2010 Proceedings

24th Biennial Pronghorn Workshop:

Partnering for Pronghorn

May 18 – 21, 2010

Laramie, Wyoming

PROCEEDINGS

of the

TWENTYFOURTH BIENNIAL

PRONGHORN ANTELOPE WORKSHOP

2010

Edited by WGFD Pronghorn Working Group

Laramie, Wyoming, USA

May 18 – 21, 2010

Sanctioned by

Western Association of Fish and Wildlife Agencies

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24th Biennial Pronghorn Workshop
May 18-21, 2010
Laramie, Wyoming

Sanctioned by:
Western Association of Fish and Wildlife Agencies

Hosted by:
Wyoming Game and Fish Department
The Wildlife Society, Wyoming Chapter

---------------------------------------Tuesday, May 18--

5:30pm	9:00pm	**Registration & Social** *(Sponsored by Wyoming Biologists' Association and Wyoming Game Warden's Association)*

--Wednesday, May 19-------------------------------------

6:30am	8:00am	**Registration & Continental Breakfast** *(Sponsored by The Wildlife Society, WY Chapter)*
8:00am	8:10am	**Welcome/Introductions/Program & Conference Logistics**
8:10am	8:30am	**Opening Remarks,** *Steve Ferrell, Director WGFD*

Session 1: Pronghorn Status and Updates *(Chair - Greg Hiatt, WGFD)*

8:30am	8:55am	Pronghorn Status Updates - all attending States *Rebecca Schilowsky, Wyoming Game and Fish Department, Cheyenne, WY*
8:55am	9:20am	Current Federal Plan for the Pronghorn in Mexico *Jorge Cancino, Centro de Investigaciones Biologicas del Nororste*
9:20am	9:45am	Wind River's Pronghorn: A Modern Conservation Success Story *Pat Hnilicka, USFWS, Lander, WY*
9:45am	10:10am	**Break** *(Sponsored by Wyoming Wildlife Federation)*

Session 2: Funding Programs and Education *(Chair - Jeff Short, WGFD)*

10:10am	10:35am	National Pronghorn Interpretive & Visitors Center *Lynette Haack, Vice-President, Rawlins, WY*
10:35am	11:00am	Wyoming Game and Fish Department's Private Lands Public Wildlife Access Program *Brian Olsen, WGFD, Casper, WY*
11:00am	11:25am	Wyoming Wildlife Natural Resources Trust Program *Bob Budd, Riverton, WY*
11:25am	11:30am	**Wrap-Up / Logistics**

11:30am	1:30pm	**Lunch & Business Meeting**

Session 3: Pronghorn Management and Inventory Techniques *(Chair - Heather O'Brien, WGFD)*

1:30pm	1:55pm	Evaluation of Line-transect Sampling for Densities of Pronghorn in Alberta *Michael Grue, Alberta Conservation Association, Lethbridge, Alberta*
1:55pm	2:20pm	An Electronic Data Recording System to Aid in Improving Population Estimates from Aerial Surveys *Rich Guenzel, WGFD, Laramie, WY*
2:20pm	2:45pm	Potential Use of Unmanned Aerial Vehicles (UAV) for Surveying Pronghorn Populations in Southeastern Wyoming *Brian Beyer, Joint Training &Experimentation Center, Guernsey, WY* *Terry Creekmore, WGFD, Laramie, WY*
2:45pm	3:10pm	**Break** *(Sponsored by National Wildlife Federation)*
3:10pm	3:35pm	Notations of a Recent Translocation of Pronghorn from Nara Visa, New Mexico to Coahuila, Mexico *Ivonne Cassaigne, DVM, Wildlife Health Services, Mexico City*
3:35pm	4:00pm	Hunting and Trophy Horn Size in Pronghorn *David Brown, Arizona State University, Tempe, AZ*
4:00pm	4:25pm	Pronghorn Survival in Wyoming *Ron Grogan, University of Wyoming, Laramie, WY*
4:25pm	4:45pm	**Wrap Up / Details / Discussion**
5:00pm		**Dinner - on your own**

--Thursday, May 20--

6:30am	8:00am	**Breakfast** *(Sponsored by The Wildlife Society, WY Chapter)*

Session 4: Pronghorn Forage and Habitat Management *(Chair: Patrick Burke, WGFD)*

8:00am	8:25am	Where are all the Pronghorn Fawns: Is low Fawn Recruitment an Issue Revisited? *Paul Jones, Alberta Conservation Association, Lethbridge, Alberta*
8:25am	8:50am	The Role of Preformed Water in American Pronghorn Antelope Diets in a Semidesert Grassland *Melanie Tluczek, Arizona State University, Mesa, AZ*
8:50am	9:15am	Diet Composition and Quality of Pronghorn in Southern Arizona *Bill Miller, Arizona State University, Mesa, AZ*
9:15am	9:40am	Seasonal Forage Use/Availability by Pronghorn Antelope in North Central Arizona *Dan McDonald, Texas Tech University, Lubbock, TX*

9:40am	10:05am	A Model for Habitat Based Population Management *Daryl Lutz, WGFD, Casper, WY*
10:05am	10:30am	Genetic Variation in Pronghorn Populations in Texas *Renee Keleher, Sul Ross State University, Alpine, TX*
10:30am	11:00am	**Wrap-Up & Prepare for Field Trip**
11:00am	4:00pm	**Field Trip - Pronghorn Viewing and Discuss Local Management** Sack Lunch Provided *(Sponsored by North American Pronghorn Foundation)* Pronghorn Response to Wind Energy Development on Crucial Winter Range in South-central Wyoming *Jeff Beck and Jordan Ongstad, University of Wyoming, Laramie, WY* *Scott Gamo, WGFD, Cheyenne, WY*
5:30pm	9:00pm	**Social, Dinner, Awards, Auction, Entertainment**

--Friday, May 21--

6:30	8:00	**Breakfast** *(Sponsored by The Wildlife Society, WY Chapter)*

Session 5: Impacts and Impediments to Pronghorn, and Miscellaneous Topics *(Chair - Rick King, WGFD)*

8:00am	8:25am	Pronghorn and Petroleum: Have We Reached a Breaking Point in the Upper Green River Basin of Wyoming? *Jon Beckmann, Wildlife Conservation Society, Bozeman, MT*
8:25am	8:50am	Cumulative Effects of Development on Pronghorn Distribution and Movements across the Northern Sagebrush Steppe *Andrew Jakes, University of Calgary, Alberta*
8:50am	9:15am	Green River Valley Land Trust's Corridor Conservation Campaign *Jordan Vana, Green River Valley Land Trust, Pinedale, WY*
9:15am	9:40am	**Break** *(Sponsored by One-Shot Past Shooters)*
9:40am	10:05am	Location Density at a Landscape Level Scale in Montana *Erin Poor, Duke University, Durham, NC*
10:05am	10:30am	Internal Parasite Concentrations of Pronghorn in Trans-Pecos, Texas *Billy Tarrant, Texas Parks and Wildlife Department, Alpine, Texas*
10:30am	11:00am	Physical and Chemical Capture of Pronghorn *Terry Kreeger, Wyoming Game and Fish Department, Wheatland, WY*
11:00am		**Closing Remarks and Announcements,** Fred Lindzey, WGFD Commissioner

Poster Presentations

Surgical Sterilization of Coyotes offers a Non-Lethal Alternative
Renee Seidler, Utah State University, Logan, Utah

Horn Growth and Age in Harvested Wyoming Pronghorn
Mark Zornes, Wyoming Game and Fish Department, Green River, WY

Factors Influencing Pronghorn in the Chihuahuan Desert of White Sands Missile Range, South-central New Mexico
Mindi Avery, New Mexico State University, Las Cruces, NM

The Good, the Bad, and the Ugly; Fences are More Than Barriers to Movement
Paul Jones, Alberta Conservation Association, Lethbridge, Alberta

Pronghorn Age and Horn Size in Southern Alberta
Mike Grue, Alberta Conservation Association, Lethbridge, Alberta

Modeling Pronghorn Migration Corridors in Northern Great Plains
Erin Poor, Duke University, Durham, NC

Effects of Fence Type on Pronghorn Movement in North-Central Montana
Andrew Jakes, University of Calgary, Calgary Alberta

An Assessment of Fifty-five Years of Predator Influences on Pronghorn Neonates
Jim Yoakum, Western Wildlife, Verdi, NV

SECTION II – STATUS REPORT

Pronghorn State and Province Status Report -- 2010
24th Biennial Pronghorn Workshop, Laramie, WY, May 18-21, 2010

REBECCA D. SCHILOWSKY, Wyoming Game and Fish Department, 5400 Bishop Blvd, Cheyenne, WY 82006, USA

ABSTRACT A standardized questionnaire was sent electronically to all states and provinces within free-ranging pronghorn populations to collect 2009 population, survey, and hunting information. Responses were received from all of the 16 western states, two Canadian provinces, and two provinces from Mexico. From these responses, the North American pronghorn population is estimated to be approximately 880,000 animals. Wyoming supports about 60 percent of the total with 526,638 animals. Colorado and South Dakota have populations of 74,600 and 63,597 animals, respectively. In other states/provinces, population estimates range from 220 in Coahuila to 45,000 in New Mexico. Buck:doe ratios vary across states/provinces, ranging from 18:100 in Wyoming to 85:100 also in Wyoming. Pre-season fawn:doe ratios vary across states/provinces as well, ranging from 18:100 in Arizona to 91:100 in Wyoming. All states/provinces except Saskatchewan, Coahuila, and Sonora have a pronghorn rifle season. Total harvest generally increased in 2009 versus 1999. Wildlife/landowner conflicts are mitigated through depredation payments, transferable licenses, hunting permits for landowners, and/or hunter access programs. Partnership programs are used by 10 states/provinces.

INTRODUCTION

As a Western Association of Fish and Wildlife Agencies (WAFWA) sanctioned event, the agency hosting the Biennial Pronghorn Workshop is required to solicit data from all states/provinces known to have free-ranging pronghorn and provide a summary of those data at the workshop. In early 2010, the Pronghorn Working Group of the Wyoming Game and Fish Department sent out a standardized questionnaire electronically to all states and provinces in the United States, Canada, and Mexico known to have free-ranging pronghorn populations. The survey requested information on 2009 population size and estimation methods, hunting seasons, harvest estimates, partnership programs, and on-going research projects. Responses were received from all of the 16 western states, two Canadian provinces, and two provinces from Mexico (Table 1).

Table 1. List of state and provincial contacts for pronghorn status survey, May 2010.

	State/ Province	Contact Person	Title	Agency	Address	City	State	Zip	Country	Phone Number	Email Address
1	AB	Kim Morton	Senior Wildlife Biologist -- Prairies Area	Alberta Sustainable Resource Development -- Fish & Wildlife	2nd Floor YPM Place 530-8th Str.S.	Lethbridge	AB	T1J 2J8	Canada	403-381-5120	kim.morton@gov.ab.ca
2	SK	John Pogorzelec	Wildlife Biologist	Saskatchewan Environment	Box 5000-350 Cheadle St. W	Swift Current	SK	S9H 4G3	Canada	306-778-8522	john.pogorzelec@gov.sk.ca
3	OR	Don Whittaker	Ungulate Management Coordinator	Oregon Dept. Fish and Wildlife	3406 Cherry Ave. NE	Salem	OR	97303	USA	503-947-6325	don.whittaker@state.or.us
4	ID	Bruce Ackerman	Wildlife Staff Biologist	Idaho Dept. Fish and Game	P.O. Box 25	Boise	ID	83707	USA	208-287-2753	backerman@idfg.idaho.gov
5	MT	Quentin Kujula	Management Section Chief of the Wildlife	Montana Dept of Fish, Wildlife & Parks			MT	59230	USA	406-444-5672	qkujula@mt.gov
6	ND	Bruce Stillings	Big Game Biologist	North Dakota Game and Fish Dept.	225 30th Ave. SW	Dickinson	ND	58601	USA	701-227-7431	bstillings@nd.gov
7	SD	Luke Meduna	Resource Biologist	South Dakota Game, Fish, and Parks	3305 W. South St.	Rapid City	SD	57702	USA	605-394-2391	luke.meduna@state.sd.us
8	WY	Reg Rothwell	Supervisor of Biological Services	Wyoming Department of Game and Fish	5400 Bishop Blvd	Cheyenne	WY	82006	USA	307-777-4588	reg.rothwell@wgf.state.wy.us
9	NE	Kit Hams	Big Game Program Manager	Nebraska Game and Parks Commission	2200 N 33rd St, PO BOX 30370	Lincoln	NE	68503	USA	402-471-5442	Kit.Hams@nebraska.gov
10	CA	Joe Hobbs	Statewide Elk and Antelope Coordinator	California Dept. of Fish and Game	1812 9th Street	Sacramento	CA	95811	USA	916-445-9992	jhobbs@dfg.ca.gov
11	NV	Mike Cox	Big Game Staff Biologist	Nevada Dept. of Wildlife	1100 Valley Road	Reno	NV	89512	USA	775-688-1556	mcox@ndow.org
12	UT	Anis Aoude	Big Game Program Coordinator	Utah Division of Wildlife Resources	1594 West North Temple	Salt Lake City	UT	84114	USA	801-538-4777	anisaoude@utah.gov
13	CO	Bruce Watkins	Big Game Coordinator	Colorado Division of Wildlife	2300 S. Townsend Ave	Montrose	CO	81401	USA	970-252-6025	bruce.watkins@state.co.us
14	KS	Matt Peek	Pronghorn Program Coordinator	Kansas Dept. of Wildlife and Parks	PO Box 1525	Emporia	KS	66801	USA	620-342-0658	mattp@wp.state.ks.us
15	AZ	Jim Hinkle	Big Game Management Supervisor	Arizona Game and Fish Department	5000 W Carefree Hwy	Phoenix	AZ	85086	USA	623-236-7350	jhinkle@azgfd.gov
16	NM	Darrel Weybright	Big Game Programs	New Mexico Dept. of Game & Fish	1 Wildlife Way, P.O.Box 25112	Santa Fe	NM	87507	USA	505-476-8035	darrel.weybright@state.nm.us
17	TX	Billy Tarrant	District Leader	Texas Parks and Wildlife Dept.	109 S Cockrell	Alpine	TX	79830	USA	432-837-2051	billy.tarrant@sbcglobal.net
18	OK	Jerry Shaw	Big Game Biologist	Oklahoma Dept. of Wildlife Conservation	1801 N Lincoln Blvd.	Oklahoma City	OK	73105	USA	405-424-3392 405-301-6885 (C)	jshaw@zoo.odwc.state.ok.us
19	MEX-SO	Cristina Melendez-Torres	Coordinadro de Vida Siolvestre y CDC	CEDES		Hermosillo	Sonora	C.P. 83190	Mexico	662 2 50 67 68, 662 2 12 19 78	mcmelendez@cedes.gob.mx, mcmelendez2001@yahoo.com.mx
20	MEX-CO	Ivonne Cassaigna; Ana Soler	Veterinarian; Director				Coahuila	C.P. 03600	Mexico	(55) 56624695	icassaigne@yahoo.com; ana@grupoefferus.org

POPULATION ESTIMATES AND SURVEY METHODOLOGY

In 2009, the North American pronghorn population was estimated to be approximately 880,000 animals. Pronghorn population estimates ranged from 220 in Coahuila, Mexico to 526,638 in Wyoming (Table 2 and Figure 1). Aerial surveys were used by most states/provinces to sample populations over at least a portion of their occupied pronghorn habitat. Sex and age data were collected using aerial and/or ground surveys. Aerial line transects were the most common survey method.

Pre-season buck-to-doe ratios ranged from a low of 18 bucks per 100 does in Wyoming to a high of 85 bucks per 100 does, also in Wyoming (Figure 2). Pre-season fawn-to-doe ratios ranged from a low of 18 fawns per 100 does in Arizona to a high of 91 fawns per 100 does in Wyoming. Straight comparison of fawn:doe ratios is difficult, however, because states/provinces conducted their surveys at different times of year, using different methods. Because fawn mortality is fairly high in most areas, large differences in age ratios can result from only a month or two difference in survey times.

Pronghorn survey methods varied greatly among jurisdictions. Helicopter surveys were used by 8 states/provinces, fixed-wing aircraft were used by 17, and ground surveys were used by 8. Several states/provinces used more than one survey type. Of the jurisdictions using aerial surveys, 8 used strip transect, 11 used line transect, 5 used targeted search and count, 3 used haphazard search and count, 1 used incidental surveys, 1 used distance sampling, and 1 used double count or block transect surveys. Most ground surveys were focused on concentration areas (n=11), with 4 as trend routes, 6 as targeted areas, and 1 reported as a pre-hunt composition survey. Regardless of survey type, most states/provinces conducted pronghorn surveys during the post fawn period (n=20), followed by pre-fawn (n=9), winter (n=7) and fall (n=3). Of 20 states/provinces responding, 14 were reportedly satisfied with their survey methods. Seven states/provinces reported dissatisfaction regarding the surveys they conducted or their lack of survey effort.

Table 2. Pronghorn population estimates and estimation methods, by state and province, across North America in 2009.

State/ Prov	Population Estimate	Population Objective	Percent Observed	Pre-season B:D Ratio	Pre-season F:D Ratio	Survey Type: Heli-copter	Survey Type: Fixed-wing	Survey Type: Ground	Frequency of Aerial Coverage: Specific Area	Frequency of Aerial Coverage: Entire Range	Frequency of Ground Coverage: Specific Area	Frequency of Ground Coverage: Entire Range	Survey Method: Aerial	Survey Method: Ground	Time of Year: Aerial	Time of Year: Ground
AB	22,500	22,000	18	45	35	X			Annual	Annual	N/A	N/A	Line Transect	N/A	Post-Fawn	N/A
SK	18,000-21,000	21,600	50	44	48	X	X	X	3-4 years	Never	Annual	Annual	Line Transect, Targeted Search & Count	Representative Blocks	Pre-Fawn, Post-Fawn	Pre-Fawn, Post-Fawn
OR	22,000	N/A	Unknown	35	35	X	X	X	Annual	Never	Annual	Never	Targeted Search & Count, Haphazard/Random Search & Count	Trend Routes, Targeted Concentration Areas	Pre-Fawn, Post-Fawn	Pre-Fawn, Post-Fawn
ID	13,000	15,000	20	30-50	40-90	X	X	X	Variable	Never	Variable	Never	Line Transect, Haphazard/Random Search & Count, Incidental	Trend Routes, Targeted Concentration Areas	Post-Fawn, Winter	Post-Fawn
MT	N/A	N/A	33	N/A	N/A		X		1-3 years	3 years	N/A	N/A	Line Transect, Targeted Search & Count	N/A	Post-Fawn	N/A
ND	10,262	8,000-12,000	90	35	49		X		Annual	3 years	N/A	N/A	Strip Transect	N/A	Post-Fawn	N/A
SD	63,597	N/A	27	45	73		X		1-2 years	1-2 years	N/A	N/A	Strip Transect	N/A	Pre-Fawn, Post-Fawn	N/A
WY	526,638	461,950	Varies	18-85	24-91	X	X	X	1-3 years	Never	Annual	N/A	Line Transect	Pre-Hunt Herd Composition	Pre-Fawn	Post-Fawn
NE	11,600	Stable	N/A	32	36		X		Annual	Never	N/A	N/A	Strip Transect	N/A	Post-Fawn	N/A
CA	5,000	8,000	90	N/A	N/A		X		Annual	Annual	N/A	N/A	Line Transect, Targeted Search & Count	N/A	Winter	N/A
NV	24,500	N/A	38	42	N/A	X		X	Annual	N/A	Annual	Annual	Targeted Search & Count	Targeted Concentration Areas	Fall	Fall, Winter
UT	12,000	N/A	N/A	42	34		X		Annual	Annual	Annual	Annual	Strip Transect	N/A	Pre-Fawn	N/A
CO	74,600	66,000	25-30	51	41	X	X	X	Annual	Annual	Annual	N/A	Strip Transect, Line Transect, Haphazard/Random Search & Count, Distance Sampling	Trend Routes, Targeted Concentration Areas	Pre-Fawn, Post-Fawn	Post-Fawn
KS	2,500	N/A	60	49	60		X		Semi-Annual	Never	N/A	Never	Line Transect	N/A	Post-Fawn, Winter	N/A
AZ	9,000	N/A	48	31	18		X		Annual	Annual	N/A	N/A	Double Count, Line or Block Transects	N/A	Post-Fawn	N/A
NM	40,000-45,000	N/A	40-50	42	N/A		X		1-3 years	Never	Variable	Never	Strip Transect	Fawn Surveys	Pre-Fawn	Post-Fawn
TX	18,031	N/A	N/A	56	24		X		Annual	Annual	Annual	N/A	Strip Transect	Supplemental Aerial Survey	Post-Fawn	Post-Fawn
OK	1,500	N/A	N/A	N/A	N/A		X		Variable	N/A	N/A	N/A	Line Transect	N/A	Winter	N/A
MEX-SO	483	N/A	64	N/A	N/A	X	X	X	2 years	2 years	N/A	N/A	Strip Transect, Line Transect	Trend Routes, Targeted Concentration Areas	Post-Fawn, Winter	N/A
MEX-CO	220	500	70	N/A	20			X	N/A	N/A	N/A	Annual	N/A	Targeted Concentration Areas	N/A	Fall, Winter

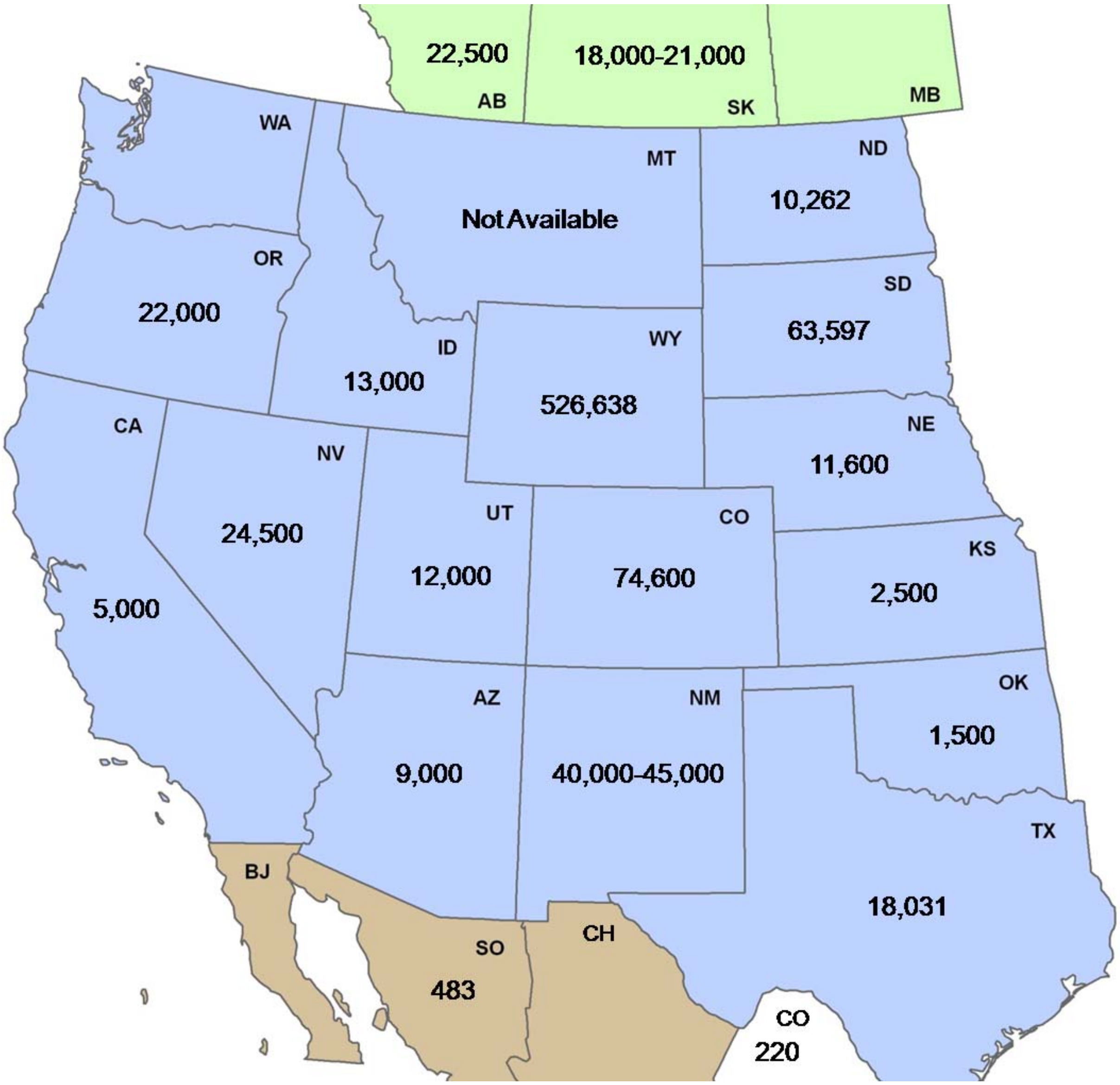

Figure 1. Pronghorn population estimates, by state and province, across North America in 2009.

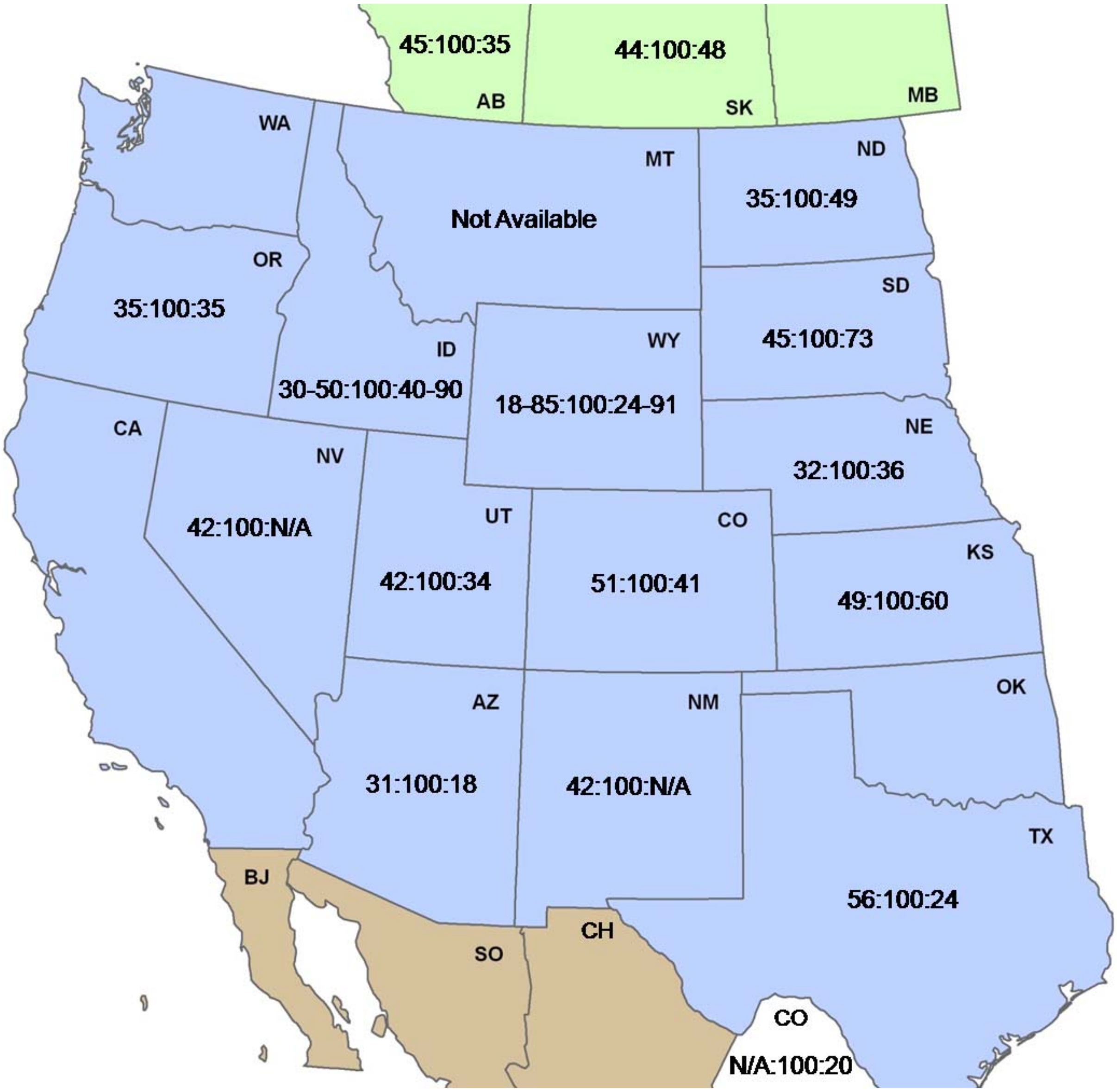

Figure 2. Pronghorn buck:doe:fawn ratios, by state and province, across North America in 2009.

HUNTING SEASON STRUCTURE

Hunting season structure varied substantially by state/province. Hunting seasons available in each state and province are listed in Table 3. Season lengths vary from a 3-day rifle season in New Mexico to a 125-day archery season in Nebraska. Many muzzleloader seasons occurred in conjunction with rifle or archery seasons. Some locations had separate muzzleloader seasons following the rifle hunt. Most archery seasons opened prior to firearm seasons.

Table 3. Pronghorn hunting season availability and length (# of days), by state and province, across North America in 2009.

State/ Province	Rifle Season	Muzzleloader Season	Archery Season
AB	12	0	18
SK	26	42	62
OR	9	9	30
ID	30	30	30
MT	29	0	36
ND	16.5	0	30.5
SD	16	0	61
WY	60	30	45
NE	16	16	125
CA	9	0	9
NV	15	10	20
UT	9	0	28
CO	7	9	37
KS	4	8	32
AZ	10	10	14
NM	3	4	9
TX	9	0	0
OK	N/A	0	14
MEX-SO	0	0	0
MEX-CO	0	0	0

HARVEST SUMMARY

Harvest data were collected in a variety of ways, ranging from mandatory registration to voluntary check stations. Questionnaires were the most commonly used method for collecting harvest information, and they were used in various ways by 13 states/provinces. Harvest data were important for providing input for population models and comparing harvest projections to actual harvest to determine if management objectives are being met. In 2009 across North America, an estimated 121,498 pronghorn were harvested, consisting of approximately 69,169 bucks and 52,329 does and fawns (Figure 3 and Table 4). Total harvest ranged from 165 pronghorn in Kansas to 56,482 pronghorn in Wyoming.

In 2009, the percent of the estimated population harvested varied from 4% in California and Texas to 23% in South Dakota. Bucks comprised the majority of annual harvest, ranging from 41% in South Dakota to 100% in several states. Does and fawns were not harvested in Arizona, California, and Texas. In locations where does and fawns were harvested, the percent of total harvest ranged from 1% in Nebraska to 59% in South Dakota.

Total harvest in most states/provinces was higher in 2009 compared to 1999 (Figure 4). Similarly, the number of rifle hunters and harvest generally increased in 2009 versus 1999 (Table 5). Rifle hunter success remained very high, averaging 77% (range 44% to 96%) across the continent. Only 9 states had muzzleloader seasons, with hunter success averaging 53% (range

24% to 80%) (Table 6). The number of archers and archery harvest increased in 2009 versus 1999 among states/provinces reporting data (Table 7). Archery success equaled that of muzzleloader seasons, however, individual states/provinces success was lowest of the 3 types of weapon seasons; averaging 53% (range 11 to 65%).

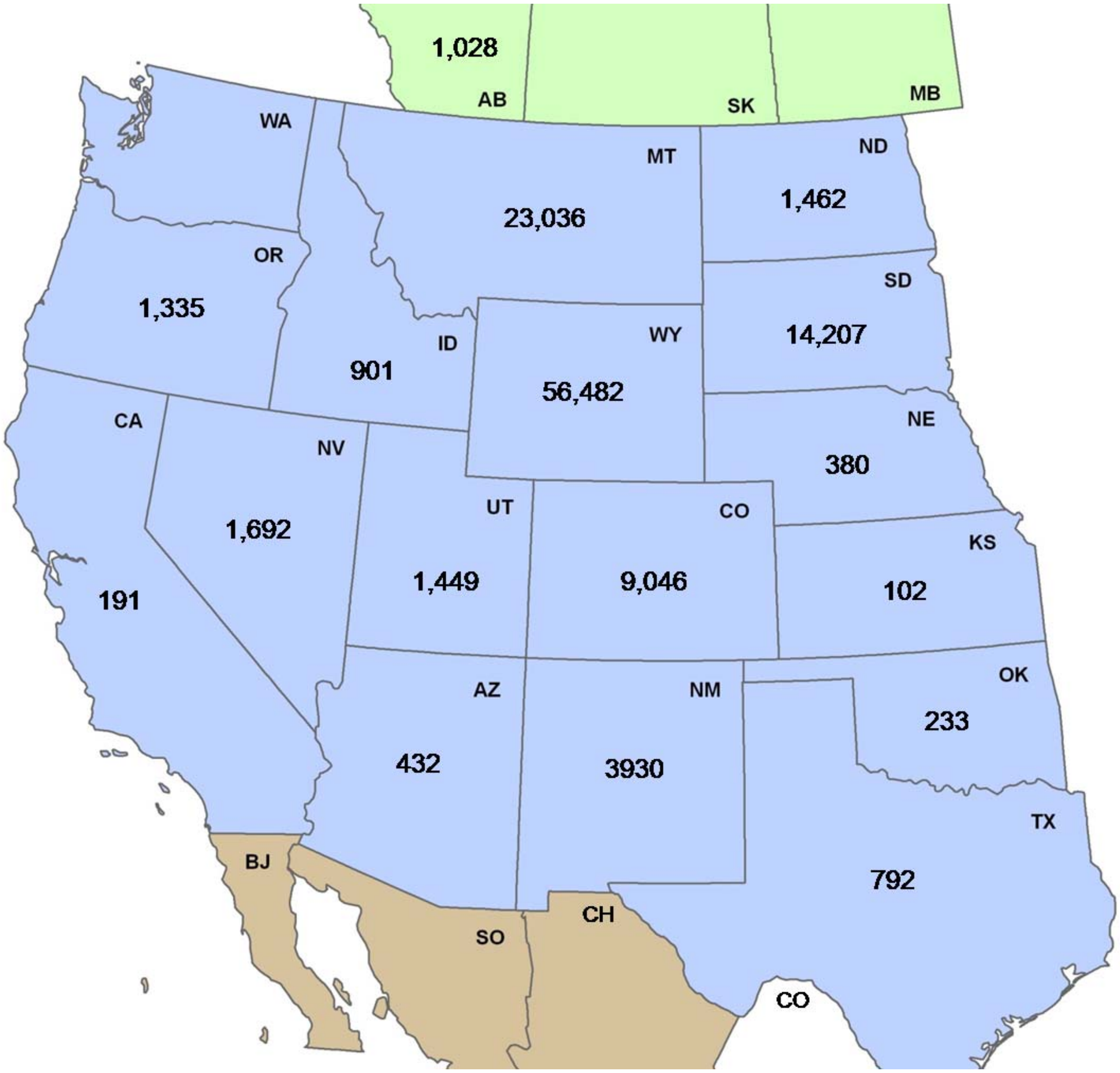

Figure 3. Estimated total pronghorn harvest, by state and province, across North America in 2009.

Table 4. Total pronghorn harvest (all weapon types), by state and province, across North America in 2009.

State/ Province	Population Estimate	Number of Pronghorn Harvested			% of Pronghorn in Harvest		
		Bucks 2009	Does & Fawns 2009	Total 2009	Bucks 2009	Does & Fawns 2009	Population 2009
AB[1]	22,500	943	203	1,146	82	18	5
SK	18,000-21,000	N/A	N/A	N/A	N/A	N/A	N/A
OR	22,000	1,340	147	1,487	90	10	7
ID	13,000	1,102	237	1,339	82	18	10
MT	N/A	12,815	11,563	24,378	53	47	N/A
ND	10,262	1,073	675	1,748	61	39	17
SD	63,597	6,156	8,756	14,912	41	59	23
WY	526,638	31,678	24,804	56,482	56	44	11
NE	11,600	626	6	632	99	1	5
CA	5,000	200	0	200	100	0	4
NV	24,500	1,601	230	1,831	87	13	7
UT	12,000	879	692	1,571	56	44	13
CO[1]	74,600	5,069	4,556	9,625	53	47	13
KS	2,500	152	13	165	92	8	7
AZ	9,000	621	0	621	100	0	7
NM[2]	40,000-45,000	3,992	308	4,300	93	7	10-11
TX	18,031	792	0	792	100	0	4
OK	1,500	130	139	269	48	52	18
MEX-SO	483	N/A	N/A	N/A	N/A	N/A	N/A
MEX-CO	220	N/A	N/A	N/A	N/A	N/A	N/A

[1]2008 Data
[2]2007 Data

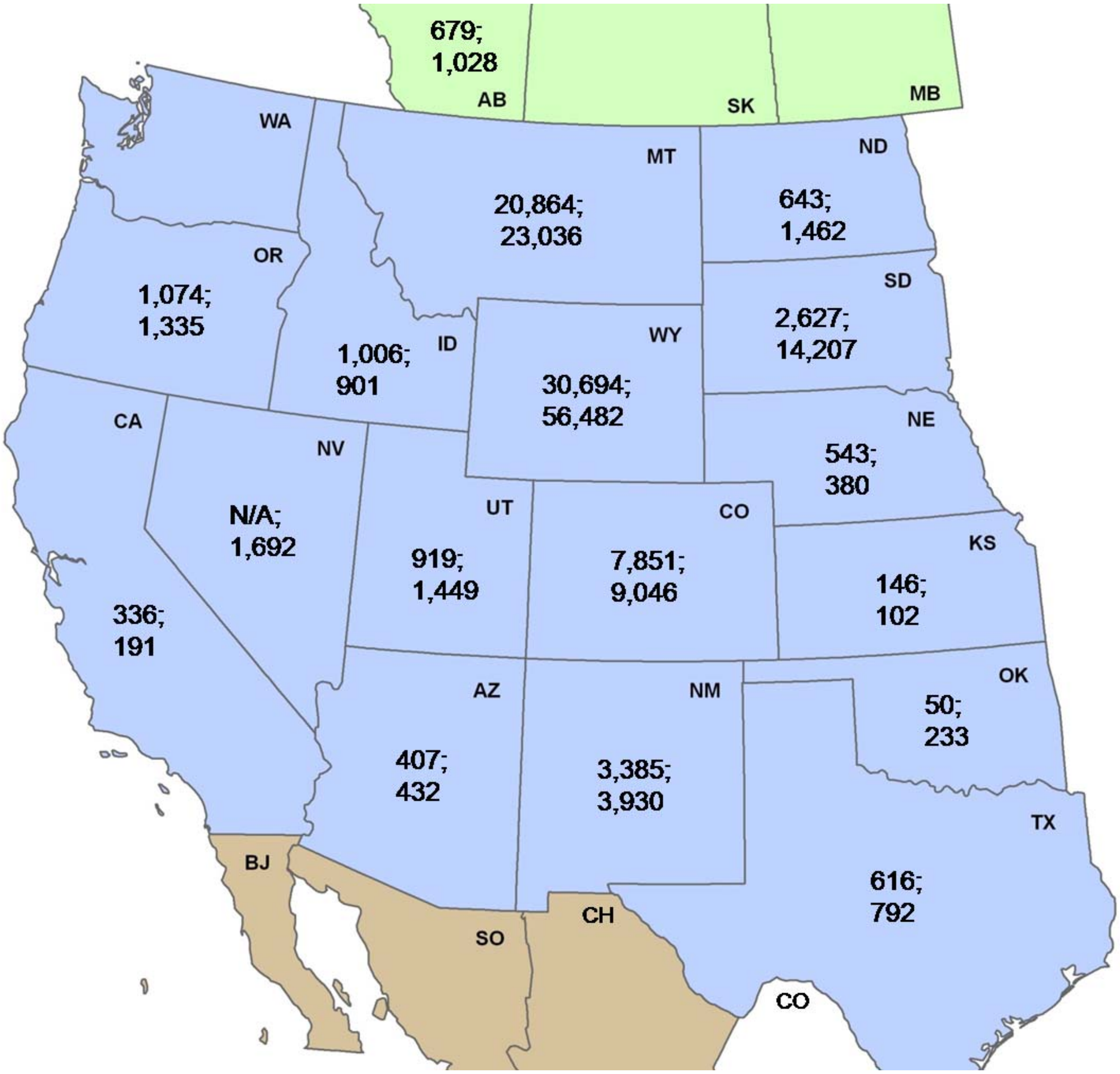

Figure 4. Estimated total pronghorn harvest, by state and province, across North America in 1999 and 2009.

Table 5. Rifle pronghorn harvest, by state and province, across North America in 1999 and 2009.

