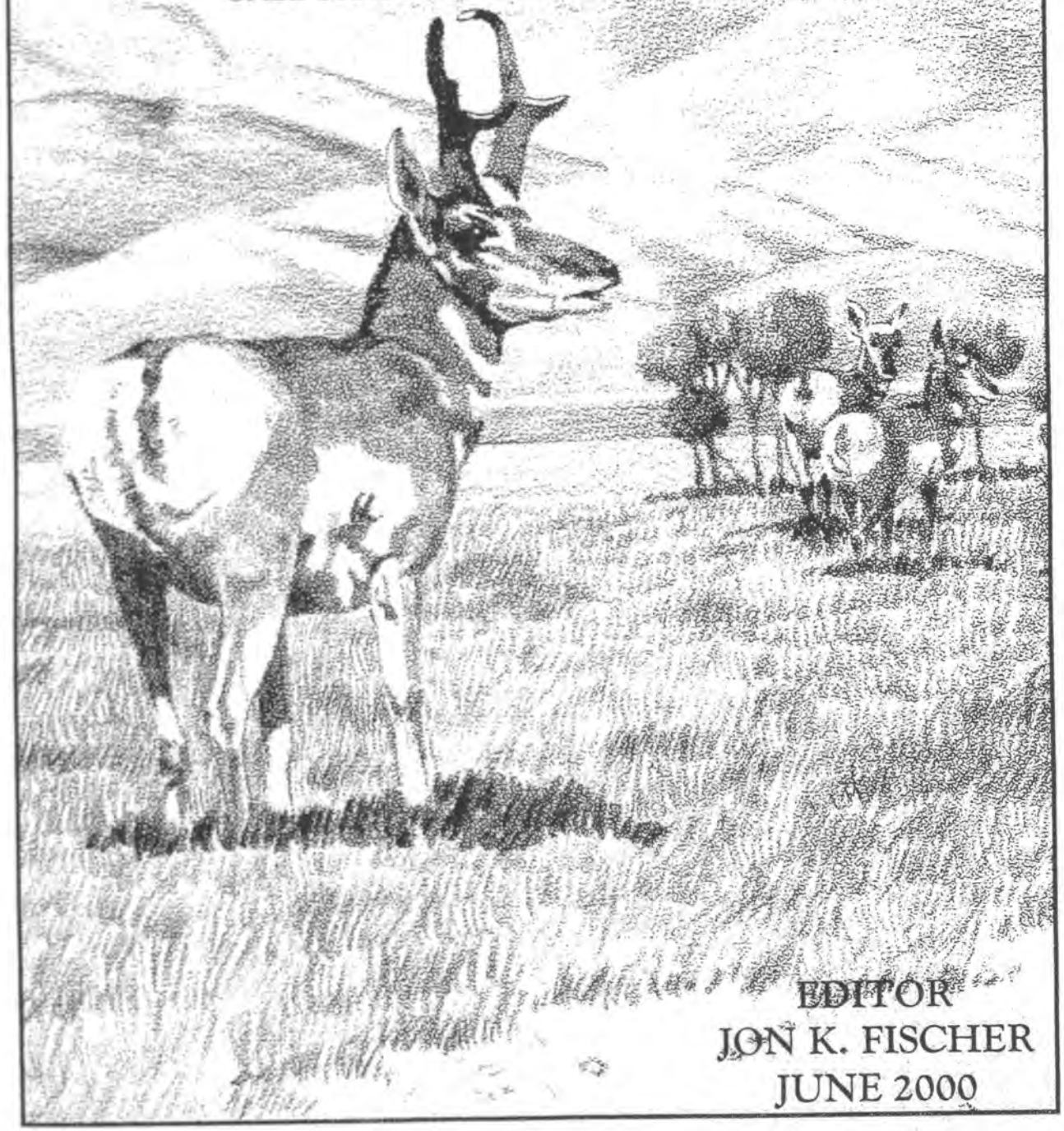
PROCEEDINGS OF THE 17th BIENNIAL PRONGHORN ANTELOPE WORKSHOP

SANCTIONED BY:
WESTERN ASSOCIATION OF FISH AND WILDLIFE AGENCIES
HOSTED BY:
CALIFORNIA DEPARTMENT OF FISH & GAME



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JUNE 2000

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PREFACE

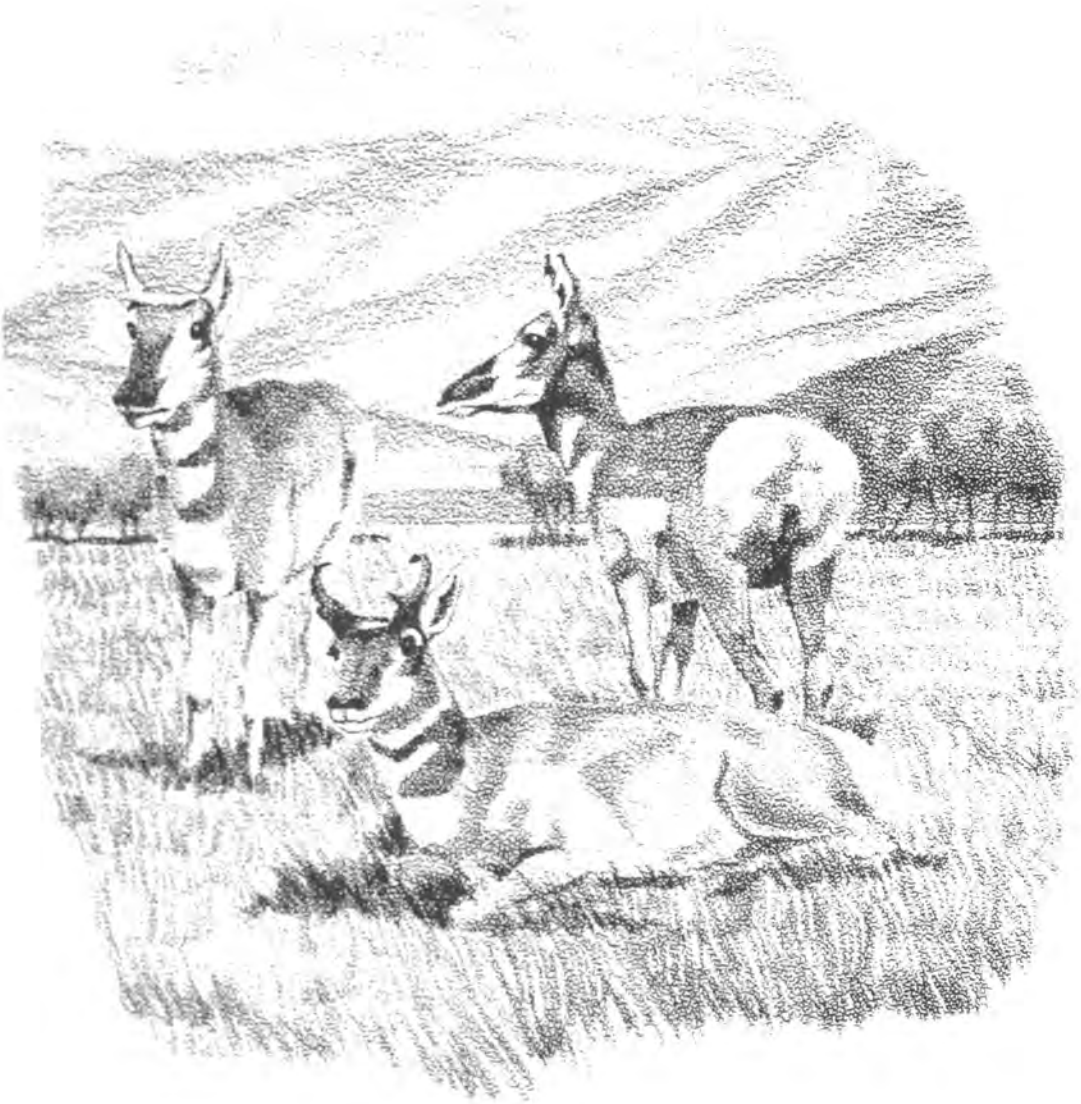
The California Department of Fish and Game hosted the seventeenth Pronghorn Antelope Workshop at Lake Tahoe from June 4-7, 1996. Eleven state wildlife and three federal (U.S.) agencies were represented at the workshop, along with five universities, three natural history museums/zoos, two livestock operators and various unattached individuals. The North American Pronghorn Foundation, Defenders of Wildlife, and the IUCN Antelope Specialist Group were represented at the workshop. Representatives from Mexico also participated in the workshop.

The ultimate purpose of the Pronghorn Antelope Workshop is to promote better management of pronghorn antelope by fostering dialogue among managers and providing a forum for presenting research findings related to the biology and management of pronghorn antelope. A field trip to inspect pronghorn antelope habitat was an optional part of the workshop.

Individual state status reports are included in these proceedings, along with technical papers presented at the workshop. The Abstracts section summarizes technical presentations at the workshop for which no written papers were received. Any discussion after the papers was not recorded. Notes regarding the business meeting were taken under the direction of Ms. Laura D. Colton.

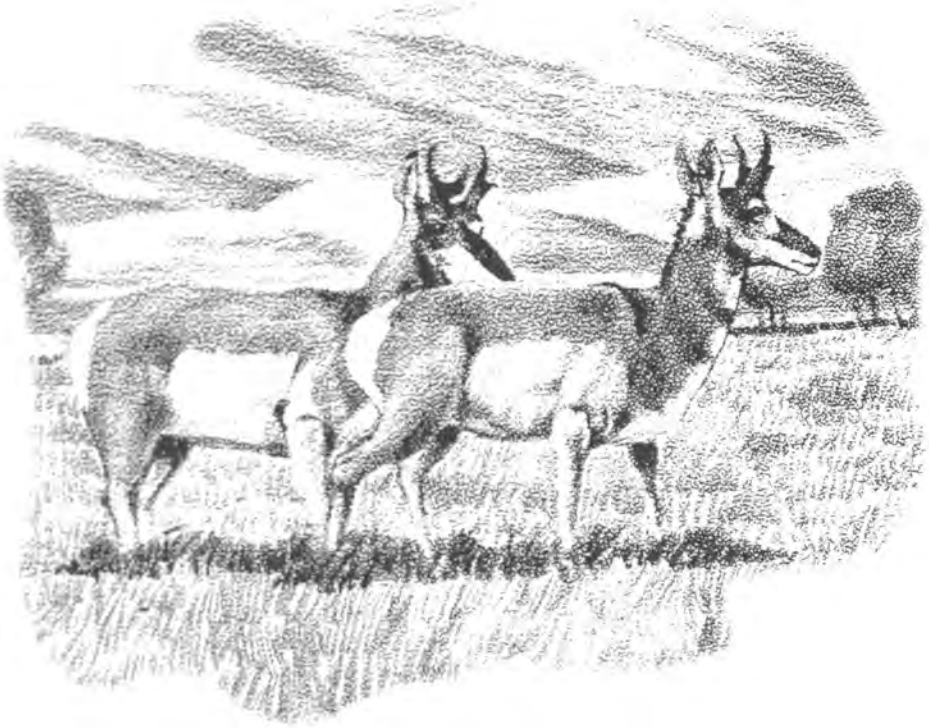
Ms. Laura D. Colton, chair of the seventeenth Pronghorn Antelope Workshop, devoted countless hours to organizing all aspects of the workshop. Without her efforts, the workshop would not have occurred at the time and location that it did. Ms. Amy J. Brinkhaus provided capable assistance with registration and numerous other details. Ms. Cristen Langer, Ms. Lisa Vandenput, and Ms. Lorna Bernard helped to organize the proceedings for publication. These individuals greatly improved the quality of the proceedings. Editing of these proceedings was limited to identifying and maintaining consistency relative to format, grammar, and punctuation. For any errors of commission or omission, I take full responsibility.

Jon K. Fischer, Editor

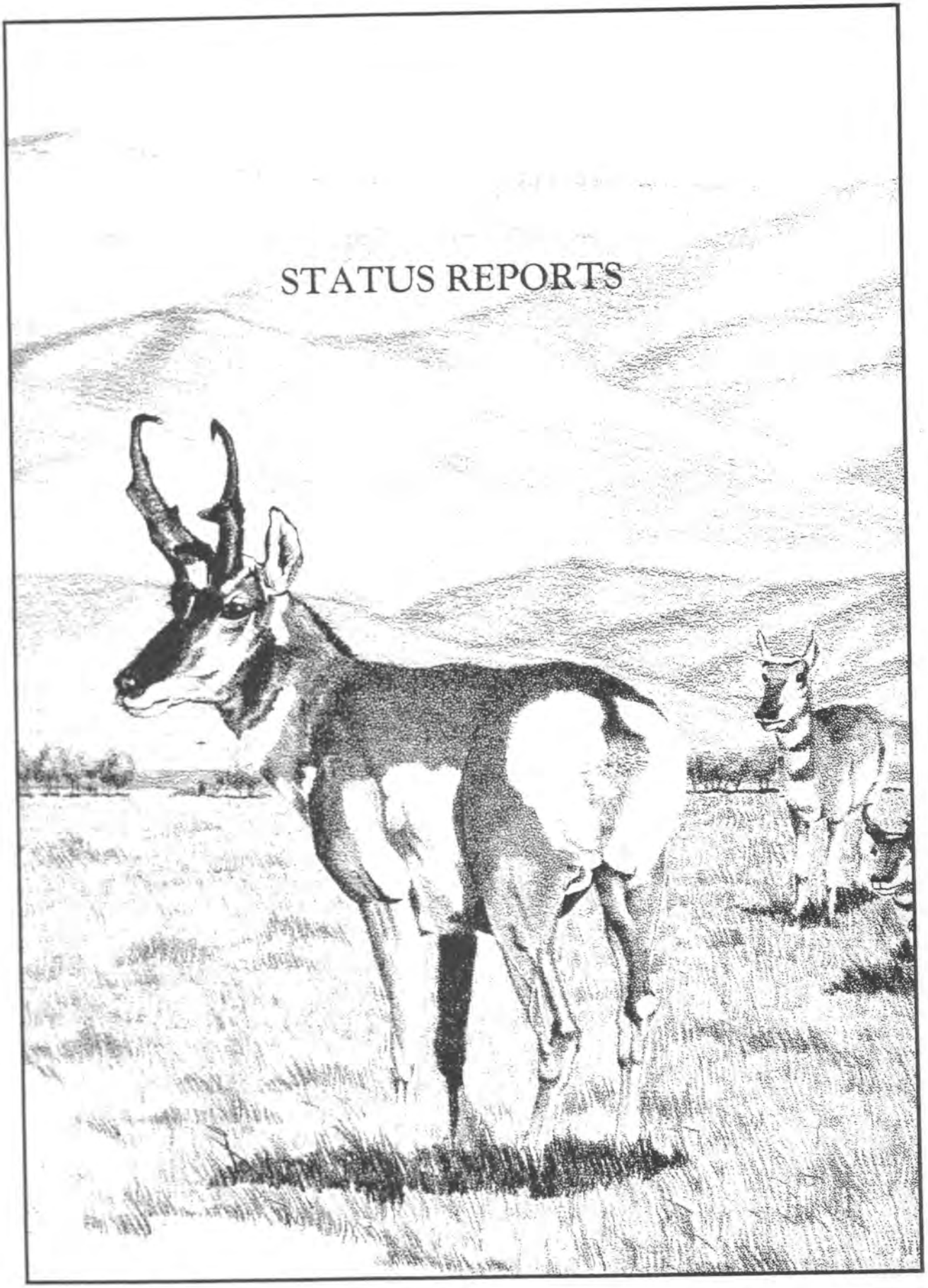


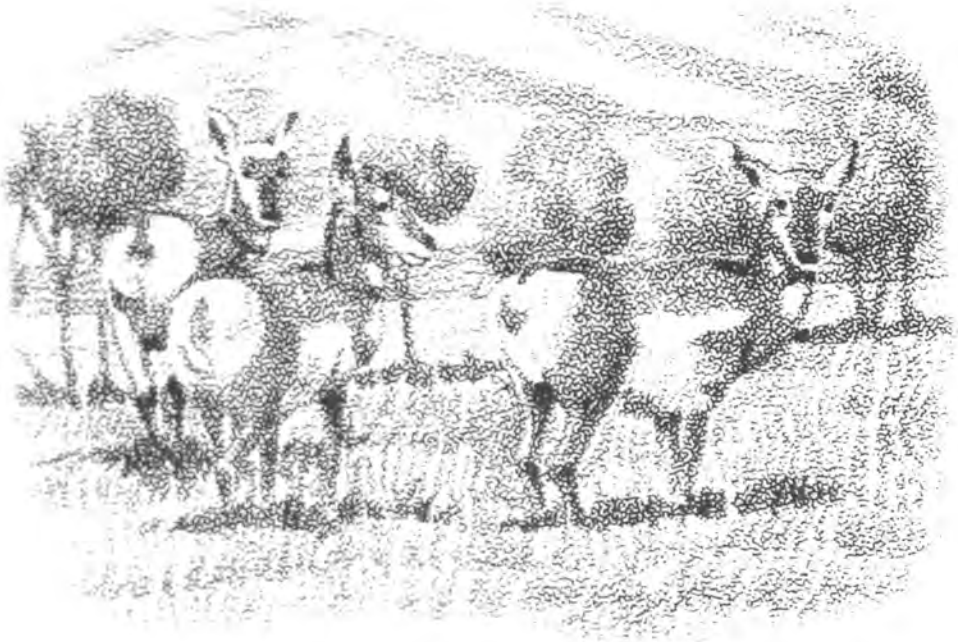
SUMMARY OF PRONGHORN WORKSHOPS HELD TO DATE

Meeting Dates and Locations	Number Attending	Chairperson	Host Agency
April 14-16, 1965 Santa Fe, NM	18	W. Huey	New Mexico Department of Fish and Game
February 16-17, 1966 Denver, CO	32	G.D. Bear	Colorado Game, Fish and Parks Department
February 5-6, 1968 Casper, WY	97	J.L Newman	Wyoming Game & Fish Commission
January 27-28, 1970 Scottsbluff, NE	85	K.I. Menzel	Nebraska Game & Parks Commission
June 19-22, 1972 Billings, MT	85	H.O. Compton	Montana Fish & Game Department
February 19-21, 1974 Salt Lake City, UT	52	D.M. Beale	Utah Division of Wildlife Resources
February 24-26, 1976 Twin Falls, ID	68	R. Autenreith	Idaho Department of Fish and Game
May 2-4, 1978 Jasper, Alberta	84	M.W. Barrett	Alberta Fish & Wildlife Division
April 8-10, 1980 Rio Rico, AZ	64	J.S. Phelps	Arizona Game & Fish Department
April 5-7, 1982 Dickinson, ND	69	J.V. McKenzie	North Dakota Game & Fish Department
April 10-12, 1984 Corpus Cristi, TX	45	C.K. Winkler	Texas Parks & Wildlife Department
March 11-13, 1986 Reno, NV	43	M. Hess	Nevada Department of Fish & Wildlife
May 31-June 2, 1988 Hart Mountain, OR	43	D. Eastman	Oregon Department of Fish & Wildlife
May 22-24, 1990 Silver Creek, CO	45	T.M. Pojar	Colorado Division of Wildlife
June 8-11, 1992 Rock Springs, WY	91	P. Riddle	Wyoming Game & Fish Commission
April 18-21, 1994 Emporia, KS	49	K. Sexson	Kansas Department of Wildlife and Parks
June 5-7, 1996 Lake Tahoe, CA	75	L. Colton	California Department of Fish and Game



STATUS REPORTS





ARIZONA PRONGHORN ANTELOPE STATUS REPORT - 1996

RAYMOND M. LEE, Arizona Game and Fish Department, 2221 W. Greenway Rd., Phoenix, AZ 85023

Pronghorn Antelope Workshop Proceedings 17:11-13

Arizona's pronghorn antelope population is comprised of 3 subspecies; *Antilocapra americana americana*, *A. a. mexicana*, and *A. a. sonoriensis*. During the survey period, which occurs in July and August, prior to the hunt and after most of the fawning mortality has occurred, Arizona's antelope population is approximately 12,250 animals; of which 11,250 are *americana*, 750 *mexicana*, and 250 *sonoriensis*.

Pronghorn antelope populations in Arizona are primarily surveyed from fixed-wing aircraft (Piper Super Cub, or STOL equipped Cessna 182 or 206). A total of 10,048 *americana* was surveyed in 1995, producing buck:doe:fawn ratios of 34:100:27. A total of 574 *mexicana* was surveyed, resulting in buck:doe:fawn ratios of 34:100:34.

Sonoriensis are not hunted, being classified as an endangered species, and are not routinely surveyed. Surveys were conducted in 1992 and 1994, producing observations of 121 and 109 animals, respectively.

Application rates for the 3 weapon types varied considerably (Figure 1). When archery hunting first began in 1974, only 16 hunters applied for the 50 permits available. In 1995, some 1,233 archers applied for 671 permits (1.8 applicants per permit). Muzzleloader permits were oversubscribed with 821 applicants for 142 permits (5.8 applicants per permit), and the general firearms application rate, with 12,960 applicants for 652 permits, was 19.9 applicants per permit. These application rates led to minor adjustments in the 1996 permit levels to more equitably allocate permits by demand. Harvest information is shown below in Table 1.

One of the most significant results of Arizona's pronghorn antelope harvest is shown in the Boone and Crockett scores. In the 10th edition of the Records of North American Big Game (1993) Arizona had produced 7 of the top 15 scores, as well as animals 1, 2, 3 and 4.

The Arizona Game and Fish Department gives each of its wildlife managers an antelope species management plan. This document provides guidance on how to conduct surveys, make hunt recommendations, fence, and supplemental feed their antelope populations.

Hunt guidelines are annual guides, reflecting the prevailing political climate as well as biological parameters for setting season dates and permit numbers. Present hunt guidelines call for pre-hunt ratios of 25-30 bucks per 100 does, and 30-40 fawns per 100 does. Permits, or hunt types, are adjusted when surveyed values are either above or below these guideline ratios. In 1996, season dates will generally be August 23-September 5 for archery-only hunts, with stratified seasons for firearms hunters of September 20-23 and September 27-October 2. The Department's strategic plan (Wildlife 2000) identifies the goals for Arizona's pronghorn antelope populations and addresses the issues and strategies for reaching them. These plans were developed with as much public input as it was possible to obtain.

The Department has been engaged in a relatively active transplant program since its first release of Nevada antelope in 1924. To date 1,357 antelope have been transplanted within Arizona (Figure 2). The 1980s was the most prolific decade with 680 animals being released. The most recent transplant occurred in 1993 with the release of 54 antelope from Wyoming.

Due to trades of bighorn sheep for antelope in the past few years, Arizona is looking forward to additional antelope transplants. Such transplants are dependant on

Table 1. Arizona's pronghorn harvest and hunter success rate, 1995

Weapon	Permits	Hunters	Days Afield	Harvest	% Success
Centerfire Rifle	652	650	1427	534	82
Muzzleloader	142	136	460	53	39
Archery	671	617	3580	106	17
Total	1465	1403	5467	693	49

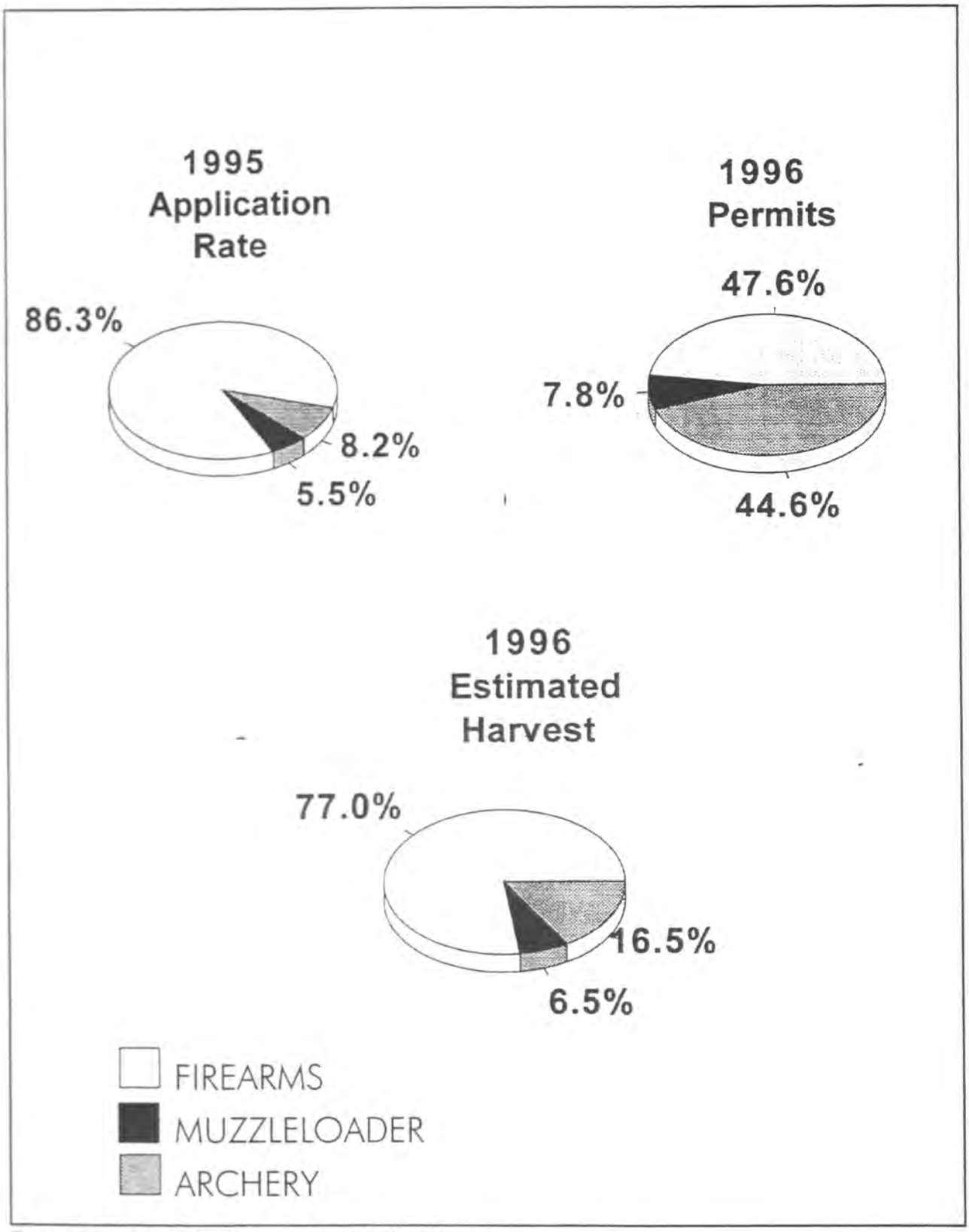


Figure 1. Arizona's antelope permit allocation.

the improved status of pronghorn populations in the host states and range conditions in Arizona, both of which have been adversely impacted by the current drought.

The Department has been engaged in a number of pronghorn antelope studies over the past several years, several of which are being reported on at this meeting. The Sonoran antelope work being conducted in cooperation with Mexico and the range-wide habitat analysis are two of these studies.

Like many other states, Arizona is in the business of auctioning or raffling special hunt permits for fund raising purposes. Since the inception in 1984, nearly $4,000,000 has been raised through this program.

The most successful species have been bighorn sheep ($303,000 for a permit) and elk ($82,500 for a permit). Pronghorn antelope permits have been auctioned for as high as $19,500. These funds are earmarked specifically for the species involved. The pronghorn antelope permit revenues have been used to fund the antelope transplant program and habitat enhancements such as water developments. This program is instrumental to the success of Arizona's big game management program.

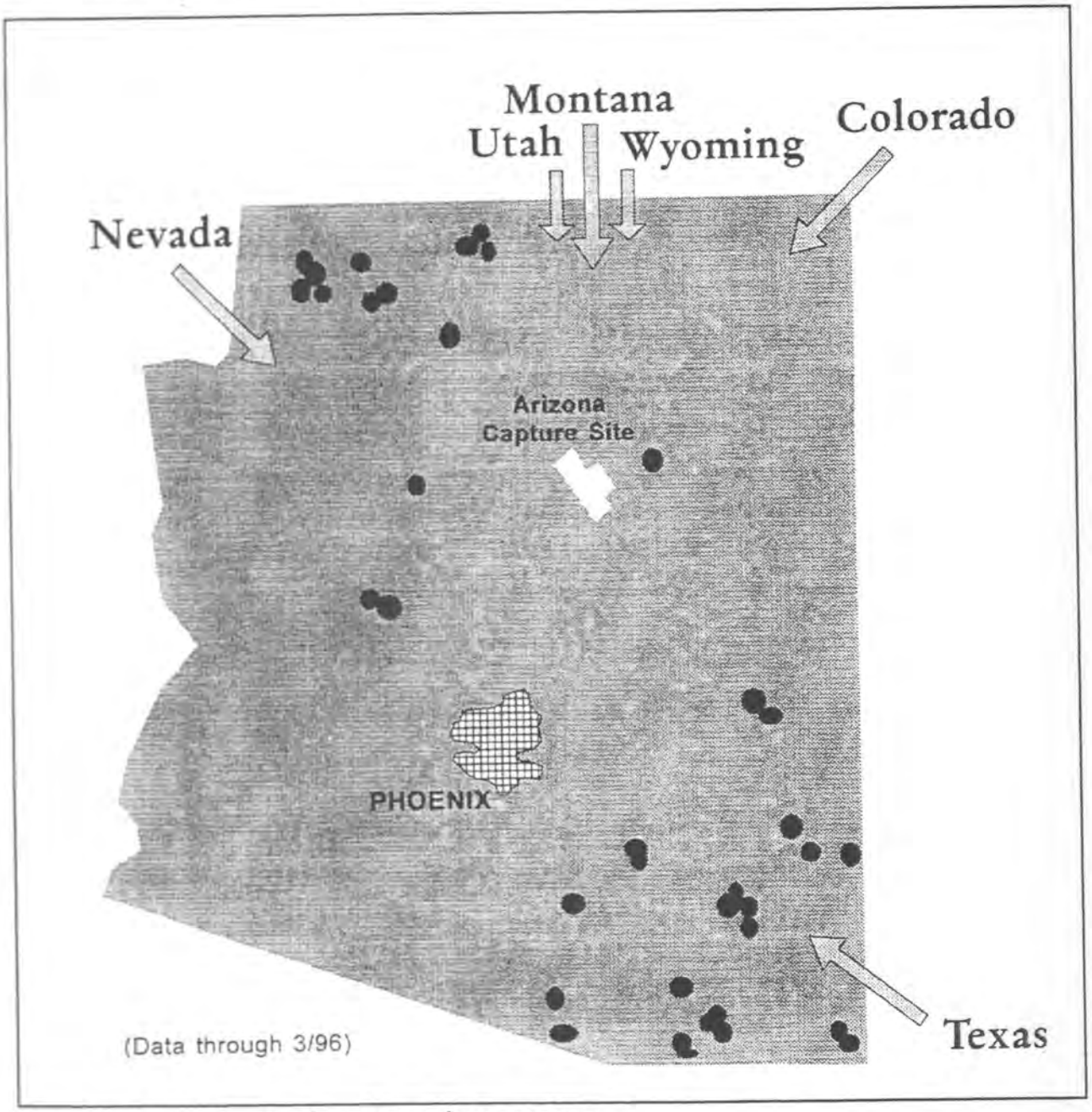


Figure 2. Arizona's pronghorn transplant program.

CALIFORNIA PRONGHORN ANTELOPE STATUS REPORT - 1996

JON K. FISCHER, California Department of Fish and Game, 1416 Ninth Street, Sacramento, CA 95814

Pronghorn Antelope Workshop Proceedings 17:14

California's pronghorn antelope (*Antilocapra americana americana*) occur primarily in the northeastern part of the state, but isolated populations exist at additional locations as a result of translocation efforts. A Cessna 185 airplane is used to complete annual censuses of known winter range in northeastern California. The Department counted 4,681 pronghorn during the 1996 census of Northeastern California. An additional 300-500 pronghorn exist outside northeastern California. Thus, California's pronghorn antelope population probably numbered in excess of 5,000 animals in January, 1996.

In 1995, the Department issued 573 pronghorn antelope tags [533 tags were issued through the public hunting program, whereas 40 tags were issued through the Private Lands Wildlife Habitat Enhancement and Management Area (PLM) Program]. In total, 8,858 applications were received for public tags which were awarded by drawing. Ten tags were issued for junior hunts; 316 junior hunters applied for these tags. Some 44 tags were designated archery-only. The exact number of archery-only applicants was unknown, but historically, archery only applications constitute less than three percent of the total applications. Remaining tags were designated general methods, which includes specific archery equipment, muzzleloaders, and centerfire rifles. The vast majority of hunters in this category use centerfire rifles and the vast majority of pronghorn taken under general methods are taken with centerfire rifles. With the exception of two tags issued through the PLM Program, all other pronghorn antelope hunting in 1995 occurred in northeastern California. Hunter success is shown below in Table 1.

In 1995, four pronghorn tags (fund-raising tags) were sold to highest bidders. By statute, revenue from such tags is used to fund pronghorn management. Desirability of these tags is enhanced by an earlier opening date for the season, longer season duration (51 days, as opposed to a 9 day general season), and the ability to hunt in any of the six public hunt zones in northeastern California (other tagholders may only hunt in one designated zone). These special pronghorn tags generally are sold for $3,000-$4,000 each.

Since 1947, the Department has translocated approximately 1,100 pronghorn from northeastern California to seven locations within their historic range. The most recent translocation effort occurred in 1990. The northeastern California pronghorn population declined because of a severe winter in 1992 and it is unlikely that additional translocation of pronghorn will occur until this population recovers.

Special Studies

Department personnel have collaboratively participated in a number of studies, some of which are contained in these proceedings. Annual winter census and summer composition surveys for northeastern California date back to 1953 and constitute the oldest ongoing annual survey of mammals in California.

Table 1. Pronghorn hunter success rate in California, 1995

Hunt Type	Tags Issued	Harvest	Percent Success
General Methods	475	347	73
Archery only	44	13	30
Junior Hunts	10	7	70
Fund-Raising Hunts	4	4	100
PLM Hunts	40	28	70

COLORADO PRONGHORN ANTELOPE STATUS REPORT - 1996

STEVE STEINERT, Colorado Division of Wildlife, 317 West Prospect, Fort Collins, CO 80526

Pronghorn Antelope Workshop Proceedings 17:15

Pronghorn populations in Colorado are currently estimated at around 60,000. Our largest herds occur in the northwest corner of the state and throughout the eastern plains. The statewide management objective is to maintain a population of 50,000-55,000.

Pronghorn population estimates are determined through modeling each separate herd. Population data are gathered by fixed-wing aircraft flights during March, April, and again in August to get age and sex ratios. Most of the state still uses the traditional 1-mile interval transects for population estimates and 3-mile intervals for age and sex ratio data.

Harvest is regulated by totally limited rifle licenses in all areas, as well as some areas for archery. However, most areas are open to unlimited archery hunting. A statewide muzzleloading season was started in 1995. A total of 100 permits was issued. Interest was high and several hundred applications were received. On average, about 15 percent of the statewide populations is harvested annually. In 1995, some 14,170 hunters harvested 5,380 bucks and 4,560 does. Statewide success by rifle hunters is 75-80 percent, and archery success is around 25 percent. There is considerable demand for antelope licenses. In most areas the number of applications received for buck licenses will exceed the number issued by four or five times. Colorado has a preference point system which ensures that the average hunter will receive a buck permit about once every three to five years. In most areas it would be possible to draw a doe permit at least every other year.

Pronghorn tend to pose less problems compared to other ungulate game populations in Colorado. However, two problems seem to prevail. The first is determining consistent, accurate population estimates. With such a high percent of hunter success, it is critical to have good population estimates to prevent over-harvest. Actual population numbers tend to fluctuate at a faster rate than shown by computer generated models. Also, regulation recommendations must be completed before reproductive data has been gathered. This can result in regulations which are not consistent with what is truly happening in the population. The end result is a "yo-yo" management rather than consistency from year-to-year. New sampling techniques have been developed and tried such as line-distance transects and helicopter quadrats. However, the traditional line transect is still used through most of the state because of cost or unavailability of properly equipped aircraft.

The second major management problem is getting private landowners to tolerate higher densities of antelope on their lands. In only a few areas are antelope populations at biological carrying capacity. Social tolerance is the main controlling factor of most herds. Even though very little game damage is paid to landowners, the complaints are numerous. These include competition with domestic livestock, damage to winter wheat, distribution of noxious weeds and soil erosion due to trampling.

Presently, only one research project is being conducted by the Colorado Division of Wildlife. Thomas Pojar is studying a population in a high mountain habitat near Kremmling.

IDAHO PRONGHORN ANTELOPE STATUS REPORT - 1996

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Pronghorn Antelope Workshop Proceedings 17:16

Based on subjective factors and the results from a limited number of line transect surveys, prior to the 1995 hunting season the statewide pronghorn antelope population in Idaho numbered approximately 12,500 animals. Fixed-wing line transect surveys of pronghorn are completed during winter. However, only about 20% of the population is counted during these surveys; results are highly variable and of questionable value.

In total, 2,435 pronghorn tags were authorized in 1995. Non-resident pronghorn tags may not exceed 10% of the total number of permits authorized. Tags were awarded by drawing from 13,395 applicants, each of which paid a $5.00 application fee. Successful resident applicants paid a $27.50 tag fee, whereas non-residents paid a $226.00 tag fee. Total pronghorn antelope harvest for 1995 was 973 bucks and 383 does (resident and non-resident, archery, muzzleloader and centerfire rifle combined).

The pronghorn antelope archery season dates were August 15-September 15, whereas general season dates were September 25-October 24. Junior hunters (under 17 years old) pay a reduced license fee. Idaho does not make pronghorn antelope fund-raising tags available. For hunting purposes, buck pronghorn are defined as having horns longer than 3 inches. Management plan objectives call for an average horn length of 12 inches for bucks and specifiy a desired pre-season ratio of at least 50 bucks per 100 does.

Idaho has a predator control program which receives state funding and is administered through a contract with USDA APHIS Wildlife Services. Wildlife depredation issues are addressed through a landowner/sportsmen coordinator for each of seven management regions in Idaho. The Department pays for crop damage on a case by case basis if individual damage claims exceed $1,000 (i.e. owner pays first $1,000).

The most recent pronghorn antelope capture and translocation effort occurred in 1989 and involved translocation of 29 animals within the State. At present (1996) the Department is not sponsoring ongoing research involving pronghorn.

KANSAS PRONGHORN ANTELOPE STATUS REPORT - 1996

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Pronghorn Antelope Workshop Proceedings 17:17-19

Population Estimates

Aerial counts using fixed-wing aircraft are conducted in July (production and composition counts) and January (population estimations). Counts in January 1994 resulted in 1,100 pronghorn being observed in the major west-central Kansas pronghorn range. The survey in 1995 resulted in only 1,000 animals being observed. There are an additional 300 animals in scattered herds located in the southwest, south-central and east-central portions of Kansas. Production surveys in the major range provided an estimated buck:doe:fawn ratio of 42:100:45 in 1994, while the survey in 1995 produced a ratio of 86:100:38 (Table 1).

Archery Season

Archery pronghorn permit availability changed from 150 per year in 1989 to unlimited permit availability for residents in 1990 and afterwards (Table 2). The 1994 archery pronghorn season was nine days in length (September 24-October 2). The open area included parts of 14 counties in west-central Kansas. Each hunter was mailed a questionnaire. Permits were issued to 126 archery hunters in 1994 and 118 of them actively pursued pronghorn for a total of 440 hunter days. They harvested 34 bucks and 6 does or fawns. Similarly, the 1995 archery season was held from September 23-October 1 within the same area. Permits were issued to 146 archery hunters in 1995 and 135 of them actively pursued pronghorn for a total of 507 hunter days. They harvested 25 bucks and 4 does or fawns.

Firearm Season

A firearm season for pronghorn in Kansas was held October 7-10, 1994. Two management units were established and 180 permits were available. Hunter demand exceeded permit availability (Table 3). Permits were unavailable for non-residents, and 769 resident hunters applied for a firearms permit. Each hunter was mailed a questionnaire. One hundred seventy hunters spent 224 days afield and harvested 127 bucks and 25 does or fawns. In 1995, the firearms season was held from October 6-9. Unit boundaries remained the same as the previous year. Applications for the 240 permits were received from 1,032 people. Two hundred twenty-seven hunters spent 303 days afield and harvested 176 bucks and 27 does or fawns.

Relocations

No pronghorn were captured or relocated to Kansas during the previous two years. The last release was in January 1992 when 85 animals obtained from near Pueblo, Colorado were released in Chase and Morton counties. No additional capture or relocation projects are currently being considered.

Research

Graduate research projects on pronghorn ecology in east-central Kansas continue under the direction of Elmer Finck of the Department of Biology at Emporia State University. Am Eccles completed his MS thesis titled, "Using GIS to analyze use of the tall-grass prairie by pronghorn in winter and spring." An additional study was initiated on fawn survival, however, the student took a full time position before completing a thesis. Funding has been provided for a study on pronghorn diet in the tall-grass prairie. That project is scheduled for completion in 1997.

Management Issues

A five dollar non-refundable service fee was added to the cost of a pronghorn permit in 1995. The service fee is collected from each applicant. A list of names is maintained on the success of each applicant in obtaining a permit. Preference points for future attempts to obtain a pronghorn permit are accumulated by unsuccessful applicants. Preference points are returned to zero if a person obtains any pronghorn permit.

Landowner tolerance of pronghorn continues to be a problem in Kansas. The pronghorn range in western Kansas is primarily private property with the grasslands managed for cattle grazing, and the croplands managed for dryland farming, predominantly of winter wheat. The exception to this condition is the Cimarron National Grassland in Morton County. Landowner concerns include damage to wheat production, possible spread of bindweed to croplands, and damage to fences. A few people have initiated unauthorized damage control actions resulting in small herds of pronghorn being shot and left in fields. The effects of these actions are considered small at this time, however, the activity creates concern with general residents, sportsmen and Department personnel.

The Kansas Department of Wildlife and Parks is considering an educational program for western Kansas residents. The goal is to develop support among unaligned people and provide them with facts which they can use when faced with erroneous information provided by people promoting the intolerance of pronghorn. Responsive management techniques will be used to develop this program.

