be more suitable than any other drug currently available.

An operation of this type is costly (14.8 hours of helicopter time totalled $1,925). Each darting attempt costs $8 for drugs and $10 for the dart. Drug and dart expense ran $936. The operation also included a total of approximately 150 man hours although a four-man crew could have processed animals in a much shorter time had the pronghorn been rapidly and completely immobilized.

SUMMARY

The dosage of 3 mg M-99 with 10 mg Acepromazine is not sufficient to rapidly immobilize excited pronghorn. A recommended dosage is 8-9 mg M-99 with either 10 mg Acepromazine or 50 mg Rompun. A dosage of this size cannot be successfully delivered with a dart from a helicopter in its present available concentration of 1 mg/cc.

It is possible to accurately place darts on running pronghorn from a helicopter. We would advise the operation be performed during a period when animals are grouped rather than solitary. In doing this one may avoid the evasive action of solitary animals.

Cap-Chur equipment lacks quality control in the production of propellent charges. To aid in more consistent results researchers should

test charge lots prior to their operation.

None of the deaths resulting from our operation was considered drug-related but caused by dart penetration or shock from handling stress.

If and when M-99 becomes available in a 5-10 mg/cc concentration it could be used in a 2-2.5 cc dart. This would permit administration of a sufficient dosage to rapidly immobilize pronghorns without excessive dart penetration.

The antagonist M-50-50 works predictably to reverse immobilization. A dosage of three times the M-99 dose may decrease recovery time to less than 4 minutes.

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COMMENTS AND QUESTIONS

AMSTRUP: What were your total figures on the number of animals you attempted to dart, the number darted and the total mortalities?

COPELAND: What it amounted to was, we had nine animals that we actually got in hand. Four of these animals survived, five of them died. Three died from dart penetration, two died from shock. We also had a total of five animals that we darted and we were unable to sufficiently sedate them to get them in hand.

AMSTRUP: Do you feel then that this technique is worthwhile for the kind of capture operation that you had in mind? And another question that I had along the same line, did you ever try darting them from the ground?

COPELAND: Well, we're going to try to do some field darting this spring, from water hole conditions. We thought that probably the time investment trying to get animals by blinding yourself in and getting within a 30 yard range would probably make it less of a desirable technique of choice. M-99, at this concentration, is not a viable alternative. The drug has a great deal of potential and, as far as the safety of dose limits, it probably is the only drug currently available on the market to use. The people who make it, that is American Cyanamide, have been reluctant and resistant to producing it in any other concentration other than the one that's on the market right now. There are potential ways of concentrating the drug, that is, researchers actually doing the concentration, and we've been working on that this winter. If we have any success at that we will

publish a note.

AMSTRUP: About the chasing of them with a helicopter to get the dart into them -- don't you think that since pronghorns are as highly excitable as they are that this is a factor in inducing mortality aside from the fact that you've darted them and put them through all the other stress?

COPELAND: Oh, I'm sure it is.

AMSTRUP: Just a comment from my own experience. I darted 11 pronghorns by stalking them on the ground last spring with new darts, the dry succinylcholine chloride, and I successfully immobilized five of them. The others showed no effect of the drug whatsoever. Of the ones we immobilized, the first one that I handled died while I was handling it, apparently because it suffocated in its own saliva. I held its head up like the books say you're supposed to do and found out later on that that isn't the best way to do it. The other four apparently survived the drug fine; three of them I've still got radios on, the other one ran off a few yards after I released it. I apparently let it up too fast and it tripped over its own feet and broke its neck. I'm sure that I had considerably less than $2,000 time invested. I've got a few more cactus spines in my knees but I think it's at least a feasible technique for capturing selected individuals.

COPELAND: Yes, we were kind of surprised at how expensive an experiment this turned out to be ourselves, and we certainly hadn't originally budgeted it to be quite as exorbitant a project as it turned out to be.

QUESTION: What was your succinyl dosage? What dosage did you have on your

succinylchloride?

AMSTRUP: I was shooting adult does, trying to find the ones that looked like they were going to fawn. In this particular area and prior to fawning I was shooting with 10 mg, a 10 mg dry dart. After fawning I was shooting with 8 mg dry darts.

PYRAH: In relation to what both of you have said, we started out trying to dart antelope and didn't have time enough, but we used a silhouette to provoke territorial behaviour by the buck and we had bucks right up to the silhouette very close, as close as the front table.

COPELAND: That's interesting.

BRUNS: I'm curious to know what happened to these bucks after you released them. Did they maintain their territories?

COPELAND: Yes. We had some very interesting sidelights as a result of this operation. For instance, we had one buck that was removed, an animal that we had judged to be a dominant territorial male, that was adjacent to one of the animals that we did end up successfully transmittering. Once this animal was removed the sub-dominant animal moved in and assumed his territory. We had one animal shot on territory. We had one animal that was forced off of territory during the rut, and we had another animal that successfully bred on territory, and the fourth animal was poached sometime in late November, on territory.

BRUNS: So you concluded nothing that could go either way.

COPELAND: The study area is such that some of it is very flat and very accessible to hunting while other parts of it are relatively remote with broken rolling hills which allow some cover for the animal. The animal that successfully mated on territory was an animal that

had a remote area; the animals that got shot on territory or removed from territory were animals that were very vulnerable to across-the-road type four-wheel-drive hunting that we get very frequently in Idaho now.

LEGISLATIVE AND ENFORCEMENT APPROACHES TO ANTELOPE MANAGEMENT IN ALBERTA

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Alberta is a land rich in wildlife resources. Its diverse landscape, ranging from high mountains to dry arid prairie, provides suitable habitat for some 153 species of mammals and 329 species of birds. Indeed a challenge for wildlife managers!

For the sportsman's pleasure, 14 animals are defined as big game. There are 18 different licence options to hunt; our seasons vary in length from 3 days to several months. Alberta is, in my view, a proverbial "land of opportunity" on the North American wildlife scene.

The effective management of antelope is one of the more challenging problems faced by the province's wildlife managers. The northern extremity of the antelope range extends into southeast Alberta. The vulnerable antelope are often limited by severe winter conditions. In addition, our antelope must exist on land that has been, to a large extent, altered by man. Conflicts invariably arise, creating a variety of management problems.

Antelope hunting is restricted to no one group of people. Accessible terrain, the time of the season, generally favourable weather and the ease with which game can be found and handled, results in its being popular with virtually all types of sportmen, from the novice to the expert. It is a type of hunting that has appeal for females -- either to take an active part as a hunter or to socially accompany the hunting party. Antelope hunting provides a unique and wholesome outdoor experience for

its participants. An important part of Alberta's recreational life, it too often receives little or no tangible recognition.

However, regardless of the social and recreational value of antelope hunting, there is frequently opposition to the sport. Interest and emotions arise and, not uncommonly, a movement gains momentum to prohibit or restrict antelope hunting. Allegations of over harvest, trespass, general hunter misconduct and prairie fire hazard continually surface. Emotional and politically sensitive issues such as these are difficult to suppress, even when evidence exists to the contrary. Little or no recognition is made of the benefits to the community for having the opportunity to hunt. Nothing is mentioned of the problems relating to land use, domestic animal production or the effects of fencing.

Thus, in addition to the problem of maintaining adequate population levels, social-related problems created the need to vary our approach to the harvesting of antelope if the whole concept was to be publicly and politically acceptable. Care would have to be taken to ensure that programs reflected both resource and social desires, if an annual harvest through sports hunting was to serve as a successful tool for wildlife management.

In Alberta, in the early 1960's, antelope seasons were virtually uncontrolled. This chaotic situation was highlighted by trouble with high hunter densities in certain areas; complaints of local overkills and landowner-hunter conflicts were prominent.

It was not until we were in a period of depressed antelope populations that we began to manage not only the herd but also the hunt. The demand for licences far exceeded the number that could be harvested without having a detrimental effect on the existing population. A strategy

was required that would serve the interests of all involved -- landowner, hunter, general public and, of course, the resource.

The end result was the system as we practise it today. The antelope range is broken into several zones with a limited number of licences being issued on an annual basis. Licence draws are conducted with persons successful in one year being ineligible to obtain a licence the following year. Two types of licences are issued, one for trophy antelope and one for non-trophy antelope. The former is for a male antelope having horns greater than 12.5 cm in length (longer than the ears). The non-trophy licence permits a controlled harvest of the females.

The present system was developed with several objectives in mind:

1) That hunting could continue even during times when populations were depressed;

2) That hunter densities would be distributed so as to improve the quality of the hunt and reduce landowner objections;

3) To remove the problem of over harvest in some locales;

4) To respond more effectively to the high licence demand.

It was apparent that if the combination of strategies finally adopted did not generally meet these objectives, the acceptability of hunting antelope would decline. Pressure to either severely curtail or entirely close the antelope hunting season would gain momentum.

To ensure the program's workability the various enforcement strategies listed below have been utilized:

I) Enforcement of licence violations (e.g. obtaining more than one licence; applying while ineligible);

2) The means to ensure reasonable enforcement of the trophy and non-trophy licence system and seasons;

3) Landowners had to be assured that the level of enforcement was adequate;

4) Appropriate preventative and apprehension techniques. (Additional laws such as the prohibition of discharging firearms within 50 m of a vehicle and the regulation prohibiting vehicle harassment were enacted).

Referring to the matter of appropriate preventative and apprehensive strategies, our primary thrust is, and has been, more prevention than apprehension oriented. This is probably contrary to the preceptions of some hunters, general public and Divisional personnel.

The first consideration in our prevention program is to familiarize the hunter with the "rules of the game". Special material accompanies the legislation informing the individual of such matters as tagging requirements, maps showing the different zone boundaries, etc. The information is reviewed and revised annually by administrators to ensure that all possible data are included. It is worth mentioning that in our operations much of the material is being prepared by biological personnel who likely do not perceive the material in the same context as those required to administer enforcement matters. We are of the view that a well-informed hunter is less likely to make inadvertent errors.

The second feature of our prevention activity is the employment of a large number of uniformed officers using marked vehicles. Two years ago our Branch adopted a high-profile full-identity program as part of a general violation prevention thrust. Last year a total of 22 Fish and Wildlife Officers was used for antelope enforcement duties. Additional help was received from the R. C. M. Police, the Transportation Patrol Division and Provincial Parks Officers. The presence of a large number of Fish and Wildlife enforcement staff is proving to be effective and

landowners and local governments are reasonably satisfied that adequate supervision is taking place. Irregardless, some jurisdictions continue to complain and their position, being relatively predictable, does not seem to change despite our improved regulatory efforts.

Aircraft, both helicopter and fixed wing, are employed during the antelope season. The use of helicopters in particular has been an excellent aid in preventing and discovering violations. Personnel in helicopters can direct Officers in ground units to high-use areas as well as detect violations.

To reduce the prevalence of harassing hunters, helicopters are flown at about 500 m on a general flight pattern and generally descend only to check hunters with animals down or vehicles carrying antelope. Our experience with helicopters on the whole has been good although some complaints are expected and do occur. Allegations have been received of the deliberate misuse of helicopters by Officers to annoy hunters or scare game. Sometimes our aircraft have not even been airborne at the time the alleged incidents "occurred". However, regardless of the potential for complaints, aircraft use is efficient and plays an important function in the enforcement program. Another benefit of aircraft patrols, aside from enforcement use, is the possible detection of prairie fires during hot dry spells of weather -- a service appreciated by farm and ranch operators.

Regardless of our preventative efforts violations do, of course, occur. Apprehension capability is therefore an integral part of enforcement activity. In Alberta we make use of unmarked vehicles operated by Officers dressed in hunting garb. Such items as stock racks, hay bales, etc., camouflage the vehicles as to their primary purpose and allow the

units to operate virtually without suspicion.

Plainclothes operators are extremely helpful in securing information from hunters with respect to major illegal activities, either at the planning or operational stage. Useful information is also obtained about general hunter activity from people that normally volunteer nothing to a uniformed enforcement Officer unless they are pressed. This information is helpful in understanding the nature of concerns that may be reflected by landowners, the general public and the hunters themselves.

Plainclothes Officers are free to exercise judgment and take action where it is appropriate to do so. It should be noted here that we do not try to hide the fact that plainclothes Officers are working in the field. We consider public awareness has great value as a preventative measure.

Actual field enforcement is only one aspect of the apprehension program. Administrative requirements (respecting licence applications, etc.) can be and are, in fact, actively enforced. In conjunction with our Administrative Branch, persons can be detected who apply while ineligible or submit more than one licence application. Names of suspected violators, along with the appropriate documents, are investigated through the office of the Special Investigator. Prosecution of offenders is undertaken. This licence control monitoring of the antelope hunt is viewed as an important part of the enforcement program. It is important that hunters perceive programs of this nature to be working efficiently.

Harvest data, analyzed by our Wildlife Branch, is another potential field for violation detection. Any data that suggests illegal game was taken (i.e. females during the trophy season, a non-trophy antelope on a trophy licence) are turned over to our Special Investigator to direct the

follow-up. Investigations of this nature require experienced Officers. By such "follow-up" it is possible to ensure that any refinements to the hunting regulations meet their objectives.

As management strategies are refined there is a corresponding generation of enforcement problems. Recognizing this situation our enforcement effort has moved to improve our efficiency through the increased use of forensic science. As a result of the need to effectively enforce sex specific licencing and similar refinements we are currently researching for a means to determine the sex of a given sample of meat, blood or tissue. Without such capability there is no practical means of effectively enforcing sophisticated management legislation. In the long term, sophisticated management requires sophisticated enforcement.

In addition, we are conducting research into the nature of violation occurrence in an attempt to identify the factors causing or influencing offences. We hope, in the future, to develop techniques that are capable of influencing or changing attitudes and values. Data to date suggest that negative attitudes prevail in violation situations. Factors such as ignorance are not surfacing frequently. We believe that more positive attitudes in the minds of the sportsmen and managers are needed to alleviate many of the enforcement problems we now experience. This has particular importance in managing species such as antelope where external factors can make long-term management difficult. We must consider not only what can be done on a yearly basis but also respond to the more long-term recurring problems. Perhaps through a diversified enforcement program some of the impediments that obstruct good management strategies can be eliminated.

As a closing thought, I believe it is incumbent upon managers to

reassess their attitudes and realistically look at the potential value of their enforcement programs. For too long many have had the view that offences are the fault of Officer over-zealousness. Perhaps we should be using our energies, instead, to determine the reasons for non-compliance. In my view, violations are not a reflection of Officer failure. Instead they indicate a failure somewhere in the management program and/or its delivery to the public. The secret of effective management is to determine where the weaknesses are and to implement strategies to correct them. Enforcement designed purely as an instrument to apprehend offenders brings few permanent solutions to the complex problems of contemporary wildlife management.

HISTORIC RANGE CHANGE IN THE TEXAS PRONGHORN[1]

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Abstract: Human settlement of Texas and use of the land resources had a multifactorial effect on pronghorn range changes during the past 175 years. Agricultural practices, hunting and human settlement compounded the impact of droughts, blizzards and fires on depleted pronghorn numbers. Historical evidence is presented to show pronghorn occupied about 72 percent of Texas, extended further east than previously documented, and were absent from the central Hill Country region. Increasing human pressures are shown to have caused progressive range losses between 1800 and 1924 when Texas pronghorn reached an all-time low of about 2,500 animals occupying about 30 percent of the state. Concerted conservation efforts and a large-scale transplant program had restored some range to the species by 1945, but numbers remained low, concentrated in the Trans-Pecos region. The current status of pronghorn in Texas is about 10,000 head confined to less than 24 percent of their former range in the state.

All too often wildlife researchers are forced into making management recommendations at short notice with a paucity of background information on which to base their decisions. Considerable work has been done on various biological parameters in many species, but one aspect of great

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importance is usually overlooked. The historic distribution and abundance of a species offers not only academically interesting data for the record but some significant and practical pointers as to how management can best be accomplished. To this end we undertook an historical review of pronghorn antelope (*Antilocapra americana*) in Texas. By hindsight we were able to determine some important factors which influenced changes in the range and numbers of pronghorn through to their present limited status. These, we feel, will offer some new thinking to future management planning for both pronghorn protection and reestablishment.

METHODS

Data were collected by an extensive review of the literature written throughout the settlement and growth of the state. Pre-settlement data were gleaned from the fossil record and studies on Indian pictographs as well as diaries on the early exploration of the state. Subsequent periods were arbitrarily separated by major historic phases in the development of Texas.

Literature surveyed covered from the late 1500's to present time and ranged through multivolume diaries, biological surveys, army records and newspaper articles. Supplementary information was gathered by circulation of a wildlife questionnaire to all 254 County Historical Commissions in Texas. We had a 65 percent return of these questionnaires, which varied from those of dubious value through some which had multiple referencing of data sources. Based on our own literature reviews and analyses of these county returns, specific key counties were visited and researched in detail. Special emphasis was placed on counties along the published eastern limit of pronghorn distribution (Nelson 1925), and around the

Edwards Plateau which was included in this pristine pronghorn distribution (Figure 1).

RESULTS AND DISCUSSION

Pristine Time - 1800

This period covered the evolution of the pronghorn, predators and the Plains Indians. The pronghorn as we know it today survived the Pleistocene extinction which showed the disappearance of some closely related genera (Martin 1958), and evolved as a major Plains animal along with the bison. It was of major ecological importance on the Great Plains and played a role in the development of the American Indian culture. This time period also included the early exploration of the southwest and the establishment of the first French and Spanish mission settlements.

No estimates are available for human population numbers before 1800. American Indians are documented as hunting pronghorn (Dennis and Dennis 1925; Newcomb 1961; Mails 1972), but all descriptions indicate relatively inefficient hunting techniques which resulted in poor success and minimal impact on the species. The very limited movement and settlement by European man during this era probably had little or no effect on pronghorn range. Thus while some pronghorn were killed by man in the early days, this kill was unlikely to have been at more than a subsistance level and would have had less overall effect on animal numbers than the influences of predation, weather or fire.

The fossil record of early American ungulates is poorly known in Texas. Some 21 sites have been excavated in detail to date, but only seven of these produced identifiable pronghorn remains. Located over the state, two of these sites are along the eastern boundary of pronghorn

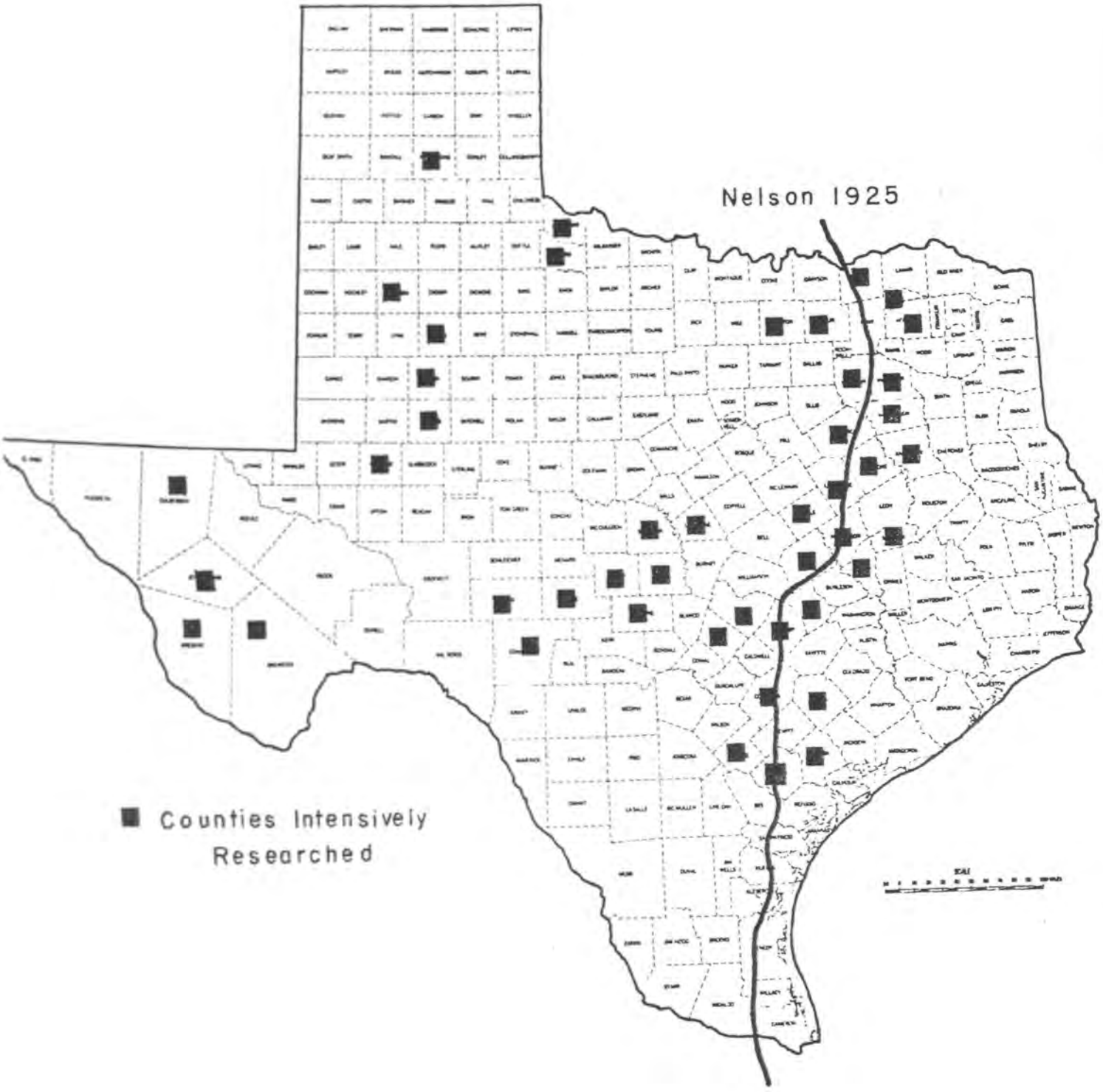

Figure 1. State map showing original eastern limits of pronghorn distribution proposed by Nelson (1925), and counties researched intensively during this study.

distribution as given by Nelson (1925). More recent Indian pictographs are known from many locations, especially in west Texas and the Edwards Plateau area (Jackson 1938), but the only illustrations of antelope are found in Trans-Pecos Texas.

The presently proposed eastern limits of pronghorn distribution were determined from diaries of early French and Spanish expeditions and from mission accounts. The earliest account of what we believe to have been pronghorn was by Joutel who accompanied the La Salle voyage in 1684-1687. Between Galveston and Lavaca Bays he noted "<u>.....the sight and abundance of goats and bullocks differing in shape from ours, and running along the coast</u>". Ashore at Lavaca Bay, Joutel described "<u>.....great lakes of salt water, little grass and tracks of goats on the sand.....and saw herds of them but could not come near them</u>" (Stiles 1906). In 1722 the chronicler for the Aquayo Expedition reported wild goats in what is now Frio County (Buckley 1911), and several other references to wild goats were found in early writings on south Texas.

We believe these wild goats to have been pronghorn. Not only were the early writers familiar with white-tailed deer so would not have mistaken them for some other species, but the sympatric occurrence of these wild goats with bullocks (buffalo), and their aggregation into large herds are clearly pronghorn characteristics. Many early writers mentioned the more impressive buffalo but failed to mention pronghorn known to have been in the area. This omission was found for all areas of the state; even the reports on Panhandle expeditions of 1594 and 1598 failed to mention pronghorn in association with buffalo (Castaneda 1936-1939, Vol. 1) although the former were present in that area in herds of over a thousand animals.

Numerous expeditions crossed the Edwards Plateau before 1800 enroute between the south Texas missions and the settlement at El Paso. None of these documented encountering pronghorn on the eastern Edwards Plateau and only mention their occurrence once west of the Hill Country. Furthermore, despite numerous animal pictographs in this area, none are of pronghorn (Jackson 1938). Detailed search of historic records in key counties of the Edwards Plateau failed to show any evidence of pronghorn ever having occurred naturally in the Hill Country.

After careful evaluation of the data accumulated from the pre-1800 literature, we propose the pristine limit of pronghorn distribution in Texas to include at least part of the Gulf Coast Prairie, and exclude the Hill Country of the Edwards Plateau (Figure 2). The former area lies beyond the limits given by Nelson (1925), while the latter area was considered by him to lie within the pre-settlement antelope range. These new limits which we propose here indicate that approximately 72 percent of the state of Texas was once occupied by pronghorn antelope.

The Period 1800 to 1850

This was a time of political unrest, some colonization in the eastern part of the state, and the pre-settlement exploration of west Texas. The Austin colony was founded in 1821, Texas won her independence from Mexico in 1836 and finally achieved statehood in 1845. The human population was about 7,000 in 1806 (Webb 1952), had risen to about 46,500 by 1833 (Barker 1924), and an official U. S. census conducted in 1850 listed the population at 212,592 Europeans (Texas Almanac 1972-1973). No estimates were found for the number of local Indians resident in the state during this time period.

In east Texas, the influx of homesteaders must have influenced the

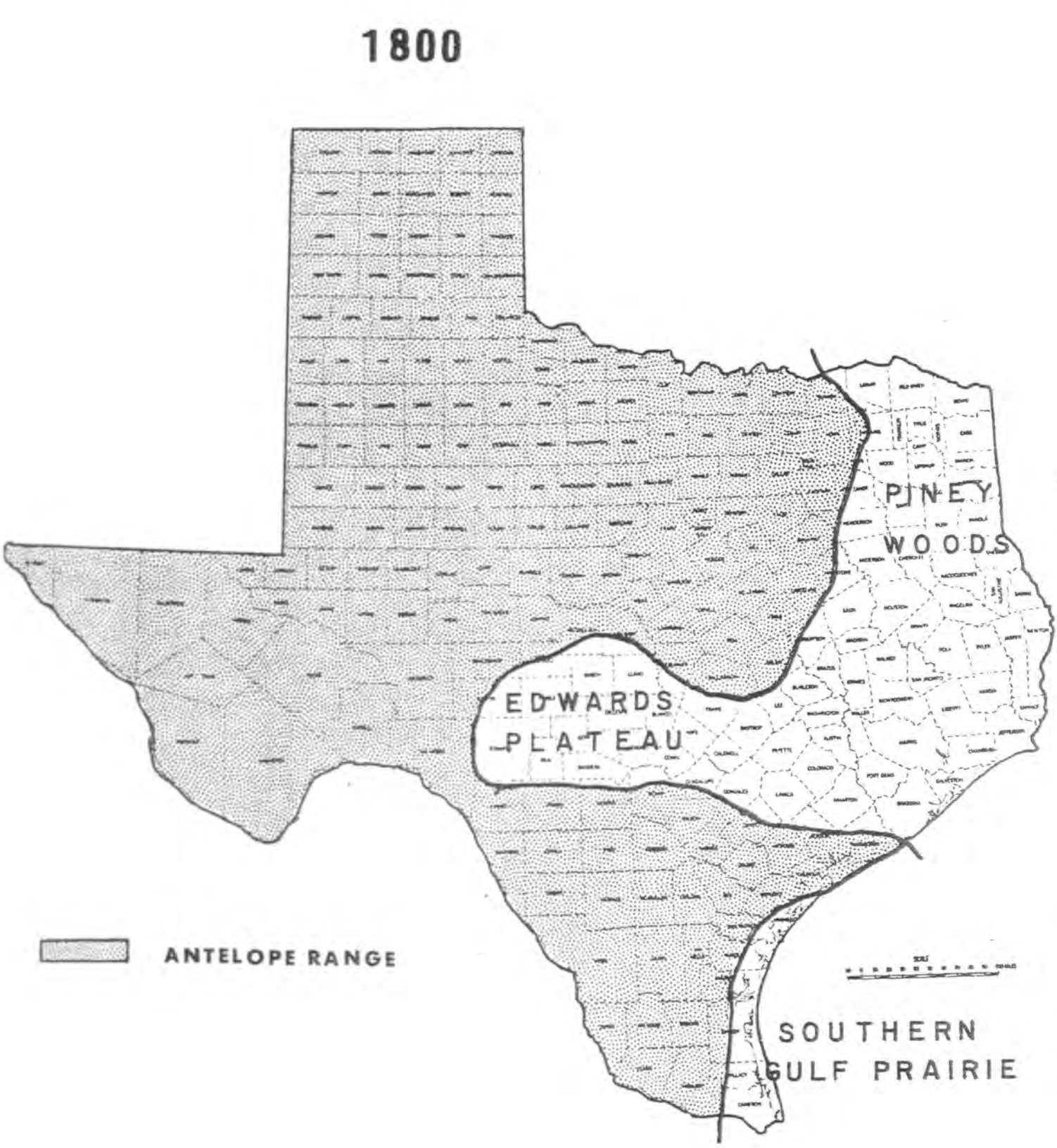

Figure 2. State map showing eastern limits of pre-1800 pronghorn distribution in Texas as established during this study.

eastern limits of the pronghorn range north of the Edwards Plateau. Any impact from this land use, however, was probably confined to the immediate vicinity of human settlements, because no major range change was determinable from the literature. South of the Edwards Plateau, Peak (1846) still found ".....good land and bad water and no timber and more deer and antelope than any man could number". However, the continued land use for the production of domestic livestock resulted in some loss of range to antelope. By 1850 pronghorn had disappeared from the Gulf Coast Prairie and the southern tip of the state, representing a loss of about 7 percent of the pristine antelope range.

A journalist with the 1819 Long expedition to the Canadian River in the Panhandle wrote: "The cabric, wild goat, or, as it is more frequently called, the antelope is common. They are numerous, and with the buffalo are the most common occupants of the Plains, from which they retire only in the quest for water" (Thwaites 1904-1907, Vol. 17). Antelope were still found in large numbers throughout the Panhandle during this period, as they were in the Rolling Plains country and north central Texas. While there was undoubtedly an increased utilization of antelope by both passing expeditions and by the early traders and settlers, the impact on the vast herds common in these areas was probably negligible.

The situation in Trans-Pecos Texas was similar. Relatively few people were in the region during this time period, and most of these were travellers to and from El Paso who had little influence on either the abundance or distribution of antelope. Early descriptions of the Trans-Pecos antelope herds all indicate smaller herd sizes than are documented for the Panhandle and the Rolling Plains. Based on these data, Leftwich and Simpson (1978a) have suggested that more antelope were found on the

Plains than in the Trans-Pecos region of the state in pristine times due to surface water availability.

The Period 1850 to 1880

These thirty years of Texas history brought many changes to the land, some of which had far-reaching effects. Permanent land settlement in east and central Texas put an increasing amount of land under agricultural use, while the earlier exploration now opened up the country to large scale livestock development in the west and south. Further exploration took place in the Trans-Pecos as part of the International Boundary Surveys, new towns and settlements were started, and although the Civil War caused a temporary setback, the state's growth increased rapidly after the war. The human population increased from 212,592 in 1850 to over 1 1/2 million people by 1880.

With the population increase in east and central Texas, there was considerable pressure on the pronghorn. In addition to the loss of range due to cultivation antelope were eliminated to reduce grazing competition with livestock and small scale market hunting developed in areas adjacent to larger settlements. In Denton County in north central Texas early settlers "<u>.....lived on beef, venison, turkey, antelope and bear</u>" (Bates 1918) in 1848, but by 1862 antelope were either scarce or entirely absent from these counties (Patterson 1935; Mills 1950).

In south Texas the early settlers had found deer and antelope to be so numerous that they were never without fresh meat (King County Historical Society 1976). Bartlett (1854) mentioned that there were still small herds of antelope scattered through this country in the 1850's, but our data indicate that by 1880 they had been extirpated from most of their historic range in this area.

The disappearance of antelope from north central and south Texas shows a further loss of about 23 percent of the pristine range during these 30 years and an accumulative loss of 30 percent under 80 years of Caucasian influence.

Changes were also evident elsewhere in Texas on existing antelope range. Throughout west Texas new competition developed for the available range resource as ranchers stocked the open ranges with increasing numbers of cattle, sheep and goats. Growing human populations made greater demands on the antelope herds as a food source, and along with the buffalo the pronghorn became a prey to market-hunting for meat and hides. Despite these various new pressures the pronghorn populations on the High Plains remained high (Haley 1929, Hornecker 1929, Williams 1939), and only began to decline after the market-hunting extirpated the buffalo from Texas in the late 1870's. In the Trans-Pecos region the pronghorn were not as affected by market-hunting pressures, but the literature indicates some decline in numbers due to drought conditions during this period. Kennerly, a naturalist who accompanied Baird on the Emory Expedition in the early 1850's, reported large concentrations of pronghorn in the Trans-Pecos, and Madison (1968) recorded antelope as still common in the 1870's with herds containing several hundred animals in Presidio County.

The Period 1880 to 1924

Land use in Texas shifted abruptly during this period. Large areas of the state were badly overgrazed and carrying capacities for both domestic and wild animals became greatly reduced. The era of open range came to a close and huge tracts of once open country were dissected by both barbed wire and net wire fencing. Farming and human settlement continued to spread into the western counties. All wildlife populations were severely

reduced through over-hunting and competition for the range resources. State game laws were established to control the hunting pressures and preserve the remnant populations of wildlife. The human population increased from 1 1/2 million to 4 1/2 million people in 1920.

Robert Maudslay recorded in 1886 that herds of 100 to 300 antelope were not unusual sights in the Rolling Plains and recalled once seeing a herd of at least 2,000 animals (Kupper 1951). He also gave the following description of an antelope herd he observed from a train on the Texas and Pacific Railroad: "....a norther brought a herd of antelope from the north; seeing the rails for the first time in their lives they were afraid to cross them, and an immense herd congregated there. It took the train about three hours going at a normal speed to get by them. The herd was estimated by this individual to be about 70 miles long and to comprise a million or more animals..... Never again were they seen in such numbers in one place" (Kupper 1951).

Antelope were also still common on the High Plains and in the Trans-Pecos at the beginning of this period, and a remnant population still survived in south Texas. However, with the disappearance of the buffalo the meat and hide hunting pressure on pronghorn increased considerably. Maudslay wrote "we took advantage of the presence of antelope to fill our larder.....at one time we had a wagonbed full of dried meat" (Kupper 1951). Glazener (1951) reported that for about 20 or 30 years antelope meat was an important item on west Texas tables and was sold commercially by the train carload in eastern markets. In the 1880's antelope were still common enough on the High Plains to be a pest to farmers, eating out whole crops of corn, and were often destroyed for this reason.

Murray (1932) felt that hunting antelope from automobiles and using

high powered rifles was the direct cause of the antelope decline in parts of the western Edwards Plateau and the Rolling Plains. Buechner (1950) attributed the drastic decline of pronghorn in the Trans-Pecos primarily to over-hunting.

Weather conditions also played an important part in the decline of Texas pronghorn during this period. There are numerous references to antelope, along with domestic livestock, being trapped in drift fences in blizzards during the 1880's and 1890's and freezing to death. A herd was trapped in this manner near the Panhandle town of Clarendon in 1882 and the settlers killed 1,500 animals (Haley 1936). Droughts took their share of animals in the Rolling Plains and the Trans-Pecos in 1886, 1891 and 1892 (Holden 1928) while Lehmann (1969) records dry conditions for 1881-1883, 1885, 1886-1887, 1890-1891 and 1893-1899 in south Texas. Utely (1966) said that 20 to 40 percent of the cattle in the Trans-Pecos perished in the drought of 1886, but made no mention of the number of antelope that died in the same drought.

Fires also frequently occurred in west Texas during this period. In the early 1900's one fire burned more than a million acres of land in west Texas and eastern New Mexico, leaving from 50-100,000 cattle without grazing. Another fire during the same year is said to have destroyed an area about 150 miles long and from 10-60 miles wide (Rickard 1934). While, again, no mention is made of pronghorn, the effect of fire on already depleted ranges could have done nothing but damage to the dwindling antelope populations.

By the turn of the century there were no longer vast herds of pronghorn to be found in the state, and in 1903 the state legislature placed a closed season on antelope hunting; this represented the first attempt at management of pronghorn in Texas. A census by Nelson (1925) showed that

less than 1,500 antelope remained in the entire High Plains and Rolling Plains combined, while the total population estimate for the whole state at the end of this time period was only approximately 2,400 animals. This represents a further 30 percent loss of the original pronghorn range in Texas and an accumulative loss of 60 percent in 124 years. We do not, unfortunately, have any measure of the magnitude of the population loss that occurred in the 124 years of European man's influence. If the conservative estimates of total pristine pronghorn population numbers suggested by Leftwich and Simpson (1978a) are accepted, the percentage would undoubtedly be in the upper nineties.

The Period 1924 to 1945

State land use patterns stabilized more than in the previous era, but cultivation continued on a wide scale. Wildlife populations throughout the state increased as a new awareness of the state's natural resources emerged. Scientific wildlife management was initiated and research programs added important life history data to the body of knowledge on many wildlife species.

The rate of human population growth was slower but nonetheless the population increased by 2 million to about 6 1/2 million in 1940. This period marked the beginning of urbanization in Texas and many small holdings developed around the larger population centers. There was an increased demand for land and the larger urban populations stimulated higher production in agriculture.

Throughout west Texas landowners became aware of dwindling antelope populations and many actively preserved their remaining animals. Antelope in the Trans-Pecos increased significantly in this era with the protection offered by some ranchers, public concern and strict law epforcement

(Buechner 1950). Numbers elsewhere in the state remained low. Approximately 400 head remained in the Panhandle and 100 were counted in Jim Hogg County in south Texas. Some increase was also reported for the scattered herds on the Rolling Plains and along the western edge of the Edwards Plateau.

State game biologists initiated research on antelope and a scientific approach was taken toward increasing populations on a statewide basis. As pronghorn numbers increased under close protection, so planned management began. Following the successful trapping and transplanting of antelope by New Mexico biologists in 1937 (Russell 1964), biologists made the first attempt to transplant antelope in Texas from Sterling County in 1939. At this time 257 head were caught and released in 21 new locations (Fisher 1942). The primary object of the management plan was to restock suitable areas from which antelope had been extirpated. Uzzell (1973) recorded that during the next 10 years approximately 4,000 antelope were trapped and transplanted throughout western Texas.

Despite the careful protection and management afforded antelope during this period, they disappeared from an additional 2 percent of their original range. However, many of the transplants were made into former range which had been lost between 1880 and 1924. Reintroductions were made on the eastern Rolling Plains, in north central Texas, and as supplements to the small population in south Texas. These transplants restored approximately 23 percent of their original range to Texas pronghorn and by 1945 the antelope distribution in the state covered 61 percent of the pristine range.

It is interesting to note that during the trapping period antelope were found in habitat types that were not used historically, and appeared

to have adapted to them. In Sterling, Irion and Reagan Counties pronghorn were found in areas with a good covering of mesquite (*Prosopis glandulosa*). In the past the vegetation cover of these counties had been grasses but, due to overgrazing and drought conditions, mesquite and juniper (*Juniperus* spp) had become dominant cover. In this area it was a common sight to see pronghorn feeding and resting in heavy stands of mesquite and juniper (Texas Game, Fish and Oyster Commission 1945).

The first controlled hunt in Texas after the 1903 closure of antelope hunting did not occur until 1944 (Lay 1946), when Trans-Pecos populations appeared to have built up enough to sustain a limited hunting pressure. The state charged five dollars for a permit, and the landowner could charge an additional twenty-five dollar land use fee. Buechner (1950) observed that by 1944 pronghorn in the Trans-Pecos had become firmly reestablished, citing the fact that 2,136 were trapped between 1939 and 1946, and 959 were killed during three hunts from 1944-1946.

The Period 1945 to 1976

Texas became a leader in energy production and this had a major influence on the state during this period. Agricultural development and urban industrialization had a widespread impact over the whole state. Wildlife research effort was increased and the resultant findings were combined with habitat manipulation in intensified management programs for all game species. Public awareness and concern for wildlife added impetus to state conservation planning. The lease-hunting system became widely established throughout the state and an integral part of the land use economy.

In the last 30 years the human population of Texas has risen from 6.5 million to 11.2 million people in 1970. East and central Texas population centers such as Houston, Dallas/Fort Worth, San Antonio and Austin have

become large metropolitan areas with sprawling suburbs, extensive industrial tracts, and corporate land speculation and development. People in the western part of the state also increased and new population concentrations emerged at Lubbock on the South Plains, and at Midland/Odessa in the Permian Basin. Although some growth occurred in the Trans-Pecos region this still remains the least populated portion of the state and still supports large tracts of native pasture under single ownership. The increased acreages converted to human use during this period were for the most part remnant, non-agricultural land and over much of west Texas these areas were the last remaining pronghorn range.

The various attempts to translocate pronghorn back into their former range met with mixed success, those transplanted to the western part of the state generally surviving better than those put into central and south Texas. After an initial buildup of numbers following restocking, antelope populations in the Trans-Pecos fluctuated considerably during this period from between a low of 4,963 animals in 1964 to a high of 13,573 in 1973; the 1976 census showed the population was down again to 6,808 head. Numbers in the Panhandle also varied from the initial 2,000 animals to 772 in 1959, were highest in 1963 when 3,252 head were counted, and the 1976 census gave a total of 1,884 pronghorn in this area. In the Permian Basin and on the western edge of the Edwards Plateau similar fluctuations have occurred in the past 30 years, with approximately 1,850 animals left in 1976 (Table 1).

Despite the addition of 256 transplant animals to supplement the small remnant herds in south Texas, by 1969 there were only 91 surviving pronghorn in two restocked areas. Robinson (1970) gave reasons for this decline as drought, mortality at time of transplant due to poor condition

TABLE 1

PRONGHORN CENSUS AND HARVEST DATA FOR THE TRANS-PECOS, PERMIAN BASIN, AND PANHANDLE FROM 1952 TO 1976

Year	Panhandle		Permian Basin		Trans-Pecos	
	census	total harvest	census[1/]	total harvest	census	total harvest
1952	---				3,356	
1953	2,142				3,844	294
1954	1,692				2,922	---
1955	2,576				4,600	586
1956	2,050				5,500	807
1957	1,564	160			7,302	774
1958	1,568	126			8,963	865
1959	722	No hunt			9,186	1,307
1960	1,979	159			8,740	1,572
1961	2,923	239			12,017	1,807
1962	2,936	269			9,037	1,699
1963	3,252	441	1,621	286	8,074	1,005
1964	2,116	257	1,157	187	4,963	231
1965	3,024	342	910[2/]	41	6,259	449
1966	1,867	236	1,699	103	5,630	469
1967	2,322	225	1,512	248	10,595	723
1968	3,162	295	2,276	74	9,618	799
1969	2,656	239	2,085	84	10,468	768
1970	2,099	209	2,251	77	8,661	610
1971	2,438	220	2,502	93	8,998	634
1972	3,230	242	2,860	90	11,108	742
1973	3,215	256	2,574	67	13,573	861
1974	1,940	65	1,781	23	5,767	257
1975	3,101	223	1,717	26	9,043	328
1976	1,884	158	1,857	150	6,808	373

1/ Adult

2/ Incomplete

of the animals, poor range condition and mechanical habitat alteration through root-plowing over large areas. In addition, Hurricane "Beulah" hit the Texas coast in 1967 completely inundating the antelope habitat on the King ranch with water. The mortality caused by this storm was not assessed but pronghorn numbers in the area were severely depleted. Since 1969 pronghorn in south Texas have been on a continuous decline and all that was left in the area by 1976 was a small herd of 51 animals in Jim Hogg County (Davis pers. comm.).

In central Texas the transplant program was even more of a failure. Some of the transplanted herds showed an initial increase in numbers before declining and eventually disappearing altogether, others went downhill from the time of introduction. Apart from a transplant near Wichita Falls in north central Texas, by 1976 only a single animal was located on transplanted former range and this was not expected to survive through winter.

The eastern limits of pronghorn range in Texas in 1976 had fallen back to approximately those of the 1924 distribution and the only range gain achieved by the transplant program was a small area of the northern Rolling Plains along the Oklahoma border. During this period, however, a large part of the South Plains was taken over by agriculture, and crop farming claimed further acreages in the Rolling Plains. The 1976 distribution of Texas pronghorn showed an additional loss of 37 percent in the past 30 years, with an accumulative loss of 74 percent of the original pronghorn range in Texas (Figure 3).

The major factor affecting pronghorn distribution during this time period was undoubtedly human utilization of the land's resources. With an overall increase in the population of the United States there was a

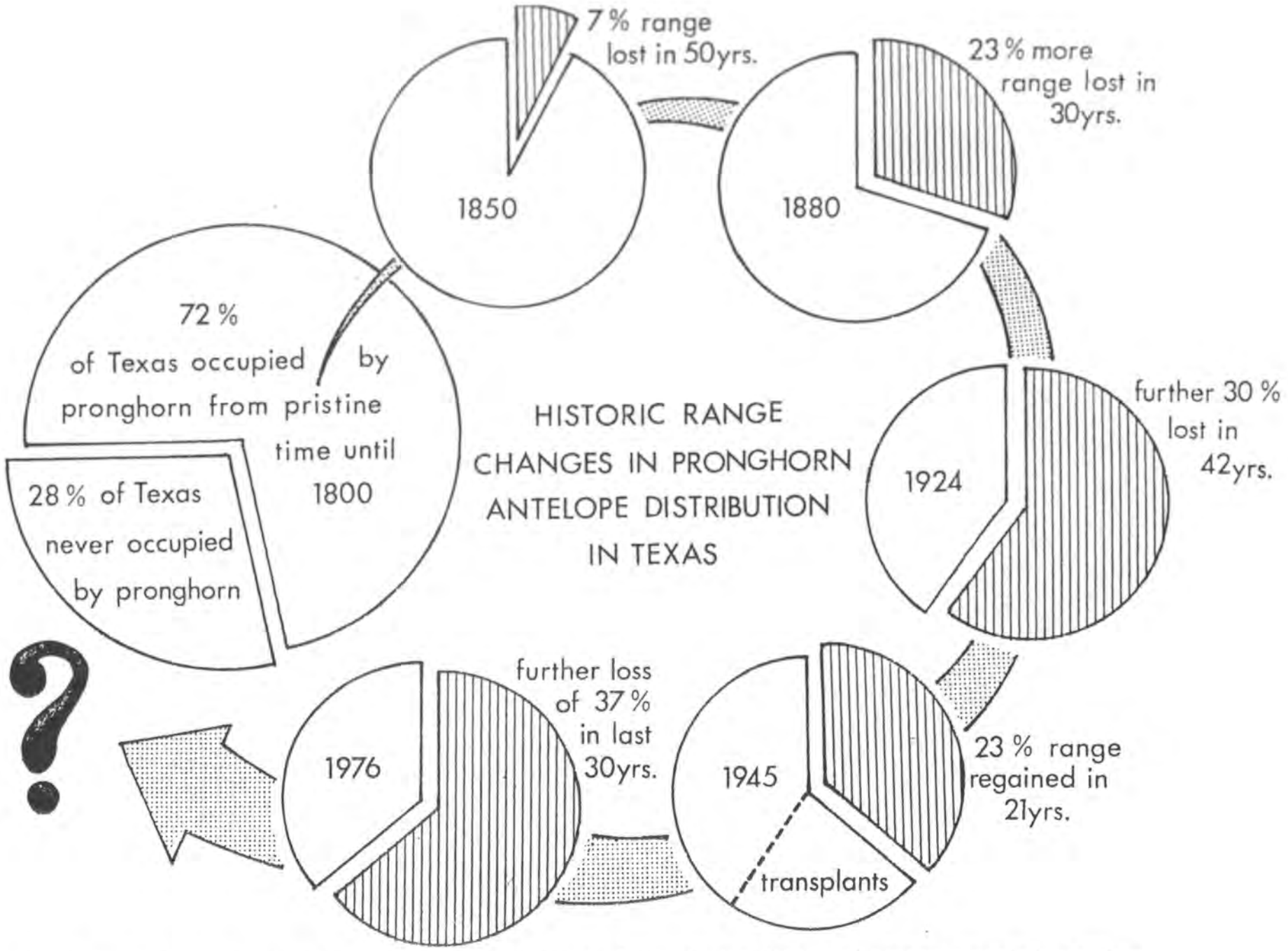

Figure 3. Relative proportions of pronghorn range in Texas during different historic periods to show the original range and subsequent changes through time.

higher demand for food and fiber products from the agricultural industry. This in turn increased the agricultural efforts toward intensified production which resulted in several detrimental pressures on pronghorn (Leftwich and Simpson 1978b). In addition to agricultural use of the land, the discovery and development of the oil fields in west Texas further disrupted the already delicate balance between animal and environment. The constant movement and use of heavy equipment combined with the waste bi-products of oil field development had a severe disturbance and displacement effect on pronghorn, while the network of roads between oil wells opened up large areas of hitherto unbroken country to illegal antelope hunting and harassment. Finally, another effect of human land use patterns was seen in the spread and increase of the now ubiquitous coyote (*Canis latrans*). The high incidence of fawn predation by coyotes is thought to be a leading factor depressing antelope populations throughout west Texas (Hailey 1976).

Environmental conditions also affected pronghorn in west Texas during this period, with drought being the most important single factor. The prolonged drought of the 1950's helped keep pronghorn populations at low levels, particularly in the Trans-Pecos area. Another drought in the early 1960's also caused a decrease in pronghorn numbers. Between June 1964 and June 1965 antelope in portions of the Trans-Pecos suffered 65 percent mortality due to malnutrition and tarbush (*Flourensia cernua*) poisoning (Hailey et al. 1966). In another portion of this region, mortality rates as high as 82 percent were recorded between June 1967 and June 1968 as a result of starvation. In 1967 large areas of the Trans-Pecos received little summer and fall precipitation and no winter moisture; investigation showed there was a critical shortage of vegetation available to the prong-

horn (Hailey 1976). In the Panhandle of Texas an estimated 700-800 pronghorn died during the early part of 1959 due to severe blizzard conditions, while a severe hailstorm in 1969 caused high fawn mortality in Borden County on the Rolling Plains (Hailey 1976).

Regulated hunting was reopened as pronghorn populations built up in different parts of the state, in 1944 in the Trans-Pecos, in the Panhandle in 1953 and in the Permian Basin in 1961. Due to population fluctuations in both the Trans-Pecos and the Panhandle regions, however, hunting seasons have had to be closed following bad years. Strict enforcement of hunting regulations and careful husbandry of pronghorn by landowners ensured that legal hunting was no longer a threat to continued pronghorn survival during the last 30 years. The effect of illegal hunting in the Trans-Pecos and the Panhandle was not considered a significant limiting factor on herds in these areas, but Hailey (1976) suggested that although there are no accurate figures available, illegal hunting of pronghorn in the oil fields of the Permian Basin may have limited numbers in this region.

CONCLUSIONS

The decline in the distribution of the pronghorn in Texas can clearly be attributed to the activities of man in his settlement and exploitation of the state. No single factor has been responsible for the extirpation of the pronghorn from three-quarters of its former range, but rather this was due to multifactorial pressures on both the animal and its environment. The changes brought about in the habitat of pronghorn by the introduction of domestic stock have put considerable competitive pressure on the species where they still exist (Leftwich and Simpson 1978b). The almost total failure of the transplant attempts to reestablish pronghorn

on their former range showed that the answer to management does not lie simply in the careful husbandry of remaining pronghorn herds. The suggestion by Leftwich (1977), Leftwich and Simpson (1978a) and Hailey (pers. comm.) that there are more pronghorn in the Trans-Pecos region of Texas than there ever were in pristine time due to the increased availability of surface water shows that management is not an impossible task. Leftwich (1977) has established some of the factors associated with the decline and disappearance of pronghorn from its former range. Using these factors to indicate areas for further research, we should be able to evaluate both the qualitative and quantitative requirements in pronghorn biology. Once these requirements are understood, management methodology can be initiated to integrate these to agricultural practices toward the survival of pronghorn within the present land use system in Texas.

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COMMENTS AND QUESTIONS

WISHART: What about the long term climatic changes that took place in your state? We had what we called the little ice age in this country, and then during the late part of the 90's we went into a warm spell. In other words, it seems that everything almost in

western North America seems to have just surged ahead and I'm wondering if we're not looking at climatic influence.

SIMPSON: Okay, this is some of the follow-up work we're doing on this. We're looking at weather, we're trying to document actual years of blizzards and of droughts. We want to look at the overall changes in the climatic situation, the local weather situation, etc.

WISHART: Weather on the short term, climate on the long term?

SIMPSON: You're looking into the geological form?

WISHART: It would be just a matter of one or two degrees, apparently.

SIMPSON: Okay; prior to 1590 there is no record. Before 1590 nobody took temperature readings. That's the problem, Bill.

USE OF REMOTE SENSING TO CLASSIFY ANTELOPE RANGE[1]

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Abstract: Pronghorn antelope (*Antilocapra americana*) were reestablished in Kansas in 1965 by the Kansas Fish and Game Commission (KF & G). Wild trapped antelope were obtained from Montana and Wyoming and released in the northwest (Sherman-Wallace Counties) and south central (Barber County) portions of the state. Current winter surveys estimate the populations in the northwest to be 1,000 animals with 50-100 in south central Kansas. As aesthetic and hunter demands for pronghorn antelope increase, the KF & G assumes the responsibility of establishing new herds. Sequential Landsat imagery can provide a useful tool for wildlife managers when evaluating and monitoring land use change in a rangeland environment. Landsat imagery and small-scaled aerial photography were used to monitor three potential pronghorn antelope release sites in Kansas. To insure maximum habitat conditions, data on total acres of land converted to agricultural use from rangeland were mapped for the period 1972 through 1976. Implications of land use change and its effect on pronghorn antelope populations and habitat are discussed.

Pronghorn antelope once flourished on the Kansas prairies. But as their native habitat declined, giving way to agricultural production, their numbers dwindled and the pronghorn populations were reduced to a few remnant herds located in isolated areas of the state. Although

[1]Paper presented by T. Funk, Kansas Fish and Game Commission, Hays, Kansas

commonly referred to as an antelope, the pronghorn is a member of a separate family, *Antilocapridae*. Found only in North America, they are the continent's swiftest mammal capable of speeds approaching 97 km (60 mi.) per hour. It has a deer-like build and averages between 45 and 64 kg (100 and 140 lbs.) in size as a mature adult. Both sexes have white rump patches which they flash when startled or in danger. The pronghorn is unique in several other respects. It is the only horned animal that sheds its horns, although it retains a core, and is the only horned animal with branched or prong horns, from which its name is derived. To some degree, they have a beneficial effect on that rangeland that is also used for cattle grazing. Pronghorn eat many types of vegetation eschewed by cattle such as sagebrush, forbs and cacti, thereby creating a better vegetation balance for cattle grazing purposes.

Kansas Fish and Game Commission's first successful pronghorn transplant was in 1964 when 75 animals from the National Bison Range in western Montana were released in Wallace and Sherman Counties in extreme northwest Kansas (Figure 1). Another 61 antelope were trapped in Colorado 2 months later and released in Barber County in the south central part of the state (Figure 1).

Pronghorns tend to congregate into herds of 25 to 30 pronghorns during the winter months, making population counts easier to acquire by aerial surveys. Pronghorn numbers in northwest Kansas are estimated to be 1,100 as of January 1977. This population's habitat includes about 101,215 ha (250,000 acres) of contiguous rangeland located along the Smoky Hill River. Since 1969 the herd has been increasing at over 20 percent annually. Barber and Comanche Counties have an estimated 50 to 100 pronghorns in its region of the state. The population estimates

in this area are hindered due to the rugged terrain.

Pronghorn in Kansas are associated with large tracts of rangeland containing scattered fields of cropland. There are few remaining areas in Kansas that can support large herds (50 or more) of pronghorn. Morton County is extreme southwest Kansas-Cimarron National Grasslands; Barber, Kiowa, Comanche and Clark Counties in the south central part of the state; Gove, Eastern Logan, Trego Counties adjacent to the existing northwest herds; Lincoln, Saline and Ellsworth Counties in central Kansas and the Flint Hills in eastern Kansas are the only remaining habitat that may support pronghorn populations (Figure 1). The future of Kansas pronghorn depends on the ability of the pronghorn to expand into and adapt to these new habitat regions. Because of the dramatic increase of pronghorn herds since 1964, hunting of this animal was permitted for the first time in 1974. Response to this hunting opportunity was great as about 500 requests were received for the 80 permits issued. These requests plus the success of the established herds, prompted KF & G to consider the possibility of stocking other areas of Kansas with pronghorns.

METHODS

In August 1977 the Kansas Fish and Game Commission contacted the University of Kansas Applied Remote Sensing Program (KARS) to evaluate the possibility of using remote sensing data in determining pronghorn habitat conditions in Kansas. Subsequently, KARS staff and KF & G personnel analyzed the pronghorn habitat sites using the Kansas Land Use Patterns map prepared by KARS in 1974 and current KF & G field data. A plan was approved by KF & G to involve the capture of 100 pronghorn in Wyoming and subsequent releases of 50 animals each in two selected re-

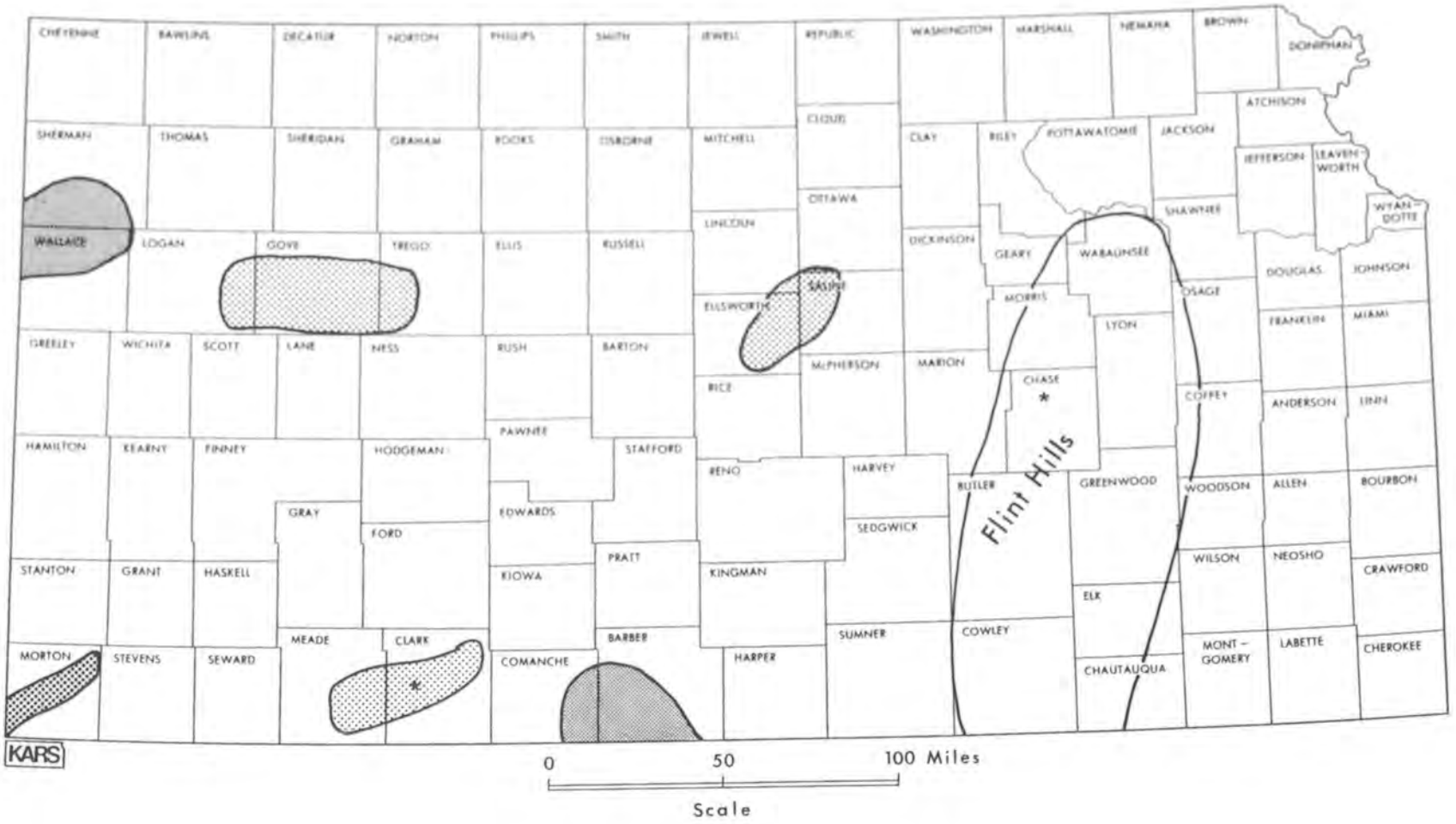

Figure 1.

Current Pronghorn Habitat in Kansas
and Selected Study Areas

* Selected Release Sites

lease areas in Kansas. A list of five potential release sites were established: (1) Clark County area, (2) Morton County, (3) Gove County area, (4) Flint Hills region and (5) Ellsworth County area (Figure 1). Since pronghorn require large expanses of rangeland, with few man-made barriers (agricultural land, highways, urban areas, etc.), the Flint Hills region in east central Kansas was selected for one of two release sites of 50 pronghorn. KF & G personnel selected three other potential release sites based on proximity to the established 1964 herds and field observations. Those sites included: (1) Logan, Gove, Trego County area, (2) Meade and Clark County area, and (3) Ellsworth, Saline and Lincoln County area.

Realizing that some 80 percent of the land cover in Kansas is used for agriculture, KF & G personnel were interested in mapping increases of agricultural land into rangeland in the three study sites. KARS personnel suggested that Landsat satellite photography for 1972 through 1976 would provide information on agricultural trends for the three sites.

Landsat imagery was acquired for the three potential release sites in a 1:500,000 black and white print format. Imagery between May and September of the years 1972 through 1976 were used to interpret agriculture encroachment onto rangeland. Four Landsat images were interpreted for each year. Statistical data were provided to the KF & G personnel for evaluation in selecting the final release site (Table 1). Available ASCS and SCS aerial photography were used as ground truth as well as current field surveys prepared by KF & G.

Table 1. Data from Landsat imagery used to evaluate potential pronghorn stocking sites.

MEADE-CLARK COUNTY AREA

	Study Area	233,561 ha (577,128 acres)
1972	Agriculture	88,648 ha (219,050 acres)
	Rangeland	144,912 ha (358,078 acres)

Rangeland Converted to Agricultural Land		Percent Change
1973	1,071 ha (2,647 acres)	.7
1974	2,930 ha (7,239 acres)	2.0
1975	1,134 ha (2,802 acres)	.8
1976	1,512 ha (3,736 acres)	1.0

ELLSWORTH-SALINE-LINCOLN AREA

	Study Area	191,272 ha (472,633 acres)
1972	Agriculture	112,874 ha (278,911 acres)
	Rangeland	78,410 ha (192,752 acres)

Rangeland Converted to Agricultural Land		Percent Change
1973	1,481 ha (3,659 acres)	1.9
1974	1,638 ha (4,048 acres)	2.1
1975	1,827 ha (4,515 acres)	2.3
1976	977 ha (2,413 acres)	1.3

LOGAN-GOVE-TREGO COUNTY AREA

	Study Area	300,346 ha (742,155 acres)
1972	Agriculture	163,341 ha (403,616 acres)
	Rangeland	137,005 ha (338,539 acres)

Rangeland Converted to Agricultural Land		Percent Change
1973	31,030 ha (76,675 acres)	22.7
1974	6,773 ha (16,736 acres)	5.0
1975	5,482 ha (13,545 acres)	4.0
1976	6,962 ha (17,203 acres)	5.1

Data obtained from Landsat showed interesting and alarming results. This analysis of the Landsat data provided the KF & G with current agricultural trends on each of the three areas. Of particular importance

was the data on the Gove County area. Based upon its location and general area the KF & G had anticipated that this area would be selected as the second release site. The Landsat analysis showed that the Gove County area had experienced approximately a 37 percent decline in rangeland over the 5 year period between 1972 and 1976. This was judged to be unacceptable by KF & G officials. Selection of the final release went to the Meade-Clark County area which featured an average annual loss of rangeland of only 1 percent.

In January 1978 KF & G personnel secured permission from the state of Wyoming to trap excess pronghorn populations in that state. A total of 100 antelope were taken and returned to the Kansas release sites with 63 of the pronghorn going to the Clark County site. The remaining 37 pronghorns were released at the Flint Hills location. KF & G officials have recommended that the KARS program be awarded funds to continue monitoring the pronghorn habitat sites every 3 to 5 years and to conduct a similar study on the present pronghorn range in Wallace and Sherman Counties in northwest Kansas. Pronghorn may eventually be introduced into other areas when determined suitable by KF & G personnel. Through the cooperative efforts of KARS and KF & G, Landsat satellite photography is making a continuing contribution to the renaissance of this unique North American big game animal in Kansas.

ACKNOWLEDGEMENTS

This project was supported by a grant to the University of Kansas from the National Aeronautics and Space Administration (NASA) University Affairs Office. I am grateful to Kent Montei, Bill Hanzlick, Bill Peabody and Terry Funk whose cooperation and evaluation made this study possible.

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COMMENTS AND QUESTIONS

STUBBS: I was wondering if you have any indication of public versus private land?

FUNK: Okay; the areas we considered were all public grounds, and if we can get the lights off again I'll go back to the state map that we have here and show you where our public lands are. We just don't have any public lands in the prime antelope range. In the very southwest corner of the state there are some public grounds there. Other than that our public grounds are strung out through the state. The majority of them are east of this easternmost line of our prime antelope range or what we feel is prime antelope range, and they are broken up in tracts of 2,000 to 4,000 acres. We just don't have any public ground available to stock antelope on. If we were able to acquire additional stocks this year we would put some in this area right here, and you can see that the expansive rangeland there is awful small. What we are afraid of is even though we go out of state and trap these antelope that they are going to have greener pasture over in Colorado and it's going to be a wasted effort. Another site that we are considering is a large expansive piece of rangeland where we have an existing population that we will bolster.

It amounts to about 30 antelope now. Ken Montei, who was in this position last, felt that once a herd of antelope reached 50 head the population would increase at a much more rapid rate. We will also go into this area here which is not really the most desirable, but if we are going to maintain our antelope herd in Kansas we've got to grab at every chance we've got. But there are just no public lands available for stocking.

QUESTION: Do you have any method of controlling land use either on private or on the public lands you have?

FUNK: We are hamstrung as all agencies are, I'm sure, especially with doing anything with use on private land. If I can relate to you one of the problems we are having right now in the sandsage prairie where we have a remnant flock of lesser prairie chickens. They are sinking wells for pivot irrigation so fast that that sandsage prairie is being eaten up. We have the authority to completely shut down the drilling for wells in order to save that remnant population of lesser prairie chickens, but at the same time as a commission if we do it then we've got every farmer in the state against us, and any other programs we try to implement on private lands are going to go down the drain because of 300 or 400 lesser prairie chickens. Yes, we do have the authority to stop them from breaking up that rangeland, but we can't do it.

TRACE MINERAL CONTENT OF ANTELOPE TISSUES[1]

M. J. STOSZEK, W. B. KESSLER and H. WILLMES, University of Idaho
Moscow, Idaho

Abstract: Liver samples collected from 55 pronghorn antelope (*Antilocapra americana*) in Pahsimeroi River, Little Lost River and Birch Creek drainages of eastern Idaho and from Bonhomme Ranch in Montana were analyzed by neutron activation technique for concentrations of iron, zinc, cobalt and selenium. Pronghorns from all three Idaho drainages had significantly lower ($P < .01$) mean concentrations of liver selenium and reduced zinc and cobalt levels when compared with Montana antelopes. Selenium deficiency of Idaho pronghorns can be one of the factors responsible for poor health and low survival rate of fawns in the study area.

Pronghorn antelope herds in Pahsimeroi River, Little Lost River and Birch Creek drainages of eastern Idaho have lower fawn survival than herds in nearby Montana. Necropsy of dead fawns often reveals changes similar to those found in calves with "weak calf syndrome". This syndrome, frequently found in the study area, is characterized by a general weakness of the newborn animal, absence of the suckling reflex, and difficulty in standing and walking. Edema and hemorrhages are found most often on the sternum and tarsus, together with dark bloody discoloration of synovial fluid and fibrin in the tarsal joint (Card et al. 1973). Secondary bacterial infections are often found shortly after birth.

The factors responsible for weak calf syndrome are not fully under-

[1]University of Idaho, Forest, Wildl. and Range Exp. Sta. Contribution No. 128.

stood. High intake of protein by pregnant cows somewhat decreased incidence of this syndrome (Bull et al. 1974), while cold stress during rearing of neonatal calves produced higher incidence of pathologic lesions (Bull et al. 1978). The possible effect of trace mineral deficiency or imbalance on the incidence of this condition in pronghorns received practically no attention.

MATERIAL AND METHODS

Tissue samples were collected in the fall of 1977 from 55 hunter killed pronghorns at Pahsimeroi River, Little Lost River and Birch Creek drainages of eastern Idaho, and at Bonhomme Ranch at the foothills of Crazy Mountains, some 48 km east of Bozeman, MT. The Montana herd, with good survival and apparently healthy animals, was selected as a control for "normal" mineral concentrations of antelope tissues. Samples of liver, muscle, heart, kidney and spleen, which were frozen, are being analyzed for concentration of iron, zinc, cobalt and selenium by neutron activation, and for copper by atomic absorption technique.

RESULTS AND DISCUSSION

The neutron activation analysis of all liver samples has been completed. The data are summarized in Table 1. All three Idaho herds had significantly lower ($P < .01$) mean concentrations of liver selenium when compared with Montana pronghorns. A similar, though less pronounced, trend appears in concentrations of liver zinc and cobalt.

Most essential trace minerals are needed to activate specific enzymes. Enzymes act as catalysts in chemical reactions occurring in the body. Each chemical reaction is catalyzed by only a few, or often only by one

enzyme. In the absence of active enzymes the reactions either proceed at a speed too slow to maintain life, or do not take place at all. Since normal metabolic processes consist of long sequences of individual chemical reactions, inadequate speed or actual blockage of a single reaction halts the whole metabolic sequence, creating a critical shortage at one end and a surplus of often toxic material at the other. Selenium is needed to activate the enzyme glutathione peroxidase. In selenium deficiency, accumulation of highly toxic peroxides leads to destruction of cell membranes (Underwood 1977). Low fertility, white muscle disease and general lack of health are frequently found in Se - deficient animals. Selenium levels found in pronghorn livers in Idaho can be considered deficient when compared to "normal" levels found in Montana pronghorns, and also when compared to similar normal levels of other animal species. In fact, individual pronghorns had liver selenium reduced to 0.2 ppm -- the level often found in selenium-deficient farm livestock suffering from clinical signs of white muscle disease (Underwood 1977). Zinc, cobalt, copper and iron levels will be evaluated after completion of laboratory analyses.

Table 1. Mineral concentration of pronghorn liver tissues in Montana and Idaho.

Location	Number of Animals	Mineral, ppm, dry basis						
		Se		Zn		Co		Fe
Montana	16	1.12[a]	100%	100.3	100%	.231	100%	364
Pahsimeroi River	17	.50[b]	45%	82.1	82%	.198	86%	332
Birch Creek	9	.56[b]	50%	83.9	84%	.188	81%	465
Little Lost River	13	.67[b]	59%	91.6	91%	.187	81%	329

[a,b]Means with unlike superscripts are different ($P < .01$)

The preliminary results of this study indicate that, compared to the Montana site, all three Idaho drainages are of inferior quality and do not supply pronghorns with adequate amounts of essential mineral nutrients. The resulting marginal to in some individuals, severe selenium deficiency could be directly responsible for poor health and low survival rate of pronghorns in the study area.

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COMMENTS AND QUESTIONS

FICHTER: Do you have any evidence that any or all of these minerals can vary in absolute amounts or in availability in response to either soil moisture and/or soil temperature?

STOSZEK: Definitely. Yes. The plant uptake of minerals from the soil

varies from year to year, from season to season and from plant to plant, so it is a well-known fact if you have a drought the plant usually does not absorb nearly as much mineral. In the livestock industry it is a well-known fact that they have to supplement more in some years.

FICHTER: In other words, there could be significant variations over relatively short periods of time, like 2 or 3 years?

STOSZEK: Shorter than that. It would be from year to year. You have to visualize most of these elements as being of rather short supply within the body. Each animal has an ability to store essential elements within his body. The organ where it is stored for most of them is the liver, with a few exceptions. In the case of selenium, you can deplete animal selenium in less than a month if you feed deficient forage.

QUESTION: Over how long a period did you take your samples?

STOSZEK: We took our samples only in the fall. This was fall when the season on antelope opened. It was practically opening day plus a day or two afterwards when we waited for hunters to bring in the animals and we sampled them.

QUESTION: How many falls?

STOSZEK: This was over one fall; last fall.

BAILEY: Would you care to comment on how much variation there might be among ruminent species and among various races, say strains of sheep or something like that, in terms of their susceptibility to mineral deficiencies?

STOSZEK: There is some variation. Unfortunately, this is really not known as well as I would like to see it. Some evidence from Australia,

however, was able to identify basically two or three genetic potentials in sheep for copper metabolism. One being tied to allele A could do with less copper than could an AB intermediate. So there is very strong evidence that differences do exist even within one animal species. I would not be myself surprised if you could have an animal for example that was adapted for generations to one area, then you capture it and move it to a different area, then it would not do as well there as the previous population that evolved there for a much longer period of time.