State/ Province	Number of Pronghorn				Number of Hunters				Number of Hunter Days				% Hunter Success	
	Bucks		Does &		Resident		Non-resident		Resident		Non-resident			
	1999	2009	1999	2009	1999	2009	1999	2009	1999	2009	1999	2009	1999	2009
AB[1]	679	825	0	203	766	861	N/A	N/A	1,603	3,813	N/A	N/A	87	96
SK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
OR	872	1,204	202	131	1,391	1,787	19	31	3,952	5,958	N/A	N/A	27	70
ID	764	777	242	124	1,424	1,110	N/A	62	3,986	3,419	N/A	197	73	77
MT[2]	13,798	11,854	7,066	11,182	22,486	26,915	3,570	5,671	59,994	87,270	12,160	23,296	72	65
ND	314	855	329	607	756	2,056	N/A	N/A	1,589	4,764	N/A	N/A	85	71
SD	1,882	5,640	745	8,567	3,651	11,109	N/A	1,342	6,937	26,217	N/A	3,167	72	44
WY	20,808	29,711	8,836	23,264	17,235	22,492	14,670	32,283	51434[3]	78361[3]	39363[3]	104278[3]	93[4]	97[3]
NE	543	380	N/A	N/A	803	492	N/A	N/A	N/A	N/A	N/A	N/A	68	77
CA	232	191	104	0	513	234	N/A	1	1,072	442	N/A	2	66	83
NV	N/A	1,462	N/A	230	N/A	1,798	N/A	197	N/A	4,315	N/A	532	N/A	83
UT	429	757	490	692	392	750	44	74	640	4,659	71	518	98	92
CO[5]	3,974	4,563	3,877	4,483	10950[6]	10,840	0[6]	800	19960[6]	19,242	0[6]	1,459	72	78
KS	124	95	22	7	194	132	N/A	0	266	217	N/A	0	75	77
AZ[6]	407	432	0	0	484	506	0	0	1,088	1,490	0	0	84	85
NM[7]	3,126	3,630	259	300	N/A	1,733	N/A	2,347	N/A	2,341	N/A	3,550	89	94
TX[3]	612	792	4	0	767	1,097	N/A	N/A	N/A	N/A	N/A	N/A	80	70
OK	36	105	14	128	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A	50	N/A
MEX-SO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MEX-CO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

[1]2000 and 2008 Data

[2]2000 Data

[3]Includes all license types

[4]Because of the way the old report lumped kills per hunter, this reflects the fact that hunters killed more than 1 pronghorn in a given year.

[5]2008 Data

[6]Combined Resident & Non-Resident Data

[7]2007 Data

Table 6. Muzzleloader pronghorn harvest, by state and province, across North America in 1999 and 2009.

State/ Province	Number of Pronghorn Harvested				Number of Hunters				Number of Hunter Days				% Hunter Success	
	Bucks		Does & Fawns		Resident		Non-resident		Resident		Non-resident			
	1999	2009	1999	2009	1999	2009	1999	2009	1999	2009	1999	2009	1999	2009
AB[1]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
OR	34	42	1	1	141	164	1	3	500	747	N/A	N/A	9	24
ID	79	84	32	25	207	277	N/A	4	1,299	1,119	N/A	19	54	39
MT[2]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ND	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
WY	179	263	76	206	148	199	126	286	N/A	N/A	N/A	N/A	N/A	N/A
NE	67	96	N/A	N/A	139	120	N/A	N/A	N/A	N/A	N/A	N/A	52	80
CA	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
NV	N/A	9	N/A	0	N/A	19	N/A	0	N/A	73	N/A	0	N/A	47
UT	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CO[3]	48	103	43	56	176[4]	513	0[4]	15	463[4]	1,402	0[4]	38	52	30
KS	N/A	35	N/A	1	N/A	48	N/A	0	N/A	103	N/A	0	N/A	75
AZ[4]	57	70	0	0	95	103	0	0	254	358	0	0	63	68
NM[5]	131	158	0	2	N/A	191	N/A	70	N/A	433	N/A	154	60	61
TX	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
OK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MEX-SO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MEX-CO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

[1]2000 and 2008 Data
[2]2000 Data
[3]2008 Data
[4]Combined Resident & Non-Resident Data
[5]2007 Data

Table 7. Archery pronghorn harvest, by state and province, across North America in 1999 and 2009.

State/ Province	Number of Pronghorn				Number of Hunters				Number of Hunter Days				% Hunter Success	
	Bucks		Does & Fawns		Resident		Non-resident		Resident		Non-resident			
	1999	2009	1999	2009	1999	2009	1999	2009	1999	2009	1999	2009	1999	2009
AB[1]	64	118	N/A	N/A	171	237	N/A	N/A	649	1,107	N/A	N/A	37	50
SK	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
OR	43	94	3	15	526	536	6	6	2,116	1,957	N/A	N/A	N/A	N/A
ID[2]	150	241	30	88	772	1,423	N/A	40	3,787	6,980	N/A	244	24	45
MT[2]	290	961	144	381	N/A	5,573	N/A	1,181	N/A	N/A	N/A	N/A	N/A	20
ND	119	218	6	68	500[3]	1,692	N/A	119	2936[3]	8386[3]	N/A	N/A	22	16
SD	103	516	14	189	512	1,713	106	686	2,662	7,657	551	3,066	19	16
WY	558	1,704	237	1,334	462	1,290	393	1,852	N/A	N/A	N/A	N/A	N/A	N/A
NE	34	150	N/A	6	345	617	N/A	80	N/A	N/A	N/A	N/A	10	22
CA	9	9	1	0	35	24	N/A	0	136	78	N/A	4	28	38
NV	N/A	130	N/A	0	N/A	371	N/A	47	N/A	1,936	N/A	240	N/A	31
UT	27	122	N/A	N/A	50	175	6	20	150	814	16	90	48	65
CO[4]	292	403	25	17	1672[3]	1,850	0[3]	193	8698[3]	9,105	0[3]	832	19	21
KS	12	22	7	5	146	245	0	5	514	920	N/A	18	13	11
AZ[3]	97	119	0	0	562	343	0	0	3,417	2,123	0	0	17	35
NM[5]	148	204	0	6	N/A	280	N/A	113	N/A	624	N/A	283	27	54
TX	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
OK	N/A	25	N/A	11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MEX-SO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
MEX-CO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

[1]2000 and 2008 Data
[2]2000 Data
[3]Combined Resident & Non-Resident Data
[4]2008 Data
[5]2007 Data

NON-RESIDENT HUNTING SEASON OPPORTUNITY

Pronghorn hunting is very popular across most of their current range. One of the goals of pronghorn management is to provide a sustainable surplus for hunting opportunities to both residents and nonresidents. All states/provinces imposed restrictions on the number of non-resident rifle and muzzleloader licenses. The percentage of non-resident rifle hunters varied from 0% in California, Nebraska, and Oklahoma to 59% in Wyoming.

WILDLIFE/LANDOWNER PARTNERSHIP PROGRAMS

Ten states and provinces had partnership programs aimed at reducing wildlife/landowner conflicts (Table 8). Programs generally provided either direct monetary compensation, licenses for the landowner, licenses that could be sold, or payments in return for hunter access to private land.

Table 8. Current pronghorn partnership programs, by state and province, across North America in 2009.

State/ Province	Program Description	Funding	Results
SK	Crop Depredation Assistance	100% Crop Loss Coverage, Free Doe/Fawn License Assistance	
OR	Landowners are guaranteed doe tags based on acreage owned.		
ID	Access Yes!		
	Landowner Appreciation Permits		
MT	Block Management Program	$5,000,000 (All Species)	~8 Million acres of enrolled private lands, including antelope habitat
WY	Private Lands, Public Wildlife	$728,088	
	Landowner Licenses		
	Parnership for project proposal for impact mitigation with landowners, industry, NGOs, and WYDOT (fences)		
	Events such as the Pronghorn Workshop		
NV	Landowner Compensation Tag Program	Landowner issued 1 tag	Increase landowner tolerance of wildlife
CO	Habitat Partnership Program		
	Ranching for Wildlife		
	Big Game Access Program		
NM	Antelope Private Lands Use System (A-PLUS)		Provides some public access on private land
TX	NRCS EQIP-Wildlife Resource Concern	$618,915	92,009 acres. Majority for fence modification and brush control.
	TPWD Landowner Incentive Program	$18,564 (2010)	Improved water distribution and mesquite spraying.
	TPWD Public Hunting Opportunities for Pronghorn	5,000	Provides some public access on private land
OK	Depredation Permits		

HABITAT ENHANCEMENT PROGRAMS

Most (55%) of the states/provinces had on-going habitat enhancement projects for the benefit of pronghorn (Table 9).

Table 9. Habitat enhancement projects conducted for pronghorn, by state and province, across North America in 2009.

State/Province	Habitat Enhancement Project
AB	Several non-government groups are replacing bottom wires with smooth wire and lifting it as well in areas where it is identified as a travel corridor or a potential barrier to movement.
ID	Rehabilitation of 483,000 acres of sagebrush steppe habitat burned in the Murphy Complex wildfire in 2007.
MT	Use of conservation easements, fee title acquisition or implementation of prescriptive grazing systems to maintain and enhance native shrub steppe habitat types.
WY	Sagebrush enhancement projects are currently being conducted in many locations across Wyoming that benefit all sagebrush obligate species, when possible.
CA	Private Lands Management Program (PLM) -- some private ranches complete habitat enhancements on their property in exchange for tags.
NV	Water developments built and repaired.
UT	Restoration of hundreds of thousands of acres of sage steppe habitat to benefit not only pronghorn, but all other sage obligates.
CO	Water developments, improving fence problems.
AZ	Fence modification or removal, highway crossings, and grassland restoration.
NM	Water developments, modifying fences, and getting rid of encroaching woody plant species in order to restore grasslands.
TX	Private landowners conduct habitat enhancements on their own lands. Improvement of prairie chicken habitat.

PREDATOR CONTROL

One of the largest sources of mortality on pronghorn reported by participating states/provinces was predation of young. The main predator reported by states/provinces was the coyote. States and provinces were asked to report if they implemented any predator control measures (Table 10). Eight states/provinces reported having some form of predator control. However, typically control was not used as a pronghorn management tool by all states/provinces reporting. Predator management was most often conducted in conjunction with livestock programs.

Table 10. Current predator control measures (programs), by state and province, across North America in 2009.

State/Province	Predator Control Measures (Programs)
SK	Trapping -- price driven.
SD	Trapping, aerial gunning and targeted trapping
WY	County management boards conduct control activities for pronghorn if meets criteria/objectives.
NV	None for pronghorn specifically, primarily in overlapping mule deer herds.
UT	Wildlife Services, mostly for livestock.
AZ	Aerial gunning and leg-hold trapping removal in selected management units with chronically low fawn survival.
NM	Landowners conduct their own.
TX	Private landowners.

RESEARCH AND TRANSPLANTS

Pronghorn managers and researchers throughout pronghorn range are continually striving to better understand the species. This understanding is necessary to manage for continued existence of pronghorn throughout its range. Landscapes are being altered at an accelerated rate. Table 11 lists current research being conducted by different states/provinces. For information on these programs, the host state/province should be contacted directly. In some states/provinces, it has been necessary to transplant pronghorn from healthy populations into other areas of their own state/province or through gifts of pronghorn from other states or provinces (Table 12).

Table 11. Current pronghorn research projects, by state and province, across North America in 2009.

State/Province	Research Project / Program Description
AB	Habitat and range use, travel cooridor identifications, horn growth & age comparisons.
SK	Understanding the cumulative effects of man-made disturbance related to prefered migration routes and habitat selection.
OR	Pronghorn migration triggers and resource selection in southeastern Oregon.
MT	Assessing connectivity and affects of development (oil and gas as well as other anthropogenic features) on antelope in the northern shrub steppe of northcentral Montana, southeast Alberta, and southwest Saskatchewan.
CA	Very limited and just beginning. Some fawn survival studies and migration patterns.
AZ	Pronghorn movements in relation to fenced highways and interstates.
NM	Future research projects involving the cause and timing of pronghorn mortality.
TX	Genetic research to determine if pronghorn are genetically different statewide and among herd units. Disease surveillance to help indicate what may be causing pronghorn declines in some areas of the Trans-Pecos ecoregion.

Table 12. Pronghorn transplants, by state and province, across North America in 2009.

State/Province	Pronghorn Transplants
UT	Augment populations as needed.
CO	Done to supplement small populations that have suffered high mortality due to unusual drought or winter conditions.
AZ	Translocation of pronghorn from areas where residential development and fragmentation have isolated a population in an unsustainable area. Captured pronghorn are translocated to historic, suitable habitats where pronghorn herds are below population objective or absent.
NM	Used to reduce pronghorn in irrigated croplands and to restore and augment populations in suitable habitat.

DISCUSSION

The questionnaire used for this 2010 status report was based on questionnaires used historically with a few minor changes. Based on responses from the various states/provinces, there is a wide range of survey methods and protocols being used currently. Standardization of data collection and reporting (i.e. definitions for line versus strip transect sampling) would assist in comparison of results among the states/provinces. Additionally, if each state/province were to provide a contact list (minimum of 2 individuals) to the host meeting organization, completion of the questionnaire summary report would be facilitated.

Ackerman (2006) indicated that survey results for 1993, 2003 and 2006 would be incorporated into an on-line database accessible through the web. A centrally located database that could be populated every year by the various states/provinces would assist the host agency with reporting status of pronghorn across North America, and provide for the analysis of long-term trends in populations. This would further facilitate the transfer of information among jurisdictions.

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Current Federal Plan for the Pronghorn in Mexico

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ABSTRACT There is a new federal plan for the pronghorn in Mexico named Programa de Acción para la Conservación de la Especie – Berrendo (PACE-BERRENDO) (Species Conservation Action Program-Pronghorn). It was prepared in 2009 by specialists in pronghorn conservation, management and biology. That year was also the pronghorn's year. This plan is part of another wider program headed by the Comisión Nacional de Areas Naturales Protegidas (CONANP; Natural Protected Areas National Commission), via Dirección de Especies Prioritarias para la Conservación with the: Programa de Conservación de Especies en Riesgo (PROCER) (Species at Risk Conservation Program), which advocates the development and implementation 30 species at risk actions programs during this federal administration. The current PACE-BERRENDO has, besides the biological and ecological generalities of the species (description, evolution, food habits, distribution, etc.), the description of the threats, and the actions to revert the current low status per population. Those actions are distributed in six conservation strategies: Restoration, Protection, Management, Culture for Conservation, Outreach and Administrative Issues. The PACE is also planned to be evaluated periodically and updated according with achievements, under a vision of adaptive management. This program is based on the previous federal plan which was updated with the team of Mexican specialists on the species. It contains a brief history for each state where pronghorn inhabit or were transferred. There is also a technical card for the species beside the whole document in the internet. Their e-addresses are:
http://www.conanp.gob.mx/pdf_especies/pace_berrendo.pdf
http://www.conanp.gob.mx/pdf_especies/berrendo.pdf
Some of the goals included in the PACE are the recovery of the different populations of pronghorn in Mexico, including major efforts conducted with the Peninsular Pronghorn, continuation of the Coahuila populations recovery of through enhancement of the populations previously translocated, to management of the Chihuahua populations, and continuation with the collaboration in Sonora. It is very important to include habitat conservation using the available schemes form Mexico, the Natural Protected Areas and the Conservation Management Units (UMAs); with the participation of all the social sectors: academia, land owners and government in its different levels.

KEY WORDS Conservation, management, Mexican federal plan, pronghorn.

The pronghorn is an endemic species from North America, in Mexico there are three well defined groups: one in North and Central Mexico, another in Baja California Peninsula, and the third one in Sonora. This species in Mexico is ranked in the NOM-059-SEMARNAT-2001 as "Endangered Species" (SEMARNAT, 2002) and it is also in Appendix I of CITES (UNEP-WCMC, 2010).

Although there have been several efforts to conserve this species, which started in 1922 when President Alvaro Obregon ordered the permanent closure of pronghorn hunting (INE-SEMARNAP. 2000), several conservation efforts are required to contribute to recovery effectively, integrating the landowners in conserving, managing wildlife populations and their habitat.

As part of recent efforts to contribute to conservation from an approach involving different sectors of society, in early 2007, the Mexican government through the National Commission of Natural Protected Areas, launched the Conservation Program of Species at Risk (PROCER). The objective is to establish bases, to coordinate, and to promote the efforts of the Federal Government and diverse sectors of society, in the conservation and recovery of thirty species at risk, through the Species Conservation Action Programs (PACE). Its preparation included the combined efforts of all stakeholders and concerned about the conservation of the species, habitat and sustainable development of the region, government institutions, academia, international agencies and nongovernmental organizations.

The PACE: Pronghorn, also collects the work and expertise generated by experts in the past, considering the Project for Conservation and Sustainable Management of the Species (known as PREP) (INE-SEMARNAP 2000, DGVS 2001), and by proposing concrete actions for their conservation and management . It identifies the critical needs for the conservation of the species and promote concrete actions needed to cover them, relying on technology development and proper management of the species, seeking to recover the populations in the historical range. Currently the PACE is now considered Mexico's strategy for the conservation and recovery of species.

Within the PACE, are six areas of action or components, representing the six strategies for the conservation by the CONANP to contribute to the conservation and recovery of biodiversity. PACE’s conservation strategies are as follows: 1) Protection, 2) Restoration, 3) Habitat and wildlife management, 4) Knowledge, 5) Cultural and 6) Administrative management. Each of these strategies include a list of activities to be undertaken covering aspects for the establishment and management areas under a scheme of *in situ* conservation, habitat restoration projects and management of populations, knowledge generation, environmental education, awareness, and planning of projects with institutional synergies between different sectors.

For its implementation, the Mexican government has established collaborative actions with different wildlife agencies, including some from the United States, whose experience has greatly enriched knowledge about the management of this species. Also, the implementation of recovery projects in several Mexican states. Derived from the positive results these efforts have enabled both authorities and various stakeholders, recognize the importance of joint bi-national cooperation and participation of various sectors of society in a common goal.

Within the Mexican policy on wildlife conservation, the fundamental actor is the legal owner of the land, who although they have right to the use of natural resources, require government permission. That is why within the PACE is considered fundamental to working with landowners where the species is distributed, who in future, with viable populations of pronghorn, will make use of this resource. Also with them promotes the implementation of federal and state programs for rural development that enable them to obtain financial resources for conservation and habitat management and wildlife populations and improve their quality of life. The PACE also considers those landowners interested, it means, not just those that already have a pronghorn population.

In terms of population, with the implementation of PACE is to increase the number of individuals and populations of pronghorn at least 30% nationally in the midterm (10 years); with the collaboration of all sectors involved and a constant budget. Additionally, the pronghorn has faced a severe lack of interest in various sectors involved in land tenure, since the closures and restrictions on legal use, have promoted the vision of pronghorn as a kind of low and zero value for the organized hunting tourism and other rural productive activities, this same phenomenon also has been responsible for continued poaching, with no alternative management and generation of economic resources on the species.

Deriving the diagnosis made in the PACE have been able to identify several of the needs and goals in terms of populations in each of the regions where the species is distributed. In the Baja California Peninsula long-term collaboration within Federal government, civil organizations and the private sector have allowed populations to recover within the Biosphere Reserve El Vizcaino in Baja California Sur, subject to a semi-extensive, and general improvements in the state's population. However, it is necessary to take the next step for conservation, which includes continuing with a semi-extended management, particularly in the Natural Protected Area Valle de los Cirios, involving local communities in their management, conservation and making a sustainable activity.

For its part the populations of Sonora and Chihuahua face additional risks and needs, in these states has an acceptable number of wild individuals for recovery management, however, isolation by habitat loss, agricultural activities and poaching, have led to their populations remain low and be required to address this problem to prevent its demise. In this sense, the strategies proposed are aimed at the protection and surveillance, especially population management in protected areas, the protection of critical areas and habitat conservation.

The rest of the country has faced the extirpation of pronghorn populations since late 1990, resulting in some recovery efforts and translocation of groups of individuals from the United States. Success has been varied, however it is relevant the effort in Coahuila, where in 2009 and 2010 had been transplanted up to 300 pronghorns to strengthen the translocated groups 10 years ago. In these zones is very important to control illegal hunting and especially to conduct coyotes management and control, which have severely limited the populations of pronghorn, to prey on large numbers offspring during births seasons, at least in Coahuila (Valdés et al. 2006). In Zacatecas translocations were also made, but the success has been low and requires intensive management due to fawns that have been used in these movements. Further investment of time is needed to increased the population, that will required long term efforts to consolidate populations in wild. In the rest of the country that historically had antelope the situation was more complex, around middle of Mexico has limited availability of suitable habitat and several pressures due to the high density of human population, despite potential for short-term efforts can be made in Durango, and some locations in San Luis Potosi and Nuevo Leon.

Finally, in order to measure and verify the degree of effectiveness of actions and the scope of the objectives and goals in the PACE, it contemplates periodic evaluations using pre-established success indicators, which will amend needs and activities, so the PACE incorporate adaptive management in its concept and execution.

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ABSTRACT In February 2009, 122 pronghorn were translocated from New Mexico to three different localities in Coahuila, Mexico. Fortyfour of these animals were moved to the ranch “Rincon de la Madera”. Mexican federal laws require placing the animals in quarantine enclosures. Animals were placed in two different temporary enclosures. Transportation of the animals lasted 36 hours. After 4 days of being released 3 animals died due to suspected capture myopathy. However, eight days after release, mortality was 38%. Samples of different tissues and fluids were collected during necropsies of 4 animals. Pathology, urine analysis and levels of sodium in aqueous humor confirmed the diagnosis of severe dehydration. Although the animals were provided with supplemental food and water, the stress associated with translocation to a different habitat and segregation were probably the causes related for them not to drink water. Three animals were treated and one survived. A group of 18 animals that stayed together survived in the enclosure. Additionally, a group of 8 animals was placed in a smaller enclosure of 2 ha resulted in no mortalities. After the animals learned how to obtain water and food, mortalities stopped. Does gave birth to 16 fawns from which 2 died.

For future translocations in cases where the habitat is dissimilar, smaller temporary enclosures of 1 ha per 2 – 4 animals, are preferred instead of big ones. However these enclosures will need to have certain characteristics in order to reduce stress in the animals.

KEYWORDS Diagnosis, pronghorn translocation, stress.

INTRODUCTION

Pronghorn’s populations in Mexico have drastically declined in the last two centuries. Latest estimations are less than 1,500 pronghorn in all Mexico; slightly more than 500 pronghorn for Baja California Sur, 400 pronghorn in Sonora, and more than 300 in Chihuahua. In Coahuila they were extirpated around the 1960’s and are considered extinct in Baja California Norte.

In 1996 and 1998 a pronghorn recovery program was launched for Coahuila. In a bi-national cooperation program with the state of New Mexico, 150 pronghorn were translocated in those years from New Mexico to Valle Colombia in Coahuila. However dispersion and predation reduced the population to 35 animals by the year 2003.

Pronghorn translocation from New Mexico to Coahuila

In 2009, the Mexican government decided to restore pronghorn populations in 3 different locations in Coahuila: Valle Colombia, Rincon de la Madera-La Mesa and Maderas del Carmen.

122 pronghorn were translocated that year to the 3 Wildlife Management Units (UMA) to the above mentioned locations. From these, Rincon de la Madera received 44

animals that were split into two temporary enclosures. Both were built with a 3 meter high fence and electrical wire. Habitat inside of the enclosures was desert type without adequate forage, therefore pellets and alfalfa were distributed along the enclosures for supplementation. The main difference between both enclosures was the size, one being of 200 ha with a hill in the middle, and the other one of 2 ha. Thirty six pronghorn were released within the large enclosure and 8 in the smaller one.

After 4 days after their release, 3 mortalities were noted in the large enclosure. Capture myopathy was suspected, however animals demonstrated continuing decline, so at day 6 animals that were observed in a compromised condition were darted and moved to the smaller enclosure. Animals that were found dead appeared grossly dehydrated, as well as the ones found in compromised condition. Therefore before being released at the small pen the animals that were captured were treated with fluids and steroids. From the three animals that were treated, only one survived. At day 8, mortality was 38% (16 animals). Necropsies from 4 animals and laboratory tests were performed in order to confirm the diagnoses.

Laboratory Results

In order to rule out any viral or bacterial disease that could have been involved, ELISA tests were run for the following diseases: Anaplasma, Brucella, Bovine Viral Diarrhea, Bluetongue Virus, Chlamydia, Infectious Bovine Rhinotracheitis, Leptospira sp., Tuberculosis (PPD), Paratuberculosis (John's disease), Parainfluenza- 3, Pasteurella multocida and Manheimia haemolytica. Background exposure was found to Blue Tongue (13%), Chlamydia (13%), PI-3 (16%); Pasteurella multocida (3%) and Manheimia haemolytica (6%).

Histopathologically, kidney tissue was consistent with a multifocal nephrotoxic necrosies. No significant findings were obtained from the bacteriology analysis. Urinalysis showed presence of blood and proteins consistent with kidney damage. Urine specific gravity from 3 samples was of 1.046, 1.048 . and 1.039. These values when associated with high levels of blood urea nitrogen and creatinine are consistent with pre-renal azotemia; dehydration being the most significant related cause.

At the necropsies, all animals had very small quantities of food inside of the rumen which showed animals didn't eat at all or enough food at the pen.

As an immediate action to prevent more mortalities, more drinkers with the colors and shapes of the ones at the sight of the original capture in New Mexico were placed within the pens. More pellets and alfalfa were placed along the fence and in the inner part mixed with some of the native vegetation. Mortalities stopped and does gave birth to 16 fawns from which 2 died.

COMMENTS

The smaller enclosure of 2 ha presented no mortalities. Apparently, since the group had no way to disperse, it was easier for one animal to "teach the rest". Dehydration from the non intake of water was a consequence of segregation, which was related to adaptation to a completely different new habitat. Therefore, when habitat it's not suitable, temporary small enclosures are preferred. Finding a palatable combination of supplemented food is also necessary, like the one used in the UMA Valle Colombia consisting of alfalfa and pellets mixed with molasses.

For future translocations in cases where the habitat is not very similar, smaller temporary enclosures of 1 ha per 2 – 4 animals, are preferred instead of big ones. However these enclosures will need to have certain characteristics in order to reduce stress in the animals.

UPDATES

A second translocation of pronghorn from New Mexico to Coahuila took place in March of 2010. Thirty three pronghorn were again moved to the UMA Rincon de la Madera. Since the old group was still in the 200 ha enclosure, all the animals from the new group were placed there. Mortality from transporting and the initial adapting period was 16% (5 animals). Animals that were found dead were not dehydrated and the cause of the mortality was related to capture myopathy. The new group followed the old group, which we believe were the ones that showed them what to eat and where to drink.

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HUNTING AND TROPHY HORN SIZE IN MALE PRONGHORN

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ABSTRACT Pronghorn horn sheaths are unusual among ungulates in that much of the growth takes place during the winter months. In past papers and presentations we have demonstrated that horn size depends on genetics, nutrition, winter temperatures and age, with younger animals (ages 4-6) tending to be larger than older males (ages 6+). To evaluate the effects of minimum temperatures and hunter selection on trophy occurrence we compared the percentages of Boone and Crockett Club males in the total buck harvest in two southern states (Arizona and New Mexico) with two northern states (Wyoming and Idaho). Although the percentage of trophy animals was significantly higher in the southern states than in the norhern states, this percentage significantly increased (P<0.01) over time in all four states (r^2 = 0.55 for AZ, r^2 =0.70 for NM, r^2 = 0.49 for WY, r^2 = 0.25 for ID) even though the mean horn size of males harvested in Idaho since 1990 has decreased (r^2 = 0.26; P < 0.04) Possible reasons for these progressive increases in trophy males include increased interest in trophy recognition and/or increasing minimum temperatures. Evidence favoring the later explanation are increasing mean annual temperature minima in AZ (r^2 = 0.32; P < 0.01), NM (r^2 = 0.38;P< 0.01) and WY (r^2 = 0.28; P< 0.01). Whatever the reason, hunt pressure at recent levels does not appear to affect the number of trophy animals even though trophy males may be differentially harvested.

INTRODUCTION

There has been much debate in recent years about the potential impacts of hunting on ungulate populations, including such morphological traits as horn and antler size (Allendorf and Hard 2009, Bischof et al. 2008, Caro et al. 2009, Coltman et al. 2003, Darimont et al. 2009, Festa-Bianchet and Lee 2009, Ginsburg and Milner-Gulland 1994, Maher and Mitchell 2000, Milner et al. 2007, Milner-Gulland et al. 2009, Mysterud and Bischof 2009, Proaktor et al. 2007). Many of these discussions have been based on historical harvest regimes, or models, and not all differentiate between regulated sport hunting and unregulated harvest. While reported results have ranged from the equivocal to the controversial (e.g. Frisina and Frisina 2004, Geist 2004, DiBattista 2008), these discussions can provide important management insights into harvest methodologies and help wildlife managers make decisions.

Of particular concern is the possibility that harvesting select males provides artificial selection against certain physical traits such as trophy size and quality (e.g., Coltman et al. 2003, Geist 2004, Festa-Bianchet and Lee 2009). This concern is greater for some species than others and maintaining a certain horn size is an objective of some pronghorn (*Antilocapra americana*) harvest management plans (e.g. Compton 2008, Arizona Game and Fish Department 2009). Horn size is especially relevant to pronghorn as hunter selection may be motivated by whether an animal is of sufficient quality to score as a trophy in Boone and Crockett Club, Safari Club International or state trophy competitions (see e.g. Brown and Ockenfels 2009).

Pronghorn are unusual ungulates in that most of the growth of the deciduous horn sheaths is during the winter months (O'Gara 2004). To obtain more insights into the phenomenon of pronghorn horn sheath development we studied several aspects of horn size throughout the species' range including the effects of age, location, weather and nutrition (Mitchell and Maher 2001, 2006; Brown and Mitchell 2006, Brown et al. 2006). We concluded that most trophy pronghorn were relatively young (< 6 years of age), occurred in areas or years having mild winters, and favored by adequate nutrition with genetics also playing an undetermined role (Brown et al. 2006) To determine if past harvest levels negatively affected pronghorn horn size we hypothesized that horn size in male pronghorn as measured by length and recorded trophy occurrence would decline over time.

METHODS

We tested this hypothesis in two ways. First, we looked at the estimated number of male pronghorn harvested each year in two southern states having high percentages of trophy males in the harvest (AZ and NM) and two norhern states (WY and ID) having lower percentages of trophies in state harvest databases. We then divided the numbers of male pronghorn harvested each year into the number of Boone and Crockett Club trophy entries for that state to obtain the percentage of trophy buck pronghorn harvested (www.boonecrockett.org/community/trophyDB/act_SearchCatergory.asp?com=TRO). Annual percentages of trophy males over the period that sufficient data were available were then correlated over time using years as a dependant variable (Tables 1 and 2).

Second, since Boone and Crockett pronghorn are a small subset of all male pronghorn harvested, we compared the mean horn size of male pronghorn measured at regional check stations in Idaho between 1991 and 2007 (Compton 2008). Again, using simple linear regression, annual means were regressed over time using years as a dependant variable, to determine if any trend was present in mean horn size (Table 3).

Because pronghorn horn growth has been shown to be related to both winter temperatures and presumed nutritional levels (Brown et al. 2002, Brown and Mitchell 2006, Brown et al. 2006, Brown and Edwards 2008), we also compared each state's trend in trophy percentages and horn size with annual mean temperature and precipitation data for select weather stations within each of the four states using the Western Regional Climate Center website, http://www.wrcc.dri.edu/ (Table 4).

RESULTS

As suggested by Brown and Mitchell (2006) and Brown et al. (2006), the percentages of trophy male pronghorn were greater in the two southern states than in the two northern states (Tables 1 and 2). Nonetheless, in spite of the longitudinal differences between the states, the percentages of trophy pronghorn increased significantly (P<0.01) in all states over time, r^2 = 0.55 for Arizona, r^2 = 0.70 for New Mexico, r^2 =0.49 for Wyoming and r^2 = 0.19 in Idaho (Figures 1-4). This increasing trend occurred at both annual and 10 year intervals (Tables 1 and 2).

In contrast, trends in mean horn length of all male pronghorn harvested in Idaho showed a slight but weakly significant negative trend from 1991-2007 (r^2 = 0.26, P = 0.04; Fig. 5).

Although temperature trends for three of the four weather stations tested showed significant (P <0.01) trends toward increasing mean annual minimum temperatures (Figs 6-9), no significant (P <0.01) increases or decreases in precipitation were discernable.

DISCUSSION

We considered two possible explanations for these trends. One possibility is that a larger number of trophy male pronghorn are now being sought and registered with Boone and Crockett than formerly as the the numbers of pronghorn harvested in the four states have not consistently increased over time (Tables 1-2). Moreover, the trophy value of pronghorn, especially in Arizona, has been emphasized for some time (O'Connor 1961) and hunter interest does not adequately explain all four states having variable but generally increasing incidences of trophy animals. Nonetheless, the possibility of increasing trophy interest exists.

Another explanation for the increasing percentages of trophy male pronghorn in Arizona, New Mexico, Wyoming and possibly Idaho is the increase in mean annual minimum temperatures shown in Figures 6-8. These data suggest climate change as a possible factor in increased trophy presence since changes in temperature can affect horn size (Brown and Mitchell 2006, Brown et al. 2003, 2006), and climate change may increase the importance of genetic diversity in populations adapting to rapidly changing environments (Koons 2009). No significant changes ($P < 0.01$) resulting in either greater or lesser precipitation were noted in any of the four states during the period tested (Table 5).

The slight and weakly significant declines in the mean and median horn size of male pronghorn harvested in Idaho may be an anomoly (Table 3, Compton 2008). This decline may be due to the limited number of pronghorn measured, the shorter time frame involved (1991-2007), recent years experiencing low temperature minima, poor recent declines in nutrition, or a decrease in the availability of trophy males in Idaho populations. As Jerome, Idaho, was the only one of our climatic stations that did not show any increase in mean annual temperature minima (our metric for climate change) we attribute these observed this decline in horn length to normal fluctuations in annual horn growth and differential harvest pressure.

Regardless of the reasons for increased trophy occurrence or the decline in horn lengths in Idaho, these data indicate that pronghorn harvests, as presently conducted, are not affecting trophy male horn size. We propose several reasons for this.

Most of the studies indicating negative consequences of harvesting ungulates are based on models incorporating high harvest rates on relatively small populations of wild sheep or deer. In contrast to these studies, pronghorn management programs and hunting seasons do not allow for the removal of all or even most "trophy" males. Thus selection against horn size is neither intensive, or extensive. Given that only 4-27% of the estimated male pronghorn population is typically harvested (O'Gara and Morrison 2004) most sport hunting strategies leave ample varied age individuals, phenotypes and genotypes in the population.

Also, unlike most cervids, pronghorns with large horns do not necessarily have higher mating success than males with smaller horns. Indeed, it is the younger (4-6 year old) males that have the largest horns (Brown et al. 2006). Rather, females select for the most vigorous males (Byers 1997, Byers et al. 1994) and harvesting the largest males need not impact breeding success or subsequent horn size.

Finally, pronghorns use a variety of mating systems (Maher 1994) including both "resource defense" (territories) and "group defense" (harems). "Group defense" mating may reduce the effects of male biased harvest in some situations (Allendorf and Hard 2009, Caro et al. 2009).

The decline in horn sizes in Idaho, if real, could be due to any one, or a combination of, several possibilites. Idaho may be harvesting a lesser number of pronghorn than other states given that pronghorn >6 years of age tend to have smaller horns and it is possible that either harvest or climate may be driving horn size in this state. Most importantly, this seeming anomaly emphasizes the need for additional analyses of factors influencing pronghorn horn size.

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Table 1. Annual male pronghorn harvests and percent trophies in Arizona and New Mexico, 1959-2008.

Year	AZ males harvested	No. trophies entered	Percent	10 year means	NM bucks harvested	No. trophies entererd	Percent	10 year means
1959	589	5	0.00849		2026			
1960	722	2	0.00277		1247			
1961	687	5	0.00728		3884	2	0.000515	
1962	559	2	0.00358		1606	0	0	
1963	690	1	0.00145		742	0	0	
1964	724	1	0.00138		859	0	0	
1965	652	3	0.00460		1445	3	0.002076	
1966	542	1	0.00185		1250	0	0	
1967	667	2	0.00300		1250	0	0	
1968	352	1	0.00284	1959-1968 =.00372	1250	0	0	1961-1968=0.00032
1969	406	1	0.00246		1250	1	0.0008	
1970	589	3	0.00509		1250	2	0.0016	
1971	559	0	0.00000		1250	0	0	
1972	480	2	0.00417		1200	0	0	
1973	642	6	0.00935		1200	1	0.000833	
1974	687	4	0.00582		1300	2	0.001538	
1975	652	6	0.00920		1300	3	0.002308	
1976	525	3	0.00571		1840	2	0.001087	
1977	430	0	0.00000		2380	6	0.002521	
1978	426	1	0.00235	1969-1978 =.00442	2594	3	0.001157	1969-1978 = .00118
1979	434	2	0.00461		2807	2	0.000713	
1980	465	2	0.00430		2780	1	0.00036	
1981	469	1	0.00213		2586	1	0.000387	
1982	534	4	0.00749		2392	5	0.00209	
1983	554	7	0.01264		2933	5	0.001705	
1984	614	14	0.02280		2933	3	0.001023	
1985	635	8	0.01260		3473	5	0.00144	
1986	596	4	0.00671		3710	7	0.001887	
1987	498	10	0.02008		4133	19	0.004597	
1988	599	8	0.01336	1979-1988 =.01067	4133	7	0.001694	1979-1988 = .00158
1989	606	9	0.01485		4133	10	0.00242	
1990	545	7	0.01284		4556	22	0.004829	
1991	543	15	0.02762		4456	34	0.00763	
1992	553	7	0.01266		4302	26	0.006044	
1993	675	14	0.02074		4711	15	0.003184	
1994	704	14	0.01989		5665	18	0.003177	
1995	693	8	0.01154		5013	15	0.002992	
1996	703	12	0.01707		3732	23	0.006163	
1997	598	9	0.01505		3335	18	0.005397	
1998	593	14	0.02361	1989-1998 = .0159	2937	25	0.008512	1989-1998 = .00503
1999	573	10	0.01745		2568	28	0.010903	
2000	543	11	0.02026		2480	24	0.009677	
2001	527	7	0.01328		2480	11	0.004435	
2002	586	7	0.01195		2391	21	0.008783	
2003	415	10	0.02410		2698	26	0.009637	
2004	411	9	0.02190		2700	24	0.008889	
2005	471	4	0.00849		2700	29	0.010741	
2006	528	11	0.02083		2875	38	0.013217	
2007	570	7	0.01228		3050	17	0.005574	
2008	619	12	0.01939	1999-2008 =.017				1999-2007 = .00909

Table 2. Annual male pronghorn harvests and percent trophies in Wyoming and Idaho, 1973-2008

No. WY Year	WY males harvested	No. trophies entered	Percent	10 year means	ID males harvested	No. trophies entererd	Percent	10 year means
1973					353	0	0	
1974					371	0	0	
1975					296	0	0	
1976					293	0	0	
1977					769	0	0	
1978					813	0	0	
1979					940	0	0	
1980	31,324	16	0.00051		1030	0	0	
1981	40,128	19	0.00047		1331	3	0.0023	
1982	44,682	31	0.00069		1559	1	0.0006	
1983	52,049	30	0.00058		1602	2	0.0012	
1984	46,770	4	0.00009		1537	0	0	
1985	37,413	8	0.00021		1546	1	0.0006	
1986	31,924	6	0.00019		1730	0	0	
1987	27,752	10	0.00036		1714	0	0	
1988	27,487	10	0.00036		2008	3	0.0015	
1989	28,906	24	0.00083	0.00043	1646	0	0	0.00062
1990	29,597	32	0.00108		1566	0	0	
1991	34,501	41	0.00119		1554	2	0.0013	
1992	39,170	34	0.00087		1513	1	0.0007	
1993	33,069	11	0.00033		1210	0	0	
1994	25,830	14	0.00054		1055	0	0	
1995	22,351	11	0.00049		1007	1	0.001	
1996	21,130	13	0.00062		954	1	0.001	
1997	20,426	12	0.00059		819	1	0.0012	
1998	20,807	17	0.00082		868	1	0.0011	
1999	21,545	21	0.00097	0.00075	848	2	0.0024	0.00087
2000	23,536	25	0.00106		801	0	0	
2001	19,552	18	0.00092		872	0	0	
2002	21,611	22	0.00102		781	1	0.0013	
2003	23,333	25	0.00107		786	0	0	
2004	24,592	44	0.00179		765	1	0.0013	
2005	25,244	42	0.00166		838	2	0.0024	
2006	27,280	61	0.00224		904	0	0	
2007	30,345	49	0.00161		879	1	0.001	0.00075
2008	30,809	21	0.00068	0.00134				

Table 3. Horn Measurement data for Idaho from Compton 2008

Year	Sample Size	Mean Length	Median Length
1991	135	12.25	12.5
1992	157	11.8	12
1993	258	12.2	12.25
1994	351	12	12.7
1995	610	11.7	11.75
1996	402	11.4	11.1
1997	533	12	11.7
1998	458	11.8	12.1
1999	640	11.9	11.95
2000	727	11.7	11.85
2001	617	11.3	11.4
2002	535	11.6	11.55
2003	541	11.3	11.9
2004	541	10.8	10.9
2005	590	11.8	12
2006	536	11.5	12
2007	604	12	11.8

slope -6.940664

Table 4. Mean annual minimum temperature and annual precipitation data for select stations in AZ, NM, WY and ID