Table 1. Kansas pronghorn population trends based on aerial counts, 1963-1996

	Winter Count		Composition, North of US 40			
Year	North of US 40	South of US 40	Number Counted	Bucks :	Does :	Fawns
1963	72		47	48.3 :	100.0 :	13.8
1964	77		52	58.6 :	100.0 :	20.7
1965	140		128	42.4 :	100.0 :	51.5
1966	136		155	73.6 :	100.0 :	118.9
1967	145		186	51.2 :	100.0 :	70.2
1968	211		163	78.9 :	100.0 :	107.0
1969	247		96	82.9 :	100.0 :	91.4
1970			125	87.2 :	100.0 :	78.7
1971	531		89	82.9 :	100.0 :	71.4
1972	600		15	94.4 :	100.0 :	85.2
1973	531		134	64.1 :	100.0 :	45.3
1974	673		224	47.0 :	100.0 :	77.0
1975	790		277	57.9 :	100.0 :	40.0
1976	812		338	54.8 :	100.0 :	63.2
1977			206	69.6 :	100.0 :	91.1
1978	845		24	53.0 :	100.0 :	88.0
1979	1149		345	50.6 :	100.0 :	70.5
1980	1005		283	41.7 :	100.0 :	81.1
1981	876		376	41.8 :	100.0 :	70.6
1982	1225		242	21.7 :	100.0 :	65.9
1983	765		225	50.9 :	100.0 :	57.4
1984	641		25	48.7 :	100.0 :	65.8
1985	525		219	50.5 :	100.0 :	58.1
1986	842		244	32.0 :	100.0 :	68.0
1987	891		232	46.6 :	100.0 :	78.6
1988	788		27	53.4 :	100.0 :	76.3
1989	1370		167	12.6 :	100.0 :	49.5
1990	998	283 a	233	12.3 :	100.0 :	78.7
1991	1262	54 b	243	73.0 :	100.0 :	70.0
1992	1259	265 c	195	64.8 :	100.0 :	49.5
1993	860	169 d	300	68.6 :	100.0 :	50.4
1994	935	167	142	42.1 :	100.0 :	44.7
1995	1125	471	309	85.5 :	100.0 :	38.4
1996	806	186				

a - 153 in Logan County and 130 in Greeley County
b - Greeley County only
c - Wallace and Greeley County
d - Logan County

Table 2. Summary of pronghorn hunting in Kansas (Archery)

Year	Season Length (days)	Applications Received	Permits Available	Permits Issued	Active Hunters	Total Harvest	Bucks Harvested	Does/ Fawns Harvested	Percent Success	Days of Hunting
1976	5	54	50	50	42	7	4	3	16.7	131
1977	5	59	60	59	52	4	3	1	7.7	182
1978	5	87	60	60	50	4	3	1	8.0	148
1979	5	86	80	80	73	2	1	1	2.7	211
1980	5	60	120	60	51	10	8	2	19.6	163
1981	5	95	100	95	86	12	7	5	13.9	270
1982	9	74	100	74	69	11	8	3	15.9	233
1983	9	142	150	142	127	18	16	2	14.2	487
1984	16	119	150	119	116	12	9	3	10.3	574
1985	9	99	150	99	84	6	6	0	7.1	274
1986	9	83	150	83	57	4	3	1	7.0	207
1987	9	62	150	62	51	8	5	3	15.7	191
1988	9	65	150	65	53	6	5	1	11.3	248
1989	9	75	150	75	54	16	13	3	29.6	213
1990	9	74	*	74	68	14	12	2	20.6	262
1991	9	89	*	89	84	16	11	5	19.0	341
1992	9	112	*	112	107	18	14	4	16.8	419
1993	9	114	*	114	110	24	21	3	21.8	440
1994	9	126	*	126	118	40	34	6	33.9	414
1995	9	146	*	146	135	29	25	4	21.5	507

* Unlimited archery permits available

Table 3. Summary of pronghorn hunting in Kansas (Firearms)

Year	Season Length (days)	Applications Received	Permits Available	Permits Issued	Active Hunters	Total Harvest	Bucks Harvested	Does/ Fawns Harvested	Percent Success	Days of Hunting
1974	3	492	80	80	72	70	61	9	97.2	82
1975	3	288	80	80	78	76	68	8	97.4	88
1976	3	524	80	80	77	72	66	6	93.5	91
1977	3	501	100	100	96	91	80	11	94.8	106
1978	3	596	100	100	97	90	73	17	92.8	111
1979	3	688	100	100	94	91	76	15	96.8	100
1980	3	723	160	160	148	142	113	29	95.9	170
1981	3	853	190*	190	180	169	121	48	93.9	314
1982	3	838	190*	190	181	171	128	43	94.5	454
1983	3	984	390*	390	362	321	159	162	88.7	430
1984	3	960	420*	421	390	337	153	184	86.4	508
1985	3	874	270*	270	250	208	108	101	83.2	337
1986	3	813	245	248	223	192	148	44	86.1	328
1987	3	941	266	266	254	216	163	53	85.0	362
1988	3	661	220	222	214	193	145	48	90.2	267
1989	3	674	260	264	247	217	176	41	87.8	306
1990	4	647	170	174	158	151	131	20	95.6	198
1991	4	520	150	152	145	137	119	18	94.5	196
1992	4	620	180	181	172	160	152	8	93.0	214
1993	4	718	210	210	199	186	155	31	93.5	263
1994	4	769	180	180	170	152	127	25	89.4	224
1995	4	1032	240	241	227	203	176	27	89.4	303

* Doe - Fawn Permits issued.

NEVADA PRONGHORN STATUS REPORT 1996

MIKE DOBEL, Wildlife Biologist, Nevada Division of Wildlife, 1100 Valley Road Reno, Nevada 89512

Pronghorn Antelope Workshop Proceedings 17:20

Herd Composition

Nevada biologists classified 6,459 pronghorn during their surveys in 1995. Most of this sample was obtained in the post-hunt period. The sample size was equivalent to the 1994 sample which was slightly below the average sample for the preceding 15 years. This sample yielded a buck ratio of 29 bucks per 100 does. This was significantly lower than both the 1994 buck ratio and the 15-year average of 33 bucks per 100 does. The fawn ratio for 1995 was 25 fawns per 100 does, significantly lower than the long term average of 34 fawns per 100 does. Antelope fawn ratios for the last five years have been below average. These changes in composition indicate declines in the population.

Harvest

Hunting of pronghorn antelope in Nevada takes place under a permit system during the months of August and early September. Hunters can apply for a buck only tag in one of twenty-nine units in the state. Draw odds this past year ranged from a low of one in two up to a high of one in seventeen for the most popular unit. During 1995 a total of 1,329 tags was sold for all hunts. This total was equivalent to last year's sales and represents a declining trend, being 28% less than the peak of 1,840 tags sold in 1992. Last year resident rifle hunters reported a success rate of 72% which was down from the past five year average of 84%. Resident archery hunters also reported a significant decline in success compared to 1994.

Population Trend

The statewide antelope population was estimated at 14,835 animals this year. This was a 5% decline from 1994 and a 22% decline from the peak population of 19,107 estimated in 1991-92. We feel this decline was greatly influenced by severe drought conditions which took place during the late 1980s and early 1990s. It is interesting to note that our mule deer herds have shown the same trends.

Research and Management

Currently there is no ongoing research on antelope in Nevada. No trapping or transplanting of antelope occurred during the 1995-96 herd year. Of interest to those involved in antelope depredation problems is Nevada's Landowner Compensation Tag Program. The program allows tags to be issued to the owner of private land as compensation for damage caused by deer or antelope.

The owner can then sell the tag(s) for use within the unit where the private land occurs. One tag is issued for each 50 animals present on the private land with a cap of 200 tags statewide. Although somewhat labor intensive, this program has been a positive one in terms of the Division's relationship with private landowners, who are typically members of the livestock community.

NEW MEXICO PRONGHORN ANTELOPE STATUS REPORT - 1996

DARREL WEYBRIGHT, New Mexico Department of Game and Fish, PO Box 25112, Village Building, Santa Fe, NM 87504

Pronghorn Antelope Workshop Proceedings 17:21

Population

New Mexico's current pronghorn population is estimated near 36,000 animals. Primary populations occur throughout the eastern plains, with the highest densities located in the northeast. They also occur in less abundance along the western side of the state. While populations in northern New Mexico appear to be stable to increasing due to favorable weather conditions, southern populations have experienced declines. Precipitation has remained well below normal levels for the last 6-8 years. Low fawn survival for many of the southern units is, in all likelihood, due to poor range conditions.

Surveys

Aerial surveys are conducted during March and April to determine herd composition and population trends. These surveys are conducted from a Department-owned fixed-wing aircraft (Cessna Skymaster). The surveys are flown on north and south transects at 1/2-mile intervals. An attempt is made to complete a 100% count of all animals in the survey area. The majority of the units are surveyed on a two year rotation cycle, while some units are surveyed every year. Statewide, the buck to doe ratio is 39 bucks per 100 does, based on nearly 18,000 pronghorn counted during the 1995 survey.

Hunting

During the 1994 season, there were 12 pronghorn antelope hunts in which the Department concluded hunt agreements with over 1300 landowners. Agreements are signed with each landowner to allow hunting for a specific number of public hunters, (drawn by lottery), and a specific number of hunters that the landowners authorize to purchase a license. Hunters for the muzzleloader and rifle hunts are assigned and restricted to specific ranches, while bow licenses remain valid throughout the state.

Harvest projections for the 1994 season indicate that a total of 8,269 hunters harvested 6,294 pronghorn. Success rates were 88%, 20%, and 45% for rifle, bow, and muzzleloader hunters, respectively. New Mexico has a separate hunt for handicapped hunters. In 1994, 71 such hunters harvested 67 pronghorn for a 94% success rate.

Transplants

During 1996, two transplants were completed using an antelope corral trap, modified by New Mexico Department of Game and Fish with increased use of tarps and burlap along wing fences and in the holding and handling pens. The captures resulted in relocating 168 pronghorn within New Mexico and to the State of Coahuila, Mexico. Pre-release mortality was 2.6 percent.

Research

Currently, New Mexico State University is conducting the only pronghorn research in New Mexico.

NORTH DAKOTA PRONGHORN ANTELOPE STATUS REPORT - 1996

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Pronghorn Antelope Workshop Proceedings 17:22-23

North Dakota is on the eastern fringe of the pronghorn antelope (*Antilocapra americana americana*) range. Early explorers (e.g. Alexander Henry, Lewis and Clark, and James Audubon) did not observe pronghorn until they traveled from the tall-grass prairie of what is now the Red River Valley westward through the mixed-grass prairie to the short-grass prairie of the extreme southwestern corner of what is now North Dakota. Records and observations suggest that pronghorn antelope rivaled buffalo (*Bison bison*) is abundance.

Between then and now, pronghorn antelope were nearly extirpated from our state. E. W. Nelson (1925) reported five herds of antelope with an aggregate of only 225 animals in North Dakota. These low numbers did not start to improve until the 1940s. Then our antelope started to do what they do best, produce more antelope, until in 1951 a census disclosed 3,878 pronghorn in North Dakota and the first modern-day hunting season was proclaimed.

The pronghorn antelope survey is conducted annually from a high, fixed-wing, light aircraft (Citabria, Piper Super Cub and/or Scout). Approximately one-third of the management units are flown out completely in July of each year thus providing a complete coverage of the entire pronghorn range once every three years. Each group of antelope observed is recorded by location, number, sex, and age (at least one year old, or young of the year) resulting in the distribution, population density, sex ratio and production of the pronghorn herd.

In 1995, a total of 9,969 antelope was observed. The observed buck:doe:fawn ratio was 37:100:67. The average pronghorn antelope population in North Dakota over the last ten years (since 1985) was 8,938 animals. Over the last 45 years (since 1950) the average was 7,616 animals.

The knowledge North Dakota has gained during the 40 pronghorn gun hunting seasons since that first one in 1951 boils down to two basic facts: 1) when a permit is issued, an antelope is harvested more than 80% of the time; and 2) pronghorn antelope in North Dakota can sustain an annual harvest of 25-30% of the July population estimate.

In 1995, some 9,050 resident hunters applied for 3,240 pronghorn gun permits available. Their lottery chances were 1 in 3. Of those drawn, all but 187 individuals (6%) hunted and they harvested 2,468 animals for a success rate of 80.9%. The buck:doe:fawn ratio of this harvest was 216:100:69. The 1995 pronghorn gun harvest provided 9,350 hunter days of hunting recreation during the 16-day season.

An unlimited number of archery tags is allowed annually for residents and non-residents. In 1995, some 1,174 resident, 71 resident youth and 129 non-resident archers participated during the 52 day archery season. Hunter success data are not available, however, past information would indicate a success ratio of 25-30%, or a harvest of 350-400 pronghorns. Full body decoy hunting is a favored method of bow hunting during the "rut" in North Dakota.

The goal for the pronghorn antelope program within the North Dakota Game and Fish Department's Participative Management process is to manage the antelope resource at a level that yields maximum recreational benefits within acceptable limits to sportsmen and landowners and within the carrying capacity of the habitat. The original objectives of the strategic plan were as shown in Table 1. With the exception of those for the tertiary range, all goals were met in 1995.

Trapping for translocation has been limited to one effort in recent years: that being in 1991. This transplant

Table 1. North Dakota pronghorn antelope management objectives.

	Population Index	Hunters	Hunter Days	Harvest
Primary Range	4,500 - 5,500	1,854 - 2,265	3,708 - 4,530	1,575 - 1,925
Secondary Range	4,500	1,060	2,862	900
Tertiary Range	2,000	471	1,413	400

was influenced by bio-political decisions that were contrary to recommendations found in Guidelines for the Management of Pronghorn Antelope; subsequent observations indicate it has failed to establish a viable breeding population of pronghorn. As a result, the following guidelines were developed to address future translocation requests:

1. Pronghorn transplants will be considered in areas of the state that traditionally have held animals in the recent past and that survived well over a long period of time.

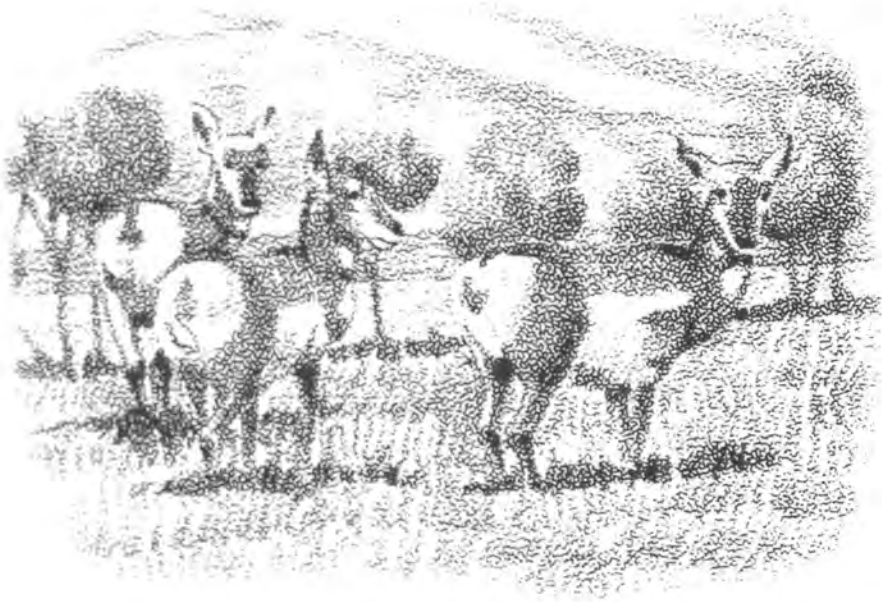
2. A release area consisting of a minimum of four square townships in size would need to be identified (144 square miles). The area would need to be habitat mapped by the project sponsors and ground-truthed by our big game staff to determine if it met the habitat requirements of pronghorn.

3. Written approval for the project by all of the landowners owning land in the proposed release area is required.

4. The sponsoring organization (e.g. wildlife club) would need to sign a cooperative agreement with the Department, taking on partial responsibility for depredation complaints and response to damage complaints by landowners.

5. The sponsoring organization would need to provide at least 75-80% of the costs of the project. Total project costs are approximately $7,500 to $10,000 per transplant, based on recent data. Cost to local sponsors would be in the $5,500 to $7,500 range.

There is no active research in progress on pronghorn antelope in North Dakota.



OKLAHOMA PRONGHORN ANTELOPE STATUS REPORT - 1996

MICHAEL SHAW, Oklahoma Department of Wildlife Conservation, Box 53465, Oklahoma City, OK 73152

Pronghorn Antelope Workshop Proceedings 17:24

The range of antelope in Oklahoma is confined to Cimarron and Texas counties in the panhandle. Populations are monitored through periodic aerial surveys conducted from a fixed-wing aircraft in late winter. Generally, 60% of the known range is surveyed. All hunting has been regulated by permits available through special drawing. Private land furnishes most of the hunting opportunity. The first antelope season, held in 1966, was deemed a success, but hunts were discontinued following the 1972 season when surveys indicated declining populations. Although herds in Texas County have continued to decline, antelope numbers in Cimarron County have increased steadily since 1979. Hunting was resumed in Cimarron County in 1987 and herds have continued to prosper. An escalation in the number of depredation complaints during the past five years has prompted a limited harvest of does to help curb growth.

Hunter success is generally quite high, averaging 86% for bucks and 63% for does since 1990. Among all types of draw hunts, antelope permits are usually second only to elk in demand. In 1995, some 4,179 individuals applied for the 100 available permits. To distribute hunter opportunity, successful applicants are not eligible to reapply for 10 years following selection.

Future management plans include providing quality hunting opportunity, maintaining hunter access, and minimizing landowner conflicts. Plans for reintroduction of antelope to Roger Mills County are currently underway. The release site, east of the 100th meridian, is an area where antelope were thought to occur historically. Agreements have been secured with landowners in the area, and public hearings indicate area residents generally favor the release. Wyoming has agreed to provide 75 antelope with the first releases scheduled for November 1996. Twelve does will be fitted with radio collars to monitor movements and productivity.

SASKATCHEWAN PRONGHORN ANTELOPE STATUS REPORT - 1996

DWIGHT DOBSON, Saskatchewan Environment and Resource Management, Maple Creek, Saskatchewan

Pronghorn Antelope Workshop Proceedings 17:25

Population Status

The 1995 pre-fawning population estimate was 20,000, a decline of 17% from the 24,500 estimated in 1990 (both surveys were flown in early June). The herd structure in 1995 was 19 kids and 35 bucks per 100 does. Poor reproduction has been experienced since the early 1990s, which prompted a collection study in the spring of 1994. The study indicated that pronghorn does were being bred and carrying to term. The pregnancy rate was very high, all does (n=45) 23 months of age or older had been bred and carried an average of 1.93 fetuses per doe. There were no indications from the study that would suggest that low reproduction was the result of poor conception, significant inutero mortality or post-parturition mortality due to poor nutrition.

Harvest

High pronghorn antelope population levels in the early 1990s created concerns from landowners over damage to standing field crops. In response, a non-trophy season was initiated in 1991, and in 1993 the either-sex season was removed from the draw system and licences were sold over the counter with no wildlife management zone (WMZ) restrictions. In 1994, the non-trophy season was eliminated, and in 1995 the either-sex season was returned to the draw system, both in response to poor reproduction. The 1995 pronghorn antelope season saw 3,432 hunters harvest 2,188 animals, for a hunter success rate of 64%.

Presently (1996), Saskatchewan has a pronghorn antelope either-sex season for residents only, on a draw system with quota allotments for specific WMZs. In most WMZs, a one license concept is in place where a hunter can participate in the archery, muzzleloader and rifle season, as long as his or her license is still valid. All licenses are valid for one pronghorn antelope of either-sex. There is not a non-trophy season, or a pronghorn hunting opportunity for sportsmen from outside the province in place at this time.

Quotas for the 1996 season will not be finalized until completion of the population survey, but it is anticipated we will be experiencing a significant reduction from the 4,200 licences that were available in 1995.

Research

Saskatchewan is not presently involved in any research. A population survey is being conducted in June of 1996, with sex and age surveys planned for July.

TEXAS PRONGHORN ANTELOPE STATUS REPORT - 1996

CALVIN L. RICHARDSON, Texas Parks & Wildlife Department, Lubbock, Texas

Pronghorn Antelope Workshop Proceedings 17:26-31

Pronghorn antelope in Texas occur in 4 ecological regions: the Trans-Pecos, the Edwards Plateau, the High Plains, and the Rolling Plains. Pronghorn are found in scattered herds in a wide variety of habitats that vary considerably in topography, vegetation, and land use.

The Trans-Pecos population primarily inhabits desert grasslands and scattered mountain ranges. Other habitats used by some herds include creosote-tarbush flats and mesquite savannahs (mesquite encroachment on grasslands). Large cattle ranches represent the primary land use, but rainfall patterns in this region tend to impact herd trends more than current land use practices.

The majority of the Edwards Plateau population is confined to one large ranch, with several smaller herds located in the northern and western portions of the region. The habitat is short-grass prairie and isolated stands of live oak. Important woody invaders include mesquite, juniper, and prickly pear. Brush encroachment and net-wire fencing for the sheep and goat industry are the primary hurdles for pronghorn in this area.

The High Plains population consists of scattered herds that are found in isolated blocks of grasslands surrounded by extensive tracts of farmland. The majority of these grasslands consists of short-grass prairies including dominant woody plants such as yucca, sandsage, and cholla. Other habitats used by some herds include Conservation Reserve Program (CRP) grasslands; croplands of corn, sorghum, and wheat; mid-grass prairies, and rolling sandhills which may or may not include dense stands of sand shinnery oak. The overriding threat to herds in this region is the vast acreages of short-grass prairie that are currently being plowed and placed under pivot-irrigation systems.

The Rolling Plains habitat includes mixed-grass prairies which are being heavily invaded by mesquite. Medium to large cattle ranches represent the primary land use, although about one-third of the land is farmed in wheat, cotton, peanuts, and alfalfa. Mesquite encroachment represents the greatest problem for pronghorns in this region. Pronghorn herds in the High Plains and Rolling Plains ecological areas fall under the management jurisdiction of the Panhandle Regulatory District, and these areas will be referred to as the Panhandle Region for the remainder of this report.

Population estimates and herd composition data are obtained annually by flying low altitude strip counts at 1/4-mile intervals on selected ranches within each herd unit during mid-June through mid-July. Approximately 300 hours of flight time is expended annually on the statewide aerial survey.

The estimated pronghorn population in Texas has fluctuated between 12,000 and 24,000 animals during the past 20 years, and has averaged 17,145 antelope. The estimated statewide pronghorn population in 1995 was 11,903 (Figure 1), 8% below the 1994 estimate and 31% below the 20 year average. The recent reduction in statewide pronghorn numbers is attributed primarily to four years of drought that has occurred in the Trans-Pecos Region, an area that normally contains 70% of the pronghorn in Texas. The current distribution of pronghorn by region is 63% in the Trans-Pecos, 30% in the Panhandle, and 7% in the Edwards Plateau (Figure 2). Results of the 1995 survey showed increases in pronghorn in the Panhandle (11%) and Edwards Plateau (15%).

The number of does per buck observed in 1995 was 1.8 in the Trans-Pecos, 2.2 in the Panhandle, and 1.4 in the Edwards Plateau. These ratios are consistent with the long term trend for each region (Figure 3). Fawn production in 1995 was 24 and 25 fawns per 100 does in the Trans-Pecos and Panhandle regions, respectively (Figure 4). Both of these regions support relatively high numbers of coyotes, which are considered to be important factors in limiting fawn survival in these areas. Pronghorn herds in the Edwards Plateau Region experienced a severe drought in 1993 and 1994, and fawn production reached an all time low of 22 fawns per 100 does. Results of the 1995 survey approached pre-drought fawn production rates at 59 fawns per 100 does. Coyotes are not a major factor in the Edwards Plateau because of intensive control of coyote numbers by the sheep and goat industry.

The pronghorn antelope season in Texas opens on the Saturday nearest October 1 and continues for 9 consecutive days. The bag limit is one antelope per hunter per year by permit only.

Because the majority of land in Texas is privately owned, permits are issued directly to qualified landowners or their agents. Permits cannot be sold, but the landowners can charge a trespass fee. A total of 994 buck permits was issued in 1995 to 368 landowners, representing 5.8 million acres of antelope range (Figure 5). Of the landowners receiving permits, only 282 (77%) allowed pronghorn to be hunted on their property. A total of 533 hunters harvested 443 buck antelope (Figure 6), representing an all time low success rate of 83% (Figure 7).

Permit utilization was only 43% in 1994 and 45% in 1995 (Figure 8). No doe permits were issued in 1995.

Pronghorn hunting on public land is available on the Rita Blanca National Grasslands in Dallam County (Panhandle Region). Hunters are selected by random draw which is conducted through the Texas Parks & Wildlife Department's public hunting program. The number of permits issued has ranged from 6 to 14 in recent years. In 1995, eight permits were issued and seven pronghorn bucks were harvested.

No relocation efforts or pronghorn research was conducted in 1994 or 1995. However, because of severe drought conditions in the Trans-Pecos Region and the resulting decline in pronghorn numbers and distribution, restoration efforts may be considered in the future.

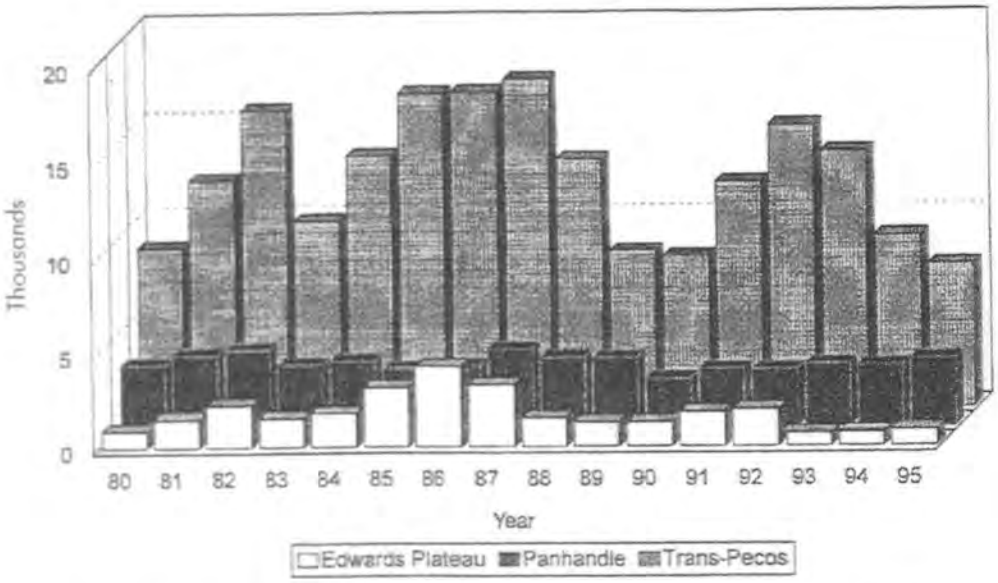


Figure 1. Estimated pronghorn population in Texas by region, 1980 - 1995.

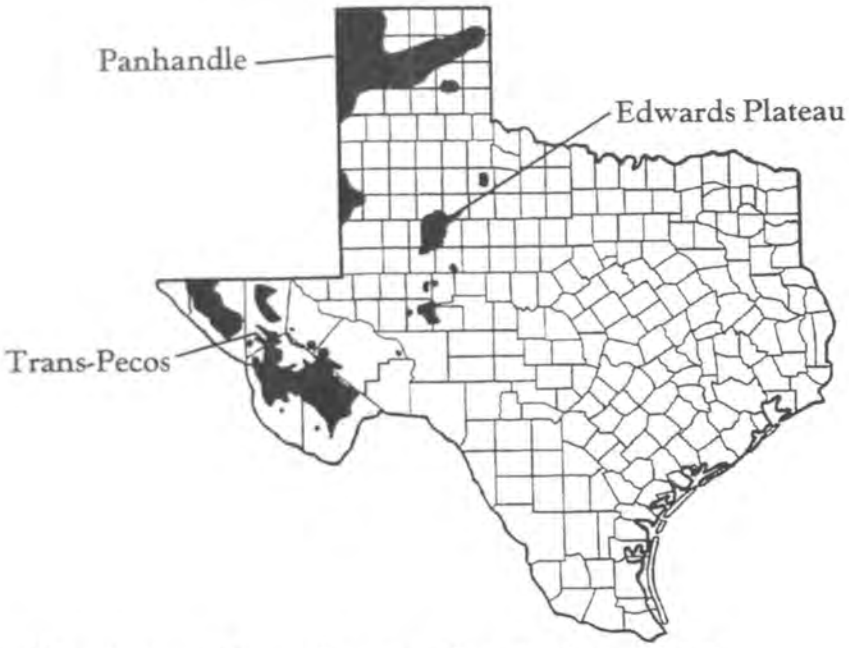


Figure 2. Distribution of pronghorn antelope in Texas, 1996.

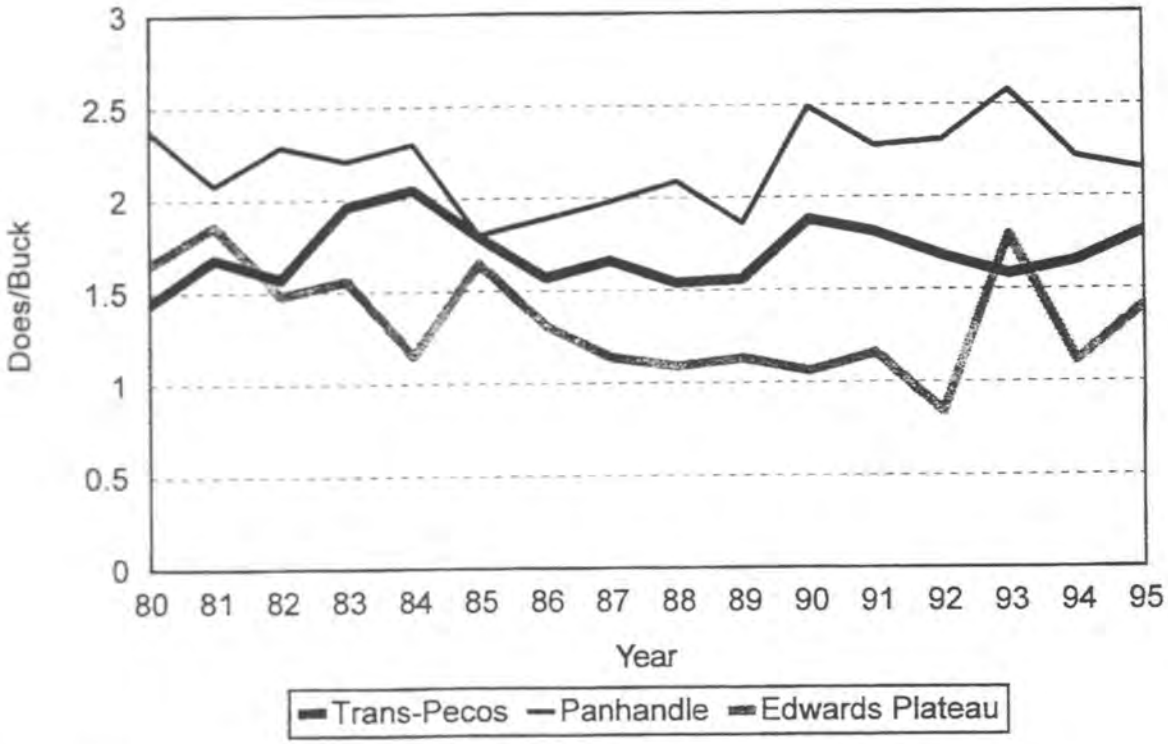


Figure 3. Pronghorn doe/buck ratios in Texas by region, 1980 - 1995.

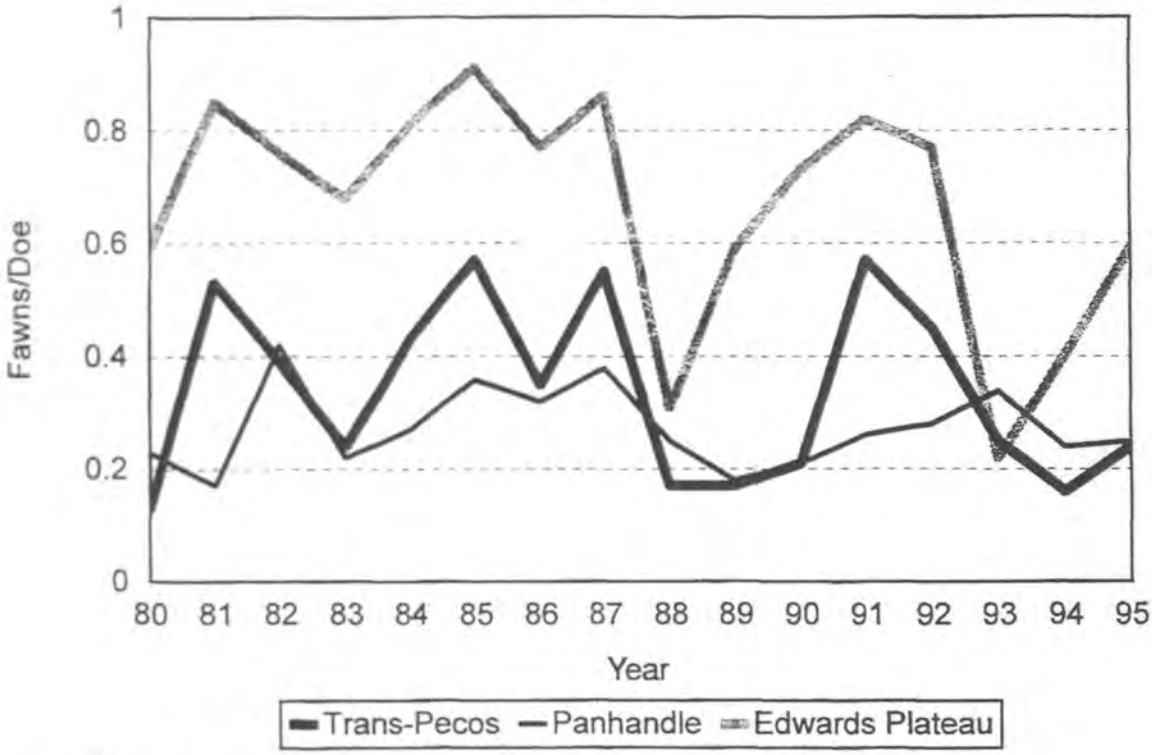
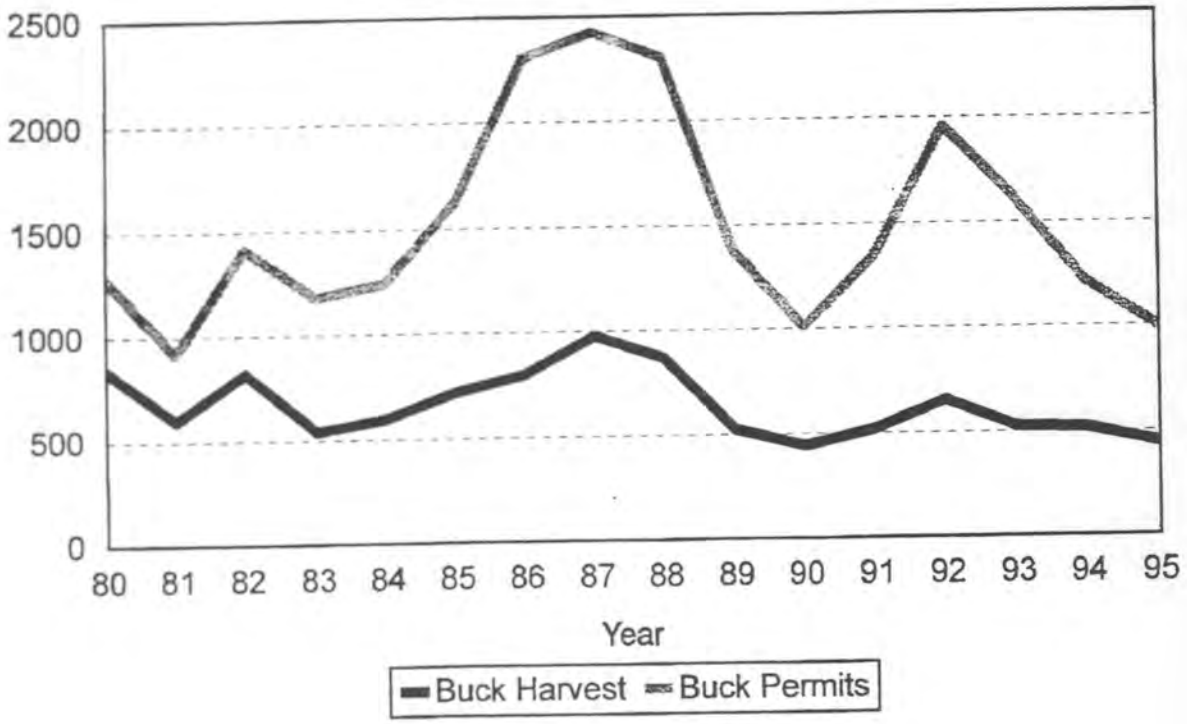


Figure 4. Pronghorn fawn/doe ratios in Texas by region, 1980 - 1995.



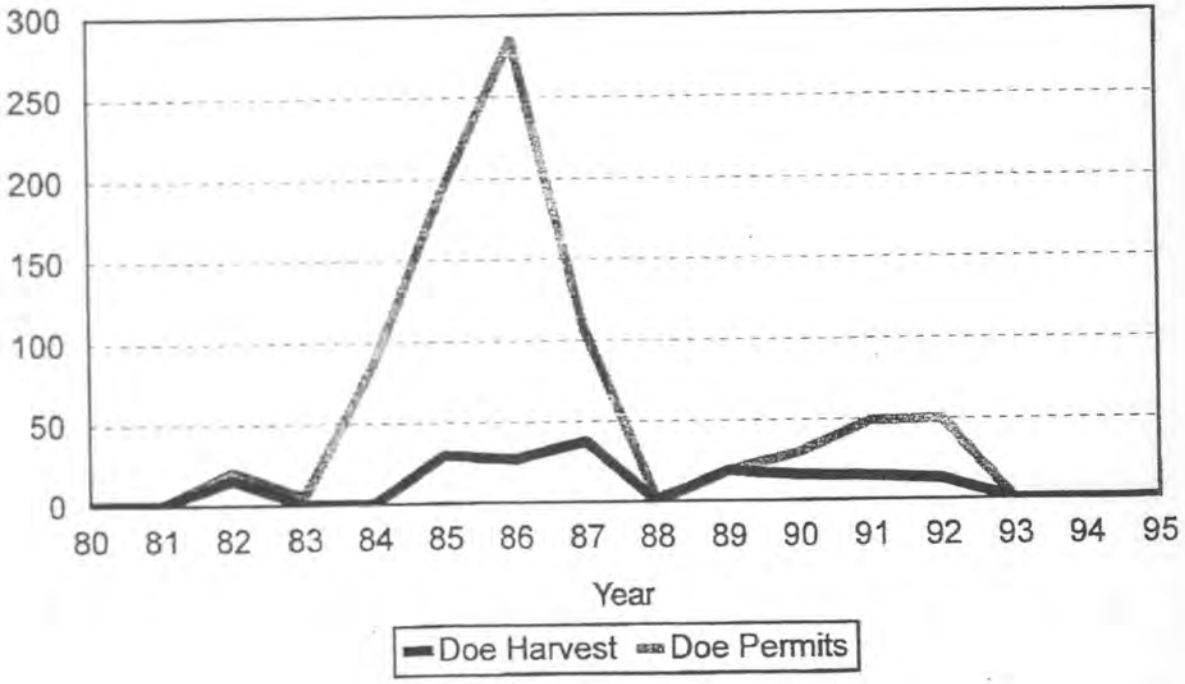


Figure 5. Number of permits issued and relative harvest rates for pronghorn bucks and does in Texas, 1980 - 1995.

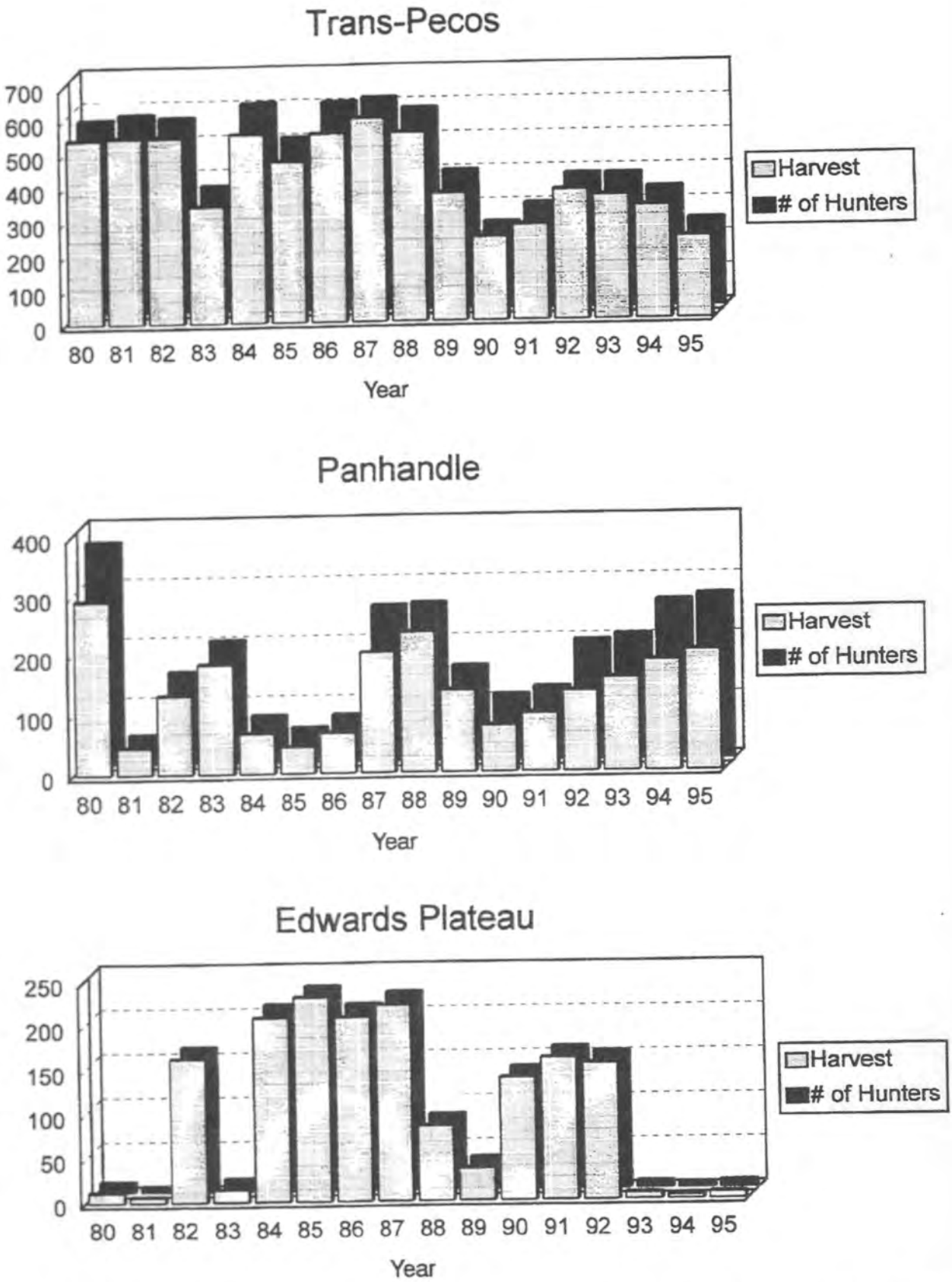


Figure 6. Number of pronghorn hunters and relative harvest by region in Texas, 1980 - 1995.