SUMMARY OF SOUTHWESTERN SASKATCHEWAN ANTELOPE STUDIES

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Fisheries and Wildlife Branch, Regina, Saskatchewan

Abstract: Pronghorn antelope (*Antilocapra americana*) were studied in Saskatchewan from 1968 to 1974. Antelope range was classified into five major land types; solonetzic soil, Coteau region, eroded benchland, sandhill and brown soil. Solonetzic soil land type constitutes less than 8 percent of the antelope range, but contains more than 20 percent of the antelope population. Nearly 72 percent of the antelope observations were made on native grass prairie habitat. Twenty-six wintering areas were identified and classified. Browse transects established on six wintering areas revealed 24 percent utilization on silver sagebrush (*Artemisia cana*). On two key wintering areas utilization was greater than 50 percent over a 3 year period. Browse utilization data indicated pronghorn numbers on winter ranges should be maintained at 25 to 37 antelope days per ha. During the study 383 animals were captured and permanently marked. Tagged animal observations revealed two distinct groups of antelope within the province; migratory and non-migratory. Of the tagged samples non-migratory animals moved an average distance of 24.8 km and migratory animals moved distances of 129 km to wintering areas in Montana and Alberta. The minimum area occupied by antelope based on three or more sightings was 177.7 km^2.

Prior to 1968 few antelope management or research studies had been

carried out in Saskatchewan. In view of the general lack of information on the ecology of antelope in Saskatchewan a 6 year research study was initiated in 1968. The primary objectives of the study were to investigate range use, locate and document wintering areas and determine status of migrant populations.

In 1972 Joe Hnatiuk, Research Ecologist who carried out the study, presented a preliminary report to the Antelope States Workshop which outlined some of the initial study results. The purpose of this paper is to update some of the study findings.

STUDY AREA

The study was carried out in the southwest portion of Saskatchewan and encompassed the entire antelope range (Figure 1). Dirschl (1963) described vegetation in representative portions of the southwest. Climate of southwestern Saskatchewan is semi-arid with low annual precipitation, high rates of evaporation, prolonged periods of drought and great extremes in temperatures between seasons. The mean annual precipitation is 35.56 cm and the mean annual temperature 5°C. Snowfall ranges from 76.2 cm to 89.6 cm.

METHODS AND MATERIALS

Range Classification

The antelope range in southwestern Saskatchewan was broadly categorized into range types based on soils, dominant vegetation and land use outlined by Dirschl (1960), Richard and Fung (1969), Coupland and Rowe (1969).

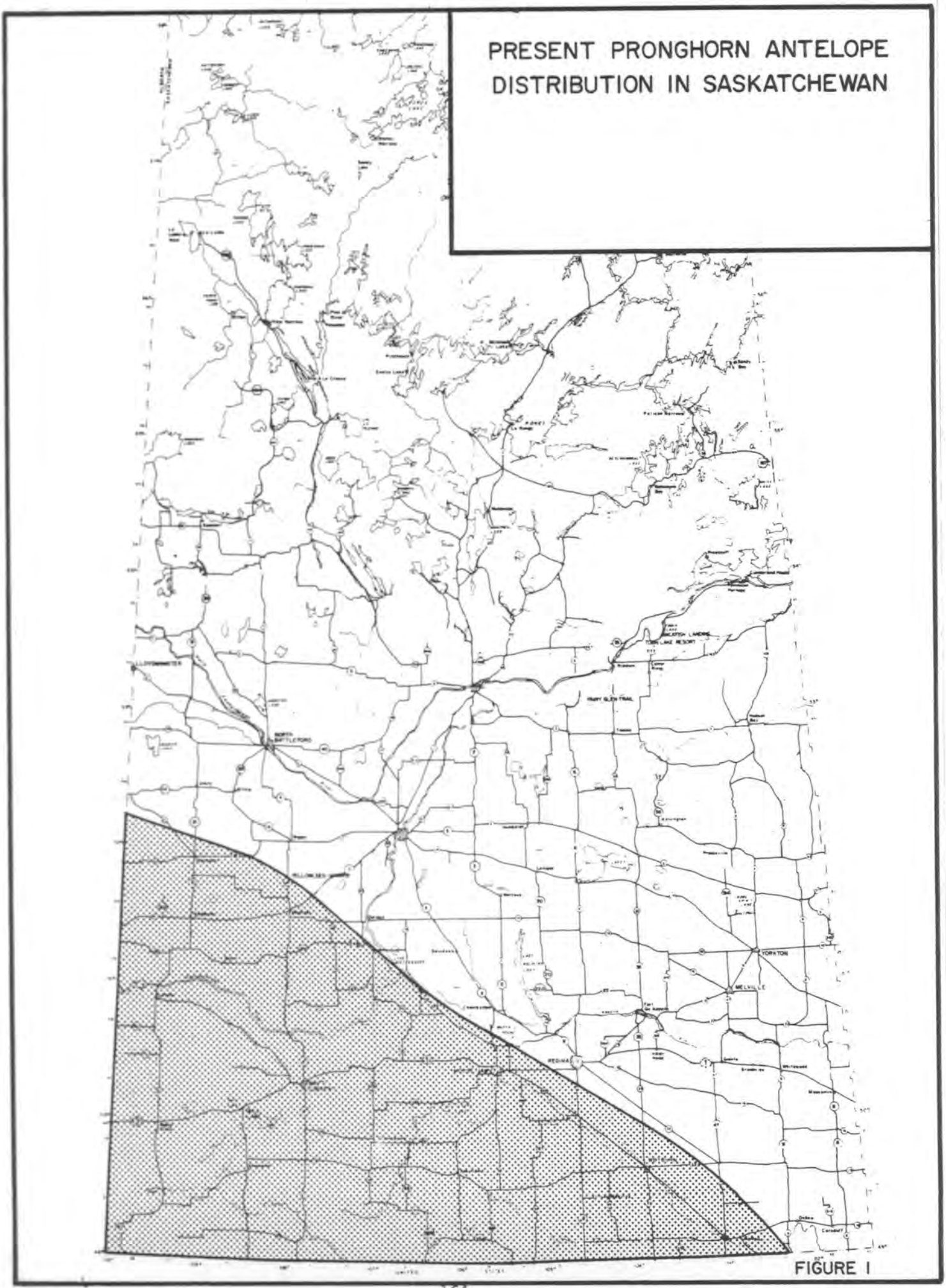

PRESENT PRONGHORN ANTELOPE
DISTRIBUTION IN SASKATCHEWAN
YORKTON
MELVILLE
REGINA

FIGURE 1

Pronghorn Distribution

Project personnel recorded number of animals observed and the habitat type on which they were seen. Density classes of shrubs were measured by the methods outlined by Daubenmire. Habitat requirements were determined by selecting 15 sample locations and calculating importance values of vegetative species.

Winter Range Classification

Aerial surveys were used to locate and classify antelope wintering areas and determine the total number of antelope using these areas. The procedure included both pre-determined and random flying throughout the antelope range during February and March.

Browse Utilization

To evaluate the extent of pronghorn use on sagebrush winter ranges permanent browse transects were established in six locations. Each transect consisted of 25 tagged plants that were selected on the basis of the closest plant technique. Browse use was recorded during October and April from 1969 to 1973 based on the method of Cole (1963).

Forage Production

The procedure outlined in the Bureau of Land Management 1968 manual was used to obtain forage production. Clippings were taken inside and outside two .405 ha enclosures from 1970 to 1972. Clipped material was separated into grasses, and sedges, forbs and individually identified browse species. The forage samples were oven dried to determine forage production.

Movement Studies

Two methods were used to capture and tag pronghorns in Saskatchewan.

A drive trap technique similar to that employed by Montana State Fish and Game Department was used to capture groups of antelope. The procedure outlined by Barrett (1973) was used to capture and tag newborn fawns. All animals were marked with ear tags and neck collars to facilitate individual identification.

Aerial and ground observations were conducted on an irregular basis on the study area. In all cases every effort was made to identify each marked animal, sex, location, habitat occupied, herd size and date of observation.

The map distance from capture site to observation site was determined to index minimum distance travelled. When three or more observations were made on a marked individual animal observation points were joined and the enclosed area was calculated to determine minimum area occupied.

RESULTS AND DISCUSSION

Characteristics of Range Types

The southwestern Saskatchewan antelope range is composed of five distinct range types (Figure 2). Solonetzic soils range type occupied about 7,801 km^2 or 8 percent of the total antelope range. Over a 4 year period our summer survey population data showed more than 30 percent of the southwest antelope population on solonetzic soils. The major portion of this range type is native grass prairie. Topography varies from gently undulating plain to pronounced eroded depressions or burn-out pits. Dominant native vegetation is spear grass, western wheat grass/blue grama habitat with silver sagebrush and greasewood (*Sarobatus vermiculatus*) situated on saline alluvial flats.

The eroded benchland range type comprises about 41,735 km^2 or 41 per-

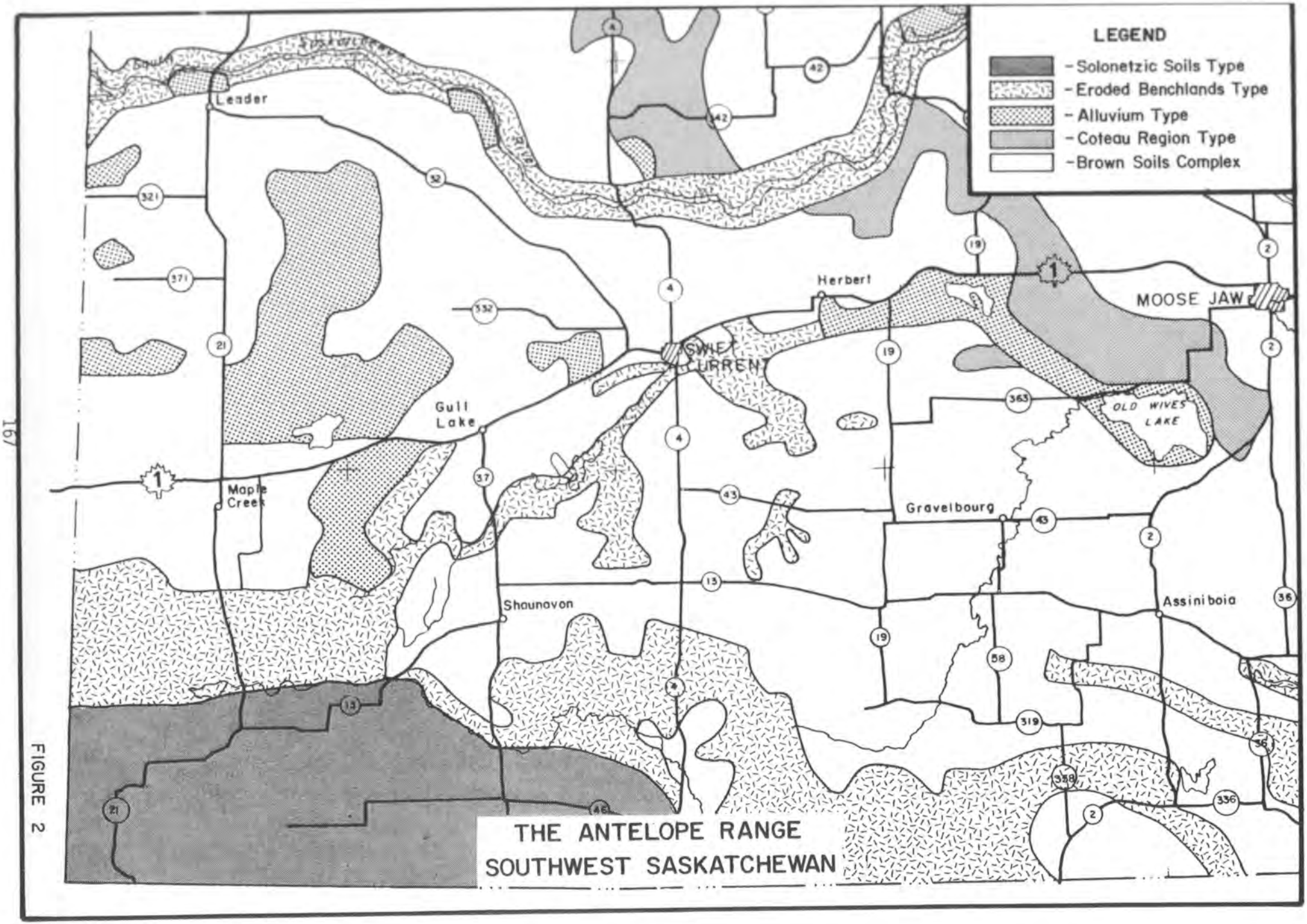

LEGEND
- Solonetzic Soils Type
- Eroded Benchlands Type
- Alluvium Type
- Coteau Region Type
- Brown Soils Complex
Leader
Herbert
MOOSE JAW
SWIFT CURRENT
Gull Lake
Maple Creek
Gravelbourg
OLD WIVES LAKE
Shaunavon
Assiniboia
THE ANTELOPE RANGE
SOUTHWEST SASKATCHEWAN

FIGURE 2

cent of the antelope range. Survey data indicates about 27 percent of the population utilize this range type. Eroded benchlands are primarily elevated plateaux dissected by valleys and coulees. Sagebrush grassland habitat is present on the steeper south facing slopes and the less alkaline soils in the valley bottoms. Sandhills range type comprises 1,756 km^2 or 2 percent of the total area. This range type is mostly fine to coarse alluvial sands reworked by wind into dune formations. Generally a transition zone of stable undifferentiated sands several miles wide separate the sand dunes and zonal soils. Dominant vegetation is grasses but sagebrush is abundant on elevated points and south and west facing slopes of the dunes. Antelope are primarily found in the transition zone. Survey data indicates about 16 percent of the population utilize sandhill range type.

Brown soils range type occupies 46,027 km^2 or 45 percent of the antelope range. Topography varies from level to hilly slopes. Majority of this range type is either disturbed land or farm land. Dominant vegetation on uncultivated lands is grasses with scattered patches of sagebrush. Although antelope densities are quite low about 21 percent of the southwest population is located on this range type. Coteau region range type comprises 4,680 km^2 or 4 percent of the total area. The Missouri Coteau forms the most important feature of this range. Topography is primarily moderately rolling to hilly. Native vegetation is predominately high moisture vegetation with extremely small quantities of drought resistant species such as sagebrush. Antelope densities are very low with about 6 percent of the population on this range type.

Pronghorn Distribution

Within the five major land types a visual habitat classification

based on antelope presence was made. The distribution of antelope in relation to various habitat types is presented in Table 1.

Table 1. Pronghorn distribution in relationship to habitat types in Saskatchewan (1969-1972).

Habitat Type	Pronghorns Observed	
	Percent	Total
Native Grass Prairie (N.G.P.)	17.0	1,537
N.G.P. - Rare *A. cana*	20.3	1,832
N.G.P. - Scattered *A. cana*	12.3	1,109
N.G.P. - Common *A. cana*	8.7	789
N.G.P. - Dense *A. cana*	1.7	153
N.G.P. - Mixed Shrub	7.9	716
N.G.P. - *A cana - Symphoricarpos*	4.4	396
Summerfallow	10.4	939
Tame Grass	5.8	524
Wheat Crops	3.4	312
Stubble	8.1	737
Total	100.0	9,044

Over 72 percent of all animals were observed on native grass prairie. Of that percentage, 55 percent of the animals were on sagebrush habitat. Barrett (1974) reported over 60 percent of the pronghorns observed during his study were on sagebrush vegetation type. Vegetative characteristics of antelope habitat are presented in Table 2.

Table 2. Importance values of vegetative types on three major antelope habitat types in southwest Saskatchewan.

Vegetative Types	Winter Habitat	Spring Fawning Habitat	Summer Habitat
Grasses and Sedges	77	84	103
Forbs	36	37	46
Cactus	45	25	56
Shrubs	93	70	51

Shrubs were the most important constituents of winter habitat. Sagebrush had the highest single importance value on winter habitat. Importance value for shrubs was lower in the fawning habitat than winter. Field observations indicated antelope selected fawning sites which had moderate amount of shrubs and forbs. Similar habitat conditions on fawning sites were noted by Barrett (1973).

Although grasses and sedges showed high summer importance value, forbs were the most frequent constituents of summer habitat. Dirschl (1962) and Mitchell and Smoliak (1971) indicated forbs comprised the most important part of antelope's summer diet.

Range Utilization

The majority of pronghorn winter ranges examined were not overbrowsed by antelope from 1969 to 1973. Although two winter ranges indicated extensive use over the study period, average winter utilization was 24.1 percent (Table 3). Barrett (1974) reported similar browse use on pronghorn winter ranges in Alberta.

Table 3. Utilization of *Artemisia cana* on permanent browse transects.

Location	No. of Transects	Winter of Use			
		1969-70	1970-71	1971-72	1972-73
Sask. Landing (East)	4	-	1.9	17.5	3.7
Sask. Landing (West)	4	-	14.7	29.9	5.8
Govenlock	2	13.4	75.3	51.0	-
Val Marie (Southeast)	2	-	2.0	6.7	5.8
Val Marie (Northwest)	4	13.4	6.8	11.8	7.0
Piapot Outside Excl.	12	67.9	84.3	57.4	6.4
Piapot Inside Excl.	2	-	43.6	29.7	3.3
Average Utilization 1969-1973 -- 24.1					

Sagebrush characteristics obtained from 28 permanent transects varied widely throughout the pronghorn range. The mean number of sagebrush plants intercepted per 60.96 m transect was 55.1. The average number of twigs per branch was 14.3 and the mean twig length was 69.6 mm. The average percent decadence per plant was 34.3 percent.

Forage production was measured over a 3 year period on the Piapot winter range. Average forage production was 995 kg of grass, 168 kg of forbs and 135 kg of browse per ha. Approximately 41 percent of all the browse production represented silver sagebrush.

Comparison of silver sagebrush production and number of antelope on the area and percent utilization indicated that sagebrush production was reduced when antelope days per ha reach 59.3. In 1970 silver sagebrush production was 296 kg per ha after 67.9 percent utilization while in 1971 after 84.3 percent utilization production dropped to 98 kg per ha.

The extreme heavy browsing during the 1970-71 winter of 84.3 percent or 59.5 antelope days per ha provided startling evidence of sagebrush over-utilization. Examination of the transects outside both exclosures indicated a reduction of silver sagebrush production from the average of 204 kg per ha in 1970 to 89.3 kg per ha in 1971. Average production within the exclosures remained relatively constant. Browse utilization inside the exclosures was 43.6 percent in 1970 and 29.7 percent in 1971.

The number of pronghorn days per ha in both years has been plotted against the percentage of silver sagebrush leaders utilized (Figure 3). Based on observations during the 1970-71 and 1971-72 winters, the maximum overwinter stocking rates should approximate 25 pronghorn days per ha. Barrett (1974) indicated Alberta winter ranges should not exceed 37 pronghorn days per ha.

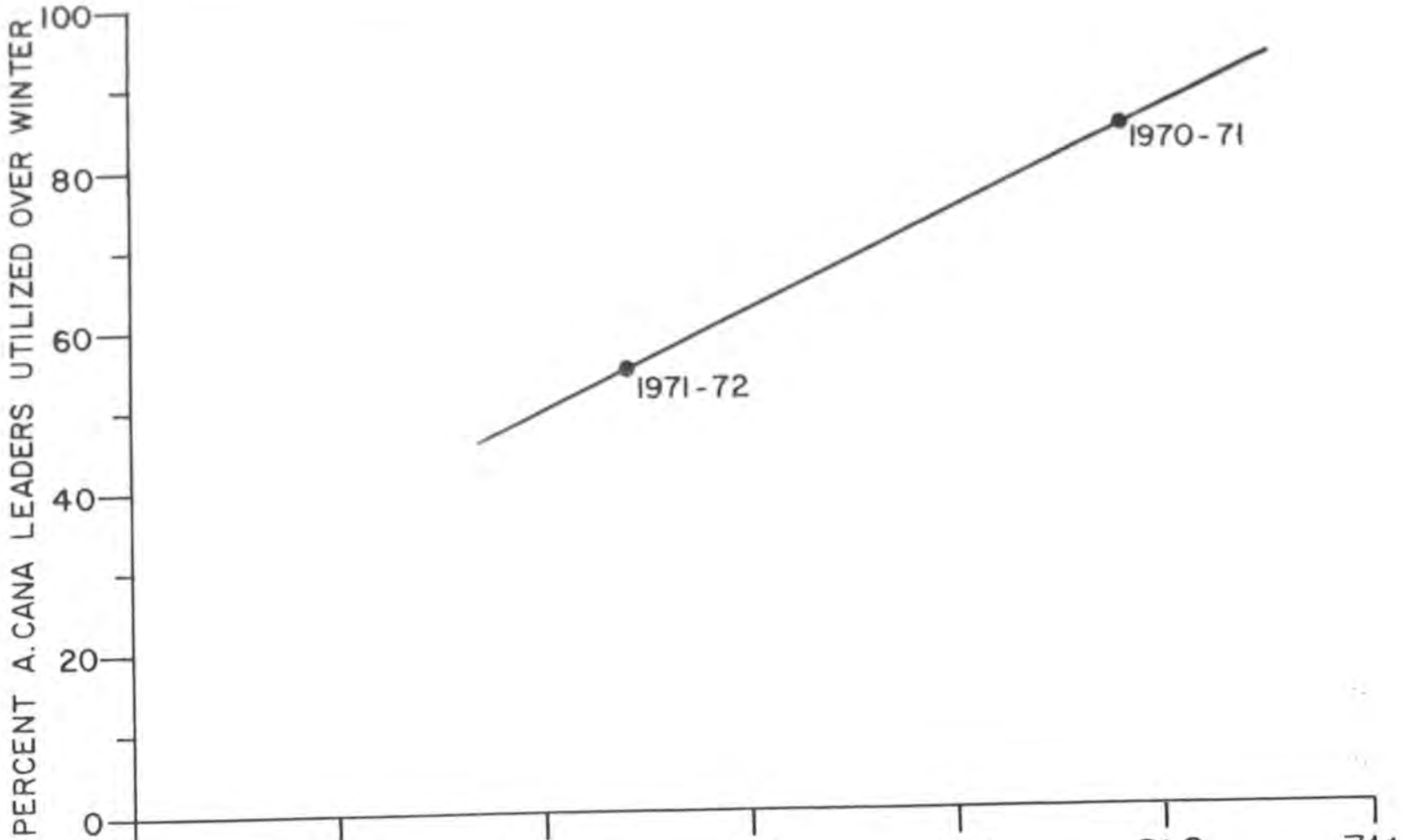


FIGURE 3

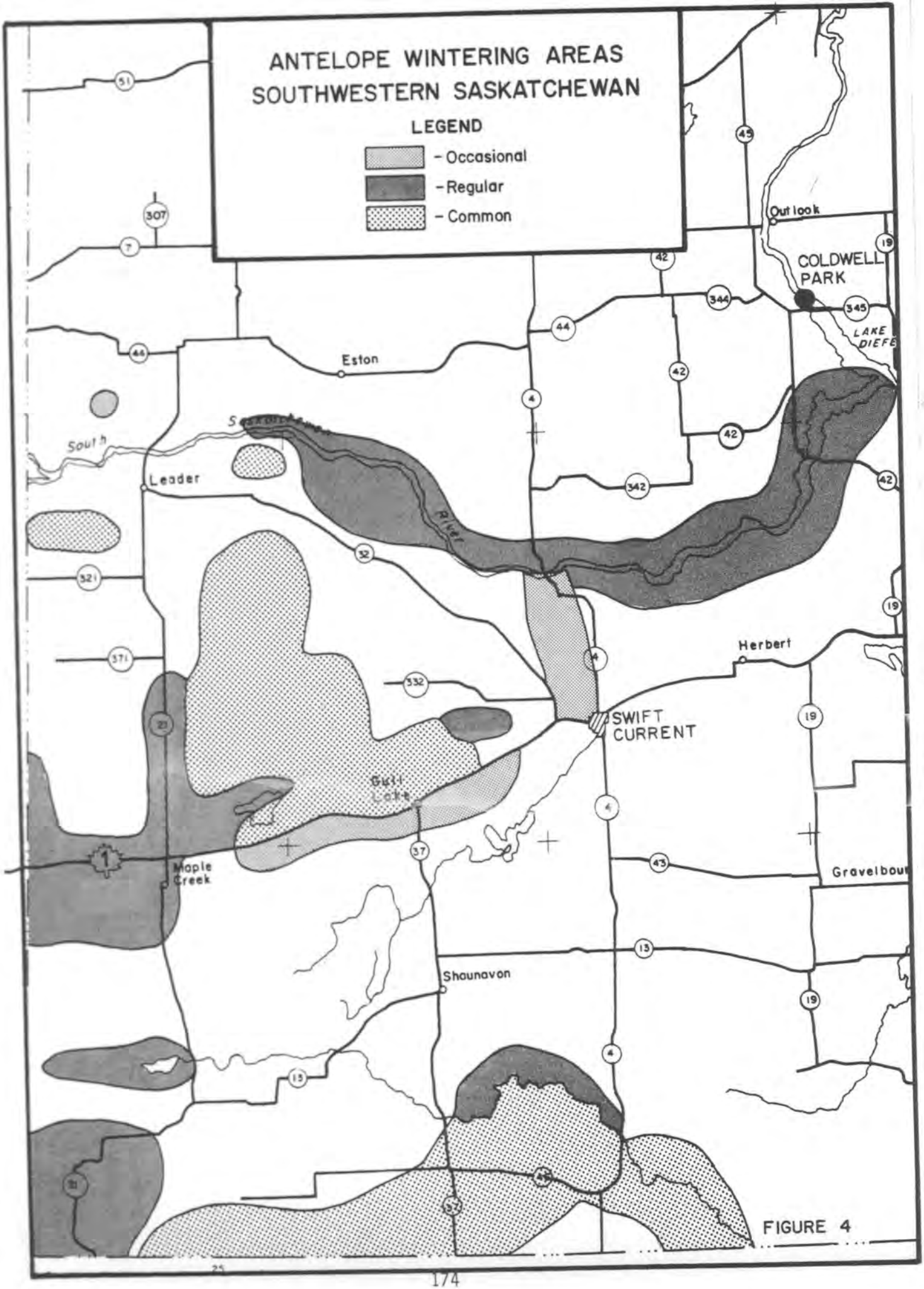
RELATIONSHIP OF PRONGHORN DAYS
PER HECTARE TO SAGEBRUSH UTILIZATION

Winter Range Classification

Winter habitat is very limited in southwest Saskatchewan. A total of 26 areas were identified as being used by antelope during the winter months. The various areas were divided into three categories (Figure 4). Regular winter areas were defined as areas used annually during the majority of the winter by large antelope concentrations. Areas classified as common were used during most winters for short time periods. Occasional areas were used for short durations and limited to one or two winters. Percent browse utilized was related to total antelope numbers and severity index (Table 4).

Table 4. Specific antelope winter census totals, severity index and percent browse utilized.

Location and Year of Census	Total Number Antelope	Severity Index	Percent Browse Utilized
Govenlock			
1970	249	1.49	61.1
1971	40+	2.07	75.3
1972	334	1.37	51.0
Piapot			
1970	168	1.49	70.6
1971	504	2.07	84.3
1972	260	1.37	64.2
Val Marie (Northwest)			
1970	300	1.49	13.4
1971	394	2.07	6.8
1972	400+	1.37	11.8
Val Marie (Southeast)			
1971	0	2.07	2.0
1972	12	1.37	6.7
Sask. Landing (East)			
1971	170	2.07	1.9
1972	203	1.37	17.5
Sask. Landing (West)			
1971	64	2.07	14.7
1972	0	1.37	29.9


ANTELOPE WINTERING AREAS
SOUTHWESTERN SASKATCHEWAN
LEGEND
- Occasional
- Regular
- Common
Outlook
COLDWELL PARK
LAKE DIEFE
Eston
South
Leader
River
Herbert
SWIFT CURRENT
Gull Lake
Maple Creek
Shaunavon
Gravelbour
FIGURE 4

Census data from the Govenlock area showed large variations in antelope numbers under different severity indices. On the Piapot range a direct relationship occurred between antelope numbers, browse utilization and severity index. Val Marie northwest area indicated consistently high animal concentration and low browse utilization with no relationship to winter severity index. Census data on Val Marie southeast range indicated low numbers of antelope and low browse utilization.

Migrations

Migration of antelope is extremely complex. Tagging results showed definite migration patterns. A total of 383 antelope were trapped and marked over a 7 year period (Table 5).

Table 5. Number of antelope trapped by both trapping techniques.

Year	Number Tagged And Released	Age Class	Sex		Male:Female Ratio
			Male	Female	
May - 1968	28	Fawns	13	15	0.87:1.00
May - 1969	29	Fawns	12	12	1.00:1.00
May - 1970	31	Fawns	14	17	0.82:1.00
Oct. - 1970	9	Fawns & Adults	6	3	2.00:1.00
Nov. - 1970	75	Fawns & Adults	31	44	0.70:1.00
Nov. - 1971	61	Fawns & Adults	32	29	1.10:1.00
May - 1972	12	Fawns	5	7	0.71:1.00
Dec. - 1972	52	Fawns & Adults	12	40	0.30:1.00
May - 1973	24	Fawns	12	12	1.00:1.00
May - 1974	62	Fawns	23	39	0.59:1.00
Total	383		160	223	0.72:1.00

Animals tagged in the Cypress Hills-Govenlock area showed significant movements. Of the 84 animals tagged in 1970 only 10 marked animal observations were made in the 65 km^2 trapping area from 1970 to 1973. Animals tagged from this area were sighted in southeast Alberta and near Big Sandy and Havre, Montana.

In 1971 and 1972 animals trapped near Crane Lake, north of Trans-Canada Highway, tended to remain within a definite area. Tagging results revealed two different groups of antelope within the province; migratory and non-migratory. Non-migratory antelope moved distances of 24 km to wintering areas. Tagged migratory antelope movements showed a definite migration corridor (Figure 5). The corridor extends from Maple Creek through Govenlock area and into Montana. The Frenchman River valley also acts as a corridor for animals moving to wintering ranges near Malta and Glasgow, Montana.

Tagging results indicate Saskatchewan antelope occupy large home ranges. The minimum area occupied by antelope was 177.7 km^2 (Table 6).

Table 6. Mean area occupied by antelope based on three or more sightings.

Group	Area Occupied (km^2)		
	Male	Female	Total
Spring - 1970	-	419.6	419.6
Fall - 1970	389.0	285.4	324.8
Fall - 1971	102.3	151.7	132.1
Fall - 1972	256.4	167.1	187.0
Spring - 1974	51.8	36.8	43.0
Mean	193.2	168.4	177.7

The need of Saskatchewan's antelope to travel more because of lack of suitable habitat and food at specific times of the year is probably the reason for larger home range.

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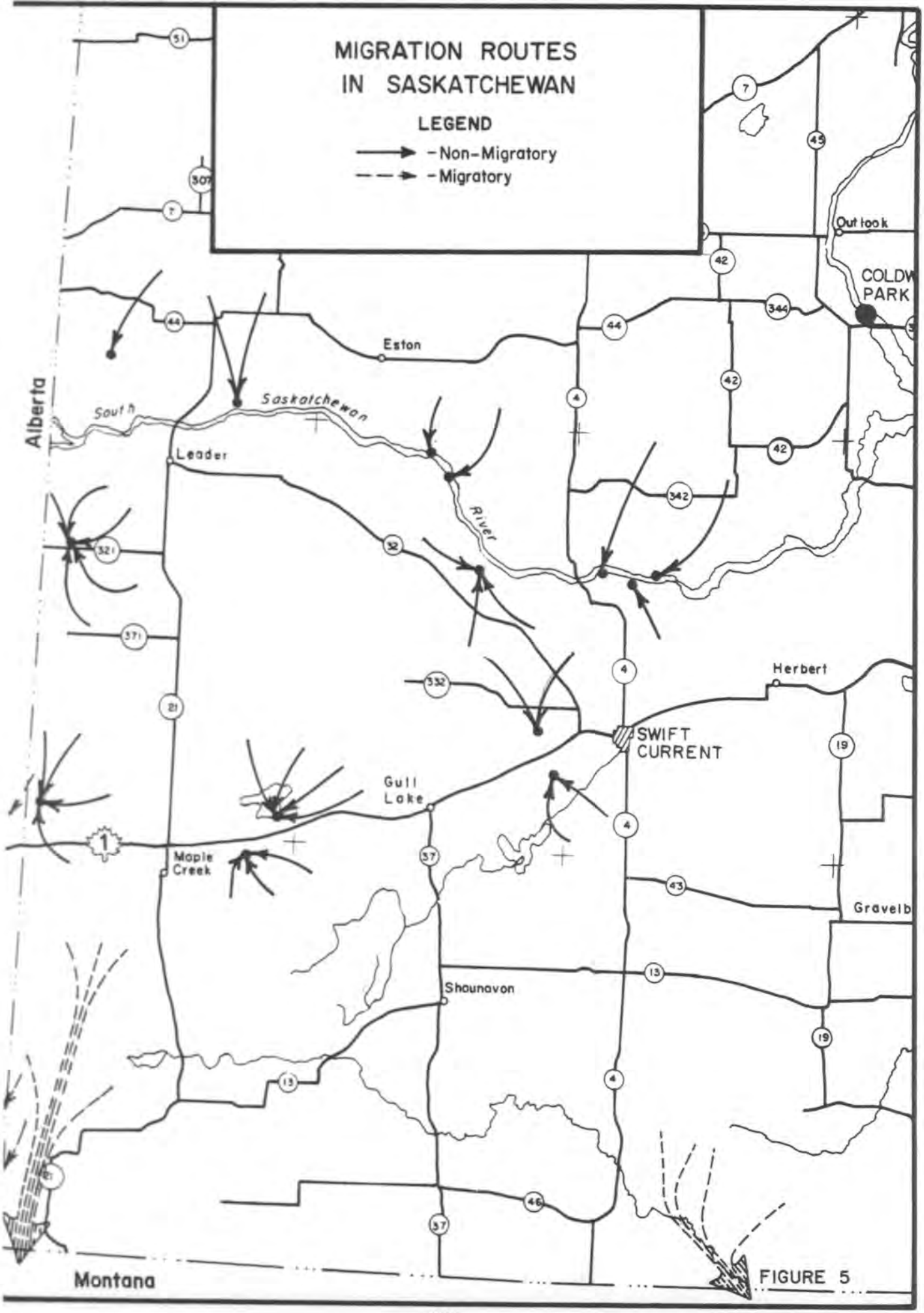
MIGRATION ROUTES
IN SASKATCHEWAN
LEGEND
-Non-Migratory
-Migratory
Alberta
Montana
South Saskatchewan River
Eston
Leader
Maple Creek
Gull Lake
SWIFT CURRENT
Herbert
Shaunavon
Outlook
COLDW PARK
Gravelb

FIGURE 5

Brooks, Alberta.

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COMMENTS AND QUESTIONS

AMSTRUP: Do you have any idea what kind of mortality you had putting

those terrible looking collars on those fawns?

WILTSE: No, not really; although there certainly was mortality with it, I know that. After fawning, I know I've run across three or four instances of fawn mortality, but I really couldn't put a handle on the exact numbers or anything.

AMSTRUP: Do you have any figures on how many of those fawns were subsequently observed at a later stage in growth?

WILTSE: Oh, yes. I couldn't give you the percentage but certainly I would say a large proportion of these fawns were observed at a later date.

BARRETT: Perhaps I can give a little information on this. We were also concerned, and we will get into this more tomorrow, about the probability of some marking increasing mortality. But in an enclosure situation where totally untractable pronghorns were monitored we did collar a sample and left approximately 60 percent of the fawns uncollared. The survival rate to 2 months of age was within 5-10 percent. So based on a relatively small sample size we do know that marking isn't going to devastate the population. I'm not really going to talk about this tomorrow so I'll provide some information off the top of my head here. I recall that approximately 25 percent of our visually marked free-ranging pronghorns were seen again. This is somewhat comparable to the survival rate, based on telemetry findings, which we will be talking about tomorrow. So I'm sure marking had an impact but perhaps less dramatic than the picture might indicate.

AMSTRUP: Was that using this collar?

BARRETT: Yes, the same type of situation.

AMSTRUP: What do you have for predator population?

BARRETT: We have a good representation.

FICHTER: I'm much delighted to hear some of the things you had to say and to see the pictures that add some dimension to our understanding that there is variation across the face of the land as regards many things that pronghorns do and the way they respond; and I'm particularly interested in habitat selection as you found it in parturient does, particularly the point that you made with an illustration on the screen that they were avoiding patches of heavy cover, heavy sagebrush cover. How many birth scenes have you witnessed, watched, from beginning to end?

WILTSE: I don't know. I really couldn't answer that. I don't think it has been documented in the study.

FICHTER: That is, you have not watched any birth scenes.

WILTSE: No, I haven't. I don't know whether the researcher that did this work watched any or not.

FICHTER: In Idaho we think we have to watch a birth scene to know what kind of habitat the doe chooses in which to give birth.

WILTSE: I can only say that we have come across fawns that are a matter of a few hours old and they certainly weren't in any areas with dense sagebrush.

FICHTER: I've known fawns to be moved more than half a mile before they were quite 4 hours old.

BRUNS: First of all, I'd like to give you a gold star for dusting off those data that Joe collected. Having spent several months in all the greasy spoons between Manyberries and Val Marie I can appreciate the randomness of the data you had to deal with. I would also question that business about birth site selection. I wonder if it

doesn't reflect more the search effort that was made than pronghorn behaviour. I suspect the kids were found on the bare ground because that's where most of the searching was done. Was there any weighting done at that data?

WILTSE: No, not really. I don't think there was any weighting done at all. It's possible that that was the reason for it, but generally we had divided the crews up into various areas and covered various habitat types, and the majority of the fawn capture sites were recorded in these types of areas.

GOOD: Did you notice any difference between either bucks or does in the distance they moved? In the migrating animals, did you notice any difference? Did bucks migrate further than does? Does your data show that?

WILTSE: Yes, the data did show greater movement of younger animals and males than females.

FACTORS INFLUENCING PRONGHORN USE OF PLAYAS IN SOUTH CENTRAL OREGON[1]

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Abstract: Pronghorn (*Antilocapra americana*) use of four playas (intermittent lakebeds) on Hart Mountain National Antelope Refuge (NAR) in south central Oregon was studied during the summers of 1974 and 1975. Percent canopy cover of playa vegetation, plant phenology, percent desiccated vegetation, soil moisture, available surface water and pronghorn use of range sites adjacent to playas were measured for each study area; the relationship between these parameters and pronghorn use of each lakebed was determined. A total of 14,316 pronghorn observations was recorded on the four playas during the two summers. Pronghorn observations totalled 4,510 on range sites adjacent to the playas. Desert Lake received significantly ($P < 0.01$) more pronghorn use than the other playas during 1974 and 1975. No significant differences in use existed among Dobyns, Long and Spanish Lakes during either study year. Pronghorns demonstrated a greater dependence on lakebeds during a dry year than during a wet year. The importance of succulent vegetation to pronghorns was reflected in the relationship between soil moisture and pronghorn use. Pronghorns indicated a strong preference for leafy arnica (*Arnica foliosa*), particularly at Desert Lake. Other forbs eaten by pronghorns were poverty sumpweed (*Iva axillaris*) and *Oenothera flava*. On Spanish Lake during the wet year,

[1]Portions of this study were financed by The National Rifle Association, Order of the Antelope and U. S. Fish and Wildlife Service.

1975, prostrate knotweed (*Polygonum aviculare*) was an important pronghorn food. Pronghorns terminated use of a lakebed if drinking water was unavailable, but the mere presence of water on a playa did not insure use.

As upland range sites, dominated by low sagebrush (*Artemisia arbuscula*), dried, pronghorn use of playas intensified throughout summer and early fall. Pronghorns appeared to prefer the Desert Lake study site because of the combination of habitat factors which the other three playa sites lacked.

Pronghorns require a variety of habitats for their essential life activities (Einarsen 1948, Buechner 1950, Mace 1954, Cole 1954). Campbell (1970) observed that pronghorn distribution was not random in relation to habitat type. Bayless (1969) found that in Montana a sagebrush-grassland type received the heaviest use in summer and winter.

Herrig (1974) recorded use of range sites by pronghorns in south central Oregon and found that certain range sites were used more than others by pronghorns and that juxtaposition of other range sites and available surface water were important factors in influencing use.

For 4 years while working at the Hart Mountain National Antelope Refuge, the senior author observed differential use of certain playas by pronghorns. No one had attempted to compare these differences quantitatively nor explain why these apparent differences in use occurred.

The objectives of this study were to determine if there were significant differences in use by pronghorns on four playas on Hart Mountain NAR, Oregon, and to determine how certain environmental factors affected pronghorn use of these lakebeds.

STUDY AREA

The south central and southeastern portions of Hart Mountain NAR served as the study area (Figure 1). The refuge includes spring, summer and fall pronghorn ranges.

Four playa (sites) were selected for study because of their location within the area utilized by the pronghorn population on the southern portion of the refuge: Desert Lake 211 ha, 1715 m elevation; Dobyns Lake 29 ha, 1723 m elevation; Long Lake 245 ha, 1778 m elevation; and Spanish Lake 180 ha, 1790 m elevation (Figure 1).

SAMPLING METHODS

Two summers of field research were completed: 7 July through 21 September 1974, and 22 June through 13 September 1975.

ENVIRONMENTAL FACTORS

Each study site was divided into two portions: the playa and range sites adjacent to the playa.

Vegetation Analysis of Playas

We defined playa as that portion of each lake bottom which in years of average precipitation was inundated by water in May and lacked Bolander silver sagebrush (*Artemisia cana bolanderi*), except for a few small, isolated plants.

Range sites, described by Cahoon (1970), were used for this study. Cahoon (1970) divided lake bottoms on Hart Mountain NAR into two range sites, 1) Intermittent Lake and 2) Lakebed. Condition classes for range sites were obtained from the U.S. Department of Agriculture (1967). Differences in species composition were not described for each playa, thus

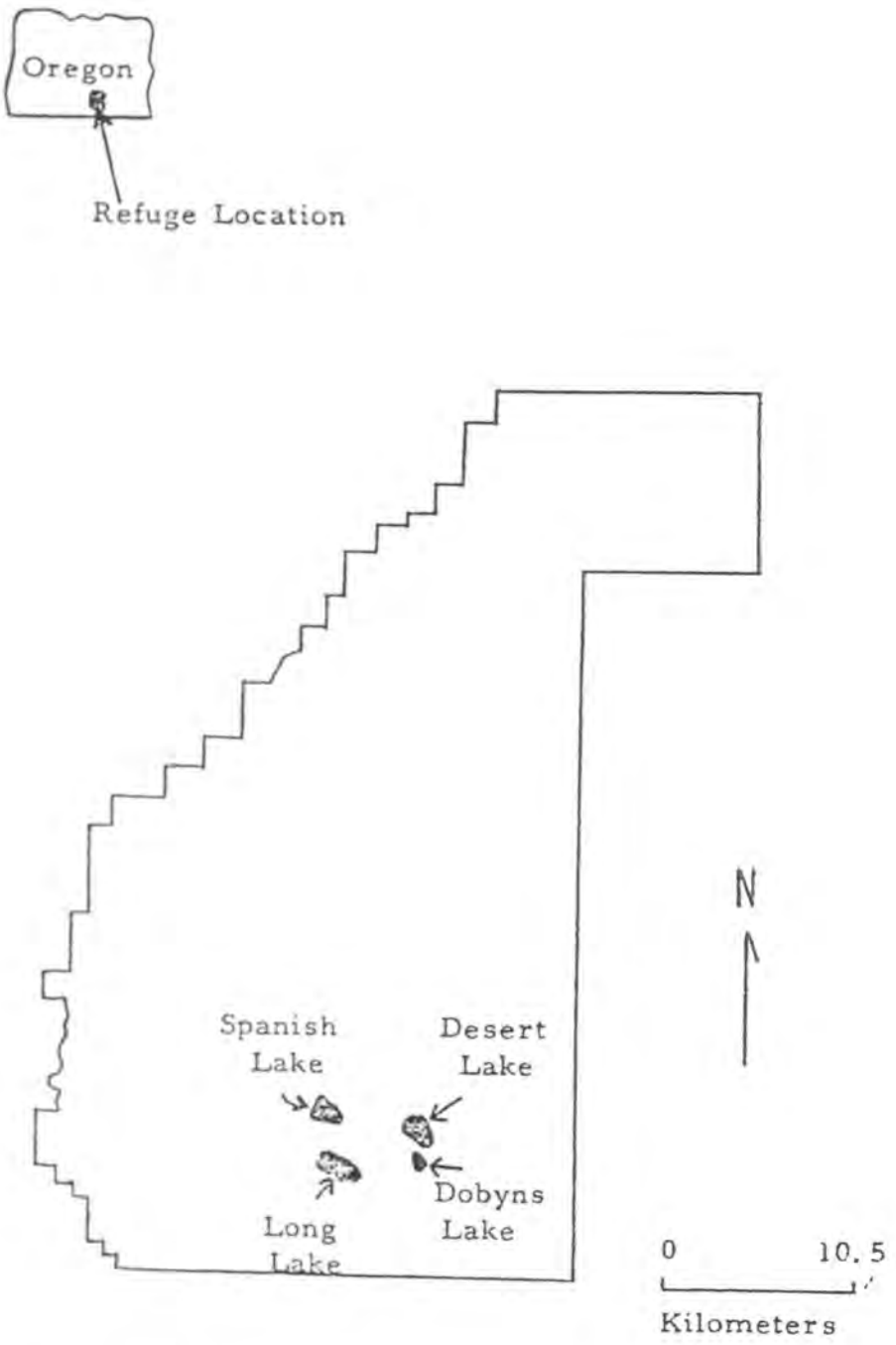


Figure 1. Location of study sites on Hart Mountain NAR.

plant communities were sampled to detect differences which existed within range sites. We delineated a plant community as a spatial and temporal organization of plants exhibiting observable differences in floristic composition and/or cover from adjacent or surrounding organizations of plants (Figures 2, 3, 4, 5).

On each playa, plant communities were sampled within a stand of vegetation which characterized that community; selection of sampling locations (macroplots) was subjective and was based on an initial reconnaissance of each playa.

Canopy coverage of vegetation was estimated by methods of Daubenmire (1959) and Poulton and Tisdale (1961). Percent frequency of species was determined by the method of Daubenmire (1970).

Range Sites Adjacent to Playas

We used the description of vegetation of Hart Mountain NAR (Cahoon 1970) to define adjacent range sites within 400 m of the edge of each playa.

Plant Phenology

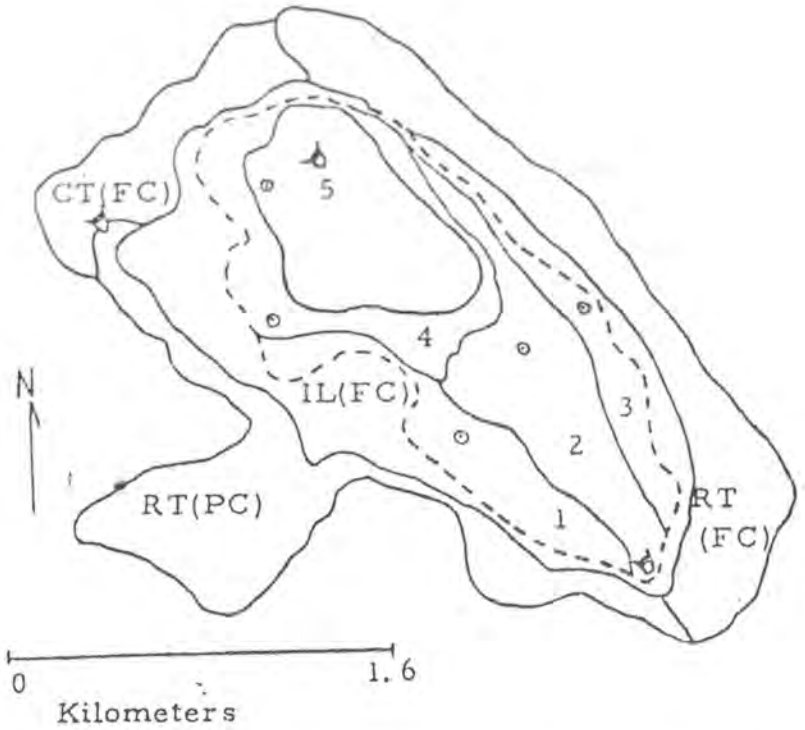
Phenological stages were divided into the following classes by plant types:

A. forbs and grasslike species, 1) early leaf growth, 2) flowering, 3) seed production, and 4) drying.

B. grasses, 1) growth initiation, 2) boot stage, 3) hard seed, 4) seed scatter, 5) summer dormancy, and 6) regreening leaves (West and Wein 1971).

Desiccated Vegetation

A visual estimate was made of the percent of the total vegetation



LEGEND

I. Playa vegetation
   A. Intermittent Lake range site communities:
      1. Eleocharis-Arnica-Muhlenbergia
      2. Eleocharis-Muhlenbergia-Iva
      3. Muhlenbergia-Eleocharis
   B. Lakebed range site communities:
      4. Eleocharis-Arnica
      5. Arnica-Eleocharis

II. Range sites adjacent to lakebed:
RT(PC) = Rocky Terrace (poor condition)
RT(FC) = Rocky Terrace (fair condition)
IL(FC) = Intermittent Lake (fair condition)
CT(FC) = Claypan Terrace (fair condition)

= Dugout (trench reservoir)

= Vegetation macroplot and soil moisture sampling locations

--- = Playa boundary

—— = Communities and range site boundaries

Figure 2. Playa range site plant communities and adjacent range sites at Desert Lake.

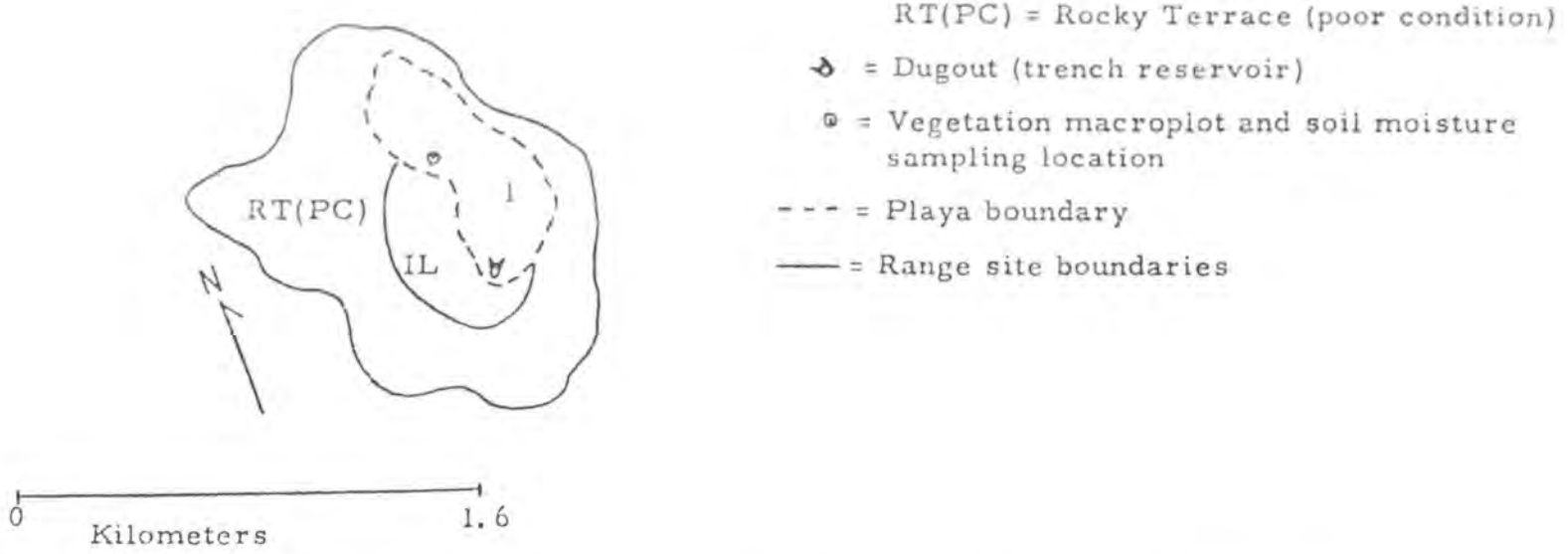
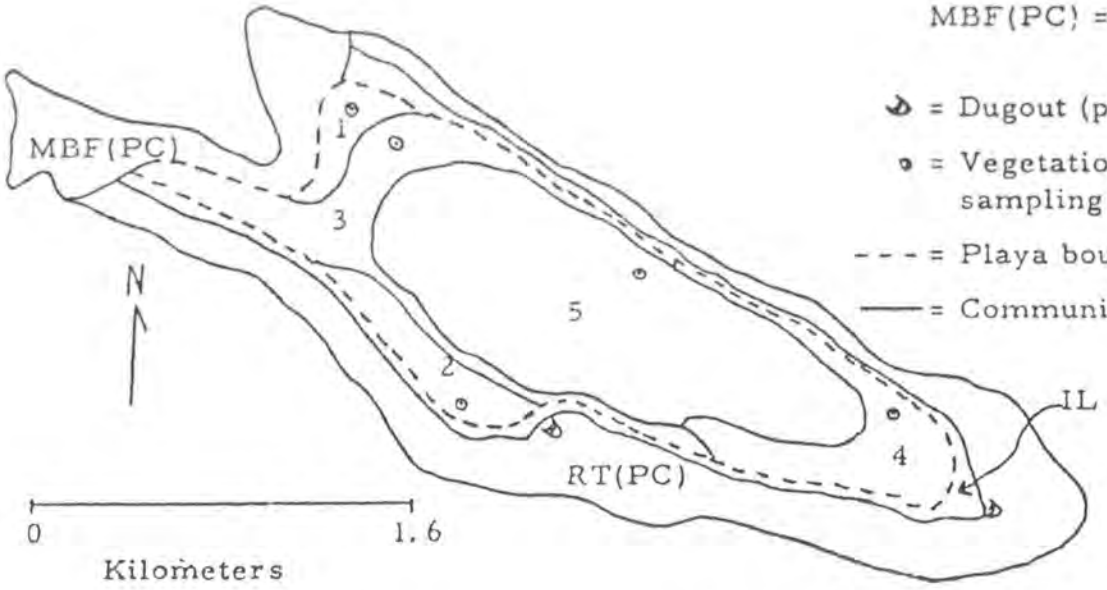


Figure 3. Playa range site plant community and adjacent range sites at Dobyns Lake.



LEGEND

I. Playa vegetation
   A. Lakebed range site communities:
      1. Eleocharis-Arnica-Polygonum
      2. Arnica-Eleocharis-Scirpus
      3. Eleocharis-Arnica
      4. Eleocharis-Arnica-Rumex
      5. Eleocharis

II. Range sites adjacent to Lakebed:
   IL = Intermittent Lake
   RT(PC) = Rocky Terrace (poor condition)
   MBF(PC) = Moist Bottomland Fan (poor condition)

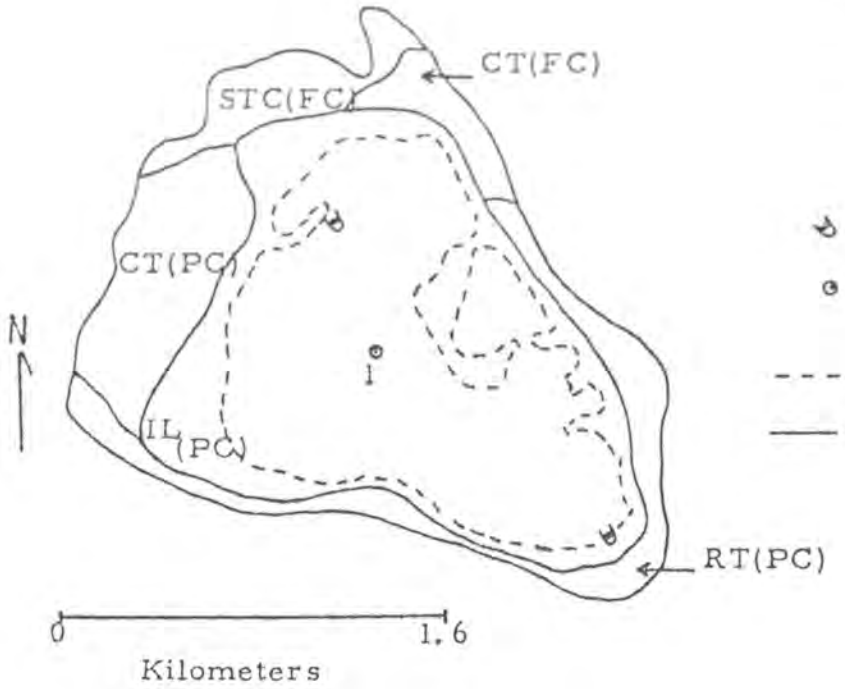
= Dugout (pit reservoir)

= Vegetation macroplot and soil moisture sampling locations

- - - = Playa boundary

—— = Communities and range site boundaries

Figure 4. Playa range site plant communities and adjacent range sites at Long Lake.



LEGEND

I. Playa vegetation
   A. Lakebed range site community:
      1. Eleocharis-Iva

II. Range sites adjacent to Lakebed
   IL(PC) = Intermittent Lake (poor condition)
   RT(PC) = Rocky Terrace (poor condition)
   CT(PC) = Claypan Terrace (poor condition)
   CT(FC) = Claypan Terrace (fair condition)
   STC(FC) = Shrubby Terrace Complex (fair condition)

= Dugout (trench reservoir)

= Vegetation macroplot and soil moisture sampling location

- - - = Playa boundary

—— = Range site boundaries

Figure 5. Playa range site plant community and adjacent range sites at Spanish Lake.

which was dried on each playa at the end of every weekly sampling period to determine the percent of desiccated vegetation.

Soil Moisture

Delmhorst cylindrical gypsum blocks were used to determine soil moisture. Blocks were placed at depths of 17.8 cm (upper level) and 45.7 cm (lower level) at opposite ends of each vegetation macroplot. The blocks were placed in the soil following the method of Shearer (1963). Weekly mean resistance measurements at the upper and lower depths were calculated and used for analysis.

Available Surface Water

Water availability at each lake bottom was observed throughout both study periods. Size and location of dugouts (trench and pit reservoirs) were recorded for each lake, and available drinking water was recorded as either present or not present.

PRONGHORN USE

Playas

Census routes for the lakebeds consisted of an existing dirt trail at each playa which was traversed by vehicle. Two playas were censused in the morning and two in the evening. Morning censusing was completed no later than 5 h after sunrise and evening censusing began about 4 h before sunset.

Numbers and locations of pronghorns were recorded from observation points along the trail at each playa. Pronghorns on each playa were censused six times/week for 11 weeks from 7 July through 21 September 1974, and 22 June through 13 September 1975. One pronghorn observation constituted one "unit of use" (Herrig 1974).

An index to pronghorn use was derived by dividing the numbers of pronghorns observed per week on each playa by the number of hectares for that playa. This value, computed weekly, was used as the dependent variable for multiple regression analyses and for comparison of pronghorn use among study sites.

Adjacent Range Sites

Censusing of pronghorns within range sites adjacent to each playa was accomplished during the pronghorn census of that playa. Census routes, times and dates were the same as those described in the preceding playa section.

Numbers of pronghorns counted per week within each adjacent range site were divided by the number of hectares in that site and constituted pronghorn use of adjacent range sites. The weekly pronghorn use figures were used to detect differential use of range sites and as independent variables for multiple regression analyses.

STATISTICAL ANALYSIS

Weekly totals of pronghorns/ha for each playa were analyzed by two-way analysis of variance (Snedecor and Cochran 1967) to determine if a significant difference in use existed between at least one of the playas and the other three. Each playa served as a treatment for comparison, and time was used as replications.

Differences between specific pairs of means were tested with Least Significant Difference (LSD) (Snedecor and Cochran 1967).

Forward stepwise multiple regression analysis (Draper and Smith 1966) was used to evaluate the relative importance and interrelationships of the following selected factors affecting pronghorn use of playas:

1) percent of desiccated vegetation, 2) adjacent range site use and, 3) soil moisture at two levels.

Differences in pronghorn use of the lakebeds and adjacent range sites between years were tested by paired t-tests at the 10 percent significance level.

RESULTS

Pronghorn Use of Playas and Adjacent Range Sites

A total of 14,316 pronghorn observations were recorded on the four playas, 9,854 in 1974 and 4,462 in 1975. Pronghorn observations totalled 4,510 on range sites adjacent to the four playas, 2,165 and 2,345 during 1974 and 1975 respectively.

During 1974 and 1975, Desert Lake received more pronghorn use than other playas (Tables 1, 2).

During 1974, the numbers of pronghorns increased as the season progressed on Desert Lake and decreased on other playas (Table 1). The number of pronghorns increased as the season progressed at Desert Lake during 1975, but in contrast to 1974 pronghorn numbers did not decrease as much at Dobyns, Long and Spanish Lakes (Tables 1, 2).

A significant difference ($P < 0.01$) in pronghorn use occurred on Desert Lake between the two study periods (Table 3). No significant differences in pronghorn use occurred between the two years on Dobyns, Long or Spanish Lakes (Table 3).

On range sites adjacent to Desert Lake, 6.47 pronghorns/ha were calculated during 1974 and 3.14 during 1975. Intermittent Lake (fair condition) range site received most pronghorn use during 1974 and 1975, accounting for 12.8 and 8.4 pronghorns/ha respectively (Table 4). A

Table 1. Weekly observations of pronghorns/ha at Desert, Dobyns, Long and Spanish Lakes, Hart Mountain NAR, 1974.

Sampling Week	Weekly Observations of Pronghorns/ha by Playa			
	Desert	Dobyns	Long	Spanish
7 - 13 July	0.03	0	0.11	0
14 - 20 July	3.52	0	1.42	0
21 - 27 July	1.02	0.04	0.16	0
28 July - 3 August	2.74	0	0.09	0.01
4 - 10 August	2.31	3.41	0.08	0
11 - 15 August	3.48	0.07	0	0
22 - 24 August	2.85	3.44	0.01	0.01
25 - 31 August	3.96	0.22	0.01	0.04
1 - 7 September	7.08	0.33	0	0.02
8 - 14 September	8.64	0	0	0.02
15 - 21 September	7.82	0	0	0.01
Total	43.45	7.51	1.88	0.11

Table 2. Weekly observations of pronghorns/ha at Desert, Dobyns, Long and Spanish Lakes, Hart Mountain NAR, 1975.

Sampling Week	Weekly Observations of Pronghorns/ha by Playa			
	Desert	Dobyns	Long	Spanish
22 - 28 June	0	0	0	0
29 June - 5 July	0.28	0	0	0
6 - 12 July	0.27	0	0	0
13 - 19 July	0.04	0	0	0
20 - 26 July	0.17	0.11	0.07	0
27 July - 2 August	0.57	0.04	0.23	0.02
3 - 9 August	0.93	0.22	0.02	0
10 - 16 August	2.79	0	0.29	0.09
24 - 30 August	4.02	0.33	0.47	0.39
31 August - 6 September	4.43	5.07	0.16	0.41
7 - 13 September	4.45	0.37	0.05	0.21
Total	17.95	6.14	1.29	1.12

significant ($P < 0.10$) difference in pronghorn use on adjacent range sites occurred between 1974 and 1975 at Desert Lake (Table 3).

During 1974 pronghorns indicated a preference for the Rocky Terrace (poor condition) range site over Intermittent Lake site at Dobyns Lake (Table 4). During the 1975 sampling period, 12.5 pronghorns/ha were recorded within the Intermittent Lake range site (Table 4).

In 1974 only 0.12 pronghorns/ha were calculated on range sites adjacent to Spanish Lake (Table 3). Adjacent range site use at Spanish Lake increased to 2.04 pronghorns/ha during 1975 (Table 3). Pronghorns apparently preferred the Rocky Terrace (poor condition) range site over other adjacent range sites at Spanish Lake with 0.4 and 3.1 pronghorns/ha calculated during 1974 and 1975 respectively (Table 4). A significant ($P < 0.05$) difference in pronghorn use on adjacent range sites occurred between 1974 and 1975 at Spanish Lake (Table 3).

Table 3. Total observations of pronghorns/ha on lakebeds and adjacent range sites, Hart Mountain NAR, 1974-75.

Lakebed[a]	1974		1975
Desert	43.75	**	17.95
Dobyns	7.51		6.14
Long	1.88		1.29
Spanish	0.11		1.12
Mean (all lakebeds)	14.82		6.71
Adjacent Range Sites[b]			
Desert	6.47[c]		3.14
Dobyns	0.56		2.57
Long	0.78*		3.45
Spanish	0.12*		2.04
Mean (all range sites)	2.63		2.86

[a] N = 11
[b] N = 9
[c] $P < 0.10$
**$P < 0.01$
*$P < 0.05$

At Long Lake pronghorns showed a preference for the Rocky Terrace (poor condition) range site as 1.0 and 4.1 pronghorns/ha were calculated during 1974 and 1975, respectively (Table 4). A significant ($P < 0.05$) difference in pronghorn use on adjacent range sites occurred between 1974 and 1975 at Long Lake (Table 3).

Table 4. Total observations of pronghorns/ha on range sites, adjacent to playas, Hart Mountain NAR, 1974-75.

Playa	Range Site	Pronghorns/ha 1974	1975
Desert Lake	Intermittent Lake (fair condition)	12.8	8.4
	Rocky Terrace (fair condition)	6.9	2.5
	Rocky Terrace (poor condition)	3.5	0.6
	Claypan Terrace (fair condition)	0.2	0.5
Spanish Lake	Rocky Terrace (poor condition)	0.4	3.1
	Intermittent Lake (poor condition)	0.1	2.9
	Claypan Terrace (fair condition)	0.1	0.1
	Claypan Terrace (poor condition)	0	1.1
	Shrubby Terrace Complex (fair condition)	0	0.4
Long Lake	Rocky Terrace (poor condition)	1.0	4.1
	Moist Bottomland Fan (poor condition)	0.1	1.3
	Intermittent Lake	0.9	3.5
Dobyns Lake	Rocky Terrace (poor condition)	0.6	0.6
	Intermittent Lake	0.3	12.5

REGRESSION ANALYSIS OF DATA

Desert Lake

A significant ($P < 0.05$) regression coefficient ($R^2 = 0.887$) was calculated during 1974 between pronghorn use (Y), upper soil moisture (X_2) and lower soil moisture (X_3). The regression equation by the method of least squares was $Y = 5.035 + 0.175X_2 - 0.154X_3$. For 1975, variables

showing a significant ($P < 0.05$) regression coefficient ($R^2 = 0.942$) were pronghorn use (Y) and lower soil moisture. The regression equation was $Y = 2.649 - 0.014X_2$. All other variables entering the model at each stage were not significant. However, a close relationship between upper and lower soil moisture existed during both study periods. In 1975 this relationship led to the selection of lower soil moisture as the only independent variable showing a significant ($P < 0.05$) relationship with pronghorn use; however, upper soil moisture also was closely related to pronghorn use.

Dobyns Lake

None of the variables entering the model were significant during 1974. Multiple regression was not used during 1975 because Dobyns Lake was inundated during the first 4 weeks of the study period which precluded soil moisture readings.

Spanish Lake

None of the variables entering the model were significant during 1974. Multiple regression was not used during 1975 because Spanish Lake was inundated during the first 6 weeks of the study period which precluded soil moisture readings.

Long Lake

Results for 1974 showed a significant ($P < 0.05$) regression coefficient ($R^2 = 0.999$) between pronghorn use (Y) and desiccated vegetation (X_2), Moist Bottomland Fan (X_3), upper soil moisture (X_4) and lower soil moisture (X_5). The calculated regression equation was $Y = 0.253 + 0.002X_2 - 1.746X_3 + 0.005X_4 + 0.004X_5$. Multiple regression was not used during 1975 because Long Lake was inundated for the first 2 weeks of the study

period which precluded soil moisture readings.

DISCUSSION

Desert Lake received significantly more pronghorn use than other study areas during 1974 and 1975. No significant differences in use existed among Dobyns, Long and Spanish Lakes during either year of the study.

Pronghorns demonstrated a greater dependence on lakebeds during a dry year than during a wet year. Herrig (1974) found pronghorns preferred range sites of the lowland mesic category during dry periods on Hart Mountain. Although pronghorns terminated use of a lakebed if drinking water was unavailable, the mere presence of water on a playa did not insure use. The most important relationship between precipitation and pronghorn use was in regard to the availability of succulent vegetation. Beale and Smith (1970) in Utah listed succulence as apparently the major characteristics of forage sought by pronghorns. Pronghorns indicated a strong preference for leafy arnica, particularly at Desert Lake. Leafy arnica exhibited new, green growth throughout both summers. During the dry year, 1974, leafy arnica was one of the few green plants available for pronghorns during summer.

As soil moisture decreased, desiccation of vegetation increased and pronghorn use intensified on Desert Lake where the least amount of desiccation occurred. Within the more xeric portions of Desert Lake the *Eleocharis-Arnica-Muhlenbergia*, *Eleocharis-Muhlenbergia-Iva*, and *Muhlenbergia-Eleocharis* plant communities, soil moisture was more quickly depleted than from the more mesic sites, *Eleocharis-Arnica* and *Arnica-Eleocharis*. The xeric communities exhibited the greatest amount of desic-

cation. In response to this drying, pronghorns used xeric sites during early summer and concentrated on mesic sites from July through the end of each study period. A similar relationship occurred at Long Lake; however, soil moisture was more quickly depleted on all sites at Long Lake, and when drinking water became unavailable pronghorn use ceased. At Dobyns Lake as soil moisture decreased and desiccation of vegetation increased pronghorn use decreased. During the dry year pronghorns ceased using Dobyns Lake by the last 2 weeks of the study as vegetation became very desiccated although drinking water was available. Pronghorns at Spanish Lake responded directly to available succulent forage when soil moisture was available for plant growth. During the wet year, 1975, pronghorns showed a strong preference for prostrate knotweed at Spanish Lake. Other authors also found that prostrate knotweed was a pronghorn food (Ferrel and Leach 1950, Tsukamoto and Deibert 1968).

Various studies demonstrated the importance of forbs during summer for pronghorns (Dawson 1950, Ferrel and Leach 1952, Hoover et al. 1959). Pronghorn use of playas during this study apparently was in response to available green forbs and to a lesser extent water, which the low sagebrush-dominated xeric upland range sites surrounding the playas lacked as summer progressed. Leafy arnica, a preferred forb by pronghorns on Desert Lake, had a 7.7 percent crude protein level (Deming 1958). Pronghorns in Saskatchewan preferred range plants with highest protein levels (Dirschl 1963). In an unpublished refuge report (1972) of pronghorn stomach analyses collected during Hart Mountain pronghorn hunting seasons, 1968-70, leafy arnica had a frequency of 11 percent.

Prostrate knotweed, a preferred forb by pronghorns at Spanish Lake, had a crude protein level of 11 percent (Deming 1958). During 1974, a

dry year, prostrate knotweed was hardly noticeable growing at the northern edge of Spanish Lake playa.

Poverty sumpweed grew on all playas except Long Lake. Pronghorns were observed feeding on poverty sumpweed at Desert and Dobyns Lakes, and they undoubtedly fed on it at Spanish Lake. The unpublished refuge report indicated that 33 percent of the pronghorn stomach samples contained poverty sumpweed. Pronghorns apparently fed upon succulent poverty sumpweed at all playas except Long Lake during both study periods. Pronghorns ate poverty sumpweed in northeastern California (Ferrel and Leach 1950).

Pronghorns were observed drinking from dugouts and open surface water as long as it was present on all playas.

The increased use by pronghorns during 1975 compared to 1974 at Spanish Lake was partly due to available drinking water in a shallow spring fed dugout in the Claypan Terrace (poor condition) range site 0.8 km west of the playa and to the available succulent prostrate knotweed on the playa. Water was not available in the shallow dugout after mid-July 1974. During 1975 pronghorns were observed within 1.6 km of the shallow dugout.

Pronghorns within the Desert Lake study site were always within 1200 m of water. Herrig (1974) reported mean distances to water for all pronghorn observations during summer was 725.6 m.

Early leaf growth and early flowering stages of forbs were apparently the most important developmental stages causing a selective response by pronghorns on all playas except at Dobyns Lake. Phenological stages did not seem to affect pronghorn use of Dobyns Lake.

As upland range sites, dominated by low sagebrush, dried, pronghorn use was concentrated on the playas throughout the summer and early fall.

Patterns of use by pronghorns of range sites adjacent to playas were similar between years. However, the number of observations per ha increased on all study sites except Desert Lake during the wet year. Patterns of use of the adjacent range sites supported the concept that during wet years pronghorns were less dependent on playa vegetation.

At Desert Lake, pronghorns indicated a preference for the Intermittent Lake (fair condition) range site. Pronghorns were observed feeding on Bolander's silver sagebrush within this site; silver sagebrush was documented as a pronghorn food (Baker 1953, Mitchell and Smoliak 1971, Sundstrom et al. 1973). Because of the proximity of the Intermittent Lake (fair condition) site surrounding Desert Lake playa and the relative heavy use of this adjacent range site by pronghorns throughout both sampling periods, pronghorn use of these two areas was related. Rocky Terrace (fair condition) was preferred by pronghorns over Rocky Terrace (poor condition) at Desert Lake; all Rocky Terrace range sites were dominated by low sagebrush. Mason (1952) documented the importance of low sagebrush in the diet of pronghorns on Hart Mountain. Herrig (1974) reported that Rocky Terrace was the most widespread and most consistently used upland xeric site by pronghorns on Hart Mountain.

Although we did not test the relationship of range condition to pronghorn use, it is noteworthy that the range sites adjacent to Desert Lake were in better condition than sites adjacent to the other playas.