	Wupatki N.M., AZ		Las Vegas FAA, NM		Laramie FAA, WY		Jerome, ID	
Year	Min Temp	Precip.	Min Temp	Precip	Min Temp	Precip	Min Temp	Precip
1959	44.21	7.5						
1960	43.23	7.46	33.86	15.2				
1961	43	6.61	34.1	17.37				
1962	43.99	5.73	35.15	12.59				
1963	45.14	5.53	35.48	12.92				
1964	43.19	6.68	31.84	8.21				
1965	43.01	8.53	34.45	20.81				
1966	46.67	8.23	34.52	12.92				
1967	37.52	8.24	34.62	15.24				
1968	38.25	4.6	34.5	13.63				
1969	43	7.43	35.17	21.61				
1970	43.32	8.41	33.55	14.46				
1971	42.6	9.16	33.29	15.39				
1972	44.44	13.48	34.66	23.19				
1973	43.16	8.3	33.27	14.18			38.09	10.77
1974	44.24	5.58	34.18	11.89			37.95	8.26
1975	42.04	6.87	33.66	16.09	25.33	10.67	35.02	12.13
1976	44.32	7.85	33.47	11.4	25.95	6.86	34.48	7.95
1977	44.43	9.42	35.5	16.2	27.55	11.14	35.52	8.63
1978	45.25	11.76	35.36	18.33	26.26	8.47	35.09	10.36
1979	44.47	8.4	34.07	14.55	25.44	9.01	34.06	8.98
1980	44.51	7.69	35.63	10.66	27.4	9.76	36.19	12.01
1981	45.64	10.27	37.13	21.84	28.84	11.16	37.37	12.62
1982	43.25	9.49	35.61	19.51	26.26	10.8	33.99	13.09
1983	44.4	13.81	35.25	14.5	26.75	15.8	36.49	14.7
1984	43.84	8.83	35.29	21.42	25.95	11.87	32.97	11.7
1985	44.6	9.87	36.05	22.79	25.03	11.58	31.18	9.45
1986	45.33	13.34	36.75	22.87	28.59	10.8	36.67	11.58
1987	43.83	10.78	34.55	22.62	26.58	12	36.7	8.81
1988	44.81	8.09	34.86	22.53	26.94	9.93	36.03	9.77
1989	45.68	3.98	36	14.42	26.72	8.49	34.32	9.17
1990	44.28	4.94	35.66	19.51	27.35	15.11	35.41	7.73
1991	43.56	7.13	33.19	18.76	27.36	16.6	35.38	7.74
1992	43.4	7.81	34.94	13.51	27.73	13.61	36.23	7.07
1993	44.26	7.02	35.98	19.52	25.34	14.87	32.39	9.22
1994	45.07	8.59	37.35	22.37	28.37	6.42	35.67	10.18
1995	45.74	6.26	37.58	17.54	28.59	12.97	36.31	17.98
1996	46.4	6.05	37.62	19.06	27.78	8.05	36.09	15.15
1997	45.1	11.15	35.99	21.68	27.47	11.35	37.11	8.87
1998	44.07	12.53	37.41	16.71	29.15	15.28	37.69	16.38
1999	44.19	11.39	37.43	20.61	28.38	8.09	35.03	9
2000	46.1	8.33	37.18	11.74	26.67	12.09	37.26	8.28
2001	45.98	7.25	35.23	11.45	27.72	6.05	37.82	9.43
2002	45.05	5.41	34.71	10.55	26.42	5.4	36.6	6.31
2003	47.12	5.28	36.1	7.05	28.51	8.87	38.89	9.83
2004	45.65	7.72			28.38	11.47	36.5	8.98
2005	46.41	3.18			28.43	9.65	36.05	14.05
2006	45.76	8.88			27.67	7.19	37.7	11.57
2007	47.2	5.81			28.11	11	36.73	8.02
2008	45.37	7.24					34.74	9.26
2009	45.67	3.88					35.12	10.53

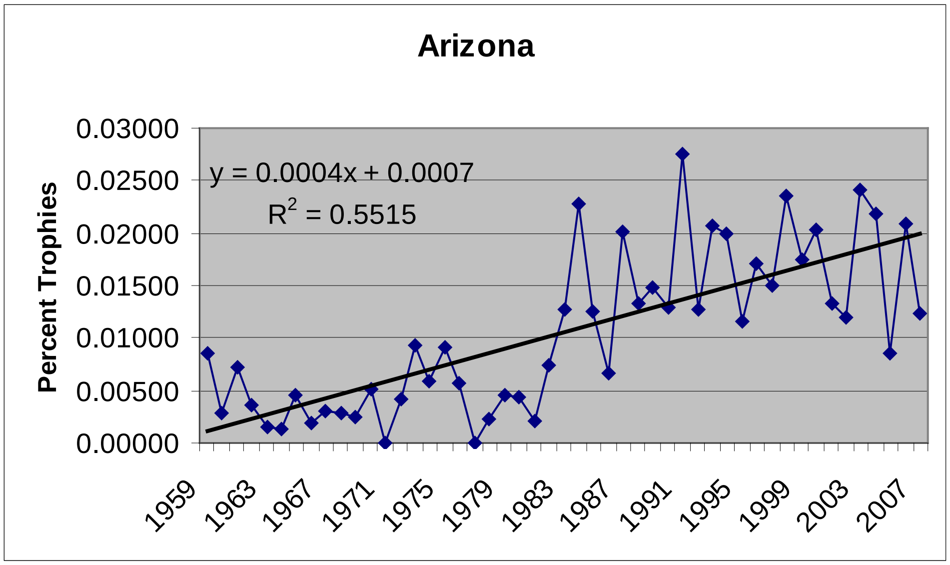


Figure 1. Percent trophy pronghorn by year, AZ

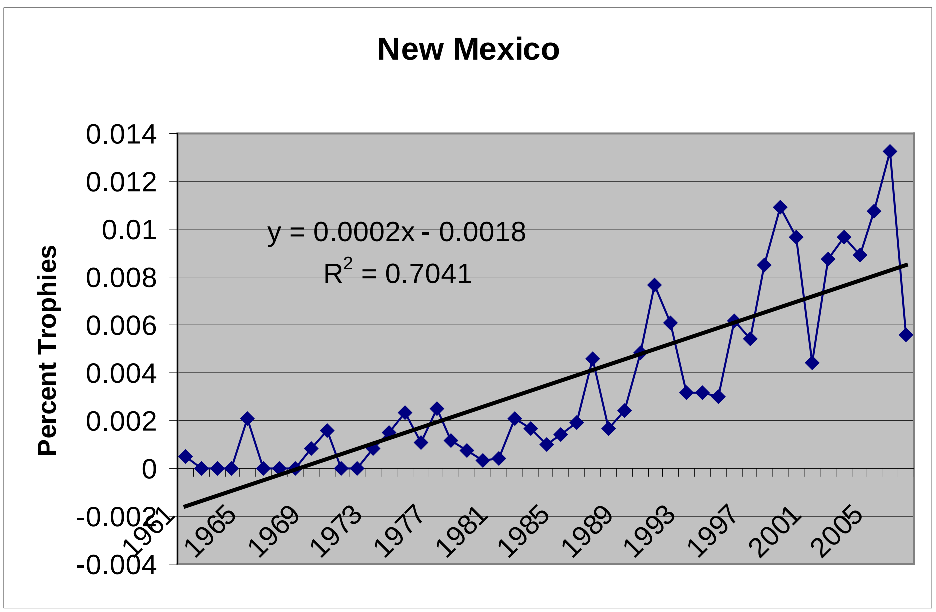


Figure 2. Percent trophy pronghorn by year, NM

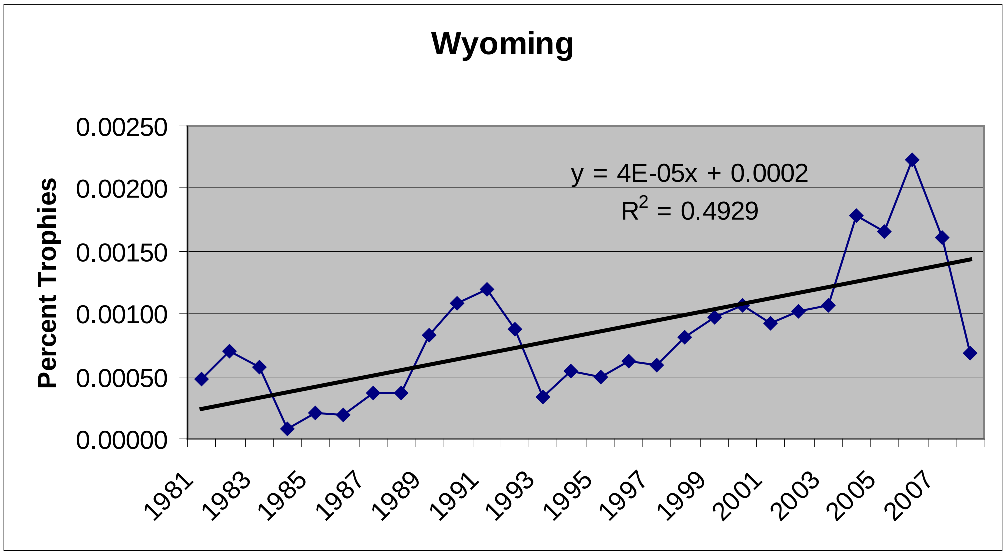


Figure 3. Percent trophy pronghorn by year, WY

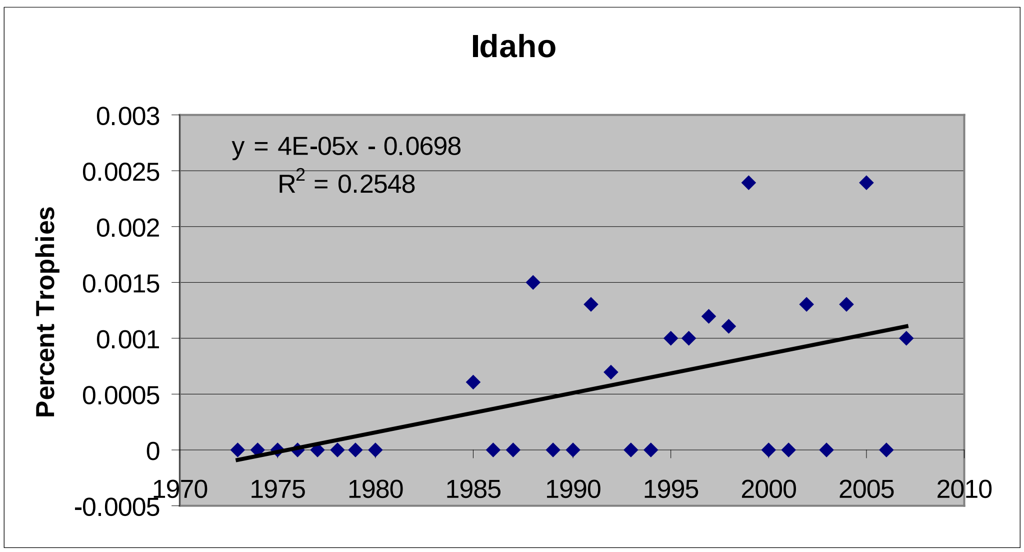


Figure 4. Percent trophy pronghorn by year, ID

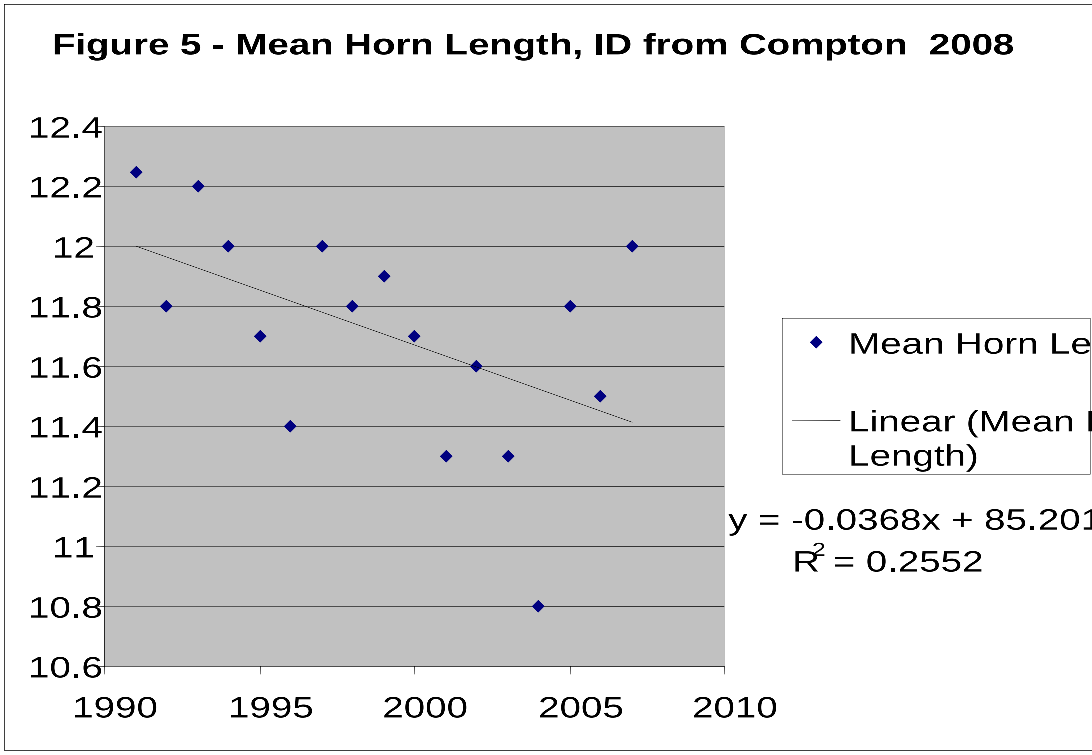


Figure 5 - Mean Horn Length, ID from Compton 2008
12.4
12.2
12
11.8
11.6
11.4
11.2
11
10.8
10.6
1990
1995
2000
2005
2010
Mean Horn Length
Linear (Mean Horn Length)
y = -0.0368x + 85.201
R2 = 0.2552

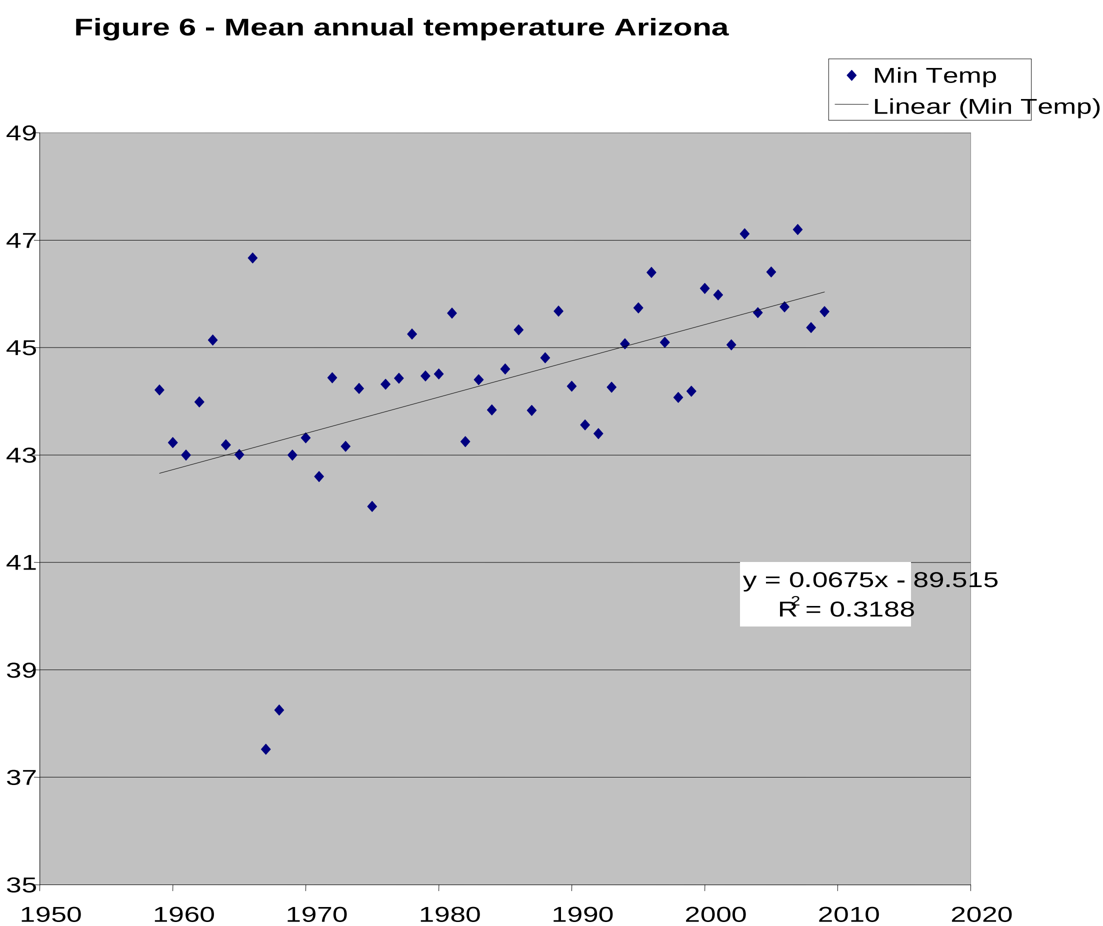


Figure 6 - Mean annual temperature Arizona
Min Temp
Linear (Min Temp)
49
47
45
43
41
39
37
35
1950
1960
1970
1980
1990
2000
2010
2020
y = 0.0675x - 89.515
R2 = 0.3188

Figure 7 - Mean Annual Minimum Temperatures, Las Vegas NM

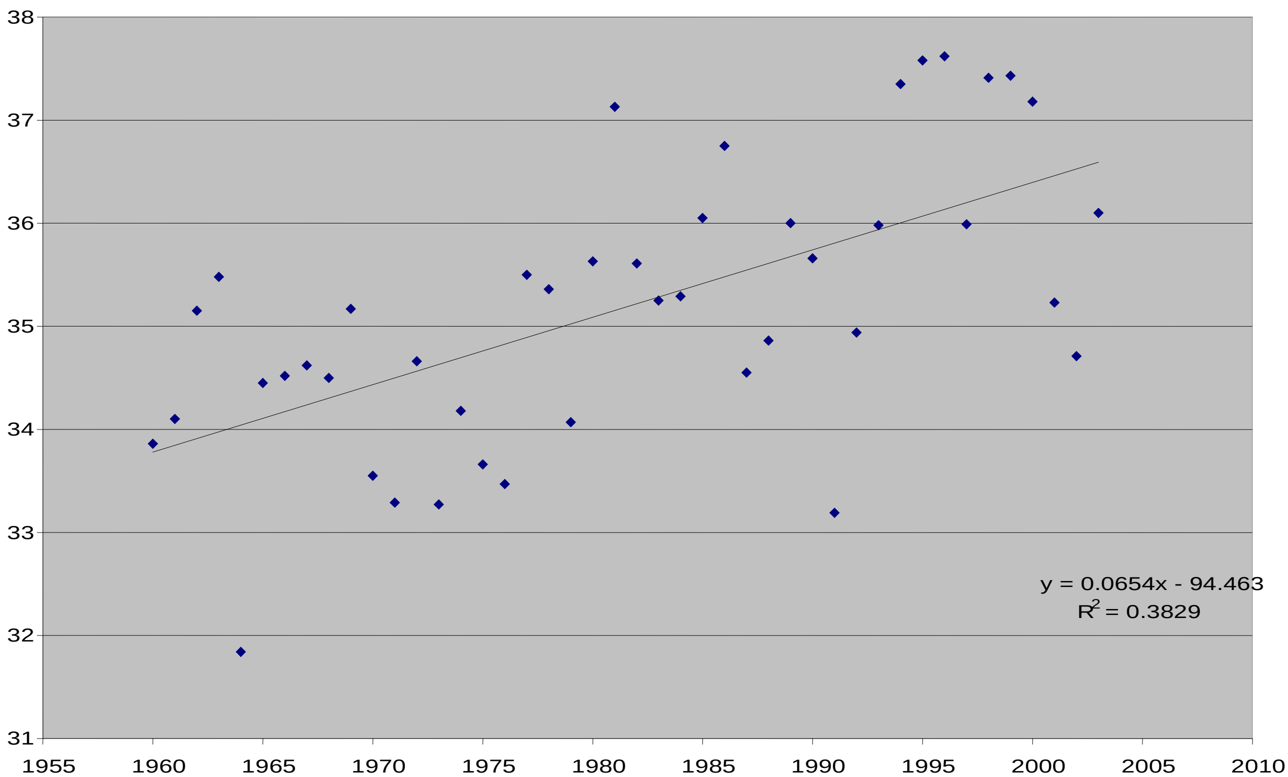


Figure 8. Mean annual minimum temperatures, WY

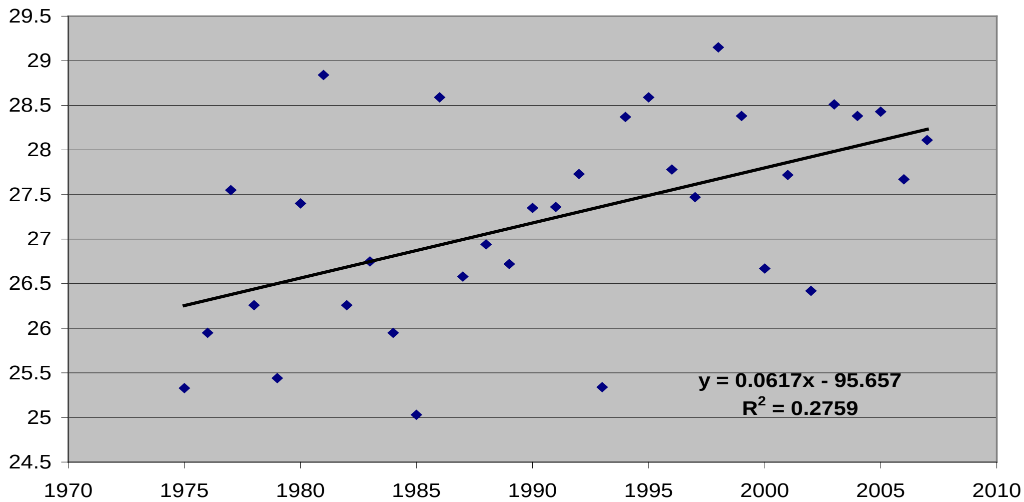
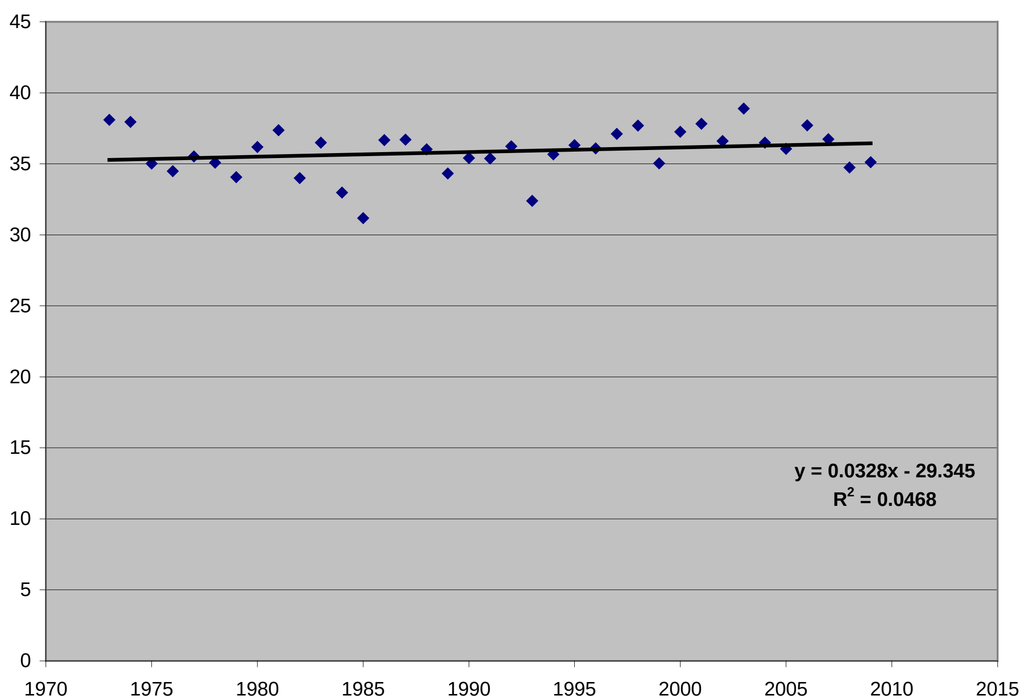


Figure 9. Mean annual minimum temperatures, ID



Pronghorn Survival in Wyoming

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ABSTRACT We estimated annual survival of adult female pronghorn (*Antilocapra americana*) in 2 hunted populations within Wyoming from April 2003 through May 2006. Annual survival rates were also calculated excluding harvested animals. We captured and radio-collared 60 adult (≥1 year old) female pronghorn from the Medicine Bow Herd in southcentral Wyoming and 60 from the Sublette Herd in southwest Wyoming. A sample size was maintained of approximately 60 animals from each herd throughout the study. Pronghorn were monitored with low-intensity aerial telemetry (1 location/8 weeks) to document survival and mortality. Annual survival estimates including harvested animals averaged 81% for the Medicine Bow Herd and 75% for the Sublette Herd. Mean annual survival estimates excluding harvested animals were 85% and 83% for the Medicine Bow and Sublette Herds respectively. The Sublette Herd Unit is currently undergoing large-scale energy development and the Medicine Bow Herd Unit is proposed for large-scale coal bed methane development in the near future. Knowledge of the survival of the adult female cohort will assist managers with making decisions regarding herd sustainability during these dynamic times.

KEY WORDS herd unit, pronghorn, radiotelemetry, survival estimation, Wyoming.

INTRODUCTION

Pronghorn (*Antilocapra americana*) are a valuable natural resource to the citizens of Wyoming as well as the national and international publics. Wyoming supports the largest population of pronghorn, approximately 57% of the world population (Hack and Menzel 2002). Knowledge-based management of the Wyoming population is of paramount importance. While there are several parameters to consider when managing pronghorn populations, one of the most important is survival of the adult female cohort.

Most studies of pronghorn survival have emphasized the fawn cohort (Beale and Smith 1973, Ockenfels 1992, Canon 1993, Fairbanks 1993, Gregg et.al. 2001, Reeve et.al. 2003, Zimmer 2004). Results of the few studies that have attempted to estimate adult survival rates illustrate the potential variation in this parameter. Sawyer and Lindzey (2000) estimated annual survival to be 97% and 84% for the 2 years of their study on adult female pronghorn in northwestern Wyoming. Data were collected using radio telemetry and analyzed with the Kaplan-Meier estimator (Sawyer and Lindzey 2000). Pyrah (1987) estimated annual survival (12 year average) to be 48% (range: 39-61%) for adult males and 81% (range: 65-95%) for adult females in a hunted population in Montana using the percent of marked animals alive since last count method. Estimates from radio-collared pronghorn over 2 years in the Trans-Pecos in Texas were 89% and 91% for females and males respectively (Canon and Bryant 1992). Mitchell (1980) estimated adult survival in 3 Alberta populations using the life-table approach and found mean annual survival rates of 55%, 62% and 71%, which were related to harvest level in the respective populations with the highest harvest level corresponding to the lowest annual survival rate. Annual survival rates of adult pronghorn of a non-hunted population in southern Arizona from 1995-2002 ranged from 17-89% and averaged 72%, using ratio of marked animals surviving (Bright and Hervert 2005).

The purpose of this research was to estimate annual survival rates of adult female pronghorn in 2 herd units in Wyoming. Wyoming Game and Fish Department defines a herd unit as an area of land used by a population of animals that includes all seasonal ranges and with < 10% immigration or emigration of the same species (Wyoming Game and Fish Department, personal communication). Pronghorn within each herd unit boundary are managed as a distinct herd (population) (Fig. 1).

STUDY AREAS

Medicine Bow Herd Unit

Located in the Upper Platte River Basin of southcentral Wyoming, the area includes portions of Carbon, Natrona, Converse, and Albany counties and pronghorn hunt areas (HA) 30-32, 41, 42, 46-48 (Fig. 1) and encompasses 14,390 km^2. The HA's are used to delineate areas within the herd unit. This herd has an estimated population size of 62,700 pronghorn, one of the largest pronghorn herds in the world. The current population objective set by Wyoming Game and Fish Department (WGFD) for this herd is 60,000 (Wyoming Game and Fish Department 2005a).

Hunting seasons generally run from mid-September to late-October annually. Average harvest from 2003-2005 was 5,764 pronghorn, with approximately 56% adult male, 22% adult female, and 22% male or female $\leq$ 1-year old (Wyoming Game and Fish Department 2005a). The number of hunting licenses issued in this area was increased from 7,200 in 2003 to 8,050 in 2005 to reduce the population to the objective of 60,000.

Topography of the area is largely rolling flats, but does include some foothills and mountainous areas and ranges in elevation from 1992-2705 m. The dominant habitat type is sagebrush-steppe dominated by Wyoming big sagebrush (*Artemesia tridentata*) and fringed sagewort (*A. frigida*).

Land ownership consists primarily of Bureau of Land Management (BLM), private, and state-owned sections. Land use includes recreation (hunting, fishing, camping etc.), cattle ranching/grazing and mineral extraction. Energy development such as coal bed methane, wind farms, surface and underground coal mining, uranium mining, and oil and gas development continue to affect pronghorn habitats in this area.

Long, cold winters with short, moderately cool summers are normal in this area with average low and high temperatures of $-6.6\,^{o}$ and 10.2^{o} C respectively. Annual mean precipitation is 25.5 cm (National Climatic Data Center 2006). This area has been experiencing extreme drought conditions since 2001 with some of the lowest Palmer Drought Severity Index (PDSI) (Palmer 1965) rankings since the 1920's (National Climatic Data Center 2006). The PDSI classifications range from 4.00 or greater for extremely wet periods to -4.00 or lower for extreme drought. From May 2003 through August 2004, PDSI rankings ranged from -3.63 to -5.15, indicating extreme drought. The PDSI rankings for September 2004 through June of 2005 ranged from -2.09 to -3.14 as the area experienced some relief from the past few years of extreme drought. However, from July 2005 to May 2006 extreme drought conditions returned to the area with PDSI rankings from -3.85 to -5.14 (National Climatic Data Center 2006). Even though drought conditions existed, there were periods of deep snow during the winter months (October through March), particularly in the 2003/2004 winter season.

There was no snow cover in the Medicine Bow area until 28 October 2003. A storm 28-31 October 2003 produced 39 cm of snow. Snow depth remained $\geq$ 15 cm through 26 December 2003. Daily maximum snowfall from 1 October 2003 to 31 March 2004 was 20 cm on 27 December 2003, bringing the total snow depth to 41 cm. Snow depth remained $\geq$ 25 cm until 15 March 2004 (National Climatic Data Center 2003, 2004, Shirley Basin, WY weather station).

The winter of 2004/2005 saw very little snow, with a maximum 1-day snowfall of 7 cm, and total snow depth not exceeding 15 cm through 31 March 2005. Again, little snow fell in the 2005/2006 winter season until 7 January 2006, when total snow depth measured 20 cm. Snow depth then remained $\geq$ 20 cm through 12 February 2006. On 13 and 14 February 2006, 29 cm of snow fell bringing total snow depth to 50 cm. Snow depth was not less than 25 cm until 23 March 2006 (National Climatic Data Center 2004, 2005, 2006, Shirley Basin, WY weather station).

Sublette Herd Unit

This herd unit is in the Upper Green River Basin of southwest Wyoming and encompasses all of Sublette and portions of Sweetwater, Lincoln, Fremont and Teton counties, includes pronghorn hunt areas 85-93, 96 and 107 (Fig. 1) and covers 27,715 km^2. Approximately 47,800 pronghorn reside in this herd, which has a population objective of 48,000 (Wyoming Game and Fish Department 2005b). Some of the pronghorn in this herd have been documented to migrate over 240 air kilometers from winter to summer range, one of the longest migrations of any North American ungulate (Sawyer and Lindzey 2000, Rudd 2001).

Hunting seasons generally run from mid-September to late-October annually. Average harvest from 2003-2005 was 4,127 pronghorn, with approximately 61% adult male, 25% adult female, and 16% male or female $\leq$ 1-year old (Wyoming Game and Fish Department 2006b). The number of hunting licenses issued in this area averaged 5,350 and varied little between 2003 and 2005 as herd objectives were achieved (Wyoming Game and Fish Department 2006b). Topography is mostly sage flats in the south and east, to more foothills and mountainous areas in the west and north with elevations ranging from 1,865 to 2,743 m. The desert shrub plant community that dominates the area is made up predominantly of sagebrush (*A. spp*), saltbrush (*Atriplex spp*) and greasewood (*Sarcobatus vermiculatus*).

Land ownership is primarily BLM, private, and state-owned sections. Seedskadee National Wildlife Refuge lies in the southwest portion of the area. Land uses include major oil and gas development and mineral extraction (coal and trona), cattle and sheep ranching/grazing, and recreation (hunting, fishing, camping etc.). Natural gas development is at an all-time high in this area, with three large gas fields (> 500 wells/field) and > 2000 additional wells authorized for the next 20-30 years. A large portion of this activity is occurring on areas classified as crucial winter range. In many areas, well densities are at 4 wells/section (640 acres) with 8 wells/section proposed for some areas (BLM 2007).

This area experiences long, cold winters and short, cool summers with average low and high temperatures of -6.7 ^{o} and 12.8^{o} C respectively in the southern portion of the area to -10.6 ^{o} and 8.3^{o} C respectively in the north (National Climatic Data Center 2006). Average annual precipitation ranges from 18.7 cm in the south to 41.4 cm in the north (National Climatic Data Center 2006). This area also has been experiencing extreme drought since 2001 with the lowest PDSI rankings in 2002 and 2003 (-5.05 to -8.37) since 1895. Extreme drought conditions persisted through August 2004. Beginning in September 2004 through June 2005, drought conditions improved considerably with PDSI values ranging from 0.29 to 1.32, indicating no drought. However, from July 2005 through May 2006, PDSI rankings steadily decreased from -0.62 to -2.33, indicating moderate drought conditions (National Climatic Data Center 2006).

Daily maximum snowfall from 1 October 2003 to 31 March 2004 in the southern portion of the study area (HA 88-93, 96, 107, and southern portion of 87) was 18 cm on 30 October 2003, however, the 3-day total for 29-31 October 2003 was 37 cm. Snow depth remained $\geq$ 15 cm until 3 November 2003, when it receded until 24 December 2003. Fifteen centimeters of snow fell between 24 and 25 December 2003, bringing snow depth to 18 cm and it remained $\geq$ 15 cm until 14 January 2004. After a storm on 2 and 3 February 2004, snow depth was 20 cm and remained $\geq$ 15 cm through 15 March 2004 (National Climatic Data Center 2003, 2004, LaBarge, WY weather station).

The early months of the 2004/2005 winter season saw little snow with snow depths not exceeding 5 cm until 4 January 2005. A storm 7-11 January 2005 produced 34 cm of snow, bringing total snow depth to 48 cm. Snow depth remained $\geq$ 25 cm through 6 March 2005 and $\geq$ 15 cm through 12 March 2005 (LaBarge, WY weather station, National Climatic Data Center 2004, 2005).

Winter months of 2005/2006 saw minimal snowfall with snow depth not exceeding 10 cm until 16 February 2006 when snow depth reached 15 cm. From 16 February through 31 March 2006 snow depth was $\leq$ 15 cm. (LaBarge, WY weather station, National Climatic Data Center 2005, 2006).

Average monthly maximum snow depth for the northern portion of this area (HA 85, 86 and northern 87) from October 2003 to March 2004 was 73 cm (range: 43-90), from October 2004 to March 2005 was 47 cm (range: 15-69) and from October 2005 to February 2006 was 36 cm (range: 20-58) (Darwin Ranch weather station, National Climatic Data Center 2003, 2004, 2005). Snow depth in this area prohibits pronghorn use during the winter months.

METHODS

Capture

Adult female pronghorn were captured using helicopter net-gunning techniques. Captured pronghorn were fitted with a very high frequency (VHF) radio collar (Advanced Telemetry Systems, Insanti, MN) and released. Collars were equipped with activity and mortality sensors.

Monitoring

Radio-collared pronghorn were aerially located approximately 4 weeks after capture to identify mortalities. Mortalities detected within 4 weeks post-capture possibly died from capture related injuries or myopathy and thus were not used in survival analyses. After the initial relocation, pronghorn were aerially located approximately once every 8 weeks.

Pronghorn were assumed alive if the collar was transmitting an activity signal, or a normal pulse rate of 60 beats/minute. Mortalities were detected by a rapid pulse (100 beats/minute) keyed by the mortality sensor. Universal Transect Mercator (UTM) coordinates were recorded for all mortalities to facilitate a ground investigation.

Mortalities

All mortalities were investigated on the ground to retrieve collars, confirm mortality, and assign cause of death when possible. Because we located pronghorn at 8-week intervals, it was not possible to assign cause of death except for those that were legally harvested, or otherwise known. If remains of the carcass were found and cause of death was not obvious, the cause of death was classified as unknown.

Analysis

Annual survival estimates were calculated using program MARK (White and Burnham 2004). A re-encounter history was constructed using telemetry data for each 8-week interval. Re-encounter histories included the total number of known live pronghorn and number of mortalities for each interval. Pronghorn that were not located in a particular interval were not included in the re-encounter history for that interval. Once re-encounter histories were constructed, survival estimates were calculated using the "known fate" model. Annual survival estimates were calculated with and without hunting. When constructing re-encounter histories without hunting, harvested animals were removed from the sample at the time of harvest and not counted as mortalities.

RESULTS

Capture

Medicine Bow Herd 2003.**—** Sixty female pronghorn were captured in HA 47 and 48 on 17 April 2003 (Fig. 2). Age structure of captured animals was: yearlings (6), 2-yr olds (2), 3-yr olds (2), and 4+ yr olds (50). On 19 December 2003, 10 adult females were captured and collared to bring the sample size back up to 59 following mortalities from the previous months. Age structure of animals captured in December was: yearlings (0), 2-yr olds (0), 3-yr olds (1), and 4+ yr olds (9). Age structure of all marked animals was: yearlings (6), 2-yr olds (2), 3-yr olds (1), and 4+ yr olds (50).

Medicine Bow Herd 2004.**—** Eleven female pronghorn were captured and collared 21 December 2004 to bring the sample size back to 58. All animals were captured in HA 47 (Fig. 2). All pronghorn captured were 4+ years old. Age structure of all marked animals (including those captured in 2003) was: yearlings (0), 2-yr olds (6), 3-yr olds (1), 4+ yr olds (12), and 5+ yr olds (39).

Medicine Bow Herd 2005.**—** Ten female pronghorn were captured and collared in HA 47 on 11 December 2005 to bring the sample size back to 59 (Fig. 2). Age structure of animals captured was: yearlings (1), 2-yr olds (2), 3-yr olds (0), and 4+ yr olds (11). Age structure of all marked animals was: yearlings (1), 2-yr olds (2), 3-yr olds (6), 4+ yr olds (8), 5+ yr olds (10), 6+ yr olds (32).

Sublette Herd 2003.**—** Twenty female pronghorn were captured in HA 90 and 93 on 14 April 2003 (Fig. 2). Age structure of captured animals was: yearlings (2), 2-yr olds (2), 3-yr olds (1), and 4+ yr olds (15). Thirty-three pronghorn from an ongoing movement study (Sheldon 2005) in this area were also monitored for survival beginning 15 April 2003, bringing the sample of marked animals to 53. Age structure of the 33 animals previously marked was; 3-yr olds (1), 4+yr olds (26) and 5+ yr olds (6). On 16-18 December 2003, 25 pronghorn from the previous study were captured to retrieve global positioning system (GPS) collars. The GPS collars were replaced with VHF collars for this study. An additional 15 pronghorn were captured and collared throughout HA 93 to bring the sample to 60 animals. Age structure of all marked animals was: yearlings (2), 2-yr olds (3), 3-yr olds (2), 4+ yr olds (37), and 5+ yr olds (6).

Sublette Herd 2004.**—** Fourteen female pronghorn were captured and collared 18 December 2004 in HA 93 to bring the sample size back to 56 (Fig. 2). Age structure of animals captured was: yearlings (0), 2-yr olds (3), 3-yr olds (0), and 4+ yr olds (11). Age structure of all marked animals was: yearlings (0), 2-yr olds (4), 3-yr olds (3), 4+ yr olds (13), 5+ yr olds (32), 6+ yr olds (4).

Sublette Herd 2005.— Seventeen female pronghorn were captured and collared 12 December 2005 in HA 93 to bring the sample size back to 56 (Fig. 2). Age structure of animals captured was: yearlings (2), 2-yr olds (6), 3-yr olds (0), and 4+ yr olds (9). Age structure of all marked animals was: yearlings (2), 2-yr olds (6), 3-yr olds (3), 4+ yr olds (11), 5+ yr olds (10), 6+ yr olds (24).

Monitoring and Mortalities

Medicine Bow Herd 2003/2004.— Seven monitoring flights were conducted from 18 April 2003 through 14 May 2004 (Table 1). Twenty mortalities were documented. Six mortalities were possible capture-related as they died within 4 weeks of being captured, 12 died of unknown causes, and 2 were harvested (Table 3).

Medicine Bow Herd 2004/2005.— Six monitoring flights were conducted from 15 May 2004 through 26 May 2005 (Table 1). Four mortalities were documented. One mortality was possible capture-related, 2 died of unknown causes, and 1 was harvested (Table 3).

Medicine Bow Herd 2005/2006.— Six monitoring flights were conducted from 27 May 2005 through 24 May 2006 (Table 1). Sixteen mortalities were documented. One mortality was possible capture-related, 11 died of unknown causes, 3 were harvested and 1 was caught in a fence (Table 3).

Sublette Herd 2003/2004.— Six monitoring flights were conducted from 15 April 2003 through 9 May 2004 (Table 2). Sixteen mortalities were documented. Three mortalities were possible capture-related, 9 died of unknown causes, 2 were harvested, 1 was hit by a vehicle and 1 was found dead with radio-transmitter not working (Table 3).