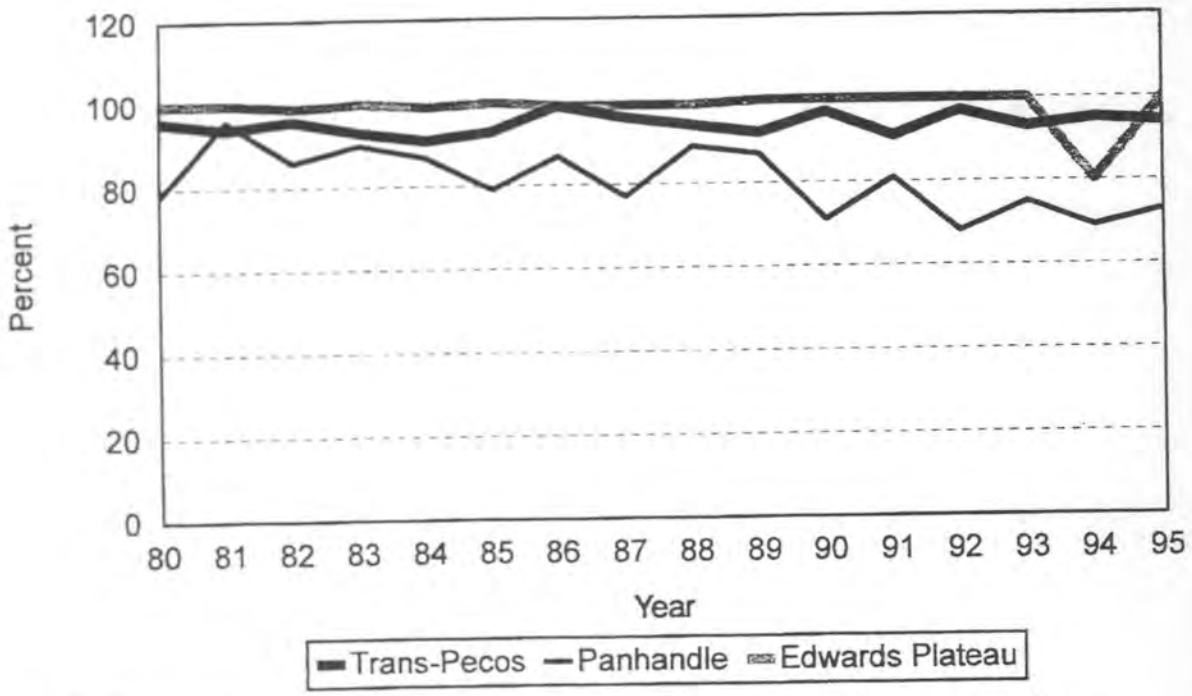


Figure 7. Percent hunter success by region during 9-day pronghorn season in Texas, 1980 - 1995.

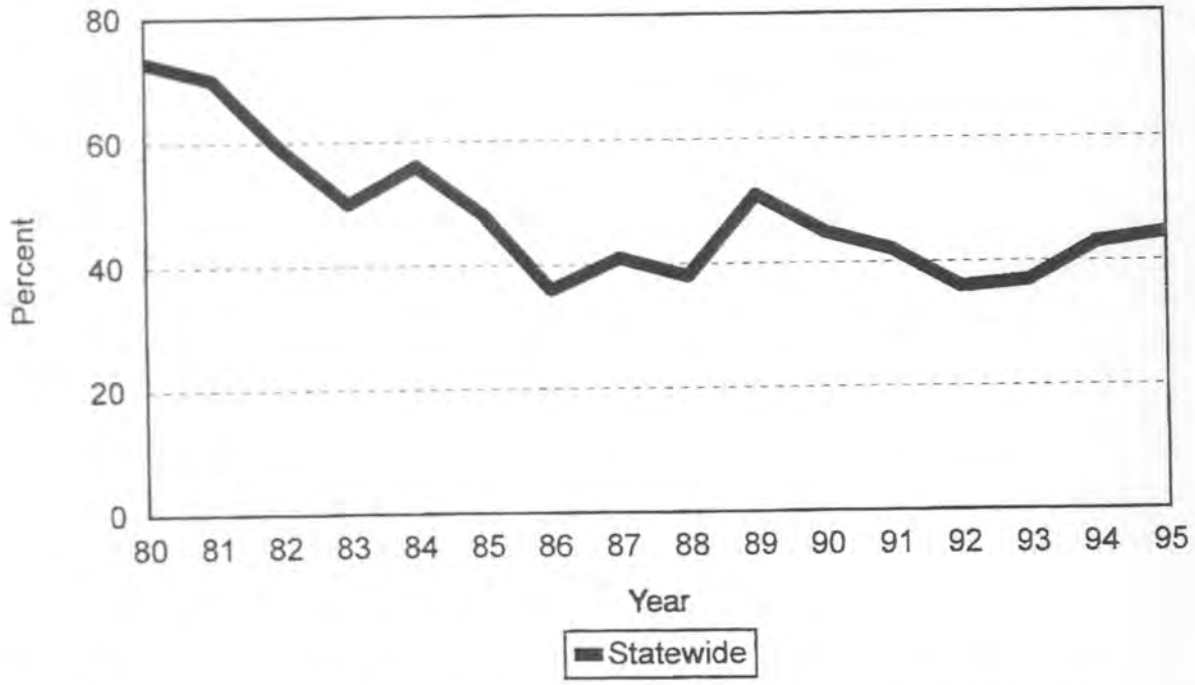


Figure 8. Percent utilization of pronghorn antelope permits in Texas, 1980 - 1995.

UTAH PRONGHORN ANTELOPE STATUS REPORT - 1996

Mike Welch, Utah Division of Wildlife Resources, 1594 West North Temple, Suite 2110, Salt Lake City, UT 84114

Pronghorn Antelope Workshop Proceedings 17:32

Approximately 11,000 pronghorn antelope existed within Utah as of December, 1995. Field surveys are completed to estimate pronghorn population numbers and composition parameters. Survey methods incorporate fixed-wing aircraft as well as ground vehicles. Sampling methodology involves both random sampling and historic survey routes. Surveys generally occur during the months of August and September, and March and April.

Hunting tags are allocated based on buck to doe ratios and fawn production. In 1995, totals of 858 resident and 91 non-resident pronghorn tags were authorized through the public hunting program (this does not include private cooperative wildlife management unit or landowner permits). Tags were issued by drawing from approximately 3560 applicants, each of which paid a $5 application fee. Harvest for 1995 was 605 bucks and 195 does/fawns. For regulation purposes, bucks are defined as having horns longer than 5 inches. One pronghorn antelope fund-raising tag was sold in 1995 for approximately $4,400. This tag was valid in any open pronghorn unit from September 1 - December 31.

The most recent capture and translocation effort occurred in November 1992 at Parker Mountain when a helicopter was used to haze animals into a corral trap. In total, 206 animals were released at sites in Nevada and Texas as a result of this project. It is anticipated that additional capture and translocation projects will occur during 1996 and 1997.

ESTIMATES OF PRONGHORN NUMBERS

BART W. O'GARA, 215 Red Fox Road, Lolo, MT. 59847

Abstract: During business meetings of the 15th and 16th Pronghorn Antelope Workshops, a need was expressed by attending members for periodic updates concerning total numbers of pronghorn in all provinces and states. I contacted personnel of provinces and states and requested data for such updates. Prehunting season population estimates for 1989 and 1995 are hereby presented by province and state. Total numbers for 1989 were 1,033,713, some 17,387 less than reported by Yoakum for 1983. Those for 1995 were 962,259, down 71,454 from 1989. The decrease apparently reflected a severe winter in 1992-93 and extended drought conditions, especially in the "pronghorn factories" of Montana and Wyoming. Population oscillations are pronounced within provinces and states and are natural, but managers should be alert that such oscillations do not mask long-term declines.

Pronghorn Antelope Workshop Proceedings 17:33-34

INTRODUCTION

During 1990, I solicited estimates of pronghorn numbers for 1989 from provincial and state conservation agencies in the range of the pronghorn, to be used in the management chapter of the Wildlife Management Institute's pronghorn book (in preparation). During the 1992 and 1994 business meetings of the Pronghorn Antelope Workshops, attending members expressed interest in periodic updates of pronghorn numbers, such as that presented by Yoakum (1986). Thus in 1996, Ms. Laura Colton and I circulated another questionnaire to provinces and states concerning estimated numbers for 1995.

RESULTS

Results of the two questionnaires are presented in Table 1. Total numbers in 1989 and 1995 were 17,387 and 88,841 less than the population size of 1,051,100 for 1983 as reported by Yoakum (1986). The total pronghorn population has remained relatively stable for more than 12 years, while provincial and state populations have fluctuated extensively. For example, numbers were high in Wyoming in 1983, more than 600,000, but dropped to just over 400,000 by 1987 and then rose to over 600,000 again in 1992. Wyoming's reported harvests reflect, actually exaggerate, estimated population numbers; 98,680 pronghorn were harvested in 1983 and 85,913 in 1992. The harvest fell to 54,355 in 1989 and to 35,549 in 1995. The 1995 harvest was the lowest in 23 years, at about one-third of that in 1983.

DISCUSSION

It should be no surprise that numbers reported for Montana and Wyoming significantly affect total numbers in North America. However, reported numbers are not necessarily based on statistically valid estimates, and the margin of error for a province- or state-wide estimate can be great. Also, the older an estimate (i.e., Nelson 1925), the more it becomes a "guesstimate". As censusing and modeling techniques improve, so should the accuracy of estimates.

In looking at the population estimates and harvests during the last 3 decades, it is tempting to try to fit pronghorn into Eustace's (Henkel 1996) concept of a 10-year cycle for mule deer (*Odocoileus hemionus*) on the prairies. A comprehensive study of all available records would be necessary to make even a tentative conclusion on this. Recent population oscillations, as indicated by provincial and state estimates, generally can be explained by weather conditions. However, pronghorn managers should be alert to long-term trends. Cumulative effects, such as fencing, housing projects, overgrazing and energy development, could lead to long-term declines masked by natural oscillations.

ACKNOWLEDGMENTS

I thank Ms. Laura Colton for assistance with the 1995 questionnaire. I also appreciate the efforts of the many provincial and state wildlife managers who took time from their busy schedules to look up records, fill out questionnaires, and answer phone calls.

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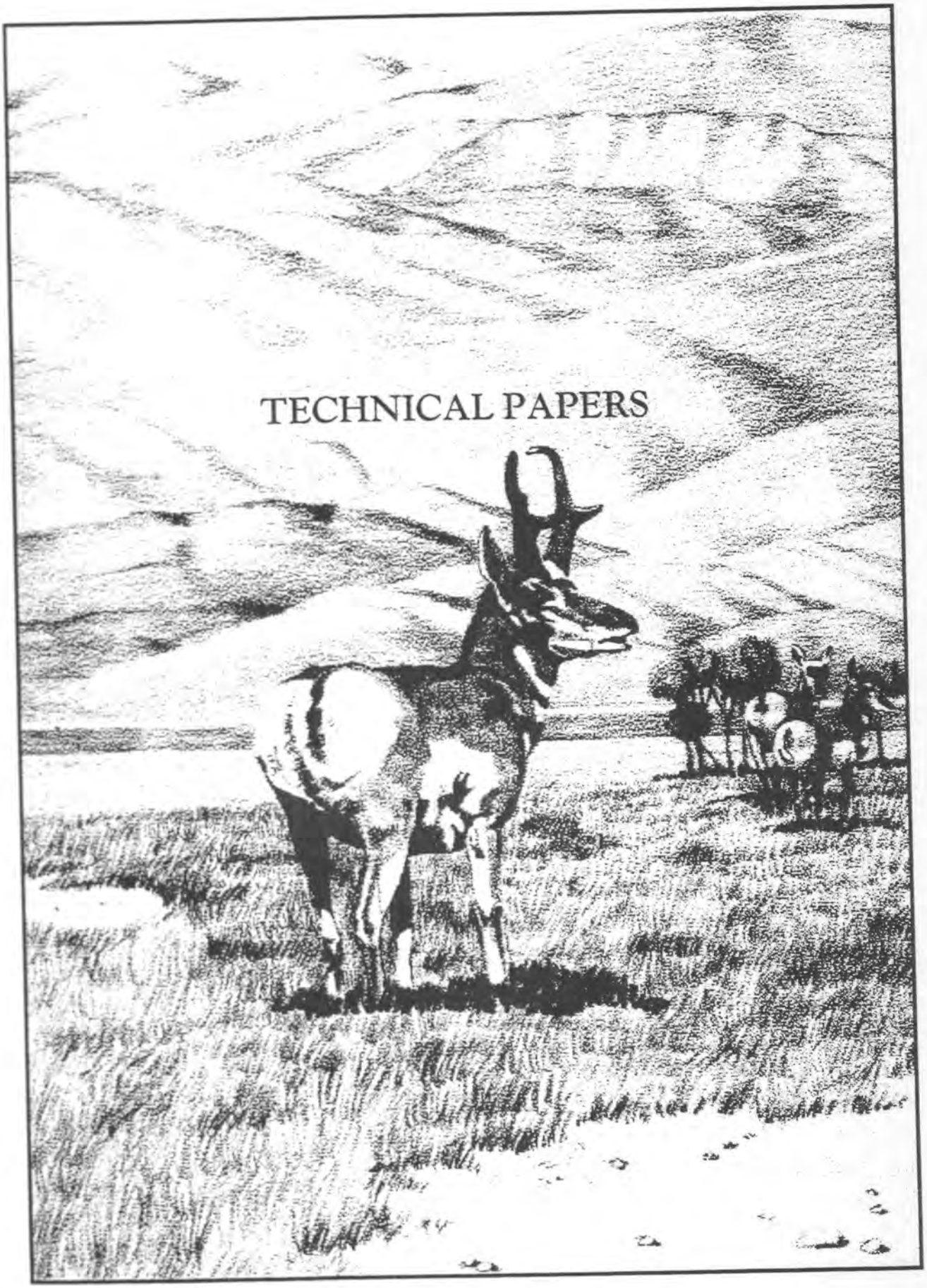
Table 1. Population estimates of pronghorn for 1989 and 1995, as reported by personnel of provincial and state conservation agencies.

Province/State	1989	1995	Increase (Decrease) 1989-1995
Alberta	22,314	17,300	(5,014)
Arizona	9,000	11,000	2,000
Lower California South	100	200	100
Chihuahua	300	172	(128)
California	7,000	6,500[1]	(500)
Coahuila	12	65	53
Colorado	58,000	68,800	10,800
Idaho	21,800	12,500	(9,300)
Kansas	2,000	1,800	(200)
Montana	300,000	225,000	(75,000)
Nebraska	2,500	4,148	1,648
Nevada	15,000	15,618	618
New Mexico	30,000	36,000	6,000
North Dakota	7,800	9,969	2,169
Oklahoma	550	1,500	950
Oregon	22,650	17,122[2]	(5,528)
Saskatchewan	27,274	22,000	(5,274)
Sonora	100	300	200
South Dakota	34,943	47,870	12,927
Texas	14,534	11,903	(2,631)
Utah	7,000	11,000	4,000
Wyoming[3]	450,836	441,492	(9,344)
Totals	1,033,713	962,259	(71,454[4])

[1] Northeastern population only.
[2] Minimum count—no estimate.
[3] Only postseason estimates available—preseason estimated by adding harvest plus 10% of harvest.
[4] Numbers for California and Oregon are not comparable for 1989 and 1995 because of the way populations were counted or estimated.


TECHNICAL PAPERS

ENVIRONMENTAL AND DENSITY-DEPENDENT EFFECTS ON A NORTHERN UTAH PRONGHORN POPULATION

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Abstract: Step-wise multiple linear regression was used to assess the effects of pronghorn (*Antilocapra americana*) density, coyote (*Canis latrans*) abundance, snow depth, summer precipitation and temperature on pronghorn population characteristics from 1984-1996. Population growth was negatively correlated with prior year pronghorn population size and snow depth ($r^2 = 0.78$; $P = 0.002$). Fall fawn:doe (F:D) ratios were negatively correlated with population size and positively correlated with April-September precipitation ($r^2 = 0.97$; $P = 0.000$). Mean annual buck harvest weights and horn mass were also negatively correlated with population size. Pronghorn used black sagebrush stands (*Artemisia nova*) and big sagebrush (*A. tridentata*)/crested wheatgrass (*Agropyron desertorum*) stands greater than available. Doe-fawn pronghorn groups used forb-rich meadows (> 30% perennial forb cover) significantly more and forb-poor (< 2% perennial forbs) sagebrush/crested wheatgrass (SC) rangelands significantly less than did buck-only groups from June-September. Doe-fawn summer bands utilizing native sagebrush rangelands (> 6% perennial forbs) averaged significantly greater fall F:D ratios than bands utilizing SC rangelands (0.94 and 0.35 F:D respectively; $P = 0.02$). Results of this ongoing investigation are consistent with hypotheses that pronghorn condition, population growth and fawn survival are strongly influenced by winter severity and intraspecific competition for available resources (summer forbs and winter sagebrush).

Key Words: Pronghorn, *Antilocapra americana*, density-dependence, survival, habitat, nutrition, population

Pronghorn Antelope Workshop Proceedings 17:36-41

INTRODUCTION

Pronghorn antelope occupy a broad range of habitat and climatic conditions in western North America. Pronghorn have adapted to the severe winters of northern sagebrush steppe and mixed prairie as well as more arid southern deserts. Despite varied climatic and vegetative conditions, forbs and shrubs appear to be important forage throughout most of the pronghorn's range (Yoakum 1990).

A few studies have noted effects of precipitation and pronghorn density on population dynamics. Martinka (1967) and Pyrah (1987) noted greater pronghorn mortality in winters with above average snow depths. Investigators have noted increased fawn:doe ratios associated with wetter summers in Utah (Beale and Smith 1970) and Montana (Martinka 1967, Pyrah 1987). However, Pyrah's (1987) 13 year study of the Yellow Water Triangle herd suggested that density of adult does had a greater influence on pronghorn fawn:doe ratios than did summer moisture.

Findings vary concerning the influence of predation on fawn survival. Beale and Smith (1975) noted significant predation of fawns by bobcats (*Lynx rufus*) in the Utah west desert. Investigators in Texas (Buechner 1950) and Nebraska (Menzel 1992) noted high predation of fawns by coyotes and golden eagles (*Aquila chrysaetos*). In contrast, Pyrah (1987) did not consider predation to be a significant influence on fawn recruitment.

This investigation reviews climatic, population and habitat use data collected 1984-1996 from a relatively closed population of pronghorn on the Deseret Land and Livestock Ranch, Utah. Approximately 100 pronghorn migrated to the study area during the severe winter of 1983-84. Although pronghorn are indigenous to the study area, they were extirpated from the ranch during the early 1900s.

The purpose of this investigation was to determine relationships between pronghorn population dynamics and the following potentially limiting factors; competition for food, climatic variability, predation, and hunting. If winter stress and forage availability are limiting pronghorn condition, fawn survival and population growth, then the following relationships should be evident:

1. Intraspecific competition for food should result in significant negative correlations between population size and pronghorn condition, fawn survival (F:D) and population growth. Interspecific competition with livestock should result in significant negative correlations between amount of forage removed by livestock (AUM removal) and pronghorn condition, fawn survival and population growth.
2. Summer forage availability should correlate positively with precipitation and negatively with growing season temperatures, since these two factors strongly influence available soil moisture and evapotranspiration rates (Branson et al. 1981). If forage quantity and quality are influenced by these climatic factors, then pronghorn

condition and population parameters should correlate positively with precipitation and negatively with temperature.

3. Forbs are preferred summer forage for pronghorn (Yoakum 1990). Forb availability may vary between vegetation types, years and seasons. If forbs are important habitat components, summer vegetation types use by pronghorn should reflect temporal and spatial differences in forb availability. If forbs are important to fawn survival, F:D ratios should increase as forb abundance increases.
4. Mean winter snow depth should correlate negatively with pronghorn condition, fawn survival and population growth since increasing snow depth reduces shrub availability and increases pronghorn energetic expenditures.

If pronghorn populations are significantly limited by coyote predation, then coyote abundance should correlate negatively with same-year fawn survival and population growth. If hunting limits pronghorn populations, the number of pronghorn harvested should correlate negatively with population growth. Neither coyote abundance nor the number of pronghorn harvested should correlate with pronghorn condition.

STUDY AREA

The study area includes 390 km^2 of sagebrush steppe, located in northern Utah. The study area is roughly rectangular, extending approximately 29 km north-south and 14 km east-west. The north end of the area is dominated by Wyoming big sagebrush and crested wheatgrass (SC, sagebrush/crested), planted in the 1960s.

Shrubs comprise 5-25% of total ground coverage. The central portion of the area is predominantly native big sagebrush stands (DNS-dense native sage), shrub coverage ranges from 15-35%. The southern end of the area is predominantly native grassland (SNS-sparse native sage). Shrub coverage is generally < 25%; rabbitbrush (*Chrysothamnus* spp.) codominates with sagebrush.

Stands of black and low sagebrush (*A. arbuscula*) occur on clay basins and gravelly ridges throughout the study area. Riparian meadows and free-water are well distributed throughout the study area.

Other shrubs commonly found on the study area include bitterbrush (*Pursia tridentata*), winterfat (*Ceratoides lanata*), and greasewood (*Sarcobatus vermiculatus*). Common rangeland grasses include Sandberg bluegrass (*Poa secunda*), western wheatgrass (*Agropyron smithii*), Indian ricegrass (*Oryzopsis hymenoides*), and needlegrass (*Stipa* spp.). Common perennial forb genera include *Phlox, Eriogonum, Erigeron, Lomatium, Linum, Senecio, Agoseris, Penstemon, Antennaria, Medicago, Trifollium, Astragalus, Allium, Taraxacum*, and *Castelleja*.

Elevations on the study area range from 1950-2070 m. Mean annual temperature is 22 ° C, summer temperatures above 45° C and winter temperatures below –10° C are common. Annual precipitation averages 24 cm, occurring primarily from September-May.

Potential predators of pronghorn on the study area include coyote, golden eagle and bobcat. Coyotes have been observed pursuing and killing pronghorn during the study.

The study area is grazed by 3000-4500 cattle annually, managed using a time-controlled grazing strategy (Savory 1988). Annual grazing plans utilize short-duration grazing periods to minimize rebiting of plants by livestock during the growing season, and maximize the benefits of seasonal rest. Fences are numerous, interior fences are generally 4-5 strand barbwire, with bottom strands at least 40 cm above ground. Immigration and emigration of pronghorn appears minimal, due to net-wire fences on the eastern and southern boundaries, mountains to the west and the town of Woodruff to the north. Approximately 87% of the study area is privately owned and managed by Deseret Land and Livestock Ranch, 13% is operated under the authority of the Bureau of Land Management (BLM).

METHODS

Approximate area of vegetation types was determined by using Geographic Information System estimates from previous studies (Homer 1990, Hunnicutt 1992). Percent forb coverage estimates were obtained in the fall of 1995 using line-intercept methods (Canfield 1941). Pronghorn population size was estimated by winter aerial counts. Attempts were made to count all pronghorn on the study area annually, however, occasional small wintering groups may have been missed. Fall F:D ratios were obtained from ground classifications in August prior to hunting season. Estimates of habitat use by pronghorn were obtained monthly (except October) 1988-1990, and during annual fall, winter and spring composition counts, 1992-1995.

Hunting of pronghorn on the study area is strictly regulated; limited numbers of buck-only and female-only permits are issued annually, specific to the study area. Harvest data collected included sex, (age based on tooth-replacement and wear), weight, lactation condition, and horn mass (Boone and Crockett score) for all harvested animals.

Estimates of coyote abundance (number observed/100 hours) were obtained each March-May between 0530 and 0930 hours, in conjunction with sage grouse (*Centrocercus urophasianus*) lek counts (20-30 mornings annually). Temperature and precipitation data were recorded at the NOAA station in Woodruff, Utah, 5 km north of the study area. Three precipitation intervals were tested as predictors of the dependent variables. These intervals were: April-September of the same year (time period when the ground is thawed and plants are actively growing), and full-year and two year intervals (September-

September). Mean temperature during the full growing season (April-September) and through the rapid growth season (April-July, the time period during which 90% of herbaceous growth occurs) were also tested as predictors of the dependent variables. Snow depths were measured every 10 days from November 1-March 20 annually on the principal pronghorn wintering area (north end of the study area).

Vegetation type use was evaluated using the chi-squared statistic. Means were compared using t-tests. Forward step-wise multiple regression was used to examine the relationships between independent and dependent variables. Once the most highly correlated variable was selected, additional variables were added only if doing so increased the model root mean squared error > 1%.

RESULTS

Population Dynamics

The pronghorn population increased from 90 to 620 adults during the study period (Table 1). Estimates of population growth (Nt/Nt-1) varied from 0.68 to 1.46 during the years studied (Table 1). Population growth was correlated positively with prior year F:D ratio, and negatively with winter snow depth, prior year population size, and number pronghorn harvested in the prior year. The variables prior year population size and snow depth best explained annual variability in population growth ($r^2 = 0.78$; $P = 0.002$; df = 10). Population growth was more strongly correlated with population size than with snow depth (Figure 1). Fawn survival estimates (F:D ratios) ranged from 0.20 to 1.17 during the years studied (Table 1). F:D ratios were correlated positively with prior year April-September precipitation and negatively with prior year pronghorn population size and the natural LOG of coyote abundance. The variables prior year population size and April-September precipitation best explained annual variability in F:D ratios ($r^2 = 0.97$; $P = 0.000$; df = 9). F:D ratios were more strongly correlated with population size than precipitation (Figure 1).

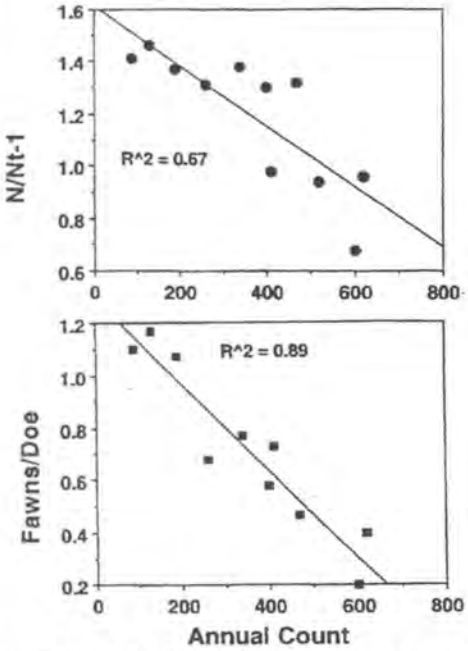

Figure 1. Relationship between population growth, fall fawn-to-doe ratios, and prior year population size, Deseret Land and Livestock study area. 1984 - 1996.

Condition

Due to small pronghorn harvest sample sizes (6 and 4 years for bucks and does respectively) multiple regression models were not formulated. Mean annual harvest weight of mature (>3 year old) bucks was negatively correlated with both harvest year population size ($r = -0.80$) and harvest year April-July mean temperature ($r = -0.54$). Mean annual harvest weight of does was

Table 1. Pronghorn population data, coyote abundance, precipitation, pronghorn harvest and snow depth. Deseret Land and Livestock study area. 1984 - 1996.

Year	Number Pronghorn	Population Growth	F:D Ratio	Coyotes/ 100 Hours	Apr-Sep Precip. (cm)	Pronghorn Harvested	Prior Winter Snow Depth (cm)
1984				0.7	21.5	—	28.7
1985	90		0.88	1.0	13.6	—	23.4
1986	130	1.41	1.10	0.3	18.7	—	18.0
1987	190	1.46	1.17	0.2	11.2	—	5.8
1988	260	1.37	1.07	1.0	5.2	—	8.4
1989	340	1.31	0.68	0.3	15.1	—	8.9
1990	470	1.38	0.77	1.0	14.6	78	4.6
1991	620	1.32	0.47	2.3	24.0	141	5.6
1992	600	0.96	0.40	9.3	10.4	104	3.3
1993	410	0.68	0.20	7.3	17.6	10	29.0
1994	400	0.98	0.73	10.0	7.7	14	4.8
1995	520	1.30	0.58	16.0	15.6	56	8.4
1996	490	0.94	—	—	—	—	4.1

most strongly correlated with prior winter mean snow depth ($r = -0.92$). Mean annual gross Boone and Crockett (B&C) scores of mature harvested bucks was used as an index of horn mass. Horn scores were correlated negatively with prior year density ($r = -0.81$) and positively with prior year mature buck harvest weight ($r = 0.60$). Larger horned mature bucks weighed significantly more than smaller horned mature bucks ($P = 0.029$). Of 68 mature bucks examined, mean weight of bucks having B&C scores >75 points was 49.4 kg; mature bucks with scores ≤ 75 points averaged 46.8 kg.

AUM removal by livestock was not significantly correlated with any of the dependent variables. Timing of livestock grazing, relative to effects on fawn post-partum hiding cover and survival was not evaluated.

Habitat Use

The study area was categorized into four broad vegetation types based on plant species composition. Vegetative characteristics are summarized in Table 2. The black sagebrush (BS) and meadow (MDW) types had the greatest percent perennial forb cover, the SC type had significantly less and MDW significantly more forb cover than BS, SNS or DNS ($P < 0.05$). Pronghorn were observed in BS and SC more than expected and SNS, DNS and MDW less than expected based on availability, January-December combined (Table 3). BS had the highest preference rating of any type (Table 3). Vegetation type use varied seasonally; Figure 2 illustrates the seasonal variation in pronghorn use of the BS and MDW types from 1988-90. Pronghorn used sagebrush dominated vegetation October-May, and increased use of MDW and SNS June-September. Buck-only pronghorn groups used vegetation types differently than doe-fawn groups June-September (Table 3). Doe-fawn groups used MDW and SNS significantly more and SC significantly less than buck-only groups ($P = 0.000$). Doe-fawn bands which summered in the SNS grasslands averaged significantly greater F:D ratios than those using the SC dominated northern fawning area (0.94 and 0.35 respectively; $P = 0.02$).

Data obtained from paired exclosure sites on the study area (Ritchie and Wolfe 1994; Ritchie, unpublished

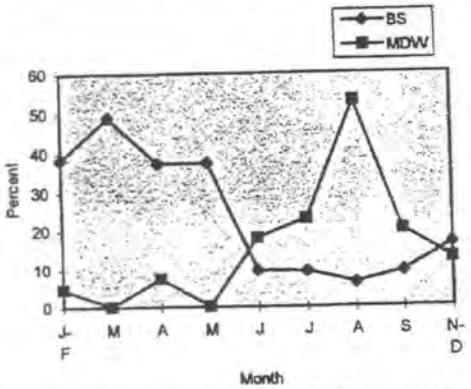

Figure 2. Comparison of differential use of black sagebrush (BS) and meadow (MDW) vegetation types by month, based on observations of 4430 pronghorn from 1988-1990, Deseret Land and Livestock study area.

Table 2. Composition of vegetation types. Deseret Land and Livestock study area, October 1995.

Vegetation Type	Percent Forb	Percent Forb Perennial	Percent Grass	Percent Shrub	Shrub Height (cm)	Percent Litter	Percent Bare Ground
BS	33.3	9.7	10.7	29.3	20.3	9.7	28.3
SC	9.6	1.0	28.9	17.3	42.9	17.0	24.3
SNS	16.0	6.3	32.0	24.0	19.1	13.5	13.5
DNS	9.3	6.3	15.0	35.0	55.9	16.3	20.7
MDW	33.3	32.7	55.3	0	0	9.3	2.0

Table 3. Vegetation type availability, pronghorn use Jan-Dec. and use by buck-only and doe-fawn groups Jun-Sept. Deseret Land and Livestock study area. 1988 - 1995.

Vegetation Type	Percent Available	Percent Use by Pronghorn Jan-Dec	Percent Buck-Group Use, Jun-Sep	Percent Doe-Group Use, Jun-Sep
BS	5.5	16.6 (3.0)[a]	13.7 (2.5)	10.6 (1.9)
SC	19.2	42.9 (2.2)	30.2 (1.6)	17.7 (0.9)
SNS	26	8.7 (0.6)	24.1 (0.9)	38.3 (1.5)
DNS	35.6	20.0 (0.6)	26.5 (0.7)	8.9 (0.3)
MDW	13.7	11.8 (0.9)	5.5 (0.4)	24.5 (1.8)

[a]preference rating = % use / % available.

data) indicate that annual biomass production of both herbaceous and shrub vegetation is dependent upon growing season precipitation. Biomass production in the cooler, wetter 1993 and 1995 seasons averaged twice the production observed in the warmer, drier 1992 and 1994 seasons. A comparison of herbaceous forage samples collected in mid-July, 1993 and 1994 is presented in Table 4. Moisture, crude protein and total digestible nutrients were all significantly greater in the cooler, wetter summer of 1993 ($P = 0.000$). These data suggest forage quantity and quality are related to growing season precipitation and temperature.

DISCUSSION

Indices of pronghorn condition (weight and horn mass), fawn survival and population growth were all significantly negatively correlated with population size, suggesting intraspecific competition and density-dependence. Reduced condition, fawn survival and population growth rates at higher population levels is consistent with a hypothesis of density dependent population regulation (Caughley and Sinclair 1994). Greater pronghorn condition (body mass) likely increases fawn survival, and fawn survival was positively correlated with subsequent population growth ($r = 0.79$).

Livestock forage removal was not correlated with pronghorn condition or population parameters. Initial data from paired exclosures on the study area (Ritchie and Wolfe 1994) suggests time controlled grazing by cattle may actually maintain or increase long-term forb availability in sagebrush steppe when compared to exclosures grazed by wildlife only. Cattle grazing reduces grass biomass, and presumably reduces competition for moisture between grasses and forbs. Our data also indicate that summer forage biomass and quality are dependent on precipitation and temperature.

F:D ratios were positively correlated with prior-year April-September precipitation. Buck harvest weights were negatively correlated with April-July mean temperature. These relationships support the theory that the combined effects of growing-season precipitation and temperature influence not only soil moisture and evapotranspiration, but affect forage availability, pronghorn condition and population dynamics as well.

Preference of BS, MDW and SNS; and avoidance of SC and DNS by doe-fawn groups during summer suggests females with young selected forb-rich areas having good visibility (low shrub height). Both perennial forb cover and F:D ratios were three times greater in SNS than SC dominated areas (Tables 1 and 2). Buck-only groups used BS and SC more than available, but used forb rich MDW and SNS less than available in summer. It appeared that buck-only groups did not select forb-rich areas as did doe-fawn groups, or (more likely) that buck-only groups avoided areas patrolled by territorial bucks.

DNS was avoided by both male and female pronghorns. Nearly 70% of the DNS type had slopes > 30% or was dominated by dense sagebrush > 50 cm in height. Pronghorn avoided these steeper, tall shrub dominated areas as has been reported elsewhere (Amstrup 1978, Yoakum 1980). Within the DNS type were two forb-rich burns (burned in 1994) and two large (> 150 ha) areas which were disked and reseeded to a mixture of grasses, perennial forbs and shrubs in 1994. Although seldom used by pronghorn prior to treatment, these four areas were consistently used by territorial bucks and doe-fawn groups during the summer of 1995, suggesting that removal of the tall shrub component and stimulating forb growth attracted lactating does and territorial bucks.

Pronghorn consistently selected BS year-round. Abundant forbs and low-growing shrubs apparently provide an optimum mix of forage and security during all but the deep snow periods.

SC appeared to provide adequate winter habitat for pronghorn but was not preferred by females in summer. SC had significantly less perennial forbs than all other types. Crested wheatgrass begins growing earlier in the spring and at cooler temperatures than most of the native species on the study area. It is presumed this early growth initiation provides crested wheatgrass a competitive advantage in obtaining moisture, thereby reducing establishment, vigor and diversity of later-growing native herbaceous species. Although annual forbs can be abundant in SC stands during years with above average moisture, they are sparse in dry years. Perennial forbs are generally lacking in SC stands.

Our data suggests winter snow depth decreases pronghorn condition and population growth, likely by increasing energy demand and decreasing available winter forage. Pronghorn selected BS and SNS during most winters, since these areas generally offered adequate sagebrush and the lowest snow depths on the study area.

Table 4. Available moisture, dry matter protein and metabolizable energy estimates from herbaceous forage samples collected at 12 sample sites, mid-July, 1993 and 1994. Deseret Land and Livestock study area.

Year	Precipitation (cm)	Temperature (°C)	Percent Moisture	Percent Crude Protein	Percent Total Digestible Nutrients (TDN)
1993	17.6	10.4	54.5	11.1	68.7
1994	7.7	12.9	38.6	5.3	60.0

During the deep snow winter of 1992-93, pronghorn sought areas with reduced snow depths, regardless of sagebrush availability. These areas included plowed roads and cattle feedrows. It is possible that northern pronghorn herds historically migrated and wintered with large herbivores such as elk (*Cervus elaphus*) or bison (*Bison bison*) in response to deep snow (J. Yoakum, pers. comm.). In an effort to reduce mortality, we created a series of hard-packed trails using a snow-cat on the pronghorn winter range during February of 1993 (snow depth > 35 cm). Our goal was to increase access between the remaining uncovered pockets of sagebrush. Within 12 hours of packing the trails, nearly all pronghorn in the vicinity were utilizing the trails and moving to new feeding areas.

Although LOG coyote abundance was negatively correlated with same-year F:D ratios ($r = -0.58$) and coyotes undoubtedly predated some portion of the annual fawn production, this analysis suggests fawn survival was more strongly influenced by pronghorn density and summer precipitation than by predation. Beale and Smith (1970) noted a positive correlation between fawn production and prior year precipitation. They suspected that precipitation influenced forage quality and thereby, doe condition and subsequent fawn production.

Although the number of pronghorn harvested annually was negatively correlated with population growth, population growth was more strongly correlated with density and snow depth. The effects of density and climate observed in this study are similar to those reported by Pyrah (1987) in the Yellow Water Triangle area, Montana. Pyrah noted that doe pronghorn bands inhabiting home ranges in poor range condition produced fewer fawns. Pyrah felt that adult female density largely determined population growth, production and size.

Management Implications

This analysis suggests that pronghorn condition, fawn survival, and population growth are limited by winter severity and intraspecific competition for forage. Forage availability (summer forbs and winter browse) differs between vegetation types and years, due to differences in plant species composition and interannual variation in precipitation and temperature. Management practices which effectively increase or prolong forb availability may increase population growth and size. In colder, northern climates subject to deep snow, long-term population size may ultimately be dependent on pronghorn carrying capacity during severe winters. In situations where migration to snow-free areas has been blocked due to increased human development, management strategies aimed at increasing winter survival on non-traditional wintering areas may be necessary. Utilizing machinery or large herbivores to open trails and pack snow may increase winter pronghorn survival by reducing energetic demands and increasing shrub availability.

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PRELIMINARY RESULTS FROM A RADIOTELEMETRY STUDY OF PRONGHORN ANTELOPE AT DUGWAY PROVING GROUND, UTAH

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Abstract: A preliminary investigation of pronghorn (*Antilocapra americana*) habitat use was initiated at Dugway Proving Ground in 1994. Six pronghorn were radio collared in 1994; four were collared 1995. A total of 180 locations was collected from seven different habitats. Locations were plotted on 7.5 minute USGS topographic maps. UTM coordinates were derived from GRASS (Geographic Resources Analysis Support System). These locations were overlaid onto a vegetation map for habitat analysis. Most locations were taken from cheatgrass and shadscale-gray molly habitat (35.5% and 45%, respectively). The null hypothesis of availability and use occuring in the same proportion was rejected (Marcum-Loftsgaarden Habitat Analysis, $\chi^2 = 82.59$, table value = 16.9, $P = 0.05$). The majority of locations were within 400 meters of paved and dirt roads (68%). Animals tended to use areas close to roads and buildings ($\chi^2 = 301.94$, table value = 9.48, $P=0.05$) more than expected. Pronghorn tended to browse in irrigated areas near buildings and in rights-of-way along roads where mowing stimulated plant growth.

Key words: *Antilocapra americana*, pronghorn, Utah, habitat use, GRASS, chi-square.

Pronghorn Antelope Workshop Proceedings 17:42-44

INTRODUCTION

Recent increases in the pronghorn antelope population at Dugway Proving Ground (DPG) have necessitated baseline studies of seasonal movements, identification of key winter and summer ranges, and habitat use. Information on pronghorn history at DPG is meager. A 1967 document stated that there were 15 pronghorn on post (US Army Dugway Proving Ground 1967). Stamm (pers. comm.) reported winter counts of 190, 210, and 230 in 1990, 1991 and 1992, respectively. This rise in population, along with fears of pronghorn/aircraft collisions, led to three consecutive years of hunting to decrease the population. Winter counts in 1996 indicated a population of 175 animals. In this report we state our findings on the habitat use of pronghorn antelope at DPG. Field assistance was provided by S. Osowski, D. Jensen, S. Handrik, and C. Colerich.

STUDY AREA

The study was conducted at Dugway Proving Ground (DPG), a US Army installation within the Testing and Evaluation Command (TECOM). Dugway Proving Ground is located 130 km (80 miles) southwest of Salt Lake City, Utah. The primary mission of the installation is to test chemical and biological defenses. Smoke and obscurant testing is also performed at DPG. The Utah National Guard and other Guard units train at DPG. Their exercises include communications, combat readiness, artillery, and deployment.

Habitats were classified for this study as (in decreasing order of acreage) pickleweed, barren salt flats, annual weeds, mixed brush, shadscale-greasewood, shadscale-greasewood-grey molly, juniper, vegetated dunes, greasewood, shadscale, and active dunes. Annual weed cover at DPG is increasing with every incidence of fire.

Dugway Proving Ground lies within the Basin and Range Physiographic Province and is characterized by a lack of exterior water drainage. The main topographic features of the vicinity, running generally north to south, are rugged, fault block mountains with fairly level intervening valleys. The largest activity area of Dugway Proving Ground (testing areas) is at an elevation of 1300 m in Dugway Valley. The housing area (elevation 1524 m) is at the southern end of the Cedar Mountains (maximum elevation 2522 m). Dugway Proving Ground is in a middle-latitude, dry climate region; it is characterized by a hot, dry summer, a cool spring and fall, a moderately cold winter, and a general year-round lack of precipitation. The valley floors receive sparse precipitation. There is wide variation of precipitation from year to year and month to month. Average annual precipitation is 17.6 cm, occuring mostly in December, April and May.

METHODS

Six animals were radiocollared in August/September of 1994; four animals were collared in August/September 1995. Animals were netgunned from roadsides from a moving vehicle. Crews of 2-3 people would restrain the animal; a towel was placed around the eyes to help calm the animal down. A Telonics MOD-500 transmitter was fitted around the neck. Locations were taken daily for each animal during August and September. After September field crews were dismissed and the number of locations recorded dropped to once or twice monthly.

Locations were plotted in the field on USGS seven-minute topographic maps. Locations were replotted on GRASS (Geographic Resource Analysis Support System) to derive UTM coordinates. Vegetation types were ground-truthed. The personal computer program RANGES was used to analyze home ranges of each animal. The outer convex polygon method was used to calculate home range size.

The Marcum-Loftsgaarden habitat analysis (Marcum and Loftsgaarden 1980) was used to test the hypothesis that pronghorn are using each habitat category in proportion to its occurence in the total area. The 'random' command within GRASS was used to produce 170 random locations across a vegetation map of the study area (Vest 1962). This map was revised to show areas now dominated by cheatgrass (*Bromus tectorum*).