Pronghorns were not observed within heavy stands of Mountain big sagebrush (*A. tridentata vaseyana*) adjacent to Desert Lake and Spanish Lake within the Rocky Terrace (poor condition) range site.

Observations indicated pronghorns preferred the Intermittent Lake (fair condition) site at Desert Lake more than the Intermittent Lake

(poor condition) site at Spanish Lake.

Because of the availability of succulent vegetation on all playas and adjacent range sites during the wet year, pronghorns did not concentrate on Desert Lake as they had during the dry year. Use of adjacent range sites was more evenly distributed during the wet year than during the dry year when pronghorns concentrated on Desert Lake.

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COMMENTS AND QUESTIONS

QUESTION: What kind of use did you have on the *Artemisia cana* there?

GOOD: It is high. Quite high. It's interesting the way they'll use it. Certain plants they seem to select and they'll hedge them right

down, particularly around Desert Lake. There was a band of that *cana* that was in poor condition, a lot heavier brush, higher brush at Spanish Lake but the pronghorns didn't use that hardly at all, compared to Desert Lake.

BRUNS: Are there other sources of water that they went to when the water dried up?

GOOD: No, there are no wells, not in this area. What we've done there is try to develop a lot of these trench type reservoirs out in that country that catch the runoff. There was always water available at Desert Lake and in 1974, a dry year, when they would move from those different playas a lot of the pronghorns in this southern population on Hart Mountain Antelope Refuge would move on to Desert Lake. It doesn't dry up completely there, unless it did last year, but I'm sure there was water probably at Desert Lake. There's always some water form out there on some of those playas. One of the main things we're going to do out in that country is put in trench reservoirs to catch any available snow runoff. The precipitation there is about 11 inches a year. That's at headquarters. But there're no wells out in that country that I know of except way out east of there. Pronghorns would usually, I suppose, move south if it became that dry; they'd have to get into a couple of those valleys. There's water up on Hart Mountain. One of the key management tools on Hart Mountain was to get that Refuge fenced because of the cattle use in the surrounding areas and the heavy sheep use of it. They would move out onto that mountain as the season progressed. There are springs up on that hill. I know the pronghorns would move up too if things really got tough but it would be rare to see them up in those heavy brush areas.

ANTELOPE AND ENERGY DEVELOPMENT

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Abstract: Energy development in the east central part of Wyoming has experienced tremendous growth in the last few years. This expansion has been in coal, oil and uranium. Aerial trend counts of the antelope population made in the same portions of the area in 1967 and again in 1977 shows about a 27 percent increase in the herd. Hunting permits were increased from 3,950 in 1971 to 7,500 in 1977. The impact of the human population increase associated with the development has had a significant affect on antelope and wildlife in general. All aspects of the energy production program are not negative and some benefits can accrue to wildlife. The uranium mining programs need to be studied and standards established for the amount of radiation that can safely be absorbed by wildlife, especially those species which may be consumed by humans.

The development of oil, coal and uranium brought about some significant changes in Wyoming. Prior to the early fifties there was a great deal of "open space" in our state where roads were few or did not exist. Intensive exploration for oil and uranium left few locations without some evidence of this activity. Public lands were covered to a greater extent than private lands and a network of roads and claim sites evolved. These roads gave the public new access to hunting areas that were previously little used or inaccessible.

A resurgence of exploration, brought about by the energy crisis in

the late sixties, produced discoveries of oil, coal and uranium that were significant. The development of these energy sources has produced some effects on wildlife and communities that were not encountered before.

Uranium, because of its hazardous potential, is of paramount concern to not only the wildlife management agencies but also to the companies mining the ore and the various state and federal agencies involved with the environment. Guidelines have been established by the state and federal authorities as to the proper mining techniques to be followed in order to protect the public, working personnel and the environment. However, since this type of mining is relatively new in Wyoming, we have no established parameters for the amount of radiation that is acceptable in various species of wildlife. This problem is in the process of being solved by studies being conducted by the University of Wyoming.

HABITAT DESCRIPTION

The antelope habitat located within the area where the development is taking place is generally of one type. It consists of low rolling hills with relatively flat valleys along the major drainages. Practically all the streams are intermittent. The soil is sandy; some alkali is found along some of the bottoms. The vegetative type is sagebrush-shortgrass. The major species found are: big sagebrush (*Artemisia tridentata*), greasewood (*Sarcobatus vermiculatus*), western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), needlegrass (*Stipa* sp), prairie sandreed (*Calamovilfa longifolia*) and prickly pear (*Opuntia* sp).

The annual precipitation in this area is generally between 25.4 and 35.6 cm. The precipitation pattern shows the lightest fall during December, January and February. A rapid increase follows with a peak in the last

half of May and the first half of June. This is followed by a rapid decrease to a low in August, followed by a secondary peak in September. After September there is a gradual decrease to the winter low.

ANTELOPE POPULATION

In 1971 more intensive management of the herds brought about the creation of five smaller areas from the one "North Douglas" area that had been in existence for many years. With the five smaller areas there has been a gradual increase in the number of permits issued each year. The number of permits issued in 1971 was 3,950; permits issued in 1977 totalled 7,500. The harvest increased from 3,521 animals to 6,936 over the same time period. Trend count data from a portion of this area showed 4,575 antelope in 1967; a count made in the same portion of the area in 1977 showed 5,829 animals. This represents a 27 percent increase for the area covered, which is roughly one-third of the total area involved.

Reproduction is very good. The overall doe/fawn ratio in August will show about 95 fawns per 100 does. The estimated antelope (*Antilocapra americana*) population in this area is 22,000.

ENERGY DEVELOPMENT

Wyoming has a wealth of energy resources which have been known for many years. Coal was the major energy source used by most industry operations and the railroads in the early part of the century. The transition from coal to diesel by the railroads and the use of other power in many of the industries left the coal industry in Wyoming in a depressed condition. This lasted until the energy crisis hit the nation in the early seventies. The low-sulfur coal that is economically strippable in Wyoming offers a tremendous potential energy source for the entire nation. There

have been several open pit mines developed in the state, with the potential for many more. The Eastern Powder River Basin, which encompasses an area within Campbell and Converse Counties, is estimated to contain about 12 percent of all the coal reserves in the world. Some estimate there is enough coal here to supply the nation's energy needs, at present levels of consumption, for somewhere between 300 and 400 years. There are, however, many issues to be ironed out before the maximum production of coal would be realized. Such items as surface rights, mineral rights, coal leasing priorities, socio-economic impacts on communities, impact on wildlife and reclamation programs are some of the particulars requiring attention before mining commences. Under the present system, it is estimated that it takes about 10 years to get a new coal mine into production.

Exploration for uranium became significant in the 1950's. There has been considerable development of this resource north of Douglas, Wyoming since the late 1960's. Several mines are now located in a relatively small area. Expansion of operations or additional mines are constantly in various stages of planning or completion. One company now has plans for nine underground and four strip mines.

Discovery of new sources of oil has stimulated additional drilling activity within this same area. New oil fields have been developed, also since the late 1960's. A new natural gas plant was built at Douglas and went into production in November of 1970.

PROBLEMS ASSOCIATED WITH ENERGY DEVELOPMENT

Once there is a significant discovery of a resource that can be profitably removed the development required for exploitation of that resource can have an affect on communities as well as wildlife and the habitat.

Some of the factors involved with energy development are as follows:

1. Increased human population: The dramatic increase in the human population in towns like Douglas, Wyoming has created the most significant impact on both the wildlife and the community. There are many towns in Wyoming which have had terrific expansion due to the influx of people associated with the production of energy in one form or another. An entirely new town was built near the center of the coal development between Gillette and Douglas, Wyoming. This town (Wright, Wyoming) is projected to have a population of 6,000 people by 1985. The conversion of a sagebrush flat in the open spaces to a town of 6,000 in about 10 years is indicative of the growth of the area. Douglas had a population of 2,700 less than 10 years ago. It is now estimated to be over 8,000 and still growing as fast as facilities are made available.

Unfortunately, this type of population increase brings many problems for the wildlife agencies. Most of the people that have moved into such places came from states where wildlife was not as available or plentiful. Some of the new arrivals cannot wait to become qualified for resident licences, which is 1 year, but simply start poaching or killing for fun. Sometimes it is not wildlife that is killed, but domestic stock has also been taken.

The increase in the human population places an increased demand for recreational opportunities of all kinds. This is reflected in the sale of deer, elk and fishing licences in those counties where energy associated growth has taken place. Table 1 below indicates the increased human population in the counties listed.

Table 1. Summary of licence sales.

County of Residence	Resident Licence Sales								
	Deer Licences			Elk Licences			Fish Licences		
	1968	1976	% Change	1968	1976	% Change	1968	1976	% Change
Campbell	1,484	2,405	+ 62%	677	1,815	+ 168%	1,298	2,548	+ 96%
Converse	1,071	1,784	+ 67%	548	1,225	+ 124%	1,010	1,814	+ 80%
Natrona	6,367	7,964	+ 25%	3,344	6,003	+ 80%	9,517	15,566	+ 64%
Sweetwater	2,720	5,335	+ 96%	2,105	4,891	+ 132%	4,344	9,032	+ 108%

The mobility of today's populace allows them to travel several hundred miles on weekends. Thus, the impact of the increased population in the energy producing locations of Wyoming, where recreation is somewhat limited, is being felt in the National Forests and other public land areas of the state. For instance, there were 1,815 elk licences sold in Campbell County in 1976. A portion of one small elk area with only 125 special permits is located within the county. Practically all of the Campbell County elk hunters had to go to the National Forests located to the west or the south. The same principle is applicable to the elk hunters from Natrona and other counties. It is quite evident that energy development in any part of Wyoming will increase the use of recreational facilities and public lands throughout the state.

2. Habitat loss: The type of development determines the actual amount of habitat loss. Strip mining for coal or uranium is the most destructive. This method removes habitat in the pit area, overburden locations, tailing ponds or dumps, areas where mills or other buildings are constructed and where new haul roads or railroads are constructed.

Underground mining disturbs far less habitat than strip mining as it involves relatively few acres for the facilities.

The solution retrieval method for uranium recovery is in the same category as oil field development in that it requires the drilling of several wells. Only one experimental unit has been observed but it appears that this method will not have too great an impact on the surface habitat. However, there is some question as to what effect it might have on the underground water supply. If an aquafer is pierced in the drilling process the complete recovery of the radioactive solution is open to question. The mining people are confident no contamination is likely to happen, but this method of uranium recovery is just starting in this area and it seems that mining of any type always has problems of one kind or other. A monitoring program should be established by one of the agencies concerned with the environment to keep checking on the efficiency of the companies in preventing the contamination of any underground water supply in the area.

Contamination of habitat can occur from the dust blown from coal or uranium strip mines. Perhaps the one major source of potential contamination lies in the tailing ponds or dumps from the mill processing wastes. These wastes are radioactive and could contaminate water supplies or surrounding habitat from the dust particles blown by the wind or carried by water downstream. There are several agencies involved in regulations concerning the safety measures in mining operations per se, but there are no standards established on what amounts of radiation can safely be tolerated in the various species of wildlife found in this vicinity. This is especially needed for those species which may be consumed by humans. The University of Wyoming is now involved in a project that will hopefully establish parameters on radiation levels that can be tolerated in various species of wildlife.

The overall loss of habitat is being kept down to reasonable levels. The reclamation of some of these areas is progressing and new techniques and forage species are becoming available to the companies as time progresses.

3. Roads: Road construction becomes a significant factor when it is done in an area that previously had no road at all or one of poor quality. Good roads, built in areas where wildlife concentrates or uses to cross between feeding and resting locations, inevitably lead to increased wildlife mortality from collisions with vehicles and illegal killing. During a 6 week period in 1977 there were 30 known cases of illegal shooting of antelope and deer along one such road. The potential for such activity is extremely high, since much of the work associated with energy development is on a 24 hour a day basis. This places people out in the field at all hours of the day and night. It is physically impossible for the limited number of enforcement personnel we have to properly cover this type of a situation.

4. Fences: Most of this area is yearlong range for antelope and they have lived with various types of fences for several generations. The majority of the fences found along the roads are sheep-tight. Even so, the antelope find places where they can get through unless there are unusual snow conditions. New fences could possibly limit the use of all available antelope habitat during the summer by restricting the free movement of the antelope beyond the perimeter of fenced pastures containing available water. Where antelope must migrate between summer and winter ranges over a distance of many miles, newly constructed sheep-tight fences of woven wire with two or three strands of barbed wire on top can be a deadly obstacle under severe snow or drought conditions.

A new railroad is under construction which will haul coal from the Gillette and Wright area south to Orin Junction. It will be fenced on both sides of the right-of-way almost entirely with sheep-tight fence, thus presenting a new situation for the antelope to face. The total length of the railroad is well over 160 km (100 miles) and it will roughly divide the entire area of discussion into an eastern one-third and western two-thirds parcel.

THE PLUS SIDE OF DEVELOPMENT

Although there seems to be a negative approach by wildlife people when confronted with such developments as coal mines, uranium mines and oil fields, some of these operations can actually enhance wildlife habitat in various ways. A few of the positive aspects of energy development are:

1. Cliff areas: Some abandoned open pit mines have cliff areas that are suitable nesting sites for raptors, swallows and other species of wildlife.
2. Ponds: Some ponds have been built or pits have filled with water suitable for a fisheries and the wildlife associated with this kind of habitat.
3. Free flowing water: This can be an important source to the wildlife in any area that is lacking an adequate supply of water.
4. Additional and diverse forage: Earlier reclamation of areas was directed primarily or entirely toward supplying domestic livestock with suitable forage, but more effort is now being placed in providing forage for wildlife by planting various browse species and legumes that are palatable to deer and antelope.
5. Miniature refuges: Most of the mining sites are closed to hunting

by the companies. This actually creates a refuge-type situation where wildlife is protected because of safety measures taken to protect the personnel working at the mines. Contrary to what some people might think, all mining areas are not biological deserts.

CONCLUSIONS

1. The antelope population in this area shows an upward trend in spite of the development that has taken place.
2. Energy development of the magnitude we have in this area has created problems for the communities and the law enforcement personnel associated with wildlife.
3. Greatly increased human populations in development areas have a far-reaching effect on wildlife and recreational activities.
4. Actual habitat loss due to energy development is not as significant as other aspects involved.
5. There are positive aspects to energy development as related to wildlife.

RANGE/WILDLIFE INTERRELATIONSHIPS -- PRONGHORN ANTELOPE

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The Rationale

Domestic livestock use of vegetation alters range ecosystems more extensively and profoundly than any other of man's range management activities. Alteration in vegetation quality and quantity, together with increased human activity, are resulting in dramatic changes which affect pronghorn antelope. Land managers and resource planners need a system for predicting the effects of range management activities on pronghorn use. The system described here is not a series of "do's and don'ts"; instead, consequences of range management actions on pronghorn habitat requirements are displayed. The system is based on the principle that first the manager must know the right combination of characteristics in the habitat requirements of pronghorns and then, with this knowledge, he can prescribe livestock management practices that will best maintain or improve the range to benefit antelope production and survival.

The primary pronghorn habitat "management tool" being used today by land managers is livestock management which has its profound effects on range vegetation. Range vegetation exhibits successional stages from near bare ground to advanced vegetation types, each stage servicing pronghorns with different degrees of quality forage.

Antelope habitat requirements are best met when the vegetation is

in mid-stage in plant succession, and this stage is met through prescribed plant management. It is important to remember that the specific relationships identified in this report are directly applicable only to ecological circumstances of the Owyhee ecosystem. The principles should, however, be usable in other ecosystems in the Great Basin biome and, with adaptation, to all pronghorn antelope ranges.

This section has been divided into several topics: definitions of optimum pronghorn habitat, forage areas and various types of cover; tips on improving habitat for on-the-ground management teams; and a discussion about range management decisions as they affect animal welfare.

Objective

The objective of this section is to provide technology to aid wildlife managers developing land management plans. The technique was developed for use in long-range land management planning as well as for evaluating individual land management plans. Its basis is that the manager must first know the antelope's habitat requirements then, secondly, he can evaluate the efforts of designing range management programs for the welfare of antelope.

Assumptions

We make these assumptions:

1. Pronghorn antelope have for eons been a compatible grazer with other herbivores. It is postulated that antelope enjoyed a symbiotic relationship with large grazers such as bison, benefiting from the bison's heavy use of forage, which in turn created forage composition more favourable to the antelope's food habits. Consequently, today's domestic cattle appear to have replaced yesterday's vast bison herds in the pronghorn's grazing relationships.

2. Forage, water and cover, singly or in combination, are the present primary limiting habitat factors for pronghorns in North America.

3. Each range has different vegetative types with different characteristics, viz., height of vegetation, species diversity; amount of forage production; juxtaposition of plant communities; soil-moisture factors. Each of these characteristics must be inventoried prior to initiating or developing management plans for livestock or wildlife.

4. Pronghorn densities (number of animals per unit area of land) are higher on some ranges than on adjacent ranges. The factor that controls high and low densities is a combination of habitat characteristics (Figures 1 through 6).

5. Through comparisons of antelope densities, the range characteristics most favourable to meeting optimum antelope habitat requirements are defined.

6. Native ranges with a mixture of grasses, forbs and short form shrubs best meet the needs of antelope.

7. Agriculture crops, other than alfalfa, are rarely used by pronghorns.

8. Projects which manipulate vegetation can be designed to benefit antelope if (1) present vegetative characteristics do not meet antelope needs, and (2) the project is designed to change undesirable vegetative characteristics to characteristics favourable to the antelope's habitat requirements. Extensive monoculture developments are not favourable to antelope.

9. Antelope need free water distributed from 1 1/2 to 8 km (1-5 mi.) intervals during all seasons of the year (Figure 1).

10. Fences constructed to control livestock movements can be barriers to antelope movements.

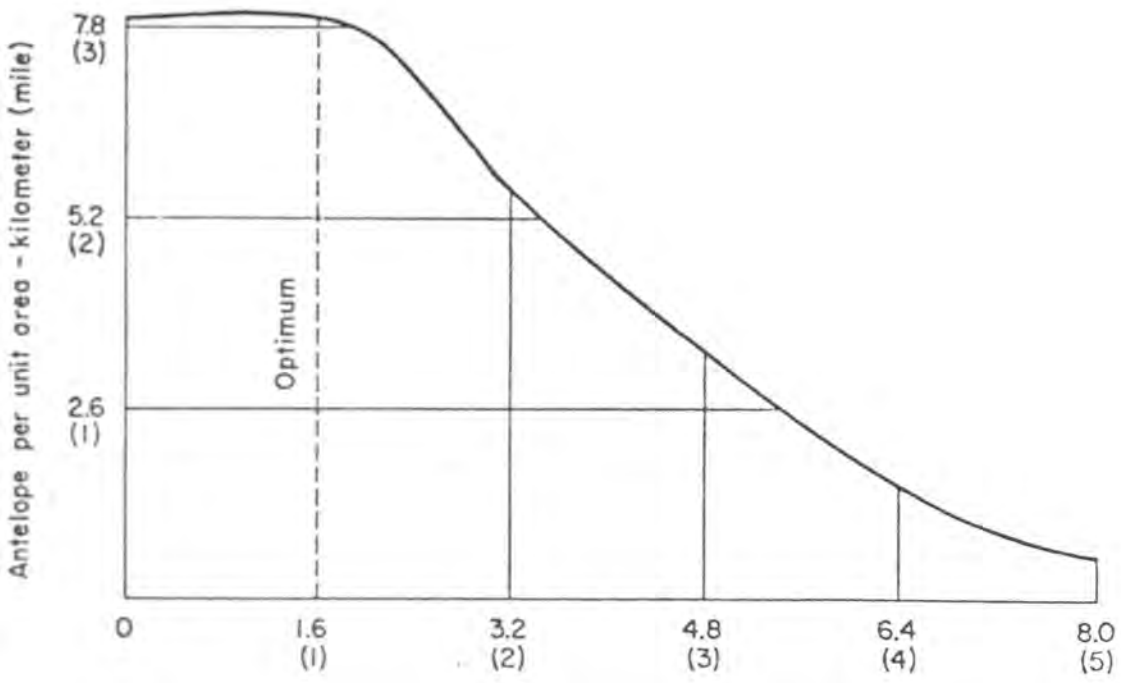


Fig. 1. Distance to water in kilometers (miles) in relation to antelope per square kilometer (mile) of sagebrush - steppe habitat.

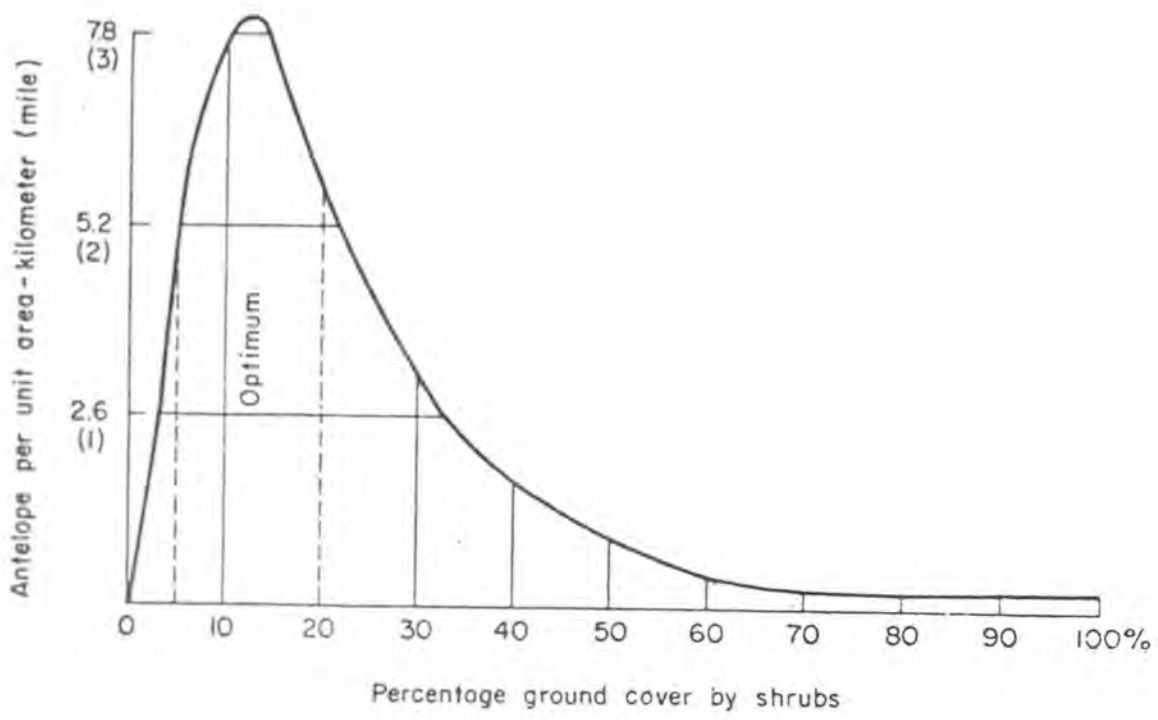


Fig. 2. Percent shrubs in ground cover in relation to antelope per square kilometer (mile) of sagebrush - steppe habitat.

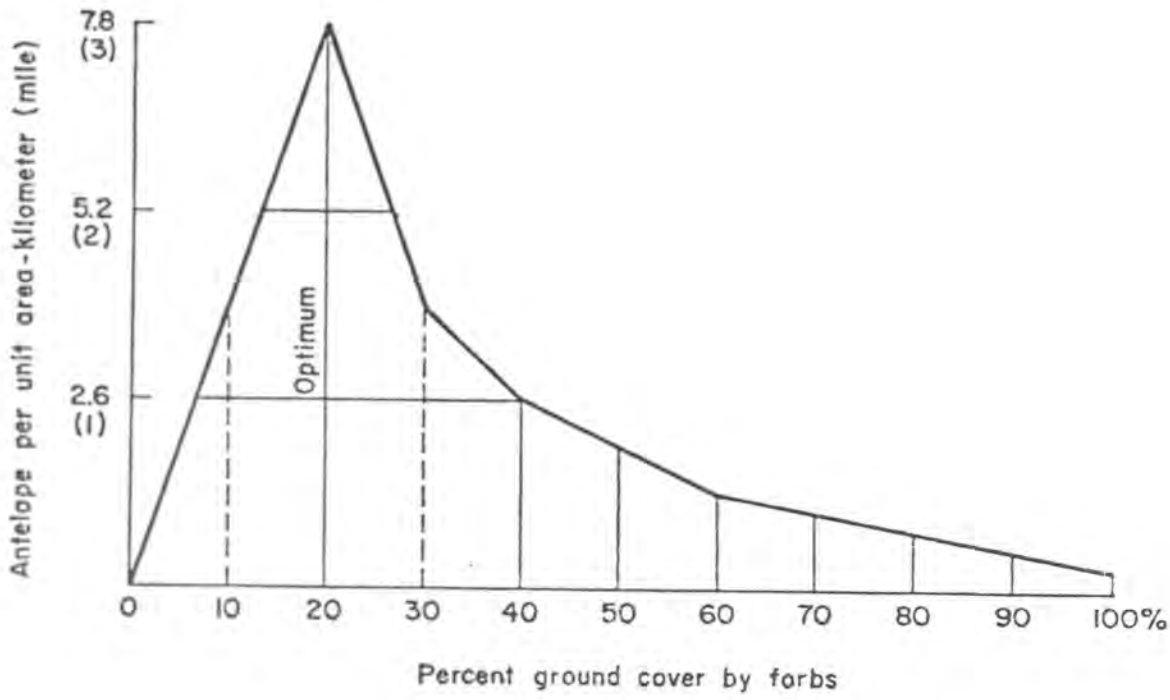


Fig. 3 Percent forbs in ground cover in relation to antelope per square kilometer (mile) of sagebrush-steppe habitat.

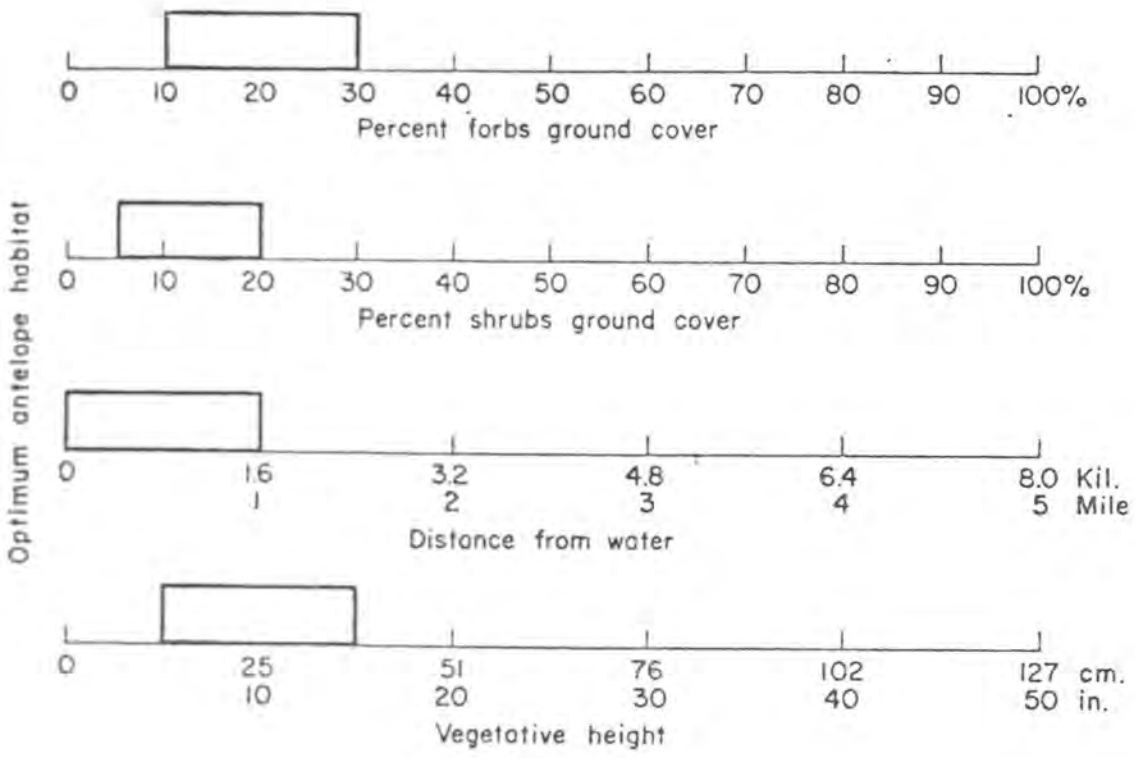


Fig. 4. Optimum habitat characteristics for pronghorn antelope within the sagebrush - steppe.

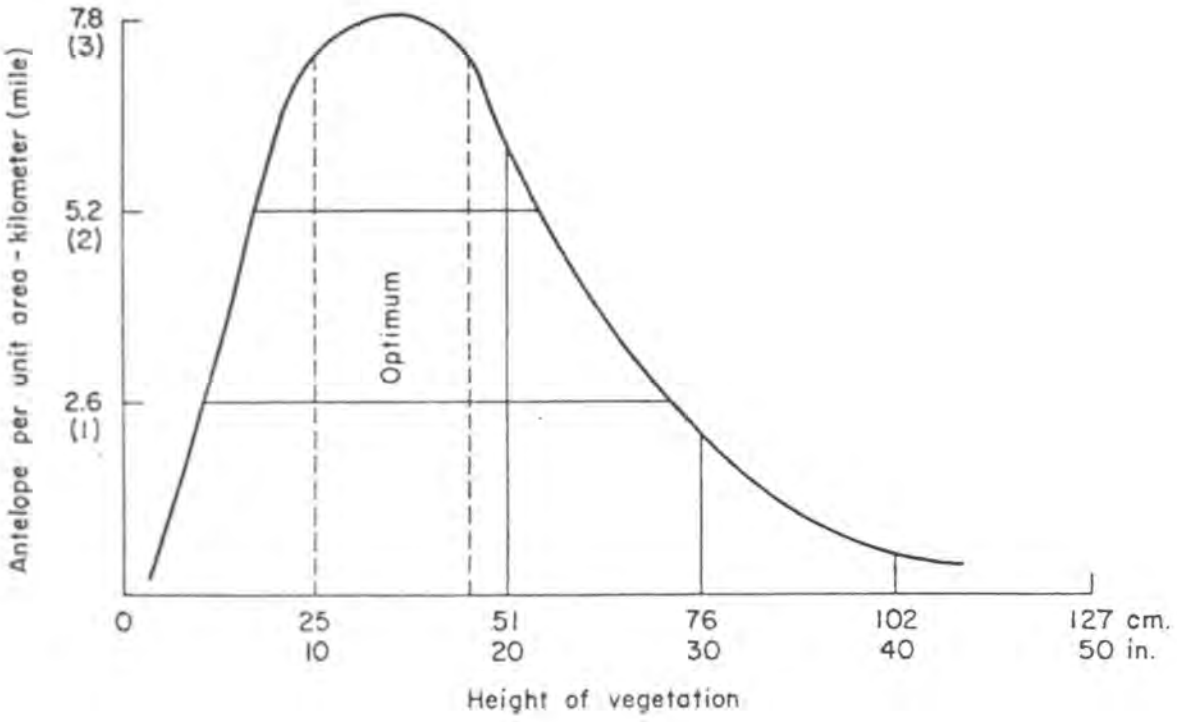
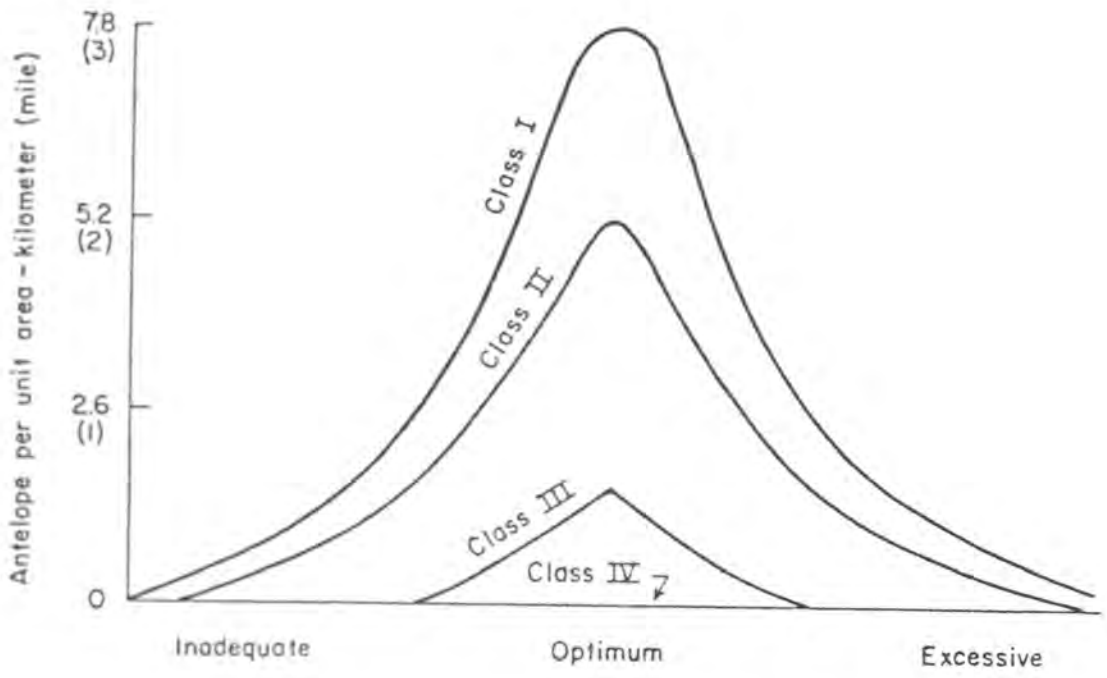


Fig. 5. Vegetative height in centimeters (inches) in relation to antelope per square kilometer (mile) of sagebrush - steppe habitat.



Class I Most productive site potential
Class II Intermediate productivity
Class III Marginal productivity
Class IV No potential for antelope production

Fig. 6. Potential production of antelope per unit area for extensive year long ranges in native condition in the sagebrush-steppe habitat.

11. Antelope requirements will be given full consideration in forage allocation and water development placement during range management planning.

12. The amounts, types and juxtaposition of forage and water areas can be manipulated to achieve positive results in terms of antelope use (Figure 4).

METHODS

The basic format for the methodology of this section on the pronghorn antelope was adapted, in part, from that established in the "Wildlife Habitats in managed forests--the Blue Mountains of Oregon and Washington" by Jack Ward Thomas (editor) (in press).

An intensive search of the literature was made to gather data. Ecological principles and research results were then used to form a framework on which to base interrelationships of pronghorn antelope and resultant population responses. The response to habitat manipulation was analyzed by task force antelope specialists. Where published data were lacking, consensus of these specialists was used.

Principle wildlife biologists were: Robert Kindschy, BLM, Vale, Oregon; James D. Yoakum, BLM, Reno, Nevada; Charles Sundstrom, U.S.F.S., Dillon, Montana; Cecil Langdon, Oregon Dept. Fish and Wildlife, Ontario, Oregon; Ellis Mason, Oregon Dept. Fish and Wildlife, Hines, Oregon.

Together, these progressional wildlife biologists total over 125 years of basic research and field experience with pronghorn antelope and its habitat.

HABITAT CHARACTERISTICS OF SOUTHEASTERN OREGON,

Preferred pronghorn antelope ranges in southeastern Oregon are generally those of low vegetative structure, viz., with shrubs no taller than 38 cm (15 in.). In summer range areas this aspect is normally provided by the low sagebrush (*Artemisia arbuscula*) plant communities; however, introduced stands of crested wheatgrass (*Agropyron desertorium* and/or *A. cristatum*) when mixed with dryland alfalfa, also fulfill this habitat requirement if situated in proper juxtaposition with other habitat components of water and available winter ranges. Occasionally rangelands populated with low form annuals such as cheatgrass (*Bromus tectorum*) will suffice as adequate spring and early summer ranges. Such seral vegetational stages often result from wildfire occurrence. Big sagebrush (*Artemisia tridentata*) range may similarly become suitable upon burning provided an attractive mixture of suitable grasses, forbs and browse survive and the other habitat components are available in the proper mixture.

Winter pronghorn antelope ranges in southeastern Oregon also present a low vegetative aspect. Prevalent shrub species are typified by black sagebrush (*Artemisia nova*), shadscale saltbush (*Atriplex confertifolia*) and associates such as spiny hopsage (*Gaeyia spinosa*) and winterfat (*Erotia lanata*). Seedings may be favoured wintering habitat in areas where snow cover is normally slight or absent and where autumn green-up is common if the vegetative composition of grasses, forbs and browse is improved over pre-treatment vegetation.

Intensively developed rangelands in the Jordan Valley area receive considerable year long antelope use. Analyses of 459 sq. km (177 sq. mi.) showed 334 drinking water sources. Distribution analysis disclosed

an average of 5.32 sq. km (2.05 sq. mi.) per water. Less intensively developed range provided only 18 waters in a similar land area for 25.5 sq. km per water (9.8 sq. mi. per water).

HABITAT REQUIREMENTS

Antelope densities vary within the Great Basin sagebrush steppe (Sundstrom et al. 1973, Yoakum 1968 and 1972, Oregon Dept. of Fish and Wildlife 1960-1976). Some ranges have similar characteristics, e.g. elevation, soils and precipitation; however, antelope densities varied within these ranges where there were other dissimilar characteristics, i.e., vegetation types, available waters. Yoakum (1974) evaluated the different habitat characteristics in relation to antelope densities and concluded that for the sagebrush steppes the following were optimum habitat requirements to produce and maintain high antelope densities.

Abiotic

Land Area: Physiography. Antelope have for centuries used land forms typified by low rolling, wide open, expansive terrain. Slope seldom exceeds 30 percent.

Examples of how ranges can vary in possessing these requirements can be illustrated by comparing three different antelope ranges within sight of the Hart Mountain Antelope Refuge in south central Oregon.

(1) The first example is an area with a diameter of 8 km (5 mi.) in Warner Valley. The site has sufficient forage and water year round. Snow depth rarely, if ever, exceeds 15 cm (6 in.). This situation results in a small resident herd.

(2) The second example is the adjacent Drakes Flat tableland--an area 24 km (15 mi.) in length. Food and water is abundant all year.

Antelope use the higher elevations (80 percent or more) all year depending on the snow depth. As soon as snow depths recede the herds move to higher elevations where preferred plants are more available. This situation results in the seasonal movement of the herd.

(3) The third example is the Hart Mountain area where the differentiation of summer and winter ranges is pronounced. The degree of travelling is related to the amount of snow, i.e., the deeper the snow the further the herds travel seeking lower elevations with less snow. Occasionally the herds may travel as far as 144 km (90 mi.).

Natural Barriers. Natural barriers affect antelope movements and thereby the occupancy of the habitat. Such natural barriers include large bodies of water; large rivers; an abrupt escarpment or mountain ridge; heavy, thick high brush or trees; deep canyons; and others. Einarsen (1948) cited examples of such barriers when he referred to two cases (one being the Columbia River and the other a heavily forested area) where pronghorns did not occupy or reestablish on nearby favourable ranges.

Elevation. Pronghorns inhabit ranges from sea level to 3,353 m (11,000 ft.). Only a few antelope occupy ranges at sea level in Mexico. Likewise, small herds use alpine meadows in Oregon and Wyoming. By far the greatest densities in the Great Basin occur on rangelands between 1,220 and 1,830 m (4 to 6,000 ft.) above sea level (Yoakum 1974).

Climate: Precipitation. The highest antelope densities appear to be within habitat averaging 25 to 38 cm (10 to 15 in.) per year. Antelope populations in precipitation belts above or below these parameters decline in population, survival and densities (Sundstrom et al. 1973,

Yoakum 1968).

Snow. Most antelope ranges receive some snow. However, when snowfalls exceed 25 to 30 cm (10 to 12 in.) antelope frequently have difficulty obtaining necessary quality and quantity of forage. Prolonged seasons of deep snows are especially detrimental to antelope when combined with factors such as: (1) low quantities or qualities of forage, (2) excessive wind increasing chill factors, and (3) obstacles (fences, etc.) to free movement to lands with less snow (Riddle and Oakley 1973, Hailey 1977, Sundstrom 1969).

Temperatures. Temperatures do not appear to be a major limitation. Antelope are adaptive to hot deserts or alpine plateaus. Freezing temperatures and precipitation at fawning may cause severe mortality to newborn young (Sundstrom 1968).

Soils: The pronghorn inhabits lands of various soil classifications, e.g., sandy, clay and rocky. Soils appear not to be a major criterion relative to antelope distribution or abundance; however, their most significant habitat types occur on Aridosols and Mollisols. These soils evolved mostly under the 25 to 38 cm (10 to 16 in.) precipitation zone and normally produce vegetation of sufficient quality and quantity to sustain antelope populations.

Water: Antelope range from semi-arid lands to lush alpine meadows. Extensive ranges producing and maintaining high antelope densities have water available every 2 to 8 km (1 to 5 mi.). Small numbers of animals can be found further than 8 km (5 mi.) from water; however, studies in Wyoming (Sundstrom 1968) disclosed that 95 percent of over 12,000 pronghorns were within a 4.8 to 6.4 km (3 to 4 mi.) radius of water.

Antelope use water from springs, streams, lakes, water catchments or metal troughs, as well as snow. Pronghorns require water throughout the year. When succulent forage is available 1 liter (.25 gal.) of water per day seems sufficient. During dry summers 4.2 to 5.7 liters (1.1 to 1.5 gal.) a day may be needed (Beale 1967). During late fall through early spring water may be available in the form of snow.

Biotic -- Vegetative

Vegetation: Quality and quantity of vegetation appear to be the major factors affecting antelope densities. The following characteristics of the sagebrush steppe based upon the step-point method (Costello and Schwan 1946) represent preferred ranges.

(1) Ground Cover. Ground cover averages 50 percent living vegetation and 50 percent bare ground, rocks and litter (Yoakum 1972) (Figures 2 and 3).

(2) Composition. The preferred composition of vegetation averages 40-60 percent grass, 10-30 percent forbs and 5-20 percent shrubs.

(3) Variety. A variety of species, ideally 5-10 grasses, 20-40 forbs and 5-10 shrubs, is present (Figure 4).

(4) Succulence. Succulent plants are highly preferred. Dietary studies disclose that during wet springs or summers producing an abundance of succulent forbs, pronghorns utilized more forbs. Antelope moved from dry ranges to intermittent lake beds and playas to seek succulent vegetation (Good 1977).

(5) Range Types. Open rangelands supporting a variety of vegetative types (meadows, forb patches, etc.) are preferred in contrast to monotypic vegetative communities (Yoakum 1957, Sundstrom et al. 1973). Antelope utilize areas of recent wildfires for foraging. Such areas

often provide grass sprouts and an abundance of succulent forbs.

(6) Height. Low vegetative structure is preferred, averaging 38 cm (15 in.), with vegetation over 61 cm (24 in.) less preferred (Figure 5). Antelope will seek higher brushy areas while travelling to or from more preferred ranges; however, their total yearlong use of 76 cm (30 in.) or higher vegetal areas is minimal. There may be a factor concerning reduced visibility, or decreased mobility, which is paramount to the antelope's survival.

Biotic -- Animal

Native Species: Pronghorns coexisted for eons with endemic herds of buffalo, elk, deer and bighorn sheep in North America (Nelson 1925, Einarsen 1948, Yoakum 1975). It is postulated that the legendary bison and antelope herds were symbiotic, viz., the bison grazed grasses heavily which in turn stimulated growth of favoured forbs and browse for antelope. Since the buffalo were free roaming they grazed and then moved on to more productive ranges.

Few records are available regarding the relationships of antelope to big game in the Great Basin region. Most early explorers reported that antelope were less abundant in the Great Basin than on the open short grasslands of mid-continent (Thwaites 1904, Burroughs 1961, Fremont 1843).

Predators: Coyotes and bobcats prey on antelope, especially fawns; however, predation is rarely a limiting factor where herds are large (Compton 1958, Yoakum 1957). Coyote predation on young antelope is likely a significant factor on certain ranges. Complicating factors like poor nutritional levels may magnify the impact of predation in local situations. Generally, where other habitat factors are sufficiently met, predation is not a limiting factor on pronghorn antelope populations.

Management Relationships

Man: Species Management. Today's scientific wildlife management practices have increased herds 1,500 percent during the past 50 years. Effective control of hunting combined with large scale trapping, transplanting and herd reestablishments to historic ranges have been major benefiting ventures. Less than 5 percent of the herds in North America occur in areas of uncontrolled hunting; these herds continue to decrease in numbers.

Habitat Management. What man does to the rangelands affects the welfare of pronghorns more than any other factor. Range management practices including forage manipulation, fence and road construction, and the development of waters all affect the antelope's well being. If these practices are accomplished with consideration of the antelope's habitat requirements then all is well. If these requirements are ignored then the range characteristics may be so altered that the habitat no longer provides needed forage, water and space for antelope reproduction and survival.

Domestic Livestock. There are three species of domestic livestock currently using the range in common with antelope today -- cattle, horses and sheep. All are exotic species to North America, for recent epoch times, having arrived with Europeans.

Within the Vale District all ranges inhabited by antelope are also used by livestock. Table 1 depicts the percentage of both livestock and wildlife AUM's used during 1974. It can be seen that the demand for vegetation by antelope is less than 1 percent of the total forage use by herbivores for the region. One should bear in mind, however, that the total region is not used equally by all herbivores.

The analysis does document that the demand for vegetation by antelope (less than 1 percent) is minor compared to licenced livestock (75 percent), wild horses (5 percent) and deer (19 percent). During 1974 there were no wild burros in the region.

Table 1. AUM's used by livestock and wildlife during 1974 in the Vale District on lands administered by BLM.

Class Animals	Number of AUM's	Percent of Total AUM's
Domestic		
Licenced cattle	429,600	75%
Sheep	2,770	Trace[1]
Wild Horses	28,000	5%
Total	460,370	80%
Wildlife		
Antelope (.14)[2]	4,200	1%
Deer (.20)	110,000	19%
Bighorns (.25)	720	Trace
Elk (.88)	352	Trace
Total	115,272	20%
Grand Total	575,642	100%

[1]Trace -- less than 1%.
[2]Body weight conversion factor to adjust to a standard 363 kg (800 lb.) "Animal Unit". Average weights from Burt and Grossenheider (1952).

If there is insufficient forage to provide the AUM demand for other herbivores, serious competition problems may develop. Conversely, if sufficient forage is available then there is little chance of competition. A recent study on the food relations of wild horses, cattle, domestic sheep, elk and antelope (Olsen and Hansen 1977) was conducted on a sagebrush grassland in Wyoming. Based upon dietary overlaps on a yearlong basis it was apparent that horses, cattle and sheep were similar, whereas antelope food habits were very dissimilar. Few studies of this

intensity for competition have been conducted to date.

Although apparently antelope experience little competition from horses and cattle, there is greater competition between domestic sheep and pronghorns (Hoover et al. 1959, Buechner 1950, Severson et al. 1968).

The impact of feral horses on antelope range has not been fully explored. Overpopulation by horses could reach a point where competition for forage and/or water would become a limiting factor.

Since both livestock and antelope use the majority of the ranges concurrently, the question frequently arises regarding the transmission of diseases between species. This topic has been studied extensively for the past 25 years, especially for anaplasmosis and brucellosis. No authenticated cases are on record. Antelope do not generally concentrate in large numbers on bedding grounds and their feeding characteristics keep them moving a great deal, which minimizes disease transmission (Honess and Winter 1956, Hailey 1977, Hoover et al. 1959).

Ranges in the Vale District are currently being managed for livestock grazing with a wide variety of grazing systems (rotation seasonal grazing, deferred-rotational grazing, repeated seasonal grazing, etc.). Yearlong livestock grazing is not permitted on Vale District lands (Heady and Bartolome 1977).

No intensive study has been accomplished in the Great Basin region to document the effects of livestock grazing systems on antelope populations. Consequently, conservative guidelines are needed and the following are provided (Pronghorn Antelope Workshop 1978).

1. Sufficient forage of all classes should be retained for seasonal use in antelope use ranges.
2. Maintain native vegetation where these ranges are in good ecological

condition.

3. Minimize livestock pressures on spring ranges in order to assure growth of vernal forbs.

4. Winter use areas by antelope are often crucial habitats and therefore need assurance of adequate forage.

5. Forbs and browse are key species to antelope; therefore, they should be considered when establishing grazing systems for livestock.

6. If waters are developed for livestock summer ranges, these water developments must be maintained for antelope use during the dry seasons.

7. Since fences often become a hinderance to antelope movements it is recommended that livestock be herded or driven in lieu of extensive range fencing.

8. Sheep trailing should be prohibited in antelope fawning areas 15 days before and after the fawning peak season (May 15 to June 15).

9. Gates should be left open when livestock are moved out of fenced pastures.

10. Summer water sources should not be made available on an area used as critical antelope winter range.

Grazing Systems. Livestock management is turning more to establishing grazing systems for livestock use. There are numerous systems with designed procedures for grazing depending on local economic and environmental conditions. All of these systems should consider the following criteria when developed for lands used dually with wild pronghorn herds:

1. When considering quality and quantity of vegetation for antelope these forage needs should be given.

a. The key species of vegetative life forms will be recognized

as forage for antelope. This includes grasses, forbs and browse based upon correct up-to-date proper use factors.

b. All forage plants should be available for antelope for the seasons of need.

c. Forage should be reserved for a reasonable number of pronghorns. Reasonable numbers should be based upon (1) the average herd population for the past 30 years, and (2) average forage production for the last 15 years.

2. All waters should be maintained for antelope for the seasons the antelope are in the pastures.

3. Livestock fence construction should meet specifications deemed appropriate for antelope movement specified in the Antelope Regional Fence Workshop (U. S. Bur. Land Mgmt. 1974).

4. Livestock grazing systems which restrict, alter, limit or deleteriously affect the habitat requirements of antelope must include mitigating measures and alternate procedures to enhance antelope habitat.

5. Prescription grazing, that is, using livestock to achieve vegetative structure or composition objectives, should be practiced in seedings and certain native ranges where high antelope habitat values exist.

RANGE MANAGEMENT

Vegetation

Native Rangeland: Maintain Ranges. Native rangelands which have developed over eons into natural vegetative communities, and remain in favourable condition today, should be maintained in favourable condition. This is especially important for historical antelope ranges.

It is postulated that pronghorns thrive best on ranges in a sub-climax

vegetative condition. Such conditions were created by (1) wildfires caused by lightning, and (2) seasonal grazing by herbivores such as bison, elk and deer. The vegetative community was in constant change which in turn produced a variety of mixed forage classes of grass, forbs and browse.

Today, range management should recognize the habitat requirements of pronghorns, and where these are presently available every effort should be made to retain such natural ranges in a healthy and productive condition based upon natural plant communities.

It cannot be emphasized too strongly that optimum range is directly related to the right combination of all identified habitat requirements in the ecosystem (Figure 6).

Developed Rangelands: Brush Control. Extensive areas of dominant big sagebrush (more than 30 percent of vegetative cover) are often low density ranges for antelope. This is especially true where the brush structure is 76 cm (30 in.) or higher. Such areas can be treated to decrease sagebrush quantity and height, thereby creating improved antelope habitat. The major objective of brush control is to create a more favourable composition and structure (see habitat requirements). Two points should be considered in such treatments: (1) it is best to plan projects not too large in size (preferably less than 405 ha (1,000 acre blocks)); (2) the project should maintain around 5-20 percent browse cover.

Brush control is frequently accomplished by mechanical practices such as (a) plowing, and (b) chaining. Plowing with large brushland plows often kills native plants, especially highly preferred forbs. Chaining is accomplished by two large tractors pulling a heavy anchor chain between them. This practice does not kill as much sagebrush and is less damaging

to native grasses and forbs.

Chemical spraying is another commonly practiced sagebrush control technique. The spray can be largely plant specific thereby controlling sagebrush and not harming native grasses and most forbs. The practice can favour antelope ranges with low sagebrush but leaves tall dead brush on big sagebrush treated areas.

Prescribed burning, another technique of brush control, has recently been tested in the Great Basin. This practice has many natural characteristics favourable to improving ranges for antelope. When properly accomplished, prescribed burning can decrease sagebrush and not seriously harm native grasses and forbs (Beardahl and Sylvester 1974, Page 1975, Lovaas 1976).

The available literature suggests that prescribed fire in land management has been studied longer and more intensively than any other available tool (Lyon, pers. comm. 1974). In a review of this subject, investigators have reported direct immediate stimulation of plant growth resulting in greater forage yield. Soils are warmer on burned areas and spring growth starts earlier. Soil fertility is usually increased by fire. Plant vigour is promoted by removal of senescent shoots and foliage and, in many situations, burning of the mulch prevents interception of light and water and thus favours plant growth. Longer term increases in growth have been achieved by timing the fire to favour the species with highest yields, by removing undesirable competing plants and by preparing seedbeds for successful reproduction. In addition to measurable increase in forage yield, greater forage availability has been reported where unpalatable plants become palatable after burning, where physical barriers to utilization have been burned, or where plants too large have been

reduced in size by burning. Most prescribed fires lead to an increase in palatability of resprouting plants. Higher protein content has been reported for resprouts of both grasses and shrubs and several have shown measurable increases in livestock gain on burned pastures even where forage yields were not increased.

Seedings. A range which has insufficient native plants for natural reproduction can be seeded. Past seeding ventures have often resulted in monocultures of exotic grasses. These seedings have limited value to antelope other than a decrease in shrub quantity and height.

However, mixture seedings have often proven highly beneficial to antelope, especially when legumes have been planted (Kindschy 1974). Mixture seedings are optimized when there are a number of native species planted. A good rule of thumb is six species each of grasses, forbs and browse.

Introduction of dryland Nomad variety alfalfa (*Medicago sativa*) was one of the most successful and important techniques accomplished during seeding in the Vale, Oregon BLM District. In excess of 22,662 ha (56,000 acres) involving 36 separate seedings have been completed in this district. The alfalfa was generally aerially seeded onto plowed sagebrush range following drilling to adapted grasses and browse species. Recent analysis of these seedings (Kindschy 1974) showed that the majority have maintained alfalfa composition at a level of 10 percent of the vegetation present over a period of 6 or more years. The seedings have increased the forb composition from 2 percent in untreated areas to 7 percent in the seeded areas. During the August 1976 antelope census more antelope with fawns were observed in intensively seeded areas than on rangelands with little

or no seeding.

Summary. The topic of vegetative manipulation has many variables for antelope; depending on how these practices are accomplished they can be either beneficial or detrimental. There are two basic principles that should be followed when planning projects for the benefit of antelope:

(1) Antelope habitat requirements must be met in order for the project to be advantageous to antelope habitat needs.

(2) All projects should be planned and accomplished in accordance with the ten basic principles of range restoration identified by Perry Plummer (1968):

Principles of Procedure for Successful Restoration

Ten principles for successful restoration of game ranges in Utah, which we have found important from investigative studies, are presented for carrying out large scale programs (Plummer et al. 1968). The procedures have wide application on similar sites throughout the west. We refer to them as "the ten commandments for success".

While there is still a great deal to be learned in developing precision to reduce costs, successful treatment and seeding of large areas depends on following these tested procedures. Some modifications may be necessary to meet differences in local environments. This will be satisfactory if they meet the conditions prescribed.

1. Changes in plant cover by the proposed measures must be determined to be desirable. Often a change in management to permit lighter grazing by livestock so that desirable species can develop may be all that is required.

2. Terrain and soil types must be suited to the changes selected. The soil and terrain should be carefully considered to determine where appropriate treatment would produce the most forage for game.

3. Precipitation must be adequate to assure establishment and survival of seeded plants. The amount of precipitation, along with occurrence of indicator plants, is the most important guide to what species may be seeded successfully (Plummer et al. 1955, Bleak et al. 1965).

4. Competition must be low enough to assure that desired species can be established. Anchor chaining has been developed as a highly versatile, effective, economical and widely applicable method for eliminating competition of trees and shrubs. Other techniques are useful on limited areas.

5. Only species and strains of plants adapted to the area should be planted. Seeded species must be able to establish and maintain themselves. There should be a balance of shrubs, forbs and grasses.

6. Mixtures, rather than single species, should be planted. It is advantageous to seed mixtures when the major purpose of restoration is for the improvement of game range.

7. Sufficient seed of acceptable purity and viability should be planted to assure getting a stand. The amount per acre depends on seed purity, size and viability and whether seeds are drilled or broadcast.

8. Seed must be covered sufficiently. Deeper than 1 1/4 cm (1/2 in.) planting is seldom desirable; likewise, leaving seed exposed is unsatisfactory (Plummer 1943, Basile and Holmgren 1957).

9. Planting should be done in the season of optimum conditions for establishment. Whenever climate permits, seeding in winter is best (December, January and February). Late fall is next best (late October

and November). Transplanting of nursery stock, seedlings and wildlings is most successful when completed while the ground is still wet from snowmelt in the spring.

10. The planted area must be adequately protected. Young plants and seedlings should not be grazed or severely trampled by livestock, big game, rabbits, rodents or insects.

Cultivated Crops: Antelope can be attracted to alfalfa, a highly preferred forage species. Winter wheat is seldom used by antelope. Generally antelope use of cultivated crops has been very minor, principally because the higher antelope populations are not located near the cultivated lands of the region.

Fences

Fences can be major obstacles where antelope mobility is restricted to procure food, water or escape from deep snow. Where restrictions occur significant changes in distribution of herds, death to individual pronghorns, or significant losses of carrying capacity has resulted (Anonymous 1972, Oakley 1973, Sundstrom 1970, Martinka 1967, Hailey et al. 1977).

Recommendations from antelope fence studies (Spillett 1965, Spillett et al. 1967, ZeBell 1968, Mapston 1972a, Interstate Antelope Conference 1962, U. S. Bureau of Land Management 1972, 1974) state that when fence construction is necessary the following specifications are best for antelope welfare:

(1) Net wire fences are generally barriers; therefore, their construction on antelope ranges is discouraged.

(2) Barbed wire fences should be constructed to the following specifications:

a. bottom wire at least 41 cm (16 in.) from the ground.

b. next wire up 25 cm (10 in.).

c. next wire up 25 cm (10 in.), comprising a total of 91 cm (36 in.) height from ground.

d. bottom wire should be smooth wire for antelope generally go under fences; barbless wire minimizes physical injuries.

e. no stays between posts as this allows for a less tight fence allowing easier antelope passage.

f. important antelope-travelled pathways, migration routes, etc., should allow for low height or lay down panels, or pass structures.

g. keep fenced areas as large as possible, thereby providing an opportunity for antelope to obtain all the basic habitat requirements.

Fence types tested under a controlled situation (Spillett 1965) which appear to offer the best possibilities for least interference with antelope movement and provide for domestic sheep management are:

(1) 81 cm (32 in.) net.

(2) 66 cm (26 in.) net and 1 barb 10 cm (4 in.) above.

(3) standard cattleguards.

A total fence height of 81 cm (32 in.) is apparently the maximum fence height that most antelope tested would readily cross. The study data indicates that adult antelope possess an inherent learning ability to cross fences and, through experience, they might be expected to learn how to cross various fence types. Standard cattleguards will frequently permit the movement of adult and yearling antelope if they are placed so they will be readily located by the animals. Study data indicates a corner location for cattleguards is more readily found and crossed by

antelope. The 81 cm (32 in.) net and 66 cm (26 in.) net with one barb wire 10 cm (4 in.) above effectively held sheep, as did standard cattleguards.

An extensive literature review is provided by Spillett (1965), indicating the difficulty with which antelope negotiate fences.

Possibly the best summary of the antelope fencing problem was the result obtained at the Regional Fencing Workshop held in Cheyenne, Wyoming during 1974. Over 60 persons attended representing dozens of state and federal government agencies, conservation and sportsmen organizations, and private farmers and ranchers. The recommendations of this workshop were codified into three specific specifications for cattle and sheep ranges as identified in Figure 7 (U. S. Bureau of Land Management 1975). These are the latest and most detailed fence plans developed that are best for allowing antelope movement.

"Antelope Passes" have been used in some areas to facilitate antelope movement through fences (June 1965). These devices are essentially miniature cattleguards, 1.22 m (4 ft.) wide rather than the standard 3.12 m (10 ft. 3 in.) wide structures (Figure 8). Vehicles cannot cross these structures. These "Antelope Passes" are placed along the fence line at locations that would appear to be used by antelope. The corners of fence lines are a favourite location for the installation of this type of device. Passes, when properly placed, help facilitate antelope movement but are a second choice to properly constructed fencing.

All fences under construction should have white rag flagging tied to the top wire between each post to allow improved visibility of the new hazard. Antelope will have become accustomed to the fence by the time the flagging deteriorates. Grey post "camouflage" steel post fences

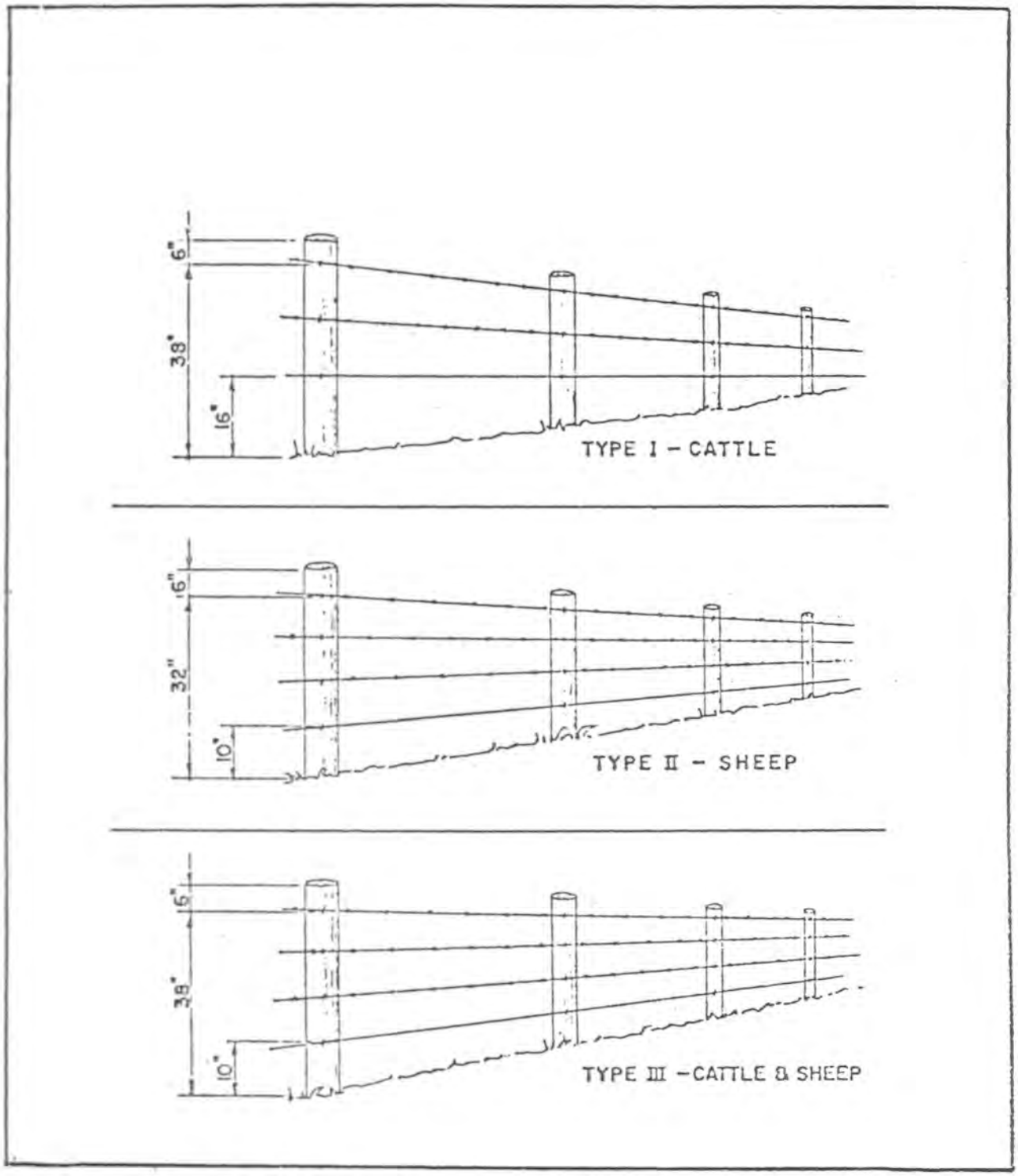


Fig. 7. Details of specifications for livestock fences constructed on antelope ranges as recommended by the Regional Fencing Workshop. (U.S. Bureau of Land Management 1965).

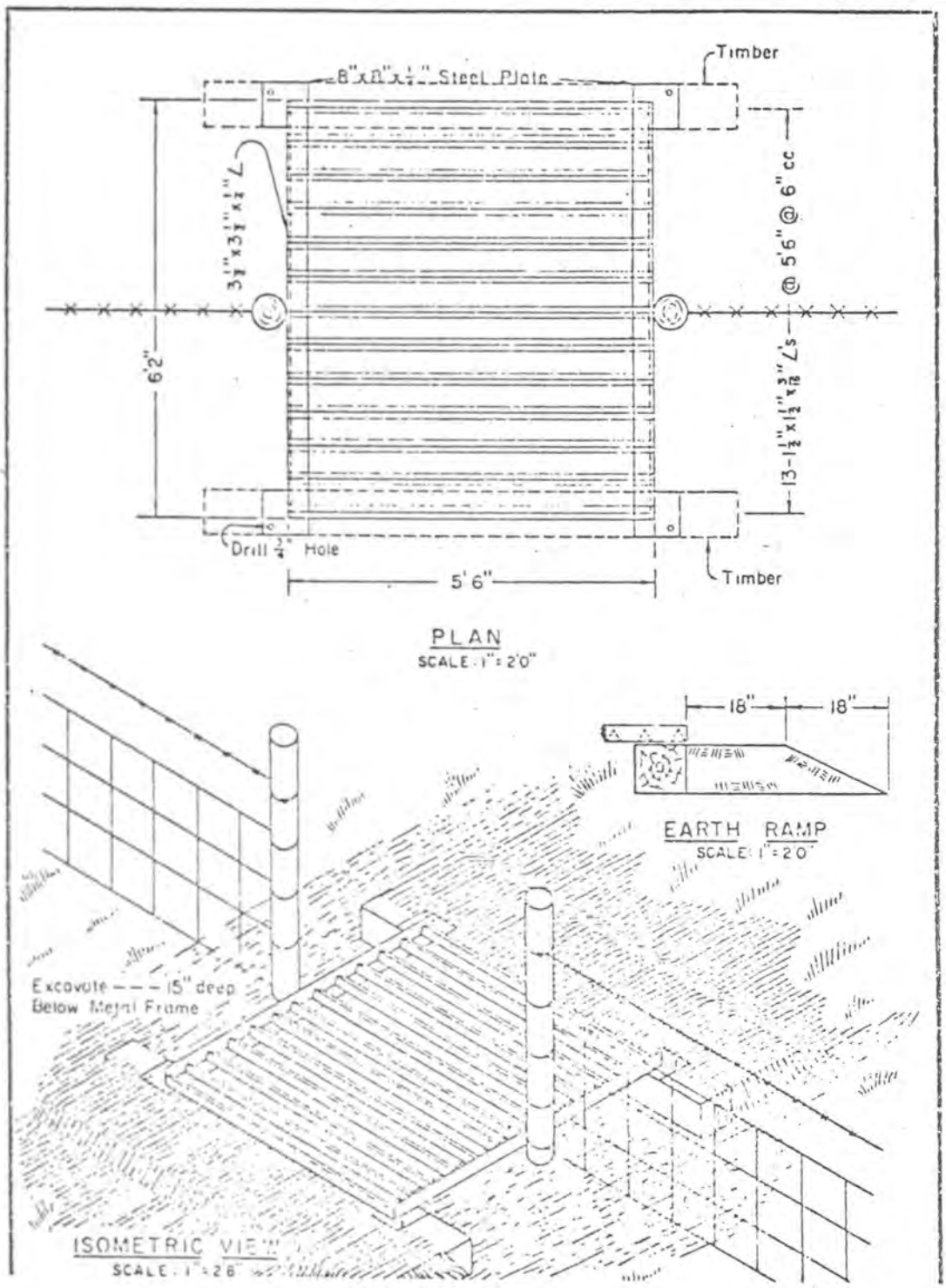


Figure 8. Antelope pass specification and recommended method of installation (Mapston 1972b).

should be avoided on antelope ranges.

Water

Quantity: Measurements were made of water consumption by 25 to 35 pronghorn antelope in a study pasture near Wamsutter, Wyoming (Sundstrom 1968). Daily water consumption rates per antelope varied from .34 liter (.09 gal.) per day in May to 4.5 liter (1.19 gal.) per day in August. Total monthly precipitation, evaporation, succulent vegetation, nursing does, average temperature and average maximum temperature had marked effects on the average daily water consumption rates.

Working in Utah, Beale (1966) found that from 1 July to 15 August 35 to 40 antelope consumed 44-66 liters (11.6 to 17.4 gal.) of water daily. In Texas, droughts brought about a reduction in vitality of antelope which resulted in decreased fertility (Jones 1949). In Wyoming Baker (1967) found that antelope killed themselves trying to get through antelope-proof fences in an attempt to reach water on an adjacent range.

Only in Colorado was it reported that some antelope herds live and die without ever taking a drink of water (Hoover et al. 1958). However, no further documentation substantiated this observation.

Quality: Little information is available concerning water quality as it affects pronghorn antelope. However, total dissolved solids and pH are probably the most common immediate concerns in this report.

In the Red Desert Sundstrom (1967) found little or no use by antelope of water sources which contained total dissolved solids in excess of 5,000 ppm. Some use did occur in one water source with an unsettled total dissolved solids of 4,620 ppm. The maximum total dissolved solids recommended for best game support is about 4,500 ppm (McKee and Wolf 1963). Livestock and poultry may be injured by drinking water that

contains excessive dissolved solids. Continuous use of such water may cause general loss of condition, weakness, scouring, unthriftiness, reduced milk production, bone degeneration and death. However, animals can drink temporarily highly saline waters that would be harmful if used continuously. Animals can also adjust gradually to the use of waters with a higher solids concentration than that which they normally drink, although sudden change from slightly to highly mineralized waters causes acute distress and diarrhea of varying severity. The limits of tolerance depend upon the kind of salts present, the species of animal, its diet, age, physiological condition, season of year, climate, etc. (McKee and Wolf 1963).

Little data is available concerning pH levels tolerated by prong-horns. In Wyoming's Red Desert it was found that when water sources exceeded a pH of 9.25, antelope appeared to seek other water sources (Sundstrom 1967). Recommended pH range for most uses such as domestic water supplies, irrigation, fish and other aquatic life, swimming and other recreation uses, appears to be from 6.5 to 8.5 (McKee and Wolf 1963).

No doubt other factors affect water quality. It is suggested that where water sources are available to antelope, but appear to be avoided, a complete water chemistry test should be made.

Region 3, of the U. S. Forest Service, has suggested the following interim guidelines for water quality for livestock and wildlife:

Table 2. Interim water quality guidelines (U.S.F.S. Region 3, 1968).

Total Dissolved Solids (mg/l)	10,000*
Free Chlorine (mg/l)	200
pH (Standard Units)	7.0-9.2
Manganese (mg/l)	10
Alkalinity (as $CaCO_3$) (mg/l)	50
Chlorides (mg/l)	1,500
Chromium (mg/l)	5
Hardness (mg/l)	500

*This figure is probably excessive.

Distribution: A close relationship was observed between antelope distribution and water locations in Wyoming's Red Desert (Sundstrom 1968). Ninety-five percent of 12,465 antelope counted by air were within a 6 km (4 mi.) radius of a water source. Occasionally adult males were found over 6 km from any apparent source of water. Benson (1956) considered the advent of water development in Saskatchewan to be associated with the spread of antelope there. In Oregon (Anonymous 1961) it was felt that there is adequate range for many more antelope, but few places for them to drink in late summer.

Types of Developments: During the 5 year antelope study in the Red Desert (1966-70) antelope were seen using every type of water source available. These consisted of springs, creeks, rivers, lakes and reservoirs, stock water developments, galvanized troughs fed by windmills and troughs filled by springs. Antelope did not appear to avoid any man-made device developed for livestock.

The installation of precipitation catchment facilities (guzzlers) on ranges lacking proper water distribution have been successful for antelope (June 1965, Sundstrom 1968). Such water developments are relatively maintenance free, not expensive, and serve a variety of wildlife.