Sublette Herd 2004/2005.— Six monitoring flights were conducted from 10 May 2004 through 25 May 2005 (Table 2). Fourteen mortalities were documented. One mortality was possible capture-related, 7 died of unknown causes, 1 was hit by a vehicle, 1 was caught in a woven-wire fence, and 4 were harvested (Table 3).

Sublette Herd 2005-2006.— Six monitoring flights were conducted from 26 May 2005 through 25 May 2006 (Table 2). Sixteen mortalities were documented. Four died of unknown causes, 2 were from vehicle collisions, 1 was caught in a fence, 8 were legally harvested, and 1 was illegally harvested (Table 3).

Survival Estimates

Medicine Bow Herd 2003/2004.— Survival estimate including harvested animals for the time period 3 May 2003 through 14 May 2004 was 0.77 (95% CI = 0.64-0.86, SE = 0.054). Survival estimate for the same time period without harvest was 0.80 (95% CI = 0.67-0.88, SE = 0.053) (Table 5).

Medicine Bow Herd 2004/2005.— Survival estimate including harvested animals for the time period 15 May 2004 through 26 May 2005 was 0.94 (95% CI = 0.84-0.98, SE = 0.031). Survival estimate for the same time period without harvest was 0.96 (95% CI = 0.86-0.99, SE = 0.026) (Table 5).

Medicine Bow Herd 2005/2006.— Survival estimate including harvested animals for the time period 27 May 2005 through 24 May 2006 was 0.73 (95% CI = 0.60-0.83, SE = 0.059). Survival estimate for the same time period without harvest was 0.78 (95% CI = 0.65-0.87, SE = 0.057) (Table 5).

Medicine Bow Herd 3-year Mean.— Mean annual survival estimate including harvested animals for the time period 3 May 2003 through 24 May 2006 was 0.81 (95% CI = 0.76-0.87, SE = 0.029). Mean annual survival estimate for the same time period without harvest was 0.85 (95% CI = 0.79-0.90, SE = 0.029) (Table 5).

Sublette Herd 2003/2004.— Survival estimate including harvested animals for the time period 15 April 2003 through 9 May 2004 was 0.79 (95% CI = 0.66-0.87, SE = 0.054). Survival estimate for the same time period without harvest was 0.82 (95% CI = 0.70-0.90, SE = 0.052) (Table 5).

Sublette Herd 2004/2005.— Survival estimate including harvested animals for the time period 10 May 2004 through 25 May 2005 was 0.76 (95% CI = 0.63-0.86, SE = 0.057). Survival estimate for the same time period without harvest was 0.83 (95% CI = 0.70-0.91, SE = 0.052) (Table 5).

Sublette Herd 2005/2006.— Survival estimate including harvested animals for the time period 26 May 2005 through 25 May 2006 was 0.70 (95% CI = 0.56-0.80, SE = 0.063). Survival estimate for the same time period without harvest was 0.85 (95% CI = 0.72-0.93, SE = 0.052) (Table 5).

Sublette Herd 3-year Mean.— Mean annual survival estimate including harvested animals for the time period 15 April 2003 through 25 May 2006 was 0.75 (95% CI = 0.69-0.81, SE = 0.029). Survival estimate for the same time period without harvest was 0.83 (95% CI = 0.78-0.89, SE = 0.029) (Table 5).

DISCUSSION

Annual survival estimates of 77%, 94% and 73% for the hunted population of pronghorn in Medicine Bow Herd Unit in 2003/2004, 2004/2005 and 2005/2006 respectively, are similar to the survival estimates of 84% and 97% found in northwestern Wyoming by Sawyer and Lindzey (2000). The 2003/2004 estimate of 77% is also similar to the 12 year average of 81% recorded by Pyrah (1987) in a hunted population in Montana. The 94% estimate for 2004/2005 is higher than other estimates in the literature of hunted populations (Mitchell 1980, Pyrah 1987, Canon and Bryant 1992), except for the estimate of 97% by Sawyer and Lindzey (2000). The 3-year mean of 81% for the hunted population is also within the range of estimates mentioned above. Annual survival estimates of 80% and 78% without harvest were within the range observed by Bright and Hervert 2005, in a non-hunted population in Texas. The 96% survival rate observed in 2004/2005 was higher than any we found in the literature for either a non-hunted or hunted population for the exception of Sawyer and Lindzey (2000).

The very mild winter conditions and moderate drought observed in 2004/2005 likely contributed to the higher than normal survival rates documented that year. Harvest of marked animals in 2004 was minimal, with only 1 pronghorn harvested while 2 and 3 were harvested in 2003 and 2005 respectively. Also, the number of harvested animals may be underestimated in this study as the Wyoming Game and Fish Department assumes a 10% wound-loss, which was not included in our estimates. Any mortality of marked animals resulting from wound-loss would have been recorded as unknown cause of death.

The wide variation of estimates between years may be difficult to explain, but there were 12 mortalities of unknown cause during 2003/2004, only 2 in 2004/2005 and 11 during 2005/2006 (Table 3). Deep snow during the winter months of the 2003/2004 and 2005/2006 years may have limited forage availability, contributing to higher mortality. Of the 23 unknown-cause mortalities in 2003/2004 and 2005/2006, 52% (n=12) occurred from 1 October to 31 March (Table 4.). Harsh winter conditions, including deep, crusted snow, can be a major cause of pronghorn mortality (Martinka 1967, McKenzie 1970, Mitchell 1980, Barrett 1982,). Extreme drought conditions in these 2 years may have also limited the quality and quantity of forage, leading to poor body condition and greater susceptibility to predation or starvation (Zimmer 2004, Bright and Hervert 2005). Poor body condition due to extreme drought and deep snow may have contributed to the 6 possible capture-related mortalities recorded in 2003.

Despite drought conditions and snow depths observed during the study, the pronghorn population in the Medicine Bow Herd Unit increased from a post-hunt estimate of 56,804 in 2003 to 62,714 in 2005 (Wyoming Game and Fish Department 2004a, 2006a). Harvest levels of females were increased in 2004 and 2005 to attempt to keep the population at or below objective (60,000) and prevent habitat degradation.

Annual survival estimates for the hunted Sublette Herd of 79%, 76%, and 70% for 2003/2004, 2004/2005, and 2005/2006 respectively, appear to be within estimates recorded in the literature (Mitchell 1980, Pyrah 1987, Canon and Bryant 1992, Sawyer and Lindzey 2000). There was variation in estimates between years however; the variation was less than observed in the Medicine Bow herd (Table 5). Survival estimates without harvest of 82%, 83%, and 85% were similar to the 3-year average of 85% for the Medicine Bow Herd.

While the drought conditions improved in the 2004/2005 year, winter snow depths were $\geq$ 25 cm from 11 January to 6 March 2005, and $\geq$ 15 cm until 12 March 2005. Deep snow may have contributed to high winter mortality documented in the 2004/2005 year. Of the 7 unknown caused mortalities, 71% (n=5) occurred from 1 October 2004 to 31 March 2005. However, snow depth is only one of many factors that may have contributed to these mortalities. Even with the high winter mortality, survival estimates were higher (76%) in 2004/2005 than in 2005/2006 (70%).

Hunter harvest in 2005 accounted for 56% (n=8) of all mortalities during 2005/2006 in the Sublette Herd. Although moderate drought conditions returned to this area from July 2005 through the end of the study in May 2006, favorable winter conditions allowed for low mortality from October 2005 to March 2006. The low survival rate in 2005/2006 was in part due to vehicle collisions (n=2) and 1 pronghorn being caught in a fence. It may also be an artifact of losing contact with 8 pronghorn, reducing the sample size from 55 to 47. We were not able to determine why we lost contact with the 8 pronghorn. It may be in part due to battery failure of the transmitters or animals dispersing from the study area. However, several hours were spent aerially searching for these animals, so dispersal is unlikely.

The pronghorn population in the Sublette Herd Unit decreased in size from an estimated 44,200 animals in 2003 to 42,500 in 2004, then increased in 2005 to 47,800, which is very close to the objective of 48,000 (Wyoming Game and Fish Department 2006b). Even though this population seems to be doing well, there are reasons for concern. Fencing of highway right-of-ways, grazing paddocks and other boundaries are major obstacles for pronghorn movement, especially during migration (Sheldon 2005). Two marked pronghorn died from getting entangled in fences and 4 more were killed in vehicle collisions. Fifteen percent of all mortalities in this area were caused by fencing or vehicle collisions. This number is likely to be higher as a portion of the unknown caused mortalities were found close to roads or fences, but cause of death could not be confirmed. New road construction and increased traffic associated with accelerated energy development in the area will likely lead to even higher mortality. The impacts of this level of development are largely unknown but it is anticipated that pronghorn will be displaced and forced to use less quality habitats resulting in increased mortality, particularly during the winter months.

Both the Medicine Bow and Sublette pronghorn herds appear to be able to withstand the level of adult female mortality documented during this study as population trends from 2003-2005 were steady to increasing in both populations. Managers may use this information to more accurately reflect survival of the adult female cohort in Wyoming pronghorn populations.

ACKNOWLEDGMENTS

We thank Wyoming Game and Fish Department as the funding agency. We thank all members of the Wyoming Pronghorn Working Group for their assistance in this project. We thank Wyoming Game and Fish personnel, especially Bill Rudd, Bob Lanka, Tom Ryder, Rich Guenzel, Ron Lockwood, Grant Frost, and Reg Rothwell. We appreciate the services of Gary Lust (Mountain Air Research) and Dwight France (France Flying Service) for the aerial telemetry necessary in making this project a success. We are grateful to Dave Edmunds for manuscript review and assistance in construction of study area maps.

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FIGURE CAPTIONS

Figure 1. Area map of the Medicine Bow and Sublette pronghorn herd units during Wyoming pronghorn survival study 2003-2006.

Figure 2. Capture locations of pronghorns during Wyoming pronghorn survival study 2003-2006.

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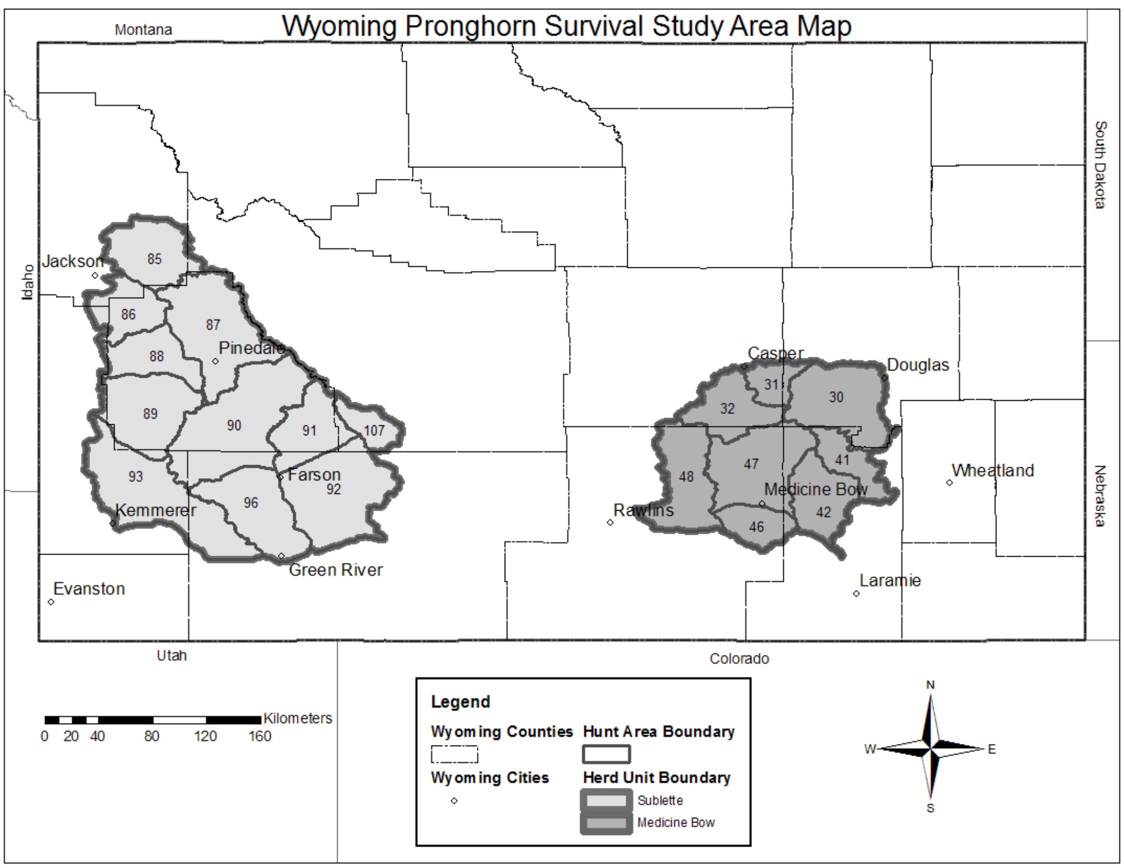

Figure 1. Area map of the Medicine Bow and Sublette pronghorn herd units during Wyoming pronghorn survival study 2003-2006.

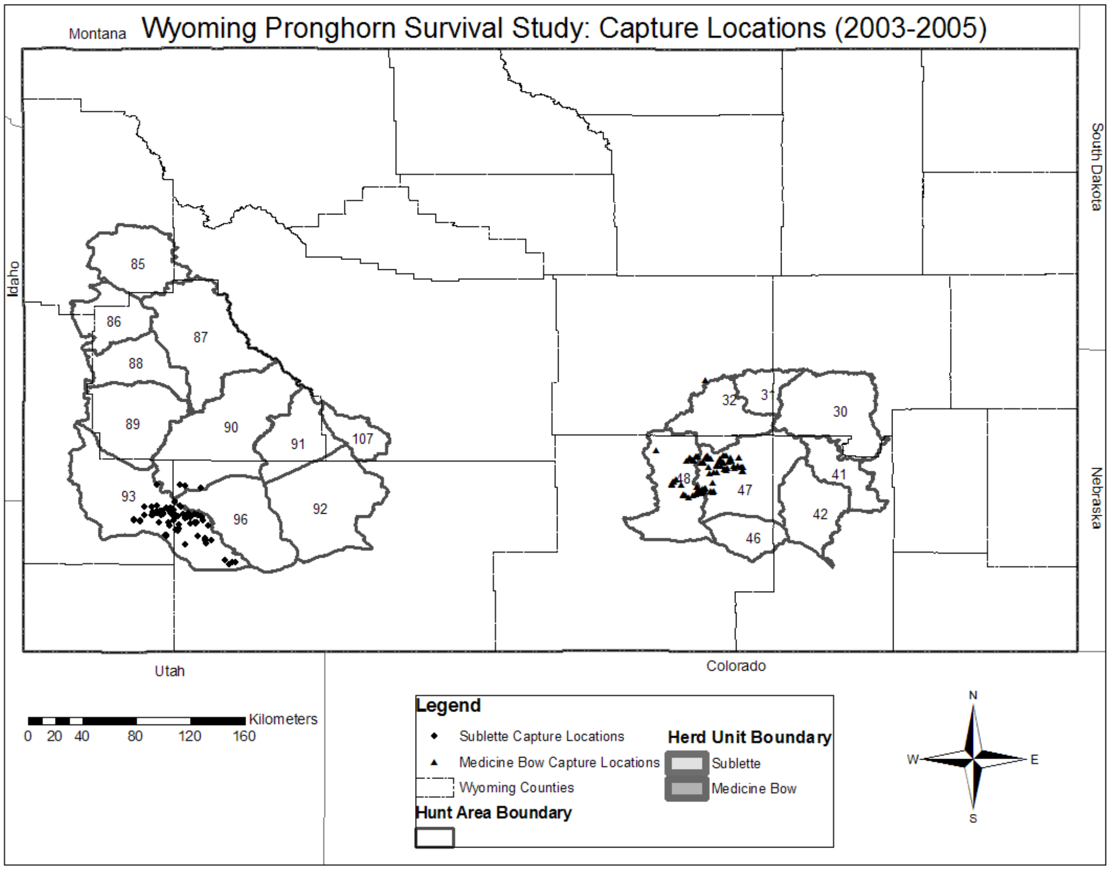

Figure 2. Capture locations of pronghorns during Wyoming pronghorn survival study 2003-2006.

Table 1. Status of pronghorn monitored in the Medicine Bow Herd of southcenteral Wyoming during telemetry flights 18 April 2003 through 24 May 2006

Date Monitored	Known Fate	Not Found	Mortalities
04/18-05/02/2003	57	0	3*
05/03-07/15/2003	57	0	1
07/16-09/18/2003	56	0	5
09/19-11/18/2003	51	0	2
11/19/2003-01/13/2004	56	0	6 (3)*
01/14-03/10/2004	52	1	2
03/11-05/14/2004	51	0	1
05/15-07/13/2004	50	0	0
07/14-09/14/2004	49	1	0
09/15-11/11/2004	49	1	3
11/12/2004-01/18/2005	56	1	1*
01/19-03/29/2005	56	1	0
03/30-05/26/2005	56	1	0
05/27-07/27/2005	55	2	3
07/28-09/27/2005	49	5	1
09/28-11/21/2005	46	7	4
11/22/2005-01/25/2006	51	7	3 (1)*
01/26-03/24/2006	49	7	4
03/25-05/24/2006	45	7	1

* Possible Capture related mortalities

Table 2. Status of pronghorn monitored in the Sublette Herd of southwest Wyoming during telemetry flights 15 April 2003 through 25 May 2006.

Date Monitored	Known Fate	Not Found	Mortalities
04/15-06/26/2003	45	0	1
06/27-09/25/2003	44	0	0
09/26-11/07/2003	44	0	0
11/08/2003-01/17/2004	54	1	5 (3)*
01/18/-03/11/2004	51	2	3
03/12-05/09/2004	49	1	0
05/10-07/12/2004	49	1	1
07/13-09/16/2004	48	1	3
09/17-11/13/2004	45	1	4
11/14/2004-01/25/2005	55	1	2 (1)*
01/26/-03/26/2005	53	2	4
03/27-05/25/2005	47	4	0
05/26-07/23/2005	47	3	2
07/24-09/22/2005	44	4	4
09/23-11/22/2005	40	4	5
11/23/2005-01/25/2006	51	5	2
01/26-03/24/2006	46	8	1
03/25-05/25/2006	45	8	2

* Capture related mortalities

Table 3. Pronghorn mortalities in the Medicine Bow and Sublette Herd Units in Wyoming from April 2003 to May 2006.

Herd Unit	Cause of Death	Estimated Age (years)								Total
		1	2	3	4	4+	5+	6+	7+	
Medicine Bow										
2003/2004	Possible Capture-related	-	-	2	-	4	-	-	-	6
	Unknown	-	1	-	-	11	-	-	-	12
	Harvested	-	-	-	-	2	-	-	-	2
	Vehicle collision	-	-	-	-	-	-	-	-	-
	Fence	-	-	-	-	-	-	-	-	-
	Annual mortalities by age	-	1	2	-	17	-	-	-	20
2004/2005	Possible Capture-related	-	-	-	-	1	-	-	-	1
	Unknown	-	-	-	-	-	2	-	-	2
	Harvested	-	-	-	-	-	1	-	-	1
	Vehicle collision	-	-	-	-	-	-	-	-	-
	Fence	-	-	-	-	-	-	-	-	-
	Annual mortalities by age	-	-	-	-	1	3	-	-	4
2005/2006	Possible Capture-related	-	-	-	-	1	-	-	-	1
	Unknown	-	-	1	-	-	2	8	-	11
	Harvested	-	-	-	-	-	1	2	-	3
	Vehicle collision	-	-	-	-	-	-	-	-	-
	Fence	-	-	-	-	-	-	1	-	1
	Annual mortalities by age	-	-	1	-	1	3	11	-	16
2003-2006	3-year total by age	-	1	3	-	19	6	11	-	40
Sublette										
2003/2004	Possible Capture-related	-	-	-	-	2	1	-	-	3
	Unknown	-	1	-	-	8	1	-	-	10
	Harvested	-	-	-	-	2	-	-	-	2
	Vehicle collision	1	-	-	-	-	-	-	-	1
	Fence	-	-	-	-	-	-	-	-	-
	Annual mortalities by age	1	1	-	-	12	2	-	-	16
2004/2005	Possible Capture-related	-	-	-	-	1	-	-	-	1
	Unknown	-	-	-	-	1	6	-	-	7
	Harvested	-	-	-	-	-	4	-	-	4
	Vehicle collision	-	-	-	-	-	1	-	-	1
	Fence	-	-	-	-	-	1	-	-	1
	Annual mortalities by age	-	-	-	-	2	12	-	-	14
2005/2006	Possible Capture-related	-	-	-	-	-	-	-	-	-
	Unknown	-	-	-	-	-	2	2	1	5
	Harvested	-	-	-	1	-	4	3	1	9
	Vehicle collision	-	-	1	-	-	-	-	-	1
	Fence	-	-	-	-	1	-	-	-	1
	Annual mortalities by age	-	-	1	1	1	6	5	2	16
2003-2006	3-year total by age	1	-	1	1	15	20	5	2	46

Table 4. Pronghorn mortalities by time of year in the Medicine Bow and Sublette Herd Units of Wyoming from April 2003 to May 2006.

Herd Unit	Time of Year			
	Period 1 Mar Apr May	Period 2 Jun Jul Aug	Period 3 Sep Oct Nov	Period 4 Dec Jan Feb
Medicine Bow				
2003/2004	6 (3)*	1	7	6 (3)*
2004/2005	0	0	3	1
2005/2006	5	3	5	3
Sublette				
2003/2004	4	2	3	7 (3)* (1)**
2004/2005	4	1	7	2 (1)*
2005/2006	3	2	9	2

* Possible capture-related mortalities (removed from sample)
** Found dead with radio-transmitter not functioning (removed from sample)

Table 5. Annual pronghorn survival estimates for the Medicine Bow and Sublette Herd Units of Wyoming from April 2003 to May 2006.

Herd Unit	Time Period	Annual Survival Estimate (95% CI)	
		With Harvest	Without Harvest
Medicine Bow			
2003/2004	3 May 2003 - 14 May 2004	0.77 (0.64-0.86)	0.80 (0.67-0.88)
2004/2005	15 May 2004 - 26 May 2005	0.94 (0.84-0.98)	0.96 (0.86-0.99)
2005/2006	27 May 2005 - 24 May 2006	0.73 (0.60-0.83)	0.78 (0.65-0.87)
3-year Mean	3 May 2003 - 24 May 2006	0.81 (0.76-0.87)	0.85 (0.79-0.90)
Sublette			
2003/2004	15 April 2003 - 9 May 2004	0.79 (0.66-0.87)	0.82 (0.70-0.90)
2004/2005	10 May 2004 - 25 May 2005	0.76 (0.63-0.86)	0.83 (0.70-0.91)
2005/2006	26 May 2005 - 25 May 2006	0.70 (0.56-0.80)	0.85 (0.72-0.93)
3-year Mean	15 April 2003 - 25 May 2006	0.75 (0.69-0.81)	0.83 (0.78-0.89)

Appendix A

Example of Annual Survival Estimate using Program MARK with the Known Fate Model {S(.)PIM} for the Medicine Bow Herd with Harvest 5 May 2003 through 14 May 2004.

```
   Program  MARK  - Survival Rate Estimation with Capture-Recapture Data
   Version 4.0(Win32) May 2004          27-Jun-2007 13:38:09    Page  001
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

  INPUT --- proc title Medicine Bow Pronghorn 03-04 with harvest
Model {S(.)PIM};

     Time in seconds for last procedure was 0.00

  INPUT --- proc chmatrix occasions=6 groups=1 etype=Known mixtures=2
  INPUT --- NoHist hist=300;

  INPUT ---    glabel(1)=Group 1;

  INPUT ---    time interval  1 1 1 1 1 1;

  INPUT ---     Known fate group=1; (Encounter histories for
pronghorn w/known fate and number of mortaliities for each monitoring period from 3 May
2003 through 14 May 2004).
  INPUT ---       57 1;
  INPUT ---       56 5;
  INPUT ---       51 2;
  INPUT ---       56 3;
  INPUT ---       52 2;
  INPUT ---       51 1;

      Number of unique encounter histories read was 12.

      Number of individual covariates read was 0.
      Time interval lengths are all equal to 1.

      Data type is known fates.

     Time in seconds for last procedure was 0.00


  Program  MARK  - Survival Rate Estimation with Capture-Recapture Data
   Version 4.0(Win32) May 2004          27-Jun-2007 13:38:09    Page  002
   SB Pronghorn 03-04 with harvest Model {S(.)PIM}
```

- -

```
 INPUT --- proc estimate link=Sin varest=2ndPart ;

 INPUT --- model={S(.) PIM};

 INPUT ---    group=1 S rows=1 cols=6 Square;
 INPUT ---              1   1   1   1   1   1;

 INPUT ---    design matrix constraints=1 covariates=1 identity;

 INPUT ---    blabel(1)=S;

 INPUT ---    rlabel(1)=S;

Link Function Used is SIN

Variance Estimation Procedure Used is 2ndPart
-2logL(saturated) = 110.83763
Effective Sample Size = 323

Number of function evaluations was 8 for 1 parameters.
Time for numerical optimization was 0.01 seconds.
-2logL {S(.) PIM} = 115.26489
Penalty {S(.) PIM} = 0.0000000
Gradient {S(.) PIM}:
 0.1651392E-04
S Vector {S(.) PIM}:
  323.0000
Time to compute number of parameters was 0.01 seconds.
  Threshold =  0.4000000E-07     Condition index =   1.000000
Conditioned S Vector {S(.) PIM}:
  1.000000
Number of Estimated Parameters {S(.) PIM} = 1
DEVIANCE {S(.) PIM} = 4.4272547
DEVIANCE Degrees of Freedom {S(.) PIM} = 5
c-hat {S(.) PIM} = 0.8854509
AIC {S(.) PIM} = 117.26489
AICc {S(.) PIM} = 117.27735
Pearson Chisquare {S(.) PIM} = 4.6506201

                    SIN Link Function Parameters of {S(.) PIM}
                                                   95% Confidence Interval
Parameter                    Beta        Standard Error      Lower          Upper
-------------------------  --------------  --------------  --------------  --------------
   1:S                    1.1513454       0.0556415       1.0422881       1.2604027
```

Real Function Parameters of {S(.) PIM}

Parameter	Estimate	Standard Error	95% Confidence Interval Lower	Upper

Program MARK - Survival Rate Estimation with Capture-Recapture Data
Version 4.0(Win32) May 2004 27-Jun-2007 13:38:09 Page 003
SB Pronghorn 03-04 with harvest Model {S(.)PIM}

- -

Parameter	Estimate	Standard Error	Lower	Upper
1:S	0.9566563	0.0113302	0.9281569	0.9741650

Estimates of Derived Parameters

Survival Estimates of {S(.) PIM}

Group	Cohort	Pr. Surviving Duration of Study	Standard Error	95% Confidence Interval Lower	Upper
1	1	0.7665416	0.0544716	0.6438899	0.8563726

Time in seconds for last procedure was 0.02

INPUT --- proc stop;

Time in minutes for this job was 0.00

E X E C U T I O N S U C C E S S F U L

Where Are All The Pronghorn Fawns: Is Low Fawn Recruitment An Issue Revisited?

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ABSTRACT Pronghorn fawn recruitment rates were previously summarized from various management agencies in Canada and the United States, with lows ranging from 43 (fawns per 100 does) in Texas to highs of 105 in South Dakota. It has been postulated that fawn recruitment may differ among major vegetative communities. We build upon these assessments by comparing fawn recruitment rates reported from 1953 to 1977 with our findings for 1978 to 2008 and by examining fawn recruitment rates for 4 major vegetative communities occupied by pronghorn. Pooled data of mean fawn recruitment rates from 1953-1977 differed from comparable data from 1978-2008. Our results show that recruitment rates differed among the 10 jurisdictions, with the 10 jurisdictions being placed into 6 groups with similar means. Nine of 10 jurisdictions had higher fawn recruitment rates from 1953-1977 as compared to 1978-2008. There were major differences in mean fawn recruitment rates among each of the 4 vegetation communities. We discuss reasons why differences may be occurring and discuss management implications. We consider our results preliminary and recommend continued effort to document fawn recruitment rates in all jurisdictions and further effort to characterize the composition of major vegetative communities.

KEY WORDS *Antilocapra americana*, Canada, Fawn Recruitment, Mortality Factors, Pronghorn, Major Vegetation Community, United States

INTRODUCTION

Demographic rates form the foundation of wildlife management and in particular ungulate management in North America. Surveys are completed to assess production, recruitment and sex ratios for ungulate species to assess population status and facilitate harvest rates that achieve management goals. These survey results allow managers to balance the need between recreational opportunities and landowner tolerances within a multi-use society (Jacques 2006). Production is an estimate of reproduction. Pronghorn (*Antilocapra americana*) have a high rate of production with fetal rates per adult female range from 1.83 in Alberta to 1.97 in Yellowstone National Park (Mitchell 1980, O'Gara 2004*a*, Zimmer 2004). More recently Zimmer (2004) found fetal rates of 1.91 per adult doe in Wyoming between 2000 and 2002. Wildlife managers for pronghorn use "fawn recruitment rate" as an index for herd reproduction and survival of fawns to 4 months of age (Autenrieth et al. 2006). The rate is based on an estimated number of does and fawns during July or August, typically by aerial surveys (Pojar 2004, Jacques 2006). Its major value to managers is that it gives an annual number of fawns surviving for a given site and time. When tabulated over a period of years, the rate indicates the trend in fawn numbers entering the herd breeding population. For example, for a summer estimate of 50 fawns and 100 does, the fawn recruitment ratio is expressed as 50FF:100DD. Recruitment rates are influenced by susceptibility of pronghorn neonates to mortality during the first 1-3 months. Factors influencing neonate mortality include parturition date (Fairbanks 1993, Gregg et al. 2001), habitat quality (Ellis 1970, Autenrieth 1984. Ockenfels et al. 1992), adverse weather (Jacques 2006), disease and parasites (Lee et al. 1998, O'Gara 2004*b*), and predation (Beale and Smith 1973, Barrett 1982, Jacques 2006). Predation, specifically by coyotes (*Canis latrans*), has been attributed as a major cause of mortality of pronghorn neonates (Barrett 1982, Byers 1997, O'Gara and Shaw 2004, Yoakum and O'Gara 2000, Jacques 2006). These factors affecting fawn recruitment rates have been determined predominately by short term (1-2 years) studies of local populations (fine scale).

Vriend and Barrett (1978) were the first to review and examine fawn recruitment dynamics across a broad geographical area. Fawn recruitment rates from 1948 to 1977 were summarized from various management agencies (hereafter referred to as jurisdictions) in Canada and the United States (hereafter identified as US), with lows ranging from 43 (fawns per 100 does) in Texas to highs of 105 in South Dakota (Vriend and Barrett 1978). They concluded that the geographic area comprising southeastern Montana, southwestern North Dakota, western South Dakota, and Wyoming had the highest fawn recruitment rates, but did not test this statistically (Vriend and Barrett 1978). This geographic area is also the core range with the highest pronghorn densities in North America. Vriend and Barrett (1978) concluded that fawn mortality rates during the first 3 months of life are high, with predominant causes being weather factors, forage/nutrition and predation, though not necessarily in that order. It was also suggested that their analysis could be taken a step further and that in the future fawn recruitment rates should be examined for different major vegetative communities (Vriend and Barrett 1978:377). Since their work, most studies on fawn recruitment continue to focus on local populations within a Province or State (Yoakum et al. 2004).

Using data provided from jurisdictions we compared fawn recruitment rates in Canada and the US from 1978 to 2008 to that for the period 1953 to 1977. Specifically we assessed 3 questions related to fawn recruitment; first was whether there were differences in recruitment rates between individual jurisdictions. Secondly, whether fawn recruitment rates have changed since 1953-1977? For this question we examined the data at 2 scales; across Canada and the US collectively and within each jurisdiction separately. Thirdly, we examined fawn recruitment rates for major vegetative communities occupied by pronghorn. Our analysis focused on the subspecies *A. a. americana*. Data from 1953 to 2008 were obtained from 2 sources; values reported in Table 1 found in Vriend and Barrett (1978) and more recently through a request to each jurisdiction. We acknowledge that survey results are dependent upon a number of factors (e.g. survey method, timing, sightability, etc) and may be reflected in the data presented.

METHODS

Fawn Recruitment Rates

A request for data was sent in March 2009 to each jurisdiction containing pronghorn in Canada and the US. We requested pronghorn fawn recruitment estimates for each major vegetation communities within the jurisdiction for the time period 1978 to 2008. The major vegetation community classification requested followed that of Yoakum (2004a:412). Data provided by jurisdictions reflected many different formats ranging from completing the table sent with the request, to providing raw data for individual pronghorn survey/management units. Some jurisdictions provided data for the time period requested (1978-2008) while others provided all data they had, including data for the same time period that appeared in the Vriend and Barrett

(1978) paper. Some jurisdictions just provided data on fawn recruitment rates and did not differentiate between vegetation communities within their jurisdiction. California provided a graph of their fawn recruitment rates which was interpreted to determine the data for the database. From all responses, we developed 2 databases to facilitate the analysis. The first consisted of a single fawn recruitment rate for each year (1953-2008 were available) for each jurisdiction, except for Texas where there are 2 estimates per year, 1 for the short grass major vegetation community and 1 for the mesquite/grama major vegetation community. We allowed 2 estimates for Texas to ensure we were not testing a mean of a mean as we did not have raw data from the jurisdiction to allow us to calculate a singe fawn recruitment rate irrespective of major vegetation type. For the time period 1953 to 1978 we used 1 of 2 sources depending on which provided the greater number of years; the data provided in Table 1 in Vriend and Barrett (1978) or that provided by the jurisdiction. The second database consisted of a single fawn recruitment rate for each jurisdiction for each year (1978-2008) for each major vegetation community as identified by the jurisdiction.

Statistical Analysis

We assessed whether there was differences in fawn recruitment rates (1953-2008) between the jurisdictions and whether there were differences in mean fawn recruitment rates between 1953-1977 and 1978-2008 across Canada and the US using a Two-way ANOVA (Fowler et al. 1998). If a significant result was detected we used Games-Howell test, which accounts for unequal sample size and unequal variances (Day and Quinn 1989), to determine which jurisdictions were different from each other. For each jurisdiction, we assessed whether there was a difference in mean fawn recruitment rates between the 2 time periods (1953-1977 and 1978-2008) using a One-way ANOVA (Fowler et al. 1998). We used a One-way ANOVA to determine if there were differences in mean fawn recruitment rates for the different major vegetation communities for data from 1978-2008 (Fowler et al. 1998). If a significant difference was detected we used the Games-Howell test to determine which were different from each other (Day and Quinn 1989). All tests were completed in SPSS© Version 11 (SPSS, Chicago, IL) and a significance level of alpha=0.05.

RESULTS

Eleven jurisdictions provided data to facilitate the analysis of fawn recruitment. Oklahoma and Idaho indicated that they do not regularly perform surveys for pronghorn and do not have the data requested. Colorado provided survey results for 5 years and thus was dropped from the analysis due to insufficient data. Appendix A contains a list of data sources for each period (1953-1977 and 1978-2008) by jurisdiction used to complete the analysis.

From 1953 to 2008 there was a significant difference in fawn recruitment rates between the jurisdictions ($F=61.06$, $p<0.001$) (Figure 1). Based on the post hoc test the individual jurisdictions could be placed into 6 groups, with each group not having a significant difference in mean recruitment rate (Figure 1). There was a significant difference in the mean recruitment rates across Canada and the US from 1953-1977 ($\bar{x} = 65.36 \pm 1.88$SE, n=143) and 1978-2008 ($\bar{x} = 52.06 \pm 1.24$SE, n=334) ($F=65.98$, $p<0.001$). There was also a significant interaction between jurisdiction and period ($F=3.09$, $p=0.001$).

Out of the 10 jurisdictions for which we have data, 9 had lower mean fawn recruitment rates from 1978-2008 compared to 1953-1977 (Figure 2). When assessing whether these differences were significant, we excluded South Dakota and Utah because of small sample sizes for 1953-1977. Seven of the 8 jurisdictions had significant differences in fawn recruitment rates between 1953-1977 and 1978-2008: Alberta ($F=24.30$, $p<0.001$), Arizona ($F=29.73$, $p<0.001$), California ($F=28.30$, $p<0.001$), North Dakota ($F=10.95$, $p=0.002$), Saskatchewan ($F=14.28$, $p<0.001$), Texas ($F=4.95$, $p=0.029$), and Wyoming ($F=40.98$, $p<0.001$). However Kansas' fawn recruitment rates ($F=1.29$, $p=0.263$) did not differ between the 2 periods. The greatest differences in mean recruitment rates occurred in Alberta, Saskatchewan and Wyoming while the least differences occurred in Kansas and Texas.

Eight jurisdictions provided fawn recruitment rates for 4 different major vegetation communities (Appendix B). Utah classified their vegetation as sagebrush and not cold desert as depicted by Yoakum (2004*a*). The most represented major vegetation community was short grass prairie followed by tall grass, sagebrush/bunchgrass and mesquite/gamma was the least. We did not receive any data for the hot desert or woodland/galleta communities. There was a significant difference in mean fawn recruitment rates between the 4 major vegetation communities ($F=54.64$, $p<0.001$) (Figure 3). Based on post hoc comparisons, each major vegetation community had significantly different mean fawn recruitment rates..

DISCUSSION

We examined fawn recruitment rates at 2 levels; across jurisdictions collectively and by major vegetative communities. Our results confirmed Vriend and Barrett's (1978) conclusion that the core area with consistently high fawn recruitment rates is North Dakota, South Dakota, and Wyoming (and likely eastern Montana but we did not have data). Of note was that recruitment rates for South Dakota were different than those of North Dakota and Wyoming. Recruitment rates gradually decreased with distance from the core area with the lowest rates reported for Arizona and Texas.

It is well documented that fawn recruitment rates vary from year to year and between populations (Ellis 1970, Mitchell 1980, Autenrieth 1982, Zimmer 2004, Smyser et al. 2006, McKinney et al. 2008). For the jurisdictions providing adequate data to allow analysis, all except Kansas, indicated differences in fawn recruitment between 1953-1977 and 1978-2008. For certain local populations (e.g. Yellowstone – Boccadori 2002, Boccadori et al. 2008; Wind Cave National Park - Sievers 2004) current declines in fawn recruitment are a major concern. But across Canada and the US we believe the lower fawn recruitment rates can be attributed to forage condition. Forage condition, both quantity and quality is related to population density and climatic conditions (i.e. precipitation). We believe these 2 factors explain the differences in pronghorn fawn recruitment for differing ecological areas.

Since the decline in the estimated North American population of pronghorn during the 1880's as a result of European settlement (Yoakum 1968), the range wide population estimate for North America has slowly increased through the 1900's. Yoakum (1968) reported the North American population in 1924 to be around 30,320 animals, increasing over 1,000% to 386,620 by 1968. Sunderstrom et al. (1973) reported the pronghorn population in 1970 at 433,000 (including animals in Hawaii and Washington). By 1984 the population had peeked at more than 1 million and remained at this plateau until 1995, after which it declined by a third by 1997 (Yoakum 2004b). The population has increased since this decline with an estimated population of 1.1 million in 2006-2007 (Morton et al. 2008). The continued population increase has been aided by the relatively mild winters over the last 10-15 years resulting in limited numbers and severity of winter die-offs, a factor that can limit pronghorn populations at their northern limit (Barrett 1982). With the increase in population we would expect fawn recruitment rates to decrease as a result of density-dependent factors. The hypothesis of density-dependence limiting forage and fawn recruitment has been identified (Aoude and Danvir 2002, Kohlmann 2004, O'Gara and Shaw 2004). Density-dependence has been previously reported as one of the factors controlling pronghorn population growth and recruitment in Alberta (Sheriff 2006), Montana (Pyrah 1976), Oregon (Kohlmann 2004), Utah (Danvir 2000), Wyoming (Smyser et al. 2006), and the Great Basin Desert of California, Nevada, and Oregon (Hess 1986, 1999). Smyser et al. (2006) concluded that forage conditions prior to conception and throughout gestation had a stronger influence on fawn survival in Wyoming than the number of fawns born each spring and that the conditions were affected by the previous year's population level. The negative relationship between fawn recruitment rates and population levels is due to limited resources per doe, as density increases, which results in poorer fawn condition, lower neonate survival, and translates into lower fawn recruitment rates (Fairbanks 1993, Sheriff 2006). One might expect this density dependent relationship between population level and recruitment rate to diminish outside the pronghorn core areas of the continent as other factors like weather, habitat quality, continuity of habitat and land use competition become more influential.

Precipitation is the other driving factor for determining the quality and quantity of forage conditions for pronghorn and has been previously documented as a density-independent factor influencing fawn recruitment. In the northern part of the range for pronghorn, precipitation levels have been positively (summer / fall) and negatively (winter) correlated with fawn recruitment (Beale and Smith 1970, Danvir 2000, Sheriff 2006, Smyser et al. 2006, Smyser et al. 2008). In the more arid environments in the south (i.e. Arizona and Texas) it was winter precipitation that has been correlated with fawn recruitment rates (Brown et al. 2002, McKinney et al. 2008). Beale and Smith (1970) noted for arid rangelands in Utah, a relationship between fawn recruitment and prior year precipitation and concluded that the prior year's precipitation influenced forage quantity and quality, which in turn influenced doe condition and subsequent fawn survival. Byers (2003) found fawns on the National Bison Range in Montana conceived in a dry summer took 5 full days of gestation longer to reach the same weight as fawns conceived during a wet summer. Smyser et al. (2006) using data from Wyoming (1979-2003) concluded that fall precipitation and time lagged growing season precipitation highlighted the importance of pre-winter condition of does and its effect on subsequent fawn recruitment rates. For arid and semi-arid habitats in Arizona, McKinney et al. (2008) reported that inadequate October to April precipitation was the limiting factor driving fawn recruitment, while Simpson et al. (2007) for Texas found a relationship with yearly precipitation and that fawn recruitment is closely tied to immediate moisture conditions. Jacques (2006) speculated that drought conditions in Fall River County, South Dakota, compounded by intensive livestock grazing, may have reduced high quality forage required by females during parturition and fawn rearing which may have resulted in larger summer ranges than those of females in Harding County, South Dakota, as females tried to meet increased energetic costs. Precipitation has been correlated with forb production (Yoakum 2004a, Sheriff 2006) which is a driving factor in the diet consumption of pronghorn during spring and summer. We believe that more nutritional forage, as influenced by precipitation levels, results in better physical condition of does, which in turn results in stronger fawns, higher recruitment rates and lower mortality rates (Ellis 1970, O'Gara and Yoakum 2004).