The 'random' command procedure was run to analyze pronghorn locations relative to paved and unpaved roads. The GRASS 'buffer' command was used to create concentric distance classes of 0-399 m, 400-799 m, 800-1199 m, 1200-1599 m, and any location over 1600 m. Because of the small number of locations, paved and unpaved road locations were pooled.

RESULTS

Table 1 shows the home range sizes for all of the animals collared in this study. Mean home range size was 9,448.94 ha, with a standard deviation of 1,687.72 ha. The two largest home ranges belonged to animals that moved to the traditional wintering area for pronghorn on DPG. The results of the Marcum-Loftsgaarden habitat analysis are shown in Table 2. Most of the habitats were used in proportion to their availability. The juniper, pickleweed, and dune habitats were avoided. The only habitat used more than in proportion to its availability was the shadscale-grey molly habitat. Table 3 exhibits results of the road use analysis. There was no linear pattern of pronghorn use relative to distance from a road. Distance class I (0-399 m) was utilized twice as much as expected. Other distance classes (III and V) were used less than expected.

Table 1. Mean home range sizes[a] of radiocollared pronghorn antelope.

Animal #	Date Collared	Home Range Size *(ha)*	Number of Locations
710	9/94	8386.09	51
681	9/94	111.77	7
670	8/94	27362.54	34
660	9/94	4586.50	30
640	9/94	3157.09	10
520	9/94	358.70	6
730	9/95	4225.38	19
740	9/95	11443.61	19
750	9/95	19727.00	20
771(male)	8/95	6040.95	22

[a]Home ranges were calculated using the outer convex polygon method

Table 2. Marcum-Loftsgaarden habitat analysis[a].

Habitat Type	Observed # of Locations	Expected # of Locations	Bonferroni 90% CI	Use vs. Availability
Shadscale/Grey Molly/Greasewood	18	19	(.08)-(-0.05)	In Proportion
Greasewood	1	4	(.043)-(-0.009)	In Proportion
Shadscale	4	1	(.0092)-(-0.043)	In Proportion
Mixed brush	4	2	(0.01)-(-0.043)	In Proportion
Cheatgrass	64	69	(0.13)-(-0.07)	In Proportion
Shadscale/Grey Molly	81	22	(-0.22)-(-0.41)	Used more
Active Dunes	0	7	(0.002)-(0.05)	Avoided
Vegetated Dunes	9	31	(0.19)-(0.06)	Avoided
Pickleweed	0	15	(0.04)-(0.12)	Avoided
Juniper	0	10	(0.03)-(0.04)	Avoided

[a]Chi-square indicated use differed from availability between habitats ($\chi^2 = 82.59$, 9 df, $P < 0.05$).

Table 3. Bonferroni simultaneous confidence intervals[a] for avoidance-selection of pronghorn locations relative to paved and unpaved roads.

Distance Class (m)	Observed # of Locations	Expected # of Locations	Bonferroni 90% CI	Use v. Availability
0-399	121	61	(-0.37)-(-0.14)	Used More
400-799	49	42	(0.10)-(-0.09)	In Proportion
800-1199	16	37	(0.08)-(0.19)	Used Less
1200-1599	6	15	(0.10)-(0.0027)	In Proportion
1600+	2	12	(0.10)-(0.01)	Used Less

[a]Chi-square indicated use differed from availability along roads (χ^2=301.94,4df,P<0.05.

DISCUSSION

Pronghorn generally avoided vegetated dunes. Pronghorn occasionally used vegetated dunes as resting and feeding habitat. Even though no locations were taken from pickleweed, juniper, and active dune habitats, the animals do travel through pickleweed 'flats' between winter and summer ranges. Animals have been seen resting beneath scattered juniper (*Juniperus osteosperma*) trees. Pronghorn seem to be using juniper habitat for resting during hot summer days (pers. comm. Steve Boyle).

Pronghorn preference for shadscale/grey molly habitat may be a statistical artifact of this study. The West Desert Test Center serves as a gathering area for much of the pronghorn population at Dugway as it provides limited shelter from coyotes (*Canis latrans*), and provides sources of food and water. The surrounding habitat is primarily shadscale/grey molly. Further research is needed to test the significance of this habitat.

Pronghorn use of roadsides is influenced by seasonal vegetation growth. As natural forage dries out in late summer and early fall, the most succulent forage is located on mowed roadsides. Other than the morning and early evening commuter traffic 'spikes,' vehicular traffic is sporadic. The pronghorn population has a high tolerance of traffic disturbance.

The tendency for this population to use areas within 400 m of roads does not contradict the findings of Ockenfels et al. (1994) that pronghorn tended to slightly avoid areas within 400 m of a road. That study included impacts from heavily traveled highways.

A more extensive study of DPG's pronghorn population will began in March 1996, and will examine habitat utilization, seasonal movements, and diet preferences of pronghorn and feral horses (*Equus caballus*).

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NATIONAL PRONGHORN RECOVERY PLAN FOR MEXICO

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Abstract: Considering the circumstances of the three native pronghorn subspecies in Mexico (*Antilocapra americana mexicana*, *A. a. sonoriensis* and *A. a. peninsularis*), the species is endangered. The subspecies *mexicana* was distributed in a great portion of the Mexican Plateau, including portions of the United States. *Sonoriensis* mainly occupied northeast Sonora and southwest Arizona. The only subspecies endemic to Mexico (*A. a. peninsularis*), was found in the Baja California Peninsula. Habitat occupied by these subspecies has drastically diminished in Mexico. *Mexicana* can only be found on some ranches in Chihuahua where they are in separate herds isolated by fences. *Sonoriensis* and *peninsularis* are only reported in the "El Pinacate" region and in the Vizcaino Desert, respectively. Translocation of a fourth subspecies (*A. a. americana*) to Mexico has occurred on at least three occasions. There are some gaps in the biology and ecology information of the desert pronghorns (*A. a. peninsularis* and *A. a. sonoriensis*). Pronghorn protection in Mexico started in 1922 with the establishment of a closed season, in force even now. In 1988 the Vizcaino Desert was declared a Biosphere Reserve; it included all habitat currently occupied by *A. a. peninsularis*. In a similar way, "El Pinacate" was declared a Biosphere Reserve, including the entire area occupied by *A. a. sonoriensis*. Preparation of a National Pronghorn Recovery Plan for Mexico is proposed, with the main objective of species recovery and removal from the protected species list. The proposed National Pronghorn Recovery Plan will include: a general description of the species and its habitat; historical management actions during the last 25 years; general and specific objectives; a strategy for fulfilling objectives; and projects that are in development at present. A multi-disciplined group, with legal, management, and technical /academic capabilities is needed to prepare and implement the recovery plan, hopefully with minimal influence from political dynamics.

Key words: Mexican subspecies, recovery plans, international collaborative projects

Pronghorn Antelope Workshop Proceedings 17:45-49

HISTORICAL BACKGROUND

Each native pronghorn subspecies in Mexico (*Antilocapra americana mexicana*, *A. a. sonoriensis*, and *A. a. peninsularis*) occupies a different habitat. All are classified endangered by the federal goverment (Secretaria de Desarrollo Social 1994) and internationally (International Union of Conservation and Nature 1996). The subspecies *mexicana* was historically distributed over a large portion of the Mexican Plateau and in Texas, New Mexico and Arizona. *Sonoriensis* occupied northeast Sonora, Mexico and southwest Arizona.. The only subspecies entirely within Mexico is *peninsularis* in the Baja California Peninsula (Figure 1). In general, the habitat and population of the three subspecies has drastically diminished in Mexico (Gonzalez-Romero and Lafon-Terrazas 1993). *Mexicana* is presently found only on private ranches or fenced lands of Chihuahua, Mexico where they are fragmented in isolated herds. *Sonoriensis* is presently limited to the "El Pinacate" Reserve (Secretaria de Desarrollo Social 1993) and nearby (Castillo 1993). *Peninsularis* is currently restricted to the Vizcaino Desert in Baja California Peninsula, Mexico (Cancino et al. 1995).

There have been at least 3 translocations of *A. a. americana* to Mexico with limited success. Quiñones (1979) refered to a translocation event in 1967 to Tiburon Island, but did not identify the subspecies or origin of the animals. Alcerreca and Sánchez (1979, 1981) described the experimental management for a herd of 52 pronghorn translocated from New Mexico to San Luis Potosi. This translocation is the most documented (Alcerreca and Sánchez 1979, Ramírez 1985, Palacio 1991). Thompson-Olais (1994) noted a translocation of *A. a. americana* from Colorado, U.S.A. to Sonora, Mexico.

Some gaps in biological and ecological information related to *A. a. sonoriensis* and *A. a. peninsularis* include water requirements, diet selection and competition, and

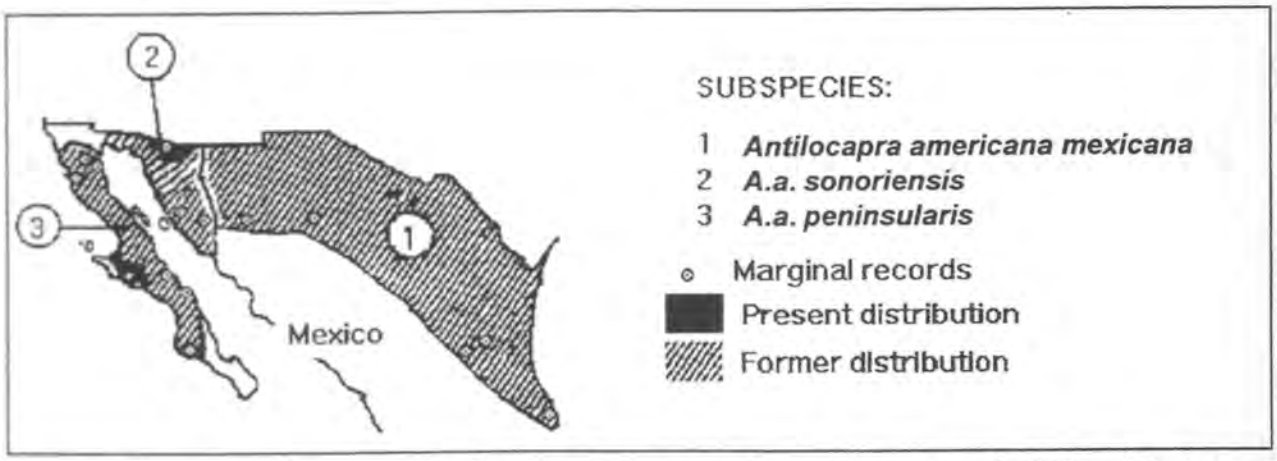

Figure 1. Former and present distribution of the pronghorn subspecies inhabiting Mexico (Modified from Sundstrom et al. 1973, and Hall 1991).

genetic status. Some of these informational needs are currently (1996) being studied. There is an experimental project in Baja California Sur currently in progress involving the transfer of embryos to obtain a greater number of fawns per year.

Recovery Plan Development

Regulations to protect pronghorn in Mexico were established in 1922 with a closed hunting season, which is still in place (Secretaria de Agricultura y Fomento 1922, Secretaria de Desarrollo Social 1994). In 1988, the Vizcaino Desert in Baja California Sur was declared a Biosphere Reserve (Secretaria de Desarrollo Urbano y Ecologia 1988). It includes almost the entire current habitat of the peninsular pronghorn. In a similar way, "The Pinacate" was declared a Biosphere Reserve (Secretaria de Desarrollo Urbano y Ecologia 1993) and includes some areas occupied by Sonoran pronghorn. In the lists of protected species (Secretaria de Desarrollo Social 1994) and in the Hunting Season Schedule (Calendario Cinegético 1997), the species is included in the endangered species group.

The proposed "National Pronghorn Recovery Plan" includes:

- General description of all 3 subspecies and their habitat;
- A summary of management actions during the last 25 years;
- General and specific management objectives;
- General strategy to fullfill the objectives; and
- Specific planned projects.

The general description of the species and its habitat would be based on O'Gara and Yoakum (in prep.) and augmented with additional information from studies conducted in Mexico. The actions and projects developed in the last 25 years were summarized by Ramirez et al. (1998) in a lecture at the 18th Pronghorn Antelope Workshop.

The current main objective of the National Pronghorn Recovery Plan is to allow all subspecies to increase in number and to protect their habitat, thereby working towards delisting each as endangered. An element of recovery includes reintroduction to areas known to be historical habitat. Once this is achieved, appropriate consumptive and nonconsumptive uses will be identified in new plans for sustained populations.

As part of the general strategy, the following will be included in the National Pronghorn Recovery Plan:

a) Biological surveys of the species
b) Demographic census
c) Studies with radio telemetry
d) Translocation of herds from the United States
e) Hand rearing of fawns
f) Captive management
g) Reintroduction of subspecies within Mexico
h) Development of information for the public.
i) Monitoring, evaluation meetings, and reports.

Some 27 state and federal agencies and conservation organizations in Mexico and the United States have been involved in restoration endeavors. However, greater participation is required. Baja California Sur, Sonora, Coahuila, and Chihuahua are the states in Mexico where restoration programs are in development (Figures 2 and 3).

A multi-disciplined group with legal, management, and technical-academic capabilites is needed to allow the Plan to develop with minimal influence from political dynamics. For this purpose, a team of counselors, advisors, researchers, and technicians is going to be formed to help develop the different projects that comprise the Plan (Figure 4). This group will first need to raise funds. The development of any component of this Plan will provide a chance to train human resources at different academic levels.

GENERAL PLAN TO PRESERVE AND INCREASE
THE POPULATION OF PRONGHORN IN MEXICO

Federal Government | Non Government Organizations | Academic Institutions | Private Sector

+ SEMARNAP - INE. SEDENA
+ Unidos para la Conservación. DUMAC.
+ Universidad Nacional Autónoma de México. Universidad Autma de Chihuahua. Centro de Investigaciones Biológicas del Noroeste.
+ Rancho "Las Mesteñas". Cia. Exportadora de Sal. Ford Motor Co. Altos Hornos de México.

INTERNATIONAL SUPPORT

+ U. S. Fish and Wildlife Service
+ Arizona Game and Fish
+ North American Pronghorn Foundation

Figure 2. Sectors, organizations, and universities involved in the Mexican General Plan for the pronghorn.

GENERAL PLAN TO PRESERVE AND INCREASE
THE POPULATION OF PRONGHORN IN MEXICO

Baja California Sur | Coahuila | Chihuahua | Sonora

+ Monitoring and protection
+ Translocations
+ Difusion and environmental education
+ Animals and habitat management
+ Research

+ Marking and monitoring
+ Population surveys
+ Capture and rearing of fawns
+ Genetic studies
+ Reproduction assisted

Figure 3. States and some aspects considered in the Mexican General Plan for the pronghorn.

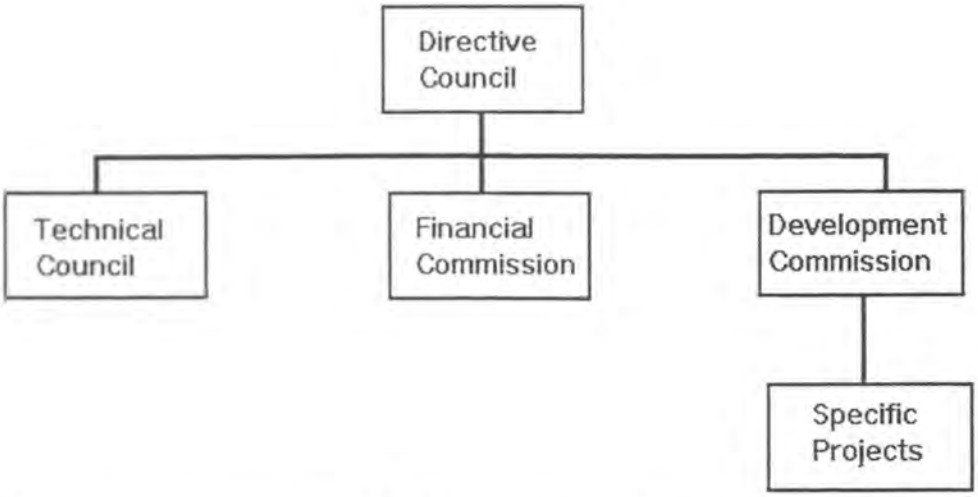

Figure 4. Organization proposed for the National Pronghorn Recovery Plan group.

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PRONGHORN FAWNING DATES IN ARIZONA

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

Key words: *Antilocapra americana*, Arizona, climatic zones, fawning dates, habitat, neonate, pronghorn, spring green-up.

Pronghorn Antelope Workshop Proceedings 17:50-55

INTRODUCTION

Recruitment of young animals into a population offsets mortality losses. Recruitment is a indicator of population health and suggests how much annual mortality a population can endure and may also be an indicator of habitat condition (Schemnitz 1980).

Monitoring recruitment helps develop habitat and harvest management strategies to best sustain a healthy population. Arizona pronghorn populations are surveyed annually to estimate recruitment based upon a fawn to doe ratio (Arizona Game and Fish Department 1995). Such surveys should be conducted at a time when all age groups are detectable to accurately census populations (Schemnitz 1980).

Pronghorn survey results can be affected by the age and pelage of fawns. The anti-predator behavior of neonate (<3 weeks old) pronghorn fawns virtually renders them undetectable until they join nursery herds. Nevertheless, the majority of fawn mortality occurs within the neonate stage (Beale and Smith 1973, Barrett 1978, Von Gunten 1978, Yoakum 1978, Tucker and Garner 1980, Autenrieth 1982, Ockenfels et al. 1992). In addition, pronghorn fawns acquire adult-like pelage by 3 months of age (Yoakum 1978), thereby affecting accurate classification. Therefore, to optimize efficiency, pronghorn fawns should seemingly be surveyed after they joined nursery herds and before they acquire adult-like pelage; this occurs when fawns are between 4-12 weeks of age.

Furthermore, surveys should be standardized to a time to best assess demographic changes across their distribution. To best determine when to properly conduct surveys, it is important to know the peak and duration of pronghorn fawning.

Yoakum (1978) noted that pronghorn fawns were generally born during May-June, but a literature review and our field observations showed much greater variation in fawning dates within and among states. Fawn production in northern states typically occurred during a 2 month time slot, whereas some southwestern states had a 3.5 month time slot (Figure 1). Thus, fawning dates varied most dramatically in the Southwest.

Peak fawning ranged from March-April in the lowest elevations of southwestern Arizona (deVos 1990), in April-June in central Arizona (Ticer and Miller 1994, Ticer In Prep.), to May-June in northern Arizona (J.L. Bright, Northern Arizona Univ., unpubl. data) (Figure 2). In our review, the earliest documented fawning dates we found occurred in January on the Baja Peninsula, Mexico (Murphy 1917), and in February in Texas (Lehmann and Fuller 1943) and southwestern Arizona (deVos 1990).

We hypothesized that variation in fawning dates may be due to differences in environmental and climatic parameters which result in changes in early spring green-up. Ellis (1970) documented the importance of early spring green-up when he attributed increased fawn survival to an abundance of nutritious grasses and forbs during late gestation and early lactation. Factors affecting early spring green-up likely include seasonal distribution of precipitation, air temperature, and photoperiod, and local factors such as elevation, latitude, terrain, and soil features (Daubenmire 1974).

This study was initiated to determine if any of these aforementioned variables can be used to predict fawning dates in Arizona. Our objective was to determine if fawning dates truly differed by location in Arizona and, if

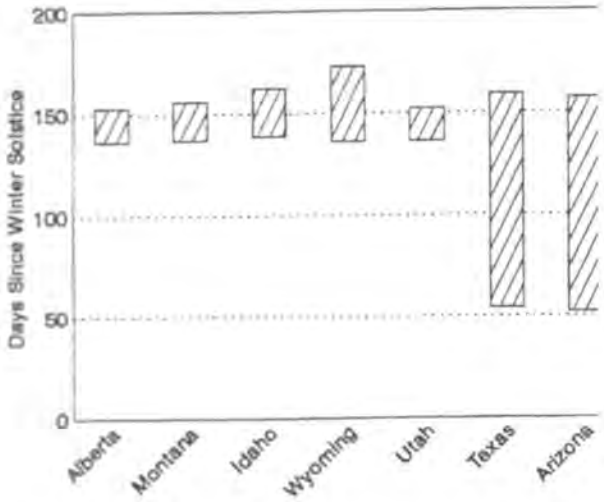

Figure 1. Range of pronghorn fawning dates in North Amercia.

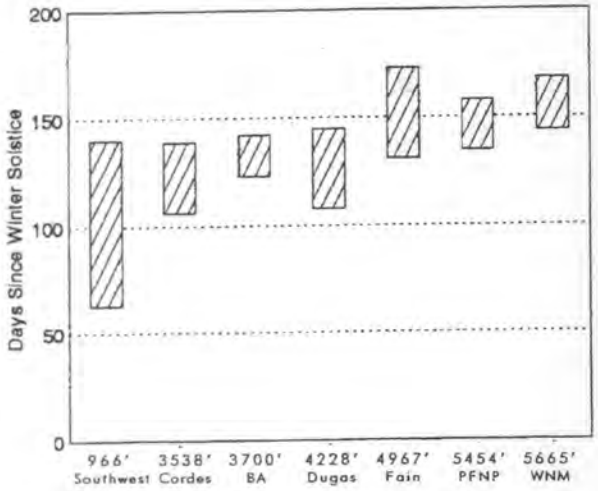

Figure 2. Range of pronghorn fawning dates with increasing elevation in Arizona.

so, which variables best predict mean fawning dates in Arizona. Arizona fawning dates we collected were supplemented by data from the following:

- J. L. Bright, Colorado Plateau Research Station, Northern Arizona Univ., for Wupatki National Monument (WNM) and Petrified Forest National Park (PFNP) in northern Arizona
- P. Landin, for Buenos Aires National Wildlife Refuge (BANWR) in southern Arizona
- J.J. Hervert of Arizona Game and Fish Department (AGFD) in Yuma, for Sonoran pronghorn data in southwestern Arizona.

Funding for this study was provided by Federal Aid in Wildlife Restoration Act Project W-78-R.

STUDY AREAS

Northern Arizona

Northern Arizona fawn dates were obtained from semidesert grasslands, open woodlands, and forests of WNM (elevations of 1,300-2,186 m) and from the semidesert grasslands of PFNP (elevations of 1,603-1,676 m). Climates of WNM and PFNP were mild with monthly average temperatures above freezing and with approximately 19 cm and 22 cm of annual rainfall, respectively (Sellers and Hill 1974). These areas also had vegetation typical of a warm-temperate grassland. However, some of the higher elevation fawn locations at WNM were from juniper (*Juniperus* spp.) and ponderosa pine (*Pinus ponderosa*) savannahs and woodlands.

Central Arizona

Most of the field data collected in central Arizona was during investigations of pronghorn fawn bed site selection (Ticer and Miller 1994, Ticer In Prep.). This area encompassed 1,367 km^2 of desert areas near Black Canyon City to the montane coniferous forest of Mingus Mountain.

Elevation was 950-1,700 m in most of the area. Most of the fawning data were obtained from semidesert grasslands (elev. of 975-1,400 m) and short-grass prairies (elev. of 1,494-1,555 m) within this area. Climate was mild, with monthly average temperatures above freezing and average annual rainfall of 34-42 cm in the semidesert grasslands and 33 cm in the short-grass prairie (Sellers and Hill 1974).

The short-grass prairie was dominated by cold-temperate species, including grama (*Boutelloua* spp.) grasses, and shrubs such as snakeweed (*Gutierrezia sarothrae*), saltbush (*Atriplex* spp.), cholla cacti (*Opuntia* spp.), beargrass (*Nolina microcarpa*), and buckwheat (*Eriogonum* spp.). Semidesert grasslands were dominated by warm-temperate species, including tobosa (*Hilaria mutica*) and curly mesquite (*H. belangeri*), cholla and prickly pear (*Opuntia* spp.), and catclaw acacia (*Acacia gregii*) and buckwheat.

South-Central Arizona

South-central fawn locations were obtained from the tropical-subtropical grasslands of BANWR (elevation 1,128 m). The climate was mild with monthly average temperatures above freezing and with 43 cm average annual rainfall. This warm-temperate grassland was invaded by Lehman's love grass (*Eragrostis lehmanniana*), but some native grama grasses, including black grama (*B. eriopoda*), blue grama (*B. gracilis*), hairy grama (*B. hirsuta*), sideoats grama (*B. curtipendula*), spruce-top grama (*B. chondrosioides*), slender grama (*B. filiformis*), curly mesquite, and some 3-awns (*Aristida* spp.), remained in scattered locations. Mesquite (*Prosopis* spp.) was scattered throughout the refuge.

Southwestern Arizona

Southwestern fawn locations were from Sonoran desert scrub, Lower Colorado River Valley subdivision, communities (Brown 1994) on the Barry M. Goldwater Gunnery Range (BMGGR; elev. 150-200 m), the Cabeza Prieta National Wildlife Refuge (CPNWR; elev. 250-525 m), and the Organ Pipe National Monument (OPNM; elev. 325-500 m). Within this arid subdivision of the Sonoran Desert, areas were characterized by open and simple plant life (Brown 1994). Monthly average temperatures for this extremely arid environ were always above freezing; average annual precipitation of BMGGR was only 8 cm, whereas the higher elevations of CPNWR and OPNM were 23 cm.

The BMGGR was dominated by creosote (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*). The CPNWR was also predominately creosote and white bursage, but had many areas of palo verde-mixed cacti. The OPNM was vegetatively similar to CPNWR, but its slightly higher elevations produced a more dense and diverse vegetative community, where palo verde (*Cercidium floridum*), mesquite, and saguaro (*Carnegiea gigantea*) were prevalent species.

METHODS

We compiled fawning dates from field studies in 7 different areas in Arizona; 2 in northern, 3 in central, 1 in south-central, and 1 in southwestern Arizona (Figure 3). Based on similar elevations, we combined 9 sub-areas of central Arizona into 2 areas called Dugas and Cordes. One-way analysis of variance (ANOVA) and a Bartlett-Box F were used to determine if these 2 areas were from the same population. Similarly, the 3 sub-areas of southwestern Arizona were tested as 1 area. Data from the closest national weather station were used to determine mean date of last freeze, mean annual and monthly precipitation, and mean minimum spring air temperature for each area.

To avoid problems encountered with circular data (i.e., calendar dates), fawning dates were first converted to julian dates (number of days since January 1), then we added 11 days to get back to winter solstice. We used number of days since winter solstice for analyses because they depict increasing photoperiod (day length) and are linear data.

Fawn birth dates were determined by backdating from the estimated fawn ages. Other variables used in analyses included: elevation and latitude taken at fawn locations; the average annual winter (December to February), summer (June to August), and spring (March to May) precipitation levels; mean minimum spring air temperature for 1941-1970; and the average date of the last freeze (Sellers and Hill 1974). Additionally, the mean number of frost-free days at each area was determined according to the climate zone from Sunset Western Garden Book (Hogan 1992).

We used means of all variables for testing. First, we tested mean fawn birth dates (i.e., days since winter solstice) for normality using a Kolmogorov-Smirnov Goodness of Fit test; ANOVA was then used to test for differences among areas. We used linear regression to determine the contribution of each variable to predict mean fawning dates in Arizona. Lastly, we used a correlation test to determine which variables were correlated, then used multiple regression to examine relationships between mean fawn birth dates and non-correlated variables.

RESULTS

We acquired data from 121 fawn locations within the 7 different areas of Arizona from February to June of 1990 through 1996. Mean fawn birth dates were normally distributed ($P = 0.68$). We found that the 7 areas differed ($F = 37.22$, $P < 0.001$) in mean birth date. Linear regression resulted in strong relationships of mean fawn birth date with mean elevation ($r^2 = 0.95$, $P < 0.001$), average number of frost-free days ($r^2 = 0.87$, $P = 0.002$), mean minimum spring air temperature ($r^2 = 0.84$, $P = 0.011$), and average date of last freeze ($r^2 = 0.71$,

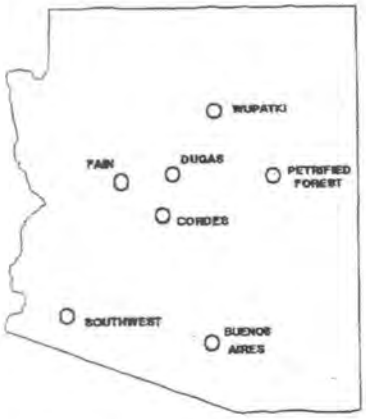

Figure 3. Locations where fawning dates were collected in Arizona.

Table 1. Simple correlation matrix[a] of variables used to test factors affecting pronghorn mean fawning dates in Arizona.

Variables	Elevation	Latitude	Annual Ppt.	Summer Ppt.	Winter Ppt.	Spring Ppt.	Date of Last Freeze	Number Frost-Free Days	Min.Spring Air Temp
Elevation									
Latitude	0.7464								
Annual ppt.	-0.144	-0.5827							
Summer ppt.	-0.0611	-0.6402	0.9180*						
Winter ppt.	-0.3093	-0.5944	0.9636**	0.8015					
Spring ppt.	-0.006	-0.4477	0.9639**	0.9202*	0.8972*				
Date of last freeze	0.8569	0.6956	-0.0372	-0.0582	-0.1788	0.1092			
Number frost-free days	-0.9850**	-0.78	0.18	0.0942	0.3457	0.0099	-0.9010*		
Min. spring air temp	-0.9263*	-0.715	-0.0204	0.0008	0.1205	-0.1597	-0.9756**	0.9422**	

[a] One-tailed significance: * = 0.01; ** = 0.001.

$P = 0.017$). Latitude and precipitation values individually accounted for <50% of the variability in mean fawning dates.

Most variables were correlated at $P = 0.01$ (Table 1). Next, we tested mean elevation with non-correlated variables to develop multiple regression models that better predict mean fawning dates. We produced 2 models with mean elevation as a base: latitude ($r^2 = 0.99$, $F = 158.68$, $P < 0.001$) and mean summer precipitation ($r^2 = 0.99$, $F = 206.03$, $P < 0.001$) contributed substantially more information.

DISCUSSION

Ellis (1970) noted that adequate green-up during a pronghorn's late gestation and early lactation period resulted in increased fawn survival. Combinations of environmental and climatic factors likely act in unison to trigger the onset of early spring green-up. Sunsets Western Garden Book (Hogan 1992) refers to several factors that interact to produce western plant climate zones. These are latitude, elevation, influences of the Pacific Ocean and continental air mass (which control moisture and air temperature trends), mountains and hills, and local terrain—which has its major effects on the cold air and frosts of fall, winter and spring. Simply, the climate of a specific area is the result of latitude, air temperature, precipitation and elevation. Further discussion of these factors helps interpret our results.

Latitude

Light is the energy to sustain life, and plants capitalize on this energy source (Daubenmire 1974). The amount and season of light energy available is determined by latitude and air temperature, and plant assimilation is greater when air temperatures are high and day length is long. Air temperature and photoperiod compliment each other, such that while air temperature decreases from the equator, photoperiod increases. It seems that suitable intensities in one compensate for deficiencies in the other.

This phenomenon partially explains why the range of fawn birth dates in the northern states is shorter than in southern states. While the northern states experience colder air temperatures than southern states, day length is longer, and once summer air temperatures are warm enough, plant germination occurs. However, adequate warm air temperatures of northern states are of relatively short duration. Born too early, a fawn freezes, born too late, it succumbs to the winter because it is too small. Conversely, in summer, southerly states do not have as long of day length as northern states, but they have sufficiently warm air temperatures sooner and for a longer period. Overall, pronghorn in northern states must fawn

within a narrower window as opposed to pronghorn in the southern U.S.

We did not find a strong independent relationship of mean fawning dates with latitude, but latitude tested in conjunction with elevation helped explain more variability. We suspect that range of latitude within Arizona may not have been sufficient to detect a relationship that probably occurs over a wider band. Over a narrow band, elevation had a substantially greater impact that did latitude.

Air Temperature

The number of frost-free days, minimal spring air temperature, and date of last freeze each explained considerable variability in mean fawning dates in Arizona. All reflect air temperature. Plant germination, or spring green-up, must fall within the frost-free part of the year (Daubenmire 1974). Southern states have a longer growing period than northern states due to more frost-free days, a direct result of warmer air temperatures. Within Arizona, the number of frost-free days differs substantially by area according to elevation and latitude. For example, pronghorn fawning in southwestern areas was likely earliest because of earlier warmer air temperatures and an earlier growing season. Additionally, air temperature may be the result of localized elevation and topographic differences within areas. However, this seemingly has little effect on peak fawning.

Precipitation

Seed germination is dependant upon seasonal distribution of water, and plants must complete their annual growth and set seed before accumulation of moisture is exhausted (Daubenmire 1974). Most precipitation in the desert grasslands of Arizona occurs bimodally, during winter and summer rains (Sellers and Hill 1974). The severity of evaporative conditions after a rainfall has a bearing upon the duration of favorably moist conditions and, the more cool and humid the environment, the more effective a given amount of rainfall (Daubenmire 1974). Thus, spring green-up in response to winter precipitation is likely to be more predictable and of greater duration for pronghorn fawning season than during the warmer summer season, when high air temperatures greatly increase evaporation.

Our data showed that precipitation alone did not explain significant variability in mean fawning dates in Arizona. However, summer precipitation in conjunction with elevation increased our ability to explain variability. A possible explanation for this is summer precipitation influences onset of doe estrus to ensure proper timing of fawning during spring green-up. Furthermore, summer precipitation may influence spring fawn survivability by providing nutritious foods at a critical time of the cycle for fawns and for does preparing for the next reproduction cycle.

Elevation

Elevation has a local affect on air temperature in which temperature drops 0.5° C for every 100 m rise in elevation (Daubenmire 1974). Since elevation affects air temperature, it directly affects soil temperature and indirectly affects precipitation and moisture loss or retention. It is the predominant factor in local air temperature in the Southwest. Since elevation alone was the best single predictor of mean fawning dates in Arizona and can be taken from most maps routinely possessed, we believe elevation is the most practical variable to predict area-specific, mean fawning in Arizona. The linear regression formula to calculate mean fawn birth date (number of days since winter solstice) of an area in Arizona is:

$$y = 81.24 + 0.0120x$$

where x equals elevation in feet. To determine julian date, simply subtract 11 days, then convert to calendar date.

Management Implications

Predictability of mean pronghorn fawning dates assists resource managers with information to modify common land management practices that negatively affect pronghorn fawning. Pronghorn fawning habitat conditions could be improved by reducing impacts associated with livestock and recreationists during peak fawning season.

The most detrimental resource competition between pronghorn and livestock occurs during fawning season, when both animals prefer early spring green-up (Becker 1972) and livestock removes vegetative cover essential to fawn survival (Autenrieth 1982). O'Gara and Yoakum (1992) suggested a delayed turn-out of livestock until after the pronghorn parturition period. Alternatively, herding of livestock away from traditional fawning areas could assist in alleviating negative repercussions of livestock on fawning pronghorn.

Furthermore, since sheep compete most directly with pronghorn for food sources (Buechner 1950, Hoover et al. 1959, Severson et al. 1968, Hailey 1979), and pronghorn fawns have been known to follow sheep and become separated from does (Einarson 1948), O'Gara and Yoakum (1992) suggested that sheep trailing through pronghorn fawning areas be prohibited 15 days before to 15 days after peak fawning.

There is little information available regarding the impacts of recreationists on pronghorn. However, since does in late gestation and does with fawns are highly reactive to any form of harassment (McNay 1980), pronghorn would likely benefit during fawning season if recreational uses of traditional fawning grounds were limited or restricted.

Predictability of mean pronghorn fawning dates assists resource managers in scheduling and standardizing population surveys for the time of year that best describes pronghorn age structure. Surveys could best be conducted between 4 and 12 weeks following peak fawning, when all

age groups of the population are equally represented. However, up to 6 months is reasonable because mortality typically stabilizes before then.

Lastly, aerial gunning of coyotes could be scheduled for the most effective time period to increase fawn survivability. Coyote control has been correlated with increased pronghorn recruitment (Udy 1953, Hailey 1979, Neff et al. 1985), and Smith et al. (1986) found that coyote control just prior to fawning results in a temporary reduction in coyotes in the immediate vicinity of fawning grounds, a reduction sufficient to improve fawn survival through the first 4-5 weeks.

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RECRUITMENT IN A TRANSPLANTED PRONGHORN HERD BEHIND NET WIRE FENCES

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Abstract: The New Mexico State University, Corona Range and Livestock Research Ranch located in northern Lincoln and southeastern Torrance counties contains approximately 11,330 ha (28,000 acres) of piñon-juniper (*Pinus edulis - Juniperus* spp.) and short-grass prairie. Approximately 60% is prairie and potentially suitable pronghorn (*Antilocapra americana*) habitat. Three pastures on the eastern end of the ranch [approximately 2,830 ha (7,000 acres)] that are used for cattle grazing on a rest-rotation system were chosen for an experimental pronghorn transplant. The vegetation, topography and livestock use were sampled and documented during August 1993. The New Mexico Department of Game and Fish provided the pronghorn (4 adult males, 9 adult females, 3 juvenile males and 4 juvenile females) as part of a large capture and release program in January 1994. One adult doe and 1 fawn doe were injured in transit but were released on site. Both of these animals had been killed by coyotes (*Canis latrans*) by 3 days post-release. Twelve fawns were born in June 1994; 2 were killed by coyotes and an additional doe fawn and yearling male were lost to unknown causes in late October1994. The remaining 26 pronghorn survived the winter and were counted in April 1995. No field counts were made during summer 1995, but 3 additional does were expected to produce fawns in June 1995. A total count was conducted in early November 1995 and 45 pronghorn were present in the study pastures. Sex and age were not determined because 39 pronghorn were in 1 group and they did not remain in view long enough to get an accurate segregation., The remaining 6 animals included 2 adult males, 2 adult females and 2 immature females.

Key Words: pronghorn antelope, New Mexico, *Antilocapra americana*, recruitment, net wire fences, transplant

Pronghorn Antelope Workshop Proceedings 17:56-59

INTRODUCTION

Pronghorn antelope (*Antilocapra americana*) in the areas west and northwest of Roswell, New Mexico were estimated to exceed 3,000 total in the late 1930s. Pronghorn were so plentiful in 1938 that several hundred were trapped in east-central New Mexico and transplanted to other areas of the state, and to the Wichita Mountains National Wildlife Refuge, Oklahoma. During the 1920s and early 1930s, approximately 607,042 ha (1.5 million ac) west of Roswell were fenced extensively with net wire (Russell 1964) to facilitate an expanding domestic sheep industry.

Estimated pronghorn numbers had declined to 300 by 1977 (New Mexico Department of Game & Fish estimate) in the area enclosed by net wire fences. Hailey et al. (1966) in Texas and Russell (1951) in New Mexico described similar declines in pronghorn populations because of restrictions imposed by net wire fences on movements of pronghorns to areas providing adequate food.

The Federal Land Policy and Management Act (FLPMA) became law on October 21, 1976. Section 102(a)(8) states public land will be managed to provide food and habitat for fish, wildlife and domestic animals. Section 103(c) defines multiple use as the management of public lands and their resources so they are utilized in a combination that will best meet the present and future needs of the American people. The Roswell Office, Bureau of Land Management (BLM) initiated net wire fence modifications to allow pronghorn movement in 1975 and met with major resistance from area ranchers. After several public meetings in 1976 and early 1977, a pronghorn task force was formed in summer 1977 with representatives from the ranching industry, BLM, New Mexico Department of Game and Fish (NMDG&F) and U.S. Fish and Wildlife Service (USFWS). This task force drafted a study proposal that included the development of a model to predict suitable pronghorn habitat and the minimum area needed to support a viable pronghorn population in areas fenced with net wire. A viable population was defined as one where recruitment exceeded mortality.

The model developed from that research effort (Howard et al. 1990) was used to evaluate 3 pastures on the Corona Range and Livestock Research Ranch (CRLRR)

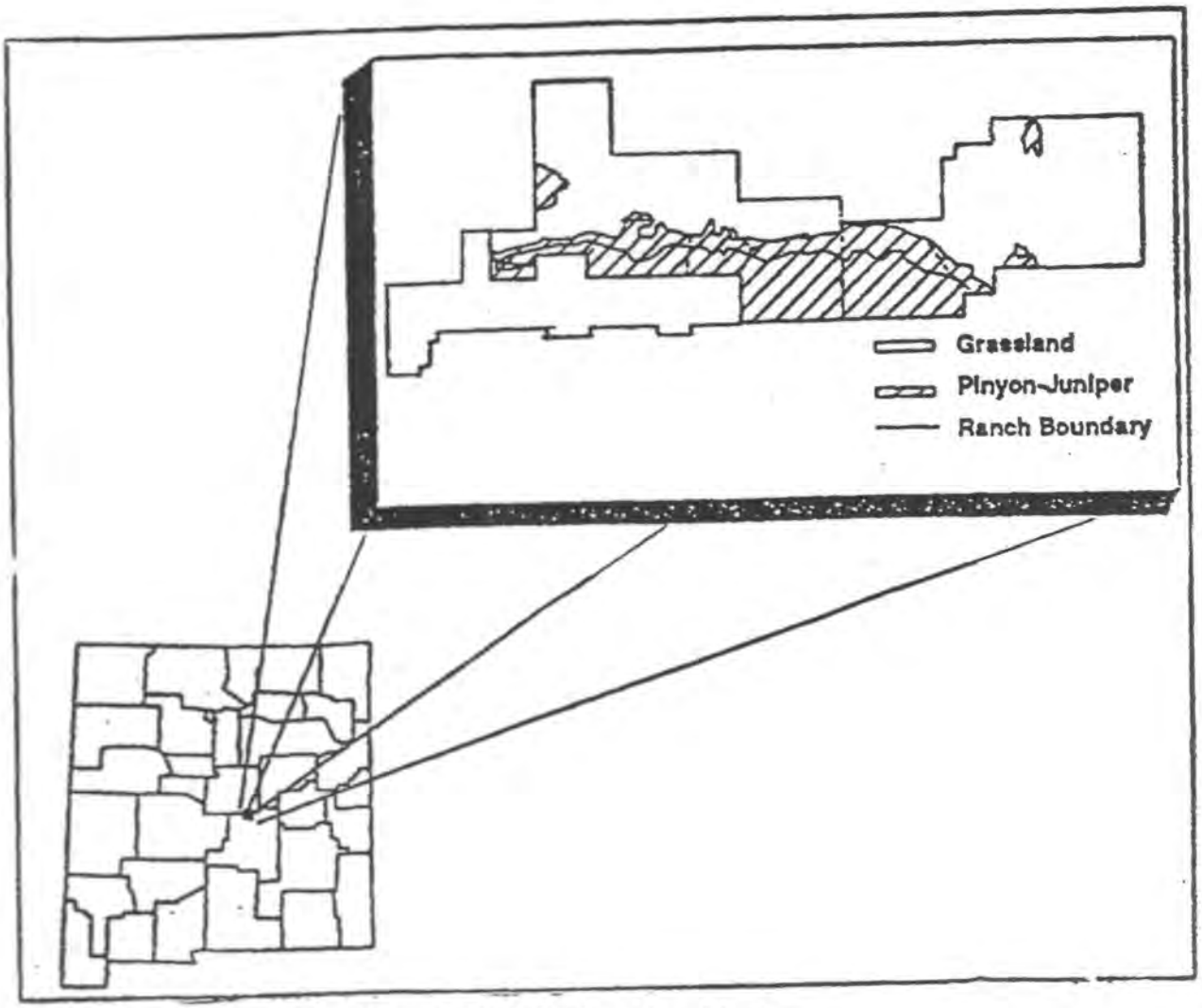

Figure 1. Study area in the Central High Plains, New Mexico.

prior to soliciting a pronghorn transplant from NMDG&F in 1994. In addition, an Environmental Assessment (EA) was completed and filed with the USFWS, Pittman-Robertson Coordinator, Southwest Regional Office, Albuquerque, NM.