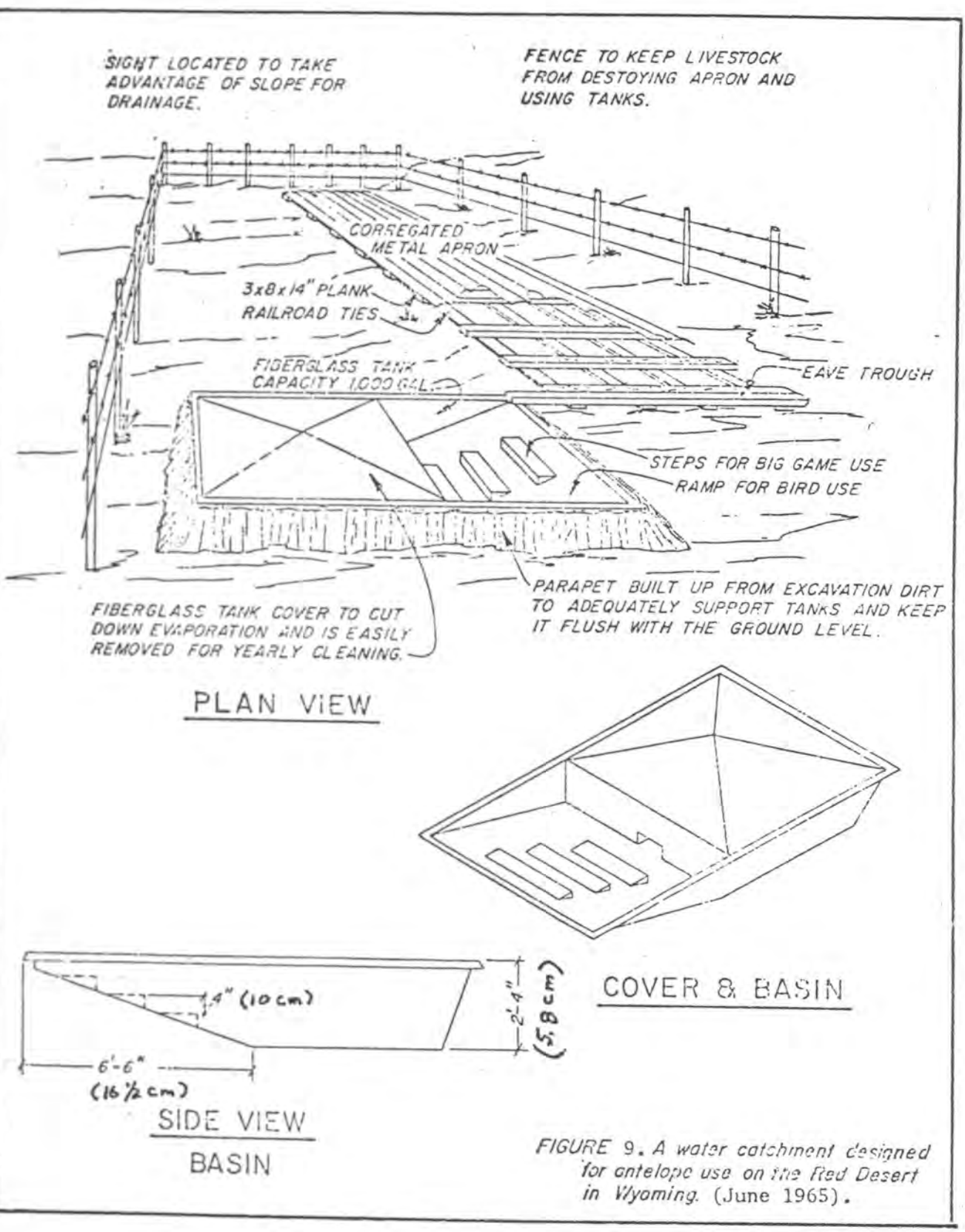


FIGURE 9. A water catchment designed for antelope use on the Red Desert in Wyoming. (June 1965).

A three-strand 81 cm (32 in.) high barbed wire fence with smooth bottom wire should be constructed around the projects to protect the facility from trampling damage and competition for use of water by cattle or horses. One or more "Antelope Passes" could also be installed in this fence line if antelope access is a problem. Figure 9 illustrates a type of guzzler design.

SITE POTENTIAL-ANTELOPE INTERRELATIONSHIPS

Sagebrush-Bluebunch Wheatgrass Communities

Each vegetative site, and its associated vegetative structure, provides different potentials for antelope productivity. To demonstrate this, a big sagebrush/bluebunch wheatgrass (/*Agropyron spicatum*) site with four ecological conditions (poor through excellent) are displayed for a hypothetical area in southeastern Oregon (Figure 10). In comparing the vegetative structure of each ecological condition it becomes apparent that the "fair" condition class more closely approaches the optimum vegetative composition and structure for antelope as defined in habitat requirements. As the ecological condition deviates from this condition class the grass/forb/browse ratios and vegetative height become less favourable to antelope production.

Under poor conditions the grass/forb/browse percentages (step point hits on vegetation) are 41 percent, 21 percent and 0 percent respectively. Vegetative height, though not considered adverse, is less than 25 cm (10 in.). As a result of the lack of browse and overabundance of annual grasses, antelope production is estimated at 40 percent less than what would be expected under fair condition.

As ecological succession advances beyond the fair rating the poten-

Site Potential: Big Sagebrush-Bluebunch Wheatgrass Community

Poor Ecological Condition				Fair Ecological Condition			Good Ecological Condition			Excellent Ecological Condition		
Initiation of Secondary Succession Stage				Mid-Successional Stage			Advanced Successional Stage			"Climax" Stage		
Vegetative Characteristics				Vegetative Characteristics			Vegetative Characteristics			Vegetative Characteristics		
Vegetative Structure	Percent Composition	Percent Ground Cover	"Step Point" Frequency	Percent Composition	Percent Ground Cover	"Step Point" Frequency	Percent Composition	Percent Ground Cover	"Step Point" Frequency			
Annuals	90%	60%		60%	10%		30%	5%		-10%	2%	
Forbs	30%	20%	19	20%	4%	4	10%	2%	2	5%	1%	1
Grasses	60%	40%	37	40%	6%	8	20%	3%	4	5%	1%	1
Perennials	10%	2%		40%	10%		70%	15%		+90%	26%	
Forbs	4%	1%	2	5%	4%	1	5%	1%	1	5%	1%	1
Grasses	6%	1%	4	15%	4%	3	35%	4%	7	55%	5%	16
Shrubs	0%	0%	0	20%	2%	4	30%	10%	6	30%	20%	9
Vegetative Height=	>10 inches			10 inches			25 inches			30-50 inches		

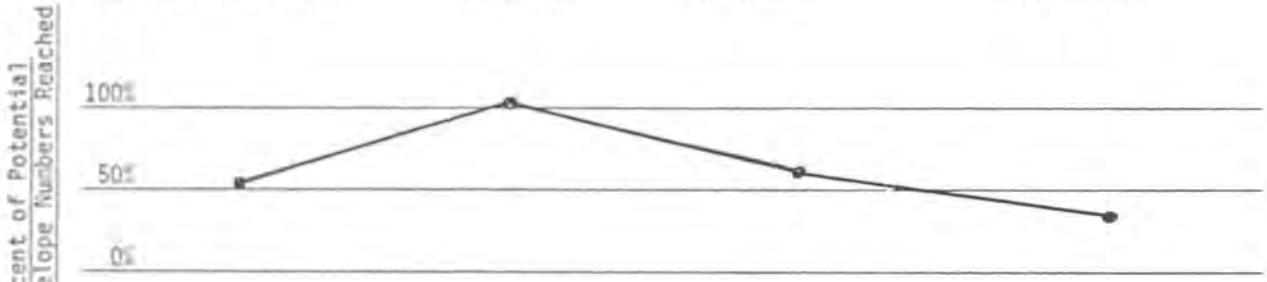


Figure 10. Example of the interrelationships of antelope populations to site potential of a big sagebrush-bluebunch wheatgrass community.

tial for antelope production again declines as a result of less than optimum ratios of grass/forbs/browse. Also, in both the "good" condition and "excellent" condition, vegetative height is in excess of 63 cm (25 in.), a condition considered to be less than optimum. Antelope production is estimated to be one-half to two-thirds less under good and excellent ecological conditions than what would be expected under fair conditions.

Land managers can use this information to regulate livestock grazing intensities or vegetative manipulation projects to favour that ecological condition most advantageous to the pronghorn antelope.

Site Development/Antelope Responses

During the Vale Range Rehabilitation Project range improvements totalling 205,000 ha (506,000 acres) of brushlands were controlled and 108,000 ha (267,000 acres) seeded. In addition, 1,600 water developments and 741 km (463 mi.) of pipelines were completed. This large-scale range rehabilitation project started in the early 1960's and terminated in the mid-1970's (Heady and Bartolome 1977).

Pronghorn antelope population censuses were conducted by the Oregon Department of Fish and Wildlife (1963-76) during the range rehabilitation project. These findings indicate that the antelope population increased from around 1,000 antelope in 1961 to 3,000 in 1976, or an increase of 200 percent.

It is postulated that the antelope population increase was related to the change in vegetation and water availability. Our delphi analysis is based on the reasoning that antelope numbers greatly increased in the project area following the large scale rehabilitation program.

Surrounding non-rehabilitated rangelands of similar vegetation and

antelope densities experienced only 5 to 20 percent increase in populations during the same period of time.

MANAGEMENT TIPS

Optimum habitat is directly related to the right combination of all the identified habitat requirements in the ecosystem. Too little or too much of any component may become the limiting factor for populations.

Pronghorn antelope, a rangeland species exclusively, is sensitive to the activities of man, especially those related to range management for livestock production. The abundance, distribution and reliability of watering sources appears of high importance. The composition and succulence of vegetation is also of major importance.

The following are management tips concerning rangeland management with regard to optimization of pronghorn antelope habitat.

Forage

(1) Maintain a vegetative structure of less than 38-51 cm (15-20 in.) in height by:

   a. livestock grazing
   b. burning
   c. plowing and seeding

(2) Maintain a vegetative composition averaging 40-60 percent grasses, 10-30 percent forbs and 5-20 percent browse (both on native range and with artificial manipulation).

(3) Maximize the persistence of succulent vegetation:

   a. selection of species for seeding (e.g. dryland alfalfas) which remain succulent late into the summer.
   b. maintenance or creation of wet meadow vegetative types through

water spreading, spring and seep modification, etc.

(4) Avoid habitat manipulation in areas of less than 15 cm (6 in.) of precipitation.

(5) Attempt to maximize habitat diversity, especially of vegetation.

(6) Maintain existing habitats of high quality.

Water

(1) Frequency of occurrence should be at no greater than 4.8 km (3 mi.) intervals.

(2) Source dependence must approximate 100 percent for the period of June through October.

(3) Quantity of water should average 1.9 liters (1/2 gal.)/antelope/day as a season-long average; 3.8 liters (1 gal.)/antelope/day from June through October.

(4) pH of water less than 9.25 and T.D.S. less than 5,000 ppm.

Cover

Vegetative cover has not been positively identified as a limiting factor among antelope in southeastern Oregon. Artificial vegetative manipulation should be designed to leave a disruptive, broken pattern of 5-20 percent of the tall shrub cover in the treatment area.

Fencing

No woven wire (sheep-tight) fencing should be allowed in antelope areas. Barbed wire fencing should be limited to the extent possible with other land management goals.

(1) Barbed wire fence specifications:

a. bottom wire 41-46 cm (16-18 in.) above ground; smooth (barbless).

b. second wire 25 cm (10 in.) above bottom wire.

c. third wire 25 cm (10 in.) above the second wire.

d. total height of 91-97 cm (36-38 in.).

e. no stays between posts.

(2) Flag all newly constructed fences with white rag flagging on the top wire to reduce the incidence of antelope collision.

(3) Avoid "grey post" or camouflage type fences.

Recreation Harassment

Nearly all human mechanized encroachment into antelope habitat creates a degree of harassment of antelope. Such recreational use of principal antelope ranges should be minimized, especially during the fawning season of May 15 to June 15. Forms of harassment include:

(1) Aircraft.

(2) Snowmobiles.

(3) Motorcycles.

Livestock Grazing Systems

Livestock grazing systems to include the following for antelope habitat needs:

(1) Reserve the right species of plants.

(2) Reserve vegetation for the season of use by antelope.

(3) Reserve the forage in the areas for the season of use by antelope.

(4) Reserve forage for a reasonable number of antelope.

(5) Maintain free water for the seasons antelope need.

(6) Fences to be constructed in accordance with specifications allowing antelope free movement.

(7) Key plant species in the range management plans will include key forbs and browse.

(8) When range management plans deteriorate antelope habitat require-

ments, mitigating measures will be implemented.

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COMMENTS AND QUESTIONS

PYRAH: You said that you sprayed 506,000 acres of sagebrush. What kind of antelope density do you have on all of that area?

KINDSCHY: This information is based on state Fish and Wildlife census figures because they're the ones that gather the biological data on the antelope. As we mentioned, on their census routes, which are aerial flies, it is approximately two per mile in these areas. Now I have participated in census routes and, quite frankly, and I

think it's similar in other areas, we do go to areas in February when they're in above average concentration and grid fly. There are vast areas that have no antelope use whatsoever and those aren't included in the density, so two per mile.

PYRAH: Two per square mile, or two per linear?

KINDSCHY: I think it's linear. It's their census route. You'd have to take that up with Oregon Fish and Wildlife. One beauty of it, it has been consistent for years, whether it's the best or not.

PYRAH: Are antelope generally distributed throughout that half a million acres or are there antelope now where there were not before?

KINDSCHY: Yes.

PYRAH: Are there antelope missing now in places where they were present before?

KINDSCHY: No. There's been translocation of use -- we did suck in antelope from Idaho. I would think the best case in point is in the Georgia Valley area, our Soldier Creek unit, which is undoubtedly the most intensively developed. In the late 1950's the biologists in the area did abandon that aerial transect. Prior to that time, back when we first came here in the mid-40's, they had approximately 100 antelope in there. It had dropped down to about 25 or so. With intensive rangeland development and the extensive water development that population now is roughly 250-300 animals. We believe some of those were brought in from Idaho. A similar case occurred in West Cow Creek. It's isolated from our Barren Valley range by a major canyon which is approximately 600 feet in depth, and a complete antelope barrier. Historically the last antelope was seen in there about 1910. None have been observed by modern ranchers. Due

to sagebrush spraying, water development, and plowing and seeding, which gives you a much better habitat for antelope, the antelope have now infiltrated the area from the north, probably, and we have resident herds in there now for the first time.

PYRAH: How much of the antelope increase could have occurred with just restructuring of the livestock use?

KINDSCHY: I doubt if you would have seen much without a long period of time elapsed. We had two basic problems for antelope there. One was the structure of the vegetation. Our big sage generally is 4 feet in height or so; this is not antelope habitat. Low sage areas had some antelope on them to be sure. The other was water distribution. Studies of Sundstrom in Wyoming and our comparisons in our Soldier Creek units where we have about one water per 2.5 square miles, as compared to the area south of it where we have one water per about 14 square miles, shows the density changes relative to water development. Water seems very critical to our antelope. The forb content of course occurs in seedings where you disturb the soil, also by seeding nomad there was a great boost. I don't think, in the studies that were shown, that the competition between cattle and antelope was that marked. Several people have mentioned this and some comparisons and I'm comparing AUM's or how many antelope it would take to eat a cow AUM; the figure of 49 sticks in my mind.

PYRAH: In our study area 70 percent of our antelope were in areas that were not grazed by cows, so there is competition between antelope and cattle.

KINDSCHY: I think what you're also pointing out is the fact that we have

such variance between habitat areas in Montana, Wyoming, the Sonora and up here, for example, in Saskatchewan and Alberta. We did find in our crested wheatgrass seedings the preferred antelope use areas are areas that had been grazed quite closely by cattle in the spring to obtain the low growth form, and then they graze it when it greens in the fall when they don't have the seed stalks to hit their noses or whatever. There's a tremendous selectivity to areas that have been grazed by livestock.

PYRAH: I wonder what your antelope did for water in pristine times without water development?

KINDSCHY: Well, according to the journals of David Thompson and Ogden and others, there were darn few antelope in the area. Most of southeastern Oregon was felt to have few antelope. They estimated around 2,000 head per all of Oregon. Now we've got 2,600 or 3,000 right in our area; and I think now they have 13,000 for Oregon. That data was just given yesterday I believe. So definitely there have been increases, yes.

GJERSING: I'm curious as to the winter conditions you have in southeastern Oregon. Have you had any hard winters when antelope would have to go on to big sage range for survival? What do you expect you're going to need for winter range in that area if you do get a hard winter?

KINDSCHY: Well, basically not. Our winters are not a limiting factor the way they are in this country. There is very little documentation of any losses from winter stress. Our antelope are mostly migratory, they go into the salt desert shrub community or into lower elevations where our precipitation is very light and it's not infrequent for

chinook type winds to blow the four or five inches of snow accumulation off. That's where three species of grasses and some winter forbs are so important.

GJERSING: You mentioned the spraying of unpalatable browse species, what were you referring to? Were they unpalatable for cattle or antelope or both?

KINDSCHY: Cattle. This program, in all honesty, is fostered by a need to prevent drastic livestock reductions. It caused a political backlash. We had a congressional inquiry; the hearings, mind you, came right up to Oregon. Forrest Sneva and others here were in on that, but it was quite an interesting show where universities, the BLM, Forest Service, and others showed -- hey, instead of making these 60-80 percent reductions, perhaps this rangeland can be repaired. Now it sure is rewarding the bad guys, one might say, and yet there is an opportunity to achieve a good many other things and in process of experience come out, I think, with a number of research projects. Godfrey's done an economic analysis and -- mind you, at $1.51 per AUM it's not economic, but at $3.00 per AUM it was economic.

GJERSING: I was wondering what the total cost of this project was in relation to the AUM return to the Bureau of Land Management in that area.

KINDSCHY: It's all in here and I have ten copies of this. I hate to quote anything because there're so many figures. Roughly we were spending somewhere between $11 and $14 million in a 10 year period. Economists blow my mind. They amortize and multiply and divide, and I don't really know if I can justify what they do.

GJERSING: From what I've seen, at least in Montana, we've had some definite beneficial effects to waterfowl from rest rotational grazing. That's one effect. But it's always been justified from a cattle industry standpoint on the basis of economics. In wildlife, it's always been either lucky or unlucky to take the side benefits from it. What I was wondering was if this thing was a total cattle operation, can we really justify this on an economic standpoint. You take a look at the total AUM return in the United States for all the BLM lands west of the Mississippi River in 1971, which is the last information I got, and it didn't even pay for the total cattle program in the state of Montana last year.

KINDSCHY: Heavens, no.

GJERSING: We seem to be very susceptible to this cattle story.

KINDSCHY: There was overproduction throughout the world of red meat. They're just now getting it down. The Forest Service and the Bureau of Land Management throughout the United States produced somewhere in the beef end of it about 6, as a maximum, percent of the cattle produced in the United States. This is insignificant to the production of a total item, but you go to a local community in Wyoming or Montana or Oregon or Nevada, and it's vital to the community there. It's a way of life. The U. S. Forest Service and others are supporting this to maintain a viable local economic base. It's not our decision that this is good or bad; it's uneconomic, to be sure. Economics use the dollar as a common denominator, and we have to equate cattle, we have to equate wildlife, water or whatever in dollar values. We're making some progress in that. When you do get a good horse to ride in government you better rein and

get him to go to where you want him to and get as much out of it as you can, and I think we did here.

GJERSING: I think we definitely got some stuff here and I think the total crux of this, to just sort of sum up, is that right now, looking at past history, in no case has the cattle industry had to justify the mass of expenditures for projects like this for benefit of cattle. Now we're trying to get some wildlife benefits out of the same land and they always come back and they hit us and say, well, what's a mallard duck worth, what's a goose worth?

KINDSCHY: They're hurting though. Our economic justifications for allotment management plans, AMP's, due to the $1.51 AUM is poor. They can't drive fence posts and economically justify it, so now they say, hey, if we face this reservoir and do some plannings around this and so forth, can't you help us out in economic justification? And I think we can. And I just mentioned the antelope impacts in the Vale project while there were benefits for waterfowl, mule deer, upland game birds and so forth in there, too.

BROWN: Do you find that sage is reinvading? We have quite a few of these projects in Colorado and some I've noticed are back almost like they were before spraying or rehabilitation or whatever they were doing.

KINDSCHY: Sagebrush is part of the climax vegetation, and eventually it will be back. This is quite controversial but I feel that grazing and sagebrush populations are not related except due to the lack of fire, due to the lack of fuel, due to grazing. Now if we get a one-two punch on sagebrush, and I'm not saying this is desirable but it could happen, if we spray an area or plow an area or an area

burns and the sagebrush, being a non-sprouter, is removed, we get sagebrush back. If it again burns or is sprayed before that sagebrush reaches sexual maturity and puts some more seed in the ground we generally have an area that's free of sagebrush for several decades. I've seen some areas that, for 30 or 40 years now, have been free of sagebrush. We got one burn area that's got about a 30 percent canopy closure which was a wildfire site and completely clean of sagebrush. Cross sectioning every sagebrush, virtually, most of them were the same age right after the fire the next year. So I think it's that one-two punch that has more to do than grazing and to look at a seeding and say, gosh, that's been mismanagement, look at the sagebrush, I feel is questionable.

BROWN: I'd agree with that. I used to think that the grazing would probably bring it back but I don't think that's really true.

ACTIVITIES AND HABITAT USE PATTERNS OF PRONGHORNS ON MONTANA-WYOMING COAL LANDS

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Abstract: Between January 1976 and August 1977, 3,410 observations of 102 marked or instrumented pronghorns (*Antilocapra americana*) were recorded. Visual observations undersampled inactive pronghorns and resulted in more disturbance than radio observations, but habitat use determination was not biased by observation type. Use of annual grass, timber, xerophytic shrub and pasture vegetation varied seasonally. Pronghorn activities were differentially dispersed between vegetation types and independent of topography. Vegetation use by pronghorn herds in different areas seemed to reflect relative availabilities of vegetation types. Pronghorns used the greatest diversity of vegetation types in summer and the least in winter. Preferences for various vegetation types shifted seasonally. Pronghorns were most active between dawn and dark, and they were less active in winter than in other seasons. Movements of pronghorns were shortest in summer and longest in spring and fall. All marked animals used different winter ranges in 1976 and 1977, and most shifted their summer activity areas significantly.

Strippable coal more completely underlays the distribution of pronghorns than that of any other large North American mammal. The present energy situation in the United States mandates that much of this coal will be removed during the next several decades. The displacement of

pronghorns in the immediate area disturbed by mining will be inescapable. However, the proximate and ultimate impacts of such displacement are unknown.

Many previous studies of pronghorns have dealt with food habits, physiology and behaviour (Yoakum 1958, Severson and May 1967, O'Gara 1969, Mitchell and Smoliak 1971, O'Gara and Moy 1972, Kitchen 1974). Habitat use patterns of pronghorns have been inferred largely from visual observations and thus have not been totally evaluated (Cole 1956, Bayless 1969). Individual movement and activity patterns, temporal and spatial relationships between activity areas and habitat preferences have not been documented. Data concerning these subjects are essential for the proper assessment and prediction of impacts coal development may have on pronghorns.

In 1976 the Denver Wildlife Research Center of the U. S. Fish and Wildlife Service began efforts to generate such data. This report presents some results of the first 18 months of those efforts. Studies are continuing and conclusions and hypotheses in this report may change.

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cooperation during all phases of the study. This research was funded by the coal program, Office of Biological Services, U. S. Fish and Wildlife Service.

STUDY AREA

My study area straddles the Montana-Wyoming state line just north of Sheridan, Wyoming (Figure 1). This approximately 1,036 km^2 area consists mainly of numerous sagebrush-grassland benches separated by small tributaries of the Tongue River which drains north through the area. Apart from the 4-5 percent of the area that is riparian, trees are largely limited to higher elevations and more mesic sites. Slopes are gradual to moderately steep and elevations range from 1,006 m at the Tongue River Reservoir to about 1,463 m near the summit of the Wolf Mountains to the west. Winters are cool and dry, and summers are warm. Annual precipitation is 35-41 cm, occurring mostly in the summer. Willmuth et al. (1976) provided more complete meteorological information on the area.

This area was selected for study because much of it has already been leased for coal development, but relatively little development has taken place so far. Potential for imminent change and for direct and indirect impacts on wildlife is very great.

METHODS

Pronghorns were captured with a cannon net or capture gun, or were run into a corral trap by helicopter. Captured animals were sexed, and aged by tooth wear and replacement. All animals were ear-tagged and neckbanded for visual identification, and selected individuals were fitted with radio-transmitting collars. Relocations were plotted on topographic

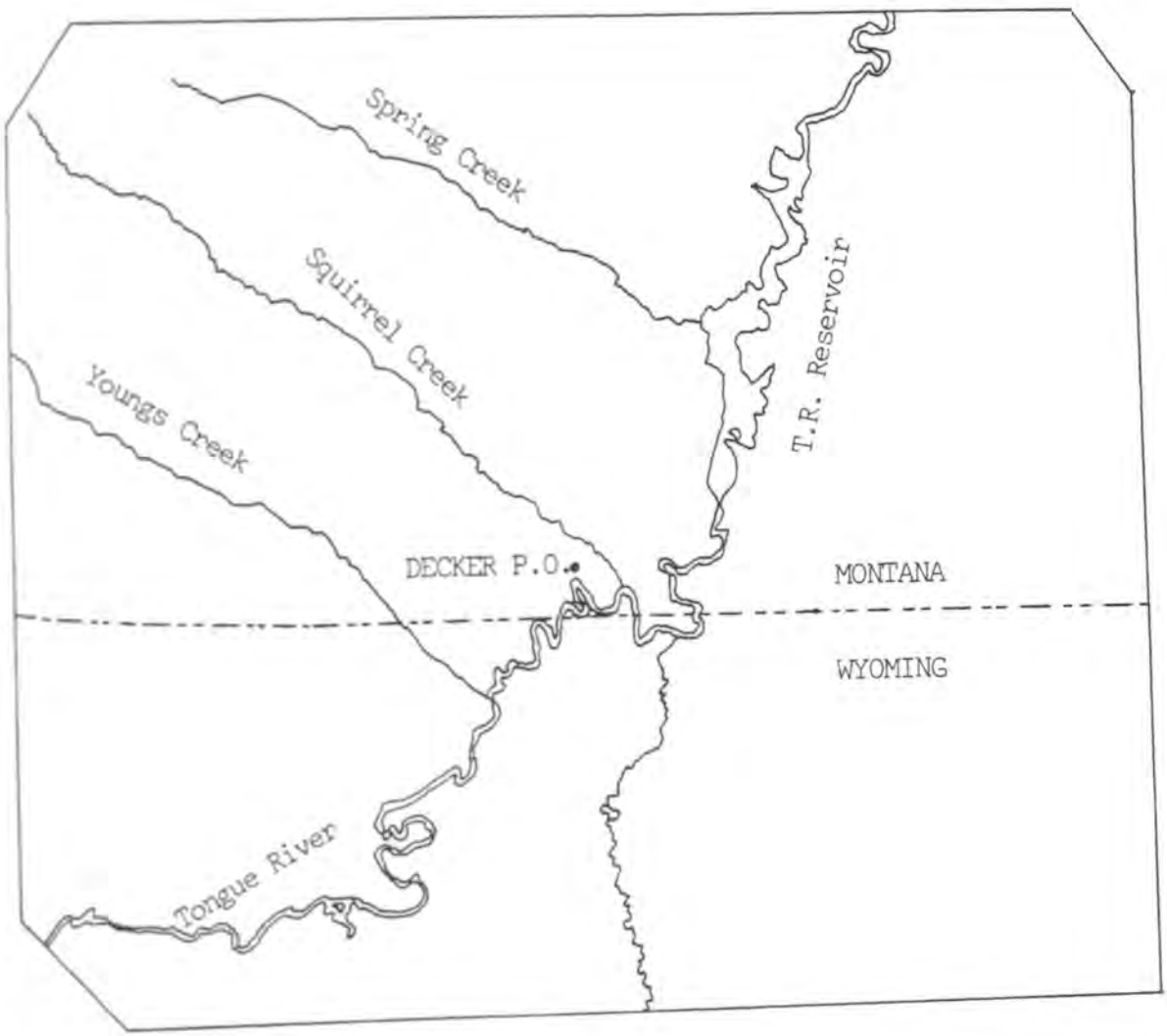



Fig. 1. Location of pronghorn study area in northern Wyoming and southeastern Montana.

maps divided into 1 km^2 quadrants. The vegetation type at each location was recorded along with slope, aspect, elevation, state of the weather and activity of the animals. Size, sex and age composition and number of marked animals were also recorded for each group observed.

To quantify diel activity patterns I monitored individual instrumented pronghorns for minimum periods of 24 hours. Visual contact was maintained as continuously as possible and was assisted by a night vision device. Each day was divided into four segments: dawn (from first light to 1 hour after sunrise); daylight; dusk (from 1 hour before sunset to darkness); and darkness.

Thirty-six vegetation types in units as small as 0.1 ha were mapped on the study area (Table 1). The vegetative distinction between the big sagebrush (*Artemisia tridentata*)/grassland and big sagebrush vegetation types was somewhat arbitrary. Pronghorn use of these two types was also similar, so they were combined into one big sagebrush vegetation group. For the same reasons, the silver sagebrush (*Artemisia cana*)/grassland and silver sagebrush types were also combined. Since pronghorns apparently did not distinguish between the five upland woodland vegetation types which they used, the ponderosa pine/juniper (*Pinus ponderosa*/*Juniper* spp), ponderosa pine/grassland, ponderosa pine/big sagebrush, ponderosa pine/deciduous shrub, and juniper vegetation types were combined into one upland woodland group. The perennial grassland, bunchgrass types were also grouped. The vegetation groups resulting from these combinations were treated in analysis as four individual vegetation types, reducing the number of vegetation types occurring on the study area to 29.

Sizes of activity areas were determined by the minimum area method (Mohr 1947). Annual shifts in seasonal activity areas were evaluated with

Table 1. Wildlife vegetation types mapped on the Tongue River pronghorn study area, Wyoming and Montana.

VEGETATION TYPES						
Woodland	Xerophytic Shrubland	Mesophytic Deciduous Shrub-Forb	Grassland	Cultivated	Disturbance	Physical Features
Deciduous Streambank Vegetation	Big Sagebrush	Upland Drainage-Seep	Perennial Grass	Alfalfa	Revegetated	Rocky Outcrop
Ponderosa Pine Forest	Big Sagebrush-Grassland	Deciduous Shrub-Grassland	Bunchgrass	Grain	Annual Forb (weed)	Pond-Impound-ment
Ponderosa Pine-Juniper	Silver Sagebrush	Floodplain-Mud Flat	Sod-forming Grass	Pasture	Barren	Stream or River
Ponderosa Pine-Grass	Silver Sagebrush-Grassland		Riparian Grassland	Fallow		
Ponderosa Pine-Deciduous Shrub	3-Leaf-Sumac-Grassland		Annual Grass			
Ponderosa Pine-Big Sagebrush	Mixed Shrub-Half Shrub					
Ponderosa Pine-Silver Sagebrush	Halophytic Shrub					
Juniper	Curlleaf Mountain Mahogany					
Aspen	Winterfat					

a paired "t" test, and vegetation availabilities within designated activity areas of pronghorns were calculated from the vegetation map with an electronic planimeter. Patterns in habitat use and activity were evaluated with contingency tables. Observed occurrences in each cell of the contingency tables were compared to expected frequencies calculated from row and column totals. Significance of variations from expected cellular values was assessed by the Bonferroni procedure (Miller 1966). Expected values for vegetation preference calculations were derived from relative availabilities of various vegetation types. Preference levels for each type were determined by "goodness of fit" tests and the Bonferroni procedure.

RESULTS AND DISCUSSION

Aerial surveys conducted by the U. S. Fish and Wildlife Service; Peter Kiewit Sons' Company, Mining District; and VTN-Wyoming suggest that six pronghorn winter complexes totalling over 1,500 animals occur on the study area. Animals from two winter complexes, one on each side of the Tongue River, were captured and marked. Between January 1976 and August 1977, 1,751 observations of 27 instrumented pronghorns and 1,659 observations of 75 neckbanded pronghorns were obtained.

Proportions of vegetation types and categories of slopes used by pronghorns were equal for visual and radio locations. Skewing of recorded habitat use toward vegetative and topographic conditions in which animals were most visible did not seem to be a general problem with visual observations of pronghorns. However, because instrumented pronghorns often associated with uninstrumented pronghorns, their transmitters assisted acquisition of visual locations of neckbanded individuals. Such "radio-

assisted" visual locations probably approximated radio locations more closely than "unassisted" visual locations. However, when "assisted" and "unassisted" visual locations were compared, recorded use of woodland types was the only difference. Unassisted visual observations of pronghorns using woodlands were less frequent than expected.

Perception of pronghorn activities was not independent of observation type. Visual observations of inactive pronghorns were less frequent than expected, and visual observations of pronghorns running, fleeing the observer, and vigilant were more frequent than expected. Differences from expected frequencies of these activities just missed being significant at the 5 percent level suggesting investigator-caused disturbances were more frequent for visual observations than for radio observations.

The habits and habitats of pronghorns make them more observable than most other North American ungulates. Visibility biases in the determination of habitat use are apparently not great, suggesting that radio and visual observations of pronghorns may often be combined in analyses. Although not as important as it might be in reducing biases in the observability of more secretive species, telemetry is a valuable aid in locating pronghorns at will, and in increasing sample sizes. It is also valuable in that it allows investigator-caused disturbances of the animals to be minimized.

Habitat Use

Topography: Most pronghorn relocations were on gently to moderately sloping land. Although pronghorns were occasionally located on slopes exceeding 50 percent, 44 percent of all relocations were on slopes of 5 percent or less. Slopes of 6 to 10 and 11 to 20 percent accounted for

32 and 17 percent of pronghorn locations. Only 7 percent of all relocations were on slopes exceeding 20 percent. It seemed that pronghorns selected bedding sites that afforded them high visibility of their surroundings. I suspected there would be a differential distribution of pronghorn activities according to slope, and that steeper slopes would be used more for bedding. However, the proportions of various pronghorn activities recorded for each category of slope did not differ significantly from the proportions of total observations in each category.

Seasonal Vegetation Use: Of 29 vegetation types mapped on the study area, 18 were used by instrumented pronghorns at some time during the year. Use of seven of those types by pronghorns differed between seasons.

Big Sagebrush

Pronghorns used the big sagebrush vegetation type significantly more often than expected during winter ($P < 0.05$). Spring and summer use of the big sagebrush type did not differ from expected, and fall use was less than expected ($P < 0.05$). Severson and May (1967), Sundstrom et al. (1973), and others have documented the importance of big sagebrush to pronghorns in winter, and my observation of heavy winter use of big sagebrush corroborates their findings. Cole and Wilkins (1958) also reported relatively few autumn observations of pronghorns in big sagebrush vegetation types although consumption of big sagebrush was high. If dietary diversity is important to pronghorns, low use of the big sagebrush type in fall might reflect attempts to vary food consumption. Pronghorns in my study area probably have limited winter diets as they do in other areas (Cole and Wilkins 1958, Severson and May 1967, Bayless 1969, Sundstrom et al. 1973). Maintaining high dietary diversity in fall should improve condition of pronghorns entering the winter period when

their diet may be limited, and thus improve overall survival (Wallmo et al. 1977).

Pronghorns used big sagebrush types more than expected for feeding and less for bedding during all seasons. This reflects the nearly universal importance of big sagebrush as food for pronghorns. It may also reflect a preference of pronghorns to rest in locations that provide them an unobstructed view. The potential obstruction of vision in sagebrush stands would be greater than in more open types.

Silver Sagebrush

Pronghorns on my study area used silver sagebrush vegetation types less than expected in summer ($P < 0.05$). They used these types more than expected during fall although the difference was not significant. Higher use of silver sagebrush in fall may partly complement the low fall use of big sagebrush. High autumn consumption of silver sagebrush reported by Cole (1956) and Cole and Wilkins (1958) suggested that pronghorns on their study areas also frequented silver sagebrush vegetation types in fall. Since silver sagebrush sites are more mesic than big sagebrush sites, high autumn use of this type may also reflect a greater abundance of succulents than occurs in some other types. Additional data are needed to explain the low summer use of the silver sagebrush type. Seasonal differences in activities of pronghorns in the silver sagebrush types were not significant.

Mixed Shrub

The mixed shrub type is characterized by an admixture of shrubs and half shrubs (e.g. broom snakeweed (*Gutierrezia sarothrae*), fringed sagewort (*Artemisia frigida*), big sagebrush and rubber rabbitbrush (*Chrysothamnus nauseosus*). It usually occurs on disturbed sites and, because of

high crown coverage, diversity and abundance of succulent species is often low. Pronghorns used the mixed shrub vegetation type significantly less than expected in spring ($P < 0.05$). Winter and summer use did not differ significantly from expected, and fall use of the mixed shrub vegetation type was greater than expected ($P < 0.05$). During the spring, pronghorns normally seek succulent grasses and forbs as a large portion of their diet (Cole and Wilkins 1958, Severson and May 1967, Beale and Smith 1970). The mixed shrub type is typically characterized by low production of succulents, which could explain its low spring use.

Consumption of rubber rabbitbrush by pronghorns appeared high on my study area in fall, and they apparently ate it in winter when they found it. Cole and Wilkins (1958) also reported high consumption of rabbitbrush by pronghorns in fall. Rabbitbrush is a common component of the mixed shrub vegetation type. Consumption of rabbitbrush, and perhaps other half shrubs, could explain high use of this type in the fall. Autumn use of this type, like the silver sagebrush type, could complement the low autumn use of big sagebrush.

With the exception of feeding, activities of pronghorns recorded in the mixed shrub type did not differ by season. In winter, pronghorns fed significantly more than expected in the mixed shrub type ($P < 0.05$), even though overall use of this type in winter was slightly lower than expected. A large portion of the winter diet of pronghorns in my study area is apparently big sagebrush, and any increased diversity resulting from feeding in the mixed shrub type should be beneficial (Wallmo et al. 1977).

Pasture

Although only 1 percent of the annual vegetation use by pronghorns was in pastures, 3 percent of the spring use was in pastures. Essentially

all use of pastures occurred in spring and summer, and spring use of pastures was significantly greater than expected ($P < 0.05$). Observation numbers were too few for meaningful breakdown by activity, but spring and summer use of pastures likely reflects their often lush green-up in spring.

Perennial Grasslands

Pronghorns used perennial grasslands less than expected in winter and more than expected in fall. These differences were not quite significant at the 5 percent level. Use of perennial grasslands during spring and summer did not differ from expected. On my study area grasses are essentially unavailable to pronghorns for much of the winter because of deep snow. A pattern of low grassland use in winter, therefore, could be expected. As with silver sagebrush, the high autumn use of perennial grasslands may reflect a tendency to use more mesic sites where forbs might still be available in the fall. Pronghorns generally feed on grasses mainly in spring (Cole and Wilkins 1958, Severson and May 1967, Beale and Smith 1970). If this is true on my study area, so far it has not been manifested in higher than expected spring use of the perennial grassland type.

Perennial grasslands were consistently used less for feeding and more for bedding than expected. These differences from expected bedding and feeding proportions were significant in all seasons except fall ($P < 0.05$). Pronghorns seemed to prefer open bedding sites, and the high use of grasslands complements the low use of big sagebrush for bedding.

Annual Grasslands

Pronghorns on my study area used annual grasslands significantly

less than expected in winter and spring and more than expected in summer ($P < 0.05$). Pronghorn use of annual grasslands did not differ from expected in fall. Low use of annual grasslands in winter is not surprising. Since pronghorns mainly feed on grasses in the spring, the annual grassland use I observed is reversed from what would seem logical (Cole and Wilkins 1958, Severson and May 1967, Beale and Smith 1970). Observation numbers were insufficient to divide use of this type by activity, and the low frequency of observations may in itself account for the apparent low annual grassland use in spring and high use in summer. Perhaps additional data will help clarify the pattern of annual grassland use by pronghorns.

Woodland

Observations suggested that pronghorns sought the various upland timber vegetation types as a source of shade. It was not uncommon to see 12 or more individuals crowded into the shadow of a juniper or clump of pines on hot afternoons. Upland woodlands comprised only 2 percent of the annual use but 5 percent of summer vegetation use by pronghorns. Pronghorn use of the upland woodland group during summer was significantly greater than expected ($P < 0.05$). During the rest of the year use of the upland woodlands did not differ from expected. Pronghorns used timber types significantly more than expected for bedding and less for feeding ($P < 0.05$), corroborating my observation that timber types were used mainly as a restful escape from the hot sun. Buechner (1950) also reported that pronghorns rested in the shade of trees and other tall vegetation on hot days.

Herd Variations

Dispersal patterns from the two winter ranges where pronghorns were

marked suggested six identifiable summer herd units. I have enough data on four of these herds to compare their vegetation use patterns. When lumped over all seasons the vegetation use patterns of these four herds often differed. However, the differences in use of the various vegetation types seemed at least partly dependent on vegetation availability in the activity area of each herd and may not indicate different vegetation preferences.

Pronghorn Herd 1 used the big sagebrush vegetation type more than expected from the proportions of total observations in each herd. Herds 2, 4 and 6 used big sagebrush types less than expected. Herd 1 spent the summer in the vicinity of the winter range it shared with Herds 2 and 4. Herd 4 spent the summer in an area 20-30 km from its winter range, and the summer activity area of Herd 2 was between those of Herds 1 and 4. Vegetation occurrence figures are not available for all of this area but observations indicated that big sagebrush was less common in the area occupied by Herd 2 and did not occur in the area occupied by Herd 4.

Big sagebrush was almost equally available to Herds 1 and 6, but perennial grasslands covered 22 percent of the area occupied by Herd 6 and only 5 percent of the area occupied by Herd 1 (see vegetation preference section). Herd 6 used perennial grasslands more and Herd 1 less than expected. The high availability of grasslands to Herd 6 almost surely reduced its use of big sagebrush. Herds 2 and 4 used perennial grasslands more than expected, and this also reflected a greater availability of grasslands in their activity areas.

Use of both sumac and silver sagebrush vegetation types was less than expected for Herds 1 and 6 and greater than expected for Herds 2 and 4. My observations suggest that both of these vegetation types were rela-

tively more abundant in the activity areas of Herds 2 and 4. Frequencies of use of the annual grassland and deciduous mesophytic shrub types also seemed to relate to their relative availabilities.

Social interactions between individuals and groups of pronghorns in summer may cause dispersal of the different herds. Instead of different vegetation preferences determining spatial distribution, the spatial distribution resulting from social interactions may determine the vegetation use by each herd. More complete vegetation availability data and higher observation frequencies for some herds are needed to substantiate this hypothesis.

Vegetation Preferences

Other investigators have reported vegetation use patterns of the type discussed above (Cole 1956, Cole and Wilkins 1958, Bayless 1969). Determination of actual preferences for vegetation types, however, can be made only by comparing use of vegetation types to their availabilities. One of the objectives of my study is to determine pronghorn vegetation preference. At this writing, vegetation availability data were still incomplete for some areas occupied by pronghorns. However, preference determinations for the winter and early spring activity area of Herd 6 and the summer and early fall activity area of Herd 1 were possible.

Herd 1 occupied an area of 3,098 ha during summers of 1976 and 1977. Nineteen vegetation types ranging in area from 0.1 to 1,786 ha were represented, and 14 were used by pronghorns. Eight of the 14 vegetation types were used in different proportions than they were available (Table 2). Mixed shrub, perennial grassland, silver sagebrush and annual forb types were used in a greater proportion than they were available ($P < 0.05$). The riparian, sumac, upland woodland and pasture vegetation

types were used less than expected according to availability ($P < 0.05$). Use of the remaining six vegetation types was as expected based on availability.

Table 2. Availability of 14 vegetation types and use by pronghorns in Herd 1 during summer and early fall. Asterisk indicates the observed frequency of use differed from the expected frequency at the 0.05 level.

Vegetation Type	Percent Available	Percent Use
Ponds	.2	.1
Riparian	4.2	.1*
Annual Grassland	1.5	3.6
Mixed Shrub	.1	6.8*
Perennial Grassland	5.8	15.8*
Big Sagebrush	58.2	57.2
Silver Sagebrush	.9	2.7*
Sumac	5.3	2.8*
Upland Seep	1.0	1.4
Upland Woodland	11.7	4.3*
Pasture	9.0	2.4*
Alfalfa	1.3	.5
Grain	.2	.6
Annual Forb	.1	1.7*
Other Types	.6	.0

During winter and early spring Herd 6 occupied an area of 1,793 ha including 14 vegetation types of 0.4 to 1,040 ha. Only three vegetation types were used by pronghorns in the winter of 1976-77 (Table 3), and big sagebrush accounted for 90 percent of that use. Perennial grasslands and silver sagebrush were used 9 and 1 percent of the time. The big sagebrush type was used significantly more than its availability, and all other types were used less than their availabilities ($P < 0.05$).

Pronghorns in Herd 6 used six vegetation types in early spring 1977 (Table 4). Perennial grasslands and big sagebrush types accounted for 65 and 23 percent of the observations. Grassland use was greater than its proportional availability, and use of big sagebrush was less than its

availability ($P < 0.05$).

Table 3. Availability of three vegetation types and use by pronghorns in Herd 6 during winter. Asterisk indicates the observed frequency of use differed from the expected frequency at the 0.05 level.

Vegetation Type	Percent Available	Percent Use
Perennial Grassland	21.7	9.4*
Big Sagebrush	58.0	89.8*
Silver Sagebrush	8.1	.8*
Other Types	12.1	.0

Table 4. Availability of six vegetation types and use by pronghorns in Herd 6 during early spring. Asterisk indicates the observed frequency of use differed from the expected frequency at the 0.05 level.

Vegetation Type	Percent Available	Percent Use
Perennial Grassland	21.7	64.9*
Mixed Shrub	.2	1.4
Big Sagebrush	58.0	23.0*
Silver Sagebrush	8.1	8.1
Sumac	3.8	1.4
Pasture	1.1	1.4
Other Types	7.0	.0

In general, vegetation type preference calculations corroborate the trends in overall seasonal vegetation use. For example, use of the big sagebrush type was greater than expected in winter, less than expected in spring, and not different than expected in summer by both procedures. Likewise, fall use of the mixed shrub type was high calculated by either method. On the other hand, summer use of silver sagebrush was greater than expected in the preference calculations and less than expected in overall use calculations. Similar differences were apparent for other vegetation types as well, emphasizing the distinction between calculations

of vegetation use and preference. Expected values in the preference calculations were derived from vegetation type availability. In the seasonal use calculations, expected values for each vegetation type and season were derived from the total number of observations obtained. Therefore, a level of use of a vegetation type does not necessarily indicate a preference level for that type.

Selection (or preference) for a vegetation type expressed in terms of use and availability provides more information than the simple analysis of use that is usually performed (Cole 1956, Cole and Wilkins 1958, Bayless 1969). Strict interpretation of habitat preferences also could be misleading, however. For example, summering pronghorns used the mixed shrub vegetation type significantly more than expected (Table 2). The big sagebrush type was not used more than expected. However, pronghorns used the big sagebrush type 57 percent and the mixed shrub type only 7 percent of the time; so it would be inaccurate to conclude that summering pronghorns prefer mixed shrub types to big sagebrush types. It can be concluded, however, that in relationship to availability, the mixed shrub type was more preferred than the big sagebrush type.

Knowledge of relative vegetation preferences could provide an expendability scale for the various habitats on an area. Such a scale could help solve many land management problems. As coal development intensifies in this area questions such as "Which of these railroad routes will have the least adverse impact on pronghorns?" will be asked more frequently. Detailed knowledge of preference for and availability of various habitats will help answer such questions.

Activity Patterns

Seasonal Activities: Only 24 percent of my observations were of inactive

pronghorns. Buechner (1950) also reported that pronghorns were inactive less than 30 percent of the time. I found pronghorns inactive 29, 22, 20 and 24 percent of the time during winter, spring, summer and fall. Compared with annual proportions pronghorns on my study area were significantly less active in winter and more active in summer than expected ($P < 0.05$). Pronghorns were also more active in spring than expected but the difference was not significant at the 5 percent level.

Bruns (1977:568) also concluded that winter activities of pronghorns were "conservative". He attributed low winter activity to low ambient temperatures and especially to difficulty in movement caused by snow. To conserve energy pronghorns should minimize activities during harsh winter conditions. Feeding bouts should be more intensive than in milder seasons when forage diversity is greater and metabolic costs of activity are lower. Bruns (1977) observed that feeding bouts of pronghorns were longer in the winter than in other seasons. Extended but less frequent feeding bouts may allow concentration of the mandatory feeding time during the most environmentally favourable parts of the day and still allow low levels of overall activity.

In spring, demands of fetal development increase and nutritious forage is more diverse and abundant. Female pronghorns must provide for fetal development as well as recoup winter energy losses. If the reproductive success of female pronghorns is related to nutrition as it is for some other mammals, time spent feeding should increase in the spring (Nalbandov 1964:249). Lactation probably demands much feeding time in summer as well. The high levels of activity I observed in spring and summer may reflect increased feeding.

The vast majority of my activity observations were for females. In

contrast to females, adult males appeared most active in late summer and fall. This increased activity seemed associated with the rut. Kitchen (1974) also observed that activity levels of territorial males increased dramatically during the rut. However, more observations are necessary to evaluate activity patterns of male pronghorns on my study area.

Diel Activities: Most of the observations from which seasonal activities were determined were diurnal, suggesting that pronghorns were highly active in daylight. Eight continual 24-hour tracking periods during summer and fall verified that pronghorns were largely diurnal and crepuscular (Table 5). Forty-four percent of 1,025 records of diel activity were for inactive animals. Only 32, 38 and 14 percent of classifiable observations during dawn, daylight and dusk periods were of inactive pronghorns. In contrast, 80 percent of pronghorns observed at night were inactive. Periods of inactivity were significantly fewer than expected during dawn, daylight and dusk, and they were greater than expected during darkness ($P < 0.05$). Kitchen (1974) reported that pronghorns engaged in all activities both day and night but offered no frequencies. Buechner (1950) reported pronghorns were active only 14 and 35 percent of 2 nights during which they were observed.

Pronghorns were observed feeding more than expected during daylight and dusk and less than expected during darkness ($P < 0.05$). They also fed more than expected during the dawn period, but the difference was not significant. All other activities also occurred less than expected at night ($P < 0.05$). The tendency for pronghorns to be active primarily during the day did not vary between July and November. During rut, male pronghorns seemed agitated and vigilant. My observations suggest that

during rut they may have been more active at night than females but they were still less active at night than during the rest of the day.

Table 5. Classifiable diel pronghorn activities during summer and fall. Does not include 13 percent of total observations classified only as active. "L" and "G" signify the activity was recorded in Lower and Greater than expected frequencies. Asterisk indicates the observed frequency of use differed from the expected at the 0.05 level.

	Activity (Percent)		
Time of Day	Inactive	Feeding	Others
Dawn	32 L*	51 G	17 G
Daylight	38 L*	50 G*	12 G
Dusk	14 L*	60 G*	26 G*
Darkness	80 G*	18 L*	2 L*

During the summer pronghorns ceased activity abruptly at darkness and usually resumed activity at first light. Daily peaks of activity occurred shortly after sunrise and shortly before sunset. Daylight periods of inactivity were highly variable, were usually longest in mid-afternoon and seemed dependent on the amount of activity the night before. Occasionally pronghorns would have an activity bout before dawn and then remain inactive for much of the early morning. Sometimes major movements (e.g. to a water hole) were made during dawn or dusk, but I do not know if these were more frequent than during other times of the day. Kitchen (1974) also reported morning and evening peaks in pronghorn activity, and Buechner (1950) and Bruns (1977) found that pronghorn activity patterns were variable.

During winter pronghorns seemed to remain inactive longer after sunrise than during summer. I have no nighttime observations during winter but the low overall activity and the apparently lower morning activity

suggest that pronghorns were probably inactive much of winter as well as summer nights. Bruns (1977) also reported a lengthening of the post-dawn inactivity period during winter. From an energy standpoint winter activity would be most advantageous during the mildest part of the day. Night, and especially early morning activities, should be minimized.

Movements

Few pronghorns east of the Tongue River have been marked and these have been monitored only one summer. Therefore, this discussion of movements pertains only to pronghorns marked west of the Tongue River. However, movement trends appeared similar east of the river.

Radio telemetry indicated that at least 30 percent of the pronghorns that wintered on the west side of my study area in 1976 and 1977 moved long distances to summer activity areas (Figure 2). Eight instrumented animals migrated to summer activity areas 15-36 km from their winter range. Since the pronghorn density on the study area was only 1.5 per km^2 and since migratory pronghorns crossed much seemingly suitable habitat, the reasons for these movements are unclear. Some landowners claim that pronghorn populations were formerly larger on my study area but they declined. They feel that pronghorn numbers have increased in recent years. If this is true, the long movements by some marked pronghorns may indicate the natural expansion of a growing population. Also, as will be discussed later, the long movements of some pronghorns may simply reflect a natural propensity to move.

Spring and fall movements of pronghorns were long and erratic. Movements of 5 and even 10 km per day were not uncommon (Figure 3). Repeated observations in the same place were not common and sometimes instrumented

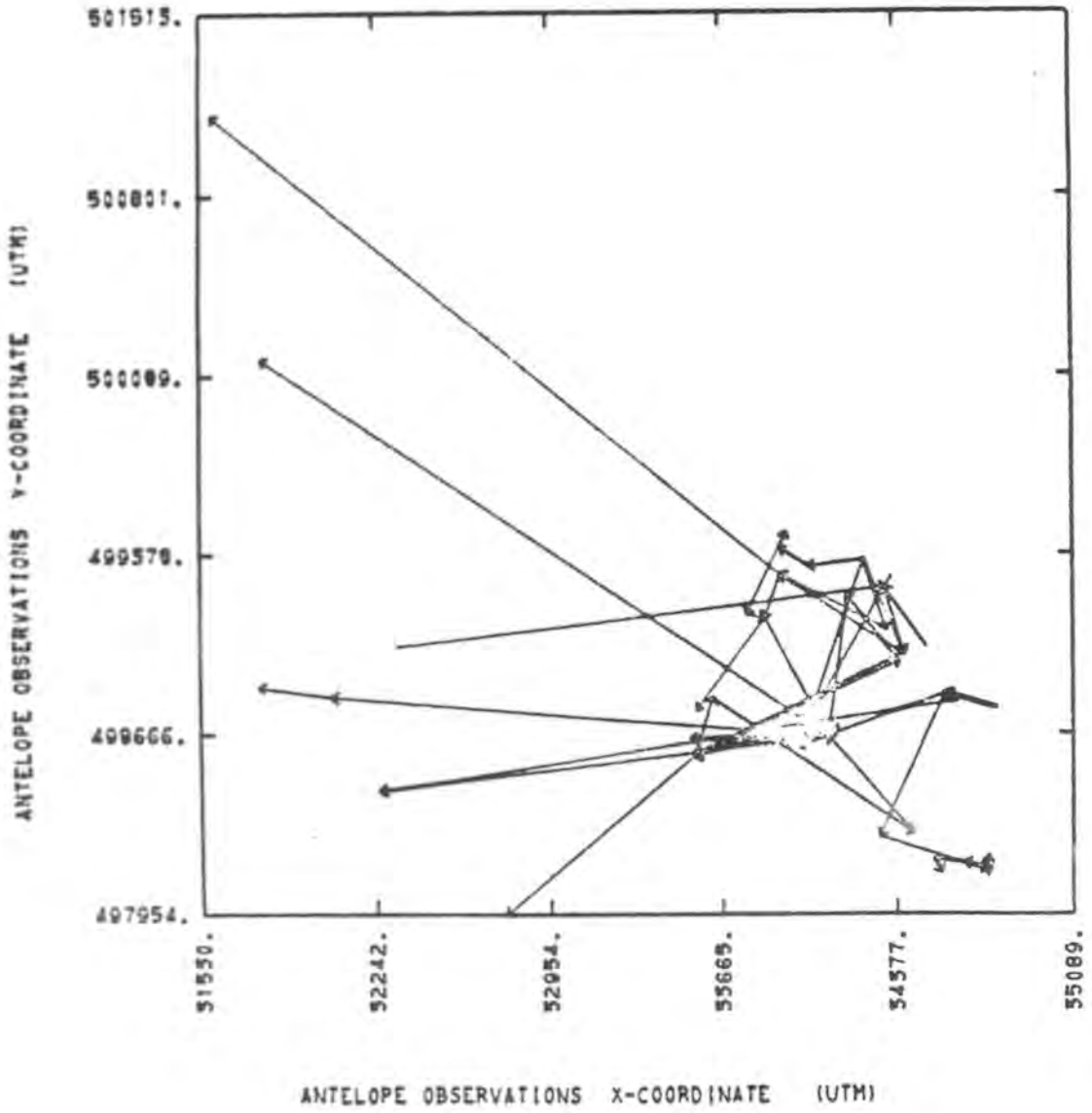

Figure 2. Spring movements of four instrumented pronghorns in 1977 showing migrations from spring to summer activity areas. Grid interval is 7.12 km. Arrows indicate direction of travel.

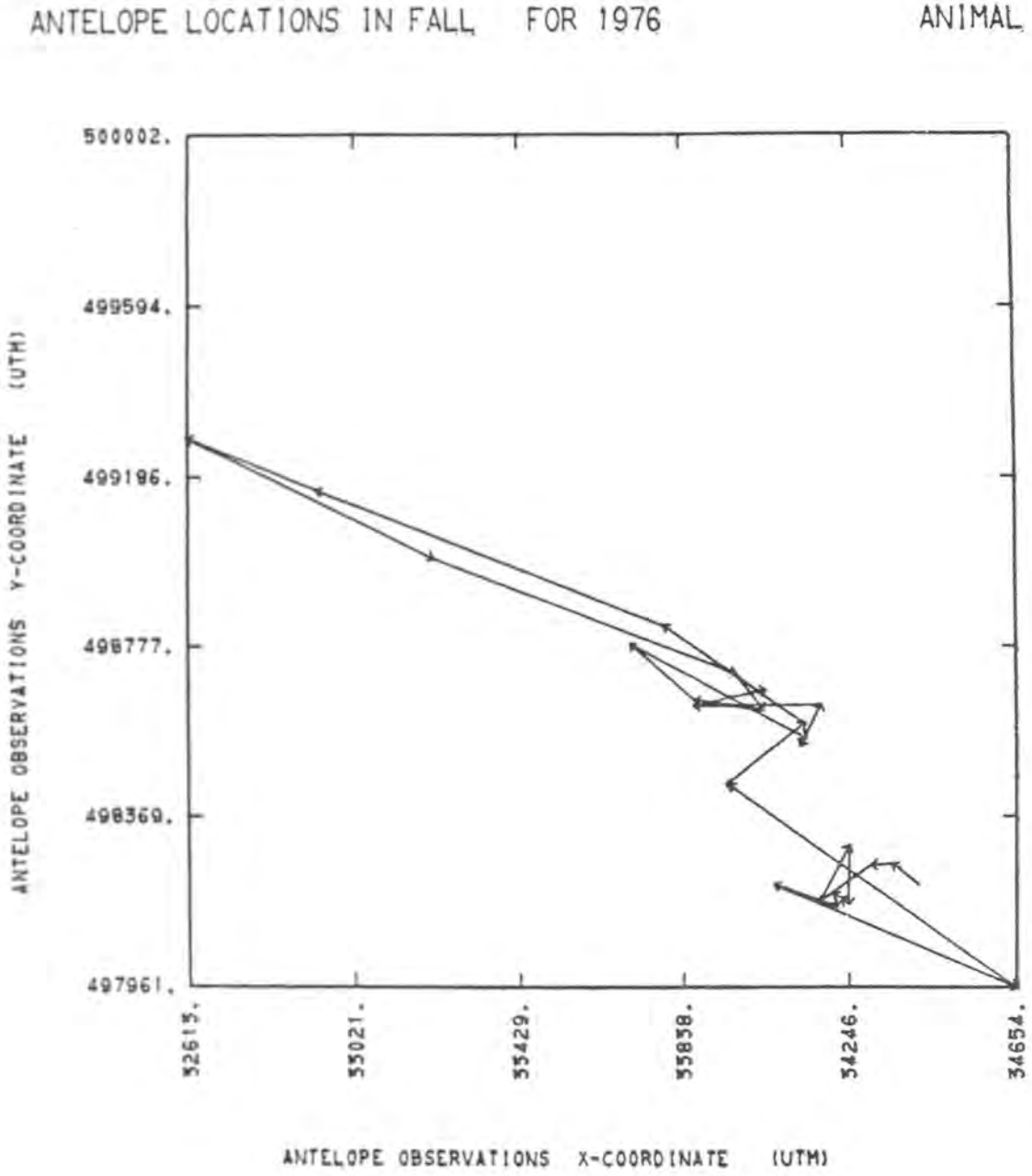

Figure 3. Plot showing extensive fall movements of female pronghorn 32 during 1976. Grid interval is 4.08 km. Arrows indicate direction of travel.

pronghorns remained unlocated for several days. In spring some pronghorns moved to distant summer activity sites; other animals moved away and returned. Pyrah's (1970) description of a "spring shuffle" closely resembles the extensive and erratic spring and fall movements I observed. The areas occupied during spring and fall were very large and reflect these long movements (Table 6).

Table 6. Sizes of seasonal activity areas of some representative marked pronghorns in 1976 and 1977.

Season	Activity Area (km^2)	
	Mean	Range
Winter	18.1	12.5-22.2
Spring	39.9	18.7-55.0*
Summer	6.4	.9-12.3
Fall	26.1	6.7-46.2

*Not including one animal's 297 km^2 activity area.

Pronghorn movements in summer were usually shorter and more predictable than during either fall or spring. By early June most pronghorns had moved to the area they would occupy until October. "Favourite" locations were used repeatedly. The mean size of pronghorn activity areas was smaller in summer than any other season, reflecting limited summer movements.

Winter movements of pronghorns were also less erratic than those of spring and fall. They were longer than movements made during summer, however, and winter activity areas were usually larger than summer activity areas. Bayless (1969) reported that pronghorns in central Montana also used large activity areas in winter.

Activity areas of most marked pronghorns shifted within as well as

between seasons. Marked pronghorns shifted their summer activity areas a mean 3 km between 1976 and 1977 (Table 7). The 1977 activity areas of a few pronghorns overlapped their 1976 activity areas (Figure 4). Other animals shifted activity areas more noticeably, greatly reducing or eliminating overlap between years (Figures 5 and 6). Overall, shifts in summer areas between years were highly significant ($P < 0.005$). Some shifts in sites where fawns were born were also observed. Autenrieth (1976) reported that pronghorns in Idaho did not fawn in the same place each year. He suggested that variations in snow conditions influenced fawning site selection, but he did not report the spatial relationships of summer activity areas in general. Kitchen (1974) found that territories of adult male pronghorns shifted from year to year. Some of the shifts in summer activity areas I observed might be explained if the distribution of females is related to male territories. However, in many cases, instrumented animals shifted activity areas while the distribution of pronghorns in general appeared unchanged.

Table 7. Distances between 1976 and 1977 seasonal activity centers for 17 pronghorns marked during both years.

Season	Distance (km)	
	Mean	Range
Winter	6.8*	5.8-8.5
Summer	3.3*	1.2-9.6

*Indicates difference between 1976 and 1977 activity centers significant at the 0.005 level.

Although I identified separate herds of pronghorns during both summer and winter, attachments to specific animal groups and locations were not strong among pronghorns on my study area. Kitchen (1974) also

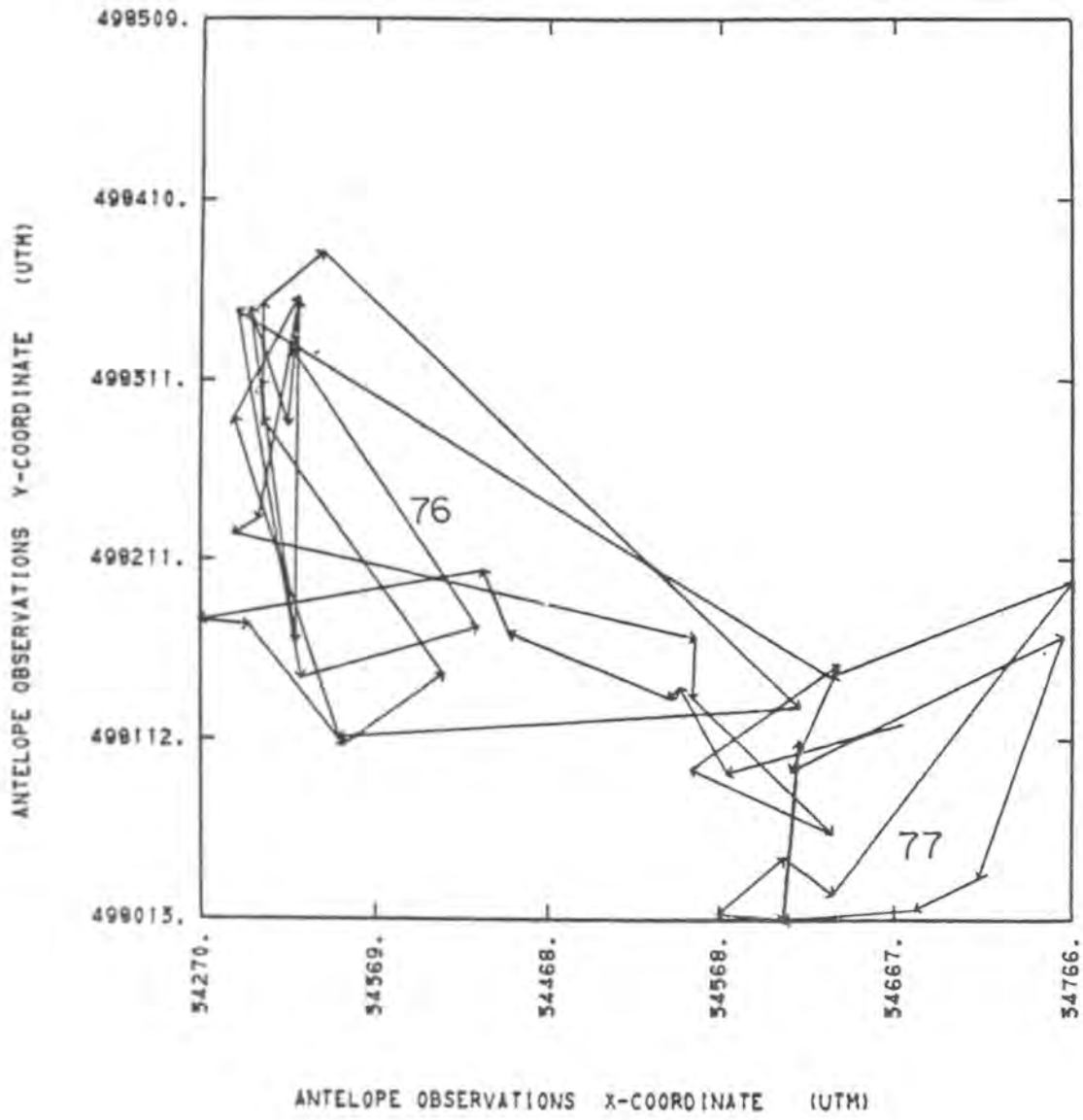

Figure 4. Summer activity areas of female pronghorn 49 in 1976 and 1977. Grid interval is 1.01 km. Asterisk indicates first location in summer 1977. Arrows indicate direction of travel.

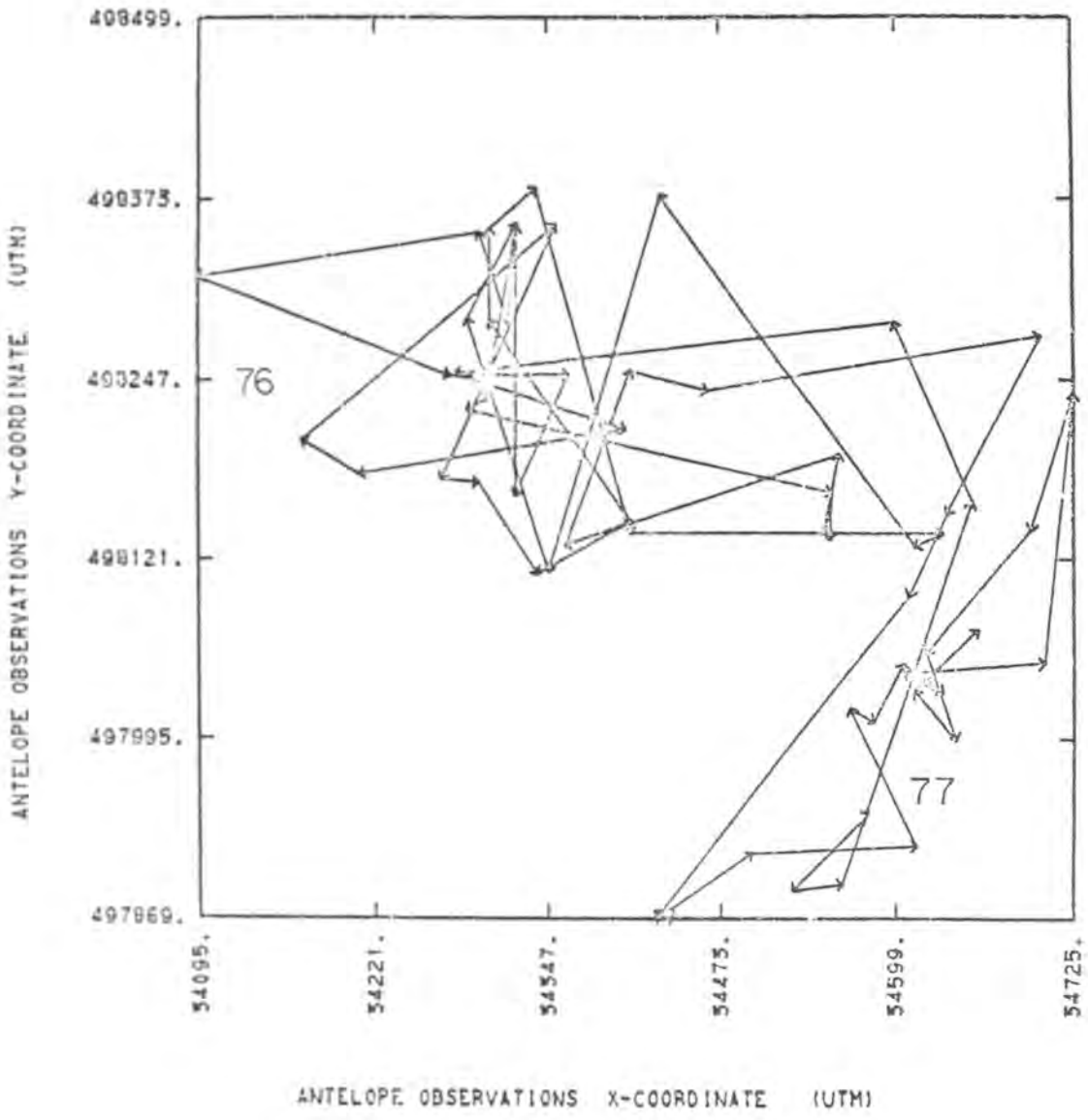

Figure 5. Summer activity areas of female pronghorn 1 in 1976 and 1977. Grid interval is 1.26 km. Asterisk indicates first location in summer 1977. Arrows indicate direction of travel.

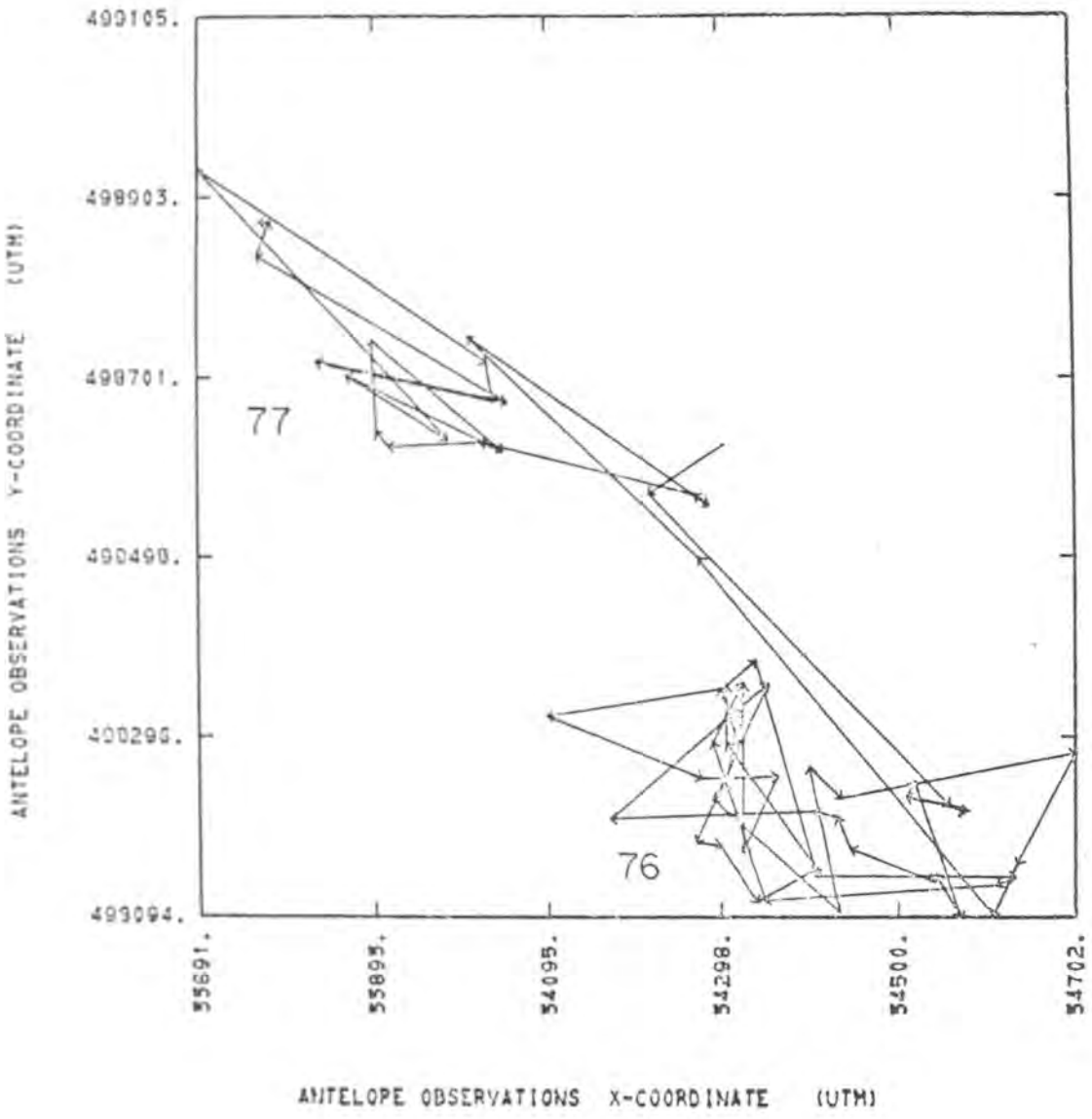

Figure 6. Summer activity areas of female pronghorn 32 in 1976 and 1977. Grid interval is 2.02 km. Asterisk indicates first location in summer 1977. Arrows indicate direction of travel.

reported that cohesion in most pronghorn aggregations was low, but Pyrah (1970) reported that individual herds of pronghorns were highly cohesive.