Predation, particularly by coyotes, has been previously reported as a primary factor affecting fawn recruitment (Barrett 1982, Byers 1997, Yoakum and O'Gara 2000, O'Gara and Shaw 2004, Jacques 2006). O'Gara and Shaw (2004) reviewed the causes of mortality for 995 radio-collared neonates from 18 different studies and showed that $\geq$ 54% of known fawn mortalities were attributed to predation. The belief that fawn recruitment in pronghorn was controlled by coyotes is attributed to publications reporting increased fawn survival rates following predator control. Following predator control, fawn recruitment rates have increased between 59% and 349% (Smith et al. 1986, Willis 1988, Menzel 1992, O'Gara and Shaw 2004). The duration of these studies were short and only provided a snap shot into the relationship between predation and fawn recruitment. The benefits of controlling coyote populations may be short lived as seen in Nebraska where there was no difference in fawn recruitment rates the year following the removal of coyotes in 1990 and 1991 (Menzel 1994). Yoakum et al. (2004) reported on a study of predation in Oregon for 10 years and concluded there was an average fawn loss due to predation of 49% (range 20 to 90%), yet the pronghorn population continued to increase. The increases in population were a result of changing low quality and quantity forage to high favorable forage conditions with the removal of domestic and feral livestock and the changing of dominate late seral stage vegetation to early seral communities through prescribed and wild burns. Predation was a common factor influencing pronghorn neonate survival but rarely was it the limiting factor for population growth (Yoakum et al. 2004). Coyotes have been, are, and will remain a natural predator of pronghorn fawns, but as long as forage conditions (quality and quantity) are adequate, neonates will develop and grow quickly and fawn recruitment rates will be generally sufficient to maintain or increase populations (O'Gara and Shaw 2004, Smyser et al. 2008).

Vegetation strongly influences the distribution and density of pronghorn across their rangelands because it provides forage, water and cover (Yoakum 2004a). We showed that fawn recruitment rates differ between the 4 major vegetation communities for which we received adequate data. These significant differences in recruitment rates were attributed to differences in climatic conditions and plant conditions (i.e. forb abundance and variety) within vegetation communities (Ellis 1970). The grassland communities of North and South Dakota had the highest fawn recruitment rates and typically have high spring precipitation levels and an abundance of preferred herbaceous forage. By comparison, the mesquite/grama communities in Texas are more arid and contain higher densities of shrub cover and had low fawn recruitment. Our results should be considered preliminary as we had data for only 4 of the 7 major vegetation communities depicted by Yoakum (2004a). Furthermore, for those 4 communities, we are missing data for jurisdictions that could alter the reported relationship between recruitment rates and major vegetative communities. Additional work is required on the composition of the major vegetative communities with particular emphasis on the forb component and the response of pronghorn to them.

MANAGEMENT IMPLICATIONS

Differences in fawn recruitment rates between jurisdictions and periods appear related to forage conditions (Ellis 1970, O'Gara and Yoakum 2004) that are the results of density-dependent (population size) and density-independent (precipitation) factors. Wildlife managers need to be aware of 2 major current factors that may be reflected in fawn recruitment rates. These factors are changes in land use (energy development and associated increase in human activity) and climate change. Recent research on pronghorn has focused on the effects that current land use or energy development may have on pronghorn habitat use and movement (Beckmann et al. 2006, Berger et al. 2006, Beckmann et al. 2008). Based on preliminary results, Berger et al. (2006) found pronghorn in Wyoming avoided concentrated gas fields once a threshold of wells and infrastructure occurred. For mule deer (*Odocoileus hemionus*) in Wyoming Sawyer et al. (2006) documented changes in habitat selection in the first year of energy development with no evidence of acclimation over time. They determined that the relationship was non-linear and believe mule deer were able to avoid localized disturbance without having to abandon home ranges completely (Sawyer et al. 2006). If a similar direct and indirect loss of habitat by mule deer as a result of energy activities impacts pronghorn, fawn recruitment rates may begin to decline as a result of density-dependence with animals forced to use smaller areas and thus becoming more concentrated. Should increased traffic volumes, often associated with energy development, be perceived as a potential predator risk, changes in grouping patterns, habitat selection, vigilance, foraging, diet, nutrition, reproductive physiology and demography may result. These changes have been demonstrated for elk in the Yellowstone Greater Ecosystem in response to perceived predation risk by wolves (Creel et al. 2009). Gavin and Komers (2006) provide evidence that pronghorn in Alberta exhibit higher risk-avoidance behavior (more vigilant and reduced foraging rates) near roads regardless of traffic volume. Further research is needed to assess how pronghorn react to energy development not only from a habitat perspective but also from population dynamic and physiological perspectives.

Climate change has the potential to alter the distribution of species by changing current vegetation conditions through shifts in temperature and precipitation (Bradley 2009). There is much debate on exactly what is likely to occur with climate change because of the variability in results based on different predicted future climate conditions (A. M. Schrag, World Wildlife Fund, unpublished data). There is strong evidence that the core and surrounding areas for pronghorn are going to be warmer with more precipitation, though the increase in precipitation will not have a positive influence on soil moisture due to increases in evaporation rates (Bradley 2009, Motha and Baier 2005, A. M. Schrag, unpublished data). Specifically the area of Montana, Wyoming and the boarder area of Alberta and Saskatchewan will become warmer and drier, compared to the area of North and South Dakota which will become warm and wetter with increased precipitation. With these changing climatic conditions there is the potential for: 1) decreasing optimal climatic conditions for sagebrush (silver sage (*Artemisia cana)* and Wyoming big sagebrush (*A.* tridentate)) (A. M. Schrag, unpublished data), 2) expansion of cheatgrass (*Bromus tectorum*) into parts of Colorado, Montana, Utah and Wyoming (Bradley 2009) and 3) an increased risk of tillage of native prairie as the agricultural community takes advantage of increasing temperatures and extended growing seasons (Motha and Baier 2005). With increasing knowledge related to changing weather patterns associated with climate change, future fawn recruitment rates will need to be assessed.

Vriend and Barrett (1978) recognized early on that pronghorn throughout most of their habitat were (a) high producers of fawns, and (b) fawn recruitment rates were low due to losses triggered by weather, forage, and predation that varied with ecosystems. They estimated post parturition mortality rates of fawns to be between 25 and 65 percent which results in recruitment rates between 50-100 fawns per 100 does (Vriend and Barrett 1978). Even with high mortality resulting in recruitment rates of 50 fawns per 100 does, pronghorn populations are able to grow (Ellis 1972, Pyrah 1976, Vriend and Barrett 1978, O'Gara and Malcolm 1986). Wildlife managers need to be aware that pronghorn exhibit naturally high levels of fawn mortality and need to be cognizant of density-dependent (population size) and density-independent (precipitation) factors when assessing recruitment rates before declaring that high fawn mortality is an issue.

Our study demonstrated that there are differences in fawn recruitment rates between jurisdictions, that there has been a decline in recruitment rates, and lastly there are differences in recruitment rates for 4 of the 7 major vegetative communities that pronghorn inhabit in Canada and the US. Our results can not be considered complete as we were missing data from other jurisdictions, including Montana and New Mexico that are key areas with high pronghorn densities. Continued effort is encouraged to fill data gaps, both jurisdictionally and by major vegetation community for Canada, Mexico and the US, that would improve knowledge of fawn recruitment rates. A multivariate approach examining fawn recruitment rates, year, population size, precipitation (e.g. Palmer drought indices) and vegetation community is recommended.

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Appendix A Source of pronghorn fawn recruitment data for each jurisdiction for the 2 time periods (1953-1977 and 1978-2008).

Jurisdiction	Period 1953-1977	1978-2008
Alberta	Vriend and Barrett (1978)	Alberta Fish and Wildlife Sheriff (2006)
Arizona	Arizona Game & Fish Department	Arizona Game & Fish Department
California	Vriend and Barrett (1978)	California Department of Fish and Game
Colorado*	Colorado Division of Wildlife	Colorado Division of Wildlife
Kansas	Kansas Department of Wildlife and Parks	Kansas Department of Wildlife and Parks
North Dakota	North Dakota Game and Fish Department	North Dakota Game and Fish Department
Saskatchewan	Saskatchewan Environment	Saskatchewan Environment
South Dakota	South Dakota Game, Fish & Parks	South Dakota Game, Fish & Parks
Texas	Vriend and Barrett (1978)	Texas Parks and Wildlife Department
Utah	Utah Division of Wildlife Resources	Utah Division of Wildlife Resources
Wyoming	Vriend and Barrett (1978)	Wyoming Game & Fish Department

* due to limited sample size, data from Colorado was not used in any analysis.

Appendix B Jurisdiction and number of years of pronghorn fawn recruitment data for each major vegetation community (1978-2008).

Jurisdiction	Vegetation Community Short Grass	Tall Grass	Sagebrush	Mesquite/Grama
Alberta	28	0	0	0
Kansas	31	0	0	0
North Dakota	0	31	0	0
Saskatchewan	30	0	0	0
South Dakota	0	31	0	0
Texas	31	0	0	31
Utah*	0	0	31	0
Wyoming	30	0	31	0
Total:	150	62	62	31

* Utah classed their vegetation as sagebrush and not cold desert as depicted in Yoakum (2004*a*).

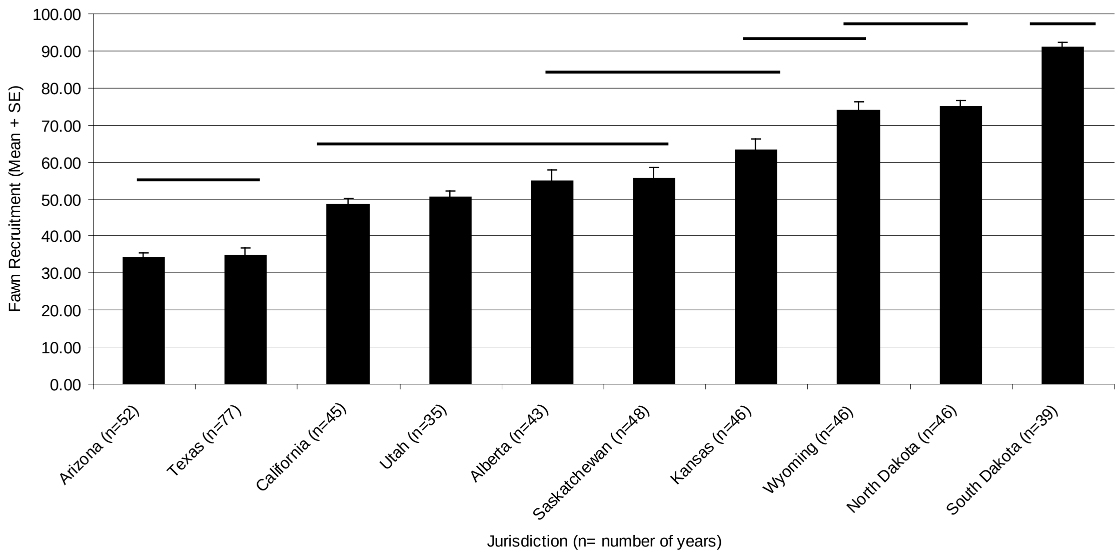

Figure 1: Pronghorn fawn recruitment rates (per 100 does) for 10 jurisdictions in Canada and the United States, 1953-2008 (lines above jurisdictions indicate not significantly different from the other jurisdiction(s)).

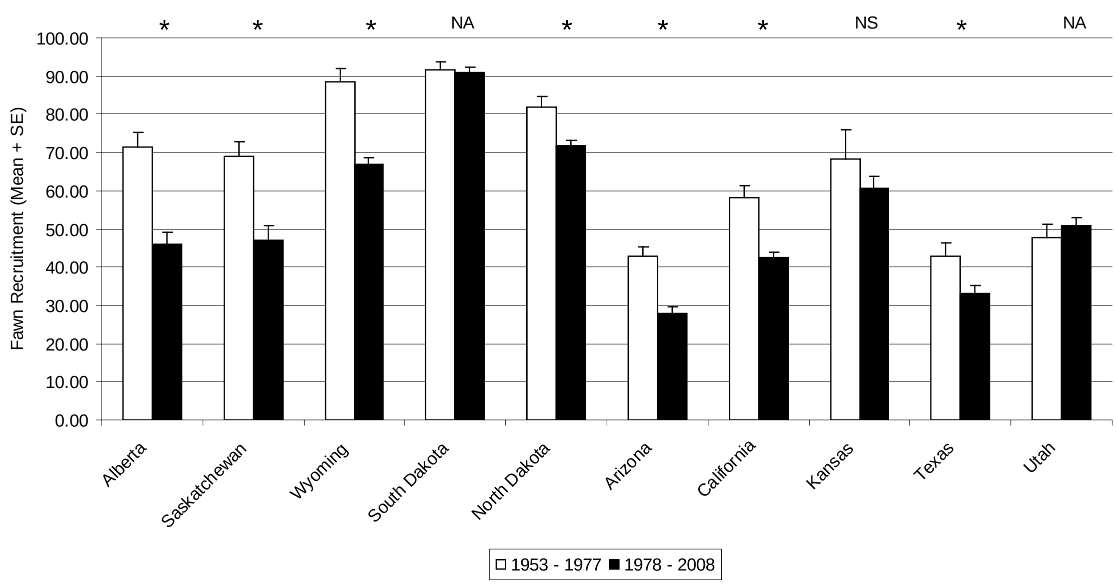

Figure 2: Pronghorn fawn recruitment (per 100 does) for 2 time periods across 10 jurisdictions in Canada and the United States (* is significantly different, NS is not significantly different and NA in not enough data to complete analysis).

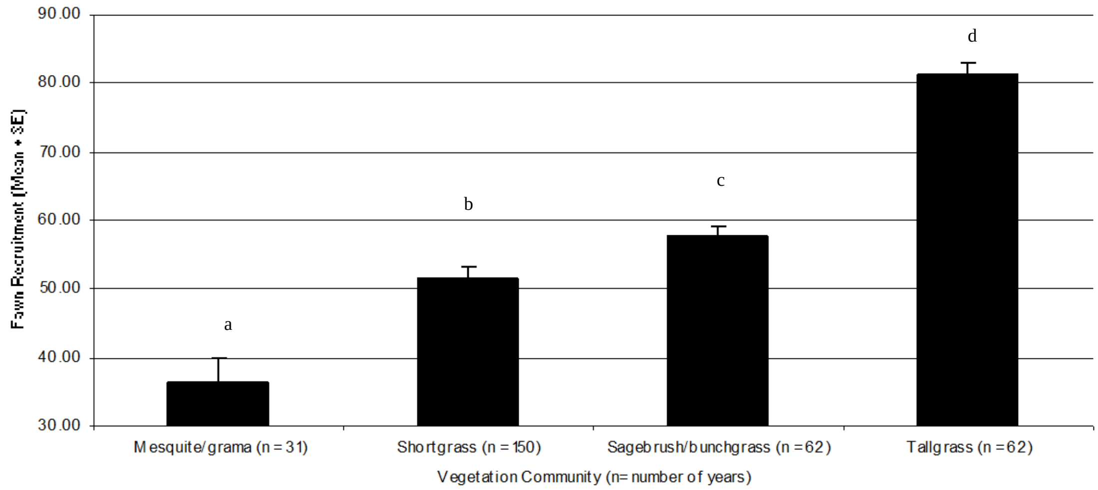

Figure 3: Pronghorn fawn recruitment rates (per 100 does) for 4 of the major vegetation communities found across the pronghorn range in Canada and the United States, 1978-2008 (different letter indicates significant difference).

Seasonal Forage Use and Availability by Pronghorn Antelope in North-central Arizona

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ABSTRACT An understanding of forage characteristics is a key consideration when managing wildlife populations. We studied forage production, food habits, and fecal indices of pronghorn (*Antilocapra americana*) condition and recruitment during 2003 and 2004 on 2 study sites in central Arizona. We investigated diet composition through microhistological analysis of fecal samples and forage selection relative to availability during gestation and lactation seasons. Forage production ranged from 69-304 kg/ha. Forbs made up the majority (47 %) of the biomass in 2003, whereas grasses made up the majority (51 %) in 2004. Pronghorn showed preference for forbs and avoided grasses on both study sites. We also determined baseline profiles of fecal nitrogen (FN) and 2,6 diaminopimelic acid (DAPA) during critical periods for females during 2003 and 2004. Fecal DAPA ranged from 0.741 to 1.802 mg/g and FN ranged from 1.009 to 1.603 %. Fecal DAPA showed a year effect (P = 0.001) but no site effect (P = 0.56). Fecal nitrogen showed a site effect (P = 0.002) but no year effect (P = 0.11). Fecal DAPA during our study reached higher levels than those of other healthy ungulate species, while FN did not reach as high a level. We found a positive correlation between FN and DAPA (P = 0.02), while neither index were correlated to precipitation. Fawn recruitment increased from 28 fawns/100 does during year 1 to 51 fawns/100 does during year 2. Forage conditions appeared optimal for fawn recruitment. Our findings suggest that a diversity of plant species provides optimal pronghorn habitat and maintenance of habitat diversity is important.

KEY WORDS *Antilocapra americana*, antelope, Arizona, availability, DAPA, diet, forage, FN, microhistological analyses

Management of ungulate habitat is based on 2 major assumptions: if adequate cover, water, and space is provided, 1) the physical well-being of the herd is directly related to the quality and quantity of its diet and 2) a herd maintained on a high nutritional plane is more productive and less influenced by predation, starvation, diseases, and parasites than a herd on a low nutritional plane (Nelson and Leege 1982). However, little is known about the nutritional qualities of forage used by pronghorn (Smith and Malechek 1974, Yoakum 2004*a*). Furthermore, their nutritional requirements vary seasonally and the availability and nutritive value of forage species vary by season and location (Nelson and Leege 1982).

Diet quality can have significant impacts on the reproductive functions of wild ruminants, depending on the stage of reproduction (Robbins 1983). During late gestation quality of diet is of particular significance to the development of fawns, while lactation places the highest nutrient demand on the doe (Robbins 1983). Consequently, during periods of poor diet quality both may be impacted negatively. Neonatal survival is reduced by low maternal diet quality, and reductions in diet quality for long durations close to parturition and lactation can have significant effects on fawn and doe (Price and White 1985).

During late gestation and lactation, dietary requirements for female ruminants increase dramatically (Nelson and Leege 1982). Energy expenditures of lactating females increase by 150 % (Robbins 1983) and protein requirements during pregnancy triple (Nelson and Leege 1982). Therefore, nutrient requirements for female pronghorn increase dramatically during spring and summer periods. If forage is deficient in either protein or energy during these periods, fawns may be born weak or milk may lack adequate nutrients for proper growth.

One possible reason for the present low productivity of pronghorn in Arizona is that the forage is deficient in one or more of the critical nutrients (Smith and Malechek 1974). Pronghorn have very high levels of energy expenditure during reproduction, and gestation length and prenatal growth rate have been shown to be significantly lower following dry summers (Byers and Hogg 1995). Given the variable nature of precipitation in Arizona and that nutrient content of forage varies by season (Van Soest 1994), inadequate protein or energy content of forage during late gestation and conception could contribute to poor mid summer fawn:doe ratios (fawn recruitment) in Arizona.

Pronghorn production and survival can be influenced by the quality and quantity of forage consumed (Ellis 1972, Hansen et al. 2001). Pronghorn densities are directly related to the quality and quantity of forage, which is directly related to climate (Yoakum 2004*a*). Precipitation and climate affect plant growth and abundance, which in turn support varying densities of pronghorn. These ecological variables determine long-term carrying capacity and thus pronghorn population dynamics (Yoakum 2004*a*).

This study was part of a statewide evaluation of factors affecting pronghorn fawn recruitment, including predator abundance, nutrition, fawn hiding cover, disease, and water availability throughout pronghorn range in Arizona. Four study sites were located throughout the state, the study sites were paired at 2 different study areas and each pair included a high and low recruitment site in an effort to determine factors affecting fawn recruitment.

We compared pronghorn diets at 2 study areas in north-central Arizona from April through August 2003 and 2004; Fain Ranch (Fain) with high recruitment and Lonesome Valley (LV) with low recruitment. Our objective was to determine the composition of pronghorn diets in Arizona during the biologically significant periods of late gestation (10 April to 25 April), parturition (5 May to 25 May), lactation (20 June to 10 July), and conception (20 August to 10 September). We tested the following predictions (1) species composition in pronghorn diets differs between sites; (2) pronghorn use available forage species in proportion to their occurrence; (3) FN and DAPA levels in pronghorn exhibit similar patterns as other ungulate species; (4) highest fecal indices will occur in summer following monsoonal rains; and (5) FN and DAPA levels differ between sites, seasons and years.

STUDY AREA

This study was conducted at 4 private ranches in a 546-km^2 area in central Yavapai County, Arizona, during spring and summer 2003 and 2004 (Figure 1). The Fain Ranch site encompassed approximately 27,684 ha. The Lonesome Valley (LV) site was a collection of 3 ranches and state land and was approximately 26,900 ha. Dominant vegetation biomes were grasslands, including short-grass prairies and some interior chaparral. Blue grama (*Bouteloua gracilis*) and ring muhly (*Muhlenbergia torreyi*) dominated the areas. Dominate forb species included redstem filaree (*Erodium cicutarium*), western blue flax (*Linum lewisii*), pursh plantain (*Plantago purshii*), and baby aster (*Leucelene erocoides*). Dominant short shrub species were broom snakeweed (*Gutierrezia sarothrae*), winterfat (*Ceratoides lanata*), and threadleaf groundsel (*Senecio douglasii*). Saltbush (*Atriplex canescens*), fendler ceanothus (*Ceanothus fendlerii*), and apache plume (*Fallugia paradoxa*) were prominent in drainages. Chaparral shrubs occurred mainly in drainages and on north-facing slopes. Chaparral species included shrub live oak (*Quercus turbinella*), skunkbrush sumac (*Rhus aromatic*), and beargrass (*Nolina microcarpa*) which dominated the eastern foothills. The climate was mild, with monthly average temperatures above freezing and average annual rainfall of 30 cm at the nearest (approximately 10 km) Western Regional Climate Center (WRCC) weather station in Chino Valley, Arizona (WRCC 2003). Precipitation patterns were bimodal, with 45% of annual precipitation during monsoonal thunderstorms from mid July through September and the remainder as irregular winter and spring snowstorms from December through February (WRCC, Desert Research Institute). Long-term minimum and maximum daily temperatures in January averaged -6 and 11° C, respectively, at Chino Valley (the nearest weather reporting station), and July temperatures averaged 15 to 33° C, respectively. The study area was disturbed as a result of residential development and was fragmented by roadway infrastructure. Land ownership was a checkerboard of state and private lands. Cattle grazing occurred at varying intensities on most of the area, including both state and private land. The only other large herbivores in the area were mule deer (*Odocoileus hemionus*), which occurred primarily in the easternmost part of the study area.

METHODS

We collected data during 2 seasons that coincided with biologically significant periods for pronghorn antelope females. Seven pellet groups from each study site for each time period were pooled to create 1 composite sample for diet analysis. Three composite samples were analyzed per time period per site, so a total of 21 pellet groups were collected from each study area during each of 4 time periods. Microhistological analyses was only conducted during 2 seasons (gestation and lactation) due to time constraints.

Diet Analysis

We determined the diet composition of each composite sample using microhistological analysis procedures described by Holt et al. (1992). Diet composition was based on the relative density of each plant species in 300 randomly located fields of a microscope preparation of composite diet samples (Koerth et al. 1984).

Forage Availability

We used a double sampling technique to estimate the availability of forage species (Higgins et al. 1994). We sampled 715 (354 Fain, 361 LV) random points throughout each study area during each season. We rated pronghorn preference of individual plant species by dividing the product of the percent of each plant species in the diet by the availability of the plant in each study area. In addition, we used chi-squared tests to determine the difference between the expected utilization of forage species (based upon their availability) and the observed frequency in the diet (Neu et al. 1974, Byers et al. 1984, Krausman 1978). We also used chi-squared tests to determine differences between species utilization at each study site. When significant differences were found we used Bailey confidence intervals to determine which forage species were selected or avoided (Cherry 1996). If avoidance or selection was detected, we used Jacobs' D to determine the magnitude and direction of forage species selection or avoidance (Jacobs 1974).

Fecal Analysis

We analyzed fecal DAPA concentrations using the methods described by Davitt and Nelson (1984). We used a Kjheltec Auto Nitrogen Analyzer model 1030™ (FOSS, Eden Prairie, MN) to determine FN concentration of composite diets. In order to determine differences in diet quality we used a 3-factor (site, season, year) ANOVA. These analyses were performed for each fecal index (FN, DAPA) using a one-way ANOVA. If significant differences were detected, we used Tukey's HSD test to separate means (Zar 1996). We used regression analyses to determine relationships between FN and DAPA and each fecal index and precipitation.

RESULTS

Analyses of feces with the microhistological technique indicated little variation between diet composition on Fain and LV during gestation and lactation seasons (Table 1). Forbs made up 60 to 69 percent of the diet samples, while shrubs comprised 19 to 28 percent (Table 1). Pursh plantain comprised the highest percentage (11.1 and 10.8) of the diet samples on Fain and LV, respectively. Other plant species that comprised at least 5 % of the diet samples at Fain included filaree, scarlet gaura (*Gaura coccinea*), baby aster, globemallow (*Sphaeralcea coccinea*), and apache plume. Other plant species that contributed at least 5 of the diet samples at LV included filaree, scarlet gaura, baby aster, fendler ceanothus, and skunkbrush. Grasses were eaten in small quantities and never made up more than 5 percent of the diet in any sampling period. The only grass that comprised more than 1 % of the diet sample was blue grama. Preference ratings indicated that forbs were preferred, followed by shrubs then grasses (Table 2).

During the gestation season, pronghorn consumed significantly more ($P < 0.05$) filaree, western blue flax, pursh plantain, tobosa grass (*Hilaria mutica*), little barley (*Hordeum pusillum*), ring muhly, buckwheat (*Eriogonum wrightii*), and rabbit thorn (*Lycium pallidum*), and consumed significantly less ($P < 0.05$) desert paintbrush (*Castilleja chromosa*), cryptantha (*Cryptantha* spp.), tansy mustard (*Descurainia pinnata*), primrose (*Oennthera caespitosa*), winterfat, and shrub live oak at LV than at Fain. During the lactation season, pronghorn consumed significantly more ($P < 0.05$) prairie zinnia (*Zinnia grandiflora*), scarlet gaura, and skunkbrush, and consumed significantly less ($P < 0.05$) cryptantha (*Cryptantha* spp.), pursh plantain, winterfat, and apache plume at LV than at Fain.

Generally, pronghorn used grasses less frequently than their availability and used most forbs and shrubs more frequently than their availability during the sampling season at both study sites. During both seasons pronghorn at Fain used all grasses less frequently than their availability, and used most forbs and shrubs more frequently than their availability. Jacobs' D indicated that 4 forbs and 2 shrubs were highly preferred at Fain Ranch during both seasons (Scarlet gaura, rabbit thorn, primrose, Russian thistle, and winterfat and apache plume, respectively). A similar pattern was observed during the gestation lactation seasons at Lonesome Valley. Jacobs' D indicated that the same 4 forb species and 2 shrubs were highly preferred during the gestation season at Lonesome Valley.

Fecal Analysis

Fecal DAPA indices for Fain generally increased as the year progressed, while DAPA indices for LV generally decreased (Figure 2). Fecal DAPA ranged from 0.741 to 1.802 mg/g DM at Fain and from 0.915 to 1.726 mg/g DM at LV. Mean FN at Fain and LV ranged from 1.009 to 1.603 % and 0.856 to 1.373 %, respectively.

Concentrations of DAPA in pellet collections indicated a significant seasonal effect ($F = 3.657$; 3, 32 df, $P = 0.023$), year effect ($F = 12.423$, 1, 32 df, $P = 0.001$), and season-by-site interaction ($F = 3.476$, 3, 32 df, $P = 0.027$), but no site effect ($F = 0.344$, 1, 32 df, $P = 0.562$). Follow-up analysis on the season-by-site interaction indicated a significant difference only during the conception season ($F = 8.069$, 1, 32 df, $P = 0.008$) with DAPA concentrations greater at Fain than at Lonesome Valley in 2003. We found a significant year effect at Fain ($F = 11.426$, 1, 16 df, $P = 0.004$) and a seasonal effect ($F = 5.555$, 3, 16 df, $P = 0.008$) with DAPA concentrations during the conception season different only from concentrations during the gestation season ($P = 0.05$; Figure 2). At Lonesome Valley we found a significant season-by-year interaction ($F = 3.753$, 3, 16 df, $P = 0.03$) and a significant seasonal effect in 2003 ($F = 11.908$, 3, 8 df, $P = 0.003$) with DAPA concentrations during the gestation season greater than concentrations during the lactation season ($P = 0.05$) and concentrations during the parturition season greater than during the lactation season ($P = 0.004$) and the conception season ($P = 0.006$; Figure 2). We found no significant seasonal effect in 2004 at Lonesome Valley.

Concentration of FN in pellet collections indicated a significant seasonal effect ($F = 6.541$, 3, 32 df, $P = 0.001$) and site effect ($F = 11.016$, 1, 32 df, $P = 0.002$; Figure 3), with concentrations at Fain greater than at Lonesome Valley. We found a significant season-by-year interaction ($F = 13.456$, 3, 32 df, $P < 0.0001$) and site-by-year interaction ($F = 26.778$, 1, 32 df, $P < 0.0001$), although these effects were qualified by a season-by-site-by-year interaction ($F = 10.259$, 3, 32 df, $P < 0.0001$). This 3-way interaction occurred because of the site-by-year interaction during the gestation ($F = 8.273$, 1, 32 df, $P = 0.007$) and conception seasons ($F = 46.455$, 1, 32 df, $P < 0.0001$). We found no significant site-by-year interaction during the parturition ($F = 0.0003$, 1, 32 df, $P = 0.871$) or lactation seasons ($F = 0.368$, 1, 32 df, $P = 0.561$). The interaction during the gestation and conception seasons occurred because there were higher FN concentrations at Fain during the gestation season of 2004 than at Lonesome Valley ($F = 16.273$, 1, 32 df, $P < 0.0001$). However, there were higher FN concentrations at Lonesome

Valley during the conception season of 2003 (F = 9.909, 1, 32 df, $P = 0.004$), and higher concentrations at Fain during 2004 (F = 42.182, 1, 32 df, $P < 0.0001$).

The range of fecal DAPA values that we found was greater than those reported for other ungulate species (Table 5) and the mean DAPA values for other ungulates were lower than those for pronghorn on our study sites (Table 5, Figure 2). Conversely, the mean and range of FN values reported for other ungulates was higher than the values that we observed (Table 5, Figure 3).

We found no correlation between precipitation and fecal DAPA ($R^2 = 0.0177$, $P = 0.75$) or precipitation and FN ($R^2 = 0.0597$, $P = 0.56$). However, FN and DAPA were positively correlated ($R^2 = 0.6296$, $P = 0.02$).

DISCUSSION

Resource availability is among the most important factors affecting the abundance of large mammals (Marshal et al. 2002). Forage resources in xeric areas are affected primarily by precipitation and are highly variable from year to year (Marshal et al. 2002). High levels of winter precipitation supports high rates of spring forb production, but has not been shown to be associated with grass production (Smith and LeCount 1979).

Our findings confirm that annual rates of precipitation influence forage production, particularly forbs. Compared to 2004, higher rainfall in 2003 (McDonald 2005) was associated with increased forb production, which is consistent with other studies reporting positive relationships between precipitation and forage production (primarily forbs) in Arizona (Smith and LeCount 1979, Fagan et al. 2004).

Vegetation quality and quantity have been identified as key factors influencing pronghorn production and survival and vegetation characteristics as related to diet selection (Yoakum 2002). The first year of this study (2003) received the lowest yearly precipitation ever recorded for central Arizona (R. Ockenfels, Arizona Game and Fish Department [AZGF], personal communication) and therefore, the productivity of forage species was probably below normal. During the final months of 2003 and April 2004, above normal precipitation was probably the cause for the increase in forage species production in 2004. In western Utah, Beale and Smith (1970) found little evidence that forage conditions affect pronghorn fawn survival, although general observations of the physical condition and growth of fawns appeared markedly better during years when abundant succulent forbs were available. However, forage conditions may indirectly affect fawns if does are in poor condition as a result of poor forage quality.

Forb-rich plant communities have a significant relationship to pronghorn fawn production (i.e., more forbs equal high fawn recruitment; Hall et al. 2000). Grassland habitats that were preferred by pronghorn included 20-60 forb species, 10-20 grass species, and 5-10 shrub species (Lee et al. 1994). However, during our study the highest fawn recruitment occurred during 2004 (AZGF, unpublished data), when the percent forb composition was lowest. This may have been a result of increased grass production in 2004. Grasses are not a major component of pronghorn diets (Yoakum 2004*a*), but they provide critical cover for pronghorn fawns (Yoakum 2004*b*). In our study, it appeared that the vegetation species composition provided adequate forage for pronghorn in this region.

When forage was relatively abundant, pronghorn diets did not conform to the proportions of the food available. Instead, pronghorn are highly selective of forbs, followed by shrubs, then grasses (Dirschl 1963, Mitchell and Smoliak 1971, Yoakum 1990, Yoakum 2004*a*). The results of this study show very few differences in pronghorn diet selection between Fain and Lonesome Valley during the gestation and lactation seasons. The consumption of browse increased from the gestation to lactation seasons on both areas. The most likely explanation for this trend is the limited availability of forbs as a result of hot, dry conditions during the summer months.

Consumption of skunkbrush and apache plume increased greatly from the gestation to lactation seasons, probably because the preferred forb forage decreased in availability during the hot, dry season. New shrub growth breaks down quickly in the rumen because it is low in fiber (Holechek 1984). However, as shrubs mature, they contain more fiber and less protein accompanied by a decrease in digestibility, which may cause pronghorn to decrease their intake of these species (Arnold 1985). High-fiber diets are poorly digested, which reduces their rate of passage and thus their rate of intake, while highly succulent low fiber diets are highly digestible. Despite their low digestibility, shrubs may be a critical component of the diets for pronghorn in this area during the dry hot periods of the summer. Nevertheless, diets during the lactation season contained a higher proportion of shrubs than other seasons, even though those diets were probably high in fiber and poorly digestible because plants were mature at that time.

Diet quality can have a significant impact on the reproductive function of wild ruminants, depending upon the stage of reproduction (Robbins 1983). Diet quality during late gestation is of particular significance to the development of the fawn, while lactation places the highest nutrient demand on the doe (Robbins 1983). Consequently, during periods of poor quality diet both the doe and fawn may be impacted negatively. It appears that during the late gestation and lactation seasons, pronghorn on our study sites received adequate nutrition for production (McDonald 2005). Fawn recruitment increased from year 1 to year 2 of this study, and it appeared that forage conditions were optimal for survival and production of pronghorn on these study sites.

MANAGEMENT IMPLICATIONS

We described forage and diet characteristics of a highly productive pronghorn population in central Arizona which should serve as baseline data for comparison by future studies. Pronghorn in this study were highly selective foragers but changed diets based on plant species availability and palatability. Forage conditions during our study appeared adequate for reproduction and survival. However, during extreme periods of drought, decreased forage availability may inhibit the ability of pronghorn to meet their nutritional requirements and negatively impact the recruitment of fawns into the population. This was the condition in 2002, when the area received < 16 cm of annual precipitation, >270 pronghorn died, and fawn:doe ratios were the lowest on record at these study sites (AZGF, unpublished data). This high rate of mortality was presumably caused by starvation (R. Ockenfels, AZGF, personal communication).

Habitat management and evaluation for pronghorn should focus not only on cover, space, and water, but should also include a careful study of forage availability and nutritional quality, primarily of forbs. Forage allocation and management should be geared towards maintaining and increasing the productivity of preferred pronghorn forage species. This information is necessary for studies designed to meet multiple-use objectives, increase plant diversity, and increase forage production. It is also important when determining whether a site is suitable habitat for translocation of pronghorn.

Fecal DAPA follows an annual cycle, reflecting the seasonal changes in diet digestibility (i.e., fecal DAPA is low when diet quality is low and high when diet quality is high). Pronghorn managers can monitor trends in diet quality and intake by using fecal DAPA and FN. Because of its relative simplicity, the greatest application of fecal analyses may be long-term monitoring programs to determine ungulate nutritional status and its association with production and recruitment.

It is important to understand the abilities and limitations of any method used to estimate diet quality. We suggest that FN and DAPA can be useful indices to diet quality, as long as investigators combine estimates of diet quality with a knowledge of diet composition and remain aware of the confounding effects that tannins may have on their results. We reaffirm the cautions of Leslie and Starkey (1987) and emphasize that FN may not be an accurate index in all situations. Fecal DAPA may be a more useful index to diet quality, and it does not appear to be influenced by tannins (Osborn and Ginnett 2001).

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Table 1. Percent composition of forage consumed by pronghorn on Fain Ranch and Lonesome Valley (LV) in central Arizona, during the gestation and lactation seasons, 2003.

Species	Percent composition					
	Gestation[a]		Lactation[b]		Total	
	Fain	LV	Fain	LV	Fain	LV
Grasses						
B. gracilis	1.6	1.4	1.0	1.5	1.3	1.5
Hilaria mutica	0.2	0.7	1.0	0.8	0.6	0.8
Hordeum pusillum	0.6	0.8	1.0	0.9	0.8	0.9
Other grasses	1.1	1.3	1.7	0.4	1.4	0.9
Total grasses	3.5	4.2	4.7	3.6	4.1	4.1
Forbs						
Castilla chromosa	6.5	3.0	1.8	1.1	4.2	2.0
Cryptantha spp.	11.4	5.2	0.5	---	6.0	2.6
Erodium cicutarium	7.7	9.7	4.9	5.2	6.3	7.5
Gaura coccinea	5.2	5.4	8.5	14.4	6.9	9.9
Leucelene ericoides	4.4	4.7	8.3	7.3	6.4	6.0
Menadora scabra	3.5	4.4	4.0	3.7	3.7	4.1
Plantago purshii	6.9	9.8	15.3	11.8	11.1	10.8
Sphaeralcea coccinea	4.3	2.2	5.1	5.2	4.7	3.7
Other Forbs	18.2	17.5	11.7	14.8	15.2	18.7
Total forbs	69.1	62.0	60.3	63.3	64.8	62.7
Shrubs						
Ceanothus fendlerii	5.1	4.1	3.7	4.9	4.4	4.5
Ceratoides lanata	1.9	0.9	4.1	1.0	3.0	0.9
Fallugia paradoxa	5.0	3.6	8.1	4.3	6.6	3.9
Rhus aromatica	0.5	0.8	4.4	8.2	2.4	4.5
Other Shrubs	6.4	11.2	7.9	8.4	7.3	9.9
Total browse	18.9	20.6	28.2	26.8	23.7	23.7
Succulents						
Opuntia spp.	0.3	---	0.2	0.1	0.3	0.1
Total succulents	0.3	---	0.2	0.1	0.3	0.1
Unknown	8.1	13.4	6.5	6.3	5.2	9.8

tr – represents < 0.1% of diet

[a] 04 April to 25 April

[b] 06 June to 07 July

Empty cells indicate plant species that were not detected in fecal samples

Table 2. Pronghorn food habits and forage preference ratings for two short-grass prairie sites in north-central Arizona, during gestation and lactation 2003.

Location	Percent of vegetation			Percent in diet			Preference rating		
	Grasses	Forbs	Shrubs	Grasses	Forbs	Shrubs	Grasses	Forbs	Shrubs
Fain Ranch									
Gestation[a]	30	64	17	3	69	19	0.1	1.1	1.1
Lactation[b]	27	31	42	5	60	28	0.2	1.9	0.7
Lonesome Valley									
Gestation[a]	15	60	25	4	62	21	0.3	1.0	0.8
Lactation[b]	20	31	49	4	63	27	0.2	2.0	0.6
Average	27	48	33	4	64	24	0.2	1.5	0.8

[a]gestation: 04 April to 25 April
[b]lactation: 06 June to 07 July

Table 5. Fecal nitrogen (FN) and fecal 2, 6 diaminopimelic acid (DAPA) values for pronghorn on Fain Ranch and Lonesome Valley in North-central Arizona compared to those of other ungulate species.