Objectives of this study were to determine survival and recruitment of a transplanted pronghorn herd, and to determine population dynamics of a pronghorn herd restricted by net wire fences to a limited area. We are grateful to the New Mexico Agricultural Experiment Station and the McNair Program for financial support; NMDG&F for trapping, collaring and transplanting the original 20 pronghorn; the U.S. Fish and Wildlife Service, Federal Aid Program, for approval of the EA and funding capture/translocation efforts; personnel on the Corona Range and Livestock Research Ranch, particularly L. Tubbs, E. Parker and S. Cox, for cooperation and monitoring pronghorn; and W. Moore for data collection and analyses for the EA.

STUDY AREA

This study was conducted in the eastern 2 pastures of the 11,400 ha (28,160 ac) CRLRR located approximately 19 km (12 mi) east of Corona, New Mexico. This region is commonly referred to as the Central High Plains of New Mexico (Figure 1).

The climate in this region is semi-arid continental (USDA 1983). Based on a 55 year average (1906-1960) the area receives 403 mm (15.9 in) of precipitation annually with nearly half coming as high-intensity, short-duration thunderstorms in July, August and September. The mean monthly minimum and maximum temperatures are 3.3°C (January, -5.6°C/7.8°C) and 18.9°C (July, 12.8°C/28.9°C). The first killing frost occurs October 10 and the last occurs May 6 (Houghton 1974). Vegetation within the 2 study pastures is mainly grasslands (*Bouteloua gracilis*, *B. curtipendula*, *Aristida purpurea* and *Lycurus phleoides*) and some piñon-juniper (*Pinus edulis - Juniperus*

monosperma) woodlands. Other common plants include walkingstick cholla (*Opuntia imbricata*), broom snakeweed (*Gutierrezia sarothrae*) and yucca (*Yucca elata*). A variety of foods occur within the study pastures and are seasonally abundant following spring/summer precipitation. However, their total ground cover is only 3% in the grasslands and <1% in the woodlands (Moore 1994).

Elevations on the CRLRR range from 1,740 m (5,710 ft) to 1,911 m (6,720 ft). Topographic relief is rolling to flat in the study pastures with intermittent karst sinks. These sinks, which range in size from a few meters to several hundred meters across, were formed when surface material collapsed after water eroded the underlying limestone parent material (Harrington 1992).

The CRLRR was purchased to serve as a field research station for New Mexico State University (NMSU). Primary research interests focus on proper range and livestock production with both sheep and cattle present on the area. The CRLRR is enclosed by net wire fences with a buried apron. Interior fences are a mixture of net wire (with apron) and suspended 4-strand barbed wire. Permanent water sources are restricted to livestock troughs with 3 troughs present in the 2 pronghorn pastures.

METHODS

In January, 1994 NMDG&F was capturing and relocating over 1,100 pronghorn from several ranches in northeastern New Mexico using methods similar to those described by Russell (1964). We requested a transplant of 20 pronghorn with an initial sex ratio of adults of 3 females: 1 male. We received our transplant on 24 January 1994. There were 9 adult females, 4 immature females, 4 adult males and 3 immature males, an approximate ratio of 2 females: 1 male. Three adult males and 8 adult females had color-coded, nylon collars (Howard, in prep.) for identification in the field. The pronghorn were released near the middle of a 907 ha (2,240 ac) pasture and 400 m downwind of a permanent water source. One adult female and 1 immature female were obviously injured when they left the transport trailer (see Table 1 for details).

The pronghorn were monitored daily for three days post-release; bi-weekly during February, March and April; and 4 times each week between 15 May and 10 July 1994. Intermittent counts were made throughout the remainder of this study. No intensive effort was made to monitor the population during the 1995 fawning period. Field data in this report ended 6 April 1996.

RESULTS

Twenty pronghorn of mixed ages were transplanted into approximately 907 ha (2,240 ac) enclosed by net wire fencing on 24 January 1994 (Table 1). Two animals were killed by coyotes (*Canis latrans*) within 2 days following their release. Both had sustained injuries during transport.

The remaining transplanted herd included 8 adult, pregnant females. These females produced 12 fawns during late May/early June 1994. Two fawns were lost to coyote predation during a 10 day period following parturition. In November 1994 the carcasses of a yearling male and a fawn female were located. Both appeared to be predation losses, but the carcasses were deteriorated and scattered so that cause of death could not be positively ascertained. Both carcasses had been fed upon extensively by predators and carrion feeding birds.

Table 1. Record of pronghorn transplant, reproduction and survival on the Corona Range and Livestock Research Ranch, New Mexico, 1996.

Date	Ad. Female	Ad. Male	Imm. Female	Imm. Male	Total
01-24-94	9	4	4	3	20 Transplant
01-26-94	1[a]			1[b]	18[c] Coyote kill
06-10-94			7	5	30 Births
06-30-94			1	1	28 Coyote Kill
11-05-94		1	1		26 Unknown
04-01-95	11	6	5	4	26 Total Count
11-18-95	16	10	10[e]	9[e]	45[d] Total Count
04-06-96	24	10	10[e]	9[e]	45[d] Total Count

[a] Shoulder gashed open at release
[b] Broken foreleg at release
[c] Collared animals include 3 Ad. Male and 8 Ad. Female
[d] Collared animals all surviving
[e] Estimated

During May 1994 the net wire fence between the release pasture and an adjoining 1,555 ha (3,840 ac) pasture was modified to allow pronghorn to move into the additional area. The 2 modifications were made at locations where pronghorn were observed along the fence on several occasions. The first modification was made in a valley near the northeast corner of the release pasture. There was an earthen stock tank approximately 200 m to the east of the fence and it contained run-off water. The second modification was made approximately 400 m to the south. This crossing is on the upper one-third of a north-facing hillside. The modification is only 5 m (16 ft) in length and 0.36 m (14 in) in height. It is used regularly by pronghorn.

In spring of 1995 there were eight mature and three yearling does (yearling does were almost 2 years old at this time) that could produce offspring. Although we did not attempt to get an accurate count of the fawns born, there obviously was a high number. In the fall we counted 19 surviving fawns. This number equates to each mature doe rearing twins and each two-year-old doe rearing a single fawn (Table 1). These fawns increased the total herd to 45 animals. All 11 of the originally collared animals were surviving, but one male had begun to remain separated from the rest.

Winter 1995-96 was relatively mild with little accumulation of snow. The spring remained dry with very few forbs being green in early April 1996. All 45 pronghorn survived the winter and appeared to be in fair condition when we counted them on April 6, 1996. However, we were not optimistic about the upcoming fawn crop. Any number above one fawn per adult doe would be considered good reproductive output in light of the limited forage that was available.

It is possible to get some very crude estimates of the vital rates of this pronghorn herd. Fecundities reported in the literature are usually one fawn per one-year-old female per year and two fawns per adult female per year. Adult pronghorn are known to live seven to ten years; thus adult survival rates of 0.75 to 0.8 are likely under optimal conditions. We assumed that survival rates of one-year-olds were the same as adult survival rates. Based on our admittedly small sample, we estimate that fawn survival is in the range of 0.667 to 0.75.

Putting these values into a Leslie matrix allows us to estimate the intrinsic rate of increase of this pronghorn herd (Caswell 1989). Assuming adult and one-year-old survival rates of 0.8 and a fawn survival rate of 0.75 gives an intrinsic rate of increase (R_0) equal to 1.375. Assuming adult and one-year-old survival rates of 0.75 and a fawn survival rate of 0.667 gives an intrinsic rate of increase equal to 1.293.

If assumptions of the Leslie Matrix are met, the population's harvestable surplus is:

$$(R_0 - 1)/R_0 \times 100\%$$

(Begon and Mortimer 1986). Applying this formula to the rates of increase given above, we conclude that the population can withstand harvesting rates of 22-27% per year without going into decline. These estimated harvesting rates will, of course, need to be validated by field monitoring if a hunt is implemented for this herd.

Management Implications

The current population of 45 pronghorn gives a density of two pronghorn per km^2 (5 per mi^2). We estimate that 2.2 pronghorn per km^2 (6 per mi^2) is near optimum for our area since cattle are grazed on a seasonal basis in both pastures. Therefore, we must plan for a removal (hunting) or opening access to an additional pasture sometime within the next two years. Very crude survival rate estimates lead us to believe that the herd can withstand a harvest rate of about 25% per year.

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PRONGHORN ANTELOPE FAWN PRODUCTION AND HABITAT CHARACTERISTICS IN NORTHEASTERN CALIFORNIA

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Abstract: We compared pronghorn antelope fawn production between 4 general types of vegetation present in recent historic and current ranges in northeastern California. Pronghorn fawn counts made from fixed-wing aircraft from 96 census blocks (polygons) from 1960-1989 were categorized by vegetation type. Pronghorn habitat capability, as expressed in actual fawns counted, is discussed and compared between 4 habitat types within 29 of these blocks.. Polygon characteristics were determined from Landsat Thematic Mapper (TM) technology. Valleys with a recent history of irrigated alfalfa production and other mesic habitats had greater numbers of fawns than more xeric range sites (ANOVA, $P<.01$). Higher fawn counts were associated with population increases from pronghorn counted during winter count flights ($r^2=.64$, $n=30$, $P<.01$). Wet herbaceous, forb-rich areas had high numbers of fawns and are considered important recruitment areas even though they make up less than 4% of the study area. Where broad scale pronghorn habitat assessment is needed and vegetation types or categories are few, our methods can provide a reasonable assessment of habitat over large geographic areas.

Key words: aerial survey, alfalfa, *Antilocapra americana*, California, fawns, herbaceous, Landsat imagery, pronghorn, xeric.

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INTRODUCTION

Habitat components and habitat suitability for pronghorn have often been reported (Kindschy et al. 1978, Yoakum 1980, Kindschy et al. 1982, Howard et al. 1983, Allen et al. 1984, O'Gara and Yoakum 1992, Ockenfels et al. 1994, 1996). Changes in pronghorn populations or fawn production in relation to specific habitat components or types have been reported less often (Sundstrom 1968b, Beale et al. 1970, Masin 1974, Good and Crawford 1978, Salwasser and Shimamoto 1984). Most of these authors have also reported on the high importance of forbs and/or succulent vegetation to pronghorn. We hypothesized that satellite imagery would be sensitive to forb occurrence in sample polygons. Further, we considered that this habitat component could be important to fawn numbers counted in each sample polygon. We compared counts of fawns obtained in northeastern California during July for 30 consecutive years (1960-1989) within 4 habitat categories derived from Landsat imagery.

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STUDY AREAS

Pronghorn occupy about 1,071 km^2 of summer range habitats in northeastern California. These habitats are typical of pronghorn habitat in the northwestern Great Basin and include juniper woodland, sage dominated shrub and herbaceous vegetation types (Lee et al. 1998). Elevations range from about 1,600 m to 2,200 m above sea level. The climate is Mediterranean with short warm summers and long cold winters. Precipitation ranges from about 10 cm to about 50 cm per year and falls mostly in winter. The study areas are located within California's Modoc Plateau bio-region (Kuchler, 1977).

METHODS

Vegetation Classification

Vegetation types were modified and adapted (Fox et al. 1997) from the basic California Wildlife Habitat Relationship (WHR) types identified by Mayer and Laudenslayer (1988). The broadest categories we used were dominated by trees, shrubs, herbaceous species, aquatic, and developed habitats such as cropland. These categories were divided into 1 type of tree dominated habitat (not commonly used by pronghorn), 14 shrub types and 8 types of herbaceous habitats. Shrub and herbaceous types were further divided into xeric (dry) and "wet herbaceous" (more mesic or succulent; Table 1) because of the important role forbs and more succulent forages play in pronghorn reproduction and summer distribution (Sundstrom 1968b, Ellis 1970, Masin 1974, Yoakum 1974, Good and Crawford 1978, Salwasser and 1980, Yoakum 1980, Salwasser and Shimamoto 1984).

Landsat Imagery

Habitat classes were spatially displayed in raster grid cell format and resolved to the Landsat pixel level (30 m by 30 m, .09 ha). The vegetation patterns broadly aggregated from the WHR classification system (Mayer and Laudenslayer 1988) indicated structural types and sizes of vegetation. Modifications by Fox et al. (1997) were performed to best utilize the discrimination abilities of Landsat spectral signatures. We used Landsat Thematic Mapper (TM) Satellite imagery acquired in August 1989 and June-August, 1994. The specific images were from Rows 31, 32, and 33; Paths 43, 44 and 45 of the TM World Wide Reference System (WRS).

A hybrid approach to spectral signature development was applied that used both "supervised" and "unsupervised" techniques (Fox et al. 1992). This application involved supervised methods for more specific homogeneous habitat types and unsupervised methods for more heterogeneous mixed habitat types. Computerized image analysis was accomplished using ERDAS, Imagine, v8.2 software applied by both the Klamath Bioregional Assessment Project at Humboldt State University, Arcata, California and the Eagle Lake Resource Area Office, Bureau of Land Management, Susanville, California.

Counting Pronghorn

Pronghorn in northeastern California were counted and classified using fixed-wing aircraft in late July of each year from 1960 through 1989. Counts were conducted to obtain herd composition information with individual animals in each observed group classified as bucks, does or fawns. Similar counts are conducted in most states and Canadian provinces with populations of pronghorn (O'Gara and Yoakum, eds, 1992, Lee et al. 1998).

Annual summer herd composition counts began in northeastern California in 1953 with 34 polygons. Additional polygons were added as the population increased and summer distribution expanded between 1950 and the mid 1980s (Pyshora 1987). By the late 1980s, some 96 count polygons were usually counted each July. We used 29 polygons in our analysis because only 29 of the original 34 polygons were counted every year from 1960 to 1989. Counting methods were similar each year for each polygon. Two observers, one on each side of the aircraft were used and transects were flown across each polygon approximately 800 m apart at an elevation of 100-150 m at approximately 110 to 145 km/hr. Counts were usually performed between 6 AM and 10 AM, and 5 PM and 8 PM DST to maximize light contrast and pronghorn visibility. Observers and pilots were experienced in surveys of pronghorn. Transects within polygons were flown in either north to south or east to west patterns each year.

Survey Polygons

We determined vegetation types present in 29 sample polygons and then allocated each of these polygons into one or more vegetation classes based on spectral imagery. Classes were based on amounts of wet herbaceous or more mesic vegetation described as follows: Class 1 polygons consisted of wet herbaceous vegetation, including alfalfa. Class 2 polygons had irrigated alfalfa present. Class 3 polygons had greater than 400 ha of succulent vegetation and no alfalfa. Class 4 polygons

Table 1. Plant community classifications (from Mayer et al. 1998) assigned to xeric and "wet herbaceous" as modified by Fox et al. (1997).

	Types (Fox et al. 1997)	Included WHR Types	Added Types (This Paper)
Xeric Classes	Mixed juniper/pinyon	Juniper	
	Greenleaf shrub	Alpine dwarf shrub	
		Montane chaparral	
		Mixed chaparral	
		Coastal scrub	
	Dead stick shrub	Alkali desert scrub	Mixed great basin shrub
		Mixed chaparral	Rabbitbrush
		Chamise-redshank chaparral	Desert saltbush scrub
		Bitterbrush	
	Soft shrub	Low sagebrush	
		Sagebrush	
	Dead grass/forb	Perennial grassland	
		Annual grassland	
Wet Herbaceous Classes	Green grass/forb	Perennial grassland	Silver sagebrush
		Annual grassland	Alkali playa - lakebed
		Pasture/cropland	
		Wet meadow	
	Wet meadow/marsh	Wet meadow	
		Fresh emergent wetland	

Table 2. Pronghorn antelope fawn counts from 29 polygons, northeastern California, 1960-1989.

Mgmt. area	Polygon	1960	'61	'62	'63	'64	'65	'66	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	Total ('60- '89)	Annual Mean
Mount Dome	Macdoel	0	0	0	0	0	0	0	3	0	0	0	0	14	7	3	15	0	2	4	32	51	76	42	44	53	62	107	75	38	99	727	24
	Red Rock Valley	0	0	0	0	0	4	7	7	4	12	16	13	20	0	14	30	23	20	6	11	30	34	31	19	26	27	17	30	65	46	512	17
	Mt. Dome	14	0	33	28	36	27	35	33	21	14	35	50	47	19	22	37	18	19	4	11	32	9	19	27	21	8	14	18	12	5	668	22
Clear Lake	Boles Creek	0	6	7	6	11	7	0	8	6	28	5	10	20	12	6	15	16	0	0	1	0	5	2	4	4	13	10	1	7	1	211	7
	Clear Lake Perimeter	9	16	39	14	27	13	15	21	16	39	38	19	49	37	36	36	46	14	6	17	11	18	3	53	37	22	24	35	23	15	748	25
	Steele Swamp	2	12	1	0	7	3	7	2	0	4	0	3	16	0	2	2	3	5	1	0	4	1	0	2	9	6	0	10	1	0	103	3
	Clear Lake Peninsula	33	38	27	63	72	37	22	69	63	94	61	93	108	42	52	50	24	87	35	36	44	63	33	37	30	42	69	97	126	69	1,716	57
Likely Tables	Rocky Prairie	6	18	19	11	3	7	5	4	15	25	15	13	38	7	8	37	21	14	6	11	16	15	15	61	66	61	73	81	85	70	826	28
	Big Sage Reservoir	18	5	4	9	4	0	8	3	2	10	22	8	16	20	17	4	13	11	5	4	2	0	0	0	4	2	0	19	18	11	239	8
	Likely Tables	9	18	23	21	42	24	25	45	47	59	84	27	33	72	46	89	101	70	47	95	117	71	90	50	61	32	80	82	67	77	1,704	57
	Davis Creek	29	17	17	16	8	6	0	23	22	33	19	10	52	46	55	69	82	47	47	32	41	59	99	60	34	87	87	114	126	135	1,472	49
	Thomas and Raker	0	2	2	0	0	0	1	1	1	9	7	0	5	10	5	1	11	3	0	0	0	2	1	1	1	0	0	7	5	7	82	3
	Engle Swamp	0	0	0	0	0	0	2	3	0	0	0	0	3	1	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	13	0.4
	Fairchild Swamp	3	0	5	3	0	0	0	7	12	8	2	0	2	7	12	0	0	0	0	0	0	0	0	0	1	6	1	0	0	0	69	2
	M & N Reservoir	0	0	0	5	0	0	0	0	0	0	0	13	8	2	0	0	0	0	0	0	0	0	0	1	0	1	0	2	2	0	34	1
Lassen	Painter Flat	2	2	3	9	11	3	5	4	17	22	9	2	1	9	2	12	2	14	15	22	29	6	35	39	42	72	16	30	28	17	480	16
	Karlo Mesa	4	21	23	19	17	6	5	12	20	23	44	12	27	8	8	0	0	7	2	5	2	4	10	9	7	7	0	2	7	0	311	10
	Pine Creek-Bogard	9	13	6	10	10	8	4	3	6	1	6	8	24	17	36	10	14	24	47	16	15	62	46	20	40	43	40	45	21	21	625	21
	Grasshopper Valley	5	11	10	10	25	17	31	37	34	20	58	23	28	26	21	15	24	22	13	22	13	19	6	7	12	18	20	11	3	16	577	19
	Madeline Plains	2	20	12	19	34	39	39	65	78	53	91	36	78	29	55	93	56	51	46	70	73	74	35	18	30	82	93	163	131	178	1,843	61
	Snowstorm	9	0	0	16	11	18	9	2	9	2	27	8	14	11	4	3	0	1	5	10	6	2	10	0	3	0	1	0	1	6	188	6
	Shinn Ranch	7	2	9	14	18	4	5	0	2	7	15	23	38	19	15	25	2	27	23	27	37	23	39	15	17	14	13	5	17	17	479	16
	Harvey Valley	0	0	0	0	0	6	0	5	0	7	2	10	13	0	8	9	18	0	5	7	0	8	11	7	14	2	17	12	3	1	165	6
	Champs Flat	0	0	0	8	5	0	5	8	14	13	7	0	11	6	2	1	3	0	7	0	0	2	0	2	1	0	6	3	2	0	106	4
	Ash Creek	0	0	6	0	4	1	2	0	0	5	4	7	4	10	5	12	0	7	8	0	10	7	2	5	2	5	12	3	0	3	124	4
	Silva Flat	13	19	22	4	5	10	10	10	23	21	30	17	15	17	18	17	28	16	8	6	9	13	7	7	3	11	28	4	8	3	402	13
Big Valley	Round Valley	10	0	10	6	6	0	2	10	10	6	6	6	11	13	5	7	5	21	29	5	15	2	2	1	4	9	10	9	12	8	240	8
	Big Valley	6	10	6	8	9	5	3	4	5	3	9	3	9	11	18	3	45	32	26	30	60	50	25	23	27	19	59	64	63	50	685	23
	Fox Mountain	6	15	14	14	14	7	14	5	16	8	12	12	13	25	20	5	15	15	26	14	35	23	8	6	13	7	4	7	11	13	397	13
TOTAL		196	245	298	313	379	252	261	394	443	526	624	426	717	483	495	597	572	529	421	484	652	648	571	518	562	658	801	931	882	868	15,746	525
Mean		7	9	10	11	13	9	9	14	15	16	22	15	25	17	17	21	20	18	15	17	23	22	20	18	19	23	28	32	30	30	543	

types were dominated by xeric vegetation. The minimum size area (400 ha) for succulent vegetation for Class 1 and Class 3 was selected because it was the smallest area that included all polygons which also contained alfalfa. Estimates of the area of irrigated production alfalfa present in each polygon were obtained from county agricultural departments.

Some polygons were categorized into more than one vegetation class. For example the Macdoel polygon with at least 400 ha of wet herbaceous vegetation and alfalfa was placed in Class 1 and Class 2. This modified the number of polygons tested to 41. We tested 3 year means of fawns counted over 30 years in each polygon and compared them to each of the 4 habitat classes. Significant differences between means were based on 1 way analysis of variance (ANOVA).

The total number of fawns counted each year in the 29 sample polygons was compared to the northeastern California pronghorn population counted on winter ranges the following winter to determine if they were related and if the changes in numbers of fawns counted over the 30 years were reflected in subsequent populations. The summer fawn counts from the 29 polygons were regressed against the following winter counts and results were compared by simple linear regression (r^2) for the 30 years, 1969-1989. Probability values of $P = .05$ were considered significant for all tests.

RESULTS

In total, 21,851 pronghorn fawns were counted and classified in northeastern California from 1960 to 1989. Of these, 15,746 (72%) were counted within the 29 polygons ($\bar{x}$ = 525 per year; Table 2) and were used for analysis in this study. Collectively, size of the 29 polygons totaled 550 km² ($\bar{x}$ = 19.0 km²; Table 3).

Twelve polygons (Class 1) had at least 400 ha of wet herbaceous vegetation. Nine polygons (Class 2) had irrigated alfalfa. Three polygons (Class 3) had a wet herbaceous component > 400 ha with no alfalfa. Seventeen polygons (Class 4) were identified as xeric, with a wet herbaceous component of < 400 ha (Table 3).

The area of wet herbaceous habitats (including irrigated alfalfa) detected in each polygon varied between 1 ha and 3,287 ha ($\bar{x}$ = 632 ha, sd = 929; Table 3). The mean percent of wet herbaceous types in each polygon was 3.5% and varied from .03% to 18%. The size of the

Table 3. Area of count polygons (1960-89) and area of vegetation components (1994), northeastern California.

Management Area	Polygon	Total Area (km²)	Wet Herbaceous (ha)	Wet Herbaceous (%)	Irrigated Alfalfa (ha)	Irrigated Alfalfa (%)
Mount Dome	Macdoel	40	1,786	5	1,656	4
	Red Rock Valley	25	1,918	8	1,918	8
	Mt. Dome	20	750	4		
Clear Lake	Boles Creek	20	296	2		
	Clear Lake Perimeter	24	14	0.06		
	Steele Swamp	5	24	1		
	Clear Lake Peninsula	9	1,593	18		
Likely Tables	Rocky Prairie	41	3,159	8	3,040	7
	Big Sage Reservoir	19	18	0.1		
	Likely Tables	34	522	2	340	1
	Davis Creek	28	1,050	4	1,020	4
	Thomas and Raker	19	101	0.1		
	Engle Swamp	5	2	0.04		
	Fairchild Swamp	6	47	0.1		
	M & N Reservoir	2	74	4		
Lassen	Painter Flat	9	449	5		
	Karlo Mesa	14	11	0.08		
	Pine Creek-Bogard	10	78	0.1		
	Grasshopper Valley	11	42	0.4		
	Madeline Plains	82	3,287	4	3,133	4
	Snowstorm	7	20	0.3		
	Shinn Ranch	10	26	0.3		
	Harvey Valley	3	1	0.03		
	Champs Flat	5	3	0.06		
	Ash Creek	15	180	1		
	Silva Flat	33	42	0.1		
Big Valley	Round Valley	10	400	4	64	0.6
	Big Valley	27	1,757	7	1,680	6
	Fox Mountain	17	1,305	8	60	0.4
TOTAL		550	18,955		12,911	
MEAN			632	3.5	1,435	2.4

alfalfa component ranged from 60 ha to 3,133 ha ($\bar{x}$ = 1,435 ha, *sd* = 1,103) within the 9 polygons. The mean percent area for alfalfa in the 9 polygons was 2.4% (range .04% - 8%).

The 3 year means of fawns counted in each of the 4 major habitat classes were significantly different between all wet herbaceous classes (both with and without an alfalfa component) and the more xeric habitats ($P < .01$; Table 4). There were no significant differences in fawns counted between groups of polygons with any type of wet herbaceous component. The mean annual fawns counted within each of the 4 habitat classes were: (1) wet herbaceous with an alfalfa component, 31.4 (n=12); (2) alfalfa present, 31.0 (n=9); (3) wet herbaceous, 31.8 (n=3); (4) xeric, 8.8 (n=17). The number of fawns counted in the 29 polygons was significantly related to the northeastern California population of pronghorn counted on winter ranges the following winter for the period from 1960 to 1989 (r^2 = .64, n=30, alpha <.01; Figure 1).

DISCUSSION

Our allocations of plant community types in the study area into the 4 broad categories detected differences in fawns counted in relation to amounts of wet herbaceous (and forb) components in each of the 29 polygons. We found that wet herbaceous, forb-rich plant community elements can have a significant relationship to pronghorn fawn production even when they occur at a mean of less than 4% (range .03%-18%) of the area within our polygons.

The importance of forb and/or succulent vegetation to pronghorn in summer has been commonly reported. Beale et al. (1970) considered succulence the major characteristic of forage sought by pronghorn in Utah. In summers of high abundance, forbs made up to 95% of the diet. When the percentage of forbs was lower in the diet, it was because of lower availability. Under favorable conditions, forbs were the principal source of the diet (Beale et al. 1970). Similarly, Masin (1974) stressed the importance of forbs for pronghorn in portions of northeastern California (which included our study sites), but presented little data to accompany that assessment. Yoakum (1974) considered succulence (and wet herbaceous species by implication) as extremely important to pronghorn in sagebrush-grassland communities. Pronghorn have been considered as opportunistic herbivores that selected the most palatable and succulent forage available at any time (Salwasser 1980). In a habitat evaluation in Arizona, Ockenfels et al. (1996) considered forbs to be of major importance in assessing pronghorn habitat and felt that any habitat modeling attempt for pronghorn would be weakened if forbs were not included as an element of habitat assessment.

Forb-rich habitats such as playas and wet basins have been the subject of a limited number of pronghorn habitat and distribution studies. Good et al. (1978) showed the importance of playas in producing succulent herbaceous forage to pronghorn in southeastern Oregon. Similarly, Herrig, (1974) found pronghorn preferred lowland mesic sites during mid summer. Beale et al. (1970) speculated that fawn survival could not be attributed to forage conditions alone. However, our results suggest that forage conditions with a higher proportion of forbs can accompany increasing fawn survival and subsequent increases in the population. Similarly, Ellis (1970) showed a doubling of mean fawns per 100 does in areas completely covered by forbs and grass, compared to areas with no forbs and grass.

While we did not evaluate forb species richness on our sites, Ockenfels et al. (1994) suggested that forb species richness was more important than absolute abundance of forbs in evaluating pronghorn use areas. We included silver sage plant communities as wet herbaceous types because they usually occupy wetter basin sites

Table 4. Analysis of variance (1 way ANOVA) differences (*P*) between three year means of fawn counts in 29 polygons based on major vegetation components, northeastern California, 1960 - 1989.

	Xeric Types (n=17)	Wet Herbaceous Types		
		Wet Herbaceous Only (n=3)	With Alfalfa (n=12)	Alfalfa Only (n=9)
Xeric Types		*P=.000003*	*P=.001*	*P=.004*
Wet Herbaceous Only				
With Alfalfa				
Alfalfa Only				

Values not shown were not significant (*P*>.05)

that are commonly rich in forbs. Salwasser (1980) also felt that silver sage sites were disproportionately important to pronghorn because of associated forbs. We also included playas as a wet herbaceous type because of the findings by Good et al. (1978) of their forb value to pronghorn. However, neither of these types was widespread or abundant in our study area and they probably do not play a major role in pronghorn distribution or fawn production in northeastern California.

Our analysis was done during substantial increases in the population (Figure 1). It is possible that similar population increases would have taken place if irrigated alfalfa had not been present in the 9 polygons. Sites with alfalfa production were more nearly level and more easily irrigated than much of the pronghorn range in northeastern California. The availability of irrigated water probably also influenced where alfalfa was planted. It is also likely that the sites with alfalfa culture were higher in soil productivity and may have contained a high percentage of wet herbaceous forage prior to the time they were converted to alfalfa. There was no significant difference between overall fawn counts in "wet herbaceous only" sites and "alfalfa only" sites for the 30 years of our study. However, the changes in fawn production we showed during that time period were much greater within alfalfa sites (Table 2, Table 3).

Spectral signatures from TM sometimes failed to identify or discriminate some specific WHR habitat types. For example, the spectral imagery used was not efficient in distinguishing crop types from other herbaceous vegetation types. The satellite views used were from mid- summer in a Mediterranean climate when succulent and more xeric vegetation types were easily discernable from other broad vegetation types but differentiating each species within wet herbaceous types was not possible. This may have been partly due to low reflectivity from vegetation height. We did not achieve desired separation of vegetation types due to broad based imaging classification problems in xeric dominated habitats where most vegetation is <1 m in height. However, where a coarse scale assessment is needed and types or categories are broad, our methods can determine vegetation components over large geographic areas of pronghorn habitat.

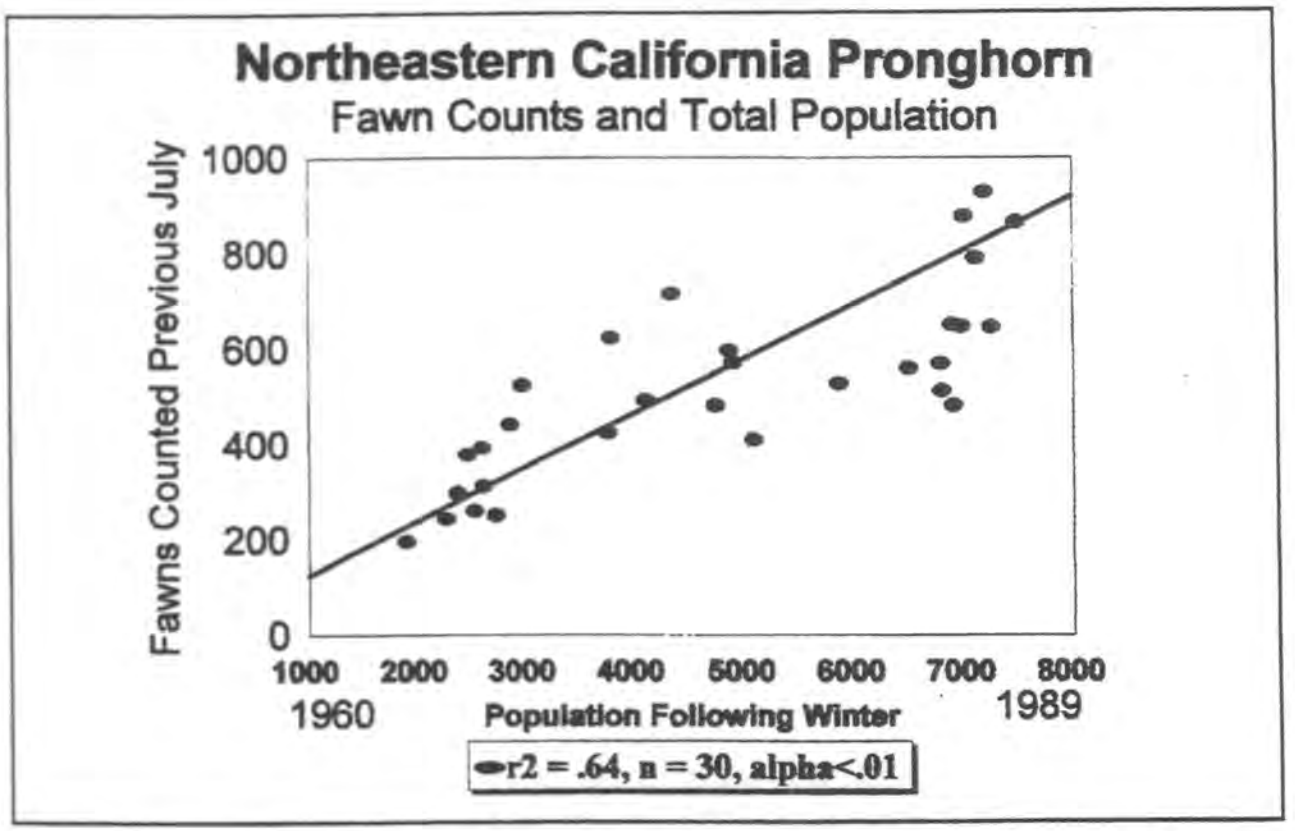

Figure 1. Fawn counts from 29 polygons and following winter populations, 1960-1989.

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ANTELOPE SURVEY CONSIDERATIONS IN ARIZONA

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Abstract: The Arizona Game and Fish Department began aerial surveys for pronghorn antelope in 1945. Survey techniques developed during 1945 and 1946 formed the basis for methodology used today. By 1947, the "Annual Antelope Airplane Survey" was being conducted over established flight areas in accordance with standardized procedures to obtain antelope management data. From 1951-1955, an average of 4,566 antelope was surveyed with an average annual reported harvest of 768 animals. From 1991-1995, the average number surveyed had more than doubled to 9,718, yet the average harvest had declined to 634. This decline can not be attributed to changes in sex or age ratios. Another variation in survey results can be seen in the classification of individual animals. Using mule deer for a comparison, which provides similar observation numbers, between 1951 and 1955, the average number of deer surveyed was 4,586, with the average percentage of unclassified animals being 12.5. Between 1990 and 1994, the average number of deer surveyed increased to 16,598, while the average percentage of animals unclassified had decreased to 1.0. The Department's Strategic Plan reported that the post-hunt adult antelope population for 1995 hunt was 7,800 animals. Adding the number of antelope bucks (2,223) and does (6,601) surveyed in 1995, and subtracting the number of bucks harvested (693) results in 8,131 post-hunt adults. This indicates a remarkably efficient survey; one observing 104% of the animals in the state.

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During World War II, Allied air force crews hunted for German submarines. It was found that while their flight paths seldom passed near a surfaced submarine, even when they did the crews often failed to see it. Of course, these were 200-foot-long ships, with cannons, a conning tower, and trailing a mile-long wake. "Aerial surveys" were intensively researched during the "war effort".

The Arizona Game and Fish Department began aerial surveys for pronghorn antelope in 1945. These aerial surveys were compared with ground surveys to determine similarities and differences between the two methods. The airplane survey techniques worked out during 1945 and 1946 formed the basis for the techniques used today. By 1947, the "Annual Antelope Airplane Survey" was being conducted over established flight areas in accordance with the standardized procedures adopted to secure antelope management data. By 1950, over 5,000 pronghorn were being classified during the annual survey.

Being production oriented, I noted the following data. From 1951 to 1955, an average of 4,566 antelope was surveyed, with an average annual reported harvest of 768 animals. Forty years later (from 1991-1995), the average number of antelope being classified had more than doubled to 9,718; yet the average harvest had declined to 634. While this decline may be thought to be due to changes in sex and age ratios, in 1994 and 1995 the average buck to doe ratio was the highest it had been for any 2-year period since 1959-1960. This caused me to consider our survey efforts.

Looking at another factor, I used mule deer as a comparison, since they provided similar observation numbers to antelope. Between 1951 and 1955, the average number of animals classified was 4,586, with the average percentage of unclassified animals being 12.5. Between 1991 and 1995, the average number of animals surveyed had increased to 16,598, while the percentage of animals unclassified had decreased to an average of 1.0. In other words, despite classifying four times more animals, the number unclassified dropped by two-thirds. This caused me to consider our survey efforts.

Of course survey results affect population estimates. In the Department's Strategic Plan, we estimated that the adult pronghorn population following the 1995 hunt was 7,800 animals. In 1995, we surveyed 2,223 bucks and 6,601 does (pre-hunt). Subtracting the number of bucks harvested (693), and counting neither recruitment (from the 1,784 fawns), nor other than hunt mortality during the hunting period, results in 8,131 post-hunt adults. This indicates that we made a remarkably efficient survey; seeing 104% of the animals in the state. This caused me to consider our survey efforts.

Another survey-related example involves Sonoran pronghorn (*A. a. sonoriensis*). In this case the Department had long stated that only 80-100 individuals of this endangered subspecies existed. This, of course, limited the management options available for trying to recover such a small group. But aerial surveys conducted in 1992 and 1994 over portions of the known range in the United States produced population estimates in excess of 200 animals, with some ranging upwards of 300. A population of this size allows for greater flexibility in management options. Which leads me to the observation that it is rarely, if ever, in our best interest to underestimate wildlife populations.

Examples of this type led me to consider how surveys were being conducted and what they were telling us. Using our own survey data, Arizona's pronghorn management guidelines specify that to obtain a sample of buck to doe or fawn to doe ratios within ±5 at the 90% confidence interval, it is necessary to survey approximately 95% of the population if it is less than 100 animals, 75% if the

population is 200-300 animals, and 50% if it is over 1,000 animals.

Since aerial surveys have been shown to consistently underestimate animal abundance, to improve the accuracy of survey estimates the number of animals missed during the surveys must be determined. The failure to observe all animals is called visibility bias. Group size and vegetative cover are major factors affecting visibility bias. In one elk study observations ranged from less than 10% of the elk observed in heavy cover up to 100% for elk in groups of over 30 animals.

Many other investigators have observed similar difficulties with aerial wildlife surveys. Aerial wildlife surveys have been grouped as being strip sampling, line transects, quadrats, mark recapture, double counts (both simultaneous and otherwise), change-in-ratio estimator, or sightablility models. Knowing that all methods underestimate the true population to varying degrees, each of these techniques has advantages and disadvantages.

Strip sampling assumes that all of the animals in a strip have been counted, and knowing the area of the strip allows an extrapolation as to the total number of animals in similar areas. The underestimation bias decreases as strip width is decreased. However, in one study 42% of the deer were missed, even with a strip width of only 40 m.

The **line transect** method, perhaps the most popular method for use with pronghorn antelope, measures the distance to the object observed, improving the estimate over that obtained in the strip sample. Line transect sampling embodies the recognition that the probability of observing an object decreases with increasing distance from the line. Particular problems occur with an inaccurate estimation of distance from the transect, thereby affecting the actual strip width. Trained observers are essential for reliable line transect estimation.

Many of the problems with line transects stem from moving animals. Assumptions of the line transect method are: animals on the center line will always be observed, animals do not move in response to the observer before they are observed, animals are not counted more than once, and the sighting of animals is independent (i.e. the movement of one does not cause movement of another).

Speed, height, and transect width are primary factors affecting line transects. When these vary, as when investigators try to get better data, population estimates tend to increase. This possibly explains the data from antelope surveys in Arizona. It has been reported that the faith in the line transect approach is not justified in many aerial surveys.

Quadrats (as well as distance measures like line transects) were primarily used for measuring the density of plant communities and closed animal populations where the animals are relatively stationary. Problems with quadrats are that different size quadrats yield different estimates of density, and that there is a tendency to include groups of animals found on the borders of the survey areas. The smaller a quadrat, the more edge effect is has, increasing subjective decisions as to whether an observation is in or out of the quadrat. Small quadrats also lead to tight turns. Large quadrats are also problematical in that they reduce sample size, and there is a loss of efficiency due to reduced visual references. Quadrat surveys are biased to produce low estimates for the population.

Mark-recapture surveys are less biased than other methods, however, they require nearly 45% of the population to be marked. Change-in-ratio estimators require two surveys be done: before and after an event which affects ratios, such as a buck-only hunt. Due to large underestimates, they require sightablility "corrections" to provide useful information.

Double counts are essentially mark-recapture counts using the number of animals seen on one survey (by one observer) as the mark, with the number of animals seen on the second survey (by the second observer) as the recapture. Of particular note in this technique is that no source of visibility bias can be estimated, as only the visible portion of the population is accessible. In many surveys, a significant portion of the population is not readily visible (beneath tree canopies, etc.). Of the visible population only some of the individuals are observed. When some objects are harder to see than others, the assumption of equal sighting probabilities will not hold. If the same objects are hard to see for both observers a negative bias will result. This method is unlikely to be useful for moving objects (animals) because of the difficulty in exact mapping.

As has been stated, aerial surveys always underestimate true animal numbers due to visibility bias. Even repeated surveys (or computer simulations of up to 200 survey runs) consistently underestimate populations. With upwards of 50% of the animals being missed, some sort of correction factor will always be needed. This has led to the development of sightablility models which attempt to determine the percentage of the animals missed during a survey.

It should be noted that the above mentioned difficulties are just those associated with estimating total population size; additional biases can be encountered in estimating sex and age ratios.

Being aware of the difficulties associated with aerial surveys (not to mention the very real safety hazards to the participants), many biologists are leaning towards the use of infrared sensors and drones equipped with cameras. It is important to realize that the level of accuracy needed by your work dictates the methodology to be used. If you need research grade work, good luck. If you only need information adequate for hunt management (which tends to be rather conservative), a well run sightablility survey should provide adequate information. With the advent of GPS technology which allows for moving map displays in the cockpit to show where you are in the survey unit at all times, surveys will become much easier to conduct. Now if we can just make aircraft cheaper and get the animals to cooperate better, our jobs will be much easier.