All pronghorns marked in 1976 and 1977 used a different winter range each year. The mean center of activity during the winter of 1976-77 was almost 7 km north of the activity center during the winter of 1975-76 (Table 7). Since nearly all marked pronghorns were on the same winter range at the same time, plots of their movements are very similar (Figures 7 and 8). Observations during the winter of 1977-78 suggested a different winter range use pattern than the previous two winters, and a different area was apparently used during the winter of 1974-75 (Coenenberg et al. 1976).

Several pronghorns also shifted activity areas within each winter. Five instrumented animals moved 10-20 km between winter herds. Snow conditions were not conducive to travel and reasons for the movements were not apparent. Bayless (1969) also reported that some pronghorns shifted winter activity areas and others did not, but movements reported by Bayless (1969) were not as long as those on my study area.

Normally, ungulate seasonal ranges are smallest in winter. This was not true for pronghorns on my study area. During the severe winter of 1977-78 pronghorns travelled extensively until severe conditions forced them to concentrate in small areas of exposed sagebrush, where they stayed until conditions moderated. During the previous two winters periods of severe concentration did not occur or were short-lived, and pronghorns continued their longer movements throughout the winter. This may suggest that normal winter range availability on my study area is great. It also suggests that pronghorns are opportunistic and that, if possible, they will move and take advantage of beneficial conditions.

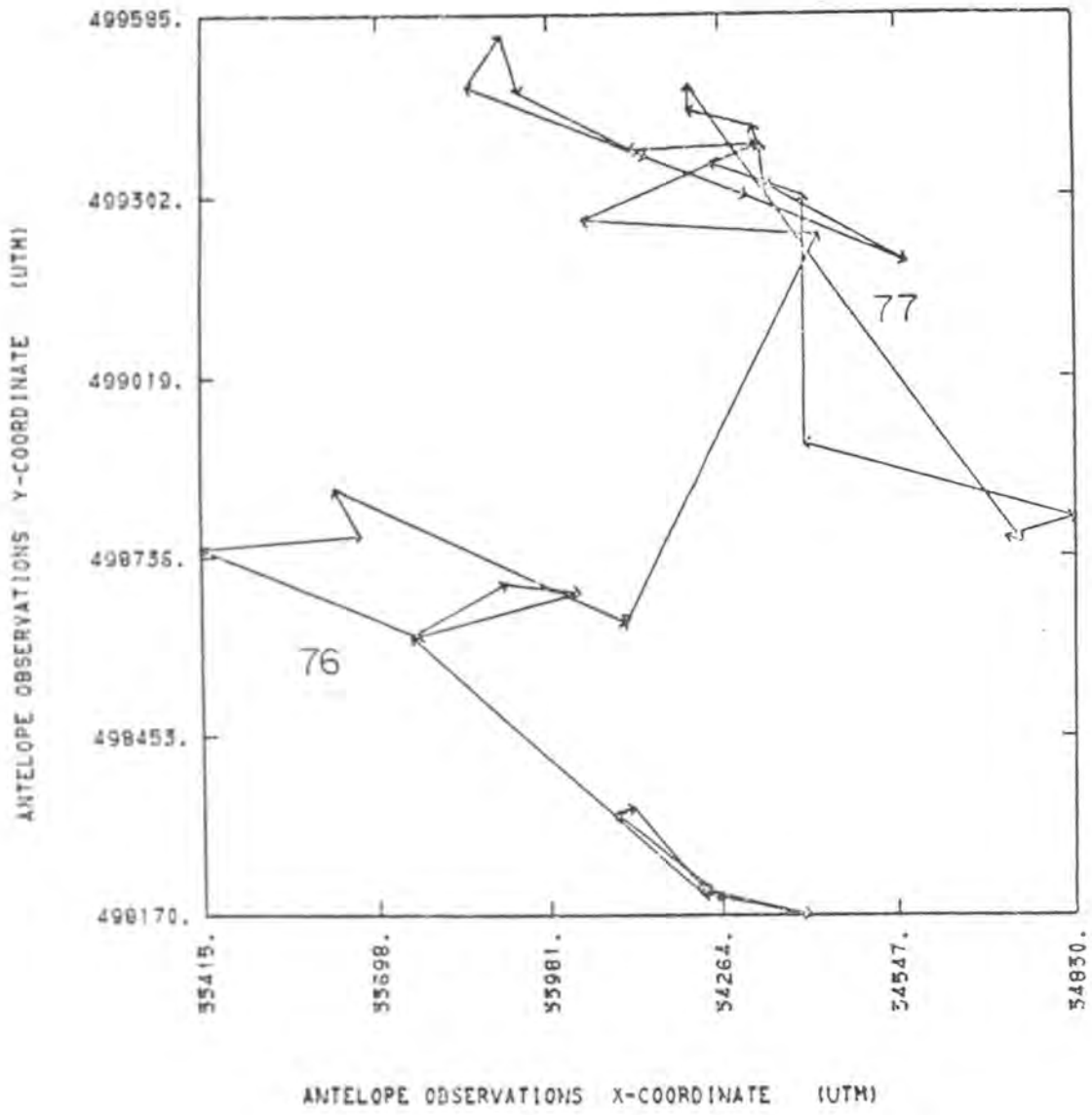

Figure 7. Winter activity areas of female pronghorn 1 in 1976 and 1977. Grid interval is 2.83 km. Asterisk indicates first location in winter 1977. Arrows indicate direction of travel.

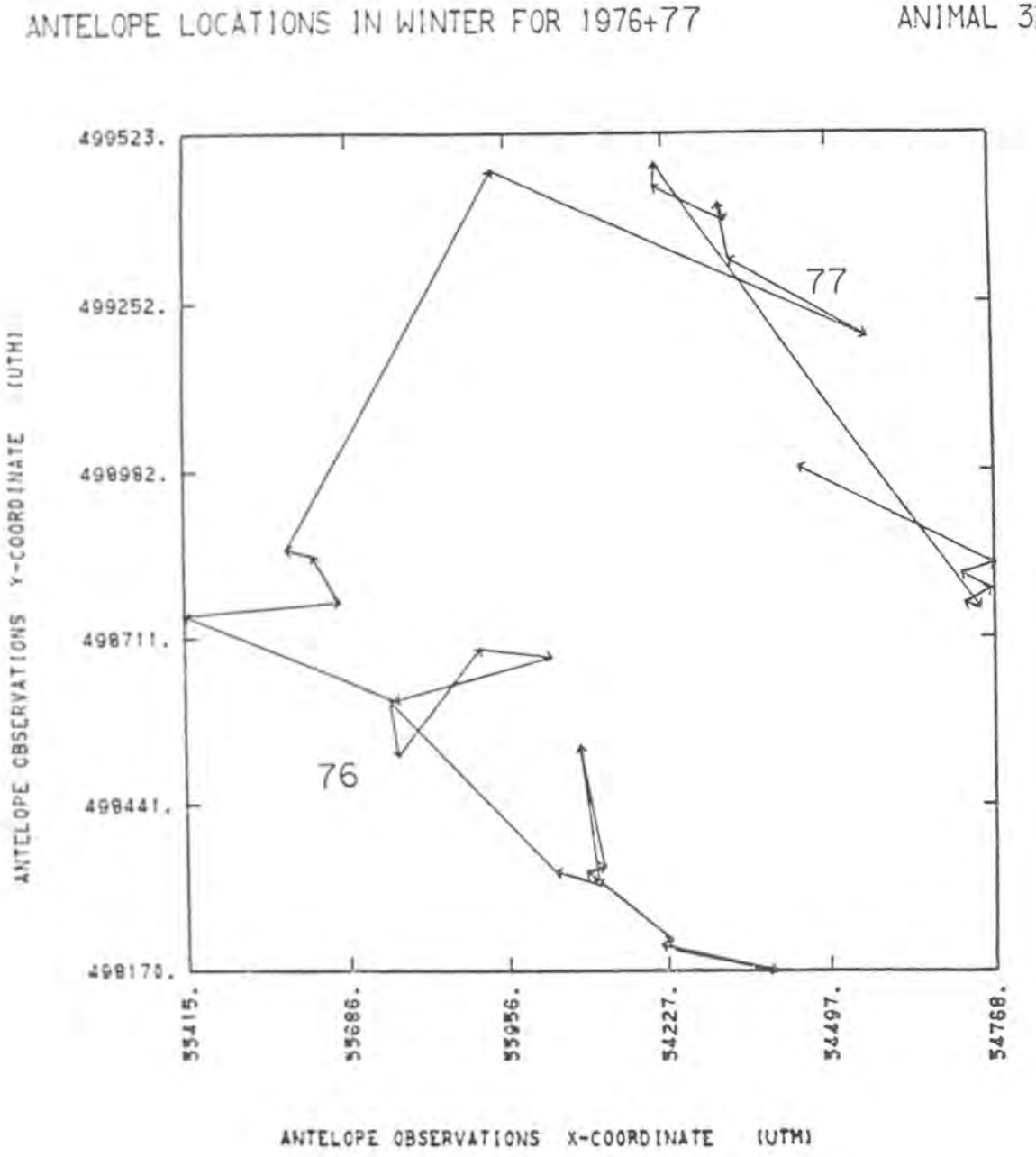

Figure 8. Winter activity areas of female pronghorn 32 in 1976 and 1977. Grid interval is 2.71 km. Asterisk indicates first location in winter 1977. Arrows indicate direction of travel.

A "willingness to move" might also explain the shifts in summer ranges and the long spring and fall movements I observed. Pepper and Quinn (1965) and Bruns (1977) also suggested that movements of pronghorns may be regulated largely by opportunity.

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COMMENTS AND QUESTIONS

AUTENRIETH: With regard to the technique of your monitoring, was it a 24-hour bout for the diel activity period?

AMSTRUP: Yes. I selected individuals at random and went out and followed them for minimum periods of 24 hours.

AUTENRIETH: And how were you determining what they were doing, other than the signal variation?

AMSTRUP: I had a night vision device, which didn't work all the time, that's why my observations aren't as frequent as I had hoped. I had to throw quite a few data out because I couldn't classify them other than being active or inactive.

AUTENRIETH: How many hours do you think you had in on night observation?

AMSTRUP: I did it ten times and two of those times were aborted because I lost track of the animals and couldn't find them in the dark, so eight complete 24-hour cycles. I was in constant contact with them most of the time. Sometimes they'd move over a ridge and I'd have to shift my position and catch up with them. The period of monitoring

was at least every 15 minutes.

AUTENRIETH: You grouped all of your movement patterns data, at least on your initial two or three graphs. I wonder if there wasn't variation, pretty important variation, between the two sexes in terms of mature animals.

AMSTRUP: I neglected to say that. All of the movement patterns that I discussed here were of adult females.

AUTENRIETH: I see. Did you have transmitters on males?

AMSTRUP: I had poor luck with males. As I mentioned, we tried some various experimental collars and it just happened that most of those went on males and they didn't work very well. So I have very scant information on males at this point. Hopefully it will improve in future.

AUTENRIETH: So there were no males included then?

AMSTRUP: In what I talked about, no. I didn't present the information on the one male that I do have 2 years of information on. He also shifted his activity area, but I didn't present that.

AUTENRIETH: Is that a 3-year-old animal or over?

AMSTRUP: Yes.

AUTENRIETH: Yes, I would expect that. If you were involved with territorial bucks and so forth it would be much smaller moves, of course, in terms of summer range as compared to the mature does.

AMSTRUP: I can't say for certain but I don't feel that the antelope on my study area are territorial in the same sense that we've heard people talking about. The marked bucks and -- I did have several marked bucks on the area and several other animals that I thought I could identify by horn structure and things like that, at least

most of the time, and they didn't seem to be in the same places the 2 years. I don't know if that's significant or not but it just didn't appear to me to be a classic situation of where a particular area of ground was being defended. They clearly did defend groups of does and fawns but these groups could move several kilometers, and in fact they did several times in the course of a few days. Following the instrumented does I was able to determine this.

WISHART: I was interested in that coal dust observation you made. We used to have situations, quite often, with gravel roads in this country passing through deer range, or whatever, and they clear off right along the roads 2 weeks before other areas, sometimes earlier. And of course this makes the animals fairly vulnerable to poaching and what not, too, but if you can run around spreading 2-4-D and other things, there doesn't seem any reason why you couldn't spread coal dust in a situation where you might need it. And the old railroad, with the old steam engine! Railroads are notoriously clear. You weren't around at that time, Steve.

AMSTRUP: You're probably aware of the work that's been done in the Middle Park area of Colorado; they did substantial experimenting with sprinkling carbon black on deer winter ranges to do just that, to melt the snow even during mid-winter to improve the conditions for deer.

O'GARA: Just a quick comment on that coal dust thing. I was overseas last spring about this time and a big percent of the caribou and practically all of the muskoxen were down wind of the Russian and Norwegian coal mines there, and the biologist there said that in bad winters they thought that the coal mine prevented the big die-off of muskoxen they'd had in previous years.

THE IMPACT OF DOMESTIC LIVESTOCK AND FARMING ON TEXAS PRONGHORN[1]

TIM J. LEFTWICH and C. DAVID SIMPSON, Department of Range and Wildlife Management, Texas Tech University, Lubbock, Texas

Abstract: Habitat deterioration and direct competition due to overstocking of sheep and goats were found to be the primary factors for loss of pronghorn range in south and southwest Texas. Cattle ranching also caused range losses, but was not totally incompatible to pronghorn survival. Fencing open range accelerated breakup of the large pronghorn herds and accentuated the impact of livestock production. Farming of row crops extirpated pronghorn from north central Texas and much of the Panhandle region. Today herds are limited to the extensive cattle ranches of west Texas.

The primary influencing factors on Texas pronghorn in the past 200 years were hunting, the livestock industry and farming. Although hunting has received much attention as a prime cause of decreases in a number of wildlife species, in the case of Texas pronghorn it certainly was only a part of the problem that caused population decline and range shrinkage (Simpson and Leftwich 1978). Before excessive hunting practices became widespread, European man had already had an influence on pronghorn through his domestic animals. With roots in the Spanish colonial period, the livestock industry grew to become one of Texas' major resources in the 19th and 20th centuries. Similarly, the raising of large acreages of row crops such as corn and cotton began early in the state's history

[1]Technical Paper No. T-9-196 of the College of Agricultural Sciences, Texas Tech University.

and grew to become a multimillion dollar business in this century. These two factors have had far-reaching effects on Texas pronghorn numbers and distribution.

Data reported in this paper are from a larger study of man's impact on Texas pronghorn. The project was supported by the Department of Range and Wildlife Management, Texas Tech University and the U. S. Forest Service Rocky Mountain Forest and Range Experimental Station. It was conducted in cooperation with Texas Parks and Wildlife Department personnel and landowners throughout the state.

METHODS

The initial phase of this research entailed an extensive survey of the historical literature on the settlement and agricultural practices in Texas. The primary source was material in the Southwest Collection, Texas Tech University, a regional repository for historical information.

In addition to the historical review, research was conducted in selected counties throughout Texas. Pronghorn populations occurring in varying habitat types were examined and correlated with the agricultural practices prevalent in the area. Interviews were conducted with landowners in an attempt to reconstruct the history of land use at the local level.

Finally, pronghorn census data were examined from records maintained by Texas Parks and Wildlife Department district and regional offices. This information was then compared to the domestic livestock numbers and agricultural practices for a given area over specific time periods. The indirect effects such as extensive fencing and habitat deterioration were also documented.

RESULTS

The greatest, man-induced impact on pronghorn during the early colonization of Texas, 1500-1800, was the introduction of domestic livestock onto pronghorn range in south Texas (Figure 1). These animals were brought into the state by the Spanish as they established missions, ranches and small settlements during the seventeenth and eighteenth centuries. During this era the numerically most significant class of livestock was sheep and goats.

Sheep and Goats

By the mid-1700's over 90,000 sheep and goats were concentrated on the lower Rio Grande. A few miles up the river from these settlements the small town of Mier claimed a sheep population of 40,000 for the same time period (Lehmann 1969). From these populations approximately 10,000 sheep were moved into the lower Trinity River valley in east central Texas in 1757 (Towne and Wentworth 1946). Smaller herds of sheep were also present at most of the Spanish missions that had been established in south central and east Texas. Sheep and goat populations at the missions in the San Antonio area numbered around 3,000 with comparable herds existing at other missions in the vicinity (Lehmann 1969).

These large concentrations of sheep and goats in south Texas had begun to cause some habitat deterioration as early as 1800. As a result of this competition with domestic livestock, pronghorn started to be displaced from their native range in south Texas along the Rio Grande and on the Gulf Coast. At about this time a general decline occurred in sheep numbers in Texas which was primarily due to the droughts of the early 1780's and a severe winter in 1783 (Lehmann 1969). Sheep and goat

numbers depressed for another 50 years but began to increase in the 1850's. By the 1870's sheep and goat populations numbered over 1.6 million in south Texas alone. Pressure from these domestic flocks was one of the important limiting factors to pronghorn in south Texas. By the late 1880's they had been all but extirpated from most of their historic range in this region.

After reaching the large populations noted above, sheep numbers in south Texas began a rapid decline so that by 1890 only approximately 100,000 animals survived in place of the 1.6 million which had occupied this area a decade earlier (Lehmann 1969). The most significant factor contributing to this decline in south Texas was range deterioration caused by too many livestock and the resultant overgrazing.

Following this decline the sheep and goat industry moved north onto the Edwards Plateau (Figure 1) and west into the Trans-Pecos region where it remains centered today.

During the period of translocation and buildup of pronghorn numbers during the 1930's and 1940's, antelope were removed from enclosed sheep ranches to the more open cattle ranges in an effort to increase productivity (Russell 1964). However, losses of transplanted pronghorn continued to occur on both sheep and cattle ranches. It was noted that from 1935 to 1945 sheep increased in parts of Presidio and Jeff Davis Counties in the Trans-Pecos from 1,105 head to 122,979 head (Buechner 1950). The pronghorn in this area were unable to compete successfully with such a large influx of sheep and as a result a decline in antelope numbers occurred in the Trans-Pecos. During the early 1900's sheep and goat numbers increased steadily on the Edwards Plateau and in the Trans-Pecos regions (Buechner 1950). By 1940 over 10,000,000 sheep and 3,000,000 goats

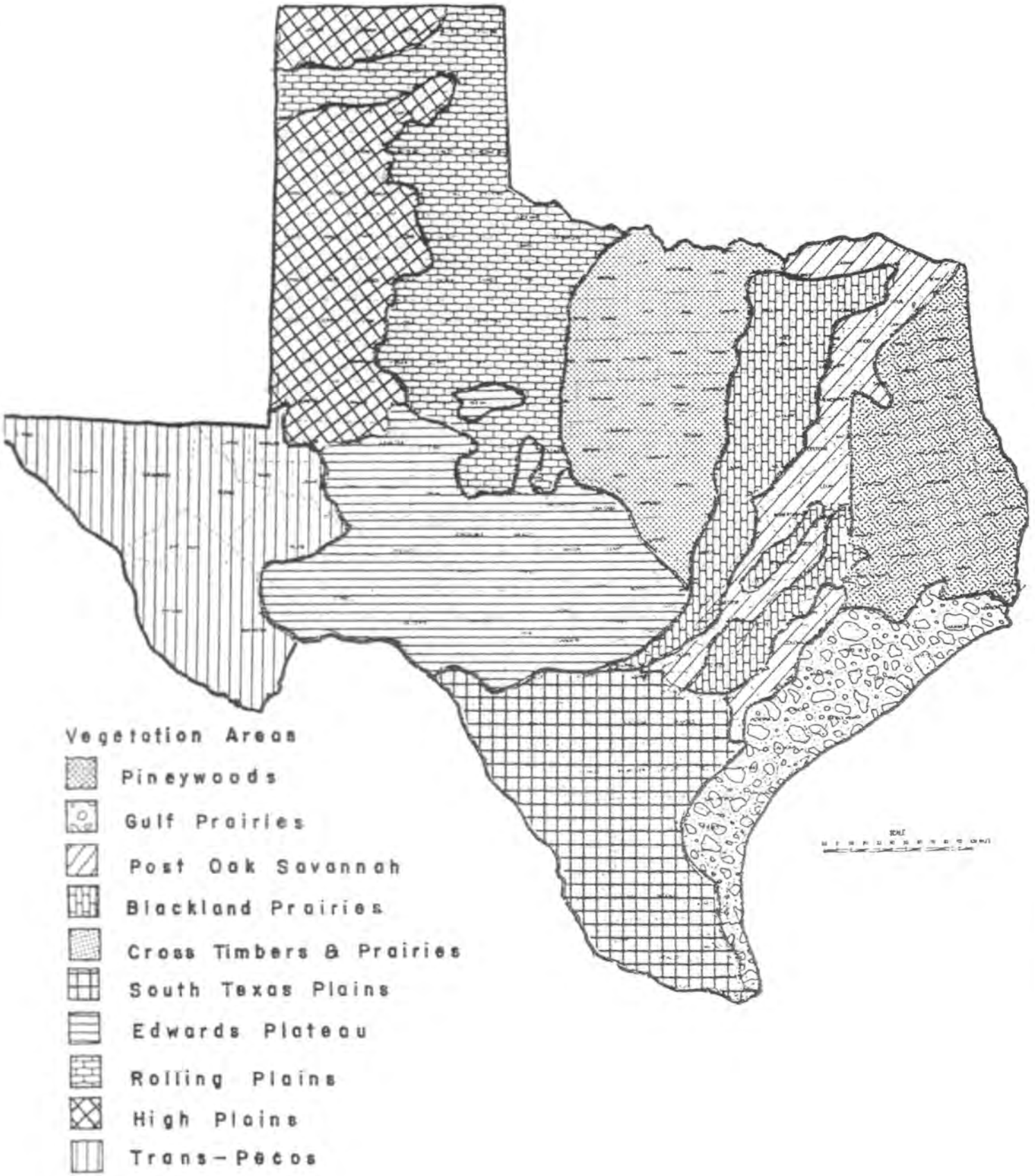

Figure 1. Vegetational regions of Texas after Gould (1969).

were populating Texas rangeland (Figure 2), with the largest concentrations occurring in the western one-third of the state (Texas Almanac 1949-50).

Sheep and goat numbers have decreased statewide in the last 30 years so that by the early 1970's there were approximately 3 million sheep and 2 million goats in Texas. However, a large percentage of these animals remained concentrated on pronghorn range in the western Edwards Plateau area. Pronghorn populations have remained depressed throughout this portion of their former range.

Cattle

Cattle were also introduced to Texas as the Spanish established their missions in the 1690's (Lehmann 1969). After the abandonment of these missions in 1693 much of the livestock, particularly cattle, was left to survive on its own (Castaneda 1936: vol. 1). When the Spanish returned in 1716 they found wild cattle grazing on the plains of east Texas and in the Trinity River bottoms (Foik 1933). Even though large-scale cattle drives from Texas to Louisiana occurred in the late 1700's which reduced the number of cattle in the state (Connor 1971), thousands of wild cattle still foraged in the valleys on both sides of the Rio Grande and on the coastal prairies of south Texas in the early 1800's (Texas Almanac 1966).

As settlement expanded, cattle were introduced over wider areas of the state. By 1834 an estimated 1.1 million head ranged throughout Texas but only a small percentage was being marketed out-of-state at this time (Webb 1952: vol. 1). The cattle industry grew rapidly during the 1850's, with large ranches being established in central and south central Texas. Following the Civil War, thousands of cattle were driven to out-of-state markets; an estimated 10 million cattle were driven up the trail during the

height of the cattle drive era which extended from 1866 to 1895 (Texas Almanac 1966-67). Despite this large export movement, over 4 million head ranged on Texas grasslands in 1880 (Figure 2). Overstocking caused range deterioration in parts of west Texas that became evident through decreased carrying capacities in the late 1870's. Excessive grazing and fire suppression favoured the development of brush vegetation in areas that had previously supported grassland, compounding the problem (Churchill 1955).

In the 1860's excellent rangeland in west Texas was stocked with cattle at the rate of 300 head per section. Thirty years later the same areas could barely support 50 head per section (Bentley 1898).

In spite of the evidence of overgrazing, cattle numbers increased during the 1880's, so that by 1891 over 9.8 million head of cattle ranged over all the suitable land in Texas (Texas Almanac 1966-67).

In the past 50 years cattle numbers have slowly increased from approximately 5.3 million in 1926 to 7.6 million in 1945 (Figure 2). From 1945 to 1971 cattle numbers increased to 12 million; however, some of this growth occurred in the central and eastern regions of the state with no direct effect on the remaining pronghorn herds which were concentrated in the western one-third of Texas. Overgrazing, combined with a series of droughts and hard winters during the 1880's and the 1890's, had a dramatic effect on Texas pronghorn. By 1900 little more than 2,000 pronghorn existed statewide.

Wire Fencing

A major impact on pronghorn resulting from the spread of the livestock industry was the use of barbed wire and net wire fencing on the range. In 1874 only 5 tons of barbed wire were manufactured in the United States (Table 1), but in just 6 years over 40,000 tons of barbed

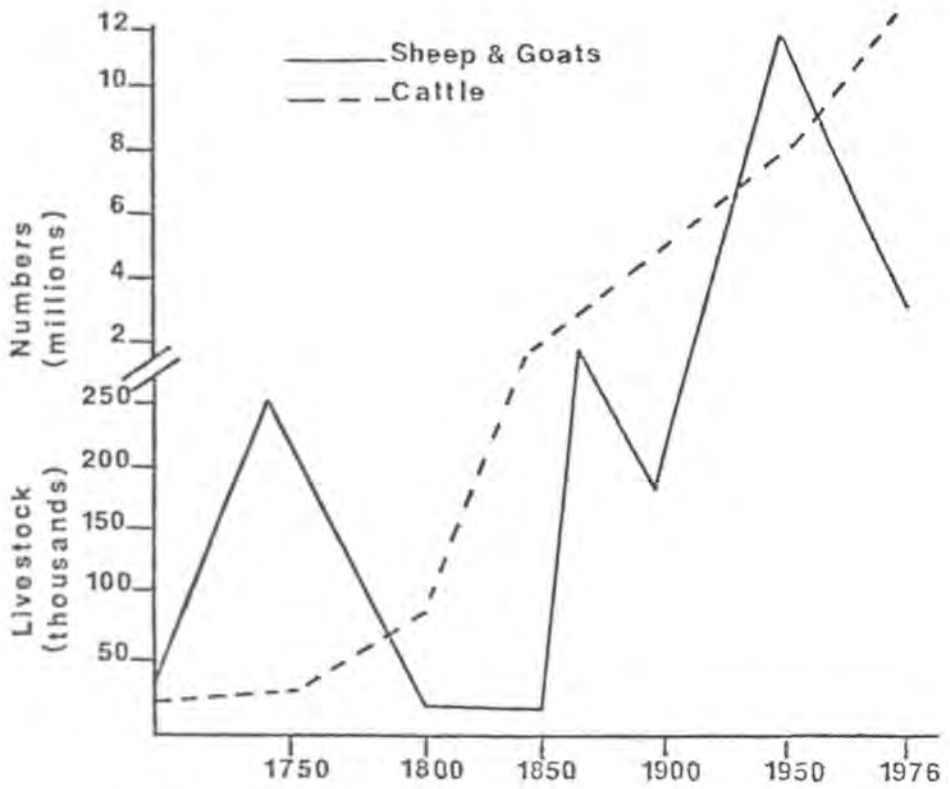

Figure 2. Cattle, sheep and goat populations in Texas from the Spanish colonial period to 1976.

wire was being strung on western rangelands (McCallum 1957). Initially, drift fences were erected which caused large numbers of cattle and pronghorn to bunch up during blizzards where many animals froze to death, unable to find suitable cover (Haley 1936). Later, as fencing increased and cross fencing of large pastures became commonplace, pronghorn population growth was further depressed (Webb 1960) and direct mortality resulted in the total disappearance of pronghorn from pastures in some instances (Hailey et al. 1966, Hailey 1976).

Table 1. United States production of all types of barbed wire from 1874 to 1945.

Tons	Year
5	1874
40,000	1880
200,000	1900
200,000	1924
180,000	1927
234,000	1945

Crop Farming

Farming, primarily of cotton and corn, as practiced by the native Indian tribes and early European colonists, had little effect on pronghorn populations (Webb 1952: vol. 1). However, after the Austin colony became established in central Texas in the early 1820's the farming of corn and cotton increased dramatically. By the year 1849 over 58,000 bales of cotton had been produced in the state (Figure 3). Although a large percent of this cotton was produced in east Texas, some crop farming in central Texas had a detrimental effect on the pronghorn herds in that region at that time.

The annual cotton production in Texas had jumped to 350,000 bales

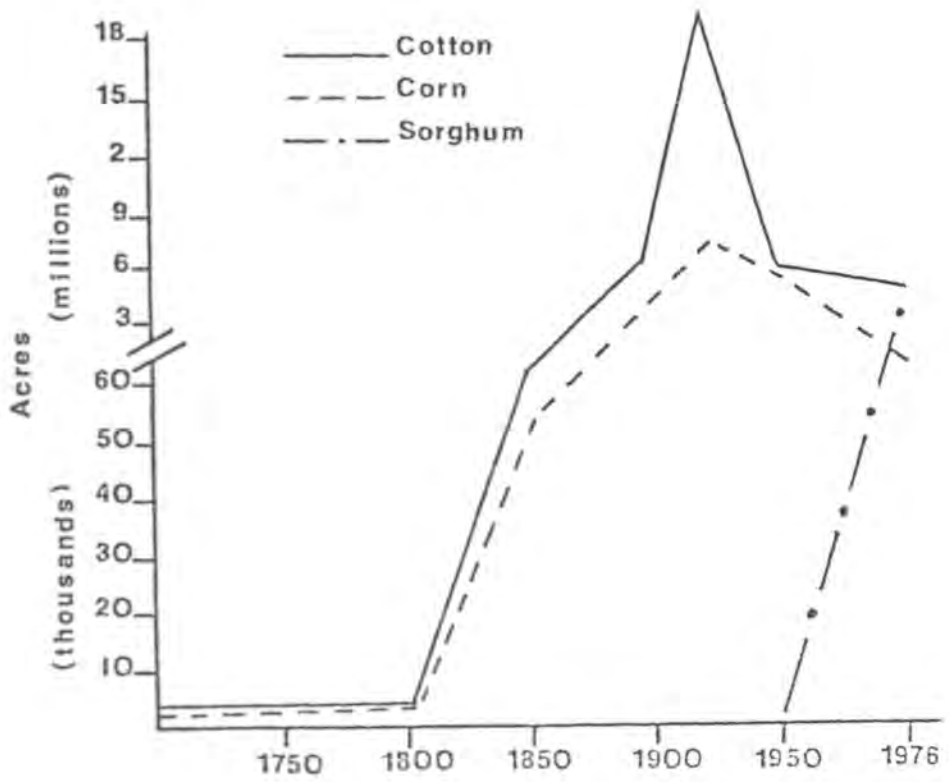

Figure 3. Acres of cotton, corn and grain sorghums planted in Texas from Spanish colonial period to 1976.

by 1869, making it one of the leading cotton producing states in the nation. As more acreage was turned by the plow, pronghorn moved out of central Texas onto the open ranges of west Texas. The trend of farming larger acreages continued with over 18.4 million acres being planted to cotton in 1925 (Texas Almanac 1972-73). In the 1950's cotton production shifted from the eastern and central part of the state to the High Plains of west Texas and to the Rio Grande Valley. Lubbock County, on the High Plains, now leads the state in both cotton acreage and total production (Texas Almanac 1972-73). As a result of this shift, large tracts of former antelope range were lost to farming; De Arment (1965) estimated that at least 75 percent of former pronghorn range in the Texas Panhandle is now under cultivation. Although the total acreage planted to cotton has decreased in the past few years, currently over 5 million acres are still being utilized to raise this cash crop.

Along with cotton, millions of acres of land have been planted to corn in the past 50 years (Figure 3). Around the turn of the century over 5.8 million acres were planted in corn, with a small decrease by the 1970's. However, the development of grain hybrids resulted in over 5 million acres of grain sorghum being planted in Texas in 1970 with a cash value second only to cotton (Texas Almanac 1972-73). The farming of these crops has displaced vast acreages of prime pronghorn habitat in west Texas and the once countless herds of the Texas Panhandle have been reduced to scattered isolates confined to the few remaining cattle ranches in the area.

SUMMARY

Overstocking of domestic livestock such as cattle, and the direct competition from sheep and goats, caused serious pronghorn declines in the

past 200 years. The habitat deterioration that resulted from too many livestock being placed on the range continues to be a limiting factor to pronghorn herd increases and range expansion.

The farming of various row crops eliminated millions of acres of pronghorn habitat in Texas. Currently, the leading cotton producing area in the world was once one of the most productive pronghorn ranges in the nation. Monocultural, high intensity agricultural systems practiced in Texas have resulted in the removal, perhaps permanently, of millions of acres of former pronghorn range. Today pronghorn in Texas are limited in their distribution to a few remaining areas of rangeland in the High Plains, the Rolling Plains and the Trans-Pecos region of Texas. Even their present range, however, is considerably different from their original habitat. Man has influenced vegetation changes through his land use practices to such an extent that what was once open prairie is now frequently deteriorated grassland with heavy brush invasion. As a result, the Texas pronghorn has not only lost most of its former range but the vegetation of these remnant areas have been radically changed. Pronghorn today can be found in mesquite (*Prosopis glandulosa*) forest, dense Cedar (*Juniperus* spp) stands, and xeric sand shinnery oak (*Quercus havardii*) communities, all probably sub-marginal habitat for pronghorn in pristine times.

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COMMENTS AND QUESTIONS

QUESTION: Does the King ranch have pronghorns?

LEFTWICH: Not now.

QUESTION: What's the current status of antelope in the southern part of the state?

LEFTWICH: They had the transplant, and I have to dig through some records there to find out the date, but the last small herd of antelope was hit by the hurricane of 1967 and the subsequent four or five animals have perished since then. The other area in the southern part of the state is in Jim Hogg County, that small area I showed you; it consisted of about 50 animals and they're living in a mesquite forest.

QUESTION: Could the influx of exotics to Texas have an effect on pronghorns?

LEFTWICH: Yes, sir. The major concentration of exotics in the state of Texas occurs mainly in hill country, which we feel was marginal pronghorn range based on historical records; but it could definitely have an effect.

MANAGING RANGELANDS FOR THE AMERICAN PRONGHORN ANTELOPE[1]

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Abstract: Pronghorns (*Antilocapra americana*) thrive best on rangelands with a diversity of vegetation, an abundance of grass-forb-browse, plants with high succulence, and growth height from 38 to 61 cm. Cultivated crops usually are not consumed extensively except alfalfa (*Medicago sativa*) which is highly preferred. Antelope densities are best on range where water is available every 2 to 8 km. It is desirable to have 1 to 4 liters of free water available each day, particularly during the warm dry summers. These big game animals use man-made water developments such as reservoirs, troughs and water catchments. Fences which restrict antelope movement for habitat requirements can be detrimental, especially for migrating herds during winters of deep snows. Woven wire fences are generally a barrier and therefore are not recommended on antelope ranges. Vegetational type manipulation projects can be advantageous or deleterious as defined. Ranges managed to meet the habitat requirements of antelope can be maintained or improved for the welfare of antelope today.

Today the American pronghorn antelope inhabits many historic ranges occupied during the early 1800's. The antelope's pristine numbers, however, have been greatly reduced. These native big game animals were on the verge of extirpation at the turn of the 1900's but have experi-

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enced a 1,500 percent increase during the past 50 years. Pronghorns coexist on western rangelands from northern Mexico up through all the western states of the U. S. and into the southern short grasslands of south central Canada. They coexist with domestic livestock now just as they did with the American buffalo (*Bison bison*) for centuries prior to the arrival of European man (Yoakum 1968).

The objective of this paper is to identify recommended range management practices to maintain or improve forage, water and range conditions in accordance with the habitat requirements of the American pronghorn antelope.

Findings and recommendations in this report were gathered over 25 years of research and field studies conducted in Canada, Mexico and the United States. In addition, the author has relied heavily on State and Federal agencies' input into the antelope chapter of a report entitled "Wildlife Habitat in Managed Range Environments" being drafted (Kindschy et al. in prep.).

ANTELOPE HABITAT REQUIREMENTS

To better understand the interrelationships of pronghorns to rangelands, it is imperative to know the animal's requirements for range characteristics (forage, water, space, etc.). Table 1 lists antelope requirements as developed to date for a sagebrush-grassland community. These requirements must be available in the correct combination. It is not sufficient to have an overabundance of one component and an inadequate quantity of another; nor can there be a total lack of any one.

Some ranges produce and maintain more antelope per range area than adjacent ranges because of the combination of habitat characteristics.

Table 1. Estimated antelope populations inhabitating grassland and grassland-brushland communities (Yoakum 1972) in Canada, Mexico and the continental United States.

Vegetational Community	Number	% of Population
Grasslands		
Shortgrass	190,210	49
Mixed Grass	71,750	19
Total	261,960	68
Grassland-Shrubland		
Bunchgrass-Sagebrush	103,810	27
Grama-Mesquite	4,600	1
Galletta-Woodland	10,950	3
Total	119,360	31
Desert		
Hot and Cold	4,170	1

Recent studies (Sundstrom et al. 1973; Yoakum 1972) link antelope densities with vegetational communities. Table 2 provides a summary of these findings. It is apparent that high antelope numbers are related to the short grasslands and shrub-grassland steppes.

RECOMMENDED RANGE MANAGEMENT PRACTICES

Vegetation

The primary principles of managing vegetation for antelope are:

1. Maintain existing native forage plants when the vegetation is in a good ecological condition and meets the requirements of antelope.
2. When the vegetation is in a poor ecological condition, or when one or more of the vegetative characteristics are inadequate for the antelope's habitat requirements, vegetative type conversions can be accomplished to correct the lacking quality components.

Table 2. Checklist of pronghorn antelope requirements for habitat in a grassland-sagebrush community.

Habitat Characteristics	Antelope Requirement[a]
ABIOTIC	
1. Physiography	Large expanse area (10 miles minimum) --low rolling terrain --no major physical barriers (large rivers, mountain ranges, etc.)
2. Climate	
--precipitation	10-15"
--snow depth	Not over 10-15" for prolonged periods
--temperature	Not a factor--populations in hot deserts to alpine meadows
3. Soils	Not a determining factor except to soilsite relationships in which some sites do not grow the right vegetation
4. Water	Desirable to have one quarter to one gallon per day for every day of year, particularly warm seasons. Water distribution every 3 to 4 miles
BIOTIC	
1. Vegetation	Ground cover--most ranges have around 50% non-vegetation Composition: 40-60% Grass 10-30% Forbs 5-10% Browse Variety: Grass - 5 to 10 species Forbs - 20 to 40 species Browse - 5 to 10 species Succulence: The more available year round the better in all plant species Communities: Variety and diversity important (meadows, intermittent lake beds, wild fire burns, etc.) Height: No higher than 24", preferably from 12-24"
2. Animal	Big game: tolerable of all species Predators: Affect antelope to some extent but rarely a limiting factor Man: Can or cannot be problem based on two major factors: --effective enforcement of indiscriminate year long killing --methods and practices of habitat or range management (maintaining or improving vegetation, waters, fences, etc.)

[a]These requirements must be available in the right combinations. Too much or too little of any one may become the major factor limiting antelope production or survival.

Native Rangelands: Native rangelands which have developed over eons into natural vegetative communities, and remain in good condition today, should be maintained in good condition. This is especially important to historical antelope ranges which possess vegetal characteristics favouring antelope habitat requirements identified in Table 1.

It is postulated that pronghorns thrive best on ranges in a sub-climax vegetative condition. Such conditions were created by (1) wild fires caused by lightning, and (2) seasonal grazing by herbivores such as bison, elk (*Cervus* sp), and deer (*Odocoileus* sp). The vegetative community was in constant change which in turn produced a variety of mixed forage classes of grasses, forbs and shrubs.

Vegetation Type Conversion: Extensive areas of dominant (more than 30 percent) big sagebrush (*Artemisia tridentata*) are often low density ranges for antelope. This is especially true where the brush is 76 cm or higher. Such areas can be treated to decrease sagebrush quality and height thereby creating desirable antelope habitat. One of the major objectives of brush control is to decrease shrubs which are competing with grasses and forbs. Two points should be considered in such treatments: (1) it is best to plan projects not too large in size (preferably less than 405 ha); (2) the project should maintain around 5 to 10 percent shrub cover.

Brush control is frequently accomplished by mechanical practices such as plowing or chaining. Plowing with large brushland plows often kills native plants, especially highly preferred forbs. Chaining is accomplished by two large tractors pulling a heavy anchor chain between them. This practice does not kill as many shrubs and is less damaging to native grasses and forbs.

Chemical spraying is another commonly practiced shrub control technique. The spray can be largely plant specific thereby controlling sagebrush and not harming native grasses and most forbs. The practice can favour antelope ranges with low sagebrush but leaves tall dead shrubs on big sagebrush treated areas.

Prescribed burning has been used to date in only limited cases to improve antelope ranges. This practice has many natural characteristics favourable to improving ranges for antelope. When properly accomplished, prescribed burning can decrease dominant shrubs and create a more natural mixed community of grasses, forbs and shrubs (Beardahl and Sylvester 1974, Page 1975 and Lovaas 1976).

Antelope ranges having insufficient native plants for natural reproduction can be seeded. Past seeding ventures have often resulted in monocultures of exotic grasses. These seedings have limited value to pronghorns other than a decrease in shrub quality and height. However, mixture seedings have often proven highly beneficial to pronghorns, especially when legumes have been planted. Mixture seedings are optimized when there are a number of native species planted. A good rule of thumb is a minimum of six species each of grasses, forbs and shrubs.

Introduction of dryland Nomad variety alfalfa was one of the most successful techniques accomplished on antelope ranges in southeastern Oregon (Kindschy 1974). In excess of 22,700 ha involving 36 separate seedings have been planted to date. The alfalfa was generally aerially seeded onto plowed sagebrush ranges following drilling to adapted grasses and shrubs. Recent analysis of the seedings disclosed that the majority have maintained alfalfa composition at a level of 10 percent of the vegetation present over a 6 year or longer period. The seedings have

increased the forb composition from 2 percent in untreated areas to 7 percent in seeded areas. During the August 1976 antelope census, more antelope does with fawns were observed in grass and forb seedings than on adjacent shrub dominant rangelands.

All vegetative type conversion projects should be planned in conformance with the basic principles and procedures for successful game range restoration identified by Plummer et al. (1968). These procedures have wide application on similar sites throughout the west. They are referred to as "the 10 commandments for success" of game ranges, and briefly are:

"1. Changes in plant cover by the proposed measures must be determined to be desirable.

2. Terrain and soil types must be suited to the changes selected.

3. Precipitation must be adequate to assure establishment and survival of seeded plants.

4. Competition must be low enough to assure that desired species can be established.

5. Only species and strains of plants adapted to the area should be planted.

6. Mixtures, rather than single species, should be planted.

7. Sufficient seed of acceptable purity and viability should be planted to assure getting a stand.

8. Seed must be covered sufficiently.

9. Planting should be done in the season of optimum conditions for establishment.

10. The planted area must be adequately protected."

While there is still a great deal to be learned in developing preci-

sion to reduce costs, successful shrub treatment and seeding of large areas depends on following these time tested procedures. Their importance for planning and implementing vegetative manipulation for wildlife cannot be overemphasized.

Cultivated Crops: Antelope can be attracted to cultivated crops, especially alfalfa, a highly preferred forage species. Winter wheat is another crop to which pronghorns may cause depredation, mainly through mechanical means of trampling and bedding. Overall, pronghorn problems regarding the use of cultivated crops is minimal.

Water

Quantity: Measurements were made of water consumption by antelope on the shrub-grass steppes of Wyoming (Sundstrom 1968). Daily water consumption rates per antelope varied from .34 liter per day in May to 4.5 liter per day in August. Total monthly precipitation, evaporation, succulent vegetation, nursing does, mean temperature and average maximum temperature had marked effects on the average daily water consumption rates. Working in Utah, Beale (1966) found that from 1 July to 15 August, antelope on semi-arid lands consumed 1.1 to 1.9 liter of water daily.

Quality: Little information is available concerning water quality as it affects pronghorns. However, total dissolved solids and pH are probably the most common concerns. In the Red Desert region of Wyoming, Sundstrom (1968) found little or no use by antelope of water sources which contained total dissolved solids in excess of 5,000 ppm. The maximum total dissolved solids recommended for best game support is about 4,500 ppm (McKee and Wolf 1963).

In Wyoming's Red Desert, it was found that when water sources exceeded a pH of 9.25, antelope appeared to seek other water sources (Sundstrom 1968).

Recommended pH level for most uses such as domestic water supplies, irrigation, fish and other aquatic life, swimming and other recreation uses, appears to be from 6.5 to 8.5 (McKee and Wolf 1963).

Distribution: A close relationship was observed between antelope and water distribution in Wyoming (Sundstrom 1968). Ninety-five percent of 12,000 antelope counted by air were within a 6 km radius of water.

Types of Developments: During a 5 year study of pronghorns in Wyoming, antelope were seen using every type of water source available. These consisted of springs, creeks, rivers, lakes and reservoirs, stock water developments, galvanized troughs fed by windmills, and troughs filled by springs. Antelope did not appear to avoid any manmade water device developed for livestock.

The installation of precipitation catchment facilities (guzzlers) on ranges lacking proper water distribution have been successful for antelope (June 1968, Sundstrom 1968). Such water developments are relatively maintenance free, not expensive, and serve a variety of wildlife and domestic livestock.

Fences

Fences can be major obstacles when antelope mobility is restricted to procure food, water, or escape from deep snows. This is most paramount for traditional antelope migrating herds moving from summer to winter ranges. Where fence restrictions occur, significant changes in distribution of herds, death to individual pronghorns, or losses of carrying capacity have resulted (Oakley 1973, Sundstrom 1970, Martinka 1967, and Hailey et al. 1977).

Recommendations from antelope-fence studies (Spillett 1965, Spillett et al. 1967, Zobell 1968, Mapston 1972a, Interstate Antelope Conference

1962, and U. S. Bureau of Land Management 1975) state that when fence construction is necessary, the following specifications are best for antelope welfare:

1. Net-wire fences are generally barriers; therefore, their construction on antelope ranges is discouraged.

2. Barbed wire fences should be constructed to the following specifications:

    a. bottom wire at least 41 cm from the ground.

    b. next wire up 25 cm.

    c. next wire up 25 cm, comprising a total of 91 cm height from ground.

    d. bottom wire should be smooth wire, for antelope generally go under fences, barbless wire minimizes physical injuries.

    e. no stays between posts, as this provides for a less tight fence allowing easier antelope passage.

    f. important antelope travelled pathways, migration routes, etc., should allow for low-height or lay down panels, or pass structures.

    g. keep fenced areas as large as possible, thereby providing an opportunity for antelope to obtain all the basic habitat requirements listed in Table 1.

"Antelope passes" have been used in some areas to facilitate antelope movement through fences (June 1965, Mapston 1972b). These devices are essentially miniature cattle guards 122 cm wide rather than the standard 312 cm structures. Vehicles cannot cross these structures. "Antelope passes" are placed at locations characteristically used by antelope. Corners of fence lines are a favourite location for the installation of this type of device. Passes, when properly placed, help facilitate antelope movement but are a second choice to properly constructed fencing.

Grazing Systems

Livestock management is turning more to establishing grazing systems for livestock use of rangelands. There are numerous systems with designed procedures for grazing depending on local economic and environmental conditions. All of these systems should consider the following criteria when such systems are developed for lands used dually with wild pronghorn herds:

1. When allotting quality and quantity of vegetation for antelope, these forage needs will be given.
    a. The right species of all vegetation will be recognized as forage for antelope. This includes grasses, forbs, and browse based upon correct up-to-date proper use factors.
    b. All forage plants will be assured availability for antelope for the seasons of need.
    c. Forage will be reserved for a reasonable number of pronghorns. Reasonable numbers will be based upon (1) the average herd population for the past 30 years, and (2) average forage productions for the last 15 years.
2. All waters will be maintained for antelope for the seasons the antelope are in the pastures.
3. Livestock fence construction will meet specifications deemed appropriate for antelope movement specified in the Antelope Regional Fence Workshop (U. S. Bur. Land Mgmt. 1975).
4. When grazing systems are designed with key plant species, plans will include forb and browse as key species, thereby assuring that the systems will be based upon phenology of these key species for antelope habitat requirements.

5. Livestock grazing systems which restrict, alter, limit, or deleteriously affect the habitat requirements of antelope, must include mitigating measures and alternate procedures to enhance antelope habitat.
6. "Prescription grazing" - using livestock to achieve vegetative form or composition objectives - should be practiced in seedings and certain native ranges where high antelope habitat values exist.

DISCUSSION

Habitat improvements specifically designed to improve range conditions for pronghorns are few and have had possibly only a minor effect on antelope populations. However, many range improvements constructed for other purposes have had some major effects, both advantageously and deleteriously, on antelope. This entire subject is not well documented in reports or publications, but more information is becoming available and warrants discussion at this time.

Fences constructed to control livestock or delineate highway rights-of-way have been reported repeatedly as a serious mortality factor to antelope. Such reports are substantiated for the open grasslands of Wyoming (Oakley 1973) to the semi-arid regions of Texas (Hailey 1977). The deleterious effect of both direct entanglement mortality and the much greater factor of entrapment and restricting migrational movements for survival are well documented. This does not mean that all fences are problems to antelope everywhere, but the evidence is substantial that fences are a serious mortality problem to certain antelope herds on a regional basis. It is also known that proper fence construction planning to include designs allowing more free antelope movement would do much to enhance antelope welfare (U. S. Bureau of Land Management 1974).

It would be well for all managers responsible for planning and constructing fences on ranges where wildlife values are of importance, to consider the tried and tested fence designs which allow access by antelope.

Just how beneficial vegetative type conversions or water developments have been to pronghorns is a matter not quantitatively reported to date. However, this subject is becoming increasingly apparent as more cases become known. There are two recent cases that substantiate well the values of multiple range improvements for the benefit of antelope.

At the Third Biennial Antelope States Workshop, Kerr (1968) reported on the interrelationships of antelope to habitat for the Tres Piedras herd in north central New Mexico. This area underwent extensive vegetative type conversions, fence construction, and water developments primarily for livestock but with proper considerations for antelope habitat requirements. The results within 3 years recorded a 130 percent (from 300 to 750) increase in the antelope population.

The second case of a large-scale range rehabilitation program affecting antelope numbers is the Vale project in southeastern Oregon. The project encompasses 100 - by 180 km of primarily sagebrush-grassland steppe rangelands. During an 11 year period, approximately $10 million was spent on the following range improvements: 205,000 ha brush control; 108,000 ha seedings; 3,330 km fence construction; 1,600 water developments and 741 km of pipelines (Heady and Bartolome 1977). The adjacent rangelands in Oregon, Idaho and Nevada had only minor range improvements accomplished during this same 11 year period.

Now 3 years following the Vale project it has been substantiated that the antelope population has increased 100 percent (from 1,000 to 2,000) while at the same time antelope in surrounding adjacent rangelands

have remained relatively static. The evidence is circumstantial, but it is indicative that properly implemented large-scale vegetative manipulation projects combined with water developments can be highly beneficial to wild free-roaming antelope herds.

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THE IMPACT OF A SEVERE WINTER ON NORTHERN PRONGHORN RANGES

CHAIRMAN'S PREFACE: *The following comments on winter severity in northern ranges have been excerpted from a lengthy, illustrated group discussion on the topic and have been edited extensively. This material is included in the proceedings because it contains information not previously published. The discussion not only updates our knowledge concerning aspects of winter mortality of pronghorns but, perhaps of more importance, it illustrates subject areas where current knowledge is lacking and future research needed.*

BARRETT: I would like to begin by providing a summary of some of our observations during the winter of 1977-78. We have some weather records from the Agricultural Research Station in the southeast corner of the province and from November through to the end of March we had 77 inches of snow on the pronghorn range. It was very cold in mid-November, snow came early, temperatures in Celsius were 25-28 below, and you're talking about 10 below Fahrenheit or thereabouts. That's in mid-November, and it gave them quite a nice start. The negative energy balance and presumably catabolism of body stores starts right then and there, on the tail end of a dry year which we've heard alluded to a number of times already. Conditions varied throughout Alberta; the southeast corner adjacent to Montana and the Saskatchewan corner was the most severely hit. On the top of about two and a half months of snow and cold there was a 7 day blizzard in mid-February; some people say they could hardly see across their farmyard for 7 consecutive days. It was just devastating at that

stage of the game and nothing could move in that country.

On some of our winter ranges where there are sage flats and snowberry stands there was just nothing showing. It was completely covered and it stayed that way for not just a day or two, but for weeks. What was evident in some of our surveys was that pronghorns moved to any place there was anything showing above snow. Things like stubble fields, until they got covered, sweet clover, Russian thistle, etc., attracted them because other than these areas it was just a sea of snow. Previous to this winter I hadn't seen antelope move into wolf willow very often. It kind of reminded me of some of the impressions of deer moving to wintering areas such as they talk about in eastern North America, but fairly atypical for pronghorns. As it turned out it didn't seem to do them an awful lot of good in the end because there was high mortality for animals that moved into willow and wolf willow. It was kind of surprising, in a way, for me anyway.

I want to make a further comment here. More than 50 percent of all the pronghorns we located were found off traditional winter ranges. We had some unusual movements, and I know that George Mitchell noted similar things in 1964-65, and others have mentioned it today as well, that some unique nontraditional movements take place in tough winters.

With regard to winter feeding of pronghorns, I would sure appreciate some input. We really got raked over the coals in a lot of places over this issue. Large numbers of pronghorns moved into or near towns, particularly in the Medicine Hat area. They just funnelled in there because of the drainage systems and so on, and

the public was able to see that animals were in trouble. Many people jumped on this and demanded that we do something. In fact, the Alberta Fish and Game Association started a feeding program. I guess we kept talking the party line, I'm not so sure whether it's right or wrong, really, by saying that it probably wouldn't do any good. I guess to sum it up, my reaction to the whole thing was that antelope that were hopelessly caught off their winter range without anything but a snow bank to eat, and you could get to them, there was very little to lose by trying to feed them. Animals that have some possibility of getting to normal winter ranges or normal vegetation types which could sustain them or are adjacent to such ranges probably shouldn't be fed. They can get hooked on this feed which may do them little good in the long run, and it will perhaps impair movement to more suitable ranges.

There was no doubt that they took the feed. They can accommodate quite nicely to the whole procedure and will actually meet the feed truck halfway across the field after awhile. In one particular herd they started feeding in mid-January and they fed until the end of March. We started with about 123 antelope and we recovered more than 70 dead ones out of this herd while on feed. Most of this loss was not associated with the initial introduction of feed to pronghorns as mortality occurred throughout winter and ran a pattern normal to what one might expect with losses through malnutrition during winter. This means that the young-of-the-year and adult males were more susceptible to loss, and these losses increased in frequency as winter progressed even though they were on feed. Based on the areas that we monitored we couldn't see appreciable differences

in survival rate in some of the herds that were on feed versus those that were off feed.

WISHART: What kind of feed were they being fed?

BARRETT: Much of it was second cut alfalfa, Bill. They tried that, pea-vine, timothy and beet tops. Beet tops have pretty good nutrition but are hard to come by and very unavailable during winter because of their nature; it's just like throwing a frozen spinach leaf out under a foot of snow -- it's difficult to make it available to pronghorns. We were criticized by some Fish and Game members for not being up to date on what other people have been able to do with regard to antelope feeding. It was suggested that you people have been feeding antelope for years in the States and what was the matter with us. They mentioned specifically Wyoming, and other spots, so gentlemen, I'm all ears.

HELMS: Do your boys in Alberta know that when we fed them in Wyoming during the blizzards they all died anyway?

BARRETT: I know Montana has toyed a bit with feeding and perhaps Duane or Frank will make comments on it because it's pretty contentious. Our Minister came down and justifiably recognized the efforts of the Fish and Game organizations to do something that was right, by giving them financial support but neither condoned nor supported the project. That's how sensitive it can become politically. So I hope someone will address this as time goes on.

BEALE: What was your analyses of why it failed? Was their intake adequate and that sort of thing?

BARRETT: Don, we did condition indices, we did necropsies on dozens, I guess hundreds, over the winter and it just ran the course that one

might expect in normal malnutrition. Even though they cleaned this feed up regularly I think that there was a continual downward slide as a result of this negative energy balance. They just weren't getting enough out of it or so it appeared. We did have some isolated problems; there were bacterial pneumonias and the foot rot problems similar to those referred to by Earl. We had some minor intestinal problems but not in large numbers.

BAILEY: Such as?

BARRETT: We had some scouring associated with a small number, probably in less than 10 percent of the antelope.

BAILEY: Did you look at the intestinal tract for damage?

BARRETT: For trauma or histological damage from overload or something of that nature?

BAILEY: Did you see anything such as impaction?

BARRETT: Yes, we did in a small percentage of cases. Some of these we referred to the veterinary services individuals for confirmation. We also had some penumonia problems but all these things put together probably accounted for no more than 20 percent of the individuals that we handled. Intestinal problems were there, but we feel they were not necessarily contributing to the bulk of mortality. We were also doing animals from adjacent unfed populations and had you not known the history you'd have been hard pressed to distinguish the groups in many cases.

BRUNS: How did you determine how much to feed them?

BARRETT: They were more or less providing feed *ad libitum*, Eldon, what they would take. Of course when you feed in the same place every day it's pretty easy to determine. They don't even move out. They

just hang around and you can gauge exactly, after a while, what they consume. Bear in mind that this was not a Fish and Wildlife Division sponsored feeding program. We were just trying to gain information generally from the whole effort, which was largely a community program.

QUESTION: Would they eat the feed alright?

BARRETT: They would only take the very high quality forage. If you put timothy out, with a lot of coarse stems, they might take 20-30 percent of it, pick out the leaves and the rest they would leave and bed on. When you used second and third cut alfalfa forage with protein content of 15-20 percent on a dry weight basis they cleaned it up. They were very fussy, but still in a lot of trouble.

STUBBS: What about predation on either the feeding sites or winter range area?

BARRETT: Some of these areas were right around the farmstead. They were feeding out the back door sort of thing so they kept predation under control. But we had problems. In Medicine Hat in 2 days dogs reportedly took eight pronghorns, and in some of the remote areas you just simply couldn't get around to tell. The whole country was inaccessible but we flew over it a few times. I'm sure the coyotes had a field day; it had to be one of the best things that ever happened to them. They just floated along the top of the crust from the 7 day blow we had down there and the pronghorns were in deep trouble. I'm sure this type of weather increases the impact of predation.

QUESTION: Were you also feeding the elk and deer in that area?

BARRETT: The Parks Division was feeding the elk. No one was feeding deer.

Elk were quite a limited side issue in the Cypress Hills primarily because of a depredation problem on adjacent ranches, and elk weren't in trouble particularly to begin with; they came through winter well on feed. Duane or Frank, would you care to comment on the feeding efforts? Didn't Trueblood do some work on feeding in Montana?

GJERSING: Yes, in 1964 he did. He tried alfalfa. Apparently he felt the alfalfa was worse for them than nothing because it went through them and they had scour problems. They tried some grain and he felt that feeding them grain actually was better than alfalfa, though none of it really seemed to work. They still went downhill and still starved. They couldn't really tell if there was any difference between the mortality of fed animals and the mortality of unfed animals. He felt that they probably hung on longer when they were fed grain, before they kicked off.

BARRETT: Thinking of that, Gary, based on your experience with white-tails and pronghorns I believe one would have to be fairly careful how you introduce the grain. Would you care to comment?

WOBESER: That is probably true. There's something else I was going to say about the white-tails in Saskatchewan. It appears that if they get started feeding on hay early enough in the winter, and by that I mean in early or late fall, they will probably come through fairly well. They're supplementing to some degree with browse. Certainly the later you let it go on in the winter before you start to feed the less effective it will be. I think rumenitis and rumen overload is something that could be a problem. We had some rumen overload in pronghorns a few years ago that was caused by animals feeding on

grain spills.

BAILEY: What do you mean by rumen overload?

WOBESER: Lactic acidosis.

BRUNS: While in Jackson Hole this winter I spent a couple of days with Ron Dean, their animal nutritionist, on their feeding programs. I talked to him about alfalfa and antelope, peavines, and what not, and what they thought antelope might do. They were feeding everything in sight when I was there, except antelope. His impression was that antelope should do just great on alfalfa. I would suggest that our problem here was that they weren't getting enough of the high grade alfalfa that they need. Maybe that means that 80 percent of the bales should be just left laying on the ground. They might be eating the whole bale but if the stems are only 2 percent protein they're not doing a hell of a lot of good. They might get scours for a week or two but they should be able to handle it.

BARRETT: Thanks, Eldon. The only comment I have is that of course our forage analysis reflects the entire sample, not just the leaves.

BRUNS: When it's 30 below and a 20 mile an hour wind blowing maybe they need 30 percent protein.

BARRETT: That just might be the issue but if it is they're going to need a lot more help than we can give them.

QUESTION: Did they try protein blocks at all?

BARRETT: In a couple of areas they did. I really cannot comment on their effectiveness because the sites were not monitored. The sites were scattered over 100 miles or so and I just don't know the effect of protein blocks.

HELMS: Getting back to the antelope, it was Ron Dean's consensus that the

losses we had that year were due to the extreme cold; the antelope just couldn't get enough energy.

BARRETT: Duane, you were going to comment.

PYRAH: I think in looking at antelope that feeding has a lot of possibilities. It gets very difficult for antelope under these kinds of conditions to eat enough to replace their metabolism energy. When you see an antelope laying out on the hillside when it's 100 degrees, that's a far cry from what the situation is during tough winters. And to expect their system to be adapted to both situations, I don't know whether it's asking too much. Having had sage grouse in captivity for 5 years and them not ever having any sagebrush I have come to appreciate the fact that most animals need two things relative to nutrition. One is their basic nutritional features plus whatever physical features their digestive system requires. I don't think that these things are that difficult to provide. The thing that we're lacking here is any research to determine what those needs are. We have an animal here that we're bound to feed like we feed a cow. It has some basic physiological needs and nutritional needs which are very similar alright but its digestive system surely has different physical needs than a cow's does. I have no doubt but given the right conditions we could take ten antelope out on the range and feed them and have them nutritionally well fed and keep them that way. We have no nutritional work and no research done on how to try to provide for these animals. It's never been economically feasible to put that much money into saving them; but if it becomes economically feasible to save them maybe the research will be done. Right now they're easy enough to replace by leaving them.

They will come back in 2 or 3 years so there you are.

BAILEY: I just want to comment on some of the work we did with mule deer in Colorado. Theoretically it seems to me that you can feed starving animals. You can't feed them just anything. I do agree with the possibility that you can't give them a digestible enough diet to make up for their heat loss in this kind of situation. Don't forget they're probably not where they chose to be, out of the wind, they're where we put the feed. And then of course that gets into the logistics of getting the food out to them, which makes it economically not feasible. We did find extreme problems with the stems of alfalfa; they did do physical damage to the digestive tract. We did not find any problem with abruptly giving starving deer a very hot digestible diet. No lactic acid problems. They weren't so far gone that they weren't going to make it. They would take anything we gave them in the way of a high protein or high energy diet.

BARRETT: Now, I surmise a few things from this. I don't think that we currently have the answers. As Duane pointed out, there are some things we know and some parallels we can make with other species. But it has never been a very high priority to game managers, per se. Getting back to Eldon's comment, maybe we aren't giving enough. I expect we could do it nicely if we said in October, this winter we're going to feed antelope; and we started in October. But having made that decision we virtually throw out the window many of our concepts of how we're going to approach the ~~management of this~~ species in almost all jurisdictions, and I guess none of us has made that decision yet for antelope. We have made it for other species

in certain areas but I don't think we're about to convert to an annual feeding program in Alberta yet. Some of these things we can look forward to down the road perhaps, with dwindling range.

SNEVA: Was their water source adequate or were they getting it out of the snow?

BARRETT: Out of the snow.

SNEVA: This might effect their thermal balance here. It takes quite a bit of energy to melt the snow for the amount of water required. I was thinking in these kinds of situations where you were getting to them you could provide the heated water source just as well as providing the feed.

BARRETT: It certainly is something we didn't consider.

WISHART: What about rounding them up and taking them to another range?

BARRETT: I guess that possibility also exists.

BRUNS: During necropsies did you find any evidence that any of their limbs or parts of their bodies had been frozen? I realize that you were picking them up dead and frozen most of the time but was there any evidence that ears or scrotum or legs or something like that had been frozen for several days or weeks ahead of dying?

BARRETT: No, Eldon, there really wasn't. We had no evidence that comes to mind. I just want to mention one more thing with respect to water availability. Of course at our latitude, free water, using that nebulous term, is almost never available to pronghorns in most winters. Everything's frozen. We worry sometimes when we don't have snow on the ground when everything's frozen, particularly in fall. We can get an early freeze in October and no snowfall sometimes until late November but no one has really documented the

effect of this on deer or antelope.

HELMS: In Wyoming, I believe in 1971 when we had that blizzard, we did find antelope that had their jaws frozen. They were still alive but they couldn't eat. So this is a possibility why some of them have the appearance of starving to death when actually the cause of death is freezing.

BARRETT: I had someone suggest that to me and I didn't take it very seriously. That would do it all right, but it's hard for me to imagine a system whereby that could happen where other more peripheral portions of the carcass would not show signs of a similar problem. It's something which we didn't really consider nor can we support from our findings. Another interesting thing that we saw was the use of the same bed site over and over again on many days. Based on ejesta it was obvious that they had to use bed sites on dozens of occasions. We don't know whether it was the same individual, of course, but these situations were frequent and clumps of recurring bed sites were evident.

Another finding almost bordered on the bizarre. Leo Gudmundson and I were out looking at a couple of the herds and saw something waving in the breeze. We put the glasses on it and saw the legs of a pronghorn. This was after a 2-day blow. We walked over and the animal was alive, its nose projecting out of the snow. There were 10-12 inches of crusted snow over the neck area. That animal, when we dispatched it and did a necropsy and our condition indices, was found to be in relatively good body condition. It was an adult doe and they were in better condition than other age and sex classes, as I mentioned. This led us to the conclusion, based on the exam-

ination made of the bed site, that that animal bedded there for 2 or 3 days during this blizzard and froze in; the snow blew over her and was crusted. We had quite a time just pulling her out of the bed. Any of you that have handled pronghorns in the trapping programs know that when you get them on their side, and get a certain weight on the shoulder, it doesn't take much to hold them down. We firmly believe that this animal was trapped during the blizzard and probably would never have gotten out. It's ominous to consider what happened in the southeast corner of the province where the blizzard raged for 7 days and there was twice as much snow as we had in this area. Another interesting thing we saw was extensive evidence of fetal resorption, and it was evident by examining the intact uterus as well as the fetuses.

GJERSING: We had an experience on our farm in the winter of 1949 and 1950 with cattle that were isolated from the ranch. Even though we took feed out to them they declined in weight very rapidly. This was an extremely cold winter, probably the worst we've had in that area until 1964 and until the present time. We also lost cattle due to freezing even though they had feed. Whether or not they froze after they died from heat loss or hypothermia or something like this we don't know, but we did lose cattle like that. One other thing, we did lose calves and also yearlings that laid down behind sagebrush and drifted over; whether these died by suffocation I can't really tell but there're two things to think about in relation to antelope along that line.

I'd just like to read to you some observations that we made while flying in my area, in February of this winter. When you took

off south from the Canadian border towards Havre all you saw was a vast sea of white. When you got to the Milk River you'd see a few cottonwood trees sticking out of the vast sea of white and it was 60 miles to the Missouri River, and all there was there was a vast sea of white. There was virtually nothing sticking out of the snow in that country. I couldn't believe it. The antelope were not even in their traditional winter ranges which are these big sagebrush flats and silver sagebrush bottoms. The snow was so deep in there they were up on the ridges, and the snow was so deep on those ridges there was nothing sticking out of there as far as vegetation went. Although they could get around on those ridges in many areas I would think that the winter conditions, especially the winds when they're isolated on a ridge top, must really cause a tremendous body heat loss, and the energy necessary to maintain an antelope in that condition must be phenomenal. I can't imagine the type of food it probably takes to keep up body weight in something like that. Reports of antelope concentrations on winter ranges in our area were received in early January 1978. Migrations of Canadian summering antelope into Montana was suspected owing to larger herd sizes observed along the Milk River drainage. Aerial observation of antelope on a regular basis was initiated in cooperation with the BLM, and the objectives of the flight were to delineate the extent and location of winter habitats and to obtain classification and total animal numbers. Because of the severity of this winter season we assumed that the habitat used by pronghorns was critical and hence subject to the designation of "crucial" by the BLM, and hopefully it would get greater emphasis in future management.

We flew the area for the first time in January and the herd size averaged 81 head. They ranged from seven head to a total of 317 in our largest herd. We don't have any way to designate whether they were resident and migratory antelope mixed up in herds or whether they were all from one or the other groups. Some animals were carrying neck bands, indicating Canadian origin. The first reports of poor body condition came from Glasgow where three antelope were autopsied by Dick Trueblood in mid-January. Reports of weakened animals in the Havre area occurred in early February, and the Fish and Game Department had received several depredation complaints in haystacks in North Blaine County resulting in fencing efforts by the law enforcement division in that area all through January and the month of February.

A trapping and relocation program was considered, as Morley mentioned. The paper published that we were taking antelope that were coming down from Alberta and Saskatchewan and moving them to Idaho. We abandoned this due primarily to my recommendation because I felt that it couldn't be justified. The conditions were not favourable and with the deep snow you just couldn't get in to where the antelope were in many cases. I felt that trapping stress imposed on antelope in weak condition would probably limit the survival success during transport and release. Unless we took them to some areas other than what we had in Montana we didn't have good winter ranges to move them to. We did have some requests, I believe, from Nebraska for some antelope, but these antelope were in such poor condition that I cancelled this trapping effort.

South and a little bit west of the Wildhorse area of Alberta

we picked up 455 antelope in the wintering area and almost all of these were Alberta and Saskatchewan antelope because we had negligible amounts of antelope in this area; we probably have 60 resident antelope up there from Montana, so almost all of those 455 were from Alberta or Saskatchewan. Further south it varied in numbers from 249 to 310 on a winter range owned primarily by the Fish and Game Department so it isn't under severe browsing conditions. Then we had about 60 to 110 scattered in another location. You'll be interested to know that by March when we flew the northern areas there were very few antelope left so they seemed to have moved to the south side of the Milk River. We did have some antelope drifting down through this area and as the tagging records show we did pick up some tags in Montana south of Havre that came from Alberta. Combined with this loss of 455 head up north we had a herd of about 310 right on the north side of Fresno and we had reason to believe that not only was the drift south across this area but it probably followed the river drainage. We had a large herd of 317 right east of Chinook, Montana that we flew the other day just to try to get some estimates of winter mortality. We've flown all our areas trying to count carcasses from the air and, based on the very limited experience that I've had, we can get about 40 to 60 percent of the total mortality, by counting carcasses from the air. I think Morley's found about the same in the Canadian areas. In this herd of 317 that we knew were wintering there we counted 129 carcasses so there was pretty severe mortality in the area. In another area where we had between 249 and 310 antelope we could only pick up eight carcasses from the air. So it really seems to

depend on the area as far as mortality goes. As you go eastward across Montana we had herds of 250, 40, down to 27, and right north of Malta area we had a herd of 1,500.

We might go through the total summer counts that we had in this area to show you the difference between the summer counts, which of course are minimal, and the winter counts, again which are minimal. In this area north of Malta where we had 1,500 antelope this winter our summer count for this particular hunting unit was 949, so probably 500 plus of those could have been Canadian antelope. In another area our total summer surveys showed 700 antelope and we had about 800 to 900 in here in winter time, so probably at least 200 of those were Canadian antelope. Again, these figures are minimal. Last time I talked to Dick Trueblood he felt they had Canadian antelope down near Glasgow but based on the concentrations they had, they weren't really sure how many. Judging from the summer counts they didn't really have that many more antelope than they had last summer when they counted the area.