Species	Geographic location	Fecal index	
		Nitrogen (%)	DAPA (mg/g)
Arizona Pronghorn	This study	0.86 – 1.60	0.82 – 1.80
Pronghorn[a]	Oregon, Nevada	1.52 – 3.12	0.51 – 0.94
Desert Bighorn[b]	Arizona	1.7 – 3.0	0.22 – 0.63
White-tailed deer[c]	Maine	1.24 – 3.72	0.48 – 1.39
Tule elk[d]	California	NA	0.57 – 1.7
Rocky Mountain elk[d]	Idaho, Washington	NA	0.34 – 1.0
Moose[c]	Maine	0.81 – 3.01	0.51 – 0.78

[a] Hansen et al. 2000
[b] McKinney et al. 2005
[c] Leslie et al. 1989
[d] Nelson and Davitt 1984

FIGURES

Figure 1. Study areas where pronghorn antelope seasonal forage use data were collected during 2003-2004 in North-central Arizona, USA.

Figure 2. Seasonal patterns of fecal 2, 6 diaminopimelic acid (DAPA) (± 95% C.I.) concentration in composite samples of pronghorn feces from central Arizona during 2003 (a) and 2004 (b). Dashed line represents a mean value for other ungulate species (white-tailed deer, mule deer, desert bighorn sheep, pronghorn, Rocky Mountain elk, and tule elk). Gestation, 10 April to 25 April; parturition, 10 May to 30 May; lactation, 20 June to 10 July; conception, 20 August to 10 September.

Figure 3. Seasonal patterns of fecal nitrogen (FN) percent (± 95% C.I.) in composite samples of pronghorn feces from central Arizona during 2003 (a) and 2004 (b). Dashed line represents a mean value for other ungulate species (white-tailed deer, mule deer, desert bighorn sheep, pronghorn, Rocky Mountain elk, and tule elk). Gestation, 10 April to 25 April; parturition, 10 May to 30 May; lactation, 20 June to 10 July; conception, 20 August to 10 September.

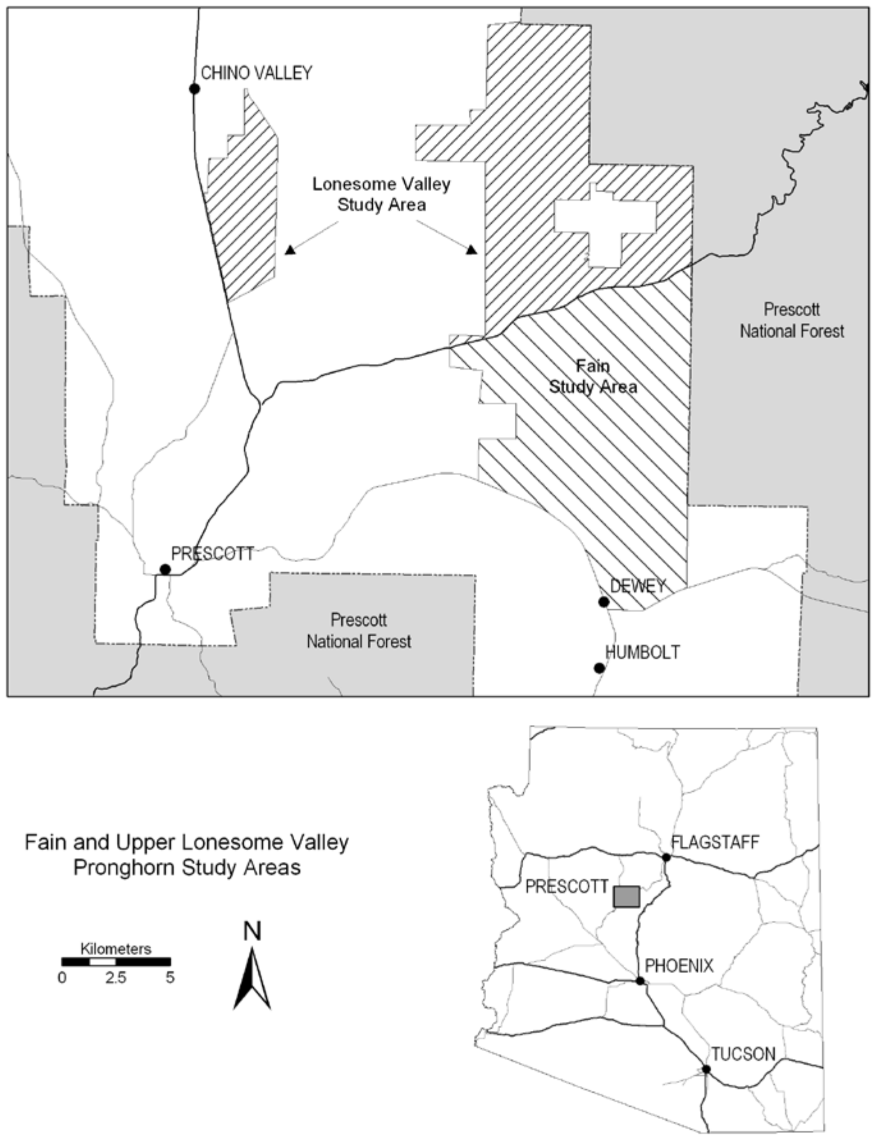

CHINO VALLEY
Lonesome Valley
Study Area
Prescott
National Forest
Fain
Study Area
PRESCOTT
DEWEY
Prescott
National Forest
HUMBOLT
Fain and Upper Lonesome Valley
Pronghorn Study Areas
Kilometers
0 2.5 5
N
FLAGSTAFF
PRESCOTT
PHOENIX
TUCSON

Figure 1.

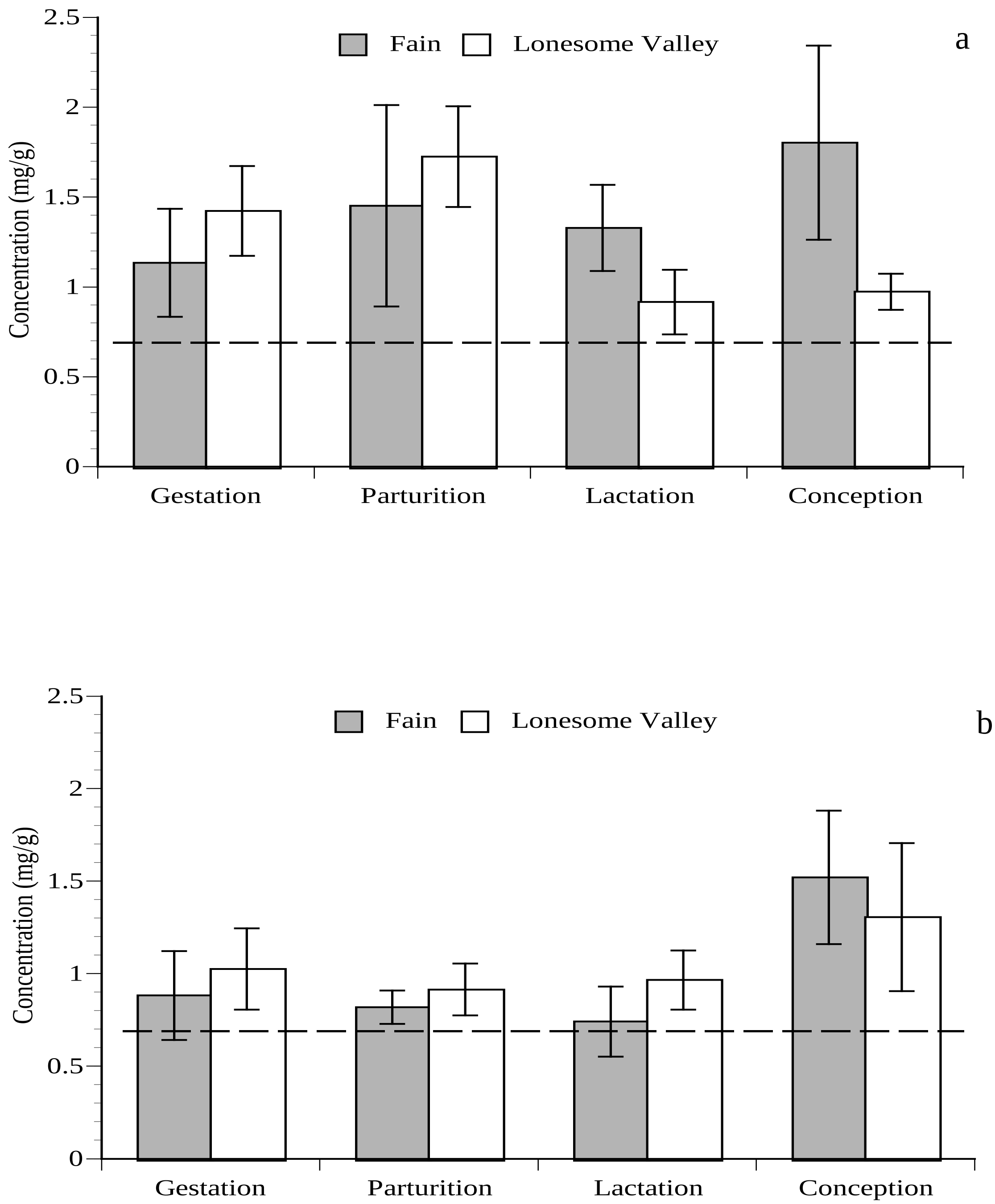
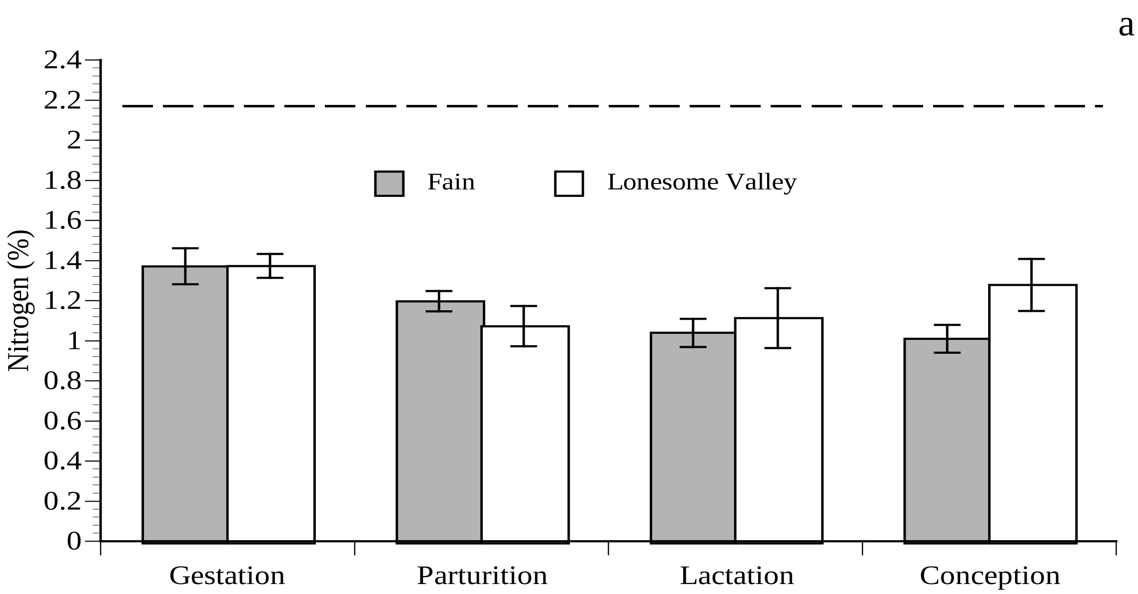

a
Fain
Lonesome Valley
Concentration (mg/g)
0
0.5
1
1.5
2
2.5
Gestation
Parturition
Lactation
Conception
b
Fain
Lonesome Valley
Concentration (mg/g)
0
0.5
1
1.5
2
2.5
Gestation
Parturition
Lactation
Conception

Figure 2.


a
2.4
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Nitrogen (%)
Fain
Lonesome Valley
Gestation
Parturition
Lactation
Conception

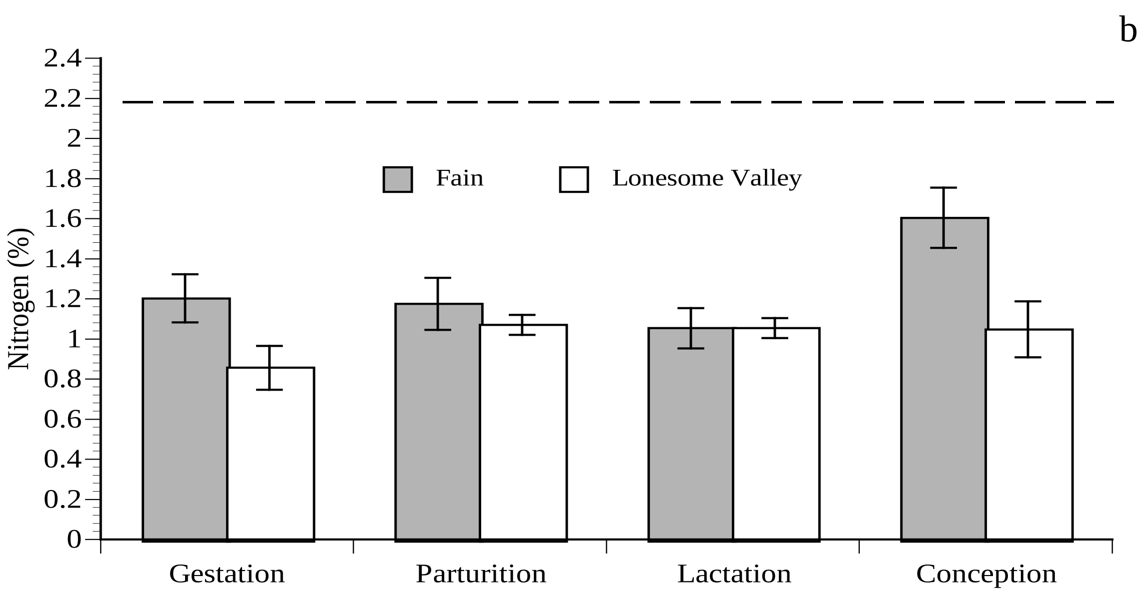
b
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Nitrogen (%)
Fain
Lonesome Valley
Gestation
Parturition
Lactation
Conception

Figure 3.

Modeling Fence Location and Density at a Landscape Level Scale in Montana

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ABSTRACT It is believed that barbed and woven wire fences, common structures across North American western prairies, sage steppes and rangelands, act as impediments to pronghorn daily and migratory movements. Furthermore, fencing may influence pronghorn habitat selection. Because of these potential impacts to pronghorn, we felt it was essential to include fences in both pronghorn movement and habitat selection models across our study area. At this time, no geospatial fencing data is available at landscape level scales. As such, we constructed a fence model using a series of land tenure assumptions for Blaine, Valley and Phillips counties, an area of approximately 37,589 km^2, in north central Montana. Field data was collected in summer 2009. Randomized 3.2 km long transects (n=738) on both paved and unpaved roads were driven to collect information on habitat, fence densities and fence type. GPS locations were recorded at every interior fence convergence to roads and where roadside fencing changed in presence/absence or fence type. Using GIS, the initial fence model consisted of parcel boundaries which were then merged and/or split depending on ownership, size, neighboring parcels and township boundaries. Local knowledge of land ownership and land use assisted in improving the final model. Using fence GPS locations, the model was validated for fence presence/absence accuracy using four buffer sizes: 15 meters, 25 meters, 50 meters and 100 meters. Fence presence accuracy was greater than 96% at the 100 meter distance, and greater than 82% at the 15 meter distance. We believe using publicly accessible ownership layers and techniques in GIS will assist in creating robust fence layers across a broad, landscape level scale. A fence layer benefits both wildlife and land managers to assess effects to pronghorn at various scales. In addition, on the ground management practices could be prioritized by identifying high fence densities along migratory pathways, an ecological necessity to sustaining pronghorn populations at the periphery of their range.

INTRODUCTION

Worldwide, most long-distance terrestrial migrations have been lost (Harris et al 2009) largely due to anthropogenic factors creating barriers to ungulate movements. Harris et al (2009) suggest that restricted access to food and water is a primary threat to migrations worldwide. Fencing has played a large role in ungulate population declines where fencing closes off parks, delineates national boundaries and separates rangelands, thus physically cutting off access to necessary resources (Whyte and Joubert 1988, Williamson and Williamson 1985, Berry 1997, Spinage 1992, Ben-Shahar 1993, Estes 1969, Harris et al 2009). In Africa, veterinary cordon fences were implemented in the 1950s to prohibit transfer of wildlife disease between livestock and wildlife populations (Harris et al 2009). In Kruger National Park, fencing restricted migrations of wildebeest and the population, cut off from seasonal water sources, declined by nearly 88% (Whyte and Joubert 1988).

In North America, 75% of seasonal migrations, mostly those of bison (*Bos bison*) and pronghorn antelope (*Antilocapra americana*) have been lost largely due to overhunting or disruption of migration routes (Berger 2004). Loss of migrations could result in extinction of migrating species due to decreased access to forage and safe calving grounds. Since migratory herbivores such as pronghorn increase grassland biodiversity, a loss of these species could result in North American prairie ecosystems suffering decreased species richness and increased fire frequency (Collins et al 1998).

Today the seasonal migration of pronghorn still exists in the Northern Great Plains of North America, but these migrations are undertaken by only a percentage of individuals in the overall population and vary greatly seasonally and yearly in length and timing (Dominey 1984). At some parts of their northern range, pronghorn generally move south in the winter to access higher quality forage (Jacques and Jenks 2007) and north in the spring to access plentiful, high quality food for the fawning season. In north central Montana, pronghorn may face serious threats to their migration routes. Fencing associated with increased human development in this area poses as a physical barrier to the movement of North America's only endemic ungulate (White et al 2007).

Although North American ungulate migrations are among the best studied, little is known about the complex interactions between pronghorn and their environment. Identification of factors influencing pronghorn movements is imperative, yet not all data of such possible factors are readily available as seamless datasets. To facilitate studies identifying pronghorn movement routes and thus the conservation of pronghorn and migratory ungulates overall, the creation of a seamless fence location layer is necessary.

Objectives

In this study we seek to create a landscape level fence location model for Blaine, Valley and Phillips counties in north central Montana. To aid in future studies identifying pronghorn migration routes or identifying factors affecting seasonal habitat selections or movements we determined it was imperative to have a readily available fence location dataset for this region. We provide methods for modeling fence locations at a large scale, in an effort to encourage the creation of GIS fence location data for important migration conservation or management areas throughout the entire Northern Sagebrush Steppe (NSS), an area that includes the prairies and sage steppes of Southeastern Alberta, Southwestern Saskatchewan and Northern Montana (Figure 1).

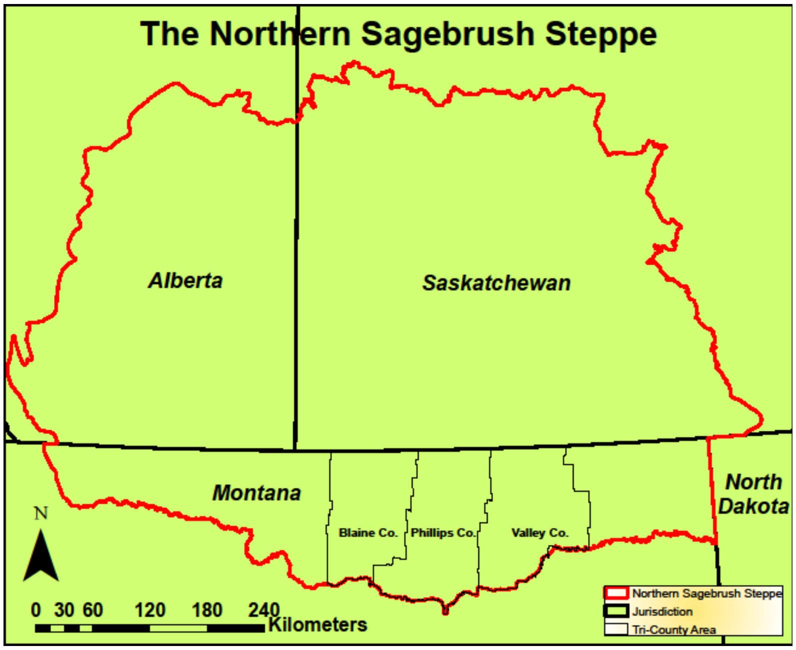

Figure 1. Northern Sagebrush Steppe boundary.

Background

Many migrations worldwide are affected by human development. Thus, to conserve long-distance migrations and to allow continued movement to optimal seasonal foraging sites, protection and maintenance of habitat outside of protected areas will be required. Because ungulates generally track seasonal forage and water sources through their migrations, erecting fencing along migration routes can restrict access to necessary habitat, resulting in declines in population numbers and eventual collapse of seasonal migrations (Harris et al 2009). In a region where fencing is a common landscape feature such as north central Montana, population numbers and migrations could suffer a decline unless landscape permeability is increased.

In North America, wire fencing was introduced in the west by the homesteaders of the 19th century who grew tired of importing timber or stone to create barriers around their land (Hayter 1939). By the late 19th century, barbed wire, an improvement on early fencing, had been invented and was being produced commercially at the high demand of homesteaders wishing to claim their land (Tufford 1960). By 1880-1884, the annual average miles of barbed wire produced was estimated at 400,000 – 600,000 (Hayter 1939). Demand for the barbed wire increased as the population of the west increased and when farmers and cattlemen realized their crops had a higher yield when not shaded (as was the case with prior fence types) and cattle could be sheltered and fed higher quality food in the winter since they no longer roamed far and wide (Hayter 1939 Raup 1947). Eventually ranchers and farmers of the west became overzealous in using fencing, blocking roads and limiting water access (Tufford 1960).

Today much of the fencing erected in the 1800s still exists and this fencing in northern Montana is profuse. It is used by land owners to delineate property, to section off agricultural fields, between parcel boundaries of the same ownership to corral cattle, and along roads for safety. Fencing type in northern Montana varies with land ownership. Three and four strand barbed wire and mesh woven fences are common within the study area (A. Jakes, University of Calgary, *unpublished data*) and these wire fences can pose as significant barriers to the movements of native wildlife.

Some researchers argue that pronghorn perceive fences as dangerous (Beckman and Siedel 2009) although perceived danger may be due to activity associated with fencing. Although pronghorn can jump vertically, they often are reluctant to do so, making traversing landscapes with fencing especially challenging. Evolutionarily, pronghorn enjoyed expanses of open land and inhabited areas of gently sloping plains and had little reason to jump. Pronghorn seem to be unaware of their jumping capability (Spillet et al 1967) and often get tangled in the top two wires of fencing. Eighty-one percent of pronghorn jumping fences became caught in the fencing in Colorado and Utah, and pronghorn density and fence-related mortality were correlated (Harrington and Conover 2006). Increased indirect mortalities of fawns being separated from their mothers occurs from woven wire fences than from plain barbed wire fences and mortalities increase with an increase in fence height (Harrington and Conover 2006). In addition to the possibility of a serious decline in population numbers, fencing poses a physical barrier to ungulate movement (Bolger et al 2007).

STUDY AREA

The study area is comprised of Blaine, Valley and Phillips counties in north central Montana. These counties are bounded by the Canadian border on the north and the Charles M. Russel National Wildlife Refuge (CMRNWR) to the south (Figure 2). This area was chosen as the study area due to the presence of a partially migratory pronghorn herd within the area. The total area for which fencing was modeled was 3,746,866 hectares (Table 1). There is slightly more land privately owned than publicly owned within the study area. The Bureau of Land Management (BLM) owned the largest amount of publicly owned land (Table 1, Figure 2).

Table 1. Land ownership within Blaine, Phillips and Valley counties.

Ownership	Area (Ha)
US National Park Service	81.00
US Government, Other	114.65
Undetermined	198.89
Right of Way	1501.24
US Department of Interior	1788.70
US Department of Defense	1944.19
Local Government	11246.53
US Bureau of Reclamation	12017.06
Water	12636.53
US Fish and Wildlife Service	155936.84
State Government	249575.64
US Bureau of Indian Affairs	382208.77
US Bureau of Land Management	1034097.65
Private	1883518.35
Total	3746866.03

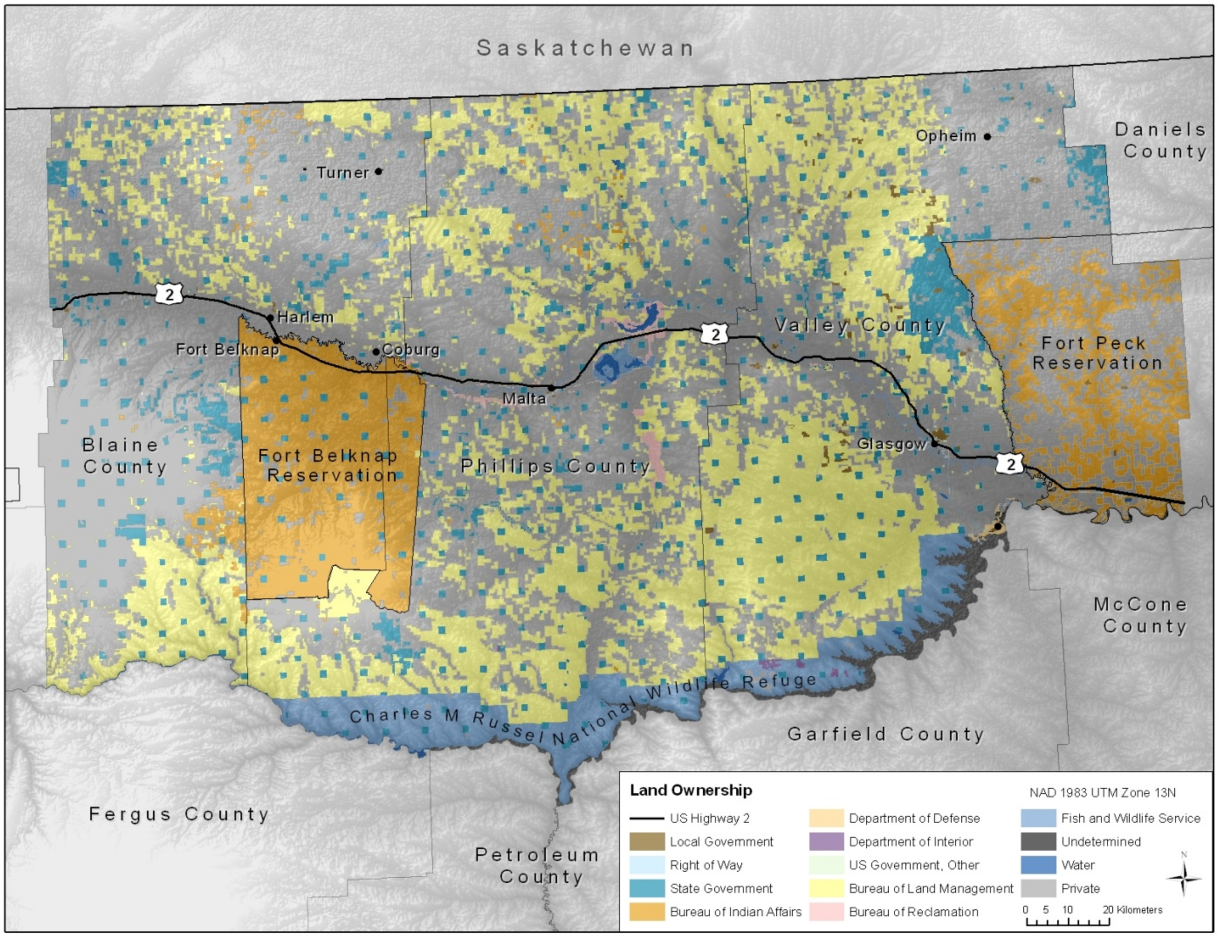

Figure 2. Land ownership within Blaine, Phillips and Valley counties.

METHODS

Fencing Location and Density Modeling

Because pronghorn often move unabated until a fence is reached, we used a binary measure of fence presence/absence for the fence model. Fence location in Blain, Phillips and Valley counties was modeled using private land ownership data provided by NSS collaborators and the Montana Public Land Ownership dataset in ArcGIS 9.3.1 (ESRI 2009). We predicted fence presence based on parcel ownership, size and ownership adjacency. Data used included the Montana Township & Range Lines, ownership data from the Montana Cadastral Database, the 2000 TIGER roads dataset and a BLM roads dataset.

We first assumed that lands with the same mailing address in the case of private lands, and lands with the same public ownership would not be fenced off if adjacent. We merged adjacent private lands with the same mailing address and merged adjacent public lands with identical ownership. We combined the public and private datasets to create one cohesive land ownership dataset. We then assumed all public lands were not fenced if they were next to or within a public land parcel of the same ownership type and selected all public lands less than 400 acres and merged all of these public lands of identical ownership based on the longest shared border. Then, all private lands of any acreage that were next to adjacent properties of the same mailing address were merged into the neighboring parcel (of identical ownership) with the largest border. Next, we removed parcel boundaries between all state government lands within the CMRNWR, and merged all state lands within Fish and Wildlife Service (FWS) lands, assuming that state inholdings would not be fenced. We then merged the state government lands within the Bureau of Indian Affairs (BIA) lands with the BIA lands, assuming that these state inholdings would not be fenced off. We then identified all privately held lands within the BIA lands and merged them with the BIA lands, assuming that small private inholdings would not be fenced. Next, we identified state lands of 700 acres or less that shared a boundary with BLM lands and merged them into the BLM lands. Here, we assumed small to mid-sized state government lands would not be fenced off from the BLM lands. We then assumed that state lands less than 660 acres would be leased to the adjacent private land with the longest shared border. To do this, we selected from the overall parcels layer the private lands and the remaining state lands. We selected state lands less than 660 acres and merged these lands with private lands. We then merged all of the adjacent Bureau of Reclamation (BR) lands together, assuming the BR parcels adjacent are not fenced. We then intersected this data with the parcels dataset and merged them together. We then selected private lands within the CMRNWR and merged these private lands with the CMRNWR lands, assuming that private lands within the CMRNWR would not be fenced. We intersected the CMRNWR lands with fence data provided by the Fish and Wildlife Service (FWS) to create fence data for CMRNWR, assuming that there would be no fences here save for those provided by FWS. We then selected parcels of any ownership or mailing address and merged them into neighboring parcels, assuming parcels of 40 acres in this landscape would be considered too small to be fenced, and that many would be relicts of prior parcel merging and data editing. Within this layer, we removed remaining ownership slivers and gaps, assuming these small oddly shaped pieces of land were due to errors accrued when merging parcels. We also merged 80 acre parcels that were completely surrounded by a contiguous parcel of differing ownership into the surrounding parcel. We converted the resulting parcel layer from a polygon dataset into a line dataset to transition parcel representation to fence representation. We then identified the larger cities and converted the parcels within the cities to lines, assuming that cities would have fencing within them, and provide a barrier to pronghorn movement. We manually removed all road fencing on tribal land except if the road was within a canyon or a large road. We manually added in the township lines where it appeared they crossed over a large part of open land and removed fences along small dirt roads (A. Jakes, University of Calgary, *personal communication,* M.Suitor, University of Calgary, *personal communication*)

From the BLM roads layer, we identified and selected roads with the designation of ‘county road’ or ‘Bureau of Indian Affairs’ and larger roads and removed these from the CMRNWR, assuming that roads would not be fenced on the Refuge. We then removed roads from the grazing pastures on public lands. We retained state highways, state owned roads and US highways on public lands, assuming these large roads would be fenced. We removed all roads on BLM land, assuming roads on this land would not be fenced. We buffered private and public roads by 25 meters on each side and removed roads that were completely within the 25 meter buffer, assuming these were the same road, represented once by each of the roads dataset.

To combine the fencing data with the roads data, we created a 25 meter buffer around the fences and erased roads that were completely within the fence buffer, assuming the fences around these roads would be represented by the fence layer. We then manually removed the remaining road segments that were on or very near the parcel boundary line, assuming that these roads’ fence would be represented by a neighboring parcel boundary. Finally, we merged the roads data with the fencing data, resulting in one comprehensive fence location dataset. Cadastral data was not available for Saskatchewan fence modeling, but fencing data of public lands was available and was combined with the modeled fence data. A focal window of one square kilometer was then used to calculate fence density per square kilometer using ArcGIS 9.3.1 (ESRI 2009).

Field Sampling

Transect Identification

The seamless landcover dataset developed by bordering state and provincial wildlife agencies in the NSS transboundary area was clipped to the specific counties of interest. From this landcover data, three generalized habitat type regions were delineated by manually drawing polygons around landcover of similar types within the GIS. Habitat types included “grassland”, “agriculture” and “shrubland”. To create a fourth generalized habitat type, we used removed areas not previously defined and classified as “mixed” habitat to include the remaining areas. Next, we identified roads, paved or unpaved, from the NSS roads dataset and intersected this layer with the generalized habitat type region within the Montana portion of the NSS data. New regions were identified, based on both generalized habitat type and road type, leaving a total of eight different classifications: Grass/Unpaved; Grass/Paved; Agriculture/Unpaved; Agriculture/Paved; Shrub/Unpaved; Shrub/Paved; Mix/Unpaved and; Mix/Paved. Within each of these generalized areas, random points along roads were generated, each which served as the middle point of each 3.2 km road transect for field surveying. Random points were generated at a minimum distance of 3.5 km apart, so there was no chance of transect overlap. Each random point had a unique transect associated with it. As such, unique transect numbers were generated and manually entered for each random point. Transect identification took place in ArcGIS 9.3.1 (ESRI 2009) and random points and transect regions coordinates were defined in WGS 1984.

Field Surveys

Using a GPS to guide, we drove to within 1.6 km of each random point location. Here, a GPS location was taken and this point was considered the beginning of a random transect. At each point along the 3.2 km transect that a roadside fencing either ended or reappeared, or changed in fence structure, a GPS location was recorded. GPS locations were also recorded at every interior fence convergence to roads. Information on GPS locations, transect number and heading, fence structure, ground cover and road type was recorded in spreadsheets using Microsoft Excel. Locations and structure of internal fencing and twinning and tripled roadside fences were also recorded. Following some general rules, fencing had to be within 200m of the road to be considered following the roadside and therefore within the transect, and changes in fence structure had to be longer than 100m to be recorded. Complete sampling protocols (Appendices 1) were created to standardize methodologies for unique fencing schematics found across the landscape and are applicable to all survey areas across the NSS.

Model Accuracy Assessment

The modeled fence layer was buffered at four different distances, 15 m, 25 m, 50 m and 100 m, to account for error in field sampling and fence modeling and because in a GIS it proved difficult to compare actual point locations of fencing collect by a GPS to line data. Using each buffer as a proxy for the modeled fence locations, we determined the accuracy of the modeled fencing.

Where the field fence locations fell within the buffer, the model was considered ‘accurate’, and where the field fence locations fell outside of the buffer, the model was considered ‘inaccurate’. This accuracy assessment was conducted separately for the four buffer distances resulting in four accuracy scores.

RESULTS

Fence Location Modeling

A total of 5,062,458.80 km of fencing was predicted within Blaine, Phillips and Valley counties (Figures 3 and 4). Maximum fence density was 15.99 kilometers of fencing per km^2. Mean fence density for the tri-county area was 0.92 km of fencing per km^2 (Figure 5). Fence density was highest along the Highway 2 corridor, through Malta and Coburg (Figures 4 and 5), and the lowest on the Fort Peck Reservation and around BLM land and the CMRNWR in the southern portions of the study area.

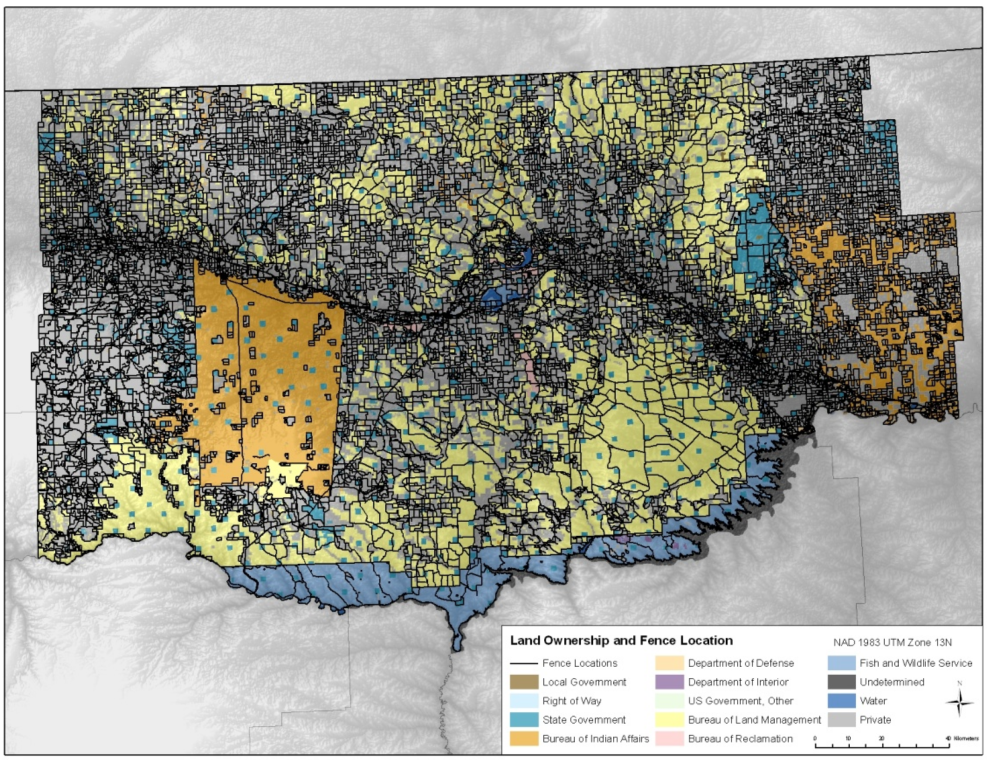

Figure 3. Fence locations within Blaine, Phillips and Valley counties.

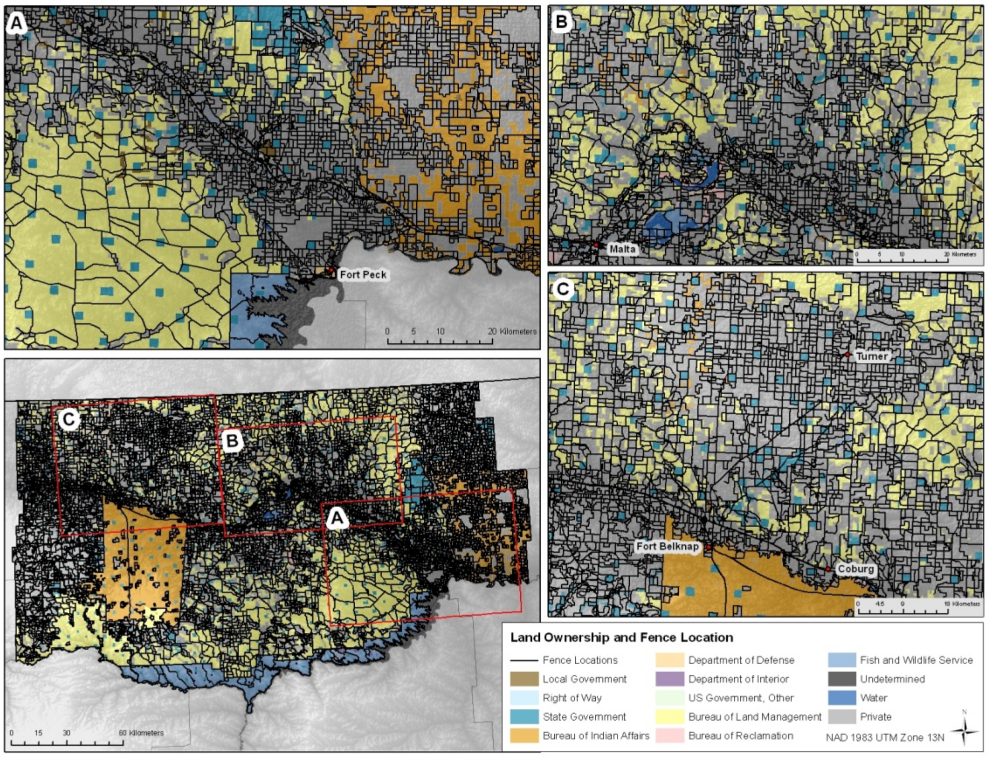

Figure 4. Fencing around Glasgow (A), Malta (B) and Fort Belknap and Turner (C).

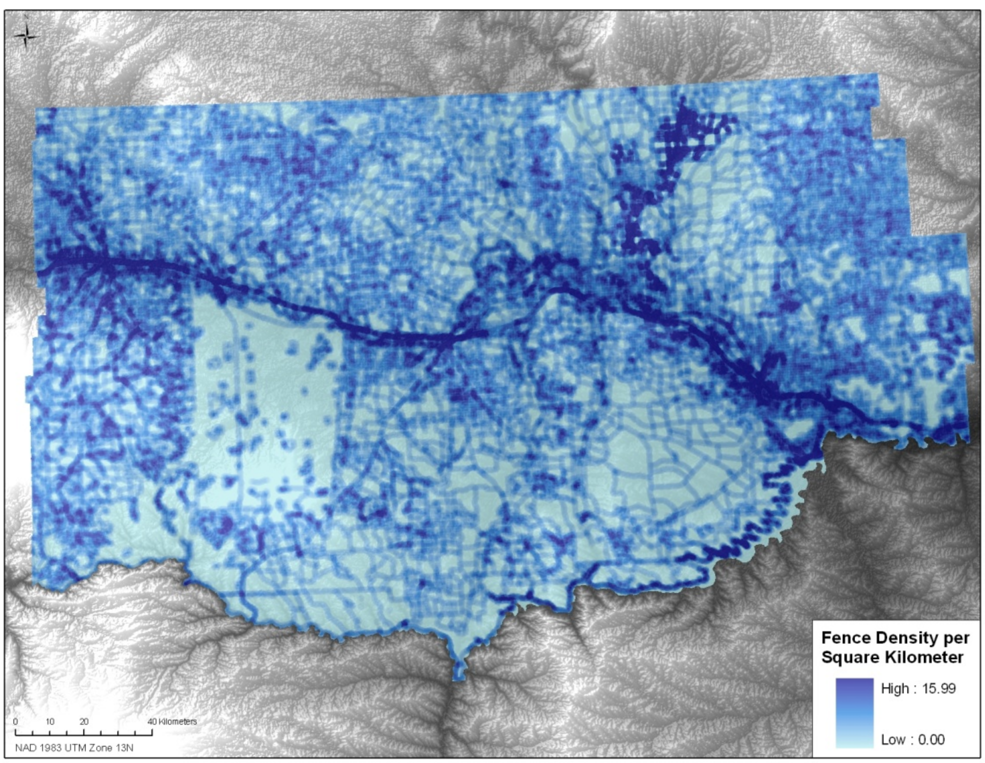

Figure 5. Fence density within Blain, Phillips and Valley counties.