HELICOPTER NET-GUN CAPTURE OF PRONGHORN

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Abstract: The helicopter net-gun technique was used to capture free ranging pronghorn in Colorado using a commercial wildlife capture company. Specific animals were required for an ongoing project addressing differential natural mortality of males and females. Average turn-around time per animal captured was <10 minutes. There was no mortality during the capture operation. However, 1 animal died 5 days post-capture. Cause of death was attributed to trauma associated with the capture process. Efficiency of the net-gun method is compared with the conventional corral trap method for labor, equipment and cost.

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INTRODUCTION

The helicopter net-gun technique was used in Middle Park, Colorado to capture free ranging pronghorn (*Antilocapra americana*) December 12 and 13, 1994. The intent was to capture and radio collar 10 male and 10 female fawns for a natural mortality study that is in progress. Helicopter Wildlife Management (HWM), a commercial wildlife capture company from Salt Lake City, Utah, was contracted to capture the animals because of their experience using this technique.

Compared to other species, HWM's experience capturing pronghorn was somewhat limited. In total, they have captured about 150 pronghorn with no direct mortalities (James Innes, pers. comm.). Of the 150 total, they captured 30 in Utah with no mortalities (Mitch Larsen, pers. comm.). Mule deer (*Odocoileus hemionus*) fawns (n=79) were captured using this method with no direct mortality and 5.1% post-capture (two weeks) mortality (White and Bartmann 1994). Others have used net-gunning to capture pronghorn but the pilot and gunner lacked the experience of HWM and they were less successful in terms of animal injuries and mortalities. Barrett et al. (1982) experimented with net-gunning and one of three adult females was injured and had to be dispatched; two fawns were captured and both suffered "acute metabolic stress" and had to be treated before release. Status of their survival was not given. Firchow et al. (1986) injured and dispatched two of 20 adult pronghorn captured by net-gun; a third animal died post-capture (four weeks) and it was not determined if the mortality was capture related.

METHODS

The HWM helicopter crew consisted of the pilot, gunner and handler on board a Hughes 500C helicopter. For this capture operation, no instructions were given to the crew for the specific capture procedure because they had experience with the technique. However, a briefing was held with the crew to outline protocol criteria including pursuit time, no-fly zones, cautions regarding livestock fences and other obstructions, and procedures for handling injured animals (see Appendix 1).

RESULTS

The HWM crew captured 10 male and 10 female fawns. Average turn around time per animal was 9.4 minutes, which included search time, hazing, capture, and ferry time. All animals were examined for injuries before processing and again before release. Animals were watched for any abnormal behavior or locomotion after release. Hair loss was minimal and only two superficial injuries were noted; one was a cut on the back from going under a fence and the other was a 2-3 inch abrasion on a front leg (different animals). Upon release all 20 animals seemed to behave normally given that they had been blindfolded and were adjusting to bright light conditions. Other groups of pronghorn were within 1 mile of the release site making it possible for a fawn to rejoin a group within minutes of release.

Two animals died within 10 days after capture. Dr. Terry Spraker, (Colorado Veterinarian Teaching Hospital) examined tissues of both animals to identify the cause of death. One death (five days post-capture) was attributed to trauma associated with the capture process. Cause of death was pulmonary edema resulting from either deep muscle bruising or head injury. A second animal died 8-10 days after capture. Examination of organ and muscle tissue ruled out capture stress as the cause of death. These tissues were healthy and showed no signs of capture myopathy or other stress related conditions. There was no evidence of aspiration of rumen material into the air passages in either animal.

DISCUSSION

The net-gun capture method has definite advantages over the conventional corral drive trapping method for certain applications. In this case, where the target animals were fawns, the conventional method would have necessitated trapping 130-150 animals to get the number of fawns needed (see Appendix 1). Normal trap mortality using the corral method can approach 5% (Hoover et al. 1959, O'Gara and Yoakum 1992), which could have resulted in the death of 5-8 animals. The net-gun capture

method resulted in 1 mortality and direct capture stress on 20 target animals, as opposed to a group of 130-150. In addition, it was possible to select sample animals from several groups within the population resulting in a statistically sound sample.

Injury to animal handlers was non-existent with the net-gun method. HWM delivered the blindfolded and hobbled animal to the processing area where it was radio collared, ear tagged, and released. During corral trapping operations, animal handlers suffer bruises and abrasions, and can incur damage to personal gear. More serious injuries (e.g. back injuries) are not uncommon and sometimes require medical care.

Maximum animal handling crew size for net-gunning is 8 because, on occasion, the capture crew brings 2 animals at a time to the processing area. This allows for 3 persons per animal to unload the animal from the helicopter and carry it to the processing point where the remaining 2 persons apply radio collars, ear tags, and record data. Normally, 40-50 persons are needed to successfully operate the conventional corral trap. Volunteers usually make up about 75% of this crew and are covered by agency insurance up to $25,000. The Colorado Division of Wildlife is still susceptible to litigation for injuries sustained by volunteers.

The time required to capture 20 animals was less than a half day for net-gunning (about 10 minutes per animal on average). Assuming an animal handling crew of 8 persons and a half day operation, the net-gun operation required a total of 4 person days to complete. Organization and scheduling of this small a crew is relatively uncomplicated. In contrast, corral trapping with a crew of 50 persons requires extensive preparation and organization. Building wing fences, assembling the corral trap, executing the trapping operation, and disassembling the trap and wing fences requires 50-100 person days.

Considerable equipment in terms of 4-wheel drive vehicles, trailers, and fencing material is required for the corral trap; vehicle access to the trap site is imperative. Other than the material for processing an animal, there are no equipment requirements for the net-gun capture method. This permits processing points to be in remote areas accessible by snow machine, helicopter or on foot.

Realistic comparison of costs for the 2 methods is difficult because assigning value to the time of volunteers and investment costs for the trap and fencing material is elusive. However, a best estimate cost comparison was made by arbitrarily assigning value to volunteer time and ignoring trap cost investments as did White and Bartmann (1994). These estimates are in Table 1.

In summary, helicopter net-gunning to capture pronghorn is cost effective and practical when specific target animals are needed. An experienced capture crew (helicopter pilot and gunner) is essential for tolerable levels (< 5%) of animal injury. For capture of larger numbers of animals, corral trapping would be more economical than net-gunning. The cost to capture 20 animals by corral trap (Table 1) would be roughly the same if 130-150 animals were captured using the same method. For larger numbers (e.g.130-150 animals), the cost drops to $60-70 per animal using corral traps.

Table 1. Estimated cost comparisons for capturing 20 pronghorn with corral trap and the helicopter net-gun method in Middle Park, Colorado during December 12-13, 1994.

	CORRAL TRAP		NET-GUN	
Source	**Person Days**	**Cost**	**Person Days**	**Cost**
Personnel				
Volunteer	50	$3,200	0	0
Division	12	$1,400	4	$480
Per diem	12	$780		
Vehicle	($0.20/mi)	$400		$20
Helicopter		$2,400		$5,000
Total		$9,380		$5,500
Cost Per Animal		$469		$275

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APPENDIX 1
PRONGHORN CAPTURE FOR NATURAL MORTALITY INVESTIGATION

PROTOCOL FOR NET-GUN CAPTURE METHOD

Background

The Colorado Division of Wildlife is investigating the sex difference in natural mortality in free ranging pronghorn (*Antilocapra americana*). The Program Narrative prescribes a total sample of 60 radioed animals (30 males and 30 females) captured over a 3 year period at a rate of 20 per year. In December 1993, the first year of the study, 20 animals were captured using the conventional drive trap method. The target animals are fawns of the year (about 5 months old). Using the drive trap method, it was necessary to process about 130 animals through the trap to obtain the 20 target animals. This put over 100 animals through the stress of trapping and handling to obtain the sample animals. During the trapping operation, 1 animal was killed and 1 suffered a broken leg; there were no post-capture mortalities of radioed animals. On December 12 and 13, 1994, some 20 target animals were captured using the helicopter net-gun method. There were no direct capture injuries or mortalities but 1 radioed animal died 5 days after capture from capture-related injuries.

Net-gunning will be used to capture 10 male and 10 female fawns in December 1995 from the Middle Park pronghorn population.

Capture Protocol

Thomas M. Pojar is the project's principal investigator and will coordinate the capture operation. All persons involved in the capture operation, including the helicopter net-gunning crew, will be instructed on the care and handling of captured animals to minimize stress and injury to both the animals and crew members. The following protocol will be followed:

1. CAPTURE TIMING AND CONDITIONS. Early to mid December may be the best time to capture and handle pronghorn in Middle Park. It is usually before very deep or crusted snow conditions prevail and there are usually some relatively mild days during mid to late December to allow the animals to recover from the stress of capture. For net-gun capture, snow depths of 15-30 cm is surmised to be desirable to help slow the speed of the animals and to break their fall when netted. Capture operations will not be attempted if crusted snow conditions exist because of skin abrasion and injury to pronghorn's legs.

2. NO-FLY ZONES. Pursuit and capture will not take place within a one-mile radius of a residence or developed area.

3. NOTIFICATION OF AFFECTED PARTIES. Local rural residents and public agencies, including federal, state, and local agencies, will be notified of the time and general area of the capture operation.

4. EMERGENCY SERVICES. Personnel will be instructed as to the contact and location of the nearest medical and emergency services.

5. RADIO COLLARS. Expandable collars will be used because target animals are young of the year and growth needs to be accommodated. The initial circumference of collars put on female fawns will be 40.6 cm (16.0 inches) expandable to 45.7 cm (18.0 inches); male collars will be 40.6 cm (16.0 inches) initially and will expand to 52.1 cm (20.5 inches).

6. COMMAND POST. The principal investigator and handling crew will be at a predetermined command post. The principal investigator will be in charge of all decisions for the care and welfare of the animals.

7. CHASE TIME. A capture will not be attempted without running the animal 1-2 minutes to "warm" animals to prevent capture myopathy. Upon location of a large group (50-100), a smaller group with one or more target animals will be separated from the large group within 1-2 minutes. The maximum pursuit time to maneuver the target group to an acceptable capture site will be 4-5 minutes. An individual pronghorn will not be actively pursued (i.e. intense pursuit to capture) by the helicopter for more than one minute. Total pursuit of the target animal (and accompanying animals) will not exceed 10± minutes. Every effort will be made to make no more than 4-6 captures out of any single large group to avoid excessive chase time of non-target

animals. Care will be taken by the helicopter crew to avoid chasing animals into fences, roads, or rivers.

8. ANIMAL CARE AND HANDLING. Upon capture, the animal will be blindfolded, restrained (hobbled), and loaded into the back compartment of the helicopter. It will be ferried to the command post, unloaded and carried to the processing point (safe distance from helicopter) by 2-3 handlers per animal. The animal will be examined for injuries before the radio collar is installed; after processing it will be released on site (See item #10). Command posts will be located within 5 km (3 miles) of capture sites. Total time for handling will not exceed 2 minutes.

9. INJURED ANIMALS. Any debilitating injury or mortality of a captured animal will be reason to suspend the capture operation to assess the cause of the injury. The capture crew will be interviewed to determine if preventative measures are possible. Topics to consider include: pursuit techniques, weather conditions, visibility, fences, animal locations, groupings, etc. The principal investigator will determine if the capture operation will resume. The severity of any animal injury will be assessed by the principal investigator and he will decide whether to release the animal or euthanize it. An animal with head, spinal, or upper extremity injuries will be euthanized immediately following guidelines of the CDOW Animal Care and Use Committee (1992, page 2 and Figure 1). The carcass will be processed for human consumption. Any other injury will be assessed on an individual basis with the primary criterion for euthanasia being the survivability of the animal. (Pending debate of ACUC euthanasia policy.)

10. RELEASE OF ANIMALS. While still hobbled and restrained, the animal will be again examined for injuries (skin abrasions will be treated with disinfectant) on the neck, back, head and extremities. First the hobbles will be removed, then the blindfold. Handlers will continue to "hold" it (not restrain) until its eyes adjust to light and it is oriented enough to attempt to escape. The command post will be located such that released animals can be observed for about a half mile. The escape path will be clear of potentially dangerous obstacles such as vehicles, fences, and roads. Upon release, the posture and gait will be observed, paying particular attention to how the head is carried (possible neck or back injury) and the use of all four legs as the animal runs. If an injury appears to meet euthanasia criteria, the animal will be immediately re-captured and euthanized according to guidelines in #9 above. Use of a video camera to document the behavior and condition of released animals would be desirable and could provide clues if post-capture mortality occurs.

11. POST-CAPTURE MONITORING. All radioed animals will be located 4-6 times within 10 days after capture to monitor for post-capture mortality. If a mortality is found, a necropsy will be performed and cause of death determined if possible. All injuries and mortalities will be recorded for future reference to the capture technique.

BROWSING EFFECT ON WYOMING BIG SAGEBRUSH BY ANTELOPE AND OTHER WILD UNGULATES

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Abstract: The effect of yearlong browsing by antelope and winter browsing by elk and mule deer on Wyoming big sagebrush was studied. The investigation was conducted near Gardiner, Montana in the ungulate rich boundary line area of the Northern Yellowstone Winter Range. Community and plant level responses were measured. Wyoming big sagebrush community canopy cover, production, and density were all significantly ($P \leq 0.05$) greater inside exclosures constructed in 1957 and 1962 compared to outside the exclosures. This was found to be the case in all eight slope-aspect combinations paired for sampling at the two exclosures. Individual sagebrush plants were also significantly different ($P \leq 0.05$) in and out of one exclosure in production, seedhead number, and leaf morphology. Wyoming big sagebrush is being severely reduced on the study area by browsing.

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INTRODUCTION

Big sagebrush (*Artemisia tridentata*) taxa are particularly important in portions of the Northern Yellowstone Winter Range (NYWR) that are relatively free of snow and thereby accessible for ungulate foraging throughout winter (Wambolt 1998). Twentieth-century naturalists (Rush 1932, Wright and Thompson 1935, Cahalane 1943, Kittams 1950) have commented on the conspicuous use of sagebrush for forage and cover by ungulates on the NYWR and expressed concern over what they considered excessive use of sagebrush in the winter diets of ungulates at Yellowstone National Park (YNP).

The effects of Yellowstone's large populations of ungulates on sagebrush taxa on the NYWR have been debated for more than 70 years (Rush 1932, Wright and Thompson 1935). The National Park Service (NPS) was concerned enough about sagebrush and other browse on the NYWR that they constructed ten 2ha exclosures on the NYWR in 1957 and 1962 to investigate the relationships between ungulate foraging and plant communities.

STUDY AREA AND METHODS

The natural winter range provided by the Gardiner Basin is created by the orographic effects on precipitation of mountain peaks up to 3,353 m in elevation. Ideal winter range on extensive south- or west-facing aspects in the Gardiner Basin have been influenced by glacial scouring, morainal deposition, and outwash sediments. The sagebrush habitat is the Wyoming big sagebrush (*A. t. wyomingensis*)-bluebunch wheatgrass (*Agropyron spicatum*) type.

Individual plant characteristics (Table 1) were sampled from 20 plants randomly paired in and out of the 1957 exclosure. Seedheads were counted. Ten leaders were clipped per plant. Leaves were counted and dried at 65°C, and dry weight determined for each leader and its leaves. The Kolmogorov-Smirnov test compared differences in distributions, and the Wilcoxon test compared distribution medians.

Sampling of community characteristics included measurements of individual sagebrush plants for seedhead number and length, average cover, major and minor axes,

Table 1. Average differences between browsed and unbrowsed Wyoming Big sagebrush plants.

Characteristic	Browsed	Unbrowsed
Production	(g/plant)10.00[a]	44.70[b]
Seedheads per plant	0.08[a]	60.30[b]
Leader length (mm)	22.90[a]	22.30[a]
Leader dry weight (g)	0.02[a]	0.02[a]
Leaves per leader	43.00[a]	44.00[a]
Leaf area (mm^2)	354.00[a]	354.00[a]
Leaf dry weight (g)	0.06[a]	0.08[b]

Values followed by different letters are significant ($P < 0.05$).

crown depth, and overall height. These measurements estimated sagebrush productivity from previous models (Wambolt et al. 1994). Additional production information is reported in Wambolt and Sherwood (1999). Shrub density and line intercept (canopy cover) were determined for both young and old plants. Because the 2-ha exclosures contained considerable environmental variation, the sagebrush habitat within each exclosure was stratified (Hurlbert 1984) by separating topographic, soil, and microclimatic variation into 19 paired sites. With random sampling using paired sites, (in and out of the exclosures) it is unlikely that comparable distributions of topo-edaphic positions would have been obtained regardless of sample size (Coughenour 1991). Sampling areas were paired in and out of each exclosure within 4 slope-aspect combinations (Table 2). These areas were compared with students' *t*-tests.

DISCUSSION

Hoffman and Wambolt (1996) tested the hypothesis that Wyoming big sagebrush plants protected from browsing for 35 years would exhibit growth characters similar to browsed plants. They made paired comparisons (Table 1) in and out of a 2ha NPS exclosure erected in 1957 (Figure 1). Because of heavy browsing, plants outside the exclosure had no terminal leader growth.

The plants inside the exclosure were dominated by terminal growth, and axial long shoots were rare. Thus, for further investigation, it was necessary to compare the terminal leaders of protected plants inside the exclosure to axial long shoots on browsed plants. Unbrowsed plants had consistently higher production than browsed plants. The average production per plant was 10 g with browsing and 45 g with protection. No measurements of dead crown were taken, but plants under protection appeared vigorous, whereas plants outside the exclosure had large amounts of dead crown.

The greatest difference between browsed and unbrowsed plants was in seedhead production. Seedheads averaged 0.08 per browsed plant, and 60.3 per unbrowsed plant. Related studies confirm that stress, such as herbivory, may delay or prevent flowering for several years (McConnell and Smith 1977, Bazzaz et al. 1987, Maschinski and Whitham 1989). The lower overall production of browsed sagebrush plants (Hoffman and Wambolt 1996) indicates that foliage loss results in reduced reproductive potential. Bilborough and Richards found that buds for flowering stems on mountain big sagebrush were located on short shoots at the distal end of the terminal leader. Because almost all terminal leaders were removed on browsed plants (Hoffman and Wambolt 1996), flowering stems would have to be initiated from elsewhere. The loss in seedhead production from browsing on the NYWR has undoubtedly resulted in declines in reproduction for sagebrush as the taxon lacks any asexual means of reproduction.

A companion study found that the addition of average seedhead weight improved the capability of models to predict production of winter forage from the 3 NYWR big sagebrush subspecies (Wambolt et al. 1994). Improved models were used when the 3 taxa exhibited light use (browse form class). Heavily used plants produced few inflorescenses; therefore, the addition of average seedhead weight to the model was most useful for predicting forage production from low-use plants. The segregation of browse form classes and inclusion of average seedhead weight in the models acknowledge the impact browsing has had on the annual production and reproduction of NYWR sagebrush and compliment Hoffman and Wambolt (1996).

Thirty-five percent of mountain big sagebrush (*A. t. vaseyana)* plants were killed by heavy browsing between 1982 and 1992 (Wambolt 1996). Many surviving plants developed a heavy-use browse form class with a high percentage of dead crown. The dead crown in the 3 big sagebrush subspecies increased in proportion to the overall amount of browsing received by each taxon. The percentage of dead crown in live plants for mountain big sagebrush, Wyoming big sagebrush, and basin big sagebrush, (*A. t. tridentata*) was 58.7, 45.4, and 30.1, respectively (Wambolt 1996).

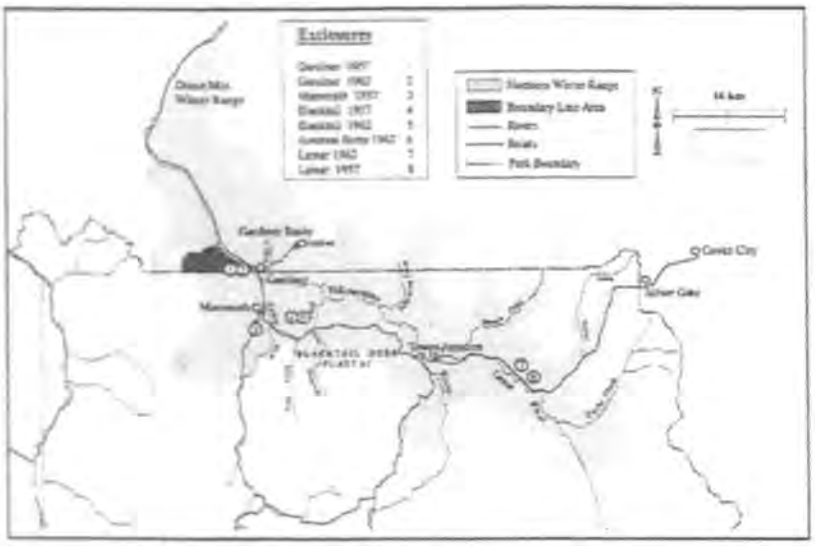

Figure 1. The Northern Yellowstone Winter Range, Montana and Wyoming. The circled numbers represent locations of the exclosures constructed in 1957 and 1962 that still exist. The Gardiner 1957 and Gardiner 1962 exclosures are discussed in this paper.

A significant difference was found between the development of protected and browsed big sagebrush communities (Table 2). Wambolt and Sherwood (1999) who studied mountain big sagebrush in addition to Wyoming big sagebrush, stated, "Since the period of exclosure construction in 1957 and 1962, there has been a significant difference in the development of protected and browsed big sagebrush communities. Average big sagebrush canopy cover on protected sites was 202% greater ($P \leq 0.00027$) than on browsed sites over the 19 paired sites. The average big sagebrush cover for all 19 sites was 19.7% inside and 6.5% outside the exclosures. This relationship was universal on sites with Wyoming big sagebrush or mountain big sagebrush, flat to very steep topographies, and all aspects and precipitation levels."

However, the differences between in and out of the exclosures at the Wyoming big sagebrush sites discussed in this paper were much greater than at the mountain big sagebrush locations. The Wyoming big sagebrush sites under protection averaged almost 10 times more sagebrush cover than where browsing had continued following exclosure construction. Ungulate browsing also affected numbers of big sagebrush plants. Across the NYWR big sagebrush plants were twice as numerous with protection as with browsing.

The production differential for Wyoming big sagebrush was great, but because browsed plants were so reduced in size, their growth parameters were not suitable for production models (Wambolt et al. 1994). The response of the sprouting shrubs (green rabbitbrush, rubber rabbitbrush, and gray horsebrush), as measured by canopy cover and density, was similar to that of big sagebrush across the NYWR.

Singer and Renkin (1995) and Wambolt and Sherwood (1999) found a large impact from browsing on the Wyoming big sagebrush in the Gardiner Basin (Figure 1). Wambolt and Sherwood (1999) considered the difference in impact between Wyoming big sagebrush and mountain big sagebrush with this statement: "Pronghorn and mule deer often forage heavily on big sagebrush taxa (Welch and McArthur 1979). Mule deer diets averaged 52% big sagebrush over a 10-year period (Wambolt 1996), only a couple of kilometers away from the 8 Wyoming big sagebrush paired sites. A high degree of utilization is reflected in the great impact on Wyoming big sagebrush populations at these 8 sites where elk may also be present with pronghorn and mule deer (Singer and Renkin 1995)."

Wambolt (1996) concluded that any of the 4 NYWR sagebrush taxa would be heavily browsed if severe winter

Table 2. Percent canopy cover of Wyoming big sagebrush and number of big sagebrush plants (with a minimum canopy of 15 cm) per 60 m² at eight environmentally paired sites, either browsed or protected. The paired sites areassociated with the exclosures established either in 1957 or 1962 (Wambolt and Sherwood 1999).

Site			Protected	Browsed	Probability > t
	Slope[1]	Aspect	Canopy cover (%)		
Gardiner-57A	Flat	Flat	3.9	0.0	0.0001
Gardiner-57B	Steep	E	3.6	0.1	0.0004
Gardiner-57C	Gentle	SW	4.5	1.1	0.0001
Gardiner-57D	Gentle	NWW	1.4	0.4	0.0073
Gardiner-62A	Moderate	NEE	21.8	0.4	0.0001
Gardiner-62B	Flat	Flat	17.6	4.3	0.0000
Gardiner-62C	Very Steep	NEE	2.4	0.2	0.0012
Gardiner-62D	Very Steep	SE	6.8	0.0	0.0001
			Density (per 60 m²)		
Gardiner-57A	Flat	Flat	9.0	0.5	0.0002
Gardiner-57B	Steep	E	8.1	0.5	0.0002
Gardiner-57C	Gentle	SW	15.1	5.0	0.0005
Gardiner-57D	Gentle	NWW	7.7	1.0	0.0001
Gardiner-62A	Moderate	NEE	36.0	1.2	0.0001
Gardiner-62B	Flat	Flat	39.2	0.2	0.0001
Gardiner-62C	Very Steep	NEE	2.2	0.0	0.0090
Gardiner-62D	Very Steep	SE	6.9	0.7	0.0001

[1] Slope classes are: Flat $\leq$3%, Gentle=4-15%, Moderate=16-29%, Steep=30-44%, Very Steep $\geq$45%.

conditions precluded ungulates from exercising their preferences. However, mountain big sagebrush was clearly the preferred taxon by mule deer and elk. The fact that Singer and Renkin (1995) and Wambolt and Sherwood (1999) found Wyoming big sagebrush to be more impacted than mountain big sagebrush was a function of snow depth limiting pronghorn and mule deer foraging over the larger distribution of mountain big sagebrush.

CONCLUSION

The historical evidence and recent studies (Patten 1993, Hoffman and Wambolt 1996, Wambolt 1996, Wambolt 1998, Wambolt and Sherwood 1999) indicate a significant decline of NYWR sagebrush. This potentially impacts ungulates that rely on sagebrush habitat for meeting their nutritional needs and other requirements. Sagebrush taxa are highly nutritious and preferred forage for ungulates (Welch and McArthur 1979). They have been bred and selected to improve the forage values of rangelands (Welch and Wagstaff 1992). Sagebrush is particularly high in protein. Welch and McArthur (1979) found the mid-winter crude protein content of 21 big sagebrush accessions averaged 12.4% (range = 10-16%).

Ungulates such as pronghorn are impacted as the loss of their highest winter protein source (sagebrush) continues (Welch and McArthur 1979). This loss will manifest itself in a decreasing ability to meet their nutritional needs and requirements for reproduction. The implications for other organisms are clear. In concert with the decline of the native vegetation (sagebrush and dependent species), it is reasonable to expect that numerous animals (Welch 1997) will be impacted.

The following points summarize our findings:

1. Wyoming big sagebrush shrubs that were protected from ungulate browsing produced significantly more forage than browsed shrubs.
2. Seedhead production was severely reduced by browsing. Heavily browsed stands may have difficulty regenerating.
3. Leaders on browsed shrubs have the same number of leaves as those on unbrowsed shrubs, but the mass of leaves is reduced.
4. Shrub composition of the Wyoming big sagebrush habitat type has been significantly changed by browsing on the NYWR.
5. Big sagebrush may be overused and severely damaged on big game winter ranges.

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HABITAT SELECTION BY PRONGHORN ANTELOPE AT WUPATKI NATIONAL MONUMENT, ARIZONA

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Abstract: We analyzed habitat selection variables including vegetation, slope and aspect for pronghorn antelope in northern Arizona. This study encompassed ungrazed land at Wupatki National Monument and grazed land on surrounding ranches. Pronghorn selected grassland habitats and avoided closed juniper woodlands, Great Basin Cold Desert shrublands and Chinle badlands. Shrub-grasslands were used by females in spring during fawning and by both males and females during winter for forage. Pronghorn selected gentle slopes, used intermediate slopes equal to availability and avoided steep slopes. Pronghorn usually showed no preference for aspect classes, but did select cooler northern exposures and avoided hot and windy southern exposures in summer.
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INTRODUCTION

Pronghorn antelope (*Antilocapra americana americana*) are found throughout Arizona, particularly in the northern part of the state and in isolated patches of habitat in central and southern Arizona. Historically, pronghorn ranged over a larger portion of Arizona but were extirpated from many areas (Nelson 1925). Surveys found only 700 pronghorn in Arizona in 1924, but primarily due to transplants from neighboring states, this number had increased to over 10,000 by the mid 1980s. Despite increases in statewide numbers, northern Arizona herds appear to have experienced a recent decline (Ockenfels 1994). Therefore, there is concern for the long term welfare of these herds and a need for research and management. Additional information about pronghorn habitat requirements is needed in order to better manage these herds and to help ensure their survival.

This paper is one part of a larger study into home ranges, movement patterns, distribution around water sources and other aspects of northern Arizona pronghorn life history. The objective of this study was to determine pronghorn habitat use and selection including animal's choices of vegetation, slope and aspect variables. Funding for this study was provided by the National Park Service, Western Region Office and by the USGS, Biological Resources Division. The Arizona Game and Fish Department, Research Branch, provided aerial relocation flights during the course of the study. The staff of Wupatki National Monument provided support, including housing and volunteer field assistance.

STUDY AREA

The study area was centered on Wupatki National Monument, located in north central Arizona, approximately 35 km northeast of Flagstaff. Terrain was flat to rolling in the north, to steeper mountainous areas further south. Chinle badland formations were common in the east while basalt rock outcrops were scattered throughout the study area. Elevations ranged from 1,300 m north of the Monument to over 2,700 m on O'Leary Peak to the south. Elevations within Wupatki National Monument were generally 1,500-1,800 m.

Vegetation varied with elevation, with lower elevations characterized by Great Basin Cold Desert shrublands and grasslands. Dominant shrubs in the cold desert shrubland were four-wing saltbush (*Atriplex canescens*), broom snakeweed (*Gutierrezia sarothrae*), Apache plume (*Fallugia paradoxa*), shadscale (*Atriplex confertifolia*), Mormon teas (*Ephedra* spp.) and sand sage (*Artemisia filofolia*).

Grasslands were made up of a mixture of grasses dominated by galleta (*Hilaria* spp.), black grama (*Bouteloua eriopoda*) and New Mexican feathergrass (*Stipa neomexicana*).

Rubber rabbitbrush (*Chrysothamnus nauseosus*) and broom snakeweed were the most common shrubs. Woodlands occurred on elevations above the grasslands, with the main vegetative components being open and closed stands of one-seed juniper (*Juniperus monosperma*) with grass or shrub understories. Coniferous forests of ponderosa pine (*Pinus ponderosa*) and pinyon pine (*Pinus edulis*) interspersed with open grassland parks occurred in the higher elevations (Bateman, 1976).

METHODS

Pronghorn antelope were captured by personnel from the Arizona Game and Fish Department in October 1992, using a net-gun fired from a helicopter. Each animal was fitted with a radio transmitter collar and individually numbered eartags. Pronghorn were then aerially located twice a month from October 1992 until

September 1994 and located on the ground, approximately twice a month from January 1993 until September 1995. Locations were plotted on 7.5' USGS topographical maps and Universal Transverse Mercator coordinates (UTMs) derived to the nearest 0.1 km from mapped locations. Global Positioning System equipment was also used during ground surveys to record animal locations. Data collected at each ground site included date, time, dominant vegetation type, slope, aspect, weather variables such as temperature, precipitation and wind speed and direction. Pronghorn group size, structure and activity were also recorded.

We divided the calender year into three seasons, based on local temperature and precipitation regimes. Spring comprised the months March through June and was characterized by warm days, cool nights and low precipitation ($\bar{x}$=4 cm). Summer was classified as July through October. Both day and night temperatures were considerably higher with more precipitation ($\bar{x}$ = 9 cm). The third seasonal category was winter (November through February), characterized by cool days and below freezing nights, and average precipitation of 6 cm.

Vegetation Mapping

The intent of this study was to test whether pronghorn used different habitats randomly or selected habitats, based on the hypothesis that visibility and mobility are important factors to them in selecting habitat. A detailed vegetation map was created for Wupatki and the surrounding area, taking into account shrub heights and densities, and density of juniper cover. This map encompassed over 90% of our pronghorn relocations and was created by ground truthing an existing vegetation map for the National Monument and a map of the CO Bar Ranch. These maps were digitized into a Geographic Information System and then existing polygons corrected from field data. New vegetation polygons were created in the field, when necessary, using a Global Positioning System to produce a final vegetation coverage.

We compared the number of times radio-collared pronghorn were observed in each habitat type to expected frequencies based on the area of each vegetation class using chi-square tests. When chi-squared tests rejected the null hypothesis (i.e. that all habitat types are used in proportion to their availability), simultaneous 90% Bonferroni confidence intervals were made for the proportion of times animals used a specific type. To determine whether a habitat type was preferred or avoided, the confidence interval was checked for overlap with the availability proportion of the corresponding habitat type (White and Garrott 1990, Byers et al. 1984, Neu et al. 1974). Differences in preferences for habitat types were analyzed between sexes and among seasons.

Slope and Aspect Mapping

We analyzed slope and aspect preferences by creating coverages and overlaying pronghorn relocations. This was done using USGS digital elevation models, converting them to grids, and then reclassifying the grids into classes useful for analyses. Slopes were grouped into three classes (0-9% slope, 10-19% slope and over 20% slope). Aspects were grouped into nine classes: north, northeast, east, southeast, south, southwest, west, northwest and no aspect (where slopes were less than one percent). These grid coverages were then converted into final polygon coverages that could be examined in ArcView.

Number of times radio collared pronghorn were relocated within each slope and aspect class was compared to expected numbers based on the relative abundance of area of each class using chi-square tests. Preference or avoidance of slope and aspect classes was determined using simultaneous Bonferroni confidence intervals. Differences in preferences between sexes and seasons were also analyzed.

RESULTS

Seventeen pronghorn antelope (13 females and 4 males) were captured and outfitted with radio transmitters. These animals were relocated a total of 1,831 times during the course of this study.

Vegetation Selection

Using the vegetation map created for this study, the following classes existed within the area encompassing more than 90% of the pronghorn relocations:

Grassland: grasses were the main component with less than 20% shrub cover and shrubs were less than 60 cm high.

Shrub-grassland: shrubs were between 20-30% cover but still less than 60 cm high. Main shrubs in this category were rubber rabbitbrush, snakeweed and shadscale.

Open Juniper grassland: juniper cover was 5-20% and the understory was primarily grasses, with shrub cover less than 20%.

Open Juniper shrubland: juniper cover was 5-20% and the understory was made up of more than 20% shrub cover.

Closed Juniper woodland: juniper cover was greater than 20%.

Cold Desert shrubland: shrubs were the main vegetation (greater than 30% cover) and were typically greater than 60 cm high. Common shrubs were Mormon tea, Apache plume, squawbush, snakeweed, rabbitbrush and four-wing saltbush.

Chinle Badlands/ Rock Outcrops: bare ground or deep cinders predominated.

Pronghorn relocations were tested against expected numbers based on area of each vegetation type. Pronghorn use of vegetation types differed from expected based on area by sex and by season (Figures 1 and 2). During the spring season, both females and males preferred the grassland type (females $\chi^2 = 198.8$, 6 df, $P<0.05$; males $\chi^2 = 73.3$, 6 df, $P<0.05$) (Tables 1 and 2). Both males and females utilized the closed juniper woodlands, cold desert shrublands and Chinle badlands less than expected. Females also preferred the shrub-grasslands, while males used this type as expected. Both sexes avoided the open juniper grasslands but used open juniper shrublands as expected.

During the summer season, pronghorn use of habitat types differed from availability of habitat types (females $\chi^2 = 191.5$, 6 df, $P<0.05$; males $\chi^2 = 54.9$, 6 df, $P<0.05$) (Tables 3 and 4). Again, both males and females preferred the grassland type. Females also used shrub-grasslands more than expected while males used this type as expected. Both sexes avoided the closed juniper woodlands, cold desert shrublands and Chinle badlands. Females avoided the open juniper habitats but males used these types as expected based on availability.

During the winter season, pronghorn habitat preference also differed from availability (females $\chi^2 = 168.1$, 6 df, $P<0.05$; males $\chi^2 = 77.1$, 6 df, $P<0.05$)(Tables 5 and 6). During the winter, both sexes preferred the shrub-grasslands. Females also used the

Table 1. Use of vegetation classes by female pronghorn compared to availability of vegetation classes in spring (March - June). Use differed from availability for females ($\chi^2 = 198.8$, 6 df, $P<0.05$). Under preference, P = preferred, A = avoided, NP = no preference.

Vegetation Class	Observed # of Locations	Expected # of Locations	Proportion of Area Available	Bonferroni 90% CI	Preference
Grassland	220	135	0.444	0.65 - 0.79	P
Shrub-grassland	18	6	0.019	0.02 - 0.09	P
Open juniper grassland	17	53	0.176	0.02 - 0.09	A
Open juniper shrubland	4	4	0.012	0.00 - 0.03	NP
Closed juniper woodland	4	17	0.057	0.00 - 0.03	A
Cold desert shrubland	6	53	0.176	0.00 - 0.04	A
Rock outcrops	0	16	0.053		A

Table 2. Use of vegetation classes by male pronghorn compared to availability of vegetation classes in spring (March - June). Use differed from availability ($\chi^2 = 73.3$, 6 df, $P<0.05$). Under preference, P = preferred, A = avoided, NP = no preference.

Vegetation Class	Observed # of Locations	Expected # of Locations	Proportion of Area Available	Bonferroni 90% CI	Preference
Grassland	82	515	0.444	0.60 - 0.82	P
Shrub-grassland	13	6	0.019	0.00 - 0.06	NP
Open juniper grassland	11	20	0.176	0.02 - 0.16	A
Open juniper shrubland	5	1	0.012	0.00 - 0.09	NP
Closed juniper woodland	0	6	0.057		A
Cold desert shrubland	0	20	0.176		A
Rock outcrops	1	6	0.053	0.01 - 0.03	A

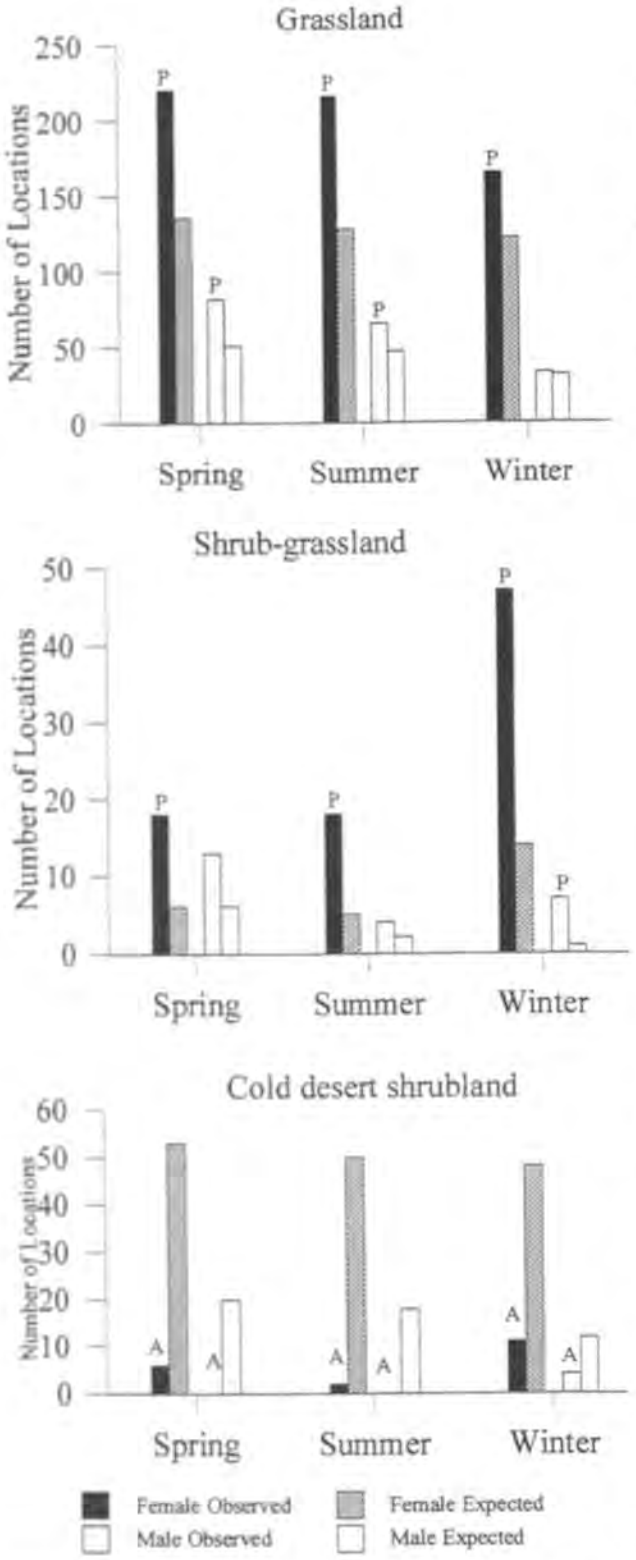

Figure 1. Observed number of pronghorn locations versus expected number of locations in grassland, shrub-grassland and cold desert shrubland vegetation types. P denotes use greater than expected, A denotes use less than expected.

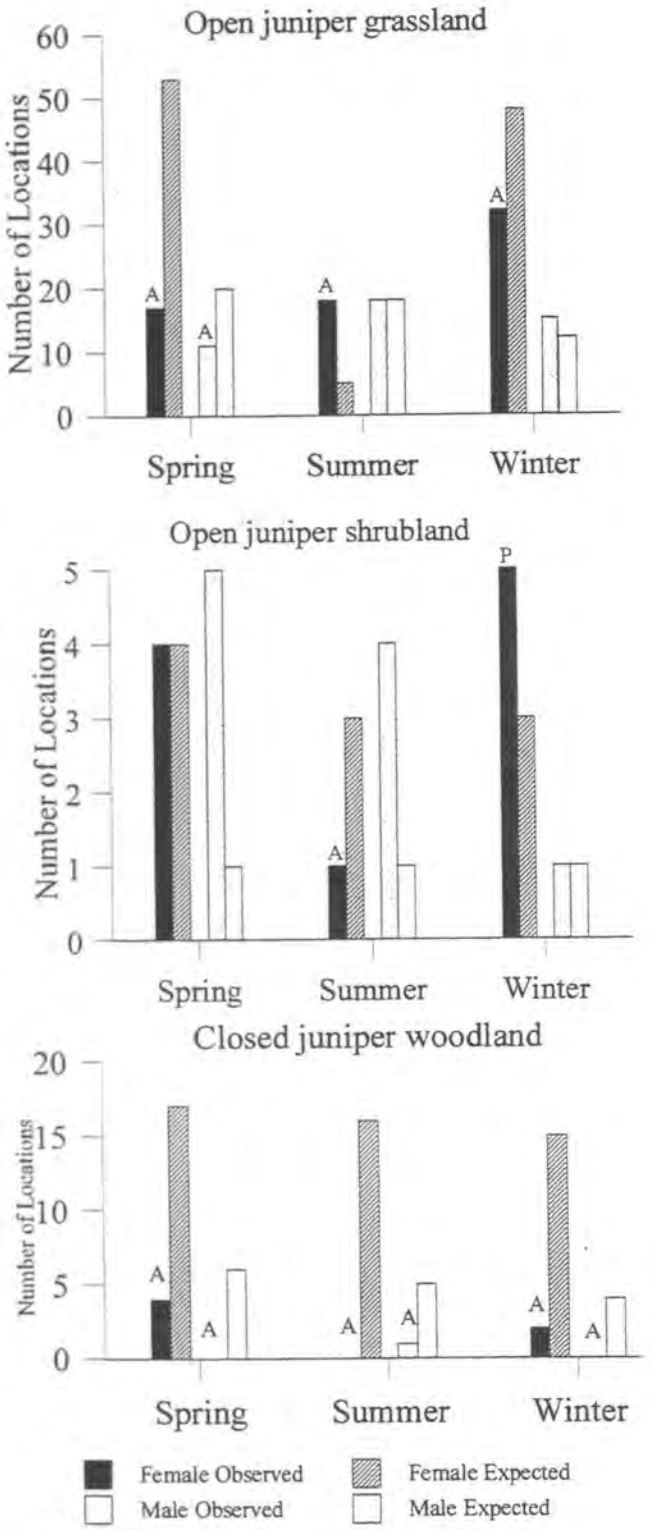

Figure 2. Observed number of observed pronghorn locations versus number of expected locations in open juniper grasslands, open juniper shrublands and closed juniper woodlands. P denotes use greater than expected, A denotes use less than expected.

grassland type more than expected, while males used this as expected. Both sexes avoided the closed juniper woodlands, cold desert shrublands and Chinle badlands. Females avoided the open juniper grasslands and preferred open juniper shrublands, while males used both these types as expected.