Now we're picking up dead antelope laying all over the prairie; in fact, if you drive the highway between Shelby and Havre there are antelope laying in the road ditches that are dead where we never even saw antelope last winter. I think a lot of this is due to blizzard conditions. We couldn't fly on a bi-weekly basis like we wanted to. I'm sure an antelope herd could come down here, and pass, and 2 days later you couldn't even see its tracks in some areas. So we missed a lot of antelope that were moving through the area. We had antelope being hit on the railroad tracks. We don't know really what our total mortality figures are. This one herd

kind of scared me, out of 317 animals we picked up 129 carcasses from the air -- that's sort of spooky. This was a herd that was pretty isolated and we watched it real close. Again, it was on an area that is traditionally tremendous winter range. It's a combination of silver sagebrush with some big sagebrush and there's antelope there every single winter, and we have had very few problems with mortality in the past but this winter we really got wiped out in that area.

Going through the weather records, as far as snow depth is concerned Havre probably had one of the worst winters on record. We had reports of snow depths in the Bearpaw Mountains that exceeded 100 inches. These figures came from some of the ranchers out in that area that kept track of what was going on. That's the most snow that I've ever recorded in those areas. We've got quite a foothills population of antelope in that area. I'm sure we've got tremendous mortality out there that we haven't even looked at yet. We're getting reports in and going out and checking on herds that are just coming out from under the snow. We've still got some snow on the southeastern slopes out there, and finding 15 to 20 antelope dead in a single area. Our mortality is high but I'm not sure of the exact percentage.

MITCHELL: When the animals come down in the Malta area, do they stay east along the Milk River or do they cross the Milk?

GJERSING: Just for an interesting sidelight along this line, this was the first year that Dick Trueblood, who lives in Glasgow, had ever seen antelope cross Fort Peck Lake. Some of these antelope actually went across Fort Peck Lake and some of these probably were Canadian

antelope. If they went across Fort Peck Lake they're never going to come back. They're going to be stuck on that side as soon as the ice breaks. So it depends on the severity of the winter but some of them follow the Milk River; some of them have crossed.

QUESTION: Did you find movement of mule deer similar to that of antelope?

GJERSING: We didn't find that much movement of mule deer, but again that's pretty hard to document because they're not bunched up in those big groups like the antelope are. But in areas that I monitored for deer this winter we had movements of deer out from the river bottoms into the winter wheat fields where there were some shallow snow depths in some areas and we picked up a lot of deer feeding on the winter wheat; mulies, also some white-tail, but a lot of mule deer. In the mountain areas and the breaks there were movements but nothing that seemed extraordinary in a severe winter situation.

QUESTION: Did you have much deer mortality?

GJERSING: Yes, we picked up some but it doesn't seem to be anywhere in the area of mortality of our antelope populations; but we did lose some deer.

PYRAH: Bob Watson, our management biologist, provided a short summary and it has a few things in it that are a little different than already recorded. In central Montana the weather of 1977-78 was one of the most severe on record. Continuous snow cover with depths up to 40 inches from approximately mid-November through mid-March had a dramatic effect on the 6,000 antelope normally found there. Most left what had been determined as antelope range. About half the antelope moved north or east into the timbered breaks of the

Missouri or Musselshell rivers. They made considerable use of the miles of major drainages, feeding upon greasewood and silver sage. Associated steep slopes, often more than 60 degrees, were extensively used as were the intermittent ridges where the forage was Rocky Mountain juniper. Mortality from starvation varied greatly among herds, and although not quantified probably averaged about 50 percent. The smaller herds experienced complete mortality.

The other half of the antelope moved south and all stopped at places with similar conditions, i.e. islands of close canopy Ponderosa pine within the sagebrush-grassland habitat. These islands were just north of highways paralleling streams with riparian vegetation. We don't know if they stopped because of the trees, the roadside fences, road or the stream but our best guess is they stopped there because of the trees and the tree environment. These antelope feeding primarily on Ponderosa pine remained in the islands of trees for much of the winter. Mortality from starvation, although not quantified, again was probably about 50 percent.

We had similar total accumulations of snow to what Morley said; 80 inches was our total snowfall for the winter and much of the winter we had about 40 inches on the ground. Our winter was very different than usual. Montana and eastern Montana, like the prairies, is noted for the wind. We didn't get any wind. We didn't get enough wind for the chinook winds to melt snow or north winds to move snow. Oftentimes if we get a 25-30 mile an hour north wind it will cut the snow off down to ground level overnight, and a chinook wind from the southwest will almost always do that same thing. That did not happen so that left us with 30-40 inches of snow on the

ground and it just stayed there and blanketed everything.

We noted the first crossings of Fort Peck ice by antelope the early part of January. We don't know where they came from nor where they went. One of the things that may be overlooked in antelope is their ability to move in this extensive fashion in order to seek out a suitable place to continue the winter, and this then was the reason for them leaving what had been traditional home ranges, traditional winter ranges, and just making extensive movements in search of suitable habitat. Presumably our cultural affects on landscape were very detrimental to their being able to capitalize on this. They can not move in any direction very far before they're to a fence, a highway, a double fenced highway; lots of things that we put there that stop them from trying to move to where they may be able to find more suitable wintering conditions for survival.

AMSTRUP: Along the Montana-Wyoming border we had somewhat less severe conditions than in the more northern ranges. From the first of January on we had about 20-25 inches of snow on the level and it remained that way until around the 17th of March in most areas. I estimated on the antelope that I was watching closely that we had about 10 percent loss and I think that it would have been a lot worse if we had had one or two more weeks of bad weather. In March we had a very short snap in the weather system. We went from 60 days when it never got above freezing to 55 degrees. One comment that Mr. Bruns made about Jackson may be worth expounding on. There traditionally has been a small group of pronghorns in Jackson Hole area and I was there in the second week of February. They said that antelope had been around until about February 6th. About 40

antelope were out regularly feeding with the elk. They had 44 inches of snow between February 7th and February 10th, and he never saw them after that; whether they were under the snow or what I don't know. And one more observation nobody else has mentioned, during February we didn't have a great deal of snow actually fall and we had a lot of bright weather although it wasn't hot. It was very seldom above freezing, but insulation was great and we developed a very hard crust on the snow, and we noticed that during the last week of February the fronts of the legs and the chests on the antelope were just torn to ribbons from plowing through the crust.

BARRETT: There is one other question that I would like to throw out to the group. Is there a stage that you feel pronghorns might reach beyond which there is little probability of recovery? I've made a couple of observations. Most of the femoral fat in antelope that we looked at was substantially below 10 percent. Body weights, omental and kidney fat, and the other usual indices were down. Body weights were 20-35 percent below normal. The interesting thing is that a week or two after snow was gone a few of the individuals that we picked up dead had improved condition indices but were still dying. Our observations suggest that once they start to lose condition they can go very quickly. The number of individuals that you'll get in the transition zone, if you will, below 80 and above 20 percent femoral fat, are very few, and most of the animals are well above that or well below it. We find very few with 60, 50, 40 percent femoral fat. That's why I have trouble rationalizing something in the 30 percent category as a useful critical level. It suggests that there is a gradual decline in condition indices

and from what we've seen we can't really support that.

HALL: We have some observations on deer from our study at Wainwright and our road kill program. When the kidney fat reaches about a level of 30 percent and the bone marrow starts a downward decline it can be a rapid decline after that point. In a week or so they'd be in an advanced stage of starvation if you look at kidney fat in relation to bone marrow. After they pass that 30 percent level your animals are bound to be in trouble.

BARRETT: Can you equate the two? When you've got a kidney fat index of 30 percent or whatever, is your marrow fat on the way down significantly at that time?

HALL: The turning point seemed to be when our kidney fat ratio reached 30 percent; our bone marrow at that time was still relatively high, in the 70-80 percent rating. Once the kidney fat passed 20 percent the bone marrow fat dropped very rapidly. I feel that once the kidney fat is less than 30 percent the animal is in very serious trouble.

LOW PRONGHORN RECRUITMENT - IS IT AN ISSUE?

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Abstract: Classification counts for pronghorns throughout their range were obtained from published documents. Production indices or the proportion of young per 100 females as determined during the midsummer surveys was used as an index to kid survival and compared to known or assumed parturition rates. Mean ratios of kids per 100 females over several years ranged from a low of 43 in Texas to highs in excess of 100 in South Dakota. A focus of high kid survival existed in southeastern Montana, Wyoming, southwestern North Dakota and western South Dakota. In the remainder of the pronghorn range the midsummer production indices were much lower. Collectively, these findings, when compared to known fetal rates, suggest that average kid losses during the first 2 - 3 months following parturition are in the order of 25 to 65 percent. We conclude that low recruitment is a reality for pronghorn populations throughout most of their North American range.

Pronghorn populations throughout much of their range are surveyed annually in midsummer. These surveys are designed to provide data on changes in distribution and density of pronghorns and on the age and sex structure of populations. Many agencies gauge annual production by calculating the number of kids per 100 females. The purpose of our paper is to investigate these indices of production and relate them to probable

parturition rates. By comparing the recruitment rate to midsummer, over most of the pronghorn range, we can gain insight into the probable magnitude of neonatal mortality. Major differences over broad geographic areas should also be evident. Survey figures used in this report were obtained from published documents and are fully referenced. Data representative of a given area or year were selected arbitrarily based on the published reports available to us. We also recognize that survey results are dependent upon many factors and may reflect different degrees of reliability.

Ellis (1972) reported that fetal rates for mature pronghorn does (over most of their North American range) are in the order of 1.92 per doe. Generally young of the year are non-breeders and this age class can be segregated from the breeding segment (Buechner 1960, Pyrah 1976). Pronghorns, however, have the capacity for rapid population expansion under suitable conditions but populations rarely achieve their growth potential. Based on the number of kids per 100 females, recruitment to 2 or 3 months of age is low over most of their present range.

NORTH AMERICAN PRONGHORN PRODUCTION

Pronghorn production indices expressed as the number of kids per 100 females in midsummer (Table 1) indicate a center of consistently high recruitment (Table 1, Figure 1). This center, comprised of Wyoming, southeastern Montana, southwestern North Dakota and western South Dakota has average summer recruitment figures of 88, 92, 100 and 105 respectively; not surprisingly, this center contains more than half of the North American pronghorns. Production indices on pronghorn ranges to the north drops to 78 in northeastern Montana, 71 in Alberta and 69 in Saskatchewan. Similar decreases are evident moving southward: Colorado 73,



Figure 1. Average midsummer production indices, expressed as number of kids per 100 does, for pronghorns in North America.

Table 1. Production indices (kids per 100 females) to midsummer for pronghorns in North America. The superscripts indicate the reference sources.

YEAR	CALIFORNIA	NEW MEXICO	TEXAS	ARIZONA	NEVADA	INTER STATE	OREGON	IDAHO	COLORADO	WYOMING	MONTANA S.E.	MONTANA CENTRAL	ALBERTA	SASKATCHEWAN
1977													58 [4]	61 [4]
1976													74 [3]	82 [4]
1975												74 [29]	54 [3]	60 [4]
1974												69 [29]	65 [3]	50 [4]
1973									54 [42]			115 [29]	61 [3]	55 [4]
1972									72 [42]			80 [29]	54 [3]	60 [4]
1971					29				68 [42]		92 [9]	73 [29]	46 [3]	70 [4]
1970					59				82 [42]		96 [9]	79 [29]	78 [3]	76 [4]
1969	69 [30]				59 [26]	27 [31]	50 [28]				93 [29]	78 [29]	80 [3]	86 [4]
1968	61 [30]				67 [39]	22 [31]	40 [22]				99 [29]	69 [29]	78 [3]	74 [4]
1967	58 [30]		34 [11]		49 [38]	29 [31]	32 [36]		90 [7]	90 [21,32]	92 [29]	42 [29]	63 [3]	82 [4]
1966	40 [30]		42 [11]		34 [17]	42 [31]	40 [36]		71 [7]	100 [21,32]	95 [29]	53 [29]	97 [3]	85 [4]
1965	52 [30]		51 [11]	29 [32]	39 [16]	36 [31]	39 [36]		54 [7]	93 [21,32]	70 [29]		86 [3]	54 [4]
1964	57 [30]		42 [10]	41 [32]	51 [15]	64 [31]	51 [36]		91 [7]	56 [21,32]	77 [29]		79 [3]	
1963	62 [30]		37 [10]	52 [32]	69 [19]	90 [13]	66 [36]	76 [35]	75 [7]	93 [21,32]	94 [29]		97 [3]	
1962	42 [30]	30 [23]	51 [10]	52 [32]	53 [14]	63 [13]	57 [36]	72 [34]		68 [21,32]	92 [29]			

Table 1. Continued.....

YEAR	CALIFORNIA	NEW MEXICO	TEXAS	ARIZONA	NEVADA	INTER STATE	OREGON	IDAHO	COLORADO	WYOMING	MONTANA S.E.	MONTANA CENTRAL	ALBERTA	SASKATCHEWAN
1961	64 [30]	65 [23]	63 [10]	49 [22]	48 [14]	54 [18]	45 [36]	76 [33]		108 [21,32]	95 [29]			
1960	39 [30]	80 [23]	51 [10]		52 [14]	53 [18]	59 [36]	69 [33]		88 [21,32]	99 [29]			
1959	53 [30]	15 [23]	32 [10]		45 [14]	68 [18]	45 [36]	74 [33]		93 [21,32]				
1958	70 [30]	95 [23]	59 [10]	45 [8]	77 [13]	74 [18]	77 [36]	72 [33]		103 [21,32]				
1957	66 [30]	100 [23]	37 [10]	40 [8]	86 [13]	96 [18]	81 [36]	71 [33]		78 [8]				
1956	57 [30]	30 [23]	31 [10]	42 [8]	51 [13]	58 [18]	59 [36]			96 [8]				
1955	77 [30]	85 [23]	57 [10]	42 [8]	52 [13]	28 [18]	59 [36]	100 [33]		81 [8]	94 [8]	83 [8]		
1954	84 [30]	90 [23]	47 [10]	65 [8]	69 [13]		65 [36]			91 [8]	98 [8]	97 [8]		
1953	40 [30]	72 [23]	11 [10]	53 [8]	62 [13]		62 [36]			88 [8]	88 [8]	95 [8]		
1952		10 [23]		85 [8]	49 [13]		49 [36]				101 [8]			
1951		45 [23]		53 [8]	60 [13]		60 [36]					91 [8]		
1950		70 [23]			91 [13]		91 [36]				93 [8]			
1949		120 [23]					89 [36]							
1948											86 [8]	79 [8]		
Average	57.3	64.8	43	50.5	56.9	54.3	57.9	76.3	73	88.4	91.9	78.5	71.3	68.8
Range	39-84	10-120	11-63	29-85	29-91	22-96	32-91	69-100	54-91	56-108	74-101	42-115	46-97	50-86

South Dakota - estimated average 105.[1, 42, 41]

North Dakota - estimated average 100.

Utah - 80% loss of kids.

Arizona 50, New Mexico 65 and Texas 43; and westward: Idaho 76, Oregon 58 and Nevada 57. Average production figures for the states west of the Great Divide are 33 percent lower than those for pronghorns on the Great Plains.

Even with substantial differences in average production indices over large geographical areas, upper limits of recruitment in some of the marginal areas approach those of prime ranges. For instances, all states and provinces, except for Texas, have recorded production indices in excess of 84 kids per 100 does and in some cases as high as 120 kids per 100 does.

SIGNIFICANCE OF PRODUCTION INDICES

The significance of the summer production figures is evident by following through a sample calculation. If we observed a midsummer population of 1,000 females and 700 young for a ratio of 70 kids per 100 females then we can gauge the extent of neonatal mortality to that point in time. A population of 1,000 females may contain 25 percent or 250 non-breeding yearling females. The remaining 750 mature females should have given birth to an average of 1.8 young each or 1,350 kids. Neonatal mortality therefore has been in the order of 650 young or 48 percent of those born. Similarly, ratios of 100 kids per 100 females indicate a postpartum mortality of 26 percent and ratios of 50 kids per 100 females indicate a 63 percent mortality.

SUGGESTED CAUSES FOR LOW RECRUITMENT

A great deal of concern has centered around this inherently low pronghorn production. In 1965 Hayley suggested that there was a positive

correlation between production and rainfall in southern pronghorn ranges. Larson in that same year found no correlation between the two and suggested that other factors play a role. In the Texas Panhandle, De Arment (1968) also found no correlation between moisture and production. In 1968 Hockley again implicated a high position correlation between production and precipitation for antelope in Wyoming.

Others have suggested that range conditions are important. Buechner (1960) implicated that more productive land combined with high pronghorn harvest resulted in more productive herds. Pyrah (1976) likewise suggested that range condition and/or weather had an overriding influence on production. He also noted that production varied inversely with the density of females. Ellis (1972) determined that a positive relationship existed between fawn survival and the proportion of vegetative cover in non-browse plant species. Winter severity has also depressed pronghorn production in some states.

In 1968 Knowlton, using data accumulated for white-tailed deer in Texas hinted at coyote predation as a factor that could seriously depress recruitment. However, a 3 year study in New Mexico on the impact of predators failed to correlate antelope fawn survival to either the degree of predator control or to the estimated coyote population (Johnson 1972). Yet Webb (1972) and Beale (1972) suspected that heavy predation by coyotes and bobcats resulted in low fawn survival in Arizona and Utah, respectively. Beale estimated an 80 percent loss of fawns in some areas in Utah.

Fluctuations in productions of pronghorns in Wyoming and southeastern Montana do not appear to be as severe as those on marginal ranges (Figure 2). Production indices for the western and southern states

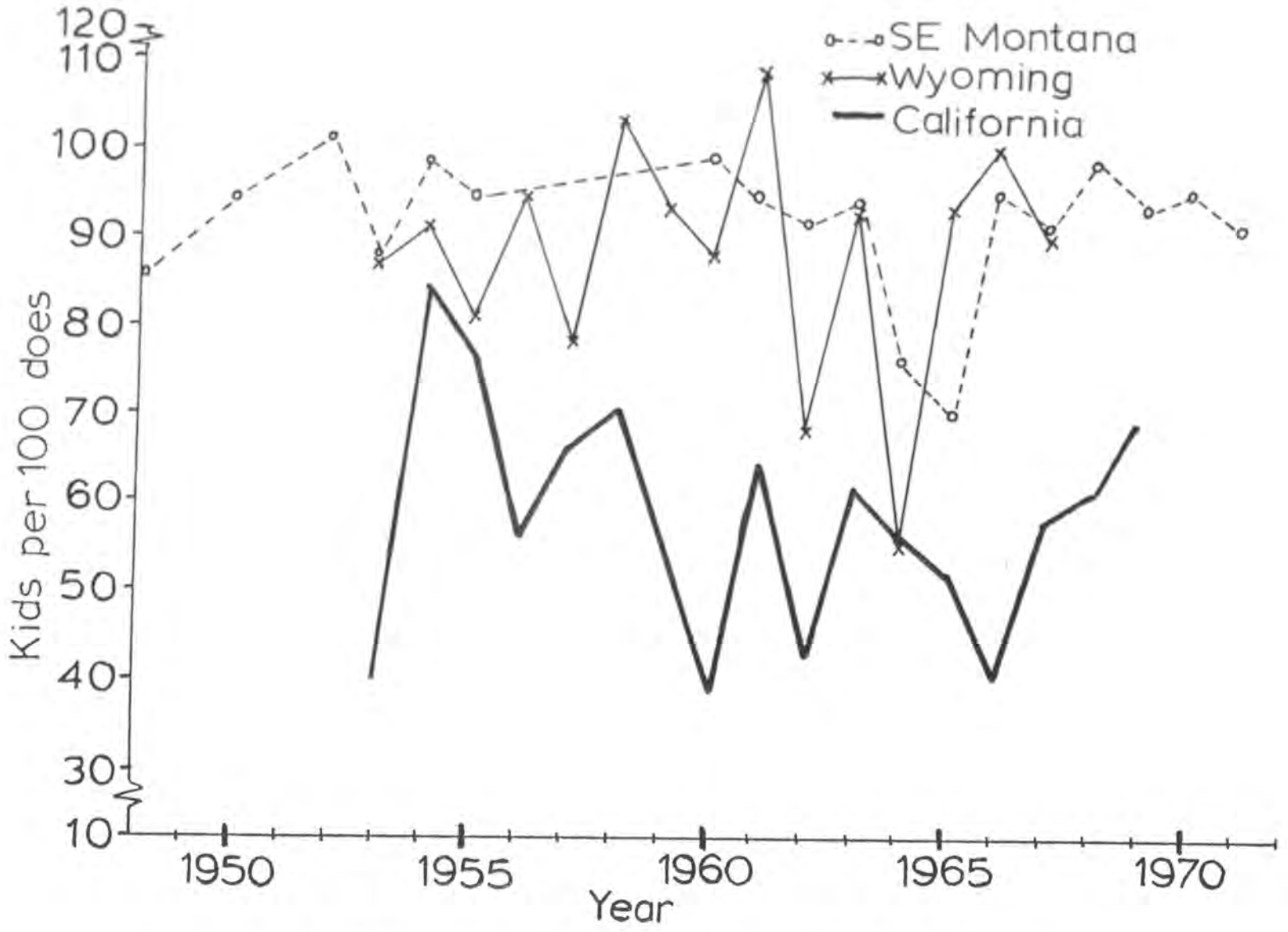

Figure 2. Average pronghorn production indices to two months of age for southeast Montana, Wyoming and California.

(Figures 3, 4 and 5) suggest some degree of correlation for the years 1949-1959 during which time production indices rose and fell three times almost synonomously. Similarly in Alberta and Saskatchewan production indices have followed the same general trend for the period 1965-1970 (Figure 6).

CONCLUSION

Occasionally females have ingested toxic substances or have been severely stressed through long winters and production of young falls; these problems are usually localized. However, there is no evidence to refute the contention that generally pronghorn natality remains high and approximates the fetal rate of 1.70-1.90 young per mature doe. Extensive kid mortality occurs in the 2-3 months following parturition; average losses throughout pronghorn range vary from 25 percent to 65 percent but frequently exceed 80 percent in some portions of the range. We must conclude that low recruitment is definitely an issue for pronghorn populations over much of their North American range. It will be up to other investigations to determine whether these mortality rates represent a major deviation from historical conditions or pose a significant obstacle in our ability to manage pronghorn populations.

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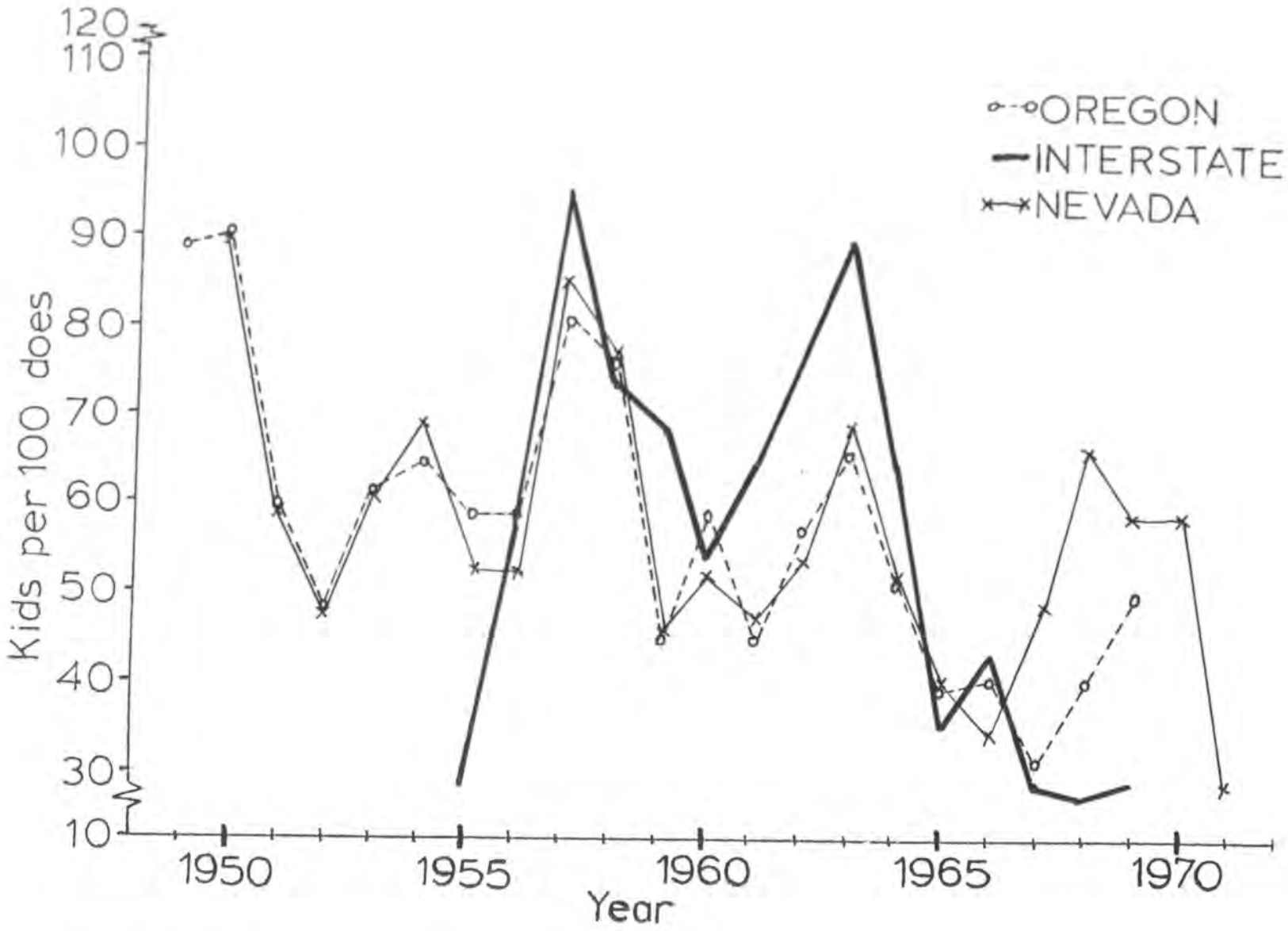

Figure 3. Average pronghorn production indices to two months of age for Oregon, Nevada and their interstate herd.

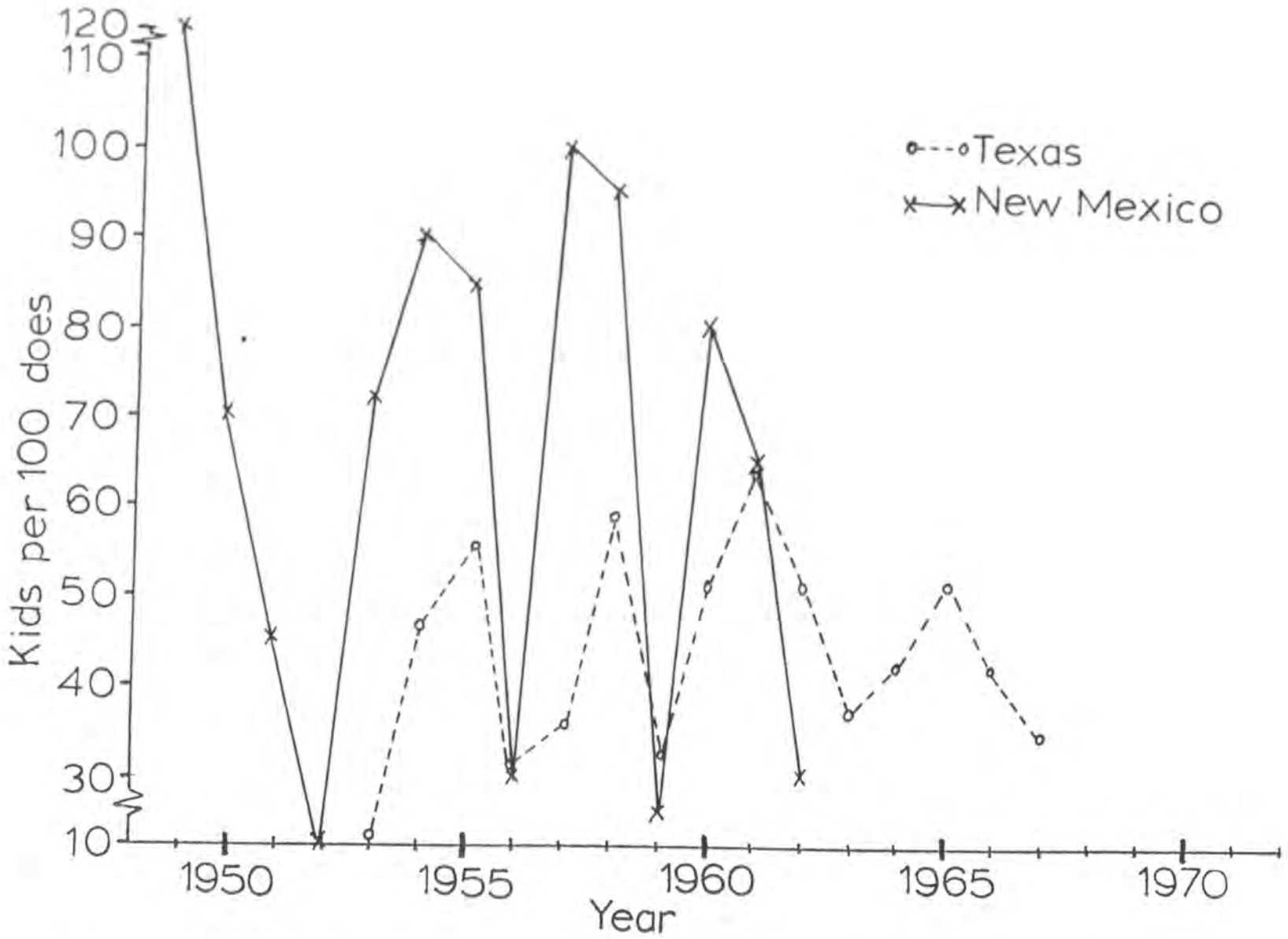

Figure 4. Average pronghorn production indices to two months of age for Texas and New Mexico.

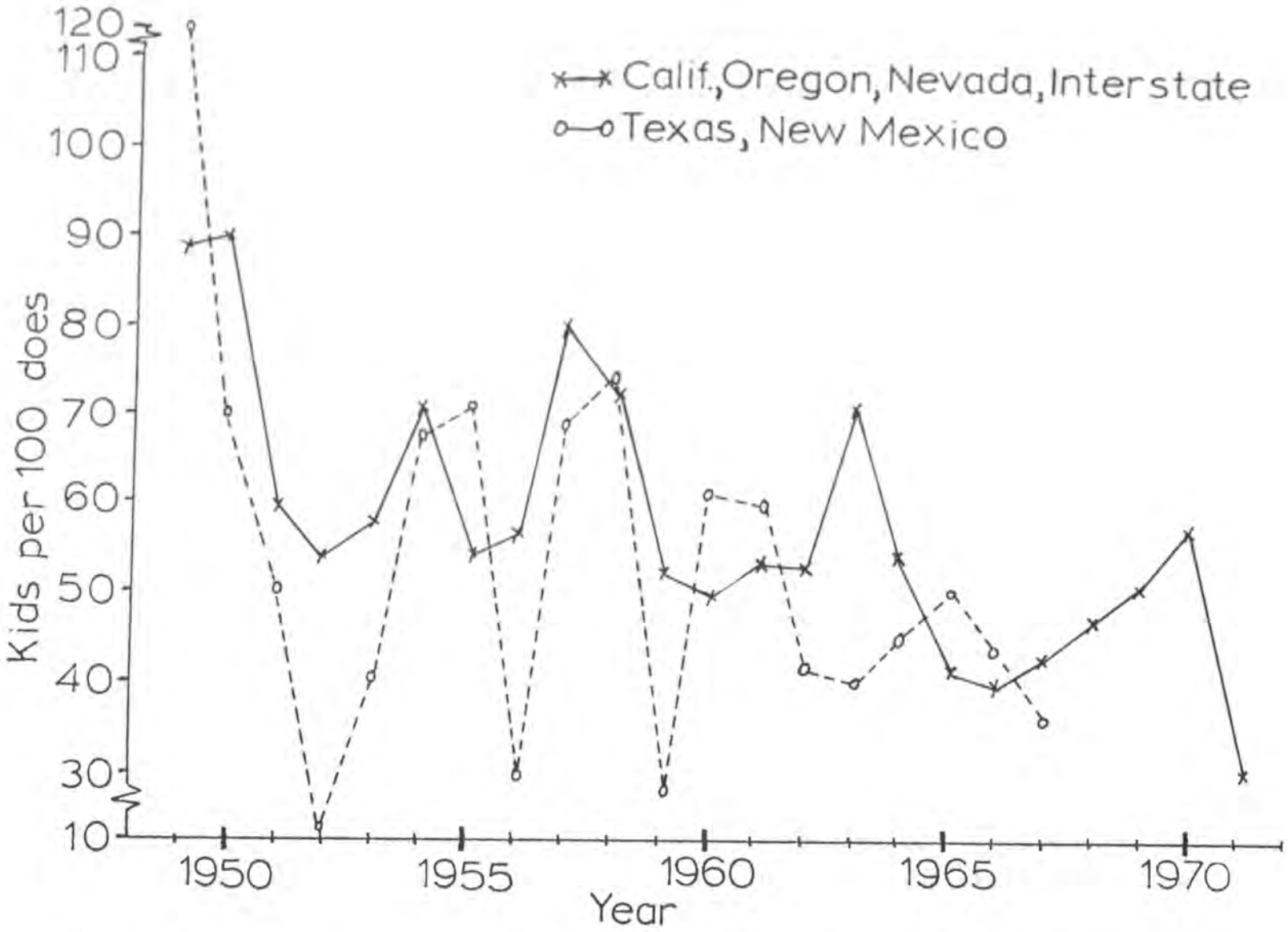

Figure 5. Average pronghorn production indices for California, Oregon, Nevada and their interstate herd in comparison to values for Texas and New Mexico.

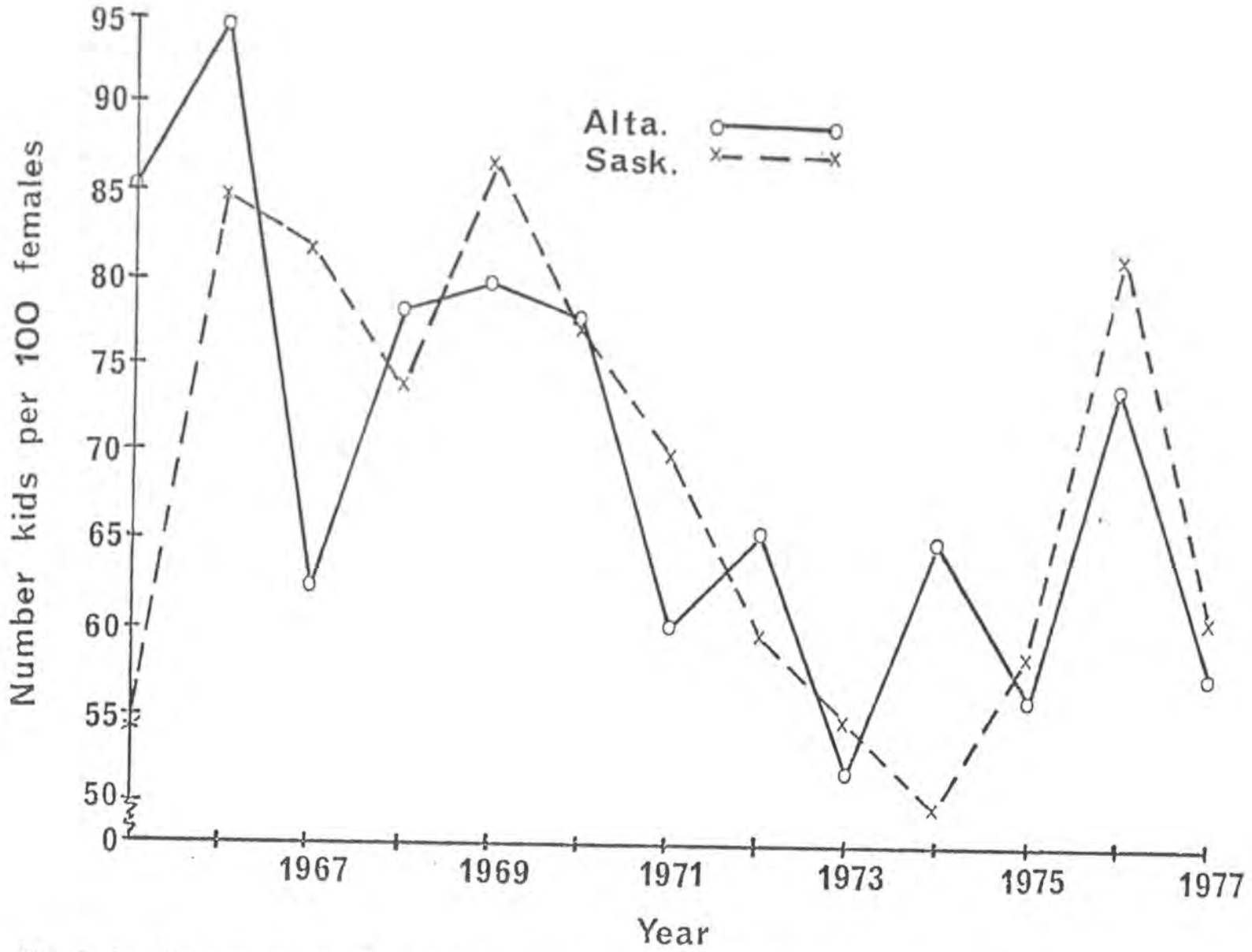

Figure 6. Average pronghorn production indices to two months of age for Alberta and Saskatchewan (Barrett 1978).

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COMMENTS AND QUESTIONS

SIMPSON: You didn't have any figure for Utah. Was that intentional or accidental?

VRIEND: We couldn't find any figures that summarized that state.

SIMPSON: Have you any idea where it fits in the pattern?

VRIEND: Beale suggested an 80 percent loss in production.

SIMPSON: That was just one year, though, wasn't it?

VRIEND: I believe so but I'm not exactly sure.

SIMPSON: Where's Don? Do you want to comment on where you think it fits in the pattern?

BEALE: It depends on the area you're talking about. If you're talking about our desert ranges it's down to 40 percent but if you're talking about some of our better areas production is up in the 80's. This geographic breakdown could be misleading.

VRIEND: I still think it does show certain geographical differences. I'm not that familiar with Utah but you do have different types of ranges, desert range, some ranges with a little better rainfall, etc.

SIMPSON: I think, Harry, from what you've done the next step might be well worth pursuing into different range types of desert, and upland range, sagebrush, and so on. That really would be an interesting comparison to give us some idea, perhaps, where pronghorn evolved

originally.

AMSTRUP: Did you really find that there was enough evidence on the actual production, or birth of fawns, in these various areas especially in the extremes that may have been isolated from other portions of the pronghorn range for long periods of time, to really say that the bulk of this drop from the apparent potential is indeed due to post-partum mortality or can you really rule out just a lower production? I would suspect, especially that animals that have been isolated for long periods of time in harsh conditions might adapt themselves to producing only one fawn for example, and I'm not aware of the evidence that would hammer this down one way or another.

VRIEND: We really can't say for sure, but I know that most of the references that we were looking at all suggested high parturition rates or high fetal rates.

HELMS: I have a comment to make on the mortality rates of fawns after we classify them. I had an experience with an area in Freemont County where we classified antelope in July. The number of fawns per 100 does at that time was 100 to 100 and I followed this through and in the end of February, which was through the hunting season, the fawn/doe ratio dropped to 57, and the number that was actually killed during the hunting season was probably less than 20. So we had mortality all year long practically on those fawns. I've been suggesting for many years that we're classifying antelope at the wrong time of the year to get the true picture of what the herd production is like.

VRIEND: That's something we never really looked at but we realize it.

HELMS: Right. We don't do it with our elk or our deer or our sheep, or anything else. We always classify them later on in the year. It's a little tougher to classify antelope later on in the year but I think it's a possibility and it really should be looked at.

VRIEND: We did look at some population structures for various pronghorn herds and again you're looking at 25 percent yearlings and that suggests continual mortality, but there's not that much information available.

BEALE: I'll just add that as far as your parturition rate of 1.9, that might be squeezing just a little bit high, but as far as all the data that I know of there's nothing to suggest that going south and east as far as Utah and New Mexico there's any drop, significant drop, in the birth rates.

DIFFERENTIAL CHARACTERISTICS OF PREDATOR KILLS

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Abstract: Feeding patterns of each predatory species are distinctive and should be used as clues but not as indicators that an animal was killed by that species of predator. During necropsies, carcasses of prey should be skinned and only the patterns of wounds typical of a predatory species accompanied by subcutaneous hemorrhages should be considered proof of kills. Some overlaps and exceptions must be expected in feeding and killing patterns, so tracks, feces and other sign should be observed.

Coyotes (*Canis latrans*) generally kill with bites to the neck. The upper canine teeth usually penetrate near an ear and the lower canines penetrate the opposite side of the trachea. Occasionally, the neck muscles are lacerated until the prey is paralyzed or the skulls of fawns are crushed. Coyotes commonly feed from the viscera, hams, or brisket, jerking off mouthfuls without bracing their feet against the carcass, scattering their prey's remains.

Bobcats (*Lynx rufus*) and mountain lions (*Felis concolor*) usually kill with bites to the back of the neck or base of the skull and leave telltale scratches on the shoulders of the prey. Cats generally eat from the shoulders and cover carcasses or pull them under rocks or bushes.

Golden eagles (*Aquila chrysaetos*) strike almost any part of an animal's body. They kill large animals by many talon stabs into the back. Eagles hollow out carcasses leaving the skin and large bones intact, but they

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

generally clip off and consume the ribs of young animals. Bald eagles (*Haliaeetus leucocephalus*) kill and feed in a similar manner. Carrion-eating birds also hollow out carcasses but cannot get to the meat next to the ground nor do they break off ribs.

Red foxes (*Vulpes vulpes*) usually take only lambs and fawns up to a month or so in age. Foxes chew a little more than coyotes do but kill much like coyotes. Foxes usually feed in from the back or rear and often lay down to feed from the underside of a carcass.

Bears, both grizzly (*Ursus arctos*) and black (*U. americana*) may kill by bites to the neck, shoulders or back, often leaving claw marks on the flanks or hams. The prey's back is sometimes broken just in front of the hips and the udder or loins are generally eaten first. Bears wallow down the vegetation around a kill and often vomit and defecate close by. Sometimes kills are moved, but bears use their feet while feeding and do not slide prey around like coyotes do.

Dogs generally are sloppy killers, making slashing-tearing attacks and leaving many cripples. Usually, if a dog-killed carcass is skinned 80 percent or more of the body will appear bruised. German shepherds, collies, huskies, and other large breeds with experience occasionally kill as cleanly as coyotes. Usually, dogs do not eat sheep or big game, but if they do they often vomit close by.

Electronic monitoring devices, allowing researchers to find carcasses before they decompose, are now available commercially. However, few wildlife biologists have had the opportunity to observe and study large numbers of predator kills. After attending a workshop on identifying

predator kills at Colorado State University, Fort Collins, I investigated over 1,200 predator kills with six of my graduate students who conducted or are conducting predator/prey studies. I observed the feeding, and occasionally killing, behaviour of six golden eagles, kept at the Montana Cooperative Wildlife Research Unit, for many years. I am frequently called upon by ranchers and state fish and game department personnel to determine causes of death for carcasses, or to view remains of animals observed being killed by predators.

This paper is designed to help biologists determine, from post-mortem evidence, whether animals were killed by predators and if so, what species of predator was responsible. Most of the information herein was gathered from domestic sheep and lambs, but the criteria for determining kills of other prey are the same. Attention will be given to only those predators that could reasonably be expected to kill pronghorns (*Antilocapra americana*).

Carcasses and suspected kill sites should be approached carefully. Evidence, such as tracks, feces, spurts of blood and wallowed down vegetation, is easily destroyed or confused if walked upon. Although feeding by a given species of predator should not be considered evidence that that species killed an animal, feeding patterns should be understood. If a coyote, golden eagle, or some other predator obviously fed upon a carcass then that predator's typical pattern of killing wounds should be looked for first.

Although the predator that fed upon or killed an animal can usually be determined there are overlaps and exceptions in feeding and killing behaviour. The predators are smart animals which occasionally learn individual feeding or killing styles and thereafter vary somewhat from

the typical feeding or killing patterns of their species. The sizes of holes made in the prey's skin by a carnivore's canine teeth are diagnostic but the width between tooth holes is not. The prey's skin is often stretched or wrinkled when the bite is made. Predators often defecate near their kills, providing another clue.

Every carcass suspected of being a predator kill should be skinned completely after a thorough examination of the kill site and exterior of the carcass is completed. Lack of external blood or evident punctures prove nothing. Subcutaneous hemorrhaging at the site of a tooth or talon puncture is proof that an animal was alive when seized or bitten.

I am grateful to the many people who contributed to this project and especially thank ranchers Bill and Greta Cook and Joe Helle. Donald Balser, U. S. Fish and Wildlife Service, contributed in many ways and graduate students Donald Henne, John Munoz, Kimber Brawley, James Reichel, Barbara Von Gunten, Walter Bodie, Max Zahn and Van Jameson assisted in many aspects of the study. Research was partly funded by the Denver Wildlife Research Center under contract 14-16-008-1135.

COYOTES

Coyotes commonly feed from the viscera of large mammals, taking the fat of the greater omentum, the kidneys with surrounding fat, the heart and pericardium, and the liver, generally in that order. When feeding on muscles, coyotes generally prefer the hams but sometimes "cut" off a shoulder and feed upon it. A coyote can eat 2.3 to 3.2 kg (5 to 7 lbs.) of meat and fat at a time, but when pups are at the den adults will often regurgitate at the den and feed at least once more. Small fawns are occasionally carried intact to coyote dens. Coyotes seem to like cartilage;

they often eat the brisket from a carcass and chew the soft lower ends of the ribs leaving ragged portions attached to the backbone. Often, young fawns are almost completely consumed; a few teeth may be the only remains. A coyote will sometimes sever the head from a carcass and carry it a considerable distance, apparently to be chewed on at leisure away from the disturbance of other feeding coyotes. The tongue and nose, up to the eyes, are usually eaten. Coyotes tend to scatter their prey's remains, jerking mouthfuls of meat from a carcass without bracing their feet against it. Thus, the carcass is often moved some distance, especially downhill, with each bite.

Coyotes occasionally bury their prey. When they do, the carcass is usually covered with dirt which is packed down. Although coyotes do not do this often, the burials are much neater than those of cats which almost always cover their prey.

Coyotes generally kill cleanly with bites to the neck and throat. About 85 percent of over 1,200 kills of lambs and ewes by coyotes during recent studies in Montana were made with this type of hold (Henne 1977, Munoz 1977, Brawley 1977). That hold left punctures by the upper canine teeth just behind or below one ear and opposing punctures on the opposite side of the trachea. The average punctures varied from .318 to .476 cm (1/8 to 3/16 inches) in diameter. Blood was usually, but not always, evident on the wool of the neck. Extensive subcutaneous hemorrhaging was always present. The hyoid bones were often crushed from the tracheal shield and the larynx and anterior end of the trachea could be lifted free of the neck musculature after skinning.

Occasionally a coyote would bite repeatedly. Such chewing appeared to lacerate the neck muscles and paralyze the prey. Coyotes sometimes

catch small (up to 6.8 kg (15 lbs.)) running prey by biting across the back. With such a catch considerable subcutaneous hemorrhaging occurs and ribs are often broken or internal organs are ruptured. Unless the prey is killed quickly the coyote then takes a throat hold. During one study in Montana (Henne 1977) one coyote ("Crusher") seemed to specialize in crushing the skulls of lambs. Location of the bite was often similar to that of bobcats but Crusher did much more extensive damage. The skulls of lambs up to about 13.6 kg (30 lbs.) were completely demolished and the heads were sometimes jerked from the atlas. Apparently the latter occurred when Crusher held on and shook a lamb vigorously.

While the throat hold resulted in obvious punctures on pronghorn fawns and domestic sheep I have investigated, the same hold on domestic calves and adult mule or white-tailed deer (*Odocoileus hemionus* and *O. virginianus*) often caused only bruises or only one or two of the four canine teeth would penetrate the skin. Subcutaneous hemorrhaging and crushing of the trachea still resulted. The lungs of adult deer that had been running had numerous small hemorrhages, apparently caused by the pressures of violent attempts to breathe after the trachea was crushed and held shut. Such lungs would have some larger blood clots that appeared to have been sucked in from the throat wound. Large animals, adult deer and yearling elk, usually had bites around the tail or on the hocks as well as the throat wound. Those bites often appear as slices rather than round punctures.

BOBCATS

Bobcats generally eat from the shoulders of their prey. Meat is cleaned off of bones but only small bones are cracked or broken. Bobcats

seldom eat entire fawns, even small ones. Carcasses are almost always covered to some extent before being left. If the prey is not too large it may be completely buried where the soil is loose, or the remains may be pulled or carried for a considerable distance to be placed under bushes or overhanging rocks.

Bobcats usually kill their prey cleanly with a bite or bites to the back of the neck or the base of the skull. Unless fawns are quite small scratches are usually evident on the shoulders, backs or sides of the victims. Scratched out hair and strips of hide are sometimes found where the prey was first caught. Adult deer sometimes carry bobcats for some distance before the cat can make the kill. I saw evidence in the snow of a bobcat riding a white-tailed doe for about 40 yards. A cat usually has to catch and hold its prey with its claws before making a killing bite and death results from dislocated neck vertebrae. However, bobcats sometimes bite fawns' heads without leaving claw marks. The skulls may be fractured but are not crushed like those bitten by coyotes.

The tooth punctures are generally smaller than those left by coyotes and measure only .159 to .318 cm (1/16 to 1/8 inch). Tooth marks on the back of an animal's neck are sometimes teardrop shaped or slit-like. Bobcat teeth seem to slash more than those of the canids.

GOLDEN EAGLES

Splashes of "whitewash" on the ground and small downy feathers on vegetation are often evident where eagles have fed. Eagles generally feed first on the viscera, eating everything but the stomach and intestines. Carcasses, heavily fed upon by eagles, appear to be turned inside out; the backbones are usually intact though devoid of ribs and the leg bones

are pulled out of the skin with most of the meat gone. The ribs of young fawns or lambs are usually neatly clipped off close to the backbone and swallowed by the birds. Eagles sometimes open the skulls without crushing them and eat the brains. Some birds hook their beaks into the foramen magnum and lift the top of the skull off. Others eat through the throat, taking the tongue and opening the skull from the bottom.

Carrion eating birds also "hollow out" ungulate carcasses but generally are unable to move them; they cannot reach the meat on the side next to the ground, or break off ribs. These birds pull meat away from the tendons leaving frilly white tufts on the bones. Eagles cut the meat and tendons cleanly.

When attacking, eagles tend to grasp almost any part of an animal's body. Eagles may simply land and start feeding on young lambs or fawns. The animal dies from bleeding as the entrails are pulled out, resulting in considerable blood on the ground. Such kills are difficult to diagnose because young animals recently dead from other causes seem to have a slow clotting time and also bleed on the ground when fed upon. Unless clear evidence of arterial spurts is visible on the ground or vegetation, carcasses without talon wounds and subcutaneous hemorrhages should not be classified as eagle kills.

Examining the pattern of wounds without removing the skin is often easier with eagle kills than with those of mammalian predators; however, skinning is often necessary. Eagles grasp their prey with three toes opposing the hallux on each foot. The middle toe is the longest so, if the prey is large enough the toe talons leave wounds 2.54 to 5.02 cm (1 to 2 inches) apart in a row or shallow V. The hallux wound is from 10 to 15 cm (4 to 6 inches) from the middle toe wound. Talon punctures

are generally deeper than those made by teeth, can be as wide as 1.27 cm (1/2 inch) without tearing and are more triangular than round. Crushing of bones is seldom noted between talon wounds.

Tough active prey such as domestic goat kids and prey larger than 13.6 kg (30 lbs.) often have so many talon wounds that the patterns described above are confused. The birds must repeatedly stab such prey until it bleeds out and is immobilized. I have seen golden eagles grab jackrabbits (*Lepus townsendii*), about the size of newborn antelope fawns, and the rabbits never struggled. Apparently the grasp was strong enough to instantly kill or paralyze. Carcasses from such kills have only one set of talon wounds. Commonly, on animals the size of small fawns, fewer than four talon marks are evident, one made by the hallux and one or two by opposing toes. Animals the size of adult pronghorns are usually killed by multiple talon stabs through the tops of the ribs or into the small of the back. Eagles talons are ideally shaped to encircle a mammal's spinal column and puncture the aorta. The victims bleed internally after the large arteries are punctured, often in the vicinity of or just anterior to the kidneys.

During a recent study in Montana (O'Gara, in press) golden eagles sometimes seized young lambs by their heads. The lambs seemed unafraid of the eagles and apparently did not flee as the wounds indicated that the lambs were struck head-on in many instances. A single puncture from the claw of the hallux appeared in the top or front of the skull and the opposing talons punctured the base of the skull or nape of the neck.

As with other carnivores only subcutaneous hemorrhaging should be considered evidence that an animal was alive when struck. When carcasses are completely consumed the hemorrhages are apparently eaten off of the

skin. Eagles kept at the Unit were not observed puncturing the skins of dead animals or those small enough to be eaten alive. However, talon punctures without subcutaneous hemorrhages should not be used as evidence of a kill since different birds kill and feed in different ways. These criteria are very conservative and carcasses so classified as eagle kills could hardly be anything else. Many fed-upon carcasses not classified as kills by such criteria undoubtedly were killed by eagles so the kills must be considered absolute minimums. Stabbed carcasses in which the hemorrhages were apparently eaten from the skin should be considered possible kills. The only bald eagle kill I investigated, a Hereford calf, was indistinguishable from that of a golden eagle.

RED FOXES

Red foxes may take young fawns. A rancher told me that when coyotes were scarce in Wyoming because of 1080 poisoning foxes were taking large numbers of fawns. He had seen foxes catch a few fawns and had found many fawn parts at fox dens. Although I have heard of foxes killing mature sheep, lambs over 11.3 kg (25 lbs.) seemed secure from fox predation on study areas where I worked. Lambs between 9.1 and 11.3 kg (20 and 25 lbs.) were occasionally attacked but not killed by foxes. Foxes commonly carry their prey to their dens. Surprisingly large prey, weighing as much as the fox, are sometimes carried. The prey is usually grasped by the head or neck and carried across the fox's shoulders and back. Feeding foxes make surprisingly straight and knife-like cuts. They often cut off the lips, udders or genitals. Foxes usually feed in from the back or rear of a carcass and often lay down and feed from the underside. Badgers (*Taxidea taxus*) also feed from the underside of carcasses but tend

to burrow clear under.

Red foxes chew more than coyotes do but kill much like coyotes do. The tooth punctures are small and eliptical and are about .159 cm (1/16 inch) long and half that wide.

RACCOONS

Raccoons sometimes feed in from the back of a carcass taking the loins much like a red fox does. More often, a raccoon will make a small hole, about 2.54 cm (1 inch) in diameter, into the side of a carcass just behind the ribs and then pull the viscera out and eat it. Only an animal with hand-like paws could clean a carcass out so neatly.

Raccoons apparently grab their prey with their paws before biting. The killing wounds look much like those of a fox but are less precisely placed. The foxes' bite marks are under the ear and over the trachea like those of a coyote, whereas the raccoon's bites seem to encircle the whole neck. Skinning the carcass will generally reveal bruises where the prey was held but not deep scratches like those of cats.

MOUNTAIN LIONS

Mountain lions, like bobcats, usually feed first from the shoulders. The big cats also cover their prey but seldom bury it. Lions bite and scratch off tufts of hair so a cached carcass is almost buried in hair.

Cougars kill in a manner similar to that described for bobcats but the tooth punctures are larger, about .635 or .794 cm (1/4 or 5/16 inch), and tend to be rounder than those of the smaller cat. The strips of hide at the site of the first attack are generally larger than those clawed out by bobcats. Lions usually bring deer-sized animals down within a few

yards of the point of first contact, except on steep hillsides. I have seen tracks indicating that a lion on the back of an elk (*Cervus elaphus*) rode about 41 m (45 yards) from the point of initial attack before making the kill.

BEARS

Bears wallow down the vegetation around a kill or carcass and often vomit and defecate close by. They sometimes move kills but leave the carcass clumped. Because bears use their feet while feeding they do not slide prey around like coyotes do. Both species of bears are said to cover their prey but I have seen only grizzlies do so. They cover carcasses quite completely, raking considerable dirt and heavy material over the animal. Bears eat the udders of lactating females first. The crotch area and the loins seem to be favoured feeding spots.

Bears may kill by neck biting but the prey often has claw marks on the flanks or hams where the bear grabbed it. Bites are sometimes delivered to the top of the prey's shoulders or back. The back is sometimes broken just in front of the hips where the bear simply crushed it down. Large bruises often indicate that a bear "slapped" an animal while catching it. The canine tooth punctures from a bear are comparatively large, varying from .635 to 1.27 cm (1/4 to 1/2 inch). Bone crushing often accompanies the bite.

RAPTORS SMALLER THAN EAGLES

Bodie (personal communication) had two pronghorn fawns attacked by small raptors during his study in Idaho. Both were bruised on one side, the livers were ruptured and talon marks were found in the heads and necks

after skinning.

DOGS

A few dogs that have gone wild may be exceptions but most dogs do not feed on the carcasses of large animals they have killed. When dogs do feed on big game they usually feed on the hams. If dogs eat sheep or freshly killed big game they often vomit close by.

Dogs are generally very sloppy killers of big game. They often make slashing, tearing attacks leaving many cripples. Intestines pulled out, hams skinned and chewed, and noses or faces lacerated are common results of dog attacks. Usually more than one dog is involved. German shepherds, collies, huskies and other large dogs occasionally gain experience and kill almost as cleanly as coyotes. Skinning the carcasses of large animals killed by dogs generally reveals that 80 percent or more of the body surface was bruised by bites that did not penetrate the skin. I saw three mule deer fawns, about 13.7 kg (15 lbs.) each that had been killed by a German shepherd. The fawns were bit across their backs and apparently crushed to death. The dog did not bite the necks.

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COMMENTS AND QUESTIONS

HELMS: Do you find that badgers are a factor in the calving areas for elk?

O'GARA: I haven't worked calving areas for elk enough to be able to say. The only place I've been around elk, grizzlies were about the only thing taking them so I don't have an answer for you. One person from the university noted badgers killing a few mountain sheep lambs in one place but I don't think I've seen a badger kill, myself, so I can't help you.

PRONGHORN FAWN MORTALITY ON THE NATIONAL BISON RANGE[1]

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Abstract: Thirty pronghorn fawns (*Antilocapra americana*) were fitted with radio transmitters, between 16 May and 4 June 1977, to determine the cause and extent of mortality on the National Bison Range in western Montana. Twenty-seven were dead at the end of September, a mortality rate of 90 percent. Nine carcasses were found with enough evidence to determine the cause of death; five were killed by coyotes (*Canis latrans*), three by bobcats (*Lynx rufus*) and one by a golden eagle (*Aquila chrysaetos*). Only bits of bone, hair, chewed elastic and the transmitters were found from 11 fawns; remains of nine were found in the vicinity of coyote dens and the fawns were undoubtedly consumed by coyotes. Information concerning deaths of seven fawns was lost due to three transmitter failures and four transmitters dropping from the animals too soon. From the number of denning areas and activities I observed, the coyote population on the Range in the summer of 1977 was estimated at 33 or more. Sampling indicated that the rodent population was low, especially *Microtus* spp.

Factors involved in the high mortality could be the high number of coyotes on the Range, the low number of alternative coyote prey, the traditional location of the fawning grounds and the concentration of

[1]Support for the study was contributed by the Montana Cooperative Wildlife Research Unit, the Denver Wildlife Research Center Contract 14-16-008-1135, the National Rifle Association and the National Bison Range.

[2]The U. S. Fish and Wildlife Service, the Montana Fish and Game Department, the University of Montana and the Wildlife Management Institute cooperating.

coyote dens near the fawning areas. Pronghorns are not indigenous to the National Bison Range, so possibly marginal habitat is contributing to the mortality.

In the early 1900's the future of the pronghorn antelope seemed very uncertain. Their numbers across North America had been reduced to about 20,000 due to uncontrolled hunting and decreased suitable habitat (Yoakum 1968). The National Bison Range (NBR) was one of the first areas to acquire pronghorns for their protection and continuation as a species. Pronghorns are not native to the NBR; 12 animals from Yellowstone National Park were colonized on the Range in 1910. They increased to 57 in 11 years, but all died during the next 2 years, due to a hard winter, disease and poachers. A second transplant was tried with nine hand-raised animals from Nevada; all died within a year (Anon. Undated a).

For 25 years antelope were absent from the NBR. They were reintroduced in 1951 and this time the transplant was more successful. By 1962 the pronghorn numbers were up to 120. Between 1962 and 1970 the fawn death rate was not more than 32 percent and recruitment into the population was high. Transplanting and cropping of surplus animals was necessary as the herd grew. In 1970 the mortality rate of fawns jumped to 66 percent and has continued to be high in recent years: 62 percent in 1971 and 80 percent in 1973 (Anon. 1956-77); 73 percent in 1974 and 69 percent in 1975 (Reichel 1976); and 93 percent in 1976 (Anon. 1956-77). As a result, the population remained relatively stable and reductions were not necessary.

A complex of factors, disease, adverse weather, range conditions and

predation could be involved in the high fawn mortality. In some pronghorn studies predation was present but was not considered a major limiting factor (Buecher 1950, Compton 1958, Beale and Smith 1966, Howard et al. 1973). Udy (1953) studied the effects of predator control on pronghorn populations in Utah and found fawn survival higher on areas with coyote-control measures than on areas with no control. Yet, he considered poor range condition and competition with livestock greater problems than predation. During 6 years, Arrington and Edwards (1951) encountered a close positive correlation between fawn crops and predator control work done in Arizona. Through the use of radio telemetry, Beale and Smith (1973) found that bobcats were involved in the high fawn mortality that had inhibited the increase of pronghorns in western Utah.

Many predation studies have concluded that the most vulnerable animals were killed, but the vulnerable were not necessarily the sick, inferior or surplus animals (Connolly 1978). According to Connolly, "Whenever very young animals are the prey it seems unlikely that weak and unfit individuals would be taken selectively, as any newborn ungulate discovered by a predator would be vulnerable".

Reichel (1976) found, by analyses of coyote scats from the NBR, that pronghorns were an important part of the coyote diet during late May and June, the time when the fawns were born. The scat analyses indicated that coyotes consumed the carcasses but did not insure that coyotes killed the fawns. Of seven fawns equipped with radio transmitters during Reichel's study, only one death could be definitely attributed to coyote predation. Four were "coyote involved" with over 95 percent of each carcass consumed. Weak calf syndrome was suspected in the other two deaths.

The research reported in this paper was conducted on the NBR, from April through September 1977, as an extension of the Reichel (1976) study.

STUDY AREA

The NBR (Figure 1) is located in western Montana at the southern end of the Flathead Valley, with elevations ranging from about 788 to 1,489 m (2,585 to 4,885 feet) above sea level. The 7,509 ha (18,541 acre) Range is completely enclosed with a game-proof, woven wire fence. My study was concentrated on the eastern half of the Range, where most of the does were located.

Two separate herds of bison (*Bison bison*) are managed through a deferred rotation grazing program, with movements restricted to two of eight pastures every 3 months. The fences are built so that the other ungulate species on the Range, pronghorns, elk (*Cervus elaphus*), white-tailed deer (*Odocoileus virginianus*), mule deer (*O. hemionus*), bighorn sheep (*Ovis canadensis*), and mountain goats (*Oreamnos americanus*) are relatively free to roam over the entire Range.

Grasslands with low ridges and small basins predominate the northern half of the Range. Much of the southern half is steep and rocky with dissecting small canyons, except for the southeast corner which is a flat area about 1/2 km^2, encompassing the three small Ravalli Ponds. The grasslands on the Range consist largely of Palouse Prairie vegetation with bluebunch wheatgrass (*Agropyron spicatum*) as the principle species. Other major grasses are Idaho fescue (*Festuca idahoensis*) and rough fescue (*F. scabrella*). Swales and drainage courses contain snowberry (*Symphoricarpos occidentalis*), hawthorn (*Crataegus douglasii*), and wild

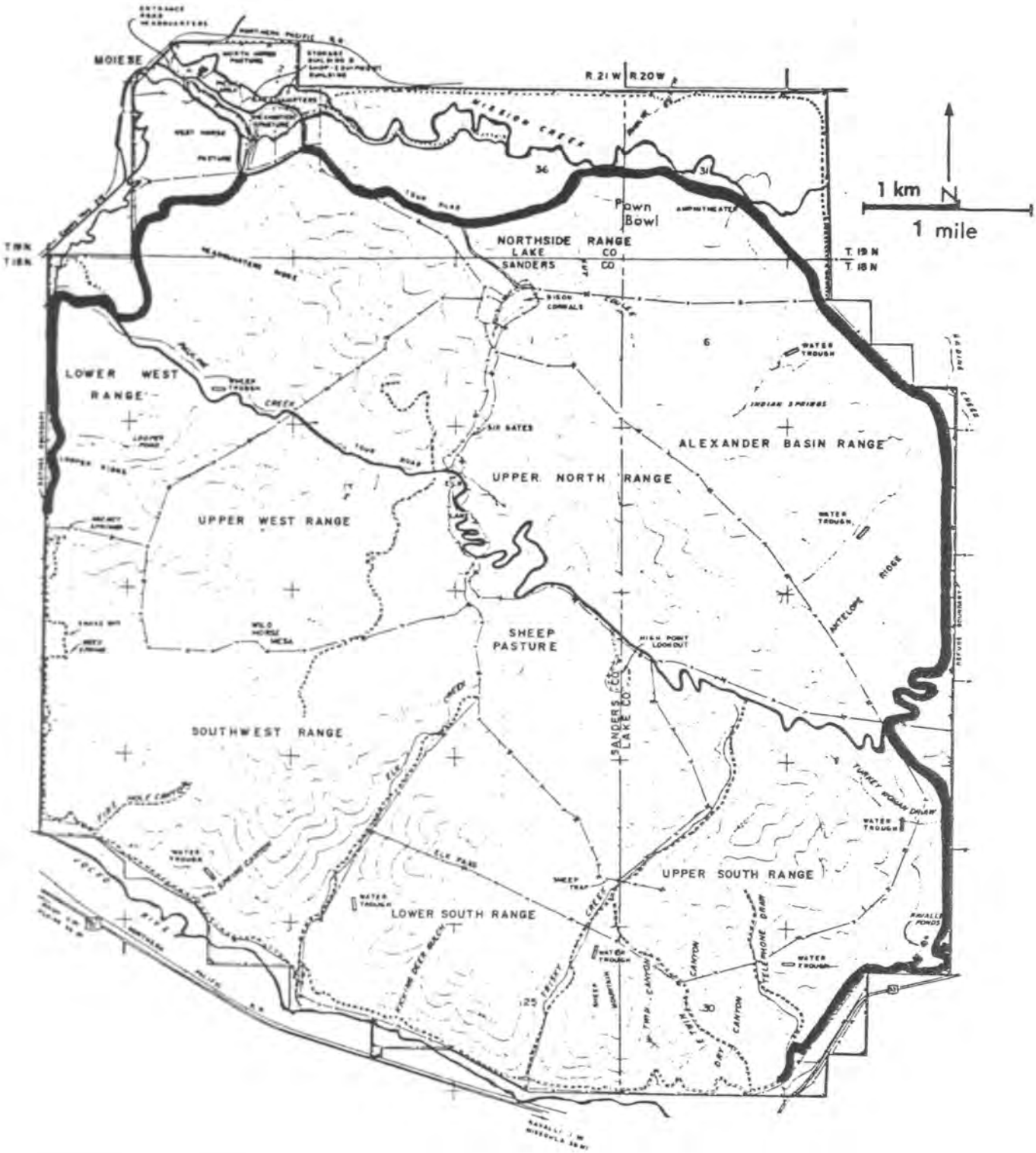

Fig. 1. The National Bison Range, Montana. The location of the standardized scent station line is marked by the heavy black line.

rose (*Rosa* spp). Rocky outcrops and stony areas support scattered stands of chokecherry (*Prunus demissa*), serviceberry (*Amelanchier alnifolia*) and mockorange (*Philadelphus lewisii*). Major forbs include balsamroot (*Balsamorhiza sagittata*), yarrow (*Achillea lanulosa*) and aster (*Aster falcatus*).

Rumen analyses by O'Gara and Greer (1970) indicated that NBR pronghorns were not on a normal diet compared to the findings of other studies of northern pronghorn food habits. Browse, especially sagebrush, made up over 80 percent of the winter diet during studies in some northern areas (Fichter and Nielson 1962, Bayless 1969, Beale and Smith 1970). Yet, forbs made up the largest part of the NBR pronghorns' diet during winter (O'Gara and Greer 1970). Monthly use of forbs ranged from 44 to 84 percent, with yarrow and aster most frequently used. Grass was eaten in trace amounts during August and September and increased to about 5 percent in the autumn, while maximum utilization of about 30 percent grass prevailed from March through June. Some browse was used throughout the year, with fringed sagebrush (*Artemisia frigida*) and snowberry occurring most frequently.

The climate at the NBR is generally mild. Winter temperatures rarely fall below -20^0 C, and summer temperatures seldom exceed 38^0 C. The 25 year average of annual precipitation, accumulated from September to August, the ecological year of the pronghorn (Fichter and Nielson 1962), is 31.9 cm, but was only 18.5 cm in 1976-77 (Anon. Undated b, NBR Records).

METHODS AND MATERIALS

Pronghorn Fawn Mortality

Observers situated at high vantage points used binoculars and spotting

scopes to scan areas for does. In past years, most fawning occurred in the northeast section of the Range (NE) in the Fawn Bowl and Alexander Basin (Kitchen 1974, Hadderlie pers. comm.). A large group of does moved to the southeast section (SE) during May 1977 and fawned there, so observations were concentrated in both eastern areas. A pregnant doe near parturition left her group and indicated impending birth by frequently standing and lying, raising her tail, humping her back and self-licking of the belly and flank areas. Postparturient does were watched until they fed their fawns.

When a fawn was located its surroundings were carefully noted. Newborn fawns were not handled until 4 hours had elapsed, allowing a mother-young imprinting period (Autenrieth and Fichter 1975). After approaching slowly and quietly a salmon net 0.8 m in diameter was gently placed over the animal. The net was unnecessary for fawns under 3 days old, but was used in all cases to assure capture. A rag tied over the fawn's eyes kept the animal quiet as it was handled. Working quickly, the fawn was sexed, aged, weighed, eartagged, checked for general condition, and the length and girth were measured. Fawns were aged by the condition of the pelage and the umbilical cord, and by their response to capture using Bromley's (1977) criteria. Fawns 1 day old or less made no or only feeble attempts to escape, had damp umbilical cords, and the hair on their backs was often in small clumps, apparently stuck together by dried amniotic fluid. Fawns from 1 to 3 days of age were easily caught, but struggled vigorously when captured, often bleating. Their umbilical cords were gone or hardened. Fawns from 3 to 7 days of age were difficult to catch with the net, leaping up as the net was placed over them.

Each fawn was fitted with a radio transmitter which had a temperature-

activated switch designed to change pulse rate by a factor of two or three times slower when the animal died and cooled down. A small patch of hair, about 2 by 4 cm, was clipped close to the skin between the scapulae to remove the insulating effect the hair might have on the temperature-activated switch. A dab of cattle-back-tag cement was used to keep the transmitter from shifting. Two pieces of elastic were stapled, one around the neck and one around the chest, to attach the package to the fawn. As the fawn grew the elastic stretched, the staples pulled out, and the radio package fell off. The behaviour of the doe was noted during and after handling to determine if the fawn was accepted or rejected.

Via car or afoot, I located fawns as often as possible using a hand-held, 3-element Yagi antenna and an AVM receiver. Data collected from live fawns included date and time sighted, location, activity and condition. Dead fawns were photographed, examined and collected with notations on date, location, approximate time of death, tracks or signs of predators and carcass description. All carcasses were later necropsied to determine cause of death. Characteristic patterns of attacking and feeding on prey species, as described by Giles (1971) and Henne (1975), were used to ascertain what predator had killed or fed on a fawn.

Over 95 percent of the does on the NBR had twins during O'Gara's (1968) study, so an estimate of fawns born was derived from a pregnant doe census taken in early May. Fawn counts were conducted during August and September to determine fawn mortality for the whole NBR pronghorn population.

Coyote Population

A standardized scent-post line was run in July and September to obtain an index of relative coyote abundance (Linhart and Knowlton 1975). The route used by Reichel (1976) was followed to standardize the index on the

Range for better comparison of population trends between years (Figure 1).

A minimum estimate of the coyote population was also obtained by direct observation of coyotes and pups at dens.

Rodent Population

Small rodents were sampled during May, July and September at 60 stations of four snap traps each, randomly placed within five habitat types. Trapping was conducted for 4 days, following 2 days of pre-baiting, using peanut butter and oatmeal for bait. After a day's catch was gathered each rodent was sexed, weighed, measured and inspected for reproductive condition.

RESULTS

Pronghorn Fawns

Thirty pronghorn fawns, 16 males and 14 females, were fitted with radio transmitters between 16 May and 4 June 1977 (Table 2). For fawns 1 day old or less, the average weight, total length, and girth were 3.71 kg, 64.8 cm and 37.9 cm, respectively, with no significant differences between males and females (Table 1).