Field Sampling
From June-August 2009, 2,362 km of fence along roadside transects were sampled in Northern Blain, Phillips and Valley Counties (Figure 6). Most transects consisted of four to eight “changes” along each transect, with a low of zero changes and as many twelve. GPS waypoints were downloaded after each field day to create an overall layer of fence changes along roadsides or where interior fences converged with roadsides across the area (Figure 6).

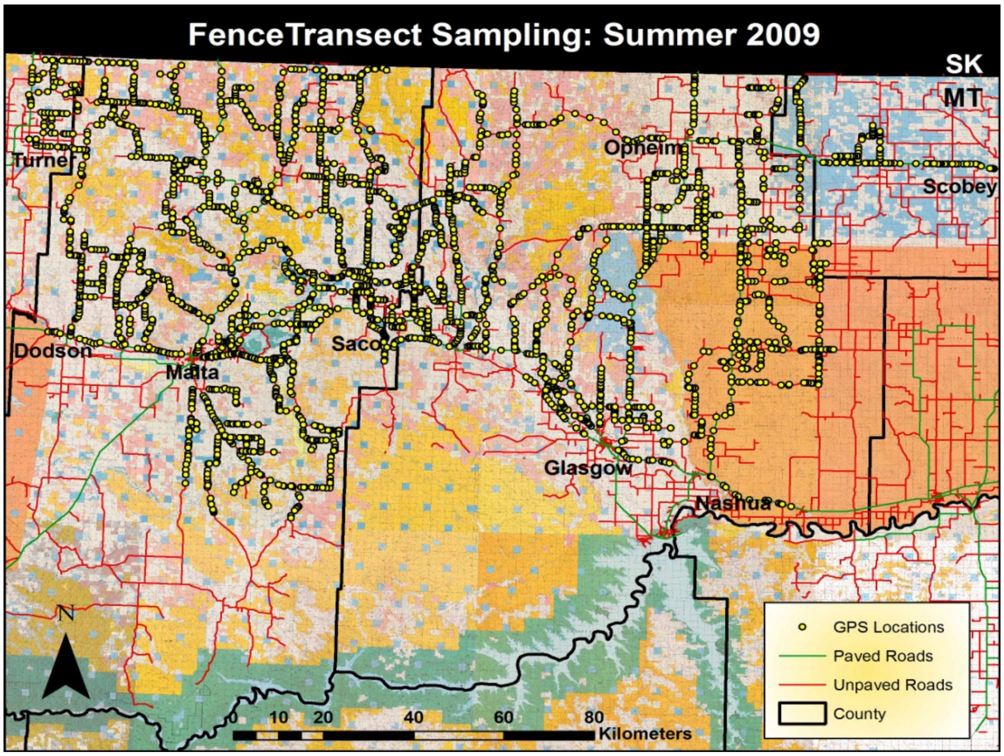

Figure 6. GPS locations of all fence changes along roadsides in Blaine, Phillips and Valley counties.

Model Accuracy Assessment
Within the study area, 1,788 GPS locations of actual fencing were used in fence validation. These fence locations were in the southeasern part of the study area, extending to the towns of Coburg and Turner in the west and to the Canadian border in the north (Figure 7). Of the four buffers for which accuracy was assessed, the modeled fencing was the most accurate when the 100 m buffer was used as the proxy for fencing, with greater than 96% of the fence location points occurring within the buffer (Table 2). More importantly, when fence location points were compared to the 15 m buffer, the accuracy was still exceptionally high, with 82.38% of the GPS locations of actual fencing falling within the buffer. This is an excellent result considering that both a high percentage of accurate fence locations fell within the smallest buffered area and the large scale fence locations and densities were modeled at (Table 2).

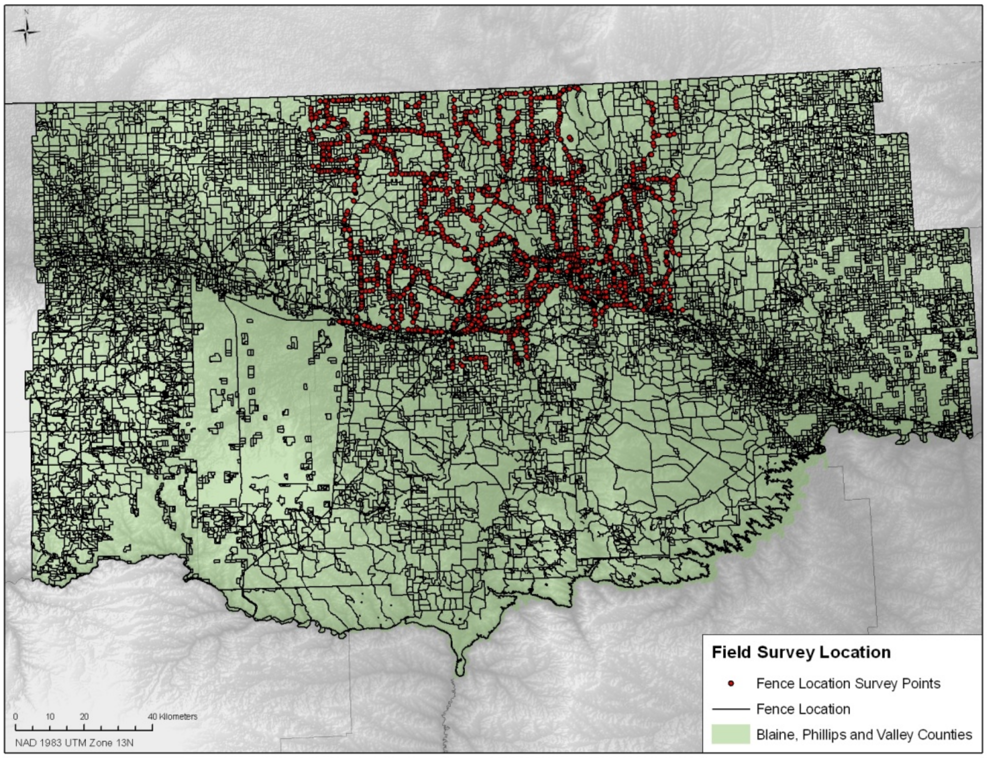

Figure 7. Fence sampling locations during summer 2009.

Table 2. Fence buffer levels and accuracy scores.

	Buffer Size (m)			
	100	50	25	15
Number Correct	1721	1691	1618	1473
Percent Correct	96.25	94.57	90.49	82.38

DISCUSSION

Fences can exhibit both indirect and direct effects on native ungulate populations worldwide (Berger et al 2008, Sheldon 2005, Thirgood et al 2004). On pronghorn, indirect effects of fencing such as animal displacement, reduced habitat availability, and habitat fragmentation may have a higher impact on populations than direct effects, by altering behavior resulting in eventual population decline (Harris et al 2009, Harrington and Conover 2006, Sheldon 2005).

Fencing can act as a semi-permeable or even complete barrier to pronghorn daily and seasonal movements (Kolar 2009, Sawyer and Rudd 2005, Sheldon 2005, Berger 2004). During daily foraging activities, dense fencing can restrict movements, confining pronghorn to smaller movement bouts within decreased areas. Thus, fencing could impact energetic maintenance, opportunities to move to safer areas from predation, and opportunities to feed on nutritionally valued vegetation. Importantly for pronghorn populations at the northern periphery of their range, individuals require opportunities to undertake seasonal long-distance migrations with varying weather and vegetative conditions. In the NSS, severe weather during winter months (October – March) can produce intolerable conditions at which time many pronghorn migrate and then return during spring to individual's traditional fawning grounds. During facultative migration, individuals move as a response to deterioration of local conditions (Dingle and Drake 2007). As within other portions of pronghorn range, only a portion of the population will migrate (Dalton 2009, Kolar 2009, White et al 2007). As such, the NSS population is considered to be 'partially migratory' (Dingle and Drake 2007). Using various strategies by individuals within a population is an important adaptation. Each individual considers trade-offs of migrating versus not migrating. In the NSS, if an individual chooses to migrate, it benefits by leaving severe weather and starvation scenarios to find tolerable access to foraging and energetic requirements. In contrast, migrating expends tremendous energy to undertake and so can be a risky strategy. From a population level perspective, it is precarious to not have an opportunity to decide which strategy to use. Barbed and woven wire fencing can be a major impediment to migratory movements, especially during winter time. Snow and ice can accumulate over the bottom-most wire, thus preventing pronghorn to crawl underneath fences. Because of this, migrating pronghorn may not be able to reach destinations, during which time they have expended energy without finding better conditions. Fencing therefore can place migrating individual pronghorn and therefore the NSS population in perilous situations.

Roads and associated fencing diminish habitat effectiveness by reducing patch size. This has consequences on pronghorn habitat selection at multiple scales. Pronghorn may select habitat that they have better access to both at the home range and within home range order of selection. These increasingly accessible landscapes include areas of lower fence densities. However, even though habitats may be more accessible, such is the case of many agriculture areas, they may lack the high nutritional value offered by native forbs, grasses and shrubs. As such, increased fencing could deter pronghorn to select home ranges with the highest quality habitat, and instead select home ranges with the greatest opportunities to forage. In addition, increased fence densities may attract pronghorn to select for sub-optimal areas within home ranges with less ominous fencing conditions.

Different fence structure types have different effects on pronghorn movement and habitat selection (Harrington and Conover 2006) and the fence layer created here did not include fence structure data. This data was being collected in the summer of 2009 and we were unfortunately unable to incorporate it into the fence layer created here. Additionally, many major roads in northern Montana have fences that parallel on either side and in this modeling effort, fences were represented by only a single fence approximately in the middle of where two fences would actually parallel each other. The presence of two fences lining a road may provide additional resistance to pronghorn movement and could thus alter and decrease the permeability of the habitat models, potentially resulting in different corridors. In addition, hand digitizing and editing was necessary. Fences were removed by hand where the accompanying roads were insignificant dirt driveways or turnarounds and were added by hand where it was assumed more fencing would exist (for example in the middle of a pasture where there was a township boundary). Finally, because this data was created with the continued reliance on assumptions about neighboring parcels of land, there may be a decrease in accuracy around the edges of the study area.

Additional improvements in accuracy of the fence layer may be made by amending the fence sampling protocol. Fence surveyors at times recorded fence locations at as much as 100 meters from the actual fence due to railroad right-of-ways and property rights and interior pasture fences off roadways were not ground-truthed. Future sampling forays are planned to sample more of the study area, which will be imperative for future landscape fence permeability analyses for pronghorn, given their mobile nature. This fence model provides room for improvements and these should be made before embarking on implementing these methods in other surveying areas.

Although this fence location and density layer can benefit from improvements in data analysis and sampling methods, this exercise did produce noteworthy results. From our validation analysis, our model displayed actual fence locations along predicted fence lines 82.38% of the time using the smallest buffered area; considered an exceptional result in the remote sensing community. Therefore, using this modeling approach offers accurate assessment of fence locations and density over a large spatial scale. In addition, regional rules can be created to hone the methodology to specific regions of interest. This novel effort uses extractable methodologies to assist in modeling a key variable towards unraveling the drivers behind ungulate seasonal migrations. For now, the connection between migration and population limitation for partially migratory ungulates remains poorly understood (Bolger et al 2007). However, modeling movement and habitat selections will first target important areas and corridors for population sustainability. From there, habitat linked population-viability analysis can be undertaken to estimate total population based on available habitat (Johnson and Boyce 2005). Although pronghorn remain a relatively common species in many areas of western North America, without planning with the proper data, the cumulative anthropogenic changes to landscapes will continue to erode habitats reducing effective habitat patch size and eliminating key-linkage areas supporting inter-range movements and possible ungulate populations.

MANAGEMENT IMPLICATIONS

A landscape level fence layer benefits both wildlife and land managers to assess effects to pronghorn at various scales, including at home range and within home range level of habitat selection, as well as identifying important corridors during seasonal migration. As a management priority, on-the-ground management practices could identify high fence densities along migratory pathways, an ecological necessity to sustain pronghorn populations at the periphery of their range and in addition, maintain robust population throughout their entire range. Another priority would be to identify and mitigate high fence densities locals within traditional pronghorn winter ranges, as these areas are spatially and resource limited. Federal, state and provincial agencies, along with non-profit organizations and community organizations all can play an important role by undertaking cooperative projects to modify fences in strategic locations to facilitate passage by pronghorn. Wildlife and habitat managers working side-by-side with community members can assist in educating the public, including landowners, about the unique and necessary biological phenomenon that is migration. In turn, landowners may become more open to conserve for the longest terrestrial migrations in the lower United States. Simple and inexpensive measures that landowners can undertake include participating in government-landowner cost shares, putting up wildlife friendly fences, opening gates during migratory periods, and utilizing specifically designed cattle guards that keep cattle while allowing for continued movement by wildlife.

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APPENDIX 1

Excel Spreadsheet

Counting each segment: First row in spreadsheet is the "start" transect (1.6 km away from random point) and GPS waypoint is taken – always as XXXXA. An additional row in the spreadsheet is added for each transect when there is a change. Examples are when an additional fence parallels the road, where there is a fence corner, when a fence on either driver side close or driver side far changes fence structure.

In "Heading" column it should be labelled as from start to finish. Example: going South to North would be written S-N, if heading changes during the transect such as when there is a corner, then change the heading to reflect change in direction.

When recording "LC Ground" along a transect, record observed. For example, if "LC General" is "grassland" and are actually in "mixed" habitat then record as "mixed".

If two corners go off in the same direction, one gets recorded as a corner, the second gets recorded in the "notes" column as "second heading fence is X strand BW and code X"

In notes, dbl = 0 means that the double dr. side close/far or paralleling fence has stopped.

When there is no fencing on a transect, there should only be one row and one waypoint for transect

When a transect middle point is moved due to transect overlap, record new middle point location in GPS only, do not add another row in Excel spreadsheet

GPS Waypoints

When a waypoint is taken for a transect, rename each as transect # and next letter in alphabet; for example, begin as 7641A, 7641B, etc. If moving the transect to fit 3.2 km distance, take waypoint in the middle and name waypoint only that transect # (no letter), for example 7641.

When a transect is moved, record new transect beginning and use vehicle odometer to record a 1.6 km distance driven to new random point. Continue to use vehicle odometer to complete a transect.

Treat each transect as separate. As such, when crossing an intersection that has already been sampled in a previous transect, still record as any other sampling effort.

No need to take waypoints for double fences that "parallel" the road, but should record in new Excel row when they change

Transect sampling rules

Fence has to be within ~100 m of road (close enough that observer can code the permeability)

Any segment needs to be 200 m long if recorded as an interior fence convergence; 100 m long if fence is "paralleling" the road.

Never double count a fence at various stops along the transect; make a new record only if there is an addition, deletion or change.

"Driver Side Close" is always to driver's left; "driver side far" is always to driver's right.

Don't count fencing around "structures" – farm houses, corrals, etc. but do note structures in "structure" and "notes" column.

If fence that "parallel" the road changes from one type of fencing to another (or change from absent to present or present to absent), must record in new Excel row. However, because it is difficult to observe when a parallel fence comes in or goes away, parallel fencing does not get a waypoint.

When classifying the heading of a double fence that parallels the road: Classify based on the direction of transect heading and lane. Example 1: If travelling south to north, observer is heading north. A double fence starts that parallels the road; fence would receive a north heading if it was off to the right-hand side (driver is in the right-hand lane) and get a south if it was off to the left-hand side (driver is not in the left-hand side lane and so is opposite). Example 2: If travelling east to west and a double fence starts that parallels the road; fence would receive a west heading if it is off to the right (driver is in the right hand lane) and get an east if it is off to the left (driver is not in the left hand side lane and so is opposite).

If a fence is on the far side of a railroad which parallels the road, that fence gets recorded as a "paralleling road", not as driver side near or far. As such, does not get a waypoint.

Even on two-track roads, and going through a gate, count one fence as two posts, thus would be two converging interior fences.

Helpful tips for codes

When choosing between C1 and C2 for three-strand BWF, go with C1 always if it is 16" off ground, even if it's sagging between fence posts.

Three-strand BWF usually gets the worst rating of C3. The only time they get a C4 is if it's a well-built new fence and the lowest strand is very low (<12')

Sampling in the Field

Map transects to sample each day by: 1) Export spreadsheet with random sample point FID number, XY coordinates, road type, and cover type (from random point attributes).

Print map of transects to sample each day and mark FID number for each random point (these are the unique identifiers for each transect). The random point is the middle of each transect and can be moved if need be.

Fence Structure Codes
Code 0 = No Fencing; Code 1 = Lowest barbed wire was higher than 16 inches; Code 2 = Lowest barbed wire was lower than 16 inches, hole/gap noted within 100m; Code 3 = Lowest barbed wire was lower than 16 inches, hole/gap noted between 100-300 m; Code 4 = Barbed wire deemed challenging to cross under except areas of low topographic dips; Code 5 = Barbed wire fence very sturdy, with low bottom wire; unlikely to get through; Code 6 = Woven wire or picket fence

General Landcover Type Codes
Grassland: 1; Agriculture: 2; Shrubland: 3; Mixed : 4

Road Classification
Paved: 1; Unpaved: 2

Gastrointestinal Nematode Concentrations of Pronghorn in Trans-Pecos, Texas

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ABSTRACT Texas Parks and Wildlife Department (TPWD) Wildlife Division staff survey pronghorn annually to document population structure and issue harvest permits to landowners. In the Trans-Pecos region of Texas, pronghorn population fluctuations have typically been associated with precipitation patterns and associated habitat conditions. In 2008, a die-off of approximately 2,500 animals was documented in the Marfa Plateau area, after an extended dry period and unseasonably late freeze in May. In 2009, despite improved range conditions, TPWD biologists recorded only 9.4 fawns:100 does in the herd units most affected by the previous year's die-off. We sampled 102 hunter-harvested pronghorn to analyze for internal parasites, selenium serum concentrations, and serum and liver copper concentrations. Mean copper blood levels were 0.67 ppm and copper liver levels averaged 7.8 ppm. Selenium serum levels had an average of 133.8 ppb. Entire abomosal contents and fecal samples were examined for internal parasite loads. Fecal egg counts were determined using a standard fecal flotation technique, and counts (*Haemonchus* spp.) averaged 57.8 eggs/slide. Eighty nine abomasums were examined and 82 (95%) were found to contain *Haemonchus* spp. The average number of individual *Haemonchus* counted per pronghorn abomasum was 552.4, with a range of 0-4,080 worms per sample. Based on these results, we believe that *Haemonchus* spp. may be an additional factor affecting population dynamics of pronghorn in the Trans-Pecos ecoregion of Texas. Further research and surveillance is needed to determine parasite significance and make appropriate management recommendations.

Gastrointestinal nematodes, such as *Haemonchus*, have been documented in many wild ruminants, including pronghorn (*Antilocapra americana*). Bever (1957) reported that *Haemonchus contortus* were numerous in sampled pronghorn from South Dakota, and this parasite has been found in the pronghorn of most western states (O'Gara and Yoakum 2004). In Texas, Hailey (1979) reported that of 48 pronghorn sampled in the Trans-Pecos ecoregion, 39 (81.3%) contained *Haemonchus contortus*. These samples, collected from 1965 to 1967, were categorized as lightly infested (21), moderately infested (7) and heavily infested (11). He concluded that the dry climate aided in preventing the spread of disease or parasites.

Haemonchus (large stomach worm, barber pole worm) is one of the most highly prolific parasitic nematodes afflicting both domestic and wild ruminants causing deleterious effects to the animal, entire populations, and animal wildlife industry (McGhee et al. 1981, Newton and Munn 1999). Adults feed by attaching to the epithelium of the stomach to reach the blood supply. Eggs are laid in feces of the host animal and subsequently passed onto the ground. If conditions are favorable, the eggs hatch and larvae undergo two molts while feeding on bacteria within the fecal material. The infectious 3rd stage larvae make their way out of the fecal material and migrate onto vegetation to be foraged by a host ruminant. As the infective larvae are ingested, *Haemonchus* molts once more into a 4th stage. The entire pre-patent period is 18-21 days (Hoberg et al. 2001).

Similar to most southwestern pronghorn populations, Trans-Pecos pronghorn densities are typically tied to precipitation patterns (Simpson et al. 2000). Since population estimates were standardized in 1977, numbers have varied from approximately 5,000 to over 17,000 (Figure 1). Pronghorn are surveyed annually by individual herd units delineated by either natural or manmade barriers to movement. In 2008, TPWD biologists documented a significant loss of approximately 2,500 pronghorn in selected herd units within the Marfa Plateau area. These animals perished after approximately 8 months with no measurable precipitation, followed by an uncharacteristically hard freeze in May. Even though overall 2009 precipitation was near normal, late winter and spring rainfall was slightly below average. In 2009, despite improved range conditions, TPWD biologists recorded only 9.4 fawns:100 does in the herd units most affected by the previous year's mortalities.

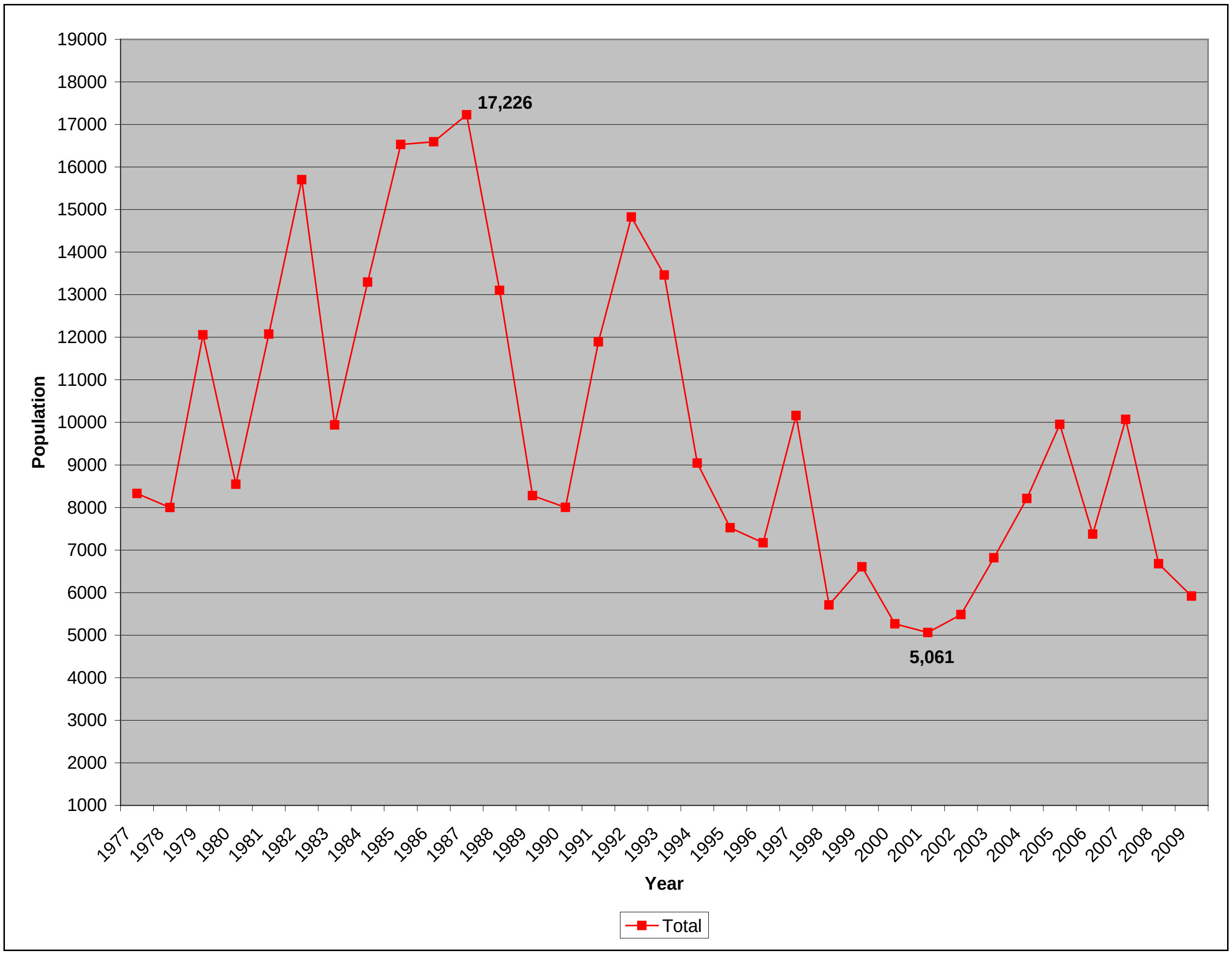

Figure 1. Trends in pronghorn numbers in the Trans-Pecos region of west Texas as estimated by Texas Parks and Wildlife Department, 1977-2009.

In 2009, TPWD biologists and cooperating wildlife veterinarians necropsied 2 does from these herd units. Both animals showed extremely high numbers of *Haemonchus* worms in the abomasums. Area landowners also reported continuing mortalities throughout the spring and summer of 2009. In August, 2009 several concerned Trans-Pecos landowners, hunters, outfitters, wildlife veterinarians, wildlife biologists, and researchers met to discuss dwindling pronghorn populations. This group, labeled the "Trans-Pecos Pronghorn Working Group", recommended sampling hunter-harvested pronghorn and testing for gastrointestinal worm concentrations and mineral deficiencies.

METHODS

Prior to the 2009 pronghorn general season, TPWD wildlife biologists contacted landowners, informed them of the sampling initiative, and requested their assistance. Assisting biologists and Borderlands Research Institute - Sul Ross State University (SRSU) students attended a training and orientation session prior to receiving assignments. Data collectors met with participating landowners, outfitters, and hunters, and accompanied them while in the field hunting. Once a pronghorn was harvested, if possible, data collectors obtained samples of the liver, blood, blood serum, fecal material, and entire abomasum.

Samples were cataloged and preliminary lab analysis commenced by SRSU student workers and researchers. Serum and liver samples were sent to the Texas Veterinary Medical Diagnostic Lab at College Station, Texas. Fecal and abomasum samples were examined at SRSU. Liver samples were analyzed for copper levels, and blood sera were analyzed for copper and selenium levels. Abomasal contents were examined for internal parasites, and *Haemonchus* levels were estimated using an accepted sample-enumeration technique (Kaplan, personal communication). Fecal samples were subject to standard fecal flotation techniques to determine the relative abundance of nematode eggs (Beck and Davies, 1976).

In January 2010, additional sampling was initiated in selected Panhandle ecoregion pronghorn herd units. The purpose of this initiative was to compare results to the Trans-Pecos sampling effort, and establish a baseline for future restocking efforts. As compared to Trans-Pecos populations, Panhandle pronghorn populations appear to be extremely viable, and these herds would most likely serve as sources for future supplemental restocking of Trans-Pecos herds. Does were selected for harvest in the Panhandle, and were typically harvested on winter wheat fields, to aid in collection efficiency.

RESULTS

In the Trans-Pecos sampling initiative, we obtained samples from 102 pronghorn representing 50 ranches and 1.8 million acres for analysis. Copper liver values averaged 7.84 ppm for the 68 samples analyzed. The average for copper serum levels was 0.674 ppm (n = 49). Selenium serum samples averaged 133.79 ppb (n = 29). Average fecal egg count (FEC) was 69.24 per slide for the 67 fecal samples examined.

Prevalence of *Haemonchus* was 95.5%; that is 85 of the 89 samples that were analyzed had barber pole worms. The average extrapolated number of *Haemonchus* per pronghorn was 552.3 worms/pronghorn and ranged from 0 to 4,080. Thirty three (37.1%) of the samples contained $\geq$ 500 worms, 24 (27%) contained $\geq$ 900 worms, and 5 (5.6%) contained $\geq$ 2,000 worms. Based on collection location, *Haemonchus* samples were placed into "sampling units" to determine any geographic differences in worm loads. Culberson County and Hudspeth County herd unit samples contained the least number of worms, while the herd units around Marfa contained the highest worms per sample (Figure 2).

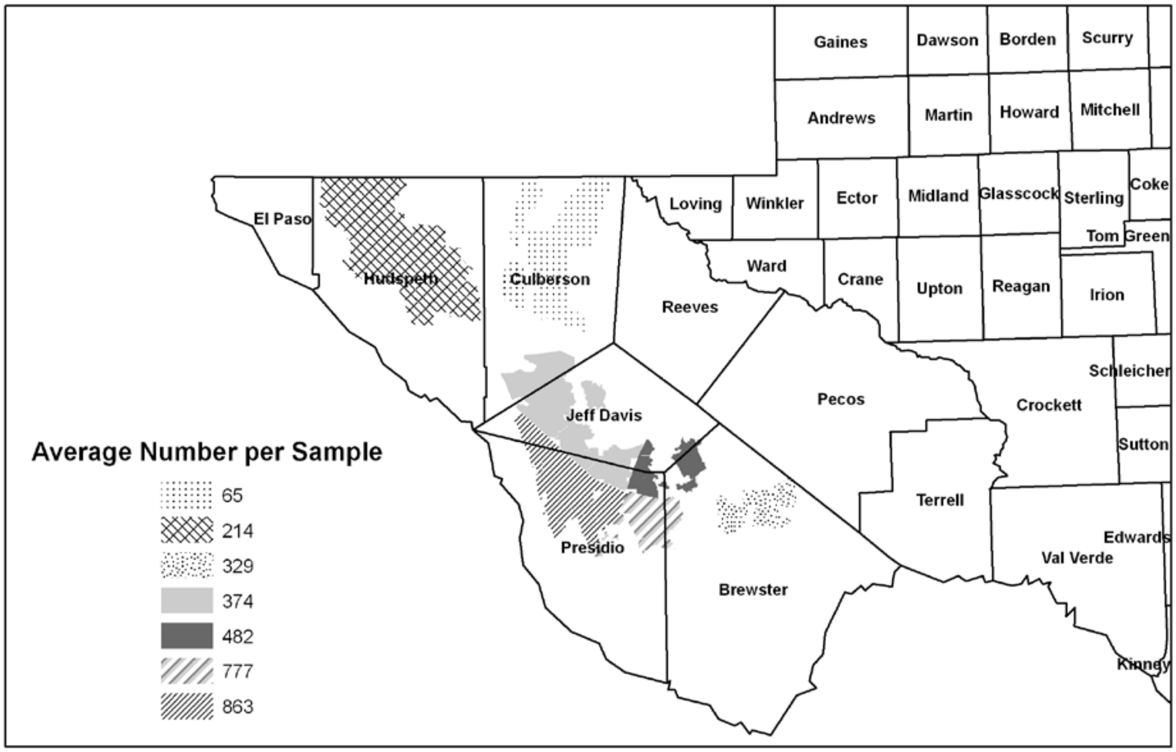

Figure 2. Mean number of *Haemonchus* counted per pronghorn abomasum within Trans-Pecos sampling units, October 2009.

FEC values were compared to extrapolated *Haemonchus* counts, and appeared to correlate (r = 0.598). A statistically significant inverse correlation (r = -0.530) was noted for extrapolated worm count and copper serum values (Table 1).

Table 1. Non-Parametric correlations of pronghorn samples collected in the Trans-Pecos, October 2009.

		Extrapolated worm count	Fecal Egg Count	Copper Serum (ppm)	Selenium Serum (ppb)	Copper Liver
Extrapoloated Worm Count	r r2 Sig. (2-tailed) N		0.598 0.358 0 53	-0.53 0.281 0 43	-0.21 0.044 0.314 25	-0.149 0.022 0.251 61
Fecal Egg Count	r r2 Sig. (2-tailed) N			-0.177 0.031 0.332 32	-0.09 0.008 0.733 17	-0.404 0.163 0.006 45
Copper serum (ppm)	r r2 Sig. (2-tailed) N				-0.043 0.002 0.842 24	0.02 0 0.894 46
Selenium serum (ppb)	r r2 Sig. (2-tailed) N					-0.065 0.004 0.743 28
Copper liver (ppm)	r r2 Sig. (2-tailed) N					

In the Panhandle, 20 samples were collected from 5 pronghorn herd units. Copper liver values averaged 10.4 ppm, copper serum levels averaged 0.40 ppm, and selenium serum samples averaged 164.4 ppb. The mean FEC was 13.9 per slide. All abomasums contained gastrointestinal parasites, and 11 contained multiple species or different larval stages of the same species. Estimated numbers of worms ranged from 2 to 336 per sample, with an average of 90 worms per sample.

DISCUSSION

When compared to other pronghorn studies, Trans-Pecos levels of copper and selenium appear low (Dunbar et al. 1999, Whittaker et al. 1999, Heffelfinger et al. 1999, Stoszek et al. 1980). Low copper levels may be symptomatic of high gastrointestinal worm levels (Waldrup, personal communication). Gastrointestinal worm numbers from the Panhandle pronghorn samples were below the range that is considered pathogenic in white-tailed deer (*Odocoileus virginianus*) (Davidson, et al. 1980). However, the high concentrations of *Haemonchus* found in many Trans-Pecos pronghorn are alarming.

There is little information available to indicate at what level *Haemonchus* are deleterious to the overall health of individual pronghorn, as well as the viability of populations. In deer (*Odocoileus* spp.), this parasite is not typically considered a significant source of mortality except in conjunction with malnutrition in overpopulated ranges (Heffelfinger 2006). Davidson et al. (1980) suggested that at levels above 1,000 worms, pathogenic effects become evident in white-tailed deer. Research (Bever 1957, Goldsby and Eveleth 1954) indicates that poorly managed rangeland can result in higher numbers of internal parasites. O'Gara (2004) felt that desiccation and cold winters on most pronghorn range prevented the buildup of the free living larvae.

Most pronghorn range in the Trans-Pecos was historically grazed by sheep and goats and netwire fences remain in most areas, even though cattle operations dominate livestock operations currently. Probable confinement of pronghorn by netwire fences may have enhanced conditions for *Haemonchus* infestations; however, several sampled pronghorns were heavily infested within ranches with more "antelope-friendly" fences. Grazing practices throughout West Texas have improved significantly during the last 50 years and most pronghorn range can be considered "well managed". In 2008, drought and an unseasonable late hard freeze undoubtedly led to extremely poor body condition in most Trans-Pecos pronghorn. This might have provided a mechanism for *Haemonchus* infestations to increase, and this increased pathogenic potential could have contributed to mortalities of immunocompromised animals. However, mortalities continued to be reported after a period of substantial rainfall and enhanced range conditions.

Of particular concern is the potential for *Haemonchus* to affect pronghorn reproduction and associated recruitment. To date, individual species and origin of *Haemonchus* in Trans-Pecos pronghorn populations are unknown. If *Haemonchus* isolates are resistant to standard anthelmintics, it may be assumed that their origin derives from sheep and goats. However, if they are drug-sensitive, then the worms likely originated from pronghorn or other wild ruminants (Kaplan, personal communication).

Pronghorn managers understand the importance of recognized limiting factors such as precipitation, habitat quality and quantity, barriers to movement, and predation. This parasite appears to be an additional factor affecting population dynamics of pronghorn in the Trans-Pecos. Relationships between parasite loads, climate, and habitat are poorly understood. Similarly, the effects of pronghorn movements and distribution on parasite numbers are not clear. Further research and surveillance are needed to determine causes and make appropriate management recommendations.

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PRONGHORN POPULATIONS IN RELATION TO PREDATOR CONTROL PRACTICES: AN ASSESSMENT OF A CASE HISTORY IN OREGON

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ABSTRACT: Factors affecting pronghorn *(Antilocapra americana)*production and survival in the Hart Mountain area of south-central Oregon have been studied for 74 years. The first research was initiated in 1936 by Arthur s. Einarsen. Studies were again conducted during the early 1950s when management agencies believed predation was apparently a major agent contributing to low fawn recruitment. Radio telemetry techniques had not been fully developed, consequently little quantitative data was obtained. At that time high numbers of permitted, trespass, and feral livestock grazed the area and competed with pronghorn for preferred nutritious herbaceous forage. Pronghorn population numbers continued to be monitored. Additional research on predation was accomplished during the 1980s concluding that coyote predation was a serious problem influencing fawn survival and recruitment. During the 1990s, the first and only long-term research project was completed that conclusively documented neonate losses were indeed frequently high. Fawn mortality attributed to predation ranged from a low of 33 percent to a high of 81 percent with a 10-year average of 49 percent. This research concluded that although pronghorn sustained neonatal mortality rates averaging around 50 percent for a decade, the herd increased in number until evidently a new carrying capacity was established. Since then, the population has consisted of some 2,000 animals; the highest long-term average for >60 years. This case history indicated that studies of predation on pronghorn neonates should be conducted long-term, and that other ecological factors should be investigated concurrently. Mortality agents such as weather conditions, inadequate nutritious forage, and predator losses, can be ascertained and the primary limiting factors responsible for herd numbers can be more accurately determined.

KEY WORDS: *Antilocapra americana*, carrying capacity, fawn recruitment rates, mortality agents, predation, pronghorn, survival factors.

INTRODUCTION

The effects of predation on pronghorn populations currently is a controversial issue for many western rangelands (O'Gara and Shaw 2004, Yoakum et al. 2004). One reason for this situation is that cooperators for pronghorn conservation have included ranchers; hunters; politicians; local, state, and federal government agencies; conservationists; and other interested sources. These partners many times have different agendas for the justification and practices of predator control and its role in pronghorn management. An advocate may promote specific control practices based on personal experiences or opinions that lack scientific justification due to inadequate research. In many, if not most cases, modern ecological field studies have not been conducted to justify the expenditure of public funds to control predators preying on wildlife. The goal of this report is to provide a better understanding of the role of predators and predator control practices in maintaining or increasing pronghorn populations in the Great Basin.

DESCRIPTION OF AREA

Pronghorn habitats on and surrounding Hart Mountain in south-central Oregon is located in the shrub steppes of the Great Basin (U.S. Fish and Wildlife Service 1994). Within this eco-region is the Hart Mountain National Antelope Refuge (HMNAR) that has been dedicated to pronghorn, native wildlife, and plant perpetuation since the mid-1930s. Elevations range from 1,800 m to 2,400 m at the top of Hart Mountain. The area is semi-arid rangeland with few springs, streams, or rivers providing drinking water. Average annual precipitation varies from 25 to 35 m with most received as snow and rain during winter and spring.

The area is within the shrub steppe ecosystem which is dominated by sagebrush *(Artemisia spp.)*, bitterbrush *(Purshia tridentata)* and rabbitbrush *(Chrysothamnus spp).* Native and exotic forbs (comprising 40 to 60 subspecies) and grasses (10 to 20 subspecies) provide less cover but important forage. Smaller juniper *(Juniperus occidentalis)* hillsides, aspen *(Populus trembuloides)* and pine *(Pinus ponderosa*) forests are less common habitats.

Native wildlife inhabiting the HMNAR include 43 subspecies of mammals, 239 subspecies of birds, and lesser numbers of fishes, amphibian, and reptiles (U.S. Fish and Wildlife Service 1994). Mammals such as mule deer *(Odocoileus hemionus)*, bighorn sheep *(Ovis canadensis)*, coyotes *(Canis latrans)* and jackrabbits *(Lepus* spp.) are generally year-long residents. Pronghorn spend most of the spring, summer, and autumn at higher elevations, but when deep snows arrive, they move to lower elevations where forage is more abundant. Few birds are residents.

The region is sparsely occupied with ranches and small towns. The largest community is Lakeview, Oregon, some 60 miles southwest of the HMNAR.

HISTORY OF RESEARCH STUDIES AND MANAGEMENT STRATEGIES:

The HMNAR is one of the most intensively studied sites for pronghorn in the Great Basin, with research accomplished by universities and government agencies (Table 1). Following is a brief review of research projects conducted for predator relations with pronghorn.

Early Research Period---1930s, 1940s, and 1950s.

Commencing in February 1936, Arthus S. Einarsen, leader of the Oregon Cooperative Wildlife Research Unit at Corvallis, Oregon, started his life history studies of pronghorn throughout North America. He concentrated his field studies on the HMNAR. Einarsen often camped at "The Post" log cabin near a small ponderosa pine forest at the south end of the HMNAR, and spent more than a decade observing pronghorn daily activities. Einarsen was an intensive observer and a dedicated naturalist. He considered the coyote a "formidable foe" of pronghorn kids (a term for fawns during this period) and adults. Several pages of his book "The Pronghorn Antelope and its Management" are devoted to observations of coyote hunting skills for fawns. His final words for pronghorn and predators were "But under normal conditions predation perhaps is rarely a factor in determining survival" (Einarsen 1949:81).

During the 1950s, wildlife managers noted depressed pronghorn populations and vast rangelands supporting low pronghorn densities (Hansen 1955, Deming 1959). Therefore, the

Oregon Cooperative Wildlife Research Unit was requested to conduct a pronghorn population dynamics project. Results of the first 2 years indicated an abundance of adult and fawn carcasses (Hansen 1955). Hansen stated numerous intact fawn carcasses were found with no evidence of disease, predation, or other causes of death.

A subsequent research project identified all known agents classified as pronghorn mortality factors: e.g., diseases and parasites, predation, severe weather conditions, natural accidents, competition with livestock, hunter harvests, automobile and train accidents, and others (Yoakum 1957). Yoakum noted that rangelands producing abundant, high quality forage supported higher pronghorn densities than similar sites yielding low quality forage. Wildlife agency managers continued to insist predation was the primary factor responsible for low pronghorn densities and requested more years of study on predation. Again, the results indicated that predation was prevalent but data were insufficient to confirm predation as the most important mortality agent (Compton 1958). Consequently, with 7 years of continuous field research unable to confirm which environmental factors was limiting pronghorn, the research was terminated. Note that mortality sensitive radio telemetry equipment was in the development stage in the early1950s and unavailable for the above field studies. Also, this research was descriptive rather than experimental. Experiments were necessary to confirm cause and effect.

Concurrent with the plight of pronghorn during this era was the common practice by wildlife managers to use predator control to enhance wildlife populations. For example, on the HMNAR, a full time predator control agent was hired to kill coyotes, bobcats, and badgers with techniques including trapping, poisoning, shooting, and coyote pup denning.

Ecological Changes---1960s and 1970s.

A new conservation legacy emerged during the 1960s and 1970s as the public became increasingly aware of various misguided management programs on public lands, and encouraged efforts such as 7 multiple-use programs and various strategies to enhance wildlife (O'Gara and McCabe 2004). Other assessments identified poorly administered predator control programs (Leopold 1964, Cain et al. 1972). With such alarms, predator control programs began to decrease. On the HMNAR, all predator control programs were terminated in 1967.

Rangeland strategies also experienced changes. In the 1960s and 1970s, large numbers of licensed, trespass, and feral livestock (domestic cattle, sheep, and horses) intensely foraged for long grazing seasons on public lands including the HMNAR. This often resulted in severe competition for herbaceous plants and shrubs preferred by pronghorn--especially during the spring reproduction period when adult females needed nutritious forage to maintain their health and produce milk for their fawns (Ellis 1970). The 1970s witnessed the beginning of major changes in livestock operations. Domestic sheep grazing was virtually eliminated on public lands because of changes in economic marketing, and a shift of sheep husbandry practices from herding on open public rangelands in eastern Oregon to fenced private pastures in western areas of the state. Feral horse management became a federal mandate and these exotic livestock were eliminated from the HMNAR and reduced in numbers by the Bureau of Land Management (BLM) on certain surrounding rangelands. BLM also implemented multiple-use resource plans resulting in increased forage for wildlife and decreased permitted livestock numbers. The sum of these changing range management strategies contributed to increased forage for pronghorn (Yoakum and Davis 1996)--resulting in steady increases in pronghorn numbers (U.S. Fish and Wildlife Service 1994).

Predator and Pronghorn Studies Return--The 1980s.

The Oregon Department of Fish and Wildlife commenced a study during the early 1980s in the Jackass Creek Area located in southern Harney County (Trainer et al. 1983, Willis 1988). Fawn survival rates were monitored for years when aerial gunning of coyotes were performed and compared to years without predator control practices. Conclusions were "High intensive, short duration coyote removal is deemed to be an appropriate and cost efficient management application for pronghorn populations with poor fawn survival during periods of medium to high predator abundance"(Willis 1988:60). The study did not address the issue of whether predator control practices contributed to increased herd numbers.

First Long-term Research Project—1994.

Predation of pronghorn fawns surfaced again as a management issue in the mid-1990s. Personnel of the HMNAR reported low fawn survival and attributed these losses to abundant coyote populations. Local hunter groups and ranchers were informed and supported initiation of a predator control program. The U.S. Fish and Wildlife Service (USFWS) developed an Environmental Assessment Report (EAR) identifying the need for government agency aerial gunning of coyotes to increase pronghorn numbers (U.S. Fish and Wildlife Service 1995). The EAR was distributed for public review and comments. Responses were received from conservation organizations challenging the proposed action program for lack of scientific data and took the case to court, whereupon the USFWS withdrew the proposed project. The USFWS developed a second EAR identifying coyote control procedures to be conducted by public hunters. Again the conservation groups argued the lack of scientific justification and took the case to court. The USFWS withdrew its control proposal and agreed to conduct a research program on the HMNAR to determine the influences of predation on pronghorn neonate survival rates. The study commenced in 1995 using radio telemetry to monitor 50 fawns for 3 months after birth. Annual fawn loses to predation were up to 81 percent (Gregg et al. 2001) and as low as 33 percent. However, for a 10-year average, the fawn loss to predation was 49 percent (Yoakum et al. 2004). Similar loses of around 50 percent were reported for pronghorn herds in other areas by O'Gara and Shaw (2004).

For the HMNAR study, Yoakum et al. (2004) documented that other ecological factors apparently influenced pronghorn populations. These included the implementation of a Comprehensive Management Plan ceasing permitted livestock and eliminating feral horses (U.S. Fish and Wildlife Service 1994). In addition, the comprehensive Management Plan noted that the Refuge had abundant tall, dense stands of shrubs with little understory of herbaceous plants. Therefore, management strategies were adopted to alternate vegetation seral stages through wild and prescribed fires to decrease shrubs and increase grasses and forbs--thus enhancing preferred, nutritious forage for parturient does and neonates (U.S. Fish and Wildlife Service 1994, Gruell 1995, Yoakum and Davis 1996). These new management strategies resulted in increased forage production meeting habitat requirements of pronghorn (Kindschy et al. 1986). Results substantiated that pronghorn populations steadily increased without a predator control program for more than a decade with resulting populations around 2,000 animals—the largest number of pronghorn on the HMNAR in the last 74 years (Yoakum et al. 2004). These increases are depicted in Figure 1 (Collins 2009).

DISCUSSION

This review assessed information for 74 years at the HMNAR verifying that predators killing pronghorn is a highly controversial, political and misunderstood wildlife management issue. Research methodology has changed during recent decades, and that current studies emphasize the need to use best science and ecological methods.

Research has provided quantitative data for many different rangelands occupied by pronghorn. Pronghorn consistently produce high numbers of fawns (Vriend and Barrett 1978, O'Gara 2004). Neonate mortality is generally high and that annual recruitment rates should not be expected to be high. Published papers as recent as this year (Jones and Yoakum 2010) reported findings that fawn recruitment rates appeared related to major vegetation communities. No longer should managers of shrub steppes or deserts expect fawn recruitment rates to be as high as the Great Plains grasslands. Indications are that fawn recruitment rates appear to be an ecological characteristic of carrying capacity that varies with climatic conditions and major vegetation communities (Jones and Yoakum 2010). More than 30 years ago, Dr. Starker Leopold (wildlife management professor at the University of California, Berkeley, California) advocated that North American wild ungulate populations were predominately influenced by vegetation conditions during critical seasons--and that all other factors were secondary (Leopold 1966).

Studies of the effects of predation on pronghorn neonates need to be accomplished over 10 years or longer because fawn recruitment rates changed over time due to changes in weather and forage conditions. For years on the HMNAR when predators were responsible for >70 percent of neonate losses, it was alluded that predation was the factor affecting populations. But when recorded mortality averages closer to 50 percent tor >10 years and pronghorn herds continued to increase, it was apparent that habitat conditions were more important than predation. If this study had been conducted as originally planned to implement a predator control program and the final result showed increased pronghorn populations as it did, then the prey population increases could have been attributed to the benefit of a predator control program--thus increasing confusion regarding predator/prey relations.

Wildlife managers are reminded that findings for this case history were specific to the shrub steppes of the Great Basin. It indicated that fawn recruitment rates may be an ecological characteristic of carrying capacity. These results may not be applicable to other major vegetation communities that may have differing carrying capacities.

This review of pronghorn research for >7 decades at Hart Mountain illustrates how wildlife managers have changed their views regarding the influence of predation on pronghorn. It provides numerous research findings and experiences based on quantitative ecological investigations. Wildlife managers today need to become acquainted with current research results regarding ecological relationships, and it is a responsibility of wildlife management personnel to inform sportsman, conservation groups, and other publics about current understanding of predator/prey relations.

MANAGEMENT FINDINGS AND RECOMMENDATIONS

A review of research projects for the Hart Mountain ecosystem of the Great Basin over the past 74 years has highlighted the following key points:

1. Fawn recruitment rates are influenced by weather conditions, vegetation quality, predation, and typically varies greatly year to year.
2. Predation of neonates (especially by coyotes) is often high; however, predation on adult pronghorn is low for habitats of high quality.
3. Predation losses of neonates can average around 50 percent and herds can continue to increase in number when forage conditions are favorable.
4. Predator control projects to increase fawn survival need to be justified by scientific data collected over 10 years or more.
5. Projects inferring predator control practices contribute to improved fawn survival rates and herd population increases can be misleading. Predator control practices have increased pronghorn fawn survival; however, most projects did not show that improved fawn survival resulted in increased herd numbers.
6. This case history of pronghorn population dynamics on the shrub steppes of the Great Basin provides another report substantiating Dr. Starker Leopold's wildlife management concept that the predominate factor influencing wild ungulate populations in North America, is generally vegetation quality during critical seasons--all other factors are secondary.
7. Wildlife managers now have long-term ecological data regarding the relations of pronghorn to predators for Great Basin rangelands. It is the responsibility of wildlifers to share this information with sportsmen, conservation groups, and the general public for a better understanding of the values and needs for predators and pronghorn to live natural lives on western rangelands.
8. In sum, a broad, long-term perspective is necessary to accurately assess the impact of predation on prey populations. When looked at from this perspective, the almost universal scientific conclusion is that predation is a part of the "ecological system" and impacts it in concert with all the other factors in the system.

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I am indebted to my major professor Arthur S. Einarsen who instilled in my academic training the concept that research on pronghorn is a long and continuous challenge for accurate information. Wildlife biologists Ock Deming, Don DeLong, Bill Pyle, and Mike Hansen provided information from field experiences on Hart Mountain. For manuscript peer reviews, Reg Barrett, Tom Pojar, and Harley Shaw provided many improvements. U.S. Fish and Wildlife Service staff personnel at the Sheldon/Hart Mountain Refuge Complex in Lakeview, Oregon enhanced the final report.

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Table 1. Research projects regarding predators, predator control practices, and pronghorn on or near Hart Mountain, Oregon, USA.

Literature Citation	Studied Adults	Studied Fawns	Major Findings and or Comments
Einarsen 1949	X	X	Coyotes were a formidable foe. Generally did not limit pronghorn numbers
Hansen 1955	X	X	Observed many carcasses. Main reason for losses not determined.
Yoakum 1957	X	X	Listed all know factors for mortality. Reported pronghorn densities to forage conditions.
Compton 1958	X	X	Conducted intensive studies of predation. No evidence that a serious problem.
Trainer et al. 1983		X	Coyote predation related to decrease in fawn recruitment rates.
Willis 1988		X	Fawn survival increased after aerial gunning of coyotes.
Yoakum et al. 2004		X	10 year average fawn losses to predation were around 50% but herds continued to increase.

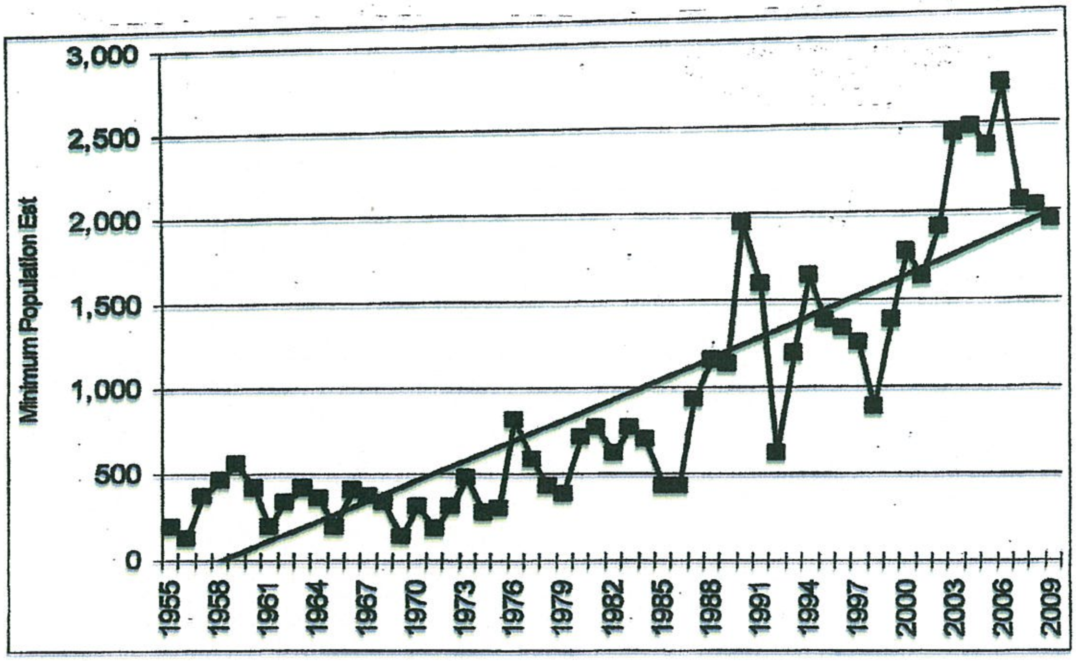

Figure 1. Estimated pronghorn populations and long-term trend from 1955 to 2009 on the Hart Mountain National Antelope Refuge, Oregon (Collins 2009).

ABSTRACTS
SESSION 1: PRONGHORN STATUS AND UPDATES

Current Federal Plan for the Pronghorn in Mexico

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ABSTRACT There is a new federal plan for pronghorn in Mexico named Programa de Acción para la Conservación de la Especie – Berrendo (PACE-BERRENDO) (Species Conservation Action Program-Pronghorn). It was prepared in 2009 by specialists in pronghorn conservation, management, and biology. That year was also the pronghorn's year. This plan is part of another wider program headed by the Comisión Nacional de Areas Naturales Protegidas (CONANP; Natural Protected Areas National Commission), via Dirección de Especies Prioritarias para la Conservación with the: Programa de Conservación de Especies en Riesgo (PROCER) (Species at Risk Conservation Program), which advocates the development and implementation of 30 species at risk actions programs during this federal administration. The current PACE-BERRENDO has, besides the biological and ecological generalities of the species (description, evolution, food habits, distribution, etc.), a description of threats and actions to revert the current low status per population. Those actions are distributed in 6 conservation strategies: Restoration, Protection, Management, Culture for Conservation, Outreach, and Administrative Issues. The PACE is also planned to be evaluated periodically and updated with achievements, under a vision of adaptive management. This program is based on the previous federal plan which was updated with the team of Mexican specialists on the species. It contains a brief history for each state where pronghorn inhabit or were transferred. There is also a technical card for the species beside the whole document in the internet. Their e-addresses are:
http://www.conanp.gob.mx/pdf_especies/pace_berrendo.pdf
http://www.conanp.gob.mx/pdf_especies/berrendo.pdf
Some of the goals included in the PACE are recovery of the different populations of pronghorn in Mexico; including major efforts conducted with the Peninsular Pronghorn, continuation of Coahuila population recovery through enhancement of the populations previously translocated, management of the Chihuahua populations, and continuation with collaboration in Sonora. It is very important to include habitat conservation using available schemes from Mexico, the Natural Protected Areas, and the Conservation Management Units (UMAs); with the participation of all social sectors: academia, land owners, and government in its different levels.

Wind River's Pronghorn: A Modern Conservation Success Story

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ABSTRACT The Wind River Reservation is home to the Eastern Shoshone and Northern Arapaho tribes. Located in west-central Wyoming, Wind River encompasses a variety of habitats from low elevation saltbush deserts to sagebrush steppe to high mountain alpine situated along the spine of the Continental Divide. The reservation was established by treaty in 1868 with the Eastern Shoshone. The Northern Arapaho were placed on Wind River in 1878 and became equal partners with the Shoshone in 1896. Pronghorn currently occupy over 456 thousand hectares (1.2 million acres) of habitat on the reservation. During the 1960s and 70s, the absence of any restrictions that regulated harvest resulted in a major decline of big game species, including the pronghorn. By 1980, there were less than 800 pronghorn reservation-wide. With the imposition of hunting regulations by the Secretary of the Interior in 1984, the "Game Code" as it was called resulted in a rapid increase in pronghorn and other big game and laid the foundation for modern wildlife management. Cooperation with the state of Wyoming increased following the advent of the Code - for instance, the Wyoming Game and Fish Department provided pronghorn for transplant to Wind River. To help expand distribution, 348 pronghorn were transplanted into depopulated areas between 1986 and 1993. Cooperation continued to develop between the WGFD and the Tribes and has included such efforts as bighorn sheep transplants, CWD testing, hunter education programs, and grizzly bear trapping and remote camera surveys to name a few. A recent aerial survey indicated the population of pronghorn is now ~7,000. Since only enrolled members are allowed to hunt on Wind River, acquiring adequate harvest of pronghorn is a challenge since interest from the pool of 1,100 hunters is minimal due to the abundance of and greater interest in elk and deer. The Game Code ensures abundance, both quantity and trophy quality, of pronghorn and other big game for current and future residents of Wind River.

SESSION 2: FUNDING PROGRAMS AND EDUCATION

National Pronghorn Interpretive and Visitors Center

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ABSTRACT The National Pronghorn Interpretive and Visitors Center (NPIVC), an incorporated 501 (c) (3) nonprofit organization, established in 2008 in Rawlins, Wyoming, is dedicated to educating the public about the biology, habitat and welfare of the pronghorn and constructing a facility to house interactive exhibits, a multi-screen theater, a research library, a game warden exhibit, a gift shop, 24/7 public restrooms, offices and a visitors center. In light of the current economic times, the NPIVC has determined that remodeling an existing building, rather than building a new structure, would be a wise financial strategy. It would also be beneficial economically to the community to repurpose a building that has been vacant for more than 20 years, as well as serve to rejuvenate a blighted strip center. The former Safeway building located in the Rawlins Plaza is easily accessible off the Rawlins East I-80 exist and located along Highway 287, which is the gateway to Yellowstone for many travelers. With

about 37,000 square feet of unoccupied space in the building, remodeling plans would include creating a multi-use facility that would include a convention center for large public and private gatherings. The Carbon County Visitors Council office will be housed in the facility and they will team up with the NPIVC to provide visitorship information about Wyoming and Carbon County to travelers. The NPIVC hopes to partner with the Wyoming Game & Fish Pronghorn Working Group to develop a pronghorn research library for wildlife biologists, as well as a Game Warden exhibit. The architecture of the existing mall lends itself to integrating solar energy into the remodeling plans. In light of the fact that pronghorn winter in Carbon County because the wind blows the snow off the sagebrush, their primary diet, wind power would also be a utilized to provide an additional energy source. By using alternative energy resources the mall could become energy neutral. It will also serve as a model for retrofitting an existing structure with renewable resources rather than "building green." It is our goal to incorporate the Green Building Initiative guidelines to make the Rawlins Plaza an energy-efficient, environmentally sustainable business facility in our community. The NPIVC is seeking funds to complete the renovation of the former Safeway Building. A film promoting this endeavor has been developed and will be shown to the public at the 24th Biennial Pronghorn Workshop: Partnering for Pronghorn. Donations and questions concerning the NPIVC should be directed its board members.

Wyoming Game & Fish Department's Private Lands Public Wildlife Access Program

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Hunter and angler numbers have been declining over the past few decades nationwide. Two of the most crucial factors for this include declining access to private land and personal time. The Wyoming Game and Fish Commission addressed these issues by creating the Private Lands Public Wildlife (PLPW) Access Program. The goal of the PLPW Access Program is to enhance and/or maintain public hunting and fishing access onto private and landlocked public lands. This is accomplished by enrolling private landowners into the PLPW Access program to allow free public access to their property. In return, landowners receive a small monetary payment, increased law enforcement presence, and the management of the sportsmen and women. Hunters and anglers now have access to millions of acres that can be located by utilizing the Department's website and publications. Hunters and anglers now have a multitude of options that they can utilize close to home. They no longer have to search for the property owners, gain access, and determine the property boundaries on their own. The Department has already gained permission for them as well as provided information on where and when to go.

Wyoming Wildlife Natural Resource Trust Program

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ABSTRACT The Wyoming Legislature created the Wildlife and Natural Resource Trust in 2005. Funded by interest earned on a permanent account, donations, and legislative appropriation, the purpose of the program is to enhance and conserve wildlife habitat and natural resource values throughout the state. Any project designed to improve wildlife habitat or natural resource values is eligible for funding. The Wildlife and Natural Resource Trust is an independent state agency governed by a nine-member citizen board appointed by the Governor. Legislative oversight is guided by a select committee of six members, three each from the House and Senate. Beginning with the first allocation of project dollars in June 2006, the WWNRT has funded 160 projects in all 23 counties of the state. Just over $14 million has been allocated from WWNRT funds, with a total project value on the ground in excess of $105 million. Every dollar spent by the WWNRT is matched on average with $6.50 from other sources, and WWNRT projects maintain agricultural operations, conservation businesses, and other job-producing enterprises, including the tourism industry. More than 60 separate entities have received funding from the Wyoming Wildlife and Natural Resource Trust program. The greatest number of projects funded has been sponsored by conservation districts, programs that are guided by local people.

SESSION 3: PRONGHORN MANAGEMENT AND INVENTORY TECHNIQUES

Evaluation of Line-transect Sampling for Densities of Pronghorn in Alberta

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ABSTRACT Historically, surveys for pronghorn (*Antilocapra americana*) in Alberta have been conducted as permanent strip-transect trend surveys. Although this method provides a general indication of population increase or decrease over time, it likely underestimates true population abundance as the magnitude of the error is unknown. Distance sampling (line-transect) methods can provide both a measurement of precision and an estimate of sightability for abundance estimates. In July 2009, we collected GPS point data for initial herd locations during a trend survey and analyzed data using the software program, Distance 5.0. The strip-transect survey estimated population density within trend blocks to be 0.54 pronghorn/km^2 while the distance sampling method provided a density of 0.70 (0.039 SE) pronghorn/km^2. We estimated an effective strip width of 493 m on either side of the aircraft and a detection probability of 0.62 across the entire 1600 m strip. Our results suggest that collecting line-transect information while conducting a strip-transect trend survey could provide useful information in interpreting the long term data set. While the distance sampling method shows a higher density with high precision, the current population model employed in Alberta must be revisited before new density estimates are used in calculating allowable harvest.

An Electronic Data Recording System to Aid in Improving Population Estimates from Aerial Surveys

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ABSTRACT Most statistically rigorous techniques for reliably estimating abundance of wildlife populations require the collection of additional information for bias reduction and increased precision. In the context of aerial surveys, such information must be recorded in as efficient a manner as possible that maintains safety and minimizes distractions to observers and pilots due to the limited time available to record observations from a moving platform. We developed an electronic data capture system for recording observations of pronghorn (*Antilocapra americana*) using Wyoming's aerial line transect survey procedures. These surveys are flown in fixed-wing aircraft with strutted high wings. In addition to calibrated strut and window markers, hardware for the aircraft system includes a Bluetooth-enabled laser rangefinder, a custom bracket to mount the rangefinder to the strut, a Windows Mobile Pocket PC with an internal GPS, touchscreen, and Bluetooth, an external antenna, and a RAM-mount for holding the Pocket PC to the yoke or airframe. The laser rangefinder can be powered via rechargeable battery handles or plugged into a cigarette lighter socket. We had the software program CyberTracker customized to automatically record height above ground level (AGL) via a Bluetooth serial connection between the rangefinder and the Pocket PC. We developed a CyberTracker application that is operated by finger on the touchscreen of the Pocket PC while in flight. GPS positions are automatically recorded. Additionally, we record transect endpoints, perpendicular distance bands for each observation, and cluster size. The system can be operated by the pilot in 2-seat aircraft restricted to a single observer, or by a dedicated crew member assigned to operate the system in multi-seat airplanes. This system is relatively portable to different airplanes. Once the flight is complete, data can be immediately downloaded to the desktop module of CyberTracker where locations can be converted to the desired system and projection (e.g., UTMs), exported to an Excel spreadsheet or another format, and ultimately imported to the program Distance for analysis where estimates are corrected for detectability. CyberTracker and Distance are available free of charge. One advantage of the current system is that heights AGL are automatically recorded, enabling options for advanced analyses. The CyberTracker system can be easily modified by the user to incorporate additional information and different survey designs. In 2007, the Wyoming Game and Fish Department incorporated this data capture system into our aerial line transect surveys for pronghorn population management. This system, or a modification of it, has been employed in other states and other types of wildlife surveys. Training of observers and pilots in the use of this system and the equipment is essential.

Potential Use of Unmanned Aerial Vehicles for Surveying Pronghorn Populations in Southeastern Wyoming

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ABSTRACT The potential exits to adapt unmanned aerial vehicle technology to wildlife survey applications. The use of thermal imaging sensors allow for nocturnal surveys of pronghorns and may reduce the effects of animals moving from the flight path in response to approaching aircraft. Future

plans include using an unmanned aerial vehicle equipped with a high resolution thermal sensor to fly overlapping transects at night over a portion of a pronghorn herd unit in southeastern Wyoming in an attempt to obtain, as near as possible, a complete count of the pronghorn population within the designated area. Beginning at daylight, a traditional line transect survey would then be conducted over the same area and results compared between the two techniques.

Notations on a Recent Translocation of Pronghorn from Nara Visa, New Mexico to Coahuila, Mexico

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ABSTRACT In February 2009, 122 pronghorn were translocated from New Mexico to three different localities in Coahuila, Mexico. Forty four of these animals were moved to the ranch "Rincon de la Madera." Mexican federal laws require to put the animals in quarantine enclosures. Pronghorns were placed in a 200 ha enclosure with a hill in the middle. Transportation of the animals lasted 36 hours. Within 4 days of being released 3 animals died due to potential capture myopathy. However, 8 days after release, total mortality was 38%. Samples of tissues and fluids were collected during necropsies of two pronghorns. Two others were treated; one of which survived. Pathology, urine analysis and levels of sodium in vitreous humor confirmed the diagnosis of severe dehydration. Although pronghorns were provided with supplemental food and water, stress associated to a different habitat and segregation were likely the causes related to reduced water intake. Pronghorns that remained together, a group of 18, survived the larger enclosure. A group of 8 animals was placed in a much smaller enclosure of 2 ha and presented no mortalities. Serological results showed previous exposure to Blue Tongue (13%), Chlamydia (13%), PI-3 (16%), Pasteurella multocida (3%), Manheimia haemolytica (6%). After the animals learned how to obtain water and food, mortality ceased. Surviving does gave birth to 16 fawns from which 2 died. For future translocations in cases where the habitat is dissimilar, smaller temporary enclosures of 1 ha per 2 – 4 animals, might be preferred to larger ones. However these enclosures will need to have certain characteristics in order to reduce stress in the animals.

Hunting and Trophy Horn Size in Pronghorn

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ABSTRACT Pronghorn horn sheaths are unusual among ungulates in that much of the growth takes place during the winter months. In past presentations we have demonstrated that horn size depends on genetics, winter temperatures and age with younger animals (ages 4-6) tending to be larger than older bucks (ages 6+). To evaluate the effects of winter temperatures on trophy occurrence we compared the percentages of Boone and Crockett Club trophy bucks in the total buck harvest in two northern states (Wyoming and Idaho) with two southern states (Arizona and New Mexico). Although the percentage of trophy animals was significantly lower in the northern states than in the southern states, this

percentage significantly increased ($P<0.01$) over time in all four states ($r^2 = 0.19$ for ID, $r^2 = 0.49$ for WY, $r^2= 0.56$ for AZ and $r^2=0.73$ for NM). Possible reasons for this progressive increase in trophy bucks include increasing minimum temperatures and/or increased interest in trophy recognition. Evidence favoring the former explanation is the increasing percentages of trophy bucks taken in the northern states. Whatever the reason, hunt pressure at recent levels does not appear to affect the number of trophy animals available.

Pronghorn Survival in Wyoming

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ABSTRACT We estimated annual survival of adult female pronghorn (*Antilocapra americana*) in 2 hunted populations within Wyoming from April 2003-May 2006. Annual survival rates were also calculated excluding harvested animals. We captured and radio-collared 60 adult ($\geq$1 year old) female pronghorn from the Medicine Bow Herd in southcentral Wyoming and 60 from the Sublette Herd in southwest Wyoming. A sample size was maintained of approximately 60 animals from each herd throughout the study. Pronghorn were monitored with low-intensity aerial telemetry (1 location/8 weeks) to document survival and mortality. Annual survival estimates including harvested animals averaged 81% for the Medicine Bow Herd and 75% for the Sublette Herd. Mean annual survival estimates excluding harvested animals were 85% and 83% for the Medicine Bow and Sublette Herds, respectively. The Sublette Herd Unit is currently undergoing large-scale energy development and the Medicine Bow Herd Unit is proposed for large-scale coal bed methane development in the near future. Knowledge of the survival of the adult female cohort will assist managers with making decisions regarding herd sustainability during these dynamic times.

SESSION 4: PRONGHORN FORAGE AND HABITAT MANAGEMENT

Where are all the Pronghorn Fawns: Is Low Fawn Recruitment an Issue Revisited?

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ABSTRACT Previously, pronghorn (*Antilocapra americana*) fawn recruitment rates from 1948-1977 were summarized from various management agencies in Canada and the United States, with lows ranging from 43 (fawns per 100 does) in Texas to highs of 105 in South Dakota. The summary postulated that fawn recruitment may differ among major vegetative communities. We build upon these jurisdictional reports by comparing fawn recruitment rates reported from 1948-1977 with our findings for 1978-2008. We also examine fawn recruitment rates for 4 major vegetative communities occupied by pronghorn. Pooled data of mean fawn recruitment rates differed from 1948-1977 compared to those from 1978-2008. Our results show that recruitment rates differed among the 10 jurisdictions, with the 10 jurisdictions being placed into 6 groups with similar means. Nine of 10 jurisdictions had higher fawn recruitment rates from 1948-1977 compared to 1978-2008. There were major differences in mean fawn recruitment rates among the 4 vegetation communities, with each

community different from the others. We discuss reasons why these declines may be occurring and discuss management implications.

The Role of Preformed Water in American Pronghorn Antelope Diets in a Semidesert Grassland

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ABSTRACT Since the 1930s water needs of pronghorn antelope (*Antilocapra americana*) have been the subject of debate, yet very little data exists on free water requirements. Some biologists have suggested that pronghorn feed at night to increase preformed water (plant moisture) intake, thus decreasing dependence on freestanding water. Our objectives were to determine pronghorn seasonal and diurnal feeding patterns, and if night feeding is an advantage in water allocation. In March, May, June and August of 2008 and 2009 we collected fresh fecal and plant material within 100 meters of observed pronghorn during the day (1400-1600) and at night (0300-0500) on the Agua Fria National Monument, Arizona. We calculated plant composition and preformed water in the pronghorn diets. In 2009 we placed 2 cameras at water tanks to capture drinking patterns. Plant moisture analysis showed a significant difference between night and day, as well as higher moisture content during March, May and August. Photographs showed percent tank visits per day increased as temperature increased and relative humidity decreased. Pronghorn were most active in the early morning and evening. Although they do not typically feed at night, pronghorn appear to need more water during the hot, dry periods and little or no water during cool, moist periods. With additional information managers can more accurately determine optimal amount and timing of water augmentation in pronghorn habitats.

Diet Composition and Quality of Pronghorn in Southern Arizona

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ABSTRACT Over the past 20 years, pronghorn (*Antilocapra americana)* populations in Arizona have declined from around 12,000 individuals to around 8,000 individuals. Recruitment into the population appears to be the main factor affecting the decline. The objectives of this study were to evaluate and compare the diet composition and quality of *A. americana* pronghorn in two game management units (GMUs) in southern Arizona; one with chronically poor recruitment (GMU 36B), and one with higher recruitment (GMU 34B). We described diet composition using microhistological analysis of fecal samples corrected for differential digestibility during four biological periods (late gestation, parturition, peak lactation, and conception) over two years (2003 and 2004). Concurrently, we conducted nutrient analysis of available forage as composited diets for dry matter digestibility (DMD), digestible protein (DP), and metabolizable energy (ME). We used these data to evaluate the adequacy of the diet to meet protein and energy requirements of an adult female, and to determine if significant differences existed in the diets between GMU 34B and 36B. GMU 34B had a significantly higher species richness both years (23.8 and 24.69 vs. 21.1 and 19.5, for 2003 and 2004 respectively). Forbs

were the dominant forage class (62.7 to 97.2%) across all biological periods and years. Significant differences in diet composition were detected in the GMU by species by bioperiod by year interaction. We found little difference in either ME or DP intake between GMU between years. In all cases the diets were insufficient to meet an adult female's nutrient requirements during all biological periods.

Seasonal Forage Use/Availability by Pronghorn Antelope in North Central Arizona

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ABSTRACT We studied forage production, food habits, and fecal indices of pronghorn (Antilopcapra americana) during 2003 and 2004 on 2 study sites in central Arizona. Diet composition (microhistological analysis of fecal samples) and selection relative to availability were investigated during gestation and lactation. Forage production ranged from 69-304 kg/ha. Forbs made up a majority (47 %) of the biomass in 2003, whereas grasses made up the majority (51 %) in 2004. Pronghorns showed preference for forbs and avoided grasses on both study sites. We also determined baseline profiles of fecal nitrogen (FN) and 2,6 diaminopimelic acid (DAPA) during critical periods for females during 2003-2004. Fecal DAPA ranged from 0.741 to 1.802 (mg/g) and FN ranged from 1.009 to 1.603 (%). Fecal DAPA showed a yearly effect (P = 0.001) but no site effect (P = 0.56). Fecal nitrogen showed a site effect (P = 0.002) but no yearly effect (P = 0.11). Fecal DAPA during our study reached higher levels than those of other healthy ungulate species, while FN did not reach as high a level. We found a positive correlation between FN and DAPA (P = 0.02), while neither index were correlated to precipitation. During our study fawn recruitment increased from 28 fawns/100 does during year one to 51 fawns/100 does during year two. Forage conditions appeared optimal for fawn recruitment. Our findings suggest that a diversity of plant species is optimal pronghorn habitat and maintenance of habitat diversity is important.

A Model for Habitat Based Population Management

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ABSTRACT Changes are occurring throughout the West in critical wildlife habitats. Most changes, attributable to a variety of natural and anthropogenic agents, most often result in decreased carrying capacity and less productive pronghorn populations. These factors lead to questions regarding proper response by wildlife managers and the potential to reverse declining trends. These questions are daunting and pose new and important challenges to resource managers. Certainly, it is unknown whether, through management actions or continued changes in climate, trends in vegetative condition will improve. It is certain doing nothing and simply hoping for the best is both irresponsible and short-minded and will most likely lead to further reduced carrying capacities for future generations. I

present data and an analysis of shrub condition parameters collected on permanent transects where vegetative production and utilization data has been collected since 1993. Finally, I make recommendations to shift to a "Habitat-Based Population Management" approach.

Genetic Variation of Pronghorn Populations in Texas

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ABSTRACT Texas Parks and Wildlife Department (TPWD) established approximately 100 herd units in the 1970s using large land holdings, historic habitat conditions, survey data, and suggested movement barriers. Today, these same herd units are the basis of Texas' pronghorn survey and harvest management program. An updated assessment of pronghorn population structure is needed. We sampled 351 pronghorn throughout their distribution in Texas during the 2007-2008 harvest seasons and genotyped 344 pronghorn at 8 microsatellite loci. We performed 6 analyses in order to assess geographic patterns of genetic similarity and to investigate the spatial scale of population structure in Texas. We detected lower levels of polymorphism and moderate levels of genetic diversity within sampled pronghorn populations, and a small but significant level of genetic structure among populations (F_{ST} = 0.034). Bayesian analyses of population structure revealed that sampled populations could be clustered into 2 groups and a correlation (r^2 = 0.024) between genetic distance and geographic distance among populations was not found. We concluded that pronghorn population structure in Texas is not strongly differentiated. This may suggest that either gene flow is occurring among and within populations, historical genetic structure is still being detected, or previous pronghorn translocations has affected the genetic structure of pronghorn populations in Texas. Future research should involve more molecular markers, and increased sample sizes from the Panhandle and Rocker b populations. Overall, information from this project can aid TPWD in delineating pronghorn metaherd units and may assist in future trap, transport, and translocation projects in Texas.

Pronghorn Response to Wind Energy Development on Crucial Winter Range in South-central Wyoming

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ABSTRACT Evaluating the influences of wind energy development on wintering pronghorn (*Antilocapra americana*) is essential given the limited availability of, but critical importance of winter ranges to pronghorn populations. Better understanding these relationships will help guide mitigation

and management decisions for pronghorn that co-occur with wind energy development. In spring and summer 2010, PacifiCorp Energy will install 74, 1.5 megawatt wind turbines on crucial pronghorn winter range on the 62.2-km^2 Dunlap Ranch in Albany County, Wyoming. Because pre-development data are not available, our study is a displacement design with an offsite comparison. Our offsite comparison encompasses 330.4-km^2 of crucial pronghorn winter range devoid of energy development south of Walcott Junction in Carbon County, Wyoming. We initiated our study in January 2010 by capturing 35 doe pronghorn in each study area to attach store-on-board GPS collars for analysis. These collars will detach in spring 2012, thus providing information across 3 winters (2010, 2010–2011, and 2011–2012). The primary objectives of our study are to: (1) compare pronghorn population use of crucial winter range with and without wind energy development in south-central Wyoming across 3 winters to evaluate pronghorn displacement related to wind energy development, (2) evaluate habitat effectiveness of pronghorn crucial winter range with and without wind energy development in south-central Wyoming across 3 winters, and (3) evaluate displacement on a site basis, through comparing pronghorn use of habitats in the Dunlap Ranch wind energy development area during 1 winter of construction activities and 2 winters of post-construction activities. Here we present an overview of our study to facilitate dialogue with others interested in similar research.

SESSION 5: IMPACTS AND IMPEDIMENTS TO PRONGHORN, AND MISC. TOPICS

Pronghorn and Petroleum: Have We Reached a Breaking Point in the Upper Green River Basin of Wyoming?

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ABSTRACT At a time when the world's energy demands are growing, great uncertainty remains about the effects of energy development on wildlife and strategies to minimize consequent impacts. In many cases, efforts to minimize potential harmful effects on wildlife are hampered by limited information on past trends in ungulate abundance, and factors influencing these trends. Due to ever increasing energy development in the Upper Green River Basin of western Wyoming, more rigorous biological data on wildlife are needed for prudent land use planning. To understand pronghorn use of winter range, we first examined distribution patterns in relation to ecological and topographical factors and snow depth. Second, we used satellite imagery to evaluate changes in the level of gas field development up to 2005, and then annually to 2009. We estimated the direct habitat loss associated with construction of well pads and roads in conjunction with the spatial pattern of habitat loss and fragmentation. Third, we looked at factors such as traffic volume that may contribute to indirect habitat loss by influencing pronghorn behavior. Finally, to estimate population-level responses, we used information from 250 GPS-collared adult, female pronghorn from 2005-2009 to develop resource selection probability function (RSPF) models to determine gas field affect on pronghorn winter habitat use. We will discuss the results of the RSPF models and how we used the models to evaluate the extent to which habitat classified as high use is concordant with areas designated crucial winter range by WGFD. Finally, while other factors also govern population performance, we elected to examine

four relatively simple surrogate measures of population performance for >400 collared, adult females in response to ambient conditions -- stress, body mass, pregnancy, and survival -- and their potential variation between pronghorn from control (i.e. no gas fields) and experimental (i.e. gas fields) sites. We will report the results of the comparisons of these measures of population performance between the two groups from 2005-2009.

Cumulative Effects of Development on Pronghorn Distribution and Movements across the Northern Sagebrush Steppe

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ABSTRACT The Northern Sagebrush Steppe (NSS) represents northern limits of the Great Plains, which spans across the transboundary region of the U.S. and Canada. This project is a cooperative venture between wildlife and land management agencies in the borderlands of Montana, Saskatchewan, and Alberta, 2 universities, and non-government conservation organizations. Unlike most others, this project is pinned to an inter-jurisdictional accord among wildlife management agencies: the NSSI M.O.U. Quantitative and applicable approaches to assess cumulative effects of development on wildlife and their habitats are needed within the NSS. Currently, our project has initiated the 3rd year of monitoring collared pronghorn within the Frenchman Creek landscape unit which spans across Montana and Saskatchewan. The objectives of this research are: 1) Assess anthropogenic and environmental contributors to model pronghorn habitat selection at multiple scales across the NSS; 2) Assess anthropogenic and environmental contributors to model pronghorn migratory pathways between seasonal ranges within and between landscape units; 3) Identify key linkage areas that are important for prioritizing on the ground conservation actions; and 4) Propose a science-based design for landscape level conservation across the NSS. Through the first 2 years of data collection, we made several key observations for pronghorn conservation at the periphery of their range: 1) Northern populations utilize habitat in both the U.S. and Canada and as such, should be managed from an ecosystem perspective; 2) In the face of severe winters, driven or forced migration is a crucial strategy for pronghorn population sustainability; 3) Specific prairie corridors are being identified to link critical wintering habitat; and 4) Identifying anthropogenic barriers such as fences, roads, and canals in key linkage areas can prioritize on the ground action. Habitat selection and movement models can be used as decision tools for evaluating landscape conservation planning options. This will be important for mitigating future development scenarios across the NSS transboundary region.

Green River Valley Land Trust's Corridor Conservation Campaign

JORDAN VANA, Green River Valley Land Trust, P.0. Box 1580, Pinedale, WY