Slope and Aspect Selection

Pronghorn did not use slopes as expected based on availability. In addition, use of slope classes differed by sex and by season. During the spring season, females preferred the gentle slopes, used intermediate slopes equal to their availability and avoided steeper slopes (χ^2 = 20.3, 2 df, $P<0.05$). Males avoided the steeper slopes and showed no preference for either gentle or intermediate slopes (χ^2 = 9.4, 2 df, $P<0.05$), (Table 7).

During the summer, females preferred the gentle slopes between 0-9% and avoided the intermediate (10-19%) and steeper slopes (χ^2 = 45.2, 2 df, $P<0.05$). Males preferred the intermediate slope, avoided the steep slopes and used the gentle slopes as expected (χ^2 = 16.4, 2 df, $P<0.05$) (Table 8).

During winter, females preferred the gentle slopes and avoided both intermediate and steep slopes (χ^2 = 59.4, 2 df, $P<0.05$). Males avoided the steep slopes and showed no preference for the gentle or intermediate slopes (χ^2 = 13.2, 2 df, $P<0.05$), (Table 9, Figure 3).

No selection of aspect classes was detected for pronghorn during the spring season (χ^2 = 7.4, $P>0.05$). However, pronghorn did not use aspect classes equal to their availability during summer and winter seasons (χ^2 = 29.2 and χ^2 = 44.6 respectively, $P<0.05$). During the summer season, pronghorn either selected for or used as expected the cooler northern exposures and avoided hot and windy southerly exposures. During the winter season, pronghorn selected northeast aspects and areas with no aspect (slope <1%), and avoided the southern aspects. All other aspects were used as expected.

Table 3. Use of vegetation classes by female pronghorn compared to availability of vegetation classes in summer (July - October). Use differed from availability (χ^2 = 191.5, 6 df, $P<0.05$). Under preference, P = preferred, A = avoided, NP = no preference.

Vegetation Class	Observed # of Locations	Expected # of Locations	Proportion of Area Available	Bonferroni 90% CI	Preference
Grassland	215	127	0.444	0.68 - 0.81	P
Shrub-grassland	18	5	0.019	0.03 - 0.09	P
Open juniper grassland	25	50	0.176	0.04 - 0.13	A
Open juniper shrubland	1	3	0.012	0.00 - 0.01	A
Closed juniper woodland	0	16	0.057		A
Cold desert shrubland	2	50	0.176	0.00 - 0.02	A
Rock outcrops	0	5	0.053		A

Table 4. Use of vegetation classes by male pronghorn compared to availability of vegetation classes in summer (July - October). Use differed from availability (χ^2 = 54.9, 6 df, $P<0.05$). Under preference, P = preferred, A = avoided, NP = no preference.

Vegetation Class	Observed # of Locations	Expected # of Locations	Proportion of Area Available	Bonferroni 90% CI	Preference
Grassland	65	47	0.444	0.49 - 0.74	P
Shrub-grassland	4	2	0.019	0.01 - 0.08	NP
Open juniper grassland	18	18	0.176	0.07 - 0.26	NP
Open juniper shrubland	4	1	0.012	0.01 - 0.08	NP
Closed juniper woodland	1	5	0.057	0.01 - 0.03	A
Cold desert shrubland	0	18	0.176		A
Rock outcrops	0	5	0.053		A

Table 5. Use of vegetation classes by female pronghorn compared to availability of vegetation classes in winter (November - February). Use differed from availability (x^2 = 168.1, 6 df, $P<0.05$). Under preference, P = preferred, A = avoided, NP = no preference.

Vegetation Class	Observed # of locations	Expected # of locations	Proportion of area available	Bonferroni 90% CI	Preference
Grassland	164	121	0.444	0.52 - 0.68	P
Shrub-grassland	47	14	0.019	0.03 - 0.08	P
Open juniper grassland	32	48	0.176	0.07 - 0.17	A
Open juniper shrubland	5	3	0.012	0.02 - 0.04	P
Closed juniper woodland	2	15	0.057	0.00 - 0.02	A
Cold desert shrubland	11	48	0.176	0.01 - 0.07	A
Rock outcrops	0	14	0.053		A

Table 6. Use of vegetation classes by male pronghorn compared to availability of vegetation classes in winter (November - February). Use differed from availability (x^2 = 77.1, 6 df, $P<0.05$). Under preference, P = preferred, A = avoided, NP = no preference.

Vegetation Class	Observed # of locations	Expected # of locations	Proportion of area available	Bonferroni 90% CI	Preference
Grassland	33	31	0.444	0.31 - 0.62	NP
Shrub-grassland	7	1	0.019	0.01 - 0.19	P
Open juniper grassland	15	12	0.176	0.09 - 0.34	NP
Open juniper shrubland	1	1	0.012	0.00 - 0.05	NP
Closed juniper woodland	0	4	0.057		A
Cold desert shrubland	4	12	0.176	0.01 - 0.12	A
Rock outcrops	0	4	0.053		A

Table 7. Use of slope classes by pronghorn compared with slope availability during the spring (March - June) season. Use differed from availability for females (x^2 = 20.3, 2 df, $P<0.05$) and males (x^2 = 9.4, 2 df, $P<0.05$). Under preference, P = preferred, A = avoided, NP = no preference.

Sex	Slope Class (%)	Observed # of locations	Expected # of locations	Proportion of area available	Bonferroni 90% CI	Prefer
Female	0	331	304	0.73	0.75 - 0.84	P
	10-19	68	66	0.16	0.12 - 0.20	NP
	20	18	46	0.11	0.02 - 0.06	A
Male	0	117	108	0.73	0.71 - 0.86	NP
	10-19	27	23	0.16	0.11 - 0.25	NP
	20	5	17	0.11	0.00 - 0.07	A

DISCUSSION

Pronghorn utilize specific habitats throughout the year for their life requirements, such as mating, birthing and weaning fawns, predator detection and avoidance and shelter from weather. Vegetation composition and structure have been long known to influence pronghorn use of an area (Yoakum 1980). Since vision and mobility are hypothesized to contribute to predator detection and avoidance for pronghorns, they are thought to avoid tall, dense vegetation (Sundstrom et al. 1973, Kindschy et al. 1978, 1982). Pronghorn typically inhabit open grasslands, shrub-grasslands, steppes and deserts that provide adequate forage supplies, shelter, and hiding cover for fawns (Yoakum 1974). Numerous studies have determined that pronghorn do not use vegetation types in proportion to their availability. Yoakum (1974, 1979, 1980) found that pronghorn prefer vegetation less than 60 cm high. He considered vegetation over 60 cm as suboptimal because it obstructs views of the surrounding area. In addition, he found that areas with a dense ground cover of shorter shrubs were less preferred because such areas reduce the mobility of pronghorn and increase vulnerability to predation. Willis et al. (1988) also reported that pronghorn select areas of low shrub volume.

Pronghorn in this study did not use vegetation classes based on their availability, with males and females selecting different habitat classes at different times of the year. Pronghorn avoided the closed juniper woodlands and cold desert shrublands where shrub and tree height and density greatly reduce visibility and mobility during all seasons. Chinle badland and rock outcrop classes where bare ground dominated were also avoided. Additionally, during all seasons, pronghorn preferred the grassland type, where shrubs made up less than 20% of the vegetation.

Pronghorn preferences for shrub-grasslands (shrubs 20-30%) varied by sex and by season. Females selected the shrub-grasslands during the spring and summer, when fawning is occurring in northern Arizona. The heavier shrub component may contribute to better quality fawning areas by providing more cover for fawns which decreases detection by predators (Alldredge et al. 1991, Autenrieth 1982, Barrett 1981).

During the winter, both males and females used shrub-grasslands more than expected. This is most likely due to the fact that forbs were becoming unavailable and the pronghorn were turning from forbs to browse for forage. The importance of browse for pronghorn during

Table 8. Use of slope classes by pronghorn compared with slope availability during the summer (July-October) season. Use differed from availability for females (x^2 = 45.2, 2 df, $P<0.05$) and males (x^2 = 16.4, 2 df, $P<0.05$). Under preference, P = preferred, A = avoided, NP = no preference.

Sex	Slope Class (%)	Observed # of Locations	Expected # of Locations	Proportion of Area Available	Bonferroni 90% CI	Prefer
Female	0	364	305	0.73	0.83 - 0.90	P
	10-19	42	67	0.16	0.07 - 0.13	A
	20	13	47	0.11	0.02 - 0.05	A
Male	0	121	122	0.73	0.64 - 0.80	NP
	10-19	41	26	0.16	0.17 - 0.32	P
	20	6	19	0.11	0.00 - 0.07	A

Table 9. Use of slope classes by pronghorn compared with slope availability during the winter (November- February) season. Use differed from availability for females (x^2 = 59.4, 2 df, $P<0.05$) and males (x^2 = 13.2, 2 df, $P<0.05$). Under preference, P = preferred, A = avoided, NP = no preference.

Sex	Slope Class (%)	Observed # of Locations	Expected # of Locations	Proportion of area available	Bonferroni 90% CI	Prefer
Female	0	336	273	0.73	0.86 - 0.93	P
	10-19	37	60	0.16	0.06 - 0.13	A
	20	3	42	0.11	0.00 - 0.02	A
Male	0	98	92	0.73	0.69 - 0.85	NP
	10-19	27	20	0.16	0.13 - 0.29	NP
	20	2	14	0.11	0.00 - 0.04	A

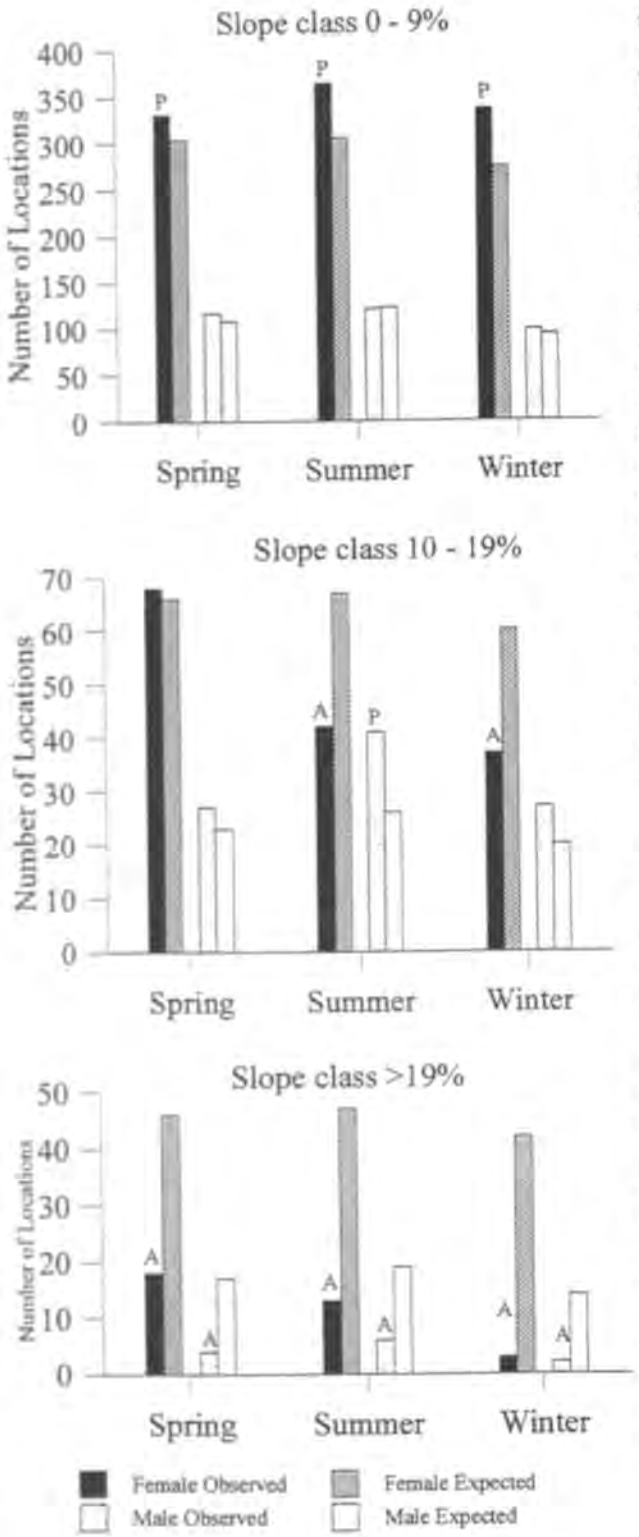

Figure 3. Observed number of pronghorn locations versus expected number of locations in slope classes 0-9%, 10-19% and >19%. P denotes use greater than expected, A denotes use less than expected.

the winter has been well documented by numerous authors (Mitchell and Smoliak 1971, Bayless 1969, Barrett 1980, Taylor 1972, Hoover 1966). In all these studies, browse made up at least 80% of the winter diet of pronghorn. Hailey (1979) noted movements of pronghorn in winter to brushy areas in Texas. Beale and Smith (1970) contend that browse is required to sustain pronghorn during winters or droughts.

Although open juniper habitats are often considered suboptimal for pronghorn because visibility and mobility are reduced (Yoakum 1980), in our study female pronghorn used open juniper shrublands during the spring and winter. Although these habitats could increase risk of predation, Goldsmith (1990) found that pronghorn compensate for obstructed visibility and reduce the risk of predation by increasing vigilance in these habitat types. Pronghorn use has been documented in areas with taller vegetation during winter or early spring, when forb availability is low (Bayless 1969, Sundstrom et al. 1973, Neff and Woolsey 1979, 1980, Beale and Smith 1970). Dirschl (1963) found that pronghorn were concentrated during winter in areas where sagebrush and junipers provided evergreen forage for the animals. In northern Arizona, Gay (1984) found areas with taller vegetation to be winter and early spring feeding sites.

Pronghorn typically inhabit open, gentle terrain which provides enhanced visibility and mobility. Previous studies suggested that pronghorn are adapted to flat or undulating terrain of less than 20% slopes (Yoakum 1980, Kindschy et al. 1982). Pronghorn antelope in this study did not use slope classes equal to their availability. Both male and female pronghorn avoided steep slopes (≥ 20%) during all seasons of the year. Female pronghorn preferred the gentle slopes between 0-9% during all seasons. Males used both the gentle and intermediate slopes equal to their availability in all seasons, with the exception of summer when they favored the intermediate slopes, perhaps looking for cooler temperatures and shade from the intense summer sun.

No selection of aspect classes was detected for pronghorn during the spring season. During the summer season, pronghorn either selected for or used as expected the cooler northern exposures and avoided the hot and windy southern exposures. During the winter season, pronghorn selected the northeast aspect and avoided the southern aspects, again most likely avoiding the prevailing southwesterly winds.

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AN ASSESSMENT OF WILDFIRES AND PIONEERING PRONGHORN IN LONG VALLEY, CALIFORNIA/NEVADA

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Abstract: Long Valley, in northeastern California and Nevada, is a shrubsteppe ecosystem of the Great Basin. Prior to the 1970s, the Valley was dominated by dense, tall shrubs and an under story of sparse herbaceous vegetation. In the summer of 1973, a series of wildfires burned some 16,188 ha (40,000 acres), which subsequently were artificially seeded to a mixture of grasses, forbs and shrubs. Although historic pronghorn habitat, no pronghorn had been observed in the area for more than 75 years. Following the 1973 fires, a small herd pioneered into the Valley and remained as permanent residents. Data from vegetation transects and a habitat assessment model were used to analyze habitat suitability. Apparently, the wildfires and rangeland seeding changed the area from poor (unburned) to good (burned/seeded) quality habitat for pronghorn based on biological requirements for the Great Basin ecoregion.

KEY WORDS: *Antilocapra americana*, artificial seeding, Great Basin habitat conditions, pioneering pronghorn, vegetation succession, wildfire burns.

Pronghorn Antelope Workshop Proceedings 17:86-90

INTRODUCTION

Contemporary pronghorn (*Antilocapra americana*) are truly a resilient wildlife species. Herds numbered 30-60 million in the early 1800s, only to experience near extirpation by Euroamericans by 1900 (Nelson 1925). Populations rebounded in the latter half of the twentieth century and contemporary populations are estimated around one million (Yoakum 1986). A characteristic of the species that contributes to successful restoration is its ability to explore and colonize unoccupied historic habitats in favorable condition.

Vegetation is one of the most important environmental characteristics relative to quality habitat for pronghorn. Plants provide nutritional needs, water for physiological requirements, thermal cover for adverse climatic conditions, and protective cover for fawns. However, each of these vegetation characteristics/requirements have variables that determine the quality/quantity criteria for sustaining low to high populations. Often, it is the ecological seral stage of vegetation that regulates the occupation and abundance of pronghorn in habitat sites. Consequently, plant succession can be directly linked to an area's ability to sustain, decrease, or increase pronghorn densities (O'Gara and Yoakum 1992).

The objective of this paper is to assess the effects of wildfires in 1973 and subsequent artificial seedings on a herd of pronghorn that pioneered Long Valley in northeastern California and adjacent lands in Nevada. Appreciation is extended to the following for assistance: Frank Hall and Syd Kahre, California Department of Fish and Game for data on pronghorn; Rick Brigham and Jim Ramakka, United States Bureau of Land Management (BLM) for information on landscape characteristics and management; and Bart O'Gara and George Gruell for suggestions and improvements in various manuscript drafts.

Historical Perspectives

Deming (1963) observed various cases wherein wildfires in Oregon shrublands were followed by improved forage conditions for pronghorn. Thirty years later, Van Dyck (1990) reported similar findings for various sites in southeastern Oregon and concluded that certain wildfires resulted in improved herbaceous production favoring pronghorn forage needs.

According to Polenz (1976), ranchers in Bear Valley, Oregon improved forage for livestock by mechanically reducing shrubs and seeding grasses and forbs. Apparently pronghorn responded by moving into Bear Valley, and several decades later the herd had one of the highest fawn to doe ratios in Oregon (Torland 1980). In central Colorado, Pojar and Gill (1990) reported an increasing pronghorn population that pioneered a historic shrubsteppe area. The herd created depredation problems in a field of cultivated alfalfa (*Medicago* spp.) which provided relished forage (Pojar et al. 1994).

STUDY AREA

Long Valley is located some 40 km (25 miles) northwest of Reno, Nevada. The Valley is approximately 8 by 26 km (5 by 15 miles) with a mean elevation of 1,524 m (5,000 feet). Precipitation averages 20-25 cm (8-10 inches) with most moisture received during winter and spring. Summers generally lack rain, however thunderstorms occur during most years. Long Valley Creek is a perennial stream though the center of the Valley.

The pre-fire vegetative community was representative of the cold desert shrubsteppe (Clements and Young 1997). Juniper (*Juniperus osteospirma*) covered 10-15% on the north end of the Valley and had been increasing for the past 50 years or longer. Shrubs were predominantly big sagebrush (*Artemisia tridentata*), followed by antelope

bitterbrush (*Purshia tridentata*), little rabbitbrush (*Chrysothamnus viscidiflorus*) and desert peach (*Prunus andersoni*). Forb cover was not abundant but contained 40 to 60 species including arrowleaf balsamroot (*Balsamorhiza sagittata*), mule's ear (*Wyethia mollis*), buckwheat (*Eriogonium* spp.), phlox (*Phlox* spp.) and the planted dryland Nomad alfalfa (*Medicago sativa*). Endemic grasses existed throughout the Valley and were represented by bottlebrush squirreltail (*Sitanion hystrix*), Great Basin ryegrass (*Elymus canadensis*), bluebunch wheatgrass (*Agropyron spicatum*) and various needle grasses (*Stipa* spp.). The alien cheat grass (*Bromus tectorum*) was prevalent in patches and along roadways.

At the time of the 1973 fire, the Valley was sparsely occupied by humans; however the population has increased during the past 30 years and continues to do so. A railroad and interstate highway bisect the site. Cattle grazing was a primary use and continues today, although livestock numbers have decreased during the past two decades. Lands were primarily under the jurisdiction of the BLM and railroad companies. Private lands constituted less than one-third of total acreage. Recent land acquisitions by the California Department of Fish and Game provide a mandate for portions of the Valley to be managed specifically for wildlife enhancement.

The study site has been a demonstration area for training of pronghorn and other wildlife habitat management principles and practices by the Western Section of The Wildlife Society (1995) and the Pronghorn Antelope Workshop (1996). A wildlife habitat management plan was completed in 1975 and updated in 1988 (Bardwell and Brigham 1988). Preliminary findings regarding pronghorn/vegetation relationships were reported by Yoakum (1980).

METHODS

Vegetative transects were run in unburned and burned/seeded sites 7 years after the wildfires, using a modified step-point method (Evans and Love 1957). This method provided information relative to the estimated composition of vegetation and nonvegetation (e.g. rocks, litter, bare ground). Vegetation height was determined by measuring the height of the tallest forage plants (trees excluded).

Habitat quality was assessed by using the "Habitat Suitability Model for Great Basin Shrubsteppes" (US Bureau of Land Management 1980). Incorporated in the model were data from vegetation transacts conducted during this study and ecological findings in the BLM's habitat management plan (Bardwell and Brigham 1988). Results of this system provided a quantitative evaluation of the burned and unburned sites regarding quality ratings for pronghorn habitat.

RESULTS AND DISCUSSION

Long Valley has a recent history of wildfires; 11 were recorded from 1940 to 1997, and others occurred but were not recorded. Most fires were small lightning fires less than 607 ha (1,500 acres) in extent. The 1973 fire was exceptional in that it burned more than 16,188 ha (40,000 acres) (Bardwell and Brigham 1988). Fires were a natural, reoccurring disturbance factor contributing to vegetation changes. However, for many rangelands such as Long Valley, historic extensive foraging of grasses and forbs by livestock resulted in decreased herbaceous vegetation and increased shrub densities (Young et al. 1976, Miller et al. 1994, Clements and Young 1997). In some areas, aggressive fire suppression programs have limited the size and frequency of wildfires. Concurrent with the increase in shrub densities, fuel loads increased greatly, setting the stage for the catastrophic wildfires since the 1950s (Young and Sparks 1985, Gruell 1996).

Long Valley was historic pronghorn habitat. However, no pronghorn had been observed from 1900 to 1975. Small herds existed to the north and east with no physical or manmade barriers restricting their access to the Valley. A herd of six animals was first seen near Bordertown, Nevada during 1975 (Syd Kahre, pers. comm. 1995). Other small groups were observed in the Valley during the next 10 years. In 1995, the California Department of Fish and Game estimated 50 or more animals in the Valley (Frank Hall, pers. comm. 1995). The herd was believed to reside year-long in the Valley.

The pre-1973 ecosystem contained physiographic, climatic and vegetative characteristics suitable for pronghorn habitat (Yoakum 1972, 1974, O'Gara and Yoakum 1992). However, the dominance of tall, dense shrubs prior to 1973 apparently did not constitute preferred pronghorn habitat—probably the reason they had not occupied the area during this century. Vegetation transects disclosed that tall shrub cover was prevalent, and grasses and forbs were minor—especially forbs, which comprised only one percent of total plant cover (Table 1).

Ellis (1970) studied pronghorn and vegetation relationships in Great Basin and Great Plains landscapes. He concluded that Great Basin rangelands did not sustain high pronghorn densities, as reported for the Great Plains, because Great Basin rangelands lacked abundant herbaceous vegetation when does were in the last trimester of pregnancy and during the lactation period. Herbaceous plants were more nutritious than shrubs during spring and summer, and pronghorn readily grazed grasses and forbs during these seasons (Yoakum 1990). Ellis postulated that small quantities of herbaceous vegetation (due in part to lack of summer precipitation and heavy grazing by livestock) resulted in lower fawn survival rates. Vriend and Barrett (1978) concurred with Ellis' findings that fawn survival was less on the shrubsteppes of the Great Basin than the grasslands of the Great Plains.

Table 1. Percent composition and height of vegetation on wildfire burn/seeded sites and adjacent unburned sagebrush areas in Long Valley, California and Nevada.

Parameter	Unburned	Burned/Seeded
Vegetation (Percent Composition)		
Grass	12	31
Forb	1	10
Shrub	19	8
Vegetation subtotal	32	49
Vegetation Height (cm/inches)	81/32	45/17
Non-vegetation (Percent Composition)		
Bareground	61	44
Rock	3	1
Litter	4	6
Non vegetation subtotal	68	51

Influences of wildfires on wildlife habitats in the Great Basin are not well documented or understood. Two recent reports by Gruell (1995, 1996) provide historic perspectives and current findings that wildfires are a natural disturbance affecting plant succession. Gruell emphasized that fires change successional stages of shrublands, resulting in intermediate seral stages of herbaceous vegetation and shrubs. Rarely are shrubs eliminated by fires from ecosystems for long periods.

The influences of the 1973 wildfires on the shrubsteppe of Long Valley were evaluated relative to pronghorn habitat quality. The habitat suitability model developed by the BLM (1980) was used to conduct the assessment. Results are provided in Table 2. The rating for unburned sites was poor, whereas the rating for burned/seeded sites was good. Apparently, the wildfires followed by artificial seeding changed the vegetation to favor pronghorn habitat requirements as identified by Yoakum (1972, 1974) and O'Gara and Yoakum (1992). Primary reasons for this change were: (1) a decrease in shrub densities and increases in herbaceous plants for forage; and (2) a decrease in vegetation height and density, thereby improving the ability of pronghorn to see predators. The greater abundance of grasses and forbs during the parturition and lactation period promoted better pronghorn fawn survival as noted by Ellis (1970). It likewise enhanced forage class production of preferred herbaceous plants during spring and summer for all pronghorn (Yoakum 1990). Tall shrubs were identified by Alldredge et al. (1991) as detrimental to pronghorn fawn survival; consequently, the ecosystem in Long Valley was enhanced for fawn production following the 1973 wildfires.

Conclusions and Habitat Management Recommendations

More than 60 years ago, Leopold (1933) advocated fire to enhance wildlife habitat. However, the practice has not been recognized or used by some wildlife managers. An aggressive fire suppression program on the Hart Mountain National Antelope Refuge in Oregon (U.S. Fish and Wildlife Service 1994) and the Sheldon National Wildlife Refuge in Nevada (Gregg 1997) contributed to sustaining shrublands in late succession on more than 90 percent of the two refuges, thereby maintaining low quality habitat for pronghorn. Recently, societal concepts have changed and the role of fire as a natural disturbance has been recognized and in part accepted, thus leading to implementation of fire management which allows fires to burn where deemed appropriate. Active prescribed burns are now major habitat enhancement practices for certain pronghorn habitats in the Great Basin (Pyle and Yoakum 1994, Gregg 1997).

At times, wildfires can be deleterious to pronghorn habitat, (e.g. extensive fires that limit forage availability, repetitive fires followed by invasion of undesirable alien plants, and loss of the shrubs vital for winter survival). Although wildfires have burned more than half of Long Valley during the last 50 years, production of shrubs remains high, because the ecosystem had an abundance of seed and the climate favored growth of shrubs. Therefore, wildfires have not created a deficiency of shrubs for forage during critical winters. In actuality, Long Valley is currently (1996) producing sufficient winter browse to sustain all the pronghorn (N = 5,000) reported to be in California by the California Department of Fish and Game based on results of the 1997 winter census.

The role of fire in bitterbrush rejuvenation was noticeable in Long Valley. Bitterbrush was the second most frequently browsed shrub for pronghorn in Great Basin habitats (Yoakum 1958). Prior to 1973, the Valley had extensive stands of bitterbrush in decadent condition with little reproduction. Fire burned patches of these shrubs, resulting in browse being unavailable as forage for a decade or so. But 24 years later, the previously burned bitterbrush stands were 1.2-1.8 m (4-6 feet) high, pro-

duced leaders greater than 15 cm (6 inches) for browse during years of sufficient precipitation and reproduction was abundant. In contrast, unburned stands remained decadent, had poor browse production, and there was little reproduction.

Forb composition was low prior to the burn (1%) and increased to 10% following the burn. One reason for this major change in forb density was the planting of dryland Nomad alfalfa. This legume was highly nutritious, succulent and relished by pronghorn. One of its attributes is that it remains green into autumn, providing forage when many other forbs were desiccated. That the species still was abundant 20 years after seeding attests to its value for pronghorn. This forb increase was important for enhancement of pronghorn habitat. Forbs are preferred forage and are high in nutritional value and moisture content (Beale and Smith 1970, Yoakum 1990).

Based upon information gained from analyzing the effects of the fire in this study and the assessment of pronghorn habitat suitability on other burns, the following management guides are provided for pronghorn habitats on sagebrush steppes in the Great Basin:

1. Vegetation communities with plant composition of approximately one-third each of grasses, forbs and shrubs should be maintained and protected from fires.
2. Extensive rangelands dominated by shrubs in late ecological succession can be managed with fire to create a mosaic of plant succession in various seral stages, with an ultimate goal of a one-third mix of grasses, forbs and shrubs.
3. It is unlikely that ecosystems producing healthy herbaceous vegetation will need artificial seeding following fires. Seeding of productive areas can be politically motivated and wasteful.
4. Sites lacking a healthy stand of herbaceous plants prior to fires should be artificially seeded. Plant species in seed mixtures should include a variety of grasses, forbs, and in some cases, preferred shrubs. Dryland alfalfa is adapted to semi-arid rangelands and is a preferred forage for pronghorn. Grasses relished by pronghorn are fine textured species (e.g. *Poa secunda, Orzopsis hymenoides*) as opposed to coarse bunchgrasses (e.g. *Agropyron spicatum, Elymus canadensis*). Species that remain succulent into autumn should be considered.
5. The ten basic principles of big game habitat restoration advocated by Plummer et al. (1968) and Yoakum et al. (1980) should be considered for rangelands needing restoration.
6. Successive prescribed fires that provide a mosaic of successional stages provide great diversity of preferred forage species.
7. Vegetation should be monitored at 3-5 year intervals to determine if the vegetation meets the requirements of pronghorn for the ecosystem, and whether vegetation status remains static, increasing or decreasing.

Table 2. Ratings for pronghorn habitat quality in burned/seeded and unburned sites, Long Valley, California and Nevada, based on criteria in the Pronghorn Habitat Suitability Model (US Bureau of Land Management, 1980).

Parameter	Unburned Ratings	Burned/Seeded Ratings
Vegetation Quality		
Forbs	2	15
Grasses	5	5
Shrubs	3	5
Vegetation Height	5	10
Vegetation Density		
Forbs	6	12
Grasses	4	8
Shrubs	4	6
Water Availability	10	10
Water Quality	10	10
Limiting Factors	-20	-20
TOTAL	29	61
OVERALL RATING	Poor	Good

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SELECTED LITERATURE ON PRONGHORN

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Abstract: Managers and researchers need literature regarding the biology and management of pronghorn populations and habitats. A comprehensive bibliography is being compiled; however, it is not scheduled for publication in the immediate future. Consequently, a listing of selected literature is provided herein. Included are references produced in Canada, Mexico, and the United States for 10 books, 15 monographs, 45 reports for the Interstate Antelope Conference, 17 proceedings plus 2 guides from the Pronghorn Antelope Workshop, and 118 academic theses.

Key words: Interstate Antelope Conference, literature, publications, pronghorn, Pronghorn Antelope Workshop, theses.

Pronghorn Antelope Workshop Proceedings 17:91-101

INTRODUCTION

Attendees at the 16th and 17th business meetings of the Pronghorn Antelope Workshop expressed interest in an updated listing of literature pertaining to pronghorn biology and management. Much of this information is being assembled for a comprehensive bibliography, not scheduled for publication in the immediate future. Therefore, this interim report makes selected literature available now.

Three bibliographies on pronghorn have been published; all are out of print (Prenzlow 1965, Yoakum 1967, 1991). A compendium of pronghorn articles published in the *Journal of Wildlife Management* from 1937 to 1977 is available (Yoakum and Spalinger 1979). The objective of this report is to list literature references for the following:

1. Books, both technical and fictional, for adults and children. Included are monographs primarily published by government agencies relative to management principles and practices.
2. Annual reports, transactions and guides of the regional Interstate Antelope Conference from 1949 to 1994.
3. Proceedings and guides of the international Pronghorn Antelope Workshop from 1965 to 1994.
4. Academic theses concerned with pronghorn in Canada, Mexico, and the United States.

Should readers note literature not in this report but considered worthy for inclusion, the author would appreciate notification for inclusion in future bibliographies. Appreciation is extended to Bart O'Gara for obtaining information on theses in the United States, Raul Valdez and Jorge Cancino for data on theses in Mexico, and Anita and Don DeLong for compiling Figure 1.

Books and Monographs

Table 1 lists seven books devoted to pronghorn for adults and three written for juvenile readers. These publications emphasize life history, hunting practices, science and management. The first six books are reported out-of-print, but may be bought at used-book stores. The remaining four can be readily purchased.

Currently, five books on pronghorn are in preparation. One is a textbook on pronghorn ecology and management; the second records trophy horns; the third is devoted to pronghorn behavior; the fourth describes pronghorn country; and the fifth is a bibliography on the species and its habitats. All are planned for publication during the next two to three years.

Table 2 lists 15 monographs on pronghorn and their habitats. Most are technical, containing data for limited geographic locations. All provide management practices for pronghorn and their habitats. Most are still available from their respective publishers.

Table 1. Books published on pronghorn from 1948 to 1996.

Date	Author(s)	Juvenile	Adult	Fiction	Nonfiction	Major Subject(s)
1948	Einarsen		X		X	Ecology, management
1959	Popowski		X		X	Ecology, hunting, management
1962	Beebe	X		X		Life history of a young buck
1969	Van Wormer		X		X	Ecology, management
1977	Chase		X		X	Ecology
1982	Popowski and Pyle		X		X	Ecology, hunting, management
1986	Ahlstrom	X			X	Life history, ecology
1986	Cadieux		X		X	Ecology, hunting, management
1992	Lacapa	X		X		Amerindian folktale
1995	Turbak and Carey		X		X	Ecology management

Table 2. Monographs on pronghorn from 1959 to 1996.

Authors	Major Subject Content			Other
	Ecology	Management	Mortality	
Villa 1951	X	X	X	(for Mexico)
Hoover et al. 1959	X	X	X	(for Colorado)
Russell 1964		X		Trapping & translocation
Spillett et al. 1967		X		Effects of Fencing
Yoakum 1967	X	X	X	Literature review
Sundstrom et al. 1973		X	X	Abundance & Diet selection
Kitchen 1974	X			Behavior & reproduction
Autenrieth & Fichter 1975	X			Behavior of fawns
Yoakum & Spalinger 1979	X	X	X	Articles in J. Wildlife Mgmt.
Mitchell 1980	X	X	X	(for Alberta)
Smith & Beale 1980	X	X	X	(for Utah)
Pyrah 1987	X	X	X	(for Montana)
O'Gara & Yoakum 1992	X	X	X	Pronghorn Antelope workshop management guides
Ockenfels et al. 1994	X	X		(For Arizona) habitat selection
Ockenfels et al. 1996	X	X		(For Arizona) landscape survey

Three readily obtainable publications are Turbak and Carey (1995), O'Gara and Yoakum (1992), and Yoakum and Spalinger (1979). Turbak and Carey (1995) is a popular life history with many beautiful color photographs, available from Northland Publishing Company, P.O. Box 1389, Flagstaff, AZ 86002-13289. O'Gara and Yoakum (1992) stresses scientific information regarding the "state of the art" of pronghorn management, available from the North American Pronghorn Foundation, 1905 CY Avenue, Casper, WY. 82604. Yoakum and Spalinger (1979) is a compendium of articles published in the *Journal of Wildlife Management* from 1937-1977, available from The Wildlife Society, 5410 Grosvenor Lane, Bethesda, MD 20814-2197.

Interstate Antelope Conference

In 1949, a meeting concerning pronghorn was convened for the California, Idaho, Nevada and Oregon state wildlife agencies and the U.S. Fish and Wildlife Service at Lakeview, Oregon, to coordinate census techniques for interstate pronghorn herds. Through the years, these meetings continued and were called the Four-State Antelope Meeting, Tri-State Antelope Meeting (after Idaho dropped out), and Interstate Antelope Conference (IAC). The IAC meetings have produced summary documents (Table 3 provides a resume of meetings conducted from 1949-1994 and lists publications to document the meetings). As an aid to researchers and managers, the IAC published two guides regarding principles and practices for maintaining and enhancing pronghorn populations and habitats (Griffith 1962, Salwasser 1980). IAC meetings have been held for almost 50 years and represent one of the oldest, continuous, meetings of professional wildlife managers devoted to the welfare of a single wild ungulate in North America.

Pronghorn Antelope Workshop

The Pronghorn Antelope Workshop began in 1965 as the Antelope States Workshop. Subsequent workshops included participants from 19 state and provincial wildlife agencies, 7 United States federal agencies, the federal government of Mexico, the North American Pronghorn Foundation, universities and colleges, consultants, zoological parks, private companies and individuals. Meetings are held biennially with the Workshop site rotating among participating states and provinces. Workshop goals are to encourage the perpetuation of sustainable wild pronghorn as an ecological, aesthetic, and recreational natural resource on western rangelands, both public and private, at their most productive levels consistent with other land uses.

Table 4 provides a list of the 17 Workshops held and information regarding the proceedings distributed by host agencies. In addition, the Pronghorn Antelope Workshop has produced two sets of guides (Autenrieth 1978, O'Gara and Yoakum 1992). Objectives of these guides are to provide information available for managing and perpetuating pronghorn and their habitats.

Theses

One hundred eighteen theses devoted entirely, or containing major biological findings relative to pronghorn were identified, including: 4 B.S. theses, 83 M.S. theses, and 31 Ph.D. dissertations (Table 5). In Mexico, a profes-

sional B.S. degree can be accompanied with a thesis. The first M.S. on pronghorn was completed by Buck in 1947. The first Ph.D. on pronghorn was produced by Buechner in 1950. Numbers of M.S. theses increased up to and including the 1970s, and then declined. However, Ph.D. dissertations continued to increase through the 1980s. Although the 1990s have 33 percent more time for completion, the trend appears to be a marked decrease in theses (Figure 1).

Theses were completed in 2 provinces in Canada, 3 states in Mexico and 21 states in the United States (Table 5). The United States produced 107 theses with top producing states being Montana (21) and Wyoming (17). A total of 7 theses was completed in Canada (Alberta 5, Saskatchewan 2), whereas 4 were completed in Mexico. Only Bromley (1967, 1986) completed a M.S. and a Ph.D. on pronghorn.

Table 3. Reports and transactions by the Interstate Antelope Conference from 1949 to 1994.

Date	Location	# Number	Report	Remarks
2/2/49	Lakeview, OR	unrecorded	7 pp.	First meeting conducted
1950	Lakeview, OR	22	2 reports	Census & food habits
2/1/51	Lakeview, OR	11	10 pp.	Census & food habits
3/8/54	Alturas, CA	9	7 pp.	Fawn Tagging
6/12/54	Hart Mt., OR	17	7 pp.	Fawn tagging, research
4/15/55	Lakeview, OR	13	4 pp.	management process
9/14/55	Alturas, CA	20	7 pp.	management process
9/12/56	Reno, NV	26	23 pp.	management and research
9/18/57	Klamath Falls, OR	18	46 pp.	major reports on research
9/17-18/58	Sheldon NWR, NV	19	1st Trans	9th meeting F&WS hosted
9/15/59	Alturas, CA	27	2nd Trans	10th meeting BLM hosted
9/60	Lakeview, OR	28	3rd Trans	11th meeting OR hosted
9/15-16/61	Reno, NV	24	4th Trans	12th meeting NV hosted
12/4-4, 62	Boise, ID	36	5th Trans	13th meeting ID hosted
12/4-5/63	Alturas, CA	46	6th Trans	14th meeting CA hosted
12/9/64	Lakeview, OR	26	7th Trans	15th meeting OR hosted
1/18/66	Lakeview, OR	24	8th Trans	16th meeting CA hosted
1/31/67	Alturas, CA	22	9th Trans	17th meeting NV hosted
3/10/68	Alturas, CA	22	10th Trans	18th meeting OR hosted
3/5/69	Alturas, CA	28	11th Trans	19th meeting F&WS hosted
3/3/70	Alturas, CA	29	12th Trans	20th meeting CA hosted
3/2/71	Alturas, CA	23	13th Trans	21st meeting NV hosted
3/7/72	Alturas, CA	15	14th Trans	22nd meeting OR hosted
3/6/73	Alturas, CA	18	15th Trans	23rd meeting F&WS hosted
3/12/74	Alturas, CA	18	16th Trans	24th meeting CA hosted
3/11/75	Alturas, CA	16	17th Trans	25th meeting NV hosted
3/9/76	Alturas, CA	15	18th Trans	26th meeting OR hosted
3/8/77	Alturas, CA	21	19th Trans	27th meeting F&WS hosted
3/14/78	Alturas, CA	21	20th Trans	28th meeting CA hosted
3/13/79	Alturas, CA	24	21st Trans	29th meeting NV hosted
3/11/80	Alturas, CA	14	22nd Trans	30th meeting OR hosted
3/10/81	Alturas, CA	19	23rd Trans	31st meeting F&WS hosted
3/10/82	Alturas, CA	15	24th Trans	32nd meeting CA hosted
3/8/83	Alturas, CA	11	25th Trans	33rd meeting NV hosted
3/13/84	Alturas, CA	9	26th Trans	34rd meeting OR hosted
3/12/85	Alturas, CA	14	27th Trans	35th meeting F&WS hosted
3/12/86	Reno, NV	12	28th Trans	36th meeting CA hosted
3/10/87	Alturas, CA	14	29th Trans	37th meeting NV hosted
5/31/88	Hart Mt., OR	9	30th Trans	38th meeting OR hosted
3/14/89	Alturas, CA	13	31st Trans	39th meeting F&WS hosted
3/13/90	Alturas, CA	15	32nd Trans.	40th meeting CA hosted
4/1/94	Lake Tahoe, CA	14	33rd Trans.	41th meeting CA hosted

Table 4. Proceedings of the Pronghorn Antelope Workshop from 1965 to 1996.