Table 1. Means and standard deviations of weights, lengths and girths.

	Weight (kg)	Length (cm)	Girth (cm)
Fawns 1 day old or less (N = 15)	$\bar{x}$ = 3.71 s = 0.54	$\bar{x}$ = 64.8 s = 4.12	$\bar{x}$ = 37.9 s = 2.36
Fawns 2-3 days old (N = 11)	$\bar{x}$ = 3.83 s = 0.32	$\bar{x}$ = 66.6 s = 2.82	$\bar{x}$ = 38.6 s = 1.3
Fawns 4-5 days old (N = 3)	$\bar{x}$ = 4.69 s = 0.17	$\bar{x}$ = 71.67 s = 2.08	$\bar{x}$ = 42.67 s = 0.58
Fawns 6-7 days old (N = 1)	x = 5.78	x = 74	x = 43

All fawns appeared healthy and normal when handled, except for one fawn (#27) whose left front leg was dislocated at the proximal end of the cannon bone with the skin over the joint lacerated. Sixteen fawns were determined to be twins; others could have been twins but did not live long enough for me to see them feeding from the same doe.

Table 2. Physical characteristics of 30 fawns captured in 1977 on the National Bison Range.

Fawn No. -Sex	Twin No.	Date of Capture	Estimated Age	Weight (kg)	Length-Girth (cm)
1-M	-	16 May	1 day	3.9	61-39
2-M	-	21 May	2 days	4.2	64-39
3-F	4	21 May	1 day	3.9	59-38
4-F	3	22 May	2 days	3.7	71-38
5-F	-	23 May	2 days	3.9	62-41
6-F	7	24 May	4 hrs.	3.7	72-42
7-M	6	24 May	4 hrs.	3.9	67-39
8-M	9	24 May	6 hrs.	4.3	70-40
9-M	8	24 May	6 hrs.	3.2	62-38
10-M	11	24 May	4 hrs.	4.2	63-38
11-M	10	25 May	16 hrs.	4.3	71-39
12-M	13	25 May	2 days	3.4	69-37
13-M	12	25 May	2 days	4.1	67-39
14-F	15	25 May	8 hrs.	4.1	70-39
15-F	14	25 May	12 hrs.	2.7	62-32
16-M	-	25 May	8 hrs.	4.1	64-38
17-M	-	25 May	5 hrs.	2.7	63-34
18-M	-	27 May	1 day	3.9	64-39
19-F	-	27 May	2 days	3.6	65-38
20-F	-	28 May	1 day	3.1	63-37
21-F	22	29 May	3 days	4.3	69-39
22-F	21	29 May	3 days	3.5	64-36
23-M	-	30 May	3 days	4.1	69-40
24-M	25	30 May	2 days	3.9	66-39
25-F	24	30 May	2 days	3.4	67-38
26-F	-	2 June	4 days	4.6	70-42
27-F	-	2 June	4 days	4.9	74-43
28-M	-	2 June	5 days	4.5	71-43
29-F	-	2 June	8 hrs.	3.4	61-37
30-F	-	4 June	6-7 days	5.8	74-43

By the end of September, 27 of the 30 radio-equipped fawns were dead, a 90 percent mortality. Nine carcasses were found with enough evidence (hemorrhage and wound patterns) to determine the cause of death; 5 were killed by coyotes, 3 were killed and cached by bobcats and 1 was punctured by a golden eagle. The eagle kill had only a few talon-inflicted wounds in the right flank, with little bleeding and no organs being punctured. The fawn presumably died from the infection that was evident at necropsy. The mother probably frightened the eagle away before it could complete the kill.

Only bits of bone, hair, chewed elastic and the transmitters were found from 11 fawns. Nine of these remains were in the vicinity of coyote dens (Figure 2), and the fawns were undoubtedly consumed by coyotes. The fawns had been seen recently and appeared healthy. These deaths have been labelled "coyote involved" in Tables 3 and 4.

Information concerning the deaths of seven fawns was lost due to three transmitter failures and four transmitters dropping from the animals too soon. The transmitter from Fawn #18 was found in the SE part of the Range 3 days after the fawn was seen appearing listless and suffering from a shoulder injury. The cause of death is unknown.

Two-thirds of the mortality took place within the first 3 weeks of the fawns' lives, with all deaths of fawns born in the NE occurring during that time. Two fawns born in the SE moved to Alexander Basin and died there; one moved at 35 days of age and died 5 days later, the other moved at 33 days of age and died 2 days later. Both were "coyote involved" deaths.

Three of the four fawns dying in the first week of life on the SE part of the Range (Fawns #15, 17, 18) were never seen with a doe after they were captured. Only a scratched transmitter and chewed elastic were found 1 day

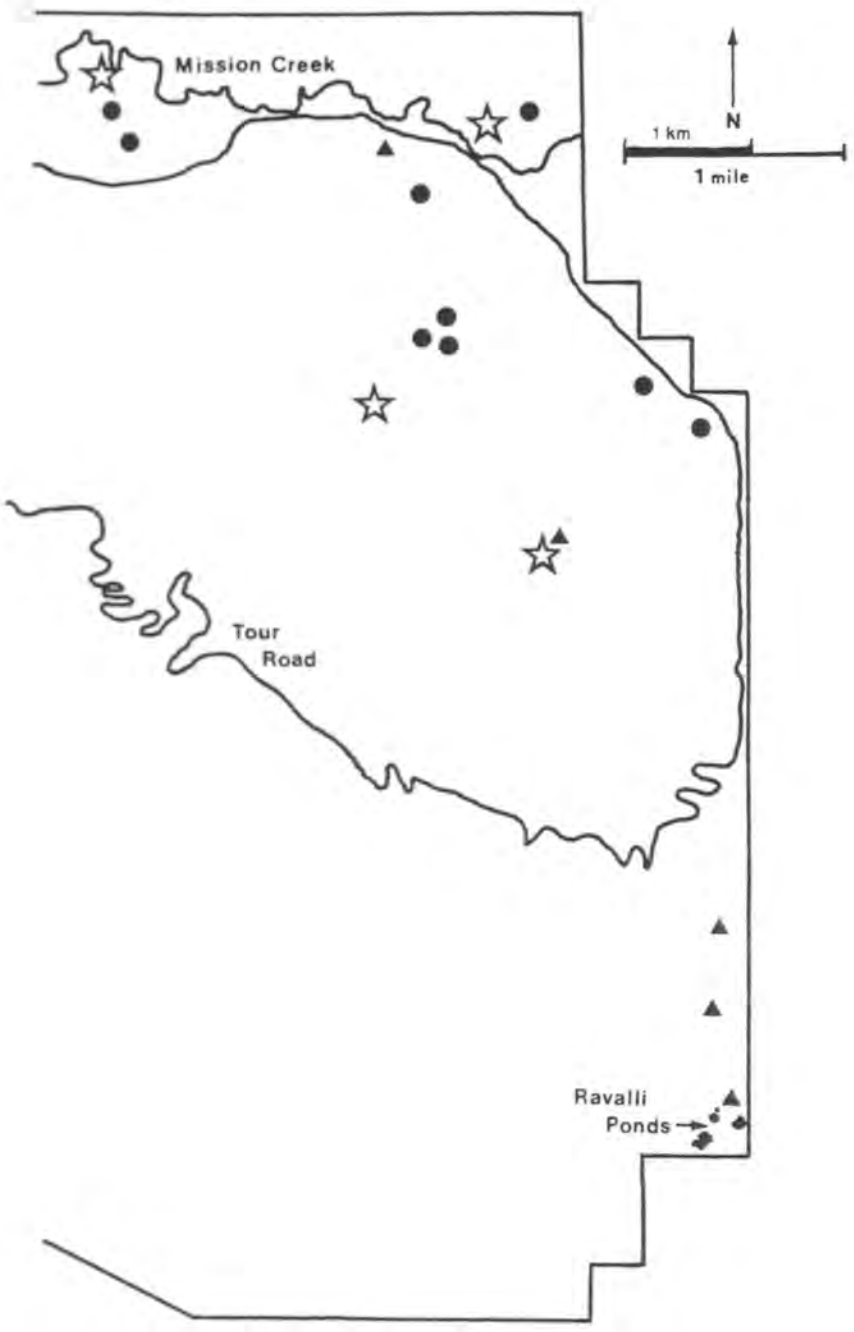

Fig. 2. The eastern portion of the National Bison Range with four coyote dens (stars), 5 coyote kills (solid triangles), and 9 coyote involved deaths (solid circles) shown.

Table 3. Fate of fourteen NE fawns.

Fawn No.	Days Surviving	Cause of Death	Remains
1	15+	Unknown	Transmitter failure, signal lost
2	3	Coyote	Head, neck, forelegs
3	10	Bobcat	Head, neck, left foreleg
4	11	Coyote involved	Transmitter
6	19	Coyote involved	Transmitter
7	9	Coyote involved	Transmitter
20	120+	Alive on 20 September	
21	10	Bobcat	Head and neck
22	10	Coyote involved	Transmitter
23	16	Coyote	Head, neck, forelegs
24	5	Coyote involved	Transmitter
25	13	Coyote involved	Transmitter[1]
26	4+	Unknown	Transmitter failure, signal lost
29	6	Coyote involved	Transmitter
Moved to Alexander Basin from SE:			
12	40	Coyote involved	Transmitter
28	35	Coyote involved	Transmitter

[1]A NBR employee saw the head with the eartag in the vicinity of a coyote den but did not retrieve it; hence, a necropsy was not performed.

after handling Fawn #18. I was unable to locate the signal of Fawn #17 after 4 days, so its fate is unknown. Number 15, the smallest fawn caught, died 2 days after handling. Hemorrhage patterns indicated that a coyote had inflicted the wounds. Whether the fawns were accepted by their mothers is unknown; possibly rejection predisposed the three fawns to their deaths. Fawn #16 was taken by a bobcat at age 5 days. All other SE deaths occurred when the fawns were over 2 weeks old (Figure 3).

The fawns which dropped their transmitters too early were assumed dead when they were not seen while censusing the pronghorn population on the Range in August and September. Does and fawns ranging in the SE started moving to the NE during the first part of July and it seems highly possible that the fawns were killed by coyotes when they arrived

Table 4. Fate of sixteen SE fawns.

Fawn No.	Days Surviving	Cause of Death	Remains
5	43+	Unknown	Dropped transmitter 1 July, last seen 5 July
8	120+	Alive on 20 September	
9	20	Coyote	Head, neck, forelegs
10	51+	Unknown	Dropped transmitter 14 June, last seen 14 July
11	24	Unknown	Transmitter
12	40	Coyote involved	Transmitter
13	120+	Alive on 20 September	
14	36+	Unknown	Dropped transmitter 19 June, last seen 30 June
15[1]	2	Coyote	Whole carcass
16	5	Bobcat	Head, neck, forelegs
17[1]	4+	Unknown	Transmitter failure, signal lost
18[1]	1	Unknown	Transmitter
19	24	Eagle	Whole carcass
27[2]	17	Coyote	Head, neck, forelegs
28	35	Coyote involved	Transmitter
30	29+	Unknown	Dropped transmitter 1 July, last seen 3 July

[1]Never seen with a doe after handling
[2]Had a dislocated leg with lacerations

in Alexander Basin. Few pronghorns were seen using the SE part of the Range after mid-July.

Fifty pregnant does were seen during the two censuses of the pronghorn population on the Range in early May; an estimated 98 fawns were born. Ten fawns were counted during the last census on 20 September, resulting in a fawn:doe ratio of 20:100.

Two of the three radio-tagged fawns that survived (#18, 13) were above the average weight, girth and length. Fawn #20, one of the smaller fawns, was the only fawn that managed to survive in the NE. Size evidently did not predetermine who would survive, and any fawn encountered by a coyote or bobcat was susceptible to predation.

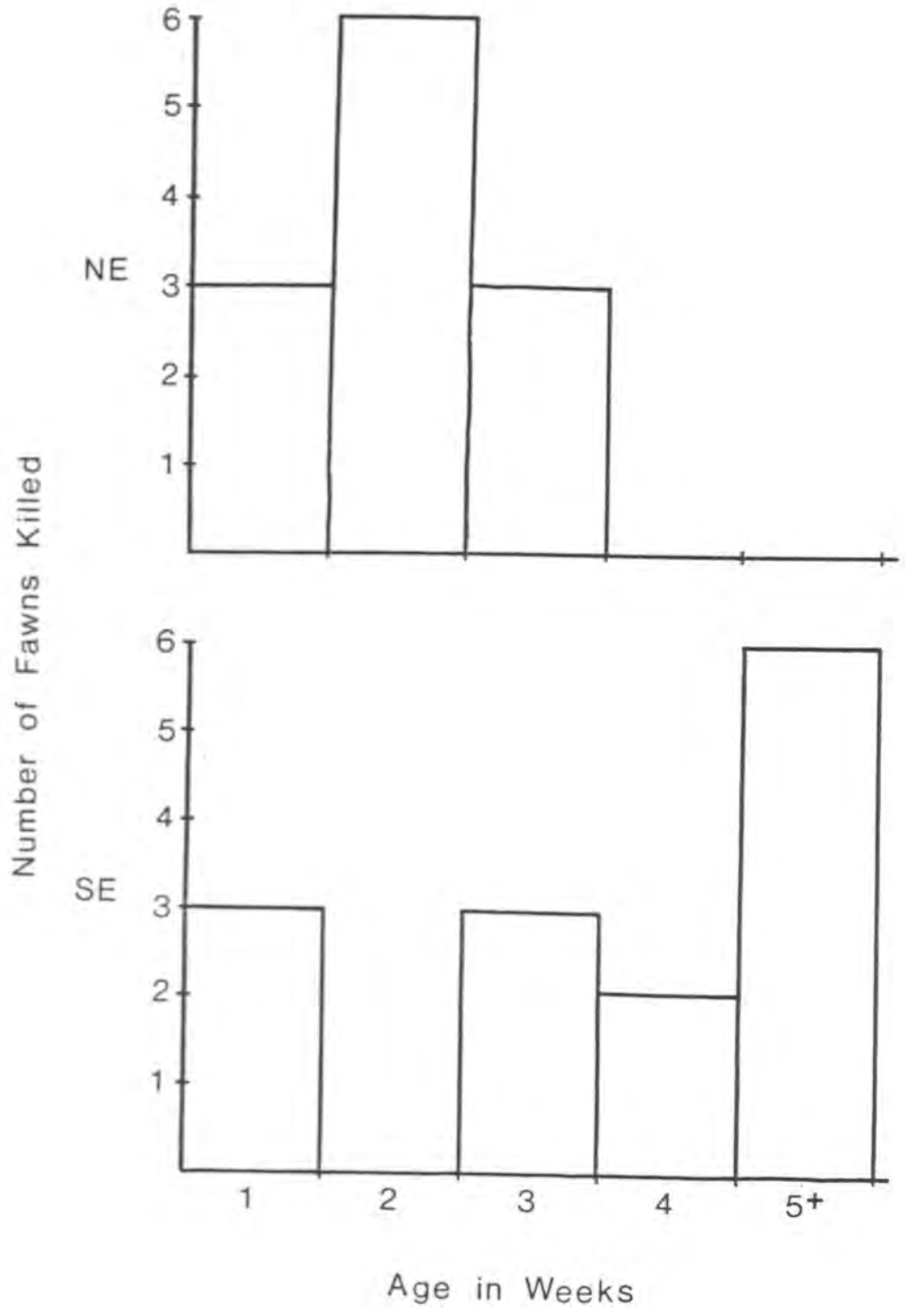

Fig. 3. The ages of 24 fawns at their deaths, grouped by their place of birth. (The three fawns whose signals were lost were not included.)

Coyote Population

Coyote control has not been practiced on the NBR since 1962 although some coyotes are killed on lands adjacent to the Range by private and government trappers. The scent post line indices from 1974, 1975 and 1977 indicate an increase in the coyote population on the Range (Table 5).

Table 5. Coyote scent station line indices.[1]

	July	September
1974[2]	41	63
1975[2]	55	-
1977	80	132

[1] Index = $\frac{\text{total coyote visits}}{\text{total operative station-nights}}$ X 1,000

[2] 1974 and 1975 indices from Reichel (1976)

Reichel (1976) estimated from direct observations that a minimum of 29 coyote adults and pups were on the Range during the summer of 1975. From the number of denning areas and activities I observed, the coyote population in the summer of 1977 was estimated at 33 or more.

Four coyote denning areas were located in the NE; none were found in the SE, but coyotes were seen using the area. Coyotes were seen many times hunting in the NE, especially in Alexander Basin and south of Mission Creek. Does would strike and snort at coyotes which approached too closely.

The higher incidence of coyote involved deaths of fawns in the NE is positively correlated to the coyote denning activity that concentrated there. Adults looking for food for their pups hunted in close proximity to the dens. Fawns born on the traditional fawning grounds located in the NE provided an easily accessible food source. Fawns born in the SE

were not near any known dens and, therefore, were not as likely to be discovered by a hunting coyote.

Rodent Population

The number of rodent captures per 1,000 trap nights provided an index of relative abundance of the rodent populations. Sampling indicated the populations were low, especially the *Microtus* spp, when compared to data collected by Reichel (1976). Reichel found *Microtus* spp were the most frequently found prey items in the NBR coyote scats throughout the year. The very low microtine abundance probably increased the magnitude of the shift to pronghorns and other prey species that were more abundant.

CONCLUSIONS

Fawn mortality is found throughout the range of the pronghorn, but rarely to the extent that I found on the NBR. September 1976 to August 1977 was a record dry period, but fawn survival has been low for many years, even in years of higher than average precipitation. Disease was not evident in any of the handled fawns. Even the possible influence of the nonnative habitat was masked by the immediate pressures of predation, the major limiting factor. The high number of coyotes on the Range, coupled with the concentration of coyote dens near the NE fawning areas, made the pronghorn fawns prime targets for predation. In addition, the low number of *Microtus*, the main component of the coyote diet, was forcing the coyote to search for other sources of prey, one of which was pronghorn fawns.

Since surplus animals are not a goal on a refuge such as the NBR, high fawn mortality cannot be considered harmful as long as there are enough young animals to replace the adults that die. If predation

increases and/or other factors add more stress, the pronghorn population faces a decline and eventual extinction from the NBR. In that case predator control will be necessary if pronghorns are to remain on the Range.

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COMMENTS AND QUESTIONS

AMSTRUP: What proportion of the mortalities occurred within 1 or 2 days after you marked the fawns? Just approximately. What I'm getting at, did you have any evidence that perhaps coyotes or other predators were following your tracks to the sites where the fawns were, to the general areas where they were, to do their search?

VON GUNTEN: In the northeast where all predation took place in the first 3 weeks it was spread out pretty much over those 3 weeks, and in the southeast the majority of predation took place after the fawns were 2 or 3 weeks old, so I don't think there is any evidence for that.

GJERSING: In reference to the talk that Earl Wiltse gave yesterday on trying to relate fawning sites to areas that they tagged the animals in, I was wondering, do you find very much movement from the actual time of birth to 4 hours afterwards? You were mentioning that you waited for 4 hours after birth before you actually went in and tagged them. Was there much movement of antelope fawns in that time?

VON GUNTEN: From the fawns that I captured I saw only three actual births and so I can only say that as far as we saw there was very, very

little movement. The other fawns that we found were usually older. They were already dry and probably over 8 hours old, so I couldn't say.

GJERSING: But there was very little movement in the 4 hour period, in the three you saw?

VON GUNTEN: Yes, that's correct.

AUTENRIETH: Did you observe the doe in her attempts to pick up fawns that you'd just handled?

VON GUNTEN: When the doe was in the area we would watch her behaviour. Very often the doe would come toward us and snort but they never came very close. If the doe was around we would wait and see if she did accept the fawn. If there was no doe around I tried to watch and see later. I would get away from the area and come back and see if the does were with the fawns, and that's the only way I could ascertain whether they were rejected or accepted.

AUTENRIETH: You did observe the doe actually pick up some of the fawns that you'd handled?

VON GUNTEN: Yes. Yes, they would run off together into the sunset, a couple of times.

AUTENRIETH: Were there any problems as far as the doe accepting the fawn?

VON GUNTEN: None that I observed. I did see one doe licking the transmitter but she didn't seem particularly perturbed about it because the fawn had been along with it and she accepted it.

AUTENRIETH: I see. I've had experiences where it's taken the doe at least 6 hours to accept a fawn that had been handled. I just wondered if you'd taken any precautions to reduce human scent on the fawn in your handling process.

VON GUNTEN: No, I didn't. The bison range is a unique situation where the does are pretty comfortable with human appearance. The tour road is right through the middle of the bison range and they see tourists all the time, taking their pictures. Actually, they're probably a lot tamer than a lot of the pronghorns you are used to working with.

AUTENRIETH: That probably reduced the problems that we've seen. We do try, at least I do, to use rubber gloves and mask the odour. I'll do some work this spring, hopefully, on transmittered fawns and I'll do things like put them in sagebrush sack for a period of time, and that sort of precaution. I don't know if it does any good.

VON GUNTEN: It probably wouldn't hurt.

BEALE: I'd just like to say that a doe running off into the sunset with her fawns is not very good evidence for acceptance, and I'd like to know what your rejection rate was like.

VON GUNTEN: Like I say, I had three fawns that I never did see with a doe; one died the next day after handling, one died 2 days after handling, one died 4 days after handling. I did observe all the fawns, all 27 that I felt were definitely accepted, nursing, so I considered that acceptance. Those three I did not see nursing.

PYRAH: Do you consider the small size of the area where your does had their fawns in the vicinity of the coyote dens as having contributed to a high fawn mortality?

VON GUNTEN: You mean the small size of the bison range in general, or just the concentration where the antelope were?

PYRAH: I believe you called it the Alexander Basin, the small size of that area where they were concentrated.

VON GUNTEN: Yes, I think it's definitely a consideration. Coyote dens were right in the area. I wouldn't say that the coyotes den there because the fawns were there but I would say that predation was higher because of coyotes denning in the area.

PYRAH: How large is this area? I think you said something about half a kilometer square?

VON GUNTEN: This is the southeast area where I had about half of my sample and half of my sample was at the Alexander Basin area. This is the first year that a lot of does have fawned in the southeast but the area is not that small.

PYRAH: What kind of escapement is possible for a doe with fawns? Is the area large enough for a doe, once she encounters a coyote, for her to leave the area in sufficient distance, to move out of the denning/hunting area of the coyote? Does she have this opportunity in that area?

VON GUNTEN: In the northeast I would say there was enough suitable habitat; in the southeast where the coyote predation doesn't seem as much of a problem it is a smaller area, with suitable escape routes, I guess you would say.

PRONGHORN FAWN MORTALITY IN THE UPPER PAHSIMEROI RIVER DRAINAGE OF CENTRAL IDAHO

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Abstract: The Idaho Department of Fish and Game initiated a study in 1976 to determine causes of pronghorn (*Antilocapra americana* Ord) fawn mortality in the Upper Pahsimeroi River Drainage in central Idaho. During 1976 and 1977, 29 fawns less than 48 hours old were fitted with miniaturized radio transmitters and their histories recorded. Fifteen of 18 known deaths occurred within 9 days after birth. Primary and secondary causes of mortality were determined for 17 of 18 fawns and divided into three categories: 1) predation, 2) starvation-disease, and 3) other.

Predation and starvation-disease were the major mortality factors. Of the 17 fawn deaths, predation was involved in nine (50 percent) cases, starvation-disease accounted for nine (50 percent), and one fawn died of trauma. Two fawns were listed in more than one category. Consequently, percentage totals exceed 100 percent. The number of fawn deaths attributed to each predator species was: golden eagles (*Aquila chrysaetos*) 4, coyotes (*Canis latrans*) 2, small raptors 2, and bobcat (*Lynx rufus*) 1. Disease contributed to at least six of the nine starvation-disease losses. One fawn died of massive internal hemorrhages. External signs of predation were not found. Eight instances of yearling pronghorns showing agonistic behaviour toward fawns were observed.

Fawn survival correlated with habitat selection. Fawns bedding in the tall sage/foothill community type had significantly higher predator-

related mortality (1/10.6 days use) than fawns using the short sage/grass community type (1/101.5 days use).

Conclusions stated in this paper are tentative since all aspects of the study will continue during the 1978 fawning season.

Although pronghorns are Idaho's most numerous trophy species the Idaho Department of Fish and Game estimates the state's pronghorn population at less than 14,000 animals. The annual harvest of approximately 1,300 animals is based on aerial surveys of winter ranges and August doe/fawn ratios. A decrease in neonatal ungulate survival was observed in most western states during the early 1970's. This decrease was observed in Idaho pronghorns and resulted in a reduction in the harvestable surplus.

Past studies concentrated on adult losses or documented levels of neonatal mortality through the use of fall young/adult ratios. Few studies concentrated on the direct causes of neonatal mortality or its affect on net productivity. Techniques were not available for monitoring newborn ungulates until about 1970. The development of miniaturized radio transmitters made fawn monitoring possible. Beale and Smith (1973) used radio telemetry to determine predation by bobcat was the major mortality factor for pronghorns in a western Utah study area.

Working in the upper Pahsimeroi Valley of central Idaho, Fichter (1961) found most fawn losses occurred during the first 30 days after parturition and that August doe/fawn ratios averaged 62 to 95 fawns/100 does. For the period 1973 to 1975 ratios dropped to an average of 43:100 does (Autenrieth 1976).

Idaho funded three studies to monitor neonatal loss rates and deter-

mine the causes of young mortality, an elk calf (*Cervus elaphus*) study in the Lochsa area of northern Idaho, a mule deer (*Odocoileus hemionus*) study in south central Idaho, and this study on pronghorn in the upper Pahsimeroi River Drainage of central Idaho.

The objectives of this study were to document the causes of neonatal losses and relate habitat selection to fawn survival.

STUDY AREA

The upper Pahsimeroi River Drainage is located in Custer County, Idaho and is a tributary of the Salmon River. The 13,000 ha study area ranges in elevation from about 2,000 to 2,700 m and lies at the base of Idaho's highest mountain, Mount Borah, elevation 3,857 m. Approximately 69 percent of the area is managed by the Bureau of Land Management, 24 percent by the United States Forest Service, two percent by the Idaho State Department of Lands, and five percent by private owners.

The Drainage is a high montane valley surrounded by steep high hills. The valley floor occurs as moraines, terraces and open flats composed of glacial and alluvial deposits. Soils are shallow and gravelly except at the base of the foothills where soils are black and deep. Three permanent streams, Burnt Creek, Mahogany Creek and the Pahsimeroi River, dissect the study area. Water is also available in several stock tanks and at several natural springs.

The climate is semiarid and typical of that found in high montane valleys. "Approximately 35 percent of the annual precipitation occurs during May and June." The amount of precipitation during this period is highly variable (Autenrieth and Fichter 1975). Near blizzard conditions occurred during the 1976 and 1977 fawning periods. Freezing temperatures

were common during the months of May and June and few days were windless during the study.

Vegetation is the semidesert type (sagebrush-grass) as described by Daubenmire (1952). Valley floor vegetative types are an extension of the cool northern Great Basin desert communities. Sagebrush (*Artemisia* spp) is the most common overstory plant (Odum 1971).

At least four species of sagebrush occur: Wyoming big sagebrush (*A. tridentata wyomingensis*), low sagebrush (*A. arbuscula*), fringed sagebrush (*A. frigida*), and threetip sagebrush (*A. tripartita*). Wyoming big sagebrush is found in the bottoms and on the slopes of ravines and moraines; the deep soil areas at the base of the foothills also support dense stands. Low sagebrush is the dominant shrub species in the shallow soils of the flats and terraces. The ecotone between low sagebrush and Wyoming big sagebrush community type is distinct. Fringed sage and threetip sage are found in minor amounts. Broom snakeweed (*Gutierrezia sarothrae*) grows in circular patches over most of the low sagebrush community. Rubber rabbitbrush (*Chrysothamnus nauseosus*) and tall green rabbitbrush (*C. viscidiflorus*) commonly occur on disturbed sites.

Idaho fescue (*Festuca idahoensis*) and Sandberg bluegrass (*Poa sandbergii*) are the most common grasses. Western needlegrass (*Stipa occidentalis*), Indian ricegrass (*Oryzposis hymenoides*), and bluestem wheatgrass (*Agropyron smithii*) are found in some areas. *Astragalus*, *Antennaria*, *Arenaria*, *Castilleja*, *Descurainia*, *Erigeron*, *Eriogonum*, *Haplopappus*, *Lupinus*, *Penstemon*, *Ranunculus*, *Senecia* and *Zigadenus* are the most commonly observed genera of forbs.

METHODS AND MATERIALS

Capture

Observation points overlooking the Ampitheater, Feralite Hill, the Carlson Ranch and Poverty Flat were used to locate pronghorn fawns and pre-parturient does. Two observers, stationed at each observation point, used spotting scopes and binoculars to observe doe-fawn behaviour and predator-prey interactions. A pregnant doe signalled impending parturition by raising her tail, self-licking of belly and flank areas, humping her back, frequent alternations of standing and lying, and frequent defecation and urination. A doe nearing parturition usually stayed in a small area and showed swelling and contractions of the flanks immediately forward of the hind legs. Does observed giving birth were watched until they left the bedded fawns. Occasionally pre-parturient does were located in areas out of view of the observation points. A foot or vehicle approach was made for closer observation.

The observation teams used portable radio transmitters to direct a marking crew to the fawns. One team member attracted a fawn's attention while the second member sneaked up behind it. An attempt was made to capture young less than 48 hours old. Fawns too wary to be captured by this technique were considered too old for study purposes.

Surgical gloves were worn when handling fawns to minimize transmittal of human scent. Fawns were equipped with a miniature 151 MHZ radio transmitter and a 3 V. lithium battery with a 1,000 mA·h rating. The transmitters were equipped with a temperature sensing device. Hopefully, when a fawn died and its body temperature dropped below 28.5^{0}C (78^{0}F), the transmitter pulse rate would change. Transmitters, batteries and antennas

were supplied by Wildlife Materials, Inc. The transmitters, batteries and antennas were assembled and set in acrylic compound manufactured by True Line, Inc. forming a transmitter package. Four 1.27 cm wide elastic straps were attached to each transmitter. Cattle tag cement held the transmitter package between the fawn's shoulder blades. The elastic bands were placed around the neck and behind the front legs and attached with staples. Hopefully, this design would keep the radio package in position but allow it to fall off as the fawn grew and stretched the elastic, allowing recovery of the transmitter. Fawns were returned to their bed sites in a curled position and their tails were rubbed until the fawns relaxed and the marker could slowly move away without disturbing them.

Relocations

An attempt was made to visually locate fawns daily. An A.V.M. Instrument Co. LA12 receiver and 3 element Yagi antenna were used. The fawn's general location was determined by vehicle and the final approach was made on foot.

Data recorded for live fawns included date and time located, distance from previous bed site, distance from twin, general condition and habitat type. Seven fawns were recaptured and weighed. Dead fawns were photographed, mapped and marked for later vegetative analysis. The sites were searched and predator signs recorded. Fawns were monitored until the transmitter fell off or August 1.

Necropsy

A general necropsy was performed. Punctures, lacerations and signs of feeding were recorded and photographed. Indications of disease, starvation, general condition and stomach contents were noted.

Predators common to the study area leave characteristic feeding and wound patterns on prey species. Patterns described by Giles (1971) and Henne (1975) were used to determine the species involved in feeding on or killing a fawn.

RESULTS AND DISCUSSION

Capture

Due to a low population and extremely wary animals, the number of fawns marked was less than anticipated. Neonatal histories were gathered for 29 fawns, 12 females and 17 males during 1976 and 1977. Mean fawn weights were 3.4 kg (7.42 lbs.) in 1976 and 3.9 kg (8.53 lbs.) in 1977. Losses by year and category are given in Table 1.

Table 1. Fates of transmittered fawns by year.

		Predation						
Date	N	Coyote	Eagle	Bobcat	Small Raptor	Disease	Starvation	Survived
1976	12	2	2	1	2[a]	1	2	2
1977	17	-	2	-	-	4	2	9
Total	29	2	4	1	2	5	4	11

[a]One fawn is also included under disease and the other under starvation.

Predation

Primary and secondary causes of mortality were determined for 17 of 18 instrumented fawns. Predation was involved in nine cases (50 percent). The number of fawns attributed to each predator species was: golden eagles 4, coyotes 2, small raptors 2, and bobcat 1. One uninstrumented fawn carcass was found which appeared to have been killed by an eagle. Seven

of nine predator kills involved fawns less than 9 days of age. Predation was much higher in 1976 (58 percent) than in 1977 (7 percent).

Golden eagles were the most successful predators and were involved in four of nine (44 percent) known predator kills. Eagles were most often observed along the foothills where air currents were apparently more conducive to hunting. On 27 May 1976 an eagle carried an instrumented fawn from a ridge top. The fawn weighed 3.3 kg (7.2 lbs.).

Coyotes were frequently observed hunting in the foothill areas and it is surprising that only two fawns were killed by coyotes. In several instances adult pronghorns were observed chasing coyotes. Most cases involved adult does either singly or leading a small group of females, although an adult buck was observed chasing a coyote from the open flats into the foothills.

An unknown small predatory bird attacked an abandoned fawn and 19 days later killed its sibling. The size of talon marks and the presence of a prairie falcon (*Falco mexicanus*) eyrie within 400 m (1/4 mile) of the kill site indicates that a falcon may have been involved in these deaths. Mean birth weights of fawns killed by predators were not significantly different from those lost to starvation-disease, or those that survived.

Starvation-Disease

Nine fawns (50 percent) died of starvation-disease. Fawns affected by disease often showed evidence of starvation and the reverse may also be true, consequently an exact determination of mortality was not always possible. Typically, diseased animals showed signs of enteritis, swollen liver and spleen, edema in hock joints and swollen lymph nodes. Fawns with

systemic infections are probably disease losses. One fawn died at 6 days of age due to a gangrenous condition of the umbilical cord. At least six of the nine starvation-disease losses showed sufficient evidence to indicate disease as the causative agent.

Starvation-disease losses were comparable during both years, 25 percent in 1976 and 21 percent in 1977. The number of fawns lost to starvation-disease in 1976 may have been higher than recorded if fawns taken by predators during the first 5 days of life had survived.

The significantly higher fawn weights in 1977 were expected to reduce starvation-disease losses. Several dead fawns were found after spring snowstorms. Increased frequency of cold rains and snow during the 1977 fawning season may have contributed to the higher than expected rate of starvation-disease loss.

Langenou and Lerg (1976) reported that a majority of whitetail fawn mortality within a few days after birth oocurred because of a maternal rejection syndrome. Fawns born to nutritionally stressed does evoked a fear and aggression response rather than the normal licking and grooming response. The importance of abandonment was difficult to determine. Rejection behaviour was observed in four cases, three of which involved transmittered fawns. In the cases of the transmittered fawns the doe allowed the fawn to nurse and began uro-genital licking, then it appeared the doe smelled the transmitter package, bolted and ran whenever the fawn approached. Two of these fawns were later accepted. The fate of the untransmittered fawn is unknown. One fawn was abandoned at the birth site while its sibling, born approximately 180 m (200 yards) away, was accepted. Fawns showing symptoms of disease also showed evidence of starvation, empty stomachs and serious atrophy of fat.

Other Mortality Factors

One fawn died of unknown causes at approximately 50 days of age. Signs of predation were absent and the fawn had been dead for about 5 days when found. A necropsy was not done due to advanced deterioration of the carcass.

One fawn died of massive internal injuries and no external signs of predation were evident. Eight instances of agonistic behaviour toward fawns by yearling pronghorns were observed. Commonly, nursing does were accompanied by yearling pronghorns. Yearlings were seen to butt fawns with sufficient force to knock them down. Yearlings sometimes insinuated themselves between the doe and fawn and prevented nursing. Nursing does did not show agonistic behaviour toward yearlings although such behaviour was observed between nursing does and other adult does.

Habitat Selection

Two hundred and seventy-seven locations by community type were recorded for nine predator killed fawns. Two kills occurred in the low sage/grass type and seven occurred in the foothill/tall sage type. Fawns bedded in the tall sage/foothill community type had significantly higher ($P < 0.05$) predator related mortality (1/10.6 days use) than fawns using the short sage/grass community type (1/101.5). The two kills in the low sage/grass community type were attributed to eagles. Eagles hunted and killed in both community types although they were most frequently observed hunting the short sage/grass type near the foothill/sage type.

A general up-valley movement of pronghorns occurs from the low sage/grass type to the foothill/sage type. This movement appears to be dependent upon plant moisture content. A reverse movement occurs after a

soaking rain.

CONCLUSIONS

Predation and starvation-disease were the most important mortality factors for instrumented fawns. Each category accounted for 28 percent of the known mortality.

Fawns bedding in the foothill/sage community types experienced increased predation for several reasons. Predators hunted this type more frequently than the short sage/grass type. Mammalian predators probably prefer the foothill/sage type because of more hiding cover and greater numbers of prey species. Foothill wind currents may assist avian predators. Possibly due to better visibility, does were more successful in defending fawns in the short sage/grass type. Selection of community type for bedding appeared to be dependent on plant moisture content.

Upper Pahsimeroi fawns are apparently subject to natural abandonment. Disturbance from handling, sickness and predators increases abandonment rates.

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PRONGHORN FAWN MORTALITY IN ALBERTA

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Abstract: As part of a program to investigate the habitat use, movement patterns and survival rate of pronghorn (*Antilocapra americana*) fawns in southeastern Alberta, 465 animals, less than 1 week of age, were captured from 1971 to 1976, inclusive. Pronghorn neonates were located throughout the 7,700 km^2 study area. Bed sites were located frequently along the banks of intermittent water courses or on gentle knolls. Most fawns were found bedded on mixed grass prairie with or without a low density of silver sagebrush (*Artemisia cana*).

In 1975 and 1976, 62 of the fawns (part of the 465 fawn group) were marked with expandable electronic neck collars and their histories subsequently recorded. These 62 fawns were marked on a 1,016 km^2 study block which was contained within the boundaries of the original study area. In all cases, study area boundaries were arbitrarily selected and pronghorn populations on historic range continued far beyond the areas of investigation. The pronghorns marked were part of a free ranging population that was not restricted by artificial barriers. The telemetry marked fawns were relocated daily for the first 2 months and the incidence and cause of mortalities noted. Within 60 days of being marked 40 of the 62 fawns were dead. Predation, starvation/unknown and trauma accounted for 27 (67.5 percent), 12 (30 percent) and 1 (2.5 percent) of the mortalities, respectively. Bobcats (*Lynx rufus*) and coyotes (*Canis latrans*) are believed responsible for all predation. There was

no indication that infectious agents contributed directly or indirectly to the death of any marked fawns.

Another major factor affecting recruitment of pronghorns in Alberta is winter. Young of the year appear more susceptible to mortality induced by deep snow and prolonged cold than other age and sex classes. Current evidence from the 1977-78 winter indicates that under extreme conditions mature females can resorb their fetuses.

Numerous other causes which led directly to mortalities were observed for unmarked fawns and included entanglement in fences, blindness, doe mortality during parturition, stillborn fawns and vehicular collisions with the doe. The impact of these factors on pronghorn populations in Alberta is unknown but believed to be of only modest importance.

Pronghorn populations in Alberta have fluctuated greatly over the years. Between 1964 and 1969 Wishart (1970) reported that population estimates for Alberta fell from 25,000 to 7,000 animals. Two intensive studies had been conducted on pronghorns in Alberta prior to this work but many questions were still unanswered. Mitchell (1965) investigated the population dynamics of pronghorns while Bruns (1969) studied their behavioural adaptations during a severe winter. These authors recognized the extreme annual population fluctuations but their studies were not designed to provide detailed information concerning the cause of pronghorn mortalities.

The present study was initiated in 1971 to investigate the magnitude and mechanisms of pronghorn fawn mortality and the important habitat relationships and movement patterns involved. Our program involved capturing and marking pronghorn neonates and adults and relocating these animals

periodically throughout the year. Responses of pronghorns to different climatic extremes were also examined. This paper deals with factors which directly affect the survival of pronghorns during their first year of life. The specific topics presented include: 1) environmental characteristics at fawn bed sites; 2) mortality of fawns in the first 2 months following parturition; and 3) general observations on winter mortality of pronghorns. Data and conclusions presented in this paper are preliminary and subject to further analyses.

METHODS

Phase I, 1971-74

From 1971 to 1974, inclusive, 400 pronghorn neonates were captured throughout a 7,700 km^2 study area in southeastern Alberta. At each capture site data on vegetation characteristics, fawn and doe behaviour and physiological parameters were recorded. Neonates were also examined for evidence of disease.

Phase II, 1975-76

In 1975 and 1976, 62 fawns (31 each year) were captured within a 1,016 km^2 study area and data collected as described for the first 4 years. In addition, attempts were made to isolate infectious bacterial and viral agents from the fawns. The 62 animals were also fitted with expandable electronic neck collars supplied by A.V.M. Instrument Co. and attempts were made to relocate each animal daily for the first 8 weeks or until it was found dead. An A.V.M. LA 12 receiver and 3 element hand held Yagi antenna were used routinely to relocate fawns. When contact could not be made with a fawn during a ground search an aircraft with a 4 element antenna was used. When dead fawns were located detailed necropsies were

conducted on the carcasses for evidence relative to the cause of death.

If predation was suspected as the cause of death, attempts were made to determine the predator species involved using guidelines similar to those outlined by O'Gara (1978). The presence of tracks, hair, scats, killing manner, feeding habits, signs of struggle and carcass concealment were considered in the investigations whenever such evidence could be found.

The Study Areas

The 7,700 km^2 block used in Phase I from 1971 to 1974 was located adjacent to the Saskatchewan and Montana borders. The vegetation is flat to gently rolling but stream banks and coulees caused by intermittent water courses interdigitate the area. The vegetation cover consists primarily of native rangeland and is characterized by western wheatgrass (*Agropyron smithii*), spear grass (*Stipa comata*) and blue gama (*Bouteloua gracilis*) types. Approximately 10 percent of the area is under cultivation and the remainder subject to grazing by domestic livestock. Much of the lowland and portions of the native range are stippled with different densities of silver sagebrush. The elevation throughout much of the study area ranges between 800 and 1,200 m.

The 1,016 km^2 Phase II study area used in 1975 and 1976 was located within and was generally representative of most of the larger Phase I block. The location of the Phase II area is referred to as the Fawn Study Area illustrated in Figure 1. All pronghorns captured over the 6 years were members of a free ranging population which was not restricted by artificial barriers. Pronghorn populations extend in all directions far beyond the study area borders.

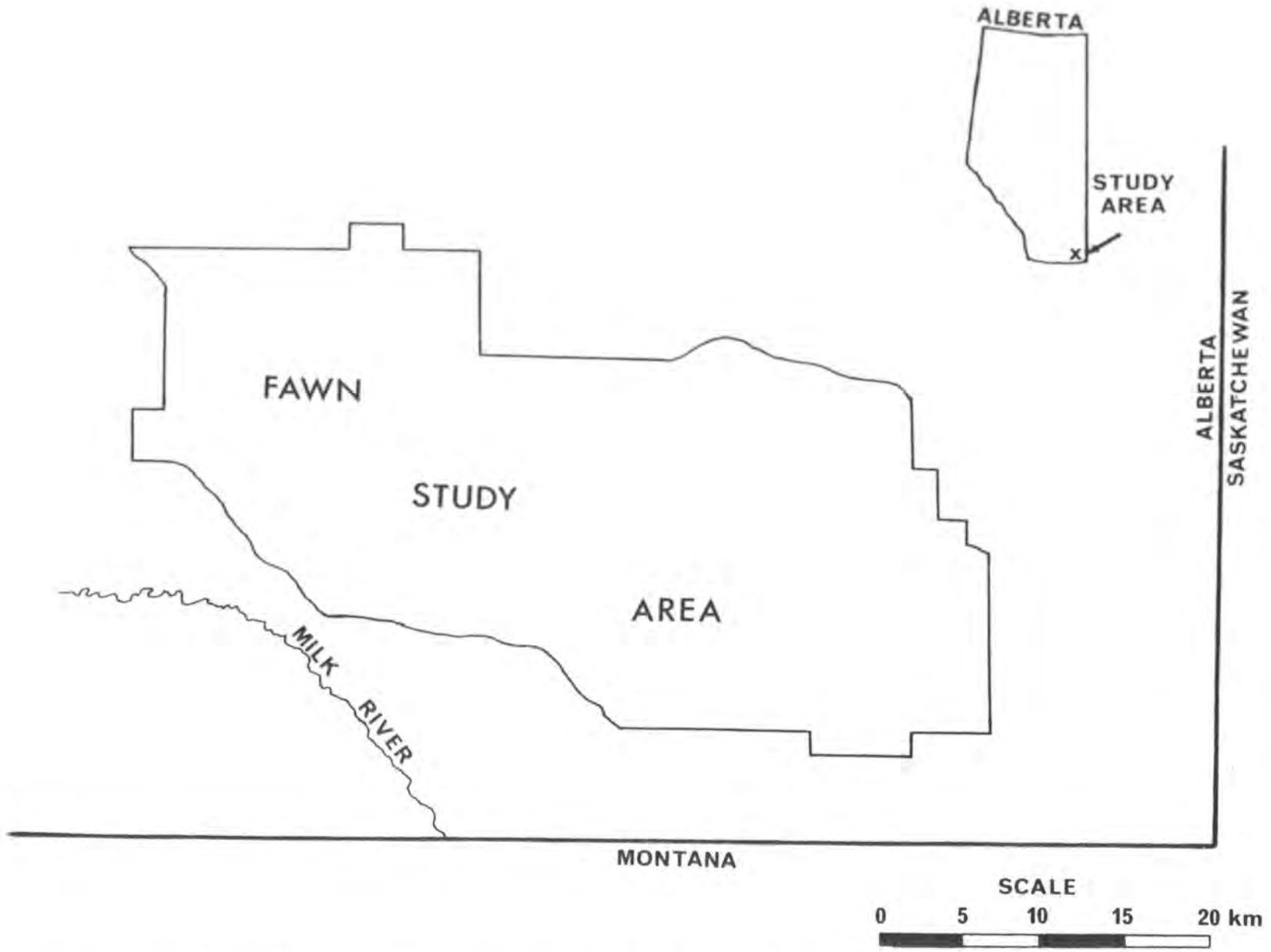

Figure 1. Location of 1,016 km^2 study area during the 1975-1976 fawn telemetry program.

Winter Mortality

Aerial surveys were conducted in 6 of the last 8 years in an attempt to locate pronghorn concentrations during winter. This information demonstrated the distribution of pronghorns during the severe winter of 1977-78. From January to April 1978 pronghorns found dead were necropsied for evidence as to the cause of death and to determine whether age and sex susceptibility to winter loss existed. Only preliminary information on mortality during this past winter is available at this time; data presented in this manuscript will pertain primarily to those findings which impact directly on recruitment to populations.

RESULTS

Habitat Relationships

Pronghorn neonates were located throughout the 7,700 km^2 area. Many were located along the banks of intermittent water courses or on gentle knolls. Most were not heavily concealed but some individuals did use sagebrush or shallow depressions for bed sites. The vegetation type in the general area of the fawn bed sites (for all years) is shown in Table 1.

Table 1. Comparison of vegetation types at pronghorn fawn bed sites and vegetation cover available on intensive study area.

General Vegetation Type	Bed Site Selection Initial Capture (all fawns, n = 392)	Available Cover Intensive Study Area[a]
Native Grass Prairie (NGP)	41%	41%
NGP - Light Sage[b]	33	41
NGP - Medium and Heavy Sage[b]	10	7
Cultivation (all types)	14	10
Others	2	1

[a]Intensive Study Area was a 1,016 km^2 block which was generally representative of the entire area.

[b]Light, medium and heavy sagebrush categories defined as 3-10, 11-25 and >25 plants per 61 m linear transect, respectively.

Most were located on native grass prairie areas (NGP) or NGP in combination with light sagebrush cover. Approximately equal numbers utilized cultivated areas and NGP - heavier sagebrush covered rangelands. Also shown on Table 1 is the total vegetation cover available on the Phase II study area which represents approximately 13 percent of the land area of Phase I. The important relationships are that fawns were found on all major habitat types available and that highly preferred habitat types for pronghorn neonates were not readily evident on the basis of these data. Preferred habitat for pronghorn fawns will be investigated further by the use of telemetry marked animals but these data are not available at present.

Mortality

Most detailed information on the mortality of fawns was obtained from the 62 telemetry marked animals. The program was designed primarily to document the extent and cause of fawn mortality during the 2 month period following parturition. The findings from the study area could then be compared with findings from the province-wide antelope survey conducted in mid-July of each year.

In the first 2 months following parturition 65 percent of the fawns perished (Table 2). Predation was the prime cause and accounted for 27 deaths or 67.5 percent of the mortality.

Twelve animals perished from relatively nondescript causes (Table 2). Two of the 12 were substantially below normal in weight and were noted to be lacking vigour when marked. When found dead the remaining ten fawns were emaciated and had not been nourished recently by the doe. Death occurred 2 to 5 days following marking and age of fawns at death ranged from 3 to 14 days. There was no evidence of trauma on any of these fawns.

Table 2. Fate of telemetry marked pronghorn fawns in Alberta.[a]

	1975	1976	Total	
			Number	Percent
Marked	31	31	62	100
Predated	16	11	27	44
Starvation/Unknown	7	5	12	19
Other Mortality	0	1	1	2
Survivors	8	14	22	35

[a]Data reflects first 60 days following parturition.

One fawn died as a result of being trampled by livestock. Aggression towards fawns by livestock was observed on four occasions; one unmarked fawn was found dead from trampling.

The losses through predation may be more extensive than Table 2 indicates. If most of the 12 seemingly malnourished fawns were abandoned as a result of being processed by humans then the losses to predation in the first 2 months approached 55 percent of all pronghorns marked. Predation, therefore, accounted for the majority of the known natural mortality of neonates.

The incidence of predation was greatest when pronghorns were between 11 and 20 days of age (Table 3).

Table 3. Age of pronghorn fawns when predated.[a]

Age Range (days)	Predator Kills	
	Number	Percent
00 - 10	6	22
11 - 20	11	41
21 - 30	4	15
31 - 60	6	22

[a]Mean age at death of all cases was 22 days.

Very young animals did not have a particularly high predation rate. The mean age of death of predated fawns was 22 days. Bobcats and coyotes accounted for all predation cases. We attempted to differentiate between coyote and bobcat predation on the basis of tracks, hair samples, scats, feeding pattern, killing techniques and preference for burying uneaten portions of the carcass. We wish to evaluate our findings further before ascribing a specific number of kills to each predator species but we believe that both predator species were nearly equally involved.

There was no evidence that infectious agents contributed to the mortality of pronghorn fawns. Attempts to culture viral and mycoplasma organisms were unsuccessful (Table 4). Bacterial cultures revealed the presence of normal flora or agents of only minor pathological significance. There was no difference in the micro flora of fawns which survived compared to findings from those that died.

Table 4. Summary of project to isolate infectious agents in pronghorn neonates.

	Number of Live Fawns Sampled	Number of Dead Fawns Sampled	Findings
Virology[a]			
1975	21	8	No isolates
1976	24	4	
Bacteriology[b]			
1975	20	3	Normal flora primarily, sporadic occurrence of potential pathogens
1976	25	2	
Mycoplasma[c]			
1976	24	0	No isolates

[a]Nasal, vaginal/prepucial and rectal swabs.
[b]Nasal and rectal swabs.
[c]Ocular swabs.

Winter Mortality

Pronghorn populations in Alberta are particularly vulnerable to winter mortality. The winter of 1977-78 presented the most severe conditions experienced in the northern great plain region in more than a decade. Only preliminary information is available at this time concerning pronghorn losses during the recent winter but mortalities are expected to be high. One factor contributing to the high mortality of pronghorns was that many were located off their normal winter ranges. Two main findings make comments on winter mortality especially appropriate for a session on fawn mortality. Firstly, fawns were extremely susceptible to winterkill and sustained an inordinate proportion of the total mortality. Secondly, numerous cases of fetal resorption were observed in does examined in February and March of 1978.

Miscellaneous Factors

During our 7 years of study numerous mortality factors have been observed that led directly to the death of unmarked fawns. These factors included entanglement in fences, injuries caused by farm implements, blindness, doe mortality during parturition, stillborn fawns and highway and railway collisions with does. The extent of mortalities attributable to these causes is unknown but we believe them to be of minor importance in most years.

DISCUSSION

The results obtained by capture and relocation programs are often questioned on the grounds that they are not truly representative of the population sampled. To investigate this possibility I derived four independent estimates of fawn mortality (Table 5). The summer aerial

survey, enclosure study, fall drive trapping program and the telemetry study were all conducted within the same antelope management unit. Survival within the 200 ha enclosure was highest but this area received partial protection from mammalian predators. Drive trap records indicate a slightly higher mortality but the time interval following parturition was greater. I conclude that the four estimates are in general agreement and provide further documentation concerning the high mortality of fawns in southeastern Alberta.

Table 5. Comparative mortality estimates for pronghorn fawns in Alberta.

Date Source	Time Period After Parturition	Mortality (Percent)
Summer Survey (1971-1977)	First 2 months	64
Enclosure Study[a] (1974-1977)	First 2 months	47
Telemetry Study (1975-1976)	First 2 months	65
Fall Drive Trapping (1971-1975)	First 6 months	71

[a]Animals afforded some protection from predation.

The 12 fawns in the starvation/unknown category may have been abandoned by the female following marking. Beale and Smith (1970) reported a similar loss of marked fawns within a few days of handling and presumed that they had been abandoned. Our field notes indicate that two of the 12 fawns were well below normal in weight and vigour when marked. Furthermore, cold weather accompanied by rain, snow and wind persisted for 2-3 days following the marking of three of the fawns and weather conditions may have contributed to their death but other fawns marked during the same period survived. Beale and Smith (1973) suggested that some does with twins may be reluctant to accept both marked siblings, especially if their milk supply was limited.

The loss of 44 percent of the marked fawns to predation in the 2 month period following parturition represented the major mortality factor. Mortality from predation may be higher if most of the animals in the starvation/unknown category were abandoned as a result of human handling. Predation rates of this magnitude on pronghorn fawns have not been reported previously for free ranging populations on historic range.

In assessing mortality it was often difficult to find evidence of the predator involved. It was usually impossible to find tracks of the predator because of the consistent cover of prairie vegetation. Some kills were heavily consumed and the remains widely scattered. I believe, but cannot confirm, that many of these scattered carcasses reflected coyote predation. Many of the fawns taken by bobcats had been partially consumed and the remaining portion, usually the anterior end, covered. Bobcat predation on pronghorn fawns has been largely unreported with the exception of work by Compton (1958) and Beale and Smith (1973). Coyote predation on the other hand has been recognized for decades as indicated by the many relevant references in Yoakum's (1967) bibliography on pronghorns. Irrespective of predator involved, a greater predation rate was evident when fawns were between 11 and 20 days of age. I believe this increased mortality reflects the time period when fawns first become more active and, by inference, more visible to predators. However, they are still highly vulnerable to predation at this stage.

Winter losses of pronghorns in northern latitudes have been reported for Alberta (Wishart 1970), Montana (Martinka 1967; Compton 1970), North Dakota (McKenzie 1970), South Dakota (West 1970) and other localities. Increased susceptibility of fawns to winter loss has been recognized previously but no reports of fetal resorption during winter are available.

Hailey et al. (1966) observed fetal resorption in three pronghorn does in Texas following a diet high in tarbrush (*Flourensia cernua*) for several months. More details on this impact of the 1977-78 winter on pronghorns in Alberta are described by Barrett (1978).

In combination, high fawn mortality and severe winters provide a formidable obstacle to the existence of pronghorns in Alberta. Because pronghorns have existed at these northern latitudes for thousands of generations the factors involved must be regarded as environmental norms. The prime question, however, centers upon the degree to which the impact of weather, predation and other environmental factors have increased because of a decrease in suitable pronghorn range and massive land use changes wrought by man.

ACKNOWLEDGEMENTS

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COMMENTS AND QUESTIONS

AUTENRIETH: Morley, how did you define your light, medium and heavy sage?

BARRETT: By the number of sage plants per 200 foot linear intercept. Heavy sagebrush was greater than 25 plants per 200 foot intercept and so on. All the categories are listed alongside the maps posted on the wall.

HELMS: I have one comment. We had an incident last summer in Wyoming and so far it hasn't been brought to life by anyone here. We lost quite a number of antelope due to a hail storm. In fact, the rancher in the area contacted us because he thought a blue tongue epidemic was breaking out again and he has a sheep operation. He had a veterinarian come out of Colorado and I went with him, and it was strange. One of the local hands even attributed it to a u.f.o. There were no tracks, no sign of predators, and yet the animals, when they were checked out, showed massive hemorrhages. I think this might be prevalent in some of the areas that do receive a lot of hail like eastern Wyoming, Nebraska and Kansas. It might be something to consider. We did find about 14 head of antelope that were actually killed plus eagles, ducks, everything that was out in the area at the time. This is another one of Mother Nature's quirks.

QUESTION: Was there any differential mortality based on sex and age of the pronghorns you picked up?

HELMS: No, it took everything and it killed the old sheep as well as lambs.

BEALE: What criteria did you use to separate your bobcat and coyote kills?

BARRETT: All but two or three of the bobcat kills were buried and covered or concealed. I don't think we had a bobcat kill that didn't have the skull punctures similar to what Bart described. They all were buried or covered, with a couple of exceptions, one of which I showed you here. That's what we use to implicate bobcats. Coyotes were more difficult. Generally there was much more disorder with bones scattered around and meat wasn't peeled from the ribs. To our minds coyote predation was much less conclusive than the cases we saw with bobcats. We looked a long time for tracks, of course, and for evidence of hair; I matched hair in some cases with known collections to determine what was probably involved.

BEALE: I would just add that out of the 27 bobcat kills I've never found one yet where the cat actually digs a hole. Debris is always put over the carcass. Often there is a hole dug where a coyote does the killing.

BARRETT: In some cases there was very, very light sandy stuff so in just two or three swipes I'm sure they'd have a sufficient hole dug. The other cases often began with a shallow depression, an old burn out or whatever you want to call them, or perhaps a rodent den or badger hole. The one I showed you on the grassland was a shallow depression to begin with.

BIRTH RATE AND FAWN MORTALITY AMONG PRONGHORN ANTELOPE IN WESTERN UTAH[1]

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Abstract: Pronghorn antelope (*Antilocapra americana*) birth rates and mortality of fawns occurring during spring and summer months were studied within an enclosed range. The study area included a large part of the Desert Experimental Range, Intermountain Forest and Range Experiment Station, U. S. Forest Service, 80 km (50 mi.) west of Milford, Utah. During the first phase of the study, 1967-1972, pronghorns were enclosed on 36.26 km^2 (14 mi.^{2}) of range. In 1975 the area was expanded to include approximately 165.8 km^2 (64 mi.^{2}) of range, thus providing a wider variety of terrain and vegetation types.

The study area is typical of much of the intermountain area in Utah and Nevada. Elevations above sea level range from about 1,585 m (5,200 ft.) at the valley bottom to over 2,592 m (8,500 ft.) at some mountain peaks. Vegetation is comprised of various communities of the northern desert shrub formations. Major shrub species present include shadscale (*Atriplex confertifolia*), winterfat (*Eurotia lanata*), rabbitbrush (*Chrysothamus* spp), snakeweed (*Gutierrezia* spp) and black sagebrush (*Artemisia nova*). Desert almond (*Prunus fasciculata*) and other tall shrubs are abundant along many drainages. In addition, there are a number of perennial and annual grasses and forbs. Pinyon pine (*Pinus monophylla*) and juniper (*Juniperus osteosperma*) occurs in many areas above 1,982 m (6,500 ft.) elevation. Herbage production is closely

[1]The study is conducted cooperatively with the Intermountain Forest and Range Experiment Station, U.S. Forest Service and Utah Division of Wildlife Resources, and financed in part by Utah Federal Aid Project W-65-R.

related to precipitation which averages 15 cm (6 in.) per year.

Over a period of 9 years 200 pronghorn antelope fawns were successfully instrumented with radio transmitters when 1 to 7 days of age. After each fawn was marked it was monitored on a daily basis until 4 months of age or until death, to determine movements and causes of mortality. A total of 127 cases of fawn mortality were discovered during the study. Predation accounted for 97 losses or 76 percent of all mortality. Thirty-nine of these losses were attributed to coyotes, 36 to bobcats, 21 to golden eagles and 1 to an unknown predator. Thirty other losses were attributed to pneumonia, salmonellosis, starvation, injury, weather and unknown causes. During this same period pronghorn birth rates ranged from about 1.4 to 1.8 fawns per mature doe.

Efforts to relate mortality of fawns to various ecological factors are as yet inconclusive but a number of factors appear to be involved. Among these are precipitation and forage abundance which affects distribution of fawns, social behaviour, summer band or herd formation and rate of fawn growth. Other important aspects appear to be abundance of jackrabbits (*Lepus californicus*) and rodent species, abundance of predators and distribution of available drinking water and type of terrain used during and following parturition.

COMMENTS AND QUESTIONS

MITCHELL: Don, we heard a couple of times today that kids bedding in heavier cover, in lower areas with higher vegetation, appear to be using travel lanes for things like coyotes and bobcats. Predation therefore is somewhat higher in these sites. We also, I think, generally feel that the home range with the mobility of the

predator somewhat exceeds that of the prey species. Now with your ability to put collars on bobcats, do you have any information to suggest that the bobcats are in fact moving out of these heavier cover areas when in fact the pronghorns do? Are they following the prey species, in order words; or are they not doing this?

BEALE: In these three cases they were, yes.

MITCHELL: They're moving out of the playas and out of the lower areas? How far were your pronghorns moving?

BEALE: The pronghorns at this time were pretty much the territorial type.

MITCHELL: They were staying within the normal daily home range then?

BEALE: Right.

MITCHELL: So you wouldn't get any distinct evidence of movement?

BEALE: The normal range of a bobcat and the antelope really doesn't differ that much.

MITCHELL: I had an idea perhaps they were moving far enough that they were sucking the bobcats with them, but on the evidence that you have presented they were moving within the normal home range of the bobcat?

BEALE: Right.

BARRETT: I've got to admit, Don, that some of the findings you show relative to coyotes look very similar to what we found for bobcats. We examined the skulls of all animals we believed to be bobcat kills; but we'll have to keep an open mind and go through them again. There are some great differences in terrain between our two study areas and the time the greatest rates of predation occurred. We may have overestimated the significance of bobcats but some I feel we are fairly firm on, based on the evidence.

COMMENT: Size of animal may really be important here. You take a 40-pound fawn, so many of our bobcat kills were of animals, you know, considerably large. They were taking place in July and August. The largest one was at 49 pounds. You don't expect a bobcat to dig a hole to bury a 49-pound fawn.

BARRETT: None of our bobcat kills were on large fawns, the pronghorns were probably all less than 20 pounds, without exception, I believe. I want to ask you, and you're maybe the only one that has looked at this long enough to know. Have you detected anything noticeable in doe behaviour that could lead you to suspect a greater probability of her young being predated? Is there any clue in the relationship between doe and fawn which leads you to presuppose a fate?

BEALE: I don't think so. One thing I do want to mention, though, that we didn't, is that golden eagle predation seems to pretty much stop when the fawn reaches 20 pounds in size. And also, most golden eagle kills took place where there was some perch within observable distance, such as the eagle might have been using to locate its prey.

ULTIMATE FACTORS, BEHAVIOUR AND FAWN RECRUITMENT

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Abstract: The analysis of fawn recruitment from the perspective of behavioural ecology permits consideration of ecological forces acting over millions of years to shape behavioural, physiological and morphological adaptations in the fawn and its mother. It is hypothesized that variations in climate, availability of food, predation and habitat physiography are the major ecological selection pressures which have acted on the pronghorn (*Antilocapra americana*). It is proposed that these four factors act with varying relative strengths over the lifetime of the individual pronghorn. The three life stages considered in this paper are (1) the few hours before, during and after birth to include selection of the first hiding site, (2) the approximately 3-week period the fawn spends most of its time hiding and separate from its mother, and (3) the approximately 7-month period from when the fawn permanently joins doe-fawn herds until the end of its first winter. According to the theory, prominent adaptations of the fawn displayed at birth, stage 1, should be attributable to predation, but few adaptations should be accountable to availability of food. Later, in stage 3, when the fawn relies progressively more on vegetation and less on milk for food, behavioural and morphological adaptations to get food should be prominent. By following this process, the general nature of the behaviour and ecology of the pronghorn at each life stage is predicted. The predictions are compared

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with the observed behavioural and morphological characteristics of the pronghorn apparent at each life stage. The available evidence supports the general theory. It is concluded that evolutionary theory and behavioural ecology provide a powerful way to synthesize what is known about the behaviour and ecology of the pronghorn fawn. The approach draws attention to critical gaps in our knowledge about fawn recruitment. Although the general predictions of the theory rest on evolutionary processes, which are difficult to test empirically, these broad generalizations provide a context for empirical analysis of specific adaptations. For example, field data on the characteristics of hiding sites selected by newborn fawns is analyzed from the interaction of terrestrial and aerial predation with the structure of the habitat.

The paper concludes with a discussion of how the theory can assist wildlife managers in predicting the long-term impact of reclamation of strip mined lands on recruitment of pronghorn fawns.

The scope of state and provincial game management agencies is expanding. In the early 1900's agencies were created to protect game species from extinction by regulating hunting and creating game preserves. Later, with the development of ecology, the agency's responsibilities enlarged to include manipulation of populations, habitats and man to provide game animals for the hunter (Dasmann 1964, Leopold 1933). Management decisions geared to providing pronghorn antelope for the hunter are based primarily on easily gathered, empirical data. As described by Buechner (1960), the mathematical method for harvest regulation is unequivocal. If the manager had the tasks of setting seasons and bag limits and informing the hunting public of population trends and expected harvests

his job would be relatively straightforward, although landowner-sportsmen relationships and other sociological problems would detract from his ability to regulate harvests. However, there are other sets of problems facing the manager which are not amenable to simple mathematical solutions and good public information programs. Wildlife managers are responsible not only for the year to year survival of populations but also responsible for the quality of resource. As Fichter and Autenrieth (1978, this volume) point out, hunting can change the genetic constitution of populations. In the long term, will we be leaving a caricature of the pronghorn to our descendents, or will the integrity of the species be maintained? A second major issue not addressed by conventional management decision making systems is prediction of the impact of massive habitat change by strip mining. If the strip mined lands are reclaimed, how should the reclamation proceed to maximize wildlife use of the new habitat? The manager is forced to speculate on the consequences of such human actions on populations of pronghorns. What is needed, I believe, is a theoretical model of the pronghorn which synthesizes what is known about the biology of the species with the general concepts of evolutionary ecology, behavioural ecology and sociology. The model proposed by Bromley (1977) employs the ultimate factors of climate, predation, availability of food and habitat structure which act on the genetic characteristics of a medium-sized ruminant to predict and explain biological characteristics of the pronghorn. By using the model, the manager can predict and suggest ways of reducing the negative impacts of major changes in habitat structure or age and sex specific mortality by hunting. As with any scientific theory, the proposed theory should be tested by developing specific hypotheses and gathering empirical data. This paper presents the essential concepts

leading up to the theory, a test of theory using observations on birth and maturation of the pronghorn fawn, and application of the theory to the reclamation of strip mined lands. The theory is developed in greater detail and expanded to include social organization, secondary sex characteristics and reproductive characteristics in Bromley (1977).

AN EVOLUTIONARY MODEL OF THE PRONGHORN

The genus *Antilocapra* has been present in the grasslands of North America since the Pliocene, some 5 to 6 million years ago (Webb 1973, O'Gara unpublished manuscript). The available evidence suggests the pronghorn is a bovid, probably stemming from a small, forest-dweller living in Eurasia and North America in the Miocene (Bromley 1977, O'Gara unpublished manuscript). Over these millions of years the basic ruminant body plan has been shaped by changing ecological forces through the process of natural selection. The sole living end product of this process is the pronghorn. There is no reason to suspect that the evolutionary process for pronghorn has stopped working in recent times. Therefore, if man understands the ecological or selection forces that shaped the pronghorn before western man inhabited the Great Plains, we should be able to recognize man-caused changes in those forces and attempt to adjust our activities to recreate the balance of forces which existed under wilderness conditions.

The Ecological Forces

Evolutionary ecologists have developed some general principles to explain the process of biological adaptation. According to Wilson (1975) ecological selection forces act on genetic material embodied in individuals of a population to produce changes in biological characteristics of the

population. The rate of change depends upon the nature of the genetic information (phylogenetic inertia) and the relative severity of ecological forces (environmental pressures). Adaptations are traits which have a specific biological function (Williams 1966). The phylogenetic inertia of the pronghorn involves its mammalian and bovid ancestry. The pronghorn possesses the normal suite of mammalian characteristics, the ungulate body shape, a ruminant digestive system and weighs approximately 50 kg. The proposed environmental forces are climate, availability of food, predation and habitat structure. These forces are widely recognized as prominent causes of adaptations (Geist 1974, Pianka 1974, Wilbur, Tinkle and Collins 1974, Wilson 1975).

The climate of the Great Plains is continental and strongly seasonal. Marked variations in temperatures, precipitation and winds from day to day, month to month, season to season and year to year are the rule. Average conditions exist as a statistical concept. Allied to climate are the incidence and effects of prairie fire. Variations in climate can affect the pronghorn directly by causing death due to exposure and indirectly through the changing availability of food. Blizzards, droughts and fires can temporarily exclude pronghorns from food, causing extensive mortality and reduction in fawn crops (Buechner 1960, Calef 1950, Hailey and DeArment 1972, Martinka 1967, Webb 1972, White 1974 and personal communication).

The second selection pressure, the availability of food, is important even when conditions are not extreme. There is great variation in the distribution and abundance of food suitable for the pronghorn over space and time. Pronghorns must feed selectively on high energy plant parts, for bioenergetic reasons (Geist 1974, Jarman 1974). Not only do pronghorns

need high quality food to survive, but also individuals who are successful competitors will maintain high energy levels in relation to their peers and can be expected to produce more viable offspring and be favoured by natural selection.

The third force is predation. Predators have stalked ungulates since their derivation from more generalized stock (Romer 1966). Predators usually kill the old, wounded, diseased or young (Kruuk 1972, Mech 1970). Pronghorns are preyed upon by coyotes (*Canis latrans*), bobcats (*Lynx canadensis*) and golden eagles (*Aquila chrysaetos*) and they were no doubt the prey of wolves (*Canis lupus*) in past years (Autenrieth and Fichter 1975, Beale and Smith 1973, Bruns 1969, McLean 1944, and others).

The fourth force is the structure of the habitat. The generally flat nature of the prairie combined with relatively short vegetation permits the pronghorn to have visual contact with other pronghorns and predators at great distances. Geist (1974) and Estes (1974) have discussed the influence of plains ecosystems on ungulate characteristics.

Expected Nature of Adaptations

The birth process normally takes place within a few days. This includes the time from when the parturient doe begins to seek out a place to give birth until her young are born and have left her for their first bedding sites in the prairie. We are concerned primarily with the behaviour of the doe immediately before, during and after parturition and the behaviour of the neonate from its birth until it finds its first bedding site. We are not concerned with the time of year birth occurs, except that it be when normal maternal care will succeed in getting the fawn through the first few days of life, barring unusually wet, cold weather. Nor are we concerned with the duration of lactation after birth, except

that suckling occurs after birth. When the time frame is restricted to the few days from when the doe begins to seek a birth site until her fawns are separated temporarily from her, the possible action of selection pressures can be anticipated with some precision. For example, we can relegate the broad sweep of climate (seasonal change, etc.) and availability of food to insignificant roles. The parturient doe cannot possibly run as fast as a doe in other reproductive states (lactation, estrus, gestation). When the doe lies down to give birth and experiences intense labour contractions, she and her young cannot escape at all. The neonate is at first too slow to outrun a predator and too small and weak to defend itself. Therefore, mortality by predation should be a major selection factor. In response, the behaviour of doe and her young should be directed toward completing the necessary processes associated with birth as rapidly as possible. Second, the birth process and bedding sites of fawns should be located where the probability of detection by predators is minimal. Here is where a second important selection pressure, habitat structure, should play a role. If both predators and prey in open habitats employ vision to capture or avoid capture, then the prey should seek out irregularities in the vertical aspects of its basically two dimensional habitat to conceal itself from detection at the ground level. To avoid predation by eagles, fawns should use variations in the horizontal features for camouflage. Since the fawns cannot escape if detected, adaptations to reduce olfactory cues of their location should be observed.

To reduce energy losses of her neonatal fawns, the doe should dry and ruffle the pelage of the fawns and select birth sites in favourable microclimates. The fawns should select bedding sites in places where their energy losses are minimized. Alexander (1968) has shown that hypothermia

is a major cause of mortality in neonatal sheep in Australia. The hypotheses on habitat selection in relation to microclimate were not tested in the field.

At the age of about 1 month the pronghorn fawn ceases lying in isolation from adults and begins to associate with its mother and other adults throughout the day (Autenrieth and Fichter 1975, Bromley 1967, Kitchen 1974). Since we assume the growing season, we are not concerned with rigors of winter. Also for this problem, we will not consider catastrophic changes in forage abundance from droughts and other causes. The focus of our attention is on the action of availability of food. The food of the pronghorn is restricted to discrete parts of plants. Since plants require time to renew nipped off parts and since over the growing season the plant taxa that are acceptable to the pronghorn grow at various times and remain acceptable over different periods once grown, the distribution and abundance of plant parts acceptable to the pronghorn varies greatly from place to place and from time to time. Since isolated individuals should be more prone to predation than individuals in groups (Estes 1974, Geist 1974a, Jarman 1974, Treisman 1975), individuals will feed in the vicinity of conspecifics. Competition between individuals for discrete food particles is inevitable (Jarman 1974). It is expected that pronghorns will compete for social dominance as an adaptation to competition for food. Dominance relations established and maintained eliminate repeated conflicts over access to point centered resources.

ASSESSING THE FEASIBILITY OF THE THEORY

Demonstration of the feasibility of the theory depends on recognition and description of adaptations. It is assumed that the human observer

will detect at least a representative sample of the adaptations. Adaptations by definition serve functions (Williams 1966). The human observer should be capable of determining function from empirical observations of the form of biological characteristics. Absolute certainty may be beyond our ability to determine; however, biological functions of many behavioural and morphological characteristics have been demonstrated experimentally (Alcock 1975, Brown 1975, Wilson 1975). The proposed theory can be considered feasible if the sum of adaptations observed during sequential life-stages of the four changes in functional weight in relation to probable changes in strength of the selection pressures, as pointed out above in The Expected Nature of Adaptations. The life-stages considered are (1) the few hours before, during and after birth to include selection of the first hiding site, (2) the approximately 3-week period the fawn spends most of its time hiding and separate from its mother, and (3) the approximately 7-month period from when the fawn permanently joins doe-fawn herds until the end of its first winter.

Adaptations Observed Before, During and Shortly After Birth

The behaviour patterns associated with birth are described in order of appearance below. More full descriptions of these and other adaptations can be found in Autenrieth and Fichter (1975), Bromley (1977), Ingold (1969) and Kitchen (1974).

Birth Site Selection: The parturient doe becomes increasingly sensitive to sudden changes in her immediate environs during the last few days of her pregnancy. She gives birth alone and in a clump of taller than average sagebrush or other vegetation (Autenrieth and Fichter 1975, Bromley 1967, Pyrah 1974) or in depressions in the habitat (Bromley 1977, Howard 1966, O'Gara 1969). Birth sites in the open were described by Ingold (1969),

however. The presence of alternatives was not mentioned in his report. By giving birth in depressions or in areas of taller than average vegetation, the doe reduces the probability of visual detection by predators and possibly reduces evaporative heat loss by her offspring through reduction of wind speed over the body of her wet offspring. Birth site selection can be explained by the interaction of predation and weather with the structure of the habitat.

Birth Process: The birth process is rapid and can be held off when disturbed. Bromley (1977) reported two instances of halted labour in which fawns were beginning to protrude from the vagina. In both instances the does were disturbed, ran away from the place where they were disturbed and gave birth in more secluded places. The parturient doe experiences episodes of strong labour contractions over a period of about 2 1/2 hours before giving birth and twins are usually born from 15 to 30 minutes apart (Autenrieth and Fichter 1975, Bromley 1977). Perhaps the episodic quality of labour is an adaptation to reduce the probability of an undetected advance by a predator.

Behavioural Interactions at the Birth Site: In the approximately 2 hours spent at birth sites, after birth, essential physiological and psychological processes are initiated. The mother stimulates muscle, respiratory and digestive systems by her licking and provision of milk (Lent 1974). By licking her young the mother learns the identity of her young, a process termed maternal imprinting (Klopfer et al. 1964, Klopfer and Gamble 1966). Also during this period the fawn apparently develops the ability to discriminate between its species and other mammals (Bromley 1977). As pointed out by Lent (1974) and others, licking of the fawn by its mother serves to reduce evaporative heat loss and reduce odours which could attract

predators to the birth site. Therefore this behaviour pattern can be explained by climate and predation acting in concert. Both mother and young vocalize low pitched sounds during this period, which would serve to maintain contact between mother and young and thereby avoid wasted time. To the observer, the behavioural events associated with birth seemed rushed. The fawn begins to walk and run within 30 minutes after birth and it often leaves the side of its mother for increasingly long trips away from the birth site. Although it would be difficult to demonstrate this, it seems that the hurried maturation of physiological and psychological processes at the birth site represents a compromise between selection for optimum physiological and psychological development of the fawn and fawn-mother relationship and selection by predation for the shortest possible period of vulnerability at the birth site (Bromley 1977). The behaviour patterns observed at the birth site can be attributed to the actions of climate and predation within the constraints of mother-young nutritional and psychological relations typical of mammals (i.e. phylogenic inertia).

Leaving the Birth Site: Either the fawn or the mother initiates departure from the birth site. The journey is approximately 150 m and lasts roughly 15 minutes (Autenrieth and Fichter 1975, Bromley 1977). It ends when the fawns are walking ahead of the mother and when the mother stands still. Perhaps the absence of a "large moving object" in the fawn's visual field causes the end to approach responses and the initiation of hiding site selection by the fawn (Bromley 1977). Aside from the fact that the mother and her fawns leave the birth site, an activity which is explained by predation, there are no outstanding, specific adaptations. Perhaps the length of the journey is a compromise between the advantages of complete

separation from the odours at the birth site and the length of time the ungainly neonate exposes himself to visual detection by predators.

Hiding Site Selection: When its mother stops moving away from the birth site, the fawn changes its body posture from head up, ears up, to head, neck and ears lowered. The fawn moves at a slower walk and at intervals it stops and moves its head and neck laterally, back and forth, through an arc of approximately 60 degrees. After this the fawn either lies down or walks slowly ahead, repeating the act until a bedding site is selected. Autenrieth and Fichter (1975) called this the head low behaviour pattern. Hiding sites described by Autenrieth and Fichter (1975) and Pyrah (1974) included nearby clumps of shrubby vegetation. Bromley (1977) found that fawns lay down on or overlapped areas of bare ground, dead and matted vegetation, buffalo dung or flat, low rocks at a significantly greater frequency than similar areas were found in immediate surroundings. The average surface area of brown patches at 36 hiding sites found by Bromley (1977) was 800 $cm^2 \pm 900$ cm^2. The usual shape was rectangular with dimensions of 20 cm by 40 cm. Twins select separate bedding sites (Autenrieth and Fichter 1975, Bromley 1977). The observations on hiding site selection are explained by predation interacting with habitat structure. When fawns lie down in bare areas near clumps of vegetation they camouflage themselves against predator detection from both horizontal and vertical vantage points. The grayish-brown coat colour blends with rocks, earth, dead vegetation and *Bison* dung. The terrestrial predator, such as the coyote, would have difficulty distinguishing the lying fawn with its head and ears down, from rocks, dung piles or thick patches of dead vegetation. A golden eagle would have difficulty transferring the visual image of one fawn detected from the air and caught to another lying fawn, because

coat colour of the fawn blends with innumerable, randomly shaped and similarly coloured bare spots in the habitat (Bromley 1977). Selection of independent lying spots as opposed to lying together by twins reduces the intensity of odour produced at the lying site, and therefore the probability of predator detection (Tinbergen et al. 1967, Treisman 1975). From these observations and analyses, it seems fair to conclude that hiding site selection can be accounted for by the interaction of predation with habitat structure.

Adaptations Observed During the Hiding Period

This period lasts from 3 to 4 weeks and ends when the fawn no longer leaves its mother after nursing to hide.

Hiding Site Characteristics: Bromley (1977) found no significant differences in hiding site characteristics as a function of maturation of the fawn.

Frequency and Duration of Mother-Young Interactions: As described in detail by Autenrieth and Fichter (1975), the mother returns to the vicinity of her bedded fawns approximately every 4 hours. At that time the fawn leaves its bed, suckles, and eliminates urine and feces. The mother nurses, licks her young and consumes the urine and feces. Consumption of body wastes is also done at the birth site and is obviously an adaptation to reduce olfactory detection of the young by predators. During the approximately 1/2 hour mother-fawn interaction period, the fawn begins to eat vegetation, runs vigorously for short periods and interacts socially with its sibling (Autenrieth and Fichter 1975, Bromley 1967). The short duration of activity period suggests that predation acts in opposition to physiological maturation. As this time period draws to a close, the activity periods become progressively longer, which parallels the increase in speed and

stamina of the fawn. The active participation in social behaviour among siblings can be explained both by predation and by availability of food, as outlined below.

Adaptations to Herd Life

The time frame from when the fawn abandons hiding sites to join doe-fawn herds until it survives through its first winter is considered here.

Joining the Herd: This act is so fundamental that its significance might be overlooked. The fawn not only joins the herd to gain greater access to its mother but also to increase its foraging time within the collective security of the herd. As pointed out by Jarman (1974) herd life represents a compromise between the disadvantages of conspecific competition for food and advantages of pooled sensory capability for predator detection.

Several specific adaptations that are consequences of herd life are described below.

Pelage Molt at Age 3 to 4 Weeks: The drab, brown-gray coat of the neonate is shed for the bright colouration of the adult at the precise time the fawn joins the herd (Bromley 1977). This colour change is attributable to predation. Predators target on individuals in a group which possess unique or different features.

Dominance Hierarchy Formation: Although human observers tend to view vigourous chasing and head-butting of young fawns as play, observations on marked fawns by Bromley (1967) and Kitchen (1974) indicate that fawns establish a dominance-hierarchy among themselves and learn their social rank with adult does and bucks by the age of 2 months. Competition for social rank is the means by which animals obtain efficient access to

resources in short supply, namely food and mates. Once the relative dominance between two animals is established, the dominant gains access to the resource without expending energy or risking injury to force away competitors. The subordinate learns to avoid the contest, which it would lose, and seek resources elsewhere.

Unique Colour Markings: Each pronghorn fawn is born with its own peculiar colour combination on its rostrum, neck, mane and tail. Individuals of both sexes usually have distinctive horn development. As Marler and Hamilton (1966:378-379) point out, individual variation in colouration facilitates establishment of social order among animals. This adaptation is ultimately attributable to competition for food and mates.

Summary

The prediction from theory was that the weight of adaptations observed during the birth process would be dominated by predation and weather but not influenced by the availability of food. The behaviour patterns involving birth site selection, duration of mother-young contact at the birth site, drab colouration of the fawn, and development of species recognition by the fawn hiding site selection conform with the expectations. The apparent interaction of predation and habitat structure resulting in selection of secluded and camouflaged sites was pointed out. The brief activity periods of mother and young during the hiding period and the maternal consumption of urine and feces were related to predation. Upon joining the doe-fawn herds, the fawn adopts adult colouration which was attributed to predation. Competition for social dominance and exhibition of unique combinations of body markings and horn development can be explained ultimately by competition for food and mates. Here the availability of food is the ecological force and competition for mates repre-

sents phylogenetic inertia. Satisfaction of energetic and reproductive needs can be considered basic to all mammals. The way these needs are met by a particular species depends upon adaptions to ecological forces, such as climate, availability of food, predation and habitat structure.

The evidence presented here does not prove the theory, but it does establish the feasibility of the model. The hypothesized interaction of ecological forces suggests not only explanations for the syndrome of behavioural and morphological traits possessed by the pronghorn but also empirical tests. For example, it is hypothesized that birth site selection is shaped by predation and perhaps by climate as well. Microclimatic measurements at birth sites shortly after birth could be compared to similar measurements in surrounding environs. Hypotheses concerning the functional value of other traits, such as the coat colour and changes in colouration of the fawn could be tested by the use of models exposed to predators. Although the evolutionary model cannot be tested directly, the predictions on the relative weights of adaptive traits assembled by their function within life-stage periods and the predictions on the functional value of specific adaptive traits can be tested empirically.

The conclusion that the model is feasible is not surprising and may strike the critic as trite. However, it is my opinion that an holistic concept of the pronghorn needs to be developed along with increasing knowledge of more specific subjects such as nutritional demands and reproductive biology. An attempt to demonstrate the usefulness of the holistic approach to wildlife management decisions is presented below.

APPLICATION OF THE THEORY TO RECLAIMED STRIP MINED LANDS

Coal lies under approximately one-third of the Great Plains. Massive alteration of the habitat of the pronghorn seems inevitable. How

can the wildlife ecologist begin to assess the precise environmental impact of such massive change? If the impact assessment rests solely on the assemblage of survey data and the bits and pieces of information we have on the myriad species of plants and animals inhabiting the prairie, the impact statement cannot help but fall short of presenting a comprehensive analysis. At the opposite pole of scientific inquiry is the holistic concept of ecosystem structure and function. Holistic theories, such as the one presented in this paper, provide a syntax for the bits and pieces of empirical information, relating what is known to the complete system, and point out what empirical information is lacking. Unfortunately, social decisions on strip mining will force wildlife managers to act before the wildlife scientist can develop and test all details and ecological concepts embodied in the prairie ecosystem. Managers should acknowledge the uncertainty of our knowledge and push for needed research and theoretical advances, but they should also use the available theories and data to provide society with the best possible predictions of the impact of large scale habitat alteration.

In the specific matter of reclamation of strip mined lands for use by pronghorn antelope, the impact of landscape modification on recruitment of pronghorn fawns can be assessed by reference to the theory. The interaction of predation and habitat structure to guide pronghorns to appropriate birth sites and fawn hiding sites was established above. If reclaimed land is shaped to conform to smooth contours and revegetated in a systematic, regular pattern, the land will be avoided by does about to give birth and not be used by fawns for hiding sites, unless there are no alternative areas. If pronghorns are forced or attracted to such areas because the soil has been heavily fertilized and possibly irrigated,

then parturient does and young fawns should be subject to relatively high mortality by predation. Alternately, if reclaimed lands are not smoothed over but rather left with some irregularities in surface conformation and if the lands are revegetated with irregularly spaced clumps of vegetation, the reclaimed lands probably will be acceptable to pronghorn does and young fawns. Retention of pronghorns over the summer and winter on reclaimed lands will depend on the availability of food. The precise irregularity of the terrain should be determined by soil scientists and civil engineers who can judge the stability of the soil. Which plants to use for revegetation should be determined by wildlife biologists, range managers and plant ecologists who are familiar with local growing conditions and the forage qualities of available plant taxa. Completion of the prescription for strip mined lands depends upon integration of the holistic model with empirical information. To proceed with one aspect without adequately considering the other would be foolish.

ADDENDUM

In the above paper it is proposed that habitat structure and predation interact. With the exception of birth sites reported by Ingold (1969), observed birth sites were located in areas offering limited visual exposure to potential predators. Such sites were in areas of taller than average sagebrush or grass or in depressions. Mr. Walter Bodie of Idaho Fish and Game reported (personal communication) that does in the Upper Pahsimeroi River Drainage avoided rough terrain and taller than average sagebrush to give birth in extensive level areas of low sagebrush. These observations conflict not only with those made by Autenrieth and Fichter (1975) on the same study area but also with the generalization made above in this paper. During the years between the field studies of Autenrieth and

Fichter and those of Bodie, the coyote population increased in density due to the ban on 1080 poisons, according to Bodie. Further, Bodie reports that coyotes were seldom seen in the extensive, low sagebrush flats. Pronghorns may have been chased by coyotes when the pronghorns entered rugged terrain or areas of tall sagebrush. If so, then parturient does probably would avoid these areas.

Do the observations by Bodie and Ingold invalidate the proposed relationship between habitat structure and predation, and cast doubt on the recommendation to incorporate diversity in land form and vegetation composition on reclaimed mined lands? These contradictions force modification, but not abandonment of the proposal. The majority of birth sites that have been reported support the generalization. The observation that pronghorn does may choose birth sites in low sagebrush flats under high coyote densities suggests that more than one criterion is used for locating a birth site. Bromley (1977:66) proposed the following three-step process including, in order of priority, (1) avoidance of areas offering great visual coverage of the habitat, (2) avoidance of habitat types where predators have been encountered, and (3) avoidance of specific places where direct disturbances occurred. The observations by Bodie and Ingold indicate that the priority of steps (1) and (2) should be reversed.

In addition to the proposed three-step process, the hypothesis that does incorporate microclimatic information to select sites where energy loss from their neonates would be minimal, should be explored.

Predation, habitat structure and microclimatic variables may each be important in birth site selection. The precise nature of the interaction cannot be determined without experimental work. At the current state of our knowledge, it would be imprudent to ignore the possibility that vari-

ability in habitat structure is an important aspect of pronghorn habitat. Until compelling evidence to the contrary has been gathered, guidelines for reclamation of strip mined lands should include provisions for variations in topography and vegetation.

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Guidelines for the Management of Pronghorn Antelope



8th Pronghorn Antelope Workshop
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GUIDELINES

for the

MANAGEMENT OF PRONGHORN ANTELOPE

ROBERT AUTENRIETH, EDITOR

PRONGHORN ANTELOPE WORKSHOP

JASPER, ALBERTA

1978

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I. INTRODUCTION

A. Development of the Guidelines

The objective of this report is to provide the best information currently available for managing and perpetuating pronghorn habitats.

Management guidelines for any species, when used by many states, provinces and agencies, must remain general in nature. Their value is found in the discussions of basic requirements and problems currently recognized in antelope management. These guidelines will provide standards which will complement the game manager's knowledge and analysis of specific population problems.

Implementation of any or all of these recommendations should be undertaken in keeping with the need for applying "a holistic approach to our endeavours at resource management", i.e., in view of current ecological knowledge management of any game species must move beyond the obsolete, fragmented, single-species approach and henceforth be based on the ecosystem (Talbot 1976). That many, if not all, of the guidelines provided here are interrelated, is consistent with the holistic concept of wildlife management.

The information assembled in the guidelines represents the current thinking on antelope management by wildlife managers and researchers. Revisions and additions will be made periodically as new data are presented.

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B. Historical Perspective

Pronghorn antelope (*Antilocapra americana*) have evolved on the prairies and deserts of western North America during the last 20 million years (Frick 1937). They are endemic only to North America (O'Gara 1978) although Nelson (1925) suggested their resemblance to some African ungulates. During pristine times these animals ranged from the south central prairies of Canada through the western grass and shrub-grass plains of the United States, south to the deserts and plateaus of northern Mexico. Today, antelope inhabit most of their historic range, although the total area of suitable habitat has been greatly restricted, possibly more than 75 percent.

Nelson (1925) estimated their "original numbers of not less than thirty to forty millions, and possibly more". Areas of highest density were said to be the short grass prairies where vast antelope and buffalo herds were legendary. Reports from the journal of Lewis and Clark (Thwaites 1905) indicated antelope were most abundant on the great plains; however, they were almost the most numerous ungulates over the drier shrub-grass plains, steppes and deserts.

Pioneers, immigrants and new generations colonized and settled the western states between 1850 and 1900. They showed little regard for antelope and their habitat as resources. During this period, pronghorn

numbers declined dramatically.

About 1920 the future for pronghorns became brighter (Nelson 1925). Conservation-minded organizations supported state and federal programs that controlled excessive hunting and provided other protection through refuges. A prolonged drought extending from 1918 to 1934 (Pechanec et al. 1937, Cole 1956), together with low prices and surpluses of farm products, made cultivated agriculture uneconomical on semiarid homestead land parcels. Consequently these marginal agricultural enterprises were abandoned and much of the cultivated land reverted to native rangeland vegetation. State, provincial and federal wildlife agencies developed management techniques that benefited antelope repopulation. Antelope were successfully reintroduced to historic ranges. In some areas, however, vegetation damage by drought and overgrazing was so great that antelope were not able to survive after being transplanted (Nielson 1962). Ending of the drought, control of hunting losses, reversion of farmland to rangeland, and normal expansion of the antelope populations no doubt provided most of the increase in numbers (Nielson 1962). The successful reestablishment of pronghorns produced a 1500 percent increase in population total numbers, and simultaneously provided over two million hunter-recreation days (Yoakum 1968).

Unfortunately, the future of pronghorns is not certain. Continued agricultural and mining expansion onto historic ranges, fencing across migration routes and removal of native vegetation by range rehabilitation projects and overgrazing are obstacles to the future success of this unique species.

II. LIFE HISTORY

A. Habitat Requirements

1. Food Habits

Antelope thrive on range with a diversity of grass-forb-shrub habitat types. Bever (1951), Fichter and Nelson (1962), Wentland (1968), Bayless (1969) and Beale and Smith (1970) found that browse, mostly sagebrush (*Artemisia* spp), made up at least 80 percent of the winter diets of northern pronghorns. Taylor (1975) found shrubs comprised 91.6 percent of the winter diet in Wyoming's Red Desert. Baker (1953) and Beale and Smith (1970) found that forbs represented 86 percent or more of pronghorn diets during summer. Pronghorns on southern ranges use more forbs throughout the year than do northern ones (Terwilliger 1953, Larsen 1966).

Pronghorns have shown some adaptability in using exotic vegetation. Hepworth (1970) reported use of winter wheat (*Triticum* spp) during winter in Nebraska where browse was not available. Domestic forbs, such as alfalfa (*Medicago* spp) are often used year round. Native vegetation, especially browse, is generally required to sustain antelope during severe northern winters or southern droughts. Sagebrush also has a more favourable nutrient content during winter than most grassland species (Barrett 1974). Martinka (1967) documented pronghorn deaths from malnutrition on grasslands and survival on sagebrush ranges during a severe winter. Mortality may further increase if a proper balance between available winter range and pronghorn population size is not maintained (Compton 1970).

2. Key Ranges

Key ranges are those areas necessary to sustain an antelope

population during the most limiting of conditions (e.g. severe winter, dry summer). The use may or may not be seasonal, often depending upon environmental conditions.

Key range areas for antelope vary widely in relation to land management practices, geographic location, climate, soils and habitat types. Key range needs identified by recent research include: 1) spring range (Becker 1972), 2) winter range (Martinka 1967, Bayless 1969, Compton 1970, McKenzie 1970, West 1970, Taylor 1975 and others), 3) migration routes, 4) free water (Sundstrom 1968b, Beale and Holmgren 1974), and 5) fawn bedding cover (Pyrah 1974, Autenrieth 1976).

3. Water

Measurements were made of water consumption by 25 to 35 pronghorn antelope in a study pasture near Wamsutter, Wyoming (Sundstrom 1968). Daily consumption rates per antelope varied from .34 liter (.09 gal.) per day in May to 4.5 liters (1.19 gal.) per day in August. Total monthly precipitation, evaporation, succulent vegetation and average maximum temperature had marked effects on the daily water consumption rates.

In Texas, droughts brought about a reduction in vitality of antelope which resulted in decreased fertility (Jones 1949). In Wyoming Baker (1953) found that antelope killed themselves trying to get through antelope-proof fences in an attempt to reach water on an adjacent range. Antelope will drink from most facilities designed for livestock use and those facilities should remain useable throughout the summer and fall on northern ranges and year-round on southern ranges.

In Colorado it was reported that some antelope herds live and die without drinking water (Hoover et al. 1959). Phelps (1978) feels

this is true of Sonoran antelope. However, the importance of abundant water sources on pronghorn ranges is not questioned.

4. Topography and Other Abiotic Features

The following are optimum requirements for pronghorns inhabiting the sagebrush-grassland communities (Yoakum 1974):

Physiography - Antelope use land forms typified by low rolling, expansive terrain. The amount of land area and movement required depends on habitat quality and snow accumulation. Differentiation of summer and winter ranges is usually based on snow accumulation. The deeper the snow, the further the herds migrate.

Natural Barriers - Natural barriers affect antelope movements and thereby the occupancy of the habitat. Such natural barriers include: large bodies of water; large rivers; an abrupt escarpment or mountain ridge; thick high brush or trees; deep canyons; and others. Einarsen (1948) cited examples of such barriers when he referred to two cases (the Columbia River and a forested area) where pronghorns did not occupy or reestablish nearby favourable ranges.

Elevation - Pronghorns inhabit ranges from sea level to 3,353 m (11,000 ft.). Only a few antelope occupy ranges at sea level in Mexico. Likewise, only small herds use alpine meadows in Oregon and Wyoming. The greatest densities in the Great Basin occur on rangelands between 1,220 and 1,830 m (4,000 to 6,000 ft.) above sea level (Yoakum 1974).

Precipitation - The highest antelope densities appear to be within habitat averaging 25 to 38 cm (10 to 15 in.) precipitation per year. Populations in precipitation belts above or below these parameters have lower survival rates and densities (Sundstrom et al. 1973, Yoakum 1968).

Snow - Most antelope ranges receive snow. When depths exceed 25 to 30 cm

(10 to 12 in.), antelope frequently have difficulty obtaining necessary forage. Prolonged seasons of deep snows are especially detrimental when combined with factors such as: 1) low quantities or qualities of forage, 2) frequent wind (increasing chill factors), and 3) obstacles to movement (fences, etc.) (Riddle and Oakley 1973, Hailey 1978, Sundstrom 1969).

Temperatures - Temperatures are seldom a major limitation. Antelope are adapted to hot deserts or alpine plateaus. Freezing temperatures and precipitation during fawning may cause mortality to newborn fawns (Sundstrom 1968).

5. Biotic

The following characteristics of the sagebrush steppe represent preferred pronghorn ranges (Yoakum 1972):

Ground Cover - Ground cover averages 50 percent living vegetation and 50 percent bare ground, rocks, litter, etc.

Composition - Generally, the composition of vegetation is 40-60 percent grass, 10-30 percent forbs and 5-20 percent shrubs.

Variety - Within the vegetative community there is a variety of species. This often averages 5-10 grasses, 20-40 forbs and 5-10 shrubs.

Range Types - Open rangelands supporting a variety of vegetative types (meadows, forb patches, etc.) are preferred in contrast to monotypic vegetative communities (Yoakum 1957, Sundstrom et al. 1973). Antelope utilize areas of recent wildfires for foraging. Such areas often provide grass sprouts and an abundance of succulent forbs.

Dietary studies disclose that during wet springs or summers producing an abundance of succulent forbs, pronghorns utilized more forbs. Antelope in Oregon moved from dry ranges to intermittent lake beds and playas to seek succulent vegetation (Good 1977).

Height - Low vegetative structure averaging 38 cm (15 in.) is preferred, with vegetation over 61 cm (24 in.) less preferred and over 76 cm (30 in.) are infrequently used. Antelope will utilize areas of higher brush while travelling to or from more preferred ranges; and have been observed using mature brush for shading; however, their use of vegetation 76 cm (30 in.) or taller is low. There may be a factor concerning reduced visibility, or decreased mobility, which is important to the antelope's survival.

B. Movements

Antelope movement is defined as occasional location changes brought about by such influences as drought, blizzards, irritating disturbances, new food sources or normal spring dispersal movements. Antelope migration is defined as traditional movement from one seasonal-use area to another area by following approximately the same route year after year.

Timing and length of the seasonal movements of pronghorns are somewhat traditional, but they are affected by range and weather conditions. In the northern parts of their range pronghorns sometimes move 160 km (100 mi.) or more in response to deep snow or to reach available winter forage (Martinka 1966, Sherwood personal communication). During dry seasons, southern pronghorns also need mobility to reach free water and succulent forage; however, they seldom migrate.

C. Reproduction

Although fawns occasionally breed (Wright and Dow 1962, Mitchell 1967), pronghorn does usually breed for the first time when 16 to 17 months of age. The gestation period, averaging 252 days, is long compared to other similar sized big game animals (Hepworth and Blunt 1966).

Most northern pronghorns breed during a short period from mid-September to early October, but southern pronghorns breed from July through October (Lehman and Davis 1942, Buechner 1950). The mean number of young produced per mature doe is usually greater than 1.75 (Buechner 1952, Ellis 1972), but twinning is less prevalent in does producing their first young. Mid-summer fawn-doe ratios are commonly used as an index of recruitment and may vary from less than 30 to more than 110 young per 100 females. Montana rates production as follows (Trueblood 1971):

Fawns/100 Does	Rating
20-39	Very poor
40-59	Poor
60-79	Fair
80-99	Good
100 +	Excellent

Pronghorns seldom live more than 9 years under natural conditions (Hepworth 1965).

D. Behaviour

Due to the ease of observation, antelope behaviour has been studied extensively. Pronghorns tend to winter in large herds, with animals of both sexes and all ages feeding and bedding in close association with minimal social conflicts. Behavioural adaptations to conserve energy in winter have been documented by Bruns (1969). In the spring, pregnant does isolate themselves to give birth. By mid-summer, does associate in doe-fawn groups and non-territorial bucks interact in bachelor herds (Cole 1956, Prenzlow et al. 1968, Kitchen 1974).

Where mature bucks are territorial the social system insures that the largest, most aggressive bucks do most of the breeding (Bromley and

Kitchen 1974) and bachelors will not compete with pregnant or lactating does on the best range (Gilbert 1973).

E. Fawn Mortality

Pronghorns are the only artiodactyls known which conceive two or three times as many embryos as are born (Mitchell 1965, O'Gara 1969). Embryonic mortality and a long gestation period are probably recent adaptations to produce fewer and more precocious fawns. Under favourable conditions, pronghorn populations can increase rapidly, but fawn mortality is usually high. Fawns may be more vulnerable to predation than the young of other species (Arrington and Edwards 1951, Udy 1953, Beale and Smith 1973 and personal communication, Morley Barrett personal communication). Hailey (1978) reported significant increases in fawn survival in an area where coyotes were intensively controlled.

F. Parasites and Diseases

Extensive epizootics controlling pronghorn populations are uncommon. Vibriosis was implicated as the cause of low recruitment in a population of pronghorns in Wyoming (Trueblood and Post 1959). Epizootic hemorrhagic disease has been reported as causing mortality of pronghorns on northern ranges (Richards 1963, Chalmers et al. 1964). Serologic evidence of exposure of pronghorns to viral and bacterial agents has been presented (De Arment 1968, Barrett and Chalmers 1975, Stauber 1976); antibodies to parainfluenza 3, bovine virus diarrhea, eastern and western encephalomyelitis, infectious bovine rhinotracheitis, leptospirosis, bluetongue and the chlamydial group have been documented. The impact of these agents on free ranging populations is not known, with the exception of recent antelope mortalities due to a bluetongue outbreak in northeast

Wyoming in 1976 (Tom Thorne, interdepartment communication June 22, 1977). Seventy-six of 94 hunter-killed antelope tested showed serologic evidence of previous exposure to bluetongue virus.

Several independent studies conducted in different parts of their range indicate that numerous species of parasites are prevalent in pronghorns; nematodes are particularly abundant. Based on current knowledge, however, pathogenicity associated with parasitism in pronghorns is limited and not considered an important factor controlling populations. Parasites of pronghorns are summarized in published reports by Goldsby and Eveleth (1954), Honess and Winter (1956) and Boddicker and Hugghins (1969). The prevalence and intensity of parasitic infections in pronghorns varies greatly throughout their range and often reflects local environmental conditions.

III. MANAGEMENT GUIDELINES

A. The Animal

1. Harassment

Little information is available concerning the impact of harassment on pronghorns. The practice of chasing animals with vehicles during the season in hopes of getting a better shot is common. It increases crippling loss and expends calories needed for the coming stress of winter. Chalmers and Barrett (1974) noted during necropsies that pronghorns dying during drive trap operations revealed hemorrhage in the muscles of the hind limbs. They point out that even sub-lethal effects of stress may be highly detrimental to the pronghorn's well-being.

Wintering pronghorns are most vulnerable to harassment due to

their concentration on winter ranges where snow machines and four-wheel drive vehicles can cause added stress.

Geist (1971a) made the following observations on harassment: ".....it does little good for the wildlife. Unfortunately, animals excited by any stimulus at unpredictable intervals begin to grow excited when they hear or see unpredictable stimuli. Excitement costs energy -- vital energy needed for survival in winter or for the growth of the fawn, calf or lamb inside the female. Excitement raises mild havoc at first -- serious havoc if chronic -- with the hormonal system, and in turn adversely affects the growing embryo. It is now known that a 17 percent loss in body weight early in gestation causes reindeer females to resorb young. Harassment, added to natural stresses, can press weight loss below that limit".

Nearly all traffic in the vicinity of antelope constitutes a degree of harassment. Regular use of established roads produced minimal disturbance. However, recreational use of four-wheel drives, motorcycles, all terrain vehicles, snowmobiles or aircraft on antelope ranges must be minimized, especially during winter months and the fawning season (May 15 to June 15 northern ranges). Closures may be necessary on winter ranges particularly vulnerable to R.V. activity.

2. Composition Counts

If a measurement of reproductive success is wanted as a basis for management of pronghorns in terms of allowable harvest, fawn-doe counts are best made after mortality of fawns has "levelled off" and the fawns are still easily distinguished as such from an aircraft -- for example, the latter half of August in central Idaho, late July or the first half of August in Kansas. (The observability of fawns, a

function of social behaviour, is involved and reaches its maximum, i.e., plateaus, by mid-July in central Idaho). Wyoming also conducts a post season fawn-doe count early in October in areas where conditions for close observation occur.

Buck:doe Counts - While no guideline as such is offered in this connection, those who make "herd composition" counts of pronghorns should be aware that the reliability of buck:doe counts -- annually conducted in some states and provinces to determine the harvestable surplus of males -- may be influenced by the timing of the counts. This concern takes into consideration the pronghorn's seasonal changes in grouping and dispersal of groups and individuals. For example, questions arise regarding the observability of lone bucks as compared to that of does, most of which are in groups; i.e., the behaviour and social system of the pronghorn may affect composition counts taken in the summer. Wyoming feels post season counts may be more reliable due to less segregation of bucks and larger groups to work with. The timing of the seasonal changes are or may be variable from population to population, from region to region, and from year to year.

April-May counts are best for southern herds because groups are small and scattered at that time.

3. Predator Control

History - Over the years the opinions expressed about the effects of predation on pronghorn populations have run the full realm of extremes. Studies have been conducted and management schemes have been proposed (Elliott 1953, Gusey 1952, Newby and Brown 1958), most geared toward reducing or preventing the losses of antelope to coyotes, bobcats and eagles. Decisions have at times been influenced by political

overtones, particularly from the livestock industry (Cain et al. 1972).

Proponents of predator control often single out the coyote as the most important problem predator of pronghorn antelope. Bobcat, eagle and domestic dog depredation, except in unusual local instances, rank as secondary problems.

During the early 1900's pronghorn populations were at a low ebb. A program was begun to control recognizable inimical factors and enhance those conditions favouring the pronghorn (Beer 1944, Buechner 1960, Edson 1960, Mussehl and Howell 1971, Nelson 1925, Seton 1929, Sundstrom 1968, Yoakum 1968). Pronghorn refuges were set aside, hunting seasons were closed, reintroduction of antelope into former ranges was begun and predator "control" was intensified, particularly in areas where pronghorn transplants were made. To be effective, predator control had to be practiced over a large area -- 100 townships or more (Arrington and Edwards 1951). Pronghorn populations began to increase (Nelson 1925, Mussehl and Howell 1971, Sundstrom 1968), as did research into the life history and biology of the animal itself.

As new biological information was documented, new thinking was instilled into pronghorn management. It was determined that predator mortality was one of a myriad of pronghorn limitations (Buechner 1960, Compton 1958, Dirschl 1960, Einarsen 1948, Hjersman and Yoakum 1958, Hoover et al. 1959). Stockpiling could actually work in reverse (Keith 1973, Leopold 1948, Linhard 1974). Subsequently, seasons were reopened (Edson 1960, Hjersman and Yoakum 1958, Mussehl and Howell 1971, Sundstrom 1968), some refuges were abandoned (Hoover et al. 1959, Mussehl and Howell 1971), range condition for pronghorns was considered (Buechner 1960, Cole 1957, Hjersman and Yoakum 1958) and predator "control" for

reducing pronghorn mortality was limited almost exclusively to transplant areas although extensive predator control, specifically poisoning, was conducted to protect livestock on much of the pronghorn range. Pronghorn populations continued to increase and expand into their former range.

In the late 1940's and 1950's, pronghorns had increased to a level where there were viable populations in most of their former range that was still antelope habitat (Einarsen 1948, Yoakum 1968). In most places predator "control" was not a standard practice for pronghorn management. Murie (1940) stated, "The coyote is not at the present time adversely affecting the antelope in Yellowstone Park". However, studies in some areas still identified predation as the limiting factor to pronghorn well-being (Arrington and Edwards 1951, Halloran 1956, Mace 1949, Mason 1947, Rosko 1948).

At present the pronghorn as a species is well established. The role of predation and predator "control" is still being studied and debated. New research, particularly concerning coyotes and mule deer, indicates that in situations where coyote numbers are high and deer numbers are low, and where "normal" prey species are scarce, coyote-caused mortality on fawns may be inhibiting mule deer increases (Allen 1975, Knowles 1976, Schladweiler 1976). Also, in some areas it is felt that fawn mortality from bobcats, coyotes and eagles is limiting the populations of pronghorn (Barrett 1978, Beale 1972, 1973, 1978, Ebert 1975, South Dakota Dept. Game, Fish and Parks 1965, Spofford 1964).

Generally, most workers in the pronghorn management field feel predators are a mortality factor, but recognize they are but one of several factors causing fluctuations in pronghorn numbers (Allen 1975).

The overriding influences on the degree of mortality are prey species population levels and the quantity and quality of habitat available to the pronghorn and how this habitat is providing cover, space and nutrition. One or several mortality factors, including predation, can have a greater influence at some sequence in time. If the habitat is such that it cannot compensate these losses, the inhibiting mortality factor must be dealt with directly providing it has been isolated as the one.

Considerations - With these viewpoints in mind the following considerations are proposed for pronghorn-predator management. It should be recognized that:

1. Predators do kill pronghorns, but that predation is only one of many factors that influence antelope population trends.
2. Predator "control" is not a panacea to be applied widespread when antelope populations are lower than desired.
3. Predator "control", as such, seldom is intensive enough to actually control predators. Often it results in stimulating production in the predator species.
4. Each herd of pronghorn is governed by controls endemic to that herd and the habitat in which it lives.
5. The quantity and quality of habitat in which a pronghorn lives is the overriding influence on all inimical factors, including predation.

Guidelines - In treating a problem situation where pronghorn populations are reduced and predators are prevalent, the following guidelines should be used.

1. Determine the pronghorn herd parameters that are desirable. This may be in terms of total numbers, rate of recruitment to the herd,

age class, base herd, etc.

2. Determine the population year-round distribution and the habitat types involved.
3. Consider other population influences including, but not limited to, mortality factors.
4. If a factor such as predation is determined as a significant inhibitor of a pronghorn herd, the cost of actually controlling predators must then be balanced against the return expected.
5. If it is determined that the increase in antelope justifies the cost, predator control should be done on those herd units where documentation dictates predator reduction would be beneficial in meeting management objectives.

B. The Habitat

1. Water

Little information is available concerning water quality as it effects pronghorn antelope. However, total dissolved solids and pH are probably the most common immediate concerns. In the Red Desert, Sundstrom (1967) found little or no use by antelope of water sources which contained total dissolved solids in excess of 5,000 ppm. Some use occurred on one water source with dissolved solids of 4,620 ppm. The maximum total dissolved solids recommended for best game support is about 4,500 ppm (McKee and Wolf 1963).

Livestock and poultry may be injured by drinking water that contains excessive dissolved solids. Continuous use of such water may cause general loss of condition, weakness, scouring, unthriftiness, reduced milk production, bone degeneration and death. However, animals can temporarily drink high saline waters that would be harmful if used

continuously. Animals can also adjust gradually to the use of waters with a higher solids concentration than that which they normally drink, although sudden change from slightly to highly mineralized water causes acute distress and diarrhea of varying severity. The limits of tolerance depend upon the kind of salts present, the species of animal, its diet, age, physiological condition, season of year, climate, etc. (McKee and Wolf 1963).

Recommended pH range for most uses such as domestic water supplies, irrigation, fish and other aquatic life, swimming and other recreational uses, appears to be from 6.5 to 8.5 (McKee and Wolf 1963). In Wyoming's Red Desert, when water sources exceed a pH of 9.2, antelope appeared to seek other water sources (Sundstrom 1967).

It is suggested that where water sources are available to antelope, but appear to be avoided, a complete water chemistry test should be made and measures taken to correct the problem. Where the water quality can not be improved, and there is no other water source in the vicinity, a guzzler should be installed.

Region 3 of the U. S. Forest Service has suggested the following interim guidelines for water quality for livestock and wildlife:

Interim Water Quality Guidelines (USFS, Region 3, 19)

Total Dissolved Solids (mg/l)	10,000*
Free Chlorine (mg/l)	200
pH (standard units)	7.0-9.2
Manganese (micro g/l)	10
Alkalinity (as $CaCO_3$) (mg/l)	50
Chlorides (mg/l)	1,500
Chromium (mg/l)	5
Hardness (mg/l)	500

*This figure is probably excessive.

Distribution - A close relationship was observed between antelope distribution and water locations in Wyoming's Red Desert (Sundstrom 1968). Ninety-five percent of 12,465 antelope counted from the air were within a 6 km (4 mi.) radius of a water source. Occasionally adult males were found over 6 km. Benson (1956) considered the advent of water development in Saskatchewan to be associated with the spread of antelope there. In Oregon (Anonymous 1961) it was felt that there is adequate range for many more antelope but few places for them to drink in late summer.

Types of Developments - During the 5-year antelope study in the Red Desert (1966-1970), antelope were seen using every type of water source available. These consisted of springs, creeks, rivers, lakes and reservoirs, stock water developments, galvanized troughs fed by windmills and troughs filled by springs.

Precipitation catchment facilities (guzzlers) on ranges lacking proper water distribution have been successful for antelope use (June 1965, Sundstrom 1968). Such water developments are relatively maintenance free, inexpensive and serve a variety of wildlife. A fence should be constructed around the projects to protect the facility from trampling damage and competition by cattle or horses. One or more antelope passes should be installed in the fence line if antelope access is a problem.

2. Vegetation

a. Range Conversions

Range improvements must provide habitat diversity. They must also avoid reducing existing food and cover plants below useable thresholds. Low diversity stands of natural or artificial origin can

be improved by adding species which provide either food or cover, whichever is most limiting.

It is postulated that pronghorns thrive best on ranges in a sub-climax vegetative condition. Such conditions were historically created by (1) wildfires caused by lightning, and (2) seasonal grazing by herbivores such as bison, elk and deer. The vegetative community was in constant change which in turn produced a variety of mixed forage classes of grass, forbs and browse.

Today, where the vegetation is in a poor ecological condition, or one or more of the vegetative characteristics are inadequate for the antelope's habitat requirements, vegetative type conversions may be accomplished to correct the quality components lacking.

The following discussions and recommendations concerning vegetative type conversions are based upon pronghorn range requirements.

Brush Control - Brush control is of questionable value for enhancing antelope habitat on much of their range. Texas indicates in no instance has brush control improved antelope habitat in their state (Charles Winkler personal communications). However, some areas of tall dominant brush (more than 30 percent of canopy cover) may be marginal or low density ranges for antelope. This is especially true where the brush is 76 cm (30 in.) or higher. Such areas may be treated to decrease brush quantity and height. Three points should be considered in such treatments: (1) it is best to limit the size of projects (preferably less than 405 ha (1,000 acre) blocks); (2) the project should maintain around 5-20 percent browse canopy cover; (3) winter ranges and spring fawning areas should not be included in brush control projects.

Plowing and Chaining - Brush control is frequently accomplished by mechanical practices such as plowing and chaining. Plowing with large brushland plows is not preferred in that it often kills native plants, especially highly preferred forbs. Chaining is accomplished by two large tractors pulling a heavy anchor chain between them. This practice does not kill as much sagebrush and is less damaging to native grasses and forbs. However, its use is usually limited to juniper or tall brush ranges.

Spraying - Chemical spraying is another commonly practiced sagebrush control technique. The spray (usually 2-4-D) controls sagebrush without harming native grasses. However, the resulting loss of forbs is detrimental to pronghorn needs. Late spring and summer spraying should not be considered. Carpenter et al. (1974) found that spraying in April while snow still covered the range resulted in an acceptable sagebrush kill with minimal impact on forbs.

Prescribed Burns - Prescribed burning has recently been tested. This practice has several characteristics favourable to improving ranges for antelope. When properly accomplished, burning can decrease sagebrush and not seriously harm native grasses and forbs (Beardahl and Sylvester 1974, Page 1975). Investigators have reported immediate stimulation of plant growth resulting in greater forage yield. Forb production may be increased (Long 1965). Soils are warmer on burned areas and spring growth starts earlier. Soil fertility is usually increased by fire. Plant vigour is promoted by removal of senescent shoots and foliage, and in many situations burning of the mulch prevents interception of light and water and thus favours plant growth. Longer term increases in growth have been achieved by timing the fire to favour

the species with highest yields, by removing undesirable competing plants and by preparing seedbeds for successful reproduction. In addition to measureable increase in forage yield, greater forage useability has been reported where unpalatable plants become palatable after burning. Greater availability was realized where physical barriers to utilization have been burned, or where large plants have been reduced in size by burning.

Most prescribed fires lead to an increase in palatability of resprouting plants. Higher protein content has been reported for resprouts of both grasses and shrubs.

Seedings - Past seeding ventures have often resulted in monocultures of exotic grasses which have limited value to antelope. However, mixture seedings have proven beneficial especially when legumes have been planted.

Nomad variety alfalfa (*Medicago sativa*) was a successful seeding in the Vale, Oregon area. Thirty-six separate seedings have been completed. The alfalfa was generally aerially seeded onto plowed sagebrush range following drilling to adapted grasses and browse species. Recent analysis of these seedings (Kindschy 1974) showed that the majority have maintained alfalfa composition at a level of 10 percent of the vegetation present over a period of 6 or more years. The seedings have increased the forb composition from 2 percent in untreated areas to over 10 percent in the seeded areas. During the August 1976 antelope census, more antelope with fawns were observed in seeded areas than on rangelands with no seeding.

Principles for Restoration - Ten principles for successful restoration of game ranges in Utah, which were found important from

investigative studies, are presented for carrying out large-scale programs (Plummer et al. 1968). The procedures have wide application on similar sites throughout the west although some modifications may be necessary to meet differences in local environments.

Changes in plant cover by the proposed measures must be determined to be desirable. -- Often a change in management to permit lighter grazing by livestock so that desirable species can develop may be all that is required.

Terrain and soil types must be suited to the changes selected. -- The soil and terrain should be carefully considered to determine where appropriate treatment would produce the most forage for game.

Precipitation must be adequate to assure establishment and survival of seeded plants. -- The amount of precipitation, along with occurrence of indicator plants, is the most important guide to what species may be seeded successfully (Plummer et al. 1955, Bleak et al. 1965).

Competition must be low enough to assure that desired species can be established. -- Anchor chaining is a highly versatile, effective, economical and widely applicable method for eliminating competition of trees and shrubs. However, in the south it promotes rather than inhibits the production of mesquite and other small trees and shrubs (Charles Winkler personal communication).

Only species and strains of plants adapted to the area should be planted. -- Seeded species must be able to establish and maintain themselves. There should be a balance of shrubs, forbs and grasses.

Mixtures, rather than single species, should be planted. -- It is advantageous to seed mixtures when the major purpose of restoration is for the improvement of game range.

Sufficient seed of acceptable purity and viability should be planted to assure getting a stand. -- The amount per acre depends on seed purity, size and viability, and whether seeds are drilled or broadcast.

Seeds must be covered sufficiently. -- Deeper than 1¼ cm (½ in.) planting is seldom desirable; likewise, leaving seed exposed is unsatisfactory (Plummer 1943, Basile and Holmgren 1957).

Planting should be done in the season of optimum conditions for establishment. -- Whenever climate permits, seeding in winter is best (December, January and February). Late fall is next best (late October and November). Transplanting of nursery stock seedlings and wildlings is most successful when completed while the ground is still wet from snowmelt in the spring.

The planted area must be adequately protected. -- Young plants and seedlings should not be grazed or severely trampled by livestock, big game, rabbits, rodents or insects.

b. Livestock Relations

Domestic livestock alter range ecosystems more extensively, rapidly and profoundly than any other of man's range management activities. Alteration in vegetation quality and quantity and increased human activity are resulting in dramatic changes which affect pronghorns. With the information presented below, managers should be able to prescribe livestock management practices that will maintain or improve the range to benefit antelope production.

Compatibility between antelope and livestock is related to the number of animals using the same range, season of use, and the condition of the forage. When reasonable stocking of antelope and livestock occurs on ranges in good condition, dual use can be advantageous by applying grazing pressure on different species in the plant community. Under these conditions, livestock and antelope use of the same areas appears to be compatible. However, where livestock density is great as is often the case under the rest rotation grazing system, the value for antelope may decline. Pronghorns withdrew from Montana range used by sheep but readily shared range with cattle (Campbell 1970). Pyrah (1973) observed that antelope moved from pastures heavily grazed by cattle to ungrazed areas in central Montana.

A recent study on the food relations of wild horses, cattle, domestic sheep, elk and antelope (Olsen and Hansen 1977) was conducted on a sagebrush grassland in Wyoming. Based upon dietary overlaps on a yearlong basis, it was learned that horses, cattle and sheep were similar, whereas antelope food habits were dissimilar. Food habits of antelope and sheep are the most similar (Hoover et al. 1959, Buechner 1950, Severson et al. 1968).

Range use by feral horses in antelope habitat has not been fully explored but overstocking of horses would likely be detrimental to pronghorns. An overpopulation by horses would obviously reach a point where competition for forage and/or water would become a limiting factor.

Utilization - Many range conservationists recommend utilization of approximately 50 percent of the current growth as a 'rule-of-thumb' guide for grazing use on native vegetation. The future

of the vegetation resource is inextricably tied to leaving sufficient residual plant cover to protect the soil surface from wind and water erosion, promote percolation and maintain soil surface humus to encourage seedling establishment and maintain plant vigour. Antelope will benefit from herbaceous cover provided by residual herbs which have been lightly to moderately grazed.

Residual stubble heights have been established for proper use of some species. However, where that criterion is not available we suggest leaving a stubble approximately one-half the biomass of the primary forage species.

Spring Use - Spring is the critical period of plant growth, lasting only 6 to 7 weeks and in many cases less (Blaisdell 1958, Pyrah 1970). It is usually during that short time the year's forage and the next year's plant reserves are photosynthesized. Protection of vegetation from overuse during this period is vital for maintenance and/or recovery of important grasses, forbs and shrubs.

Spring is also critical for antelope reproduction. Dietary overlap is the greatest during this period when livestock utilize many vernal forbs, reducing their availability to antelope. Forb vigour may be lowered if they are used repeatedly by livestock. Livestock grazing should be adjusted in spring to reduce competition for palatable vernal forbs.

Pastures grazed during the growing season should have only one-half of the allowable forage removed at that time. Spring use can be split between two pastures, returning to them later in the summer and fall to utilize the remaining allowable forage.

Summer Use - Pastures containing ungrazed mesic vegetation

should be available to each antelope social group. Livestock routinely overgraze mesic sites available to them in summer. This abuse adversely affects pronghorns on most ranges but particularly so in southern states.

Winter Use - Winter range in some areas is the most important habitat for antelope. Winter foods of antelope overlap those of sheep more than cattle. Fall and winter livestock grazing particularly can be detrimental to antelope winter range (Buechner 1950, Hoover et al. 1959, Taylor 1975).

Grazing Syetems - It is understood that proper grazing pressure is more important than the system used. Where systems are planned the following criteria should be considered when they are developed for lands used dually with pronghorns:

1. Maintain native vegetation where ranges are in good condition.

2. Consider forbs and browse when establishing grazing systems for livestock since they are key species for antelope.

3. Forage will be reserved for a reasonable number of pronghorns. Reasonable numbers will be based upon the average herd population, average forage production and current estimates of what the habitat will support. Where records are not available, reasonable numbers will be developed based upon site potential and average density per square mile estimates of similar sites where antelope presently exist.

4. "Prescription grazing" - using livestock to achieve vegetative form or composition objectives - should be practiced in seedings and certain native ranges where high antelope habitat values exist. Crested wheatgrass seedings, with the associated forbs, may be

grazed on a pasture rotational basis.

5. Efforts should be made to reduce the number of livestock during the spring on those areas most important to pronghorns for fawning, especially where "concentrations" of parturient does occur, i.e., on "fawning grounds" - which may or may not be traditional. Areas thus afforded freedom from or reduction of livestock pressure should be large enough to prevent overcrowding of does at the time when they seek seclusion or isolation. Sheep trailing should be prohibited 15 days before to 15 days after the fawning peak.

6. Livestock grazing system which adversely impact the habitat requirements of antelope must be terminated and alternate grazing procedures instituted to maintain or enhance existing antelope habitat.

7. Livestock fence construction will meet specifications deemed appropriate for antelope movement.

8. Summer water sources should not be made available to livestock on an area used as antelope winter range.

9. Herd or drive livestock in lieu of extensive range fencing.

10. Leave gates open when livestock are moved out of fenced pastures.

C. Specific Problems

1. Industrial Development

The development of energy and mineral resources and post-development land use practices in the western ranges will significantly alter pronghorn habitat in both developed and nearby undeveloped range of this species. The impacts of these developments will be compounding and cumulative. Coal, oil and gas field developments have already

impacted antelope habitat in Texas, Wyoming and Montana. Therefore, in regions where potential for extensive development exists, actions to protect and preserve antelope habitat should be planned, coordinated and applied to the entire area of expected impact. The suggestions listed below are offered as guidelines to industry and to regulatory agencies for protecting antelope populations, for mitigating habitat destruction and for reclaiming, rehabilitating and/or enhancing antelope habitat on disturbed lands.

a. Overview

Local, state, provincial and federal regulatory and management agencies when applicable should jointly develop regional priorities for areas that should and should not be developed in order to minimize the loss of the ecologically important systems within each region.

Goals - Post-development land use goals must include a commitment to maintain the production of antelope as an integral section of the development plan for each lease, on both public and private lands that supported antelope prior to development.

Steering Committee - Establish a steering committee, directed by the state or provincial wildlife management agency, and composed of involved members of industry, federal, university and interested citizen group organizations or agencies, as needed. The committees should be established on a regional basis to provide guidance and advice for providing the post-development land use goal and basic strategies for accomplishing them on each lease site.

Lead Time - Specific industrial developments and the related informational needs on antelope populations and their habitat

should be identified early enough to allow sufficient lead time for seasonal field work, budgeting, personnel assignments and for review by the state or province wildlife management agencies, and other interested parties.

b. Pre-development Surveys

Before initiating and completing an energy development plan, industry should quantitatively identify, describe and map the quality and extent of key ranges; antelope distribution, movement patterns and population characteristics; associated recreation and economic values; and baseline habitat/vegetative data for antelope. These parameters should be monitored throughout the life of the development. Study plans and progress must be directed and approved by the responsible state or provincial management agency.

Movements and Distribution - While season of use varies with geographic area a loose guideline defines summer areas occupied between May 15 and September 15; intermediate areas occupied when migration occurs between summer and winter; winter areas occupied between November 15 and March 31; year-round range areas occupied all year; and key areas as defined earlier.

Population Characteristics - Compile information on previous classifications of herds in general area of the project site. Conduct summer production classifications on and adjacent to the project site during pre-development and development phases to determine fawns per 100 does and bucks per 100 does and population trends.

Describe and document home range, movement and/or migration patterns of herds.

If available, obtain previous population estimates and

trends from reliable sources. Obtain pre-development winter population estimates. Identify factors that affect populations such as habitat, weather, private landowner tolerance, hunting pressure, distribution of hunters and hunter access.

Identify unusual and/or excessive mortality, if any, from such causes as vehicle-antelope collisions, severe weather losses, disease and predation.

Recreation and Economic Value - Calculate the recreational value of the antelope populations to be impacted considering both non-consumptive and consumptive uses, considering land status adjacent to the project site, hunter and observer access, hunting quality and annual sustained harvest. Calculate the economic value of the herd and/or value of an individual antelope.

Pre-development Vegetative Data - Prepare qualitative and quantitative vegetative type maps of the development areas prior to development. Draw maps at a scale of 1:24,000 or at a similar scale as a basis for reclamation goals and plans. Vegetation data should include a list of plant species present, plant communities present and community diversity. Quantitative data on the plants should include percent canopy cover, plant density and frequency and annual production by major species.

Identify key species of plants important for antelope in relation to the seasons of the year antelope are present on the project site.

Based upon the vegetative typing, delineate actual and potential new antelope habitat within the development area.

c. Monitoring

Basic Considerations - Specific areas identified as key

to the maintenance and perpetuation of a population, and which are difficult areas to duplicate, should receive top priority and where possible remain unaltered and available for use by antelope populations.

Controlling Access and Disturbance - County land use planning for ancillary developments (housing, shopping centers, recreational facilities) should site such developments away from critical antelope areas, particularly movement corridors, so as not to disturb antelope.

Maintain existing public access and, where desirable, provide additional access to public lands.

Minimize energy development access and operations roads.

Locate required roads and railroads on the periphery of antelope use areas. Where this is not feasible, mitigation should be pursued.

Restrict human activities to essential energy development-related efforts to prevent unnecessary disturbance to antelope.

Prohibit or minimize disturbance of key areas and maintain a buffer zone of 0.4 km.

Minimize the area for exploration and drilling and use techniques that create the least amount of activity and disturbance.

Employ a unified, consolidated storage area for all energy development equipment and materials.

d. Mitigation and Enhancement

Basic Consideration - Control all impacting actions (post-development land use, emissions, discharges, effluents) to provide a subsequent level of antelope habitat approximating or surpassing pre-development conditions. Strategies for achieving this (i.e., - increased

carrying capacity through fertilization of range, water development, livestock management, purchase of private lands by public agencies) should be detailed in formal plans (i.e., energy development plans, management framework plans, state comprehensive and operational plans).

Key areas lost during development should be mitigated by providing sites of equal value on adjacent areas when such enhancement is deemed feasible with reference to the probability of displaced antelope using the alternate site.

A major goal should be the attainment of a close juxtaposition of antelope habitat elements (food, cover, water) both during and after development.

Consider priorities for revegetation on the basis of critical quality values (i.e., nutritional values, palatability, cover needs) in habitat reclamation plans.

Physiography - Shape the disturbed areas into terrain that enhances antelope habitat.

Water - All water discharges and effluents resulting from energy development activities should be made available for antelope use and should meet or exceed standards for domestic livestock use.

Develop additional sources of strategically located water on all areas (ponds, springs, streams, guzzlers) actually or potentially occupied by antelope.

e. Reclamation

Vegetation on Reclaimed Spoils - Reclaim habitat to resemble shrub steppe-grassland, and the reseeding mixtures should include native forb and browse species important to antelope.

If the approved post-development land use is agricultural

production (i.e., wheat, alfalfa, etc.), restrict field sizes to a minimal acreage and intersperse them among islands of native vegetation.

Regulate domestic livestock and wildlife use on reclaimed areas to promote ecological succession that will benefit antelope populations.

Habitat lost to development and post-development land use should be mitigated by reducing competition with domestic livestock on adjacent, non-developed lands.

Hazards - Remove from antelope range immediately after the cessation of development operations, all unused mining equipment, hardware, wire, pipe, barrels, toxic substances, etc., which might constitute a hazard to antelope or their activities. Oil field slush pits should be fenced with net wire to prevent ingestion of toxic wastes by pronghorns.

f. Post-development Objectives

Transplant and restock antelope when deemed desirable and feasible by the state or provincial wildlife management agency.

Regulate wildlife population numbers on reclaimed areas to insure successful reclamation through cooperation with the state or provincial wildlife management agency.

Purchase easement to "land locked" public lands (i.e., by use of mineral severance taxes; by including in lease stipulations, etc.).

2. Fences

Livestock fences newly constructed on range lands traditionally used by antelope have been a problem for many years (Rouse 1954). Often these fences have been complete or partial barriers to movements of pronghorns and have obstructed seasonal migrations and travel to water or feeding areas. As a result, pronghorn populations have declined sub-

stantially on some of these range lands. Extensive mortality has occurred in some areas when animals became entangled as they attempted to negotiate these barriers (Oakley 1973).

Pronghorns must be given high priority when considering fencing. Greater effort must be made to harmonize livestock and pronghorn range use. Often, past efforts were only concerned with searching for ways to modify pronghorn behaviour to minimize the effect of fences. It cannot be assumed that pronghorns will adapt to changes in habitat resulting from livestock use or that they will learn behaviour patterns that will permit them to thrive where their physical environment has been altered by fences. Observations in Wyoming indicate: (1) there has been no marked increase in the number of pronghorns learning to jump fences; (2) older individuals have a greater tendency to jump fences; (3) no fawns have been observed jumping fences.

Many types of pass structures designed to permit pronghorns to move freely through net wire fences have been tested and, under some conditions, have worked satisfactorily or have shown promise for doing so (Mapston 1970, Spillett et al. 1967). Field use of antelope "passes" has been limited. This is particularly true where such devices are encountered infrequently such as in desert areas with low pronghorn density and on migration routes. Let-down panels have not been utilized extensively, but may serve well under some conditions. Pronghorns tend to become conditioned to fencelines, and in some instances when let-down panels have been installed they have walked past the openings during migration seemingly unaware of the opening. Gates being opened when livestock are not present will help.

Modification of existing fences provides a means of correcting

some of the past errors. Many miles of "sheep tight" fences have been constructed on range lands used by pronghorns and these fences should be modified to permit passage of pronghorns.

The Roswell Grazing District in New Mexico is one example where fences were modified to permit antelope passage. The decision to modify the fencing on public land was contested, but the appeal was dismissed in court. It appears modifying fences is on solid ground and should continue.

In light of the present knowledge regarding fences and their effect on pronghorns, the following guidelines are recommended:

There should be no fencing on pronghorn ranges until a complete evaluation has been made on each site where fencing is proposed. This evaluation should be made jointly by state, provincial and federal wildlife biologists, range managers and livestock operators. It should determine the probable effect the proposed fencing would have on pronghorns and the benefit to livestock management. A review of each specific range and its vegetation should be made. This should include such items as food habits of livestock and involved wildlife, movements and behaviour patterns of livestock and wildlife and an analysis of terrain and climatological conditions. Consideration should be given to possible change in vegetation and habitat resulting from differences in use brought about by fencing.

Where fencing is deemed necessary the minimum amount of fence should be used to provide proper land use, livestock management and a minimum hinderance to pronghorn antelope.

State or provincial wildlife agencies should prepare management plans for important pronghorn antelope populations and delineate annual

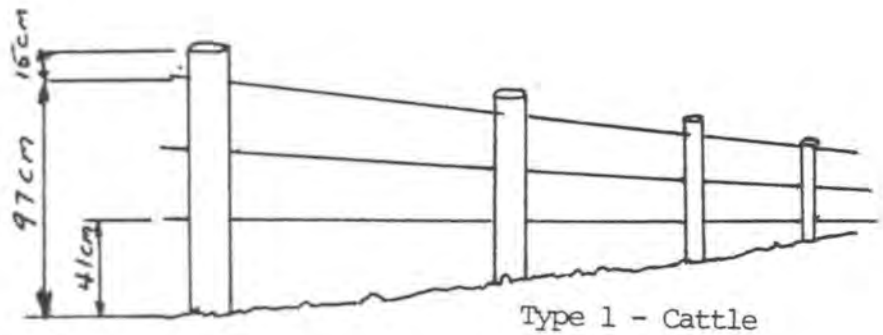
distribution, migration corridors and key habitat areas. The fencing of a water hole on dry summer range may be as detrimental to pronghorns as fencing off a migration route. Important areas should be identified and designated -- not to be fenced.

No specific fence design for pronghorn antelope ranges can be universally applied. However, the specifications most compatible with pronghorn movements consists of three or four strands of wire with a smooth bottom wire 41 to 46 cm above the ground and a total height of no more than 97 cm. This type of fence can serve satisfactorily for holding cattle. Where the fence is designed to hold sheep the problem is more complex. Any fence that will contain sheep is also restrictive to some age classes of pronghorns. Net wire should not be used on pronghorn antelope ranges. If, after adequate study, net wire is used, provisions should be made for providing unrestricted passage to all pronghorn age classes during all seasons and all weather conditions, using pass structures, let-down panels, open wire panels, cattle guards, etc. Net wire fence height should not exceed 81 cm (Figure 1).

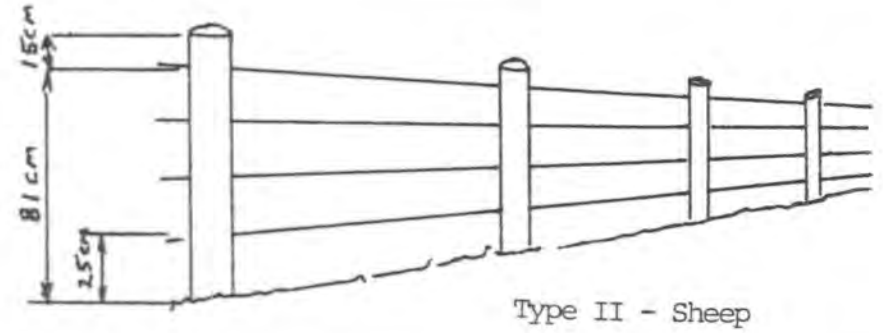
Open wire panels consist of replacing a section of the net wire with two strands of wire, the lowest strand being smooth wire and placed 41 cm above the ground. The passage panels resemble the Type 1 cattle fence. It should be emphasized that passes at best allow antelope movement with difficulty and only when the drive to move is substantial.

Fencing for Cattle - Provide a three-strand fence with the top wire no higher than 97 cm above the ground and a barbless bottom wire at least 41 cm above the ground.

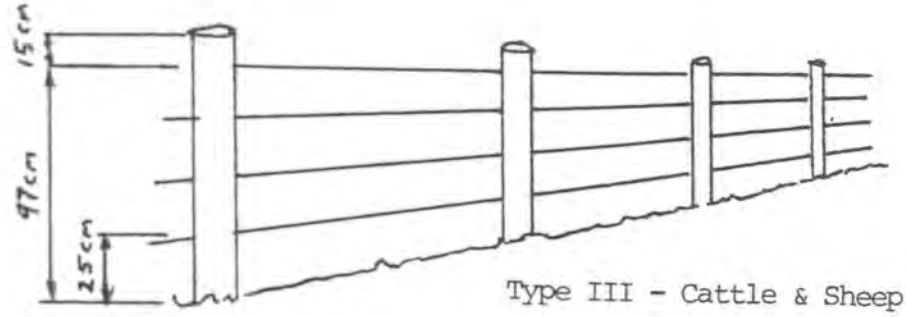
Fencing for Sheep - Provide a four-strand fence with the top wire no higher than 81 cm above the ground and a barbless bottom wire



Type 1 - Cattle



Type II - Sheep



Type III - Cattle & Sheep

ANTELOPE RANGE FENCES

Fig. 1

at least 25 cm above the ground.

Special Fence Types - Special fence types, e.g., buck and pole, rail, suspension, etc., will be no higher than 86 cm above the ground, with a bottom gap at least 30 cm above the ground.

Fencing Separating Adjacent Sheep and Cattle Use Areas - A four-strand fence with the top wire no higher than 97 cm above the ground and a barbless bottom wire at 25 cm above the ground should be used.

Newly Constructed Fences - All newly constructed fences should have white rag flagging tied to the top wire between each post to allow improved visibility of the new hazard. Antelope will have beome accustomed to the fence by the time the flagging deteriorates. Grey "camouflage" steel post fences should be avoided on antelope ranges.

Where ranch operations switch from sheep to cattle net wire fences should be removed. It is recommended less emphasis be placed on fencing. Livestock operations, especially sheep, should be managed such that fencing is minimized. Fences must not serve as a limiting factor for pronghorn populations.

It is recommended that all existing fences restricting pronghorn movements on public domain be modified to allow free passage to these animals. Modifications should be in the form of total removal of unnecessary fence, removal or relocation of strands, replacing bottom barb wire with smooth wire, and installation of passage devices, etc.

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SUMMARY COMMENTS AND SUGGESTIONS REGARDING FUTURE ANTELOPE RESEARCH NEEDS

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It is difficult for me to suggest any new recommendations or ideas to this group, since you have left few stones unturned. I enjoyed the sessions, I found them very interesting and informative. I believe there is considerable potential for future elaboration of much of the material that we have heard, such as the predation story, winter feeding ideas and the techniques for measuring animal condition.

Generally you have followed the four steps of wildlife management that we all learned at the beginning of our profession. That is, you presented inventories and productivity data. You have examined a variety of limiting factors, and you have made, or will make, management decisions based on the above.

There is another principle of wildlife management that we all learned well before school; I call it the "Bo-peep principle", i.e., "leave them alone and they will come home wagging their tails behind them", provided, of course, there is a home. I believe Wyoming is a place something like that today, at least it will be for a little while. I would like to direct my few remarks to that major area called "home" as I see it in the future needs of research.

I have detected in this conference an underlying tone of a continuing range war. In order to do battle over range you must know your opponent. Your opponent in this case is whoever has control of the land that you

require for your purposes. Both opponents suffer from the same basic human weakness, and that is greed. I am not a psychiatrist nor a social scientist, but I do know that there is a need to change this individual greed into mutual greed so that both parties will look good. There is a variety of ways to control land and I have heard some of them expressed rather incidentally at this conference; little trade-offs that are going on just for access to land. I believe that there is a number of methods or techniques available that pertain to land control that should become a major subject at one of your workshops soon. I doubt if we have the expertise to know how to do this and probably you will have to bring someone in to suggest techniques. I may be naive in this area, but here is a simple approach using human nature that you might consider. People like to have their name attached to something significant, particularly some significant landmark. Why not attach the rancher's name who owns a prime piece of habitat to an antelope reserve or name a public antelope preserve after the politician who is your greatest stumbling block?

Land control for wildlife is a matter of serious concern and urgency and I don't think we are equipped to handle it. We have to find out how to play the game. There is a need for good advice or possibly some research on ways and means of getting a handle on the land base that is essential for wildlife.

Tied in with the above is the business of having an economic value of the wildlife resource; e.g., what are people willing to pay? At the moment there appears to be no market value for big game species other than bighorns. I believe the antelope would be an excellent species for an economic appraisal. The Texans have given us some insight into

the value of antelope when they describe the cost of leased hunting. For example, the starting price is around $250.

Some economists in Alberta are now asking us to get into the bidding game to assist them with a better means of measuring wildlife values. One approach would be to determine how much applicants for antelope permits would be willing to pay to increase their chances of being drawn from say 25 percent to 100 percent? The implications of this sort of survey are rather ominous. Another approach would be to ask successful applicants at what prices they would be willing to sell their permits to unsuccessful applicants (prior to the season, of course). The purpose of the exercise would be to give a willing to pay and a willing to sell perspective to the value of wildlife which will provide much needed ammunition in our constant battle over land use. Let's face it, sooner or later we are going to have to put our money where our mouth is. Regrettably most of our problems in land use today have originated from wildlife agencies not having a mandate for some land control.

In conclusion, I would suggest that future workshops could use some hybrid vigour, such as a geneticist, an economist, a social scientist or even a Texas rancher. I would like to hear the latter in spite of the language barrier.

How about game ranching with antelope? Is this repugnant to you? Let's turn that "coyote-proof" fence around and use it.

BUSINESS SESSION

MAY 4, 1978

MORLEY BARRETT, CHAIRMAN

The meeting convened at 0900 with the following delegates present:

John Phelps, Arizona
Kent Jackson
Duane Pyrah, Montana
Charles Winkler, Texas
Steve Amstrup, USFWS
George Mitchell, University of Regina
Bart O'Gara, University of Montana
Jim Yoakum, BLM
Bob Autenrieth, Idaho
Edson Fichter, Idaho State University
Jack Herring, New Mexico
Don Beale, Utah

Management Guidelines

The business meeting dealt primarily with discussion on revision of the Antelope Management Guidelines. Many differing points of view were discussed concerning the current organization and content of the Guidelines. After lengthy discussion it was agreed that each delegate be allowed an opportunity for an additional review of the Guidelines but comments were to be forwarded to Bob Autenrieth within 5 weeks. Bob Autenrieth offered to continue his involvement with the Guidelines by evaluating and incorporating the new comments.

Publication of the Guidelines was discussed. There was general agreement that the Guidelines should be published first as part of the proceedings of the 1978 Workshop. It was also agreed that the Guidelines could be published in one additional place such as in the Wildlife Society Bulletin if that was eventually deemed appropriate. The delegates also felt that at some future date the Guidelines should be presented to the Western Association of Fish and Game Commissioners for adoption.

Library Needs

Considerable concern was expressed over the need for a central depository for the proceedings of the Workshop. There exists a possibility that some of the earlier proceedings may be unavailable if the individuals associated with the Workshop relocate to take new positions. Furthermore, some journal editors have questioned the use of Workshop material as citations when the proceedings are not readily available.

To resolve this problem, delegates decided to investigate the possibility of a permanent repository for Workshop proceedings. Two suggested sites were the Denver Federal Reference Service and the Canadian Plains Research Centre in Regina. Duane Pyrah and George Mitchell volunteered to investigate this matter and report back to the delegates.

The use of microfiche to record Workshop proceedings was also raised. It was felt that more libraries might carry the proceedings if they occupied less space. Morley Barrett volunteered to investigate the feasibility of using microfiche for the 1978 proceedings as well as for proceedings of the previous meetings.

By-Laws

Some minor revisions of the by-laws were proposed. These matters dealt mainly with distribution of Workshop notices and proceedings. Some minor editorial changes were also proposed. Morley Barrett to consolidate proposed changes and bring recommendations to the next business meeting for review.

1980 Antelope Workshop

A short review of states and provinces that had and that had not hosted previous Workshops was held. The state of Arizona volunteered

to host the 1980 meeting. John Phelps has tentatively accepted the responsibility of chairman for the 1980 meeting, pending formal approval by his agency. Charles Winkler volunteered Texas as the alternate host should Arizona be unable to hold the Workshop.

Business meeting adjourned at 12 noon.