Date	Location	Number Attendees	Proceedings	Host Agency
3/14-15/65	Sante Fe, NM	18	1:103pp	New Mexico Dept. Fish & Game
2/16-17/66	Denver, CO	32	2:85pp	Colorado Game, Fish & Parks
2/5-6/68	Casper, WY	98	3:117pp	Wyoming Game and Fish Commission
1/27-28/70	Scottsbluff, NE	85	4:139pp	Nebraska Game, Fish and Parks
6/19-20/72	Billings, MT	85	5:293pp	Montana Fish and Game Dept.
2/19-20/74	Salt Lake City, UT	52	6:183pp	Utah Division Wildlife Res.
2/24-26/76	Twin Falls, ID	68	7:222pp	Idaho Dept. Fish and Game
5/2-4/78	Jasper, Alberta	84	8:532pp	Alberta Fish and Wildlife Div.
3/8-10/80	Rio Rico, AZ	64	9:294pp	Arizona Game and Fish Dept.
3/5-7/82	Dickinson, ND	69	10:258pp	North Dakota Game and Fish
3/10-12/84	Corpus Christi, TX	45	11:251pp	Texas Parks & Wildlife Dept.
3/11-13/86	Reno, NV	43	12:101pp	Nevada Dept. of Wildlife
6/11-3/88	Hart Mt., OR	43	13:164pp	Oregon Dept. Fish & Wildlife
5/22-24/90	Silver Springs, CO	45	14:126pp	Colorado Div. Of Wildlife
6/8-11/92	Rock Springs, WY	91	15:150pp	Wyoming Game and Fish Dept.
3/18-21/94	Emporia, KA	50	16:204pp	Kansas Dept. Wildlife & Parks
6/4-7/96	Lake Tahoe, CA/NV	54	17:118pp	California Dept. Fish & Game

Table 5. Theses regarding pronghorn in Canada, Mexico and the United States, 1947 - 1996.

Province/ State/ Country	Thesis	1940s	1950s	1960s	1970s	1980s	1990s	Total B.S.	Total M.S.	Total Ph.D.
Alberta	M.S.			Bruns 1967		Glaholt 1984		2		
	Ph.D.				Bullock 1971 Bromley 1977	Barrett 1982 Gay 1984	Hughes 1991		3 2	
Arizona	M.S.					Sadak 1987			1	
California	M.S.				Ellis 1970	Goldsmith 1988	Maher 1992			3
	Ph.D.									
Colorado	M.S.			Prenzlow 1965	Hoover 1971	Boyle 1981 Sejkora 1982 Liewer 1988		5		
	Ph.D.				Wesley 1971 Schwartz 1977	Czaplewski 1986 Deblinger 1988				4
Idaho	M.S.		Folker 1956	Aunenrieth 1966	Bernt 1976 Carlton 1976 Sexson 1979	Choo 1985 Milks 1982 Simpson 1982			5	
Kansas	M.S.						Jorgensen 1992 Rothchild 1993 Fairbanks 1992 Min 1995		5	
	Ph.D.									2
Mexico	B.S.					Ramirez 1985 Cancino 1988 Palacio 1988 Jaramillo 1989		4		
Michigan	Ph.D.				Kitchen 1972	McCollough 1980				2
Minnesota	Ph.D.				Hoskinson 1977					1
Montana	M.S.	Buck 1947	Dow 1952 Cole 1955	McCutchen 1966 Bayless 1967 Bromley 1967 Wentland 1968 May 1969	Campbell 1970 Roberts 1970 Freeman 1971 Becker 1972 Reichel 1976 Roseland 1977 Von Guten 1978 Bodie 1979	Corneli 1980 McNay 1980 Segerstrom 1982 Gates 1983		20		
	Ph.D.			O'Gara 1968					1	1
Nevada	M.S.			Englebing 1969	Meeker 1979 Glidewell 1970 Trevino 1978					
New Mexico	M.S.					Ghaly 1980 Braydbough 1981 Morgan 1988				
	Ph.D.						Smith 1994 Clements 1991		7	1 1
New York	Ph.D.		Gregg 1953							
North Dakota	M.S.	-				Jatnieks 1982 Voleskey 1982			2	
Ohio	Ph.D.		Buechner 1950						1	1
	M.S.				Barrington 1975					
Oregon	M.S.		Hansen 1955 Yoakum 1957 Compton 1958 Dinges 1958		Herrig 1974 Good 1977				6	
	Ph.D.					Greenquist 1983 McInnis 1984				2
Saskatchewan	M.S.			Dirschl 1962	Pyle 1972				2	
South Dakota	M.S.		Kohler 1950	Boddicker 1966	Messinger 1978 Robinson 1970 Leftwich 1977 Tucker 1977	Giffen 1981			4	
Texas	M.S.				Fulbright 1978	Roebuck 1982	Hubers 1992 Lee 1992 Canon 1993		5	
	Ph.D.									2
Utah	M.S.			Hinman 1960 Spillett 1964					2 1	
Virginia	M.S.					Firchow 1986 Hanley 1980				2
Washington	Ph.D.			Mitchell 1965						
Wyoming	M.S.		Wenzel 1955 Edwards 1958	Morrison 1961	Taylor 1972 Jacobs 1977 Swanger 1977	Cook 1984 Forest 1985 Hoffman 1985 Gunzel 1986	Martin 1995		11	
	Ph.D.			Severson 1966 Ingold 1969	Maxell 1973	Reeve 1984 Whisler 1984 Yeo 1988				6
Totals	B.S.					4		4		
	M.S.	1	10	14	27	24	7		83	
	Ph.D.		2	4	8	11	6			31
Grand Total		1	12	18	35	39	13		118	

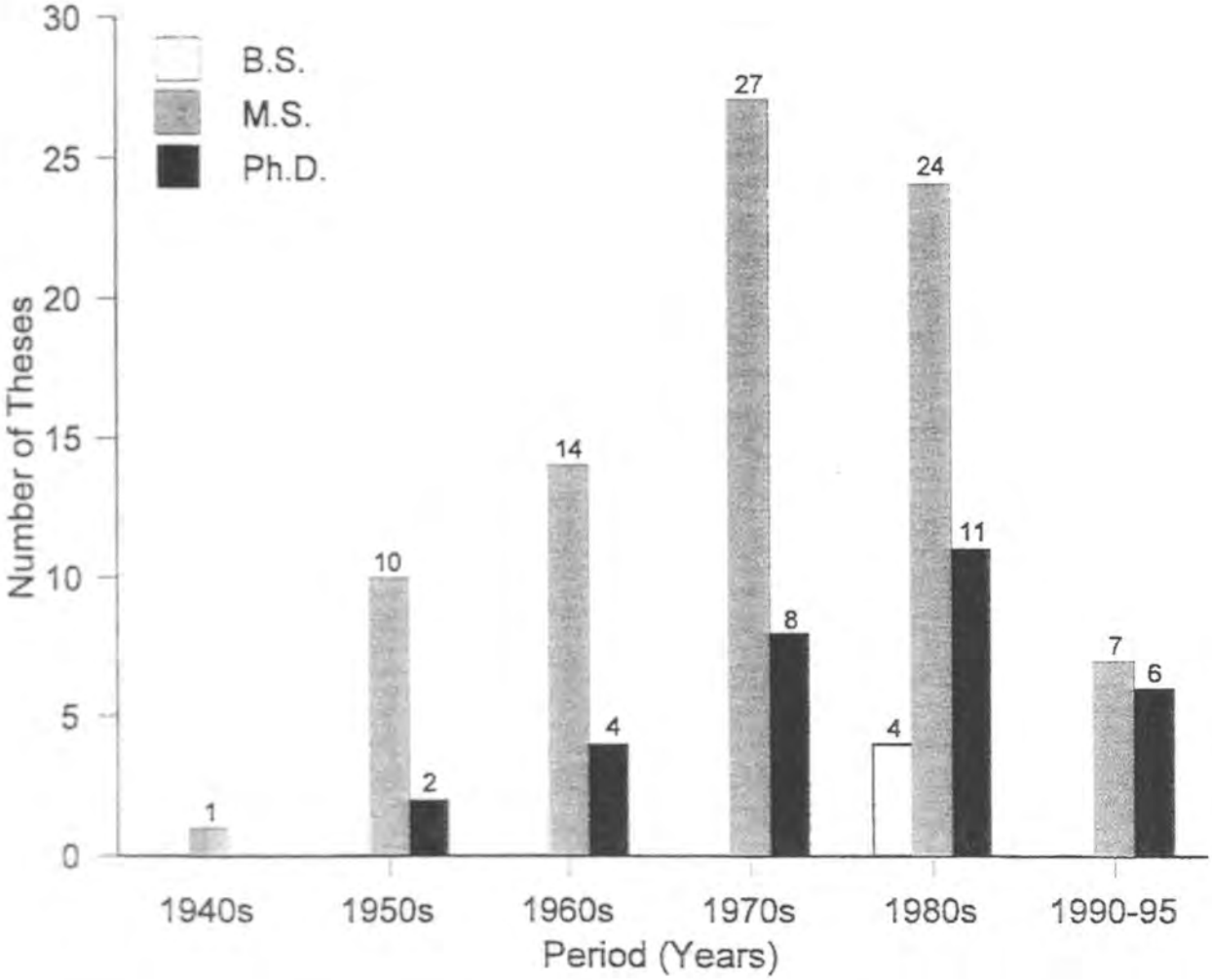

Figure 1. Trend in academic theses pertaining to pronghorn as depicted in 10 year increments from 1940 to 1996.

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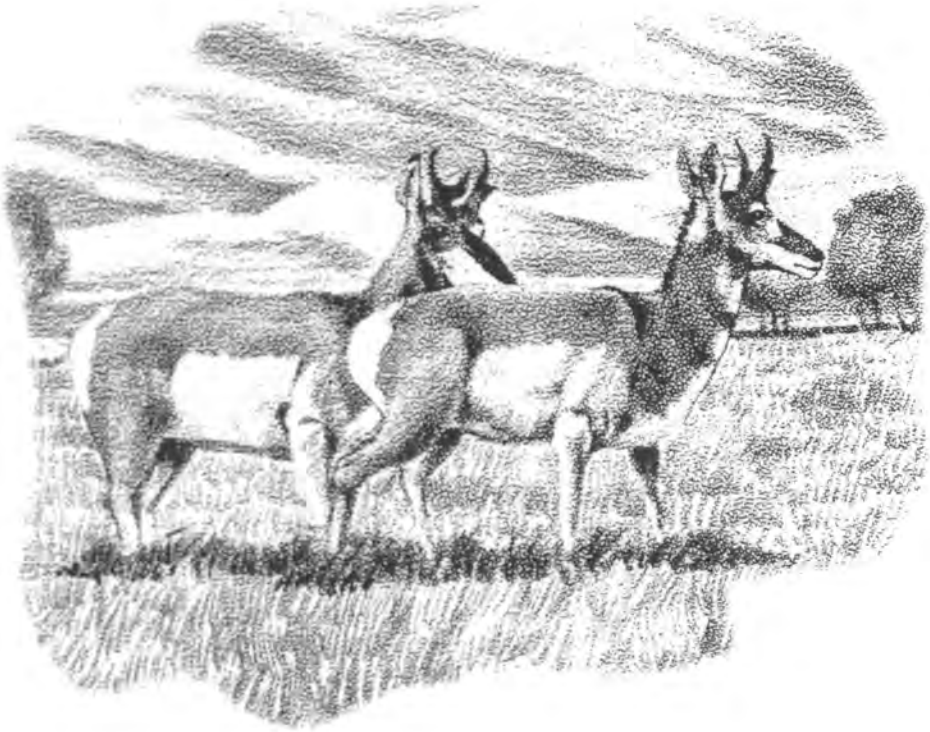

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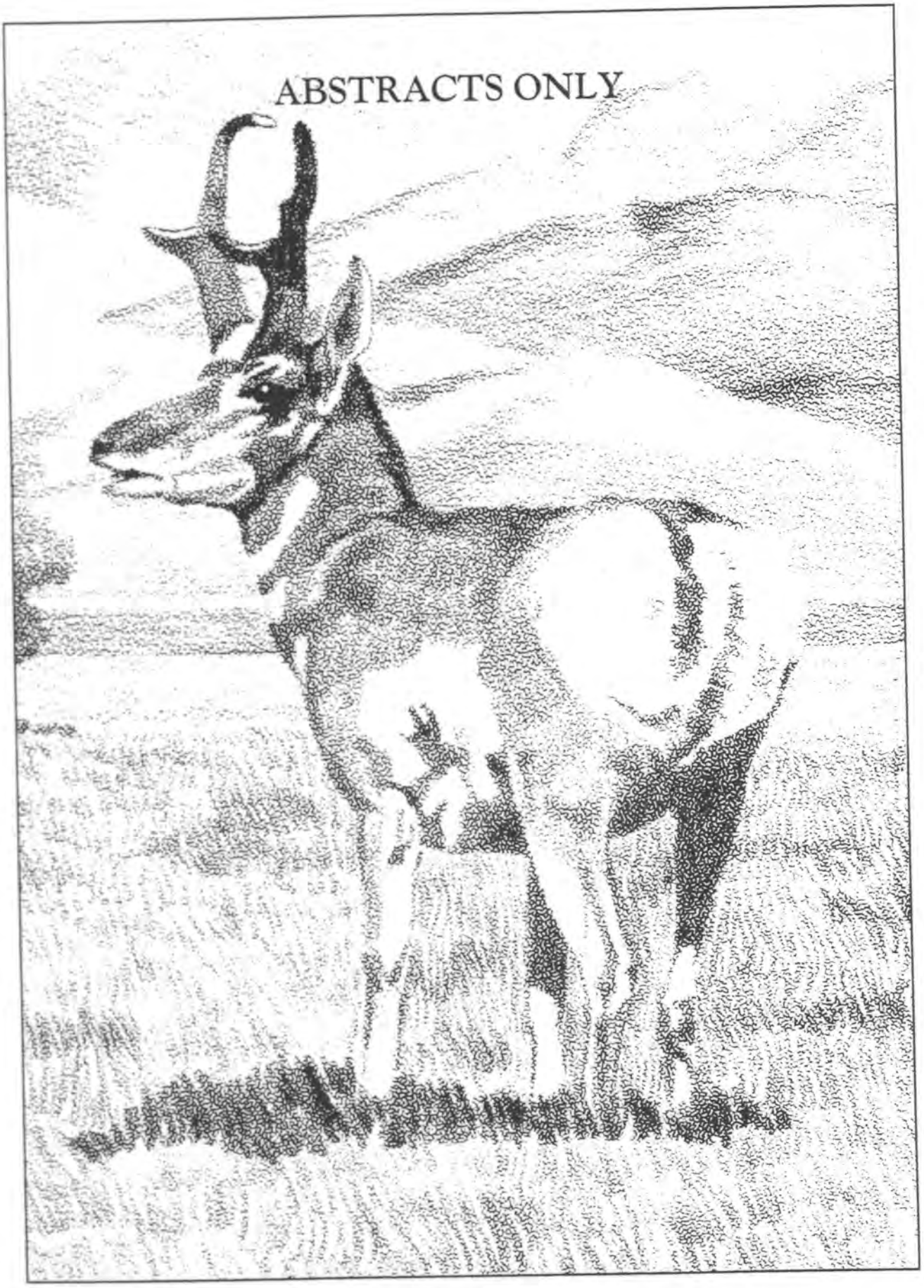

HIGHWAY AND RAILROAD EFFECTS ON PRONGHORN MOVEMENTS IN ARIZONA AND MEXICO

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Abstract: To test whether fenced highways and railroads fragment pronghorn (*Antilocapra americana*) habitat in Arizona and Mexico, we radio-marked 84 adult and 11 fawn American pronghorn (*A. a. americana*) and 19 adult Sonoran pronghorn (*A. a. sonoriensis*). We tested 3 right-of way types: (1) unfenced, paved roadways; (2) fenced, paved highways; and (3) railroad rights-of-way. Unfenced, paved roadways did not fragment pronghorn habitat, as crossings were common. No crossings of fenced, paved highways were observed within or between study areas; these fragmented pronghorn habitat in Arizona and Mexico. Furthermore, we recorded no crossings of fenced railroads, so it is likely these fragment pronghorn habitat. Fragmentation in our study areas isolated herds, creating sub-populations. Genetic isolation or loss due to fragmentation could adversely affect pronghorn population dynamics. In an attempt to facilitate movement across fenced highways and railroads and thus, possibly mitigate adverse effects, one or more of the following modifications could be used: (1) remove fences along movement corridors; (2) widen rights-of way by moving fences further away; (3) construct expansive underpasses or overpasses; or (4) relocate rights-of-way out of pronghorn habitat. If none of these mitigation features work, translocating pronghorn to maintain gene flow and supplement numbers may be the only solution.

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STATUS AND DISTRIBUTION OF THE PRONGHORN (*ANTILOCAPRA AMERICANA MEXICANA*) IN THE STATE OF CHIHUAHUA

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Abstract: In December 1995, personnel from the Secretariat of the Environment, Natural Resources, and Fisheries (Secretaría del Medio Ambiente, Recursos Naturales y Pesca) in coordination with the Autonomous University of Chihuahua (Universidad Autónoma de Chihuahua) and with the support of the Secretariat of National Defense (Secretaría de la Defensa Nacional) conducted survey flights to determine current population numbers and distribution of the pronghorn (*Antilocapra americana mexicana*) in the state of Chihuahua. The survey was conducted as a means of gaining information to help develop a state plan for a management program that would increase population numbers of the pronghorn in areas where it once occurred. Both aerial and ground surveys have been carried out in areas where pronghorn are distributed. The surveys show that pronghorn are present in 9 municipalities and that the populations have remained stable over the last 20 years, considering results of surveys conducted by Treviño (1977) González and Lafón (1985). In this paper, the problems confronted by the subspecies are discussed, including poaching, habitat deterioration, and drastic climatic changes which are the most important factors causing low numbers in Chihuahua. This presentation ends with some recommendations for management that will allow for the maintenance of the species in the most integral way possible because it is considered one of the most genetically pure populations of this species in North America.

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RECOVERY EFFORTS FOR SONORAN PRONGHORN

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STEVE S. HENRY, Cabeza Prieta National Wildlife Refuge, Ago, AZ 85321
MARK T. BROWN, Arizona Game and Fish Department, Yuma, AZ 85365

Abstract: Fixed-wing aerial surveys of Sonoran pronghorn (*Antilocapra americana sonoriensis*) in 1992 and 1994 yielded population estimates in Arizona. Pronghorn with radio telemetry collars are providing managers with data on productivity, recruitment, dependency on free-standing water, habitat use patterns, mortality rates, and predation. These efforts reflect the recently revised Recovery Plan. Mitochondrial DNA analysis will assist with subspeciation validation. Management questions such as water development, the international border fence, and predator control are controversial and under investigation. Managers are faced with reconciling efforts to recover an endangered species with wilderness and ecosystem level approaches to land management.

Pronghorn Antelope Workshop Proceedings 17:106

THE STATUS OF SONORAN PRONGHORN IN SONORA, MEXICO

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JOHN J. HERVERT, Arizona Game and Fish, Yuma, AZ 85365

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

Pronghorn Antelope Workshop Proceedings 17:107

USING THE VORTEX MODEL TO ASSESS MINIMUM VIABLE POPULATION FOR SONORAN PRONGHORN

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Abstract: The Sonoran pronghorn (*Antilocapra americana sonoriensis*) is listed as an endangered subspecies in both the United States and Mexico due to low population numbers throughout its range. Possible reasons for low population numbers include: illegal harvest, habitat loss or conversion to other uses, competition with domestic livestock, or drying of perennial waterways. Consistent with the Endangered Species Act, federal and state resource management agencies are investigating various aspects of life history and habitat use. A benefit of this work is a better understanding of population demographics. While some life history aspects remain speculative due to the lack of definitive data, there is sufficient knowledge to use a computer model to simulate population persistence under various management/environmental conditions. We elected to use the computer model VORTEX for this assessment over other available models because of desirable attributes of this model. One of the most attractive aspects of VORTEX is the fact that it is a stochastic model that incorporates random variation in both climatic and population performance that are similar to processes that occur in natural settings. We chose to use two approaches in the modeling effort. First, we used available data on Sonoran pronghorn to develop a likely scenario for this subspecies in Arizona. Where data were not available we used data from surrogate subspecies from as similar as possible habitats. We then convened a meeting of the experts on Sonoran pronghorn and used a modification of the Delphi method to determine values of variables required for VORTEX. Once this was done, we modeled these input parameters to evaluate the probability of Sonoran pronghorn persistence under these population/life history values. We defined the minimum viable population as having a probability of persistence of greater than 0.95 for a period of 100 years. We started with an initial population of 25 animals and added animals in increments of 25 until the desired probability of persistence was achieved.

Pronghorn Antelope Workshop Proceedings 17:108

GENDER IDENTIFICATION OF PRONGHORN ANTELOPE TISSUES WITH THE POLYMERASE CHAIN REACTION

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JAMES BANKS, California Dept. of Fish & Game Wildlife Forensics Laboratory, Rancho Cordova, CA 95670
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Abstract: We report on the use of the polymerase chain reaction (PCR) to determine the gender of pronghorn antelope from tissue samples. PCR probes for gender identification from limited amounts of DNA have been described for forensic and management purposes in a variety of species. To our knowledge, a test for pronghorn antelope has not been reported. This test involves generating DNA fragments from both males and females to demonstrate the presence of amplifiable DNA in the sample. In the same reaction, a second set of primers amplifies a fragment of the Y chromosomes. Our trial was conducted with a limited number of individual antelope from 2 states: California and Wyoming. We are still increasing the sample size and conducting a blind trial.

Pronghorn Antelope Workshop Proceedings 17:109

RECOMMENDED PROCEDURES FOR USING WYOMING'S AERIAL LINE TRANSECT TECHNIQUE TO ESTIMATE PRONGHORN ABUNDANCE

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Abstract: Line Transect (LT) sampling was adapted to fixed-wing aerial surveys for estimating pronghorn (*Antilocapra americana*) densities in Wyoming. Interest in applying the technique is growing. However, existing manuals and training videos have not yet been revised. This paper describes major updates to the Wyoming technique to help new users properly design and conduct aerial LT surveys. There are 3 general areas of improvement: (1) physical design of the marker system, (2) navigation and data recording, and (3) analysis. The line was moved from 50 m to 65 m from beneath the plane to improve forward visibility and eye relief. Two window marks are now used to sight with strut markers defining the first band to properly determine perpendicular distance intervals for observations. A digital radar altimeter and GPS interfaced with the onboard data acquisition system is desirable for instantaneously capturing heights above ground for each location. The radar altimeter helps pilots fly transects at the prescribed height (91.4 m). Midpoints of observed distance bands are corrected for actual height. Data are now analyzed using the DISTANCE program instead of TRANSECT-II. DISTANCE uses superior numerical procedures, more objective model selection criteria, handles size bias, calculates totals, and provides for additional options. Comments on survey design and implementation are provided. Potential users of the Wyoming technique can better design and conduct aerial line transect surveys by being aware of these improvements.

Pronghorn Antelope Workshop Proceedings 17:110

STATEWIDE EVALUATION OF PRONGHORN HABITAT IN ARIZONA : AN UPDATE

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Abstract: Across Arizona, we are assessing the relative quality of habitat to support pronghorn (*Antilocapra americana*) populations. Pronghorn are a species of special concern in Arizona due mainly to fragmentation or loss of habitat occurring through urbanization, rural development, highway construction, increased livestock fencing, fire suppression, and brush or tree encroachment. These alterations adversely affect pronghorn distribution, interchange, and population numbers. We follow the protocol of Ockenfels et al. (In press) within each game management unit (GMU), evaluating surveyed sections within the Department's Geographic Information System (GIS) TRS database as to being either mostly: (1) high quality habitat with no significant management problems; (2) high quality with a significant management problem; (3) moderate quality; (4) low quality; (5) poor quality; or (6) unsuitable quality. We assess each section for: (1) general terrain; (2) predominant vegetation; (3) level of human-related development/disturbance; (4) fencing structure and density; and (5) the relative availability of water sources. Terrain and vegetation are the most important components in the rating system. Most GMUs in Arizona have been evaluated and field work should be completed by September 1996. Access problems with private land owners occurred sporadically, however, most cooperated fully with the project. Use of the database is currently being tested to counteract rapid development in Yavapai County, for transplant programs between GMUs, and to determine the potential for habitat fragmentation and isolation across Arizona.

Pronghorn Antelope Workshop Proceedings 17:111

HISTORY OF PRONGHORN TRANSPLANTS IN ARIZONA

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Abstract: Active management practices such as transplanting have increased Arizona's pronghorn (*Antilocapra americana*) numbers from 650 in the early 1920s to over 12,000 today. Arizona began transplanting pronghorn in 1924, but it was not until the 1940s that Arizona began regularly moving pronghorn. Most early transplants consisted only of 2 or 3 animals, usually fawns, and were unsuccessful. By the mid-1960s, Arizona began coordinating pronghorn transplants with other states to supplement populations north of the Grand Canyon. Additionally, in 1981 Arizona began supplementing rangelands in southeastern Arizona with Mexican pronghorn (*A. a. mexicanus*) from Chihuahua which were endemic to the area. Prior to this date all pronghorn released in southeastern Arizona were the American pronghorn subspecies (*A. a. americana*). Today only Chihuahuan pronghorn are released in southern Arizona. Arizona's most recent transplant occurred in 2000, bringing the total number of pronghorn released in Arizona to 2,037 animals. The "Arizona Pronghorn Antelope Transplant History" table details each transplant. Arizona's pronghorn transplant program continues as opportunities are presented. The current Statewide Pronghorn Habitat Evaluation project will be a valuable tool for identifying potential transplants sites. The restoration of pronghorn in Arizona is a success story we hope to continue.

Pronghorn Antelope Workshop Proceedings 17:112-113

Table1. Arizona pronghorn antelope transplant history.

Capture Date	Capture Site	Release Site	Number Captured	Number Mortalities[1]	Number Released[1]	Release Sex[1]	Number Collared	Comments[2]
1924	Northern Nevada	Hermit Basin, Grand Canyon (1/2 way down cyn) (GMU 9)	12		12	Fawns		Pen-reared, unsuccessful [A]
1932	Chavez Pass, E. of Anderson Mesa (GMU 5B)	South of Ashfork (GMU 19B)	10	8	2	2m		Drift Net [A]
1939	Anderson Mesa (GMU 5B) (GMU 37M)	Avra Valley, Tucson Mtn Park	11	4	7	Fawns		Pen-reared, unsuccessful [A]
6/10-11/41	Anderson Mesa (GMU 5B)	Ellsworth Ranch, Whitlock Valley SE of Safford (GMU 28)	4	2	2	Fawns		Pen-reared, found dead in corral 3 weeks later [A]
1/22-24/43	Raymond Antelope Refuge (GMU 5B)	G Bar Ranch, Winchester Mts. Upper Sulphur Springs Valley (GMU 32)	24	2	22	6m,16f		Drift Net [A]
2/8/43	Raymond Antelope Refuge (GMU 5B)	Patterson Ranch near Oracle (GMU 37B)	6	2	4	4m		Drift Net, unsuccessful [A]
1/19/44	Raymond Antelope Refuge (GMU 5B)	Box Springs, Winchester Mts. Upper Sulphur Springs Valley (GMU 32)	3		3	1m, 2f		Drift Net [A]
3/9/44	Raymond Antelope Refuge (GMU 5B)	Box Springs, Winchester Mts. Upper Sulphur Springs Valley (GMU 32)	3		3	3m		Drift Net [A]
1/6/45	Raymond Antelope Refuge (GMU 5B)	Box Springs, Winchester Mts. Upper Sulphur Springs Valley (GMU 32)	3		3			Drift Net [A]
1/22/45	Raymond Antelope Refuge (GMU 5B)	Bosley Pasture, Winchester Mts. Upper Sulphur Springs Valley (GMU 32)	19		19			Drift Net [A]
1/31/45	Raymond Antelope Refuge (GMU 5B)	Box Springs, Winchester Mts. Upper Sulphur Springs Valley (GMU 32)	18		18			Drift Net [A]
2/9/45	Raymond Antelope Refuge (GMU 5B)	Double Tank Altar Valley, Manning Ranch (GMU 36C)	18		18	5m, 13f		Drift Net, unsuccessful [A]
2/11/45	Raymond Antelope Refuge (GMU 5B)	Ashburn Ranch, San Rafael Valley (GMU 35A)	9		9	4m, 5f		Drift Net [A]
3/8/45	Raymond Antelope Refuge (GMU 5B)	Ashburn Ranch, San Rafael Valley (GMU 35A)	4		4	2m, 2f		Drift Net [A]
3/12/45	Raymond Antelope Refuge (GMU 5B)	T Bar W Tank near Oracle (GMU 37B)	15		15	6m, 9f		Drift Net, unsuccessful [A]
12/19/49	Antelope Pass, N. Grapevine Cyn (GMU 5B)	Fort Huachuca Wildlife Area (GMU 35A)	72		72	unk		Drift Net [A]

Table1 continued

Capture Date	Capture Site	Release Site	Number Captured	Number Mortalities[1]	Number Released[1]	Release Sex[1]	Number Collared	Comments[2]
1/15/51	Antelope Pass, N. Grapevine Cyn (GMU 5B)	Fort Huachuca Wildlife Area (GMU 35A)	28	2	18	9m,9f		Drift Net, eartagged, 8 escaped [A]
2/1-6/51	Antelope Pass, N. Grapevine Cyn (GMU 5B)	Fence Cyn, House Rock Valley (GMU 12B) and San Rafael Valley (GMU 35A)	152	16 (5) (11)	99 (42) (57)	42m, 57f (20m, 22f) (22m, 35f)		Drift Net, eartagged
1959	Arizona	San Simon Valley (GMU 28)	12		12			Unable to substantiate
9/21-22/59	Raymond Ranch (GMU 5B)	Bonito Prairie, Fort Apache Indian Reservation (GMU 25)	60	10	34	2m,18f Fawns-4m,10f		Drift Net, 16 released capture site [A]
12/7/60	Raymond Ranch (GMU 5B)	Bonito Prairie, Fort Apache Indian Reservation (GMU 25)	57	1	37	10m,16f Fawns-6m,5f		Drift Net, eartagged, 19 released-capture site [A]
10/30/61	Raymond Ranch (GMU 5B)	June Tank, Arizona Strip (GMU 13A)	125	7	34	6m,28f		Drift Net, eartagged, 84 released-capture site [A]
10/28/65	Moiese National Bison Range, MT	June Tank, Arizona Strip (GMU 13A)	55		55	19m,26f Fawns-2m,8f		Drift Net [A]
11/16-17/71	Moiese National Bison Range, MT	Upper Clayhole RCA, Arizona Strip (GMU 13B)	37		37	11m,26f		Drift Net [A]
12/9/79	Lyman, WY	Hurricane Valley, Arizona Strip (GMU 13B)	200	18	84	37m,40f Fawns-7 unk		Drift Net, 98 released capture site [A]
2/1981	Limon, CO	Diamond Butte, Arizona Strip (GMU 13B)	86	4	82	36m,46f		Drift Net [A]
11/18/81	Buena Vista Ranch Marfa, TX	Empire Ranch (GMU 34B)	54	3	51	10m,21f Fawns-1m,19f		Drift Net [M]
12/2/82	Parker Mts, UT	House Rock Valley (GMU 12A)	50	2	48			Not Tagged [A]
1/17-19/84	Crestone, CO	House Rock Valley (GMU 12A)	83	2	81	15m,40f Fawns-14m,12f		Drift Net, orange eartags [A]
1/18-20/84	Crestone, CO	Diamond Butte, Arizona Strip (GMU 13B)	103	8	95	36m,59f		Drift Net, orange eartags [A]
11/13-14/84	Marfa, TX	Moline Tank, San Bernardino Valley (GMU 30A)	43	11	32	4m,22f Fawns-6m		Drift Net [M]
12/4-6/84	Douglas, WY	Hillside (GMU 20C); Near Winslow (GMU 4A); Phoenix Zoo	86	1 (1)	85 (51) (30) (4)	(23m,28f)		Drift Net, only those near Winslow tagged [A]
12/9-10/86	Rocker B Ranch, Big Lake, TX	San Bernardino Valley (GMU 30A)	70	1	69	33m,31f Fawns-1m,4f		White eartags [M]
12/9-10/86	Rocker B Ranch, Big Lake, TX	Day (Lazy B) Ranch, AZ/NM border (GMU 28)	39	2	37			Red eartags [M]
12/8-10/87	Big Lake, TX	Altar Valley, Buenos Aires NWR (GMU 36B); Fort Huachuca, south range (GMU 35A)	101	1	100 (86) (14)	36m,64f (31m,55f) (5m,9f)	11 (11)	Drift Net, red eartags [M]
2/11/93	Sheridan, WY	Hillside (GMU 20C)	54		54	5m,27f Fawns-8m,14f	6	Drive Net (with helicopters), red eartags [A]
1/29/97	Lamar, CO	Cedar Flat (GMU 6A); Big Flat Well (GMU 21); and Perry Mesa (GMU 21)	149	25 (9) (3) (13)	124 (65) (37) (22)	43m,81f (12m,40f Fawns-7m ,6f) (10m,17f Fawns-6m ,4f) (7m,14f Fawns-1m)	0	Drive Net w/ helicopters eartags-GMU 6A blue, GMU 21 red; F (under release sex) = fawns [A]
12/8-9/97	Loa, UT	Sipes Wildlife Area (GMU 1); Cedar Flat (GMU 6A); Big Flat Well (GMU 21); and Perry Mesa (GMU 21)	189	5 (1) (1) (1) (2)	184 (43) (64) (36) (41)	55m, 130f (10m, 23f Fawns-3m, 7f) (14m, 35f Fawns-5m, 10f) (6m, 18f Fawns-4m, 8f (8m, 19f Fawns-5m, 9f)	25 (8) (11) (6)	Drive Net (with helicopters); eartags-GMU 1 orange, GMU 6A blue, GMU 21 red & purple; F (under release sex) = fawns; both Perry Mesa mortalities were collared [A]
12/15/98	Loa, UT	Bozarth Mesa (GMU 18B); Hillside (GMU 20C); Big Flat Well (GMU 21); and Perry Mesa (GMU 21)	197	14 (2) (0) (4) (8)	183 (77) (5) (42) (59)	71m, 110f, 2unk (34m, 31f, 2unk Fawns-10m, 10f) (5m) (19m, 22f, Fawns-1m, 5f) (12m, 50f, Fawns-1m, 7f)	12 (5) (7)	Drive Net (with helicopters); eartags-GMU 18B blue, GMU 20c purple, GMU 21 green & blue; F(under release sex)=fawns; 6 mortalities were collared animals [A]
1/10-11/00	Fain Ranch (GMU 19A)	Sipes Wildlife Area (GMU 1); Arizona Strip (GMU 13B); Fort Apache Reservation; Eagle Creek (GMU 27); Buenos Aires NWR (GMU 36A); Buenos Aires NWR (GMU 36B)	189		189 (21) (14) (12) (54) (44) (44)	88m, 101f (2m, 19f) (14m) (5m, 7f) (22m, 32f) (16m, 28f) (29m, 15f)	17 (10) (7)	Drive Net (with helicopters); eartags-GMU 1 blue; GMU 13Bpink, Reservation green, GMU 27 red, GMU 36A red, GMU 36B yellow [A]

[1] Parentheses () subdivide the number of pronghorn by specific release sites. Females are denoted by "f"; males are denoted by "m."
[2] Brackets [ ] indicate subspecies; A = *americana*, M = *mexicana*, S = *sonoriensis*

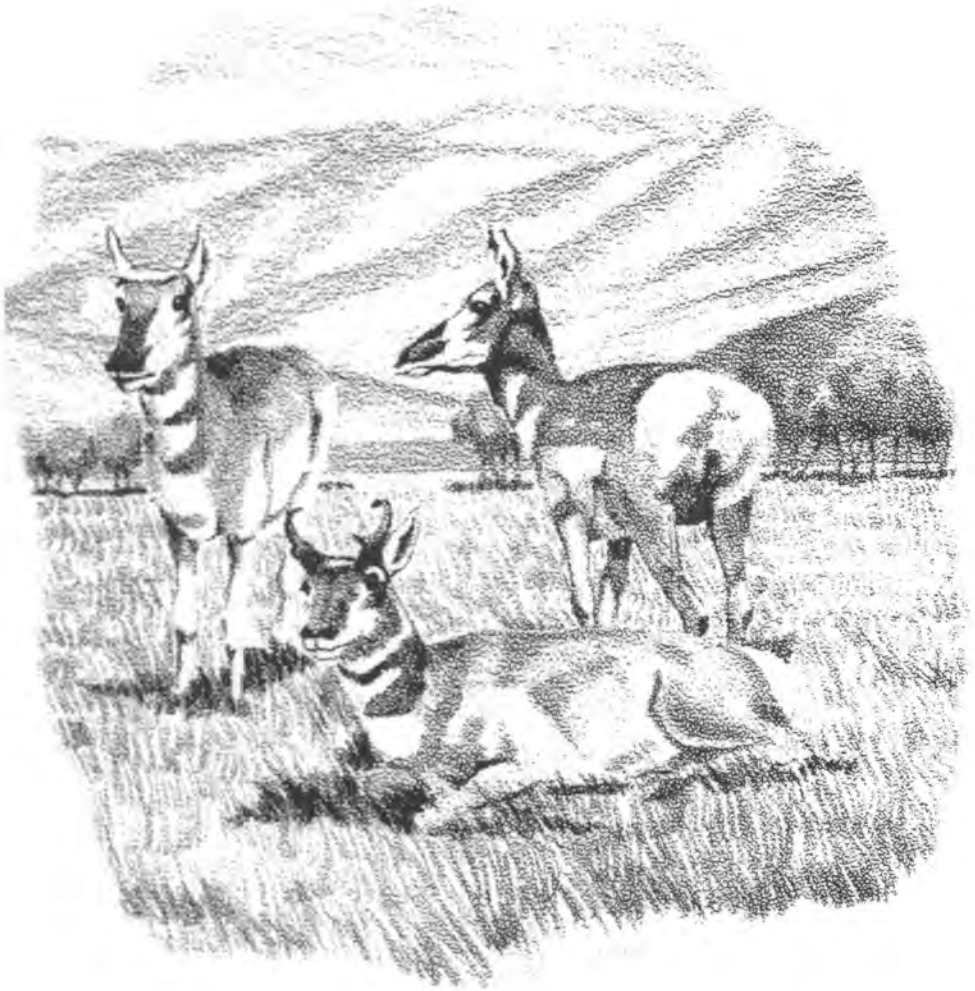
COMPARISON OF PRONGHORN AND ANTILOPINAE

BART W. O'GARA, Professor Emeritus, University of Montana, Lolo, MT 59847

Abstract: For pronghorn managers and researchers, literature related to other North American big game often has less relevance than does that related to gazelles and grassland antelope of the Old World. Those animals generally have high reproductive rates, suffer considerable fawn mortality from predation and droughts, feed selectively on succulent vegetation, shift home ranges in response to weather and rangeland conditions, and have territorial bucks. Gazelles and grassland antelope in northern climates tend to move according to succulence of vegetation and snow depths. Few are restricted in their movements by fences; movements to winter rangelands may be short or very long depending on the severity of the winter. Population numbers may fluctuate rapidly in response to weather and rangeland conditions coupled with high reproductive rates. I am not suggesting that African and Eurasian literature offers solutions to most pronghorn problems. However, few American biologists look outside their own borders for new insights and fresh ideas.

Pronghorn Antelope Workshop Proceedings 17:114

OFFICIAL BUSINESS MEETING NOTES



BUSINESS MEETING
17TH PRONGHORN ANTELOPE WORKSHOP
JUNE 7, 1996

Laura Colton, Workshop Chairperson, opened meeting. Minutes for the meeting were taken under direction of the workshop chairperson.

I. Arizona will host The 18th Biennial Pronghorn Workshop. No other proposal received, including from South Dakota.

II. Corrections should be made in guides if they are reprinted:

A. 220 guides left over currently
B. Biologists frequently use them as reference
C. Should be updated for capture techniques, modeling
D. Appoint a publishing committee (guidelines review):

Members:
- Tom Pojar, Colorado, Division of Wildlife
- Ray Lee, Arizona, Game and Fish
- Bart O'Gara, University of Montana
- Jim Yoakum

Bart O'Gara, First motion; Jim Yoakum, Second motion; motion passed

III. Jim Yoakum has items of business to address:

A. Note list of new books regarding pronghorn published in Prairie Press (Volume 5, No. 2, May 1996). Pronghorn Bibliography not released until pronghorn book published by Wildlife Management Institute.
B. List of Master's and Ph.D. theses may be available for publishing in Workshop Proceedings.
C. Interstate Antelope Conference (IAC) since 1949. Read resolution congratulating IAC for 50 years of work for pronghorn.
Jim Yoakum, first motion; Rich Guenzel, second motion
Discussion of proper voting procedure:
Seven voted yes, Zero voted no
D. Recommended establishing guidelines that can be used by the editor regarding papers submitted for publication in the workshop proceedings Guidelines to be given to publishing committee for their review.
Add Richard Ockenfels, Arizona Game and Fish, to publishing committee.
Nine voted yes, Zero voted no
Explain proper process for sending papers and abstracts:
A. Papers not presented at workshop can be published in the proceedings
B. What format exists for state reports? Elk and deer workshop formats are good examples.
Rob Hitchcock thinks this would be very helpful on disk form.
Ray Lee will send out guidelines for deer workshop
Jim Yoakum suggested inserting guidelines and disk at same time
Motion to review state report meetings.
Laura Colton, first motion; Richard Ockenfels, second motion
Seven voted yes, Zero voted no

IV. Other Business

A. Discussion of planning future meetings:
Kim Brinkley - break paper sessions up into two days
Richard Ockenfels - have four days of meeting instead of three
Tom Pojar - number of papers dictates meeting length; set limit on number of papers per day
Kim Brinkley - business meeting has always been last morning; wastes last day; start on Monday
Ray Lee - can't make guidelines; base it on what participants want
Richard Ockenfels - need more informal time, keep it in mind when scheduling
Rob Hitchcock - wants panel discussion time
Dr. Fink - poster night gathering good opportunity maybe some papers should be posters
Richard Ockenfels- posters should be on display throughout meetings, not one night
Tom Pojar- make some very general guidelines for workshop, then allow host state to make decision
Richard Ockenfels- aren't there already general guidelines? Laura answered.
Kim Brinkley- Should zoos be encouraged? She will notify zoos.
Richard Ockenfels- by laws should include all interests. He would like zoo list.
Rob Hitchcock - suggestions for getting donations for next workshop
Ray Lee - committee should review guidelines and everyone vote on changes at next business meeting
Ray Lee first motion; Mike Welch second motion
Eight voted yes, Zero voted no
Give all lists for mailing to Richard Ockenfels. Registration fees do not cover costs. Contributions needed.
Jorge Cancino - Mexico would like to continue communications
Richard Ockenfels - input for next workshop should be earlier (Mar/Apr) preference for Sonora or American
Bart O'Gara - fiscally difficult this late in the fiscal year
Kim Brinkley - send out survey asking what month is best
Ray Lee - bylaws usually dictate when meeting should be.

MEETING ADJOURNED

ATTENDEES AT THE 17TH ANNUAL PRONGHORN ANTELOPE WORKSHOP

June 4-7, 1996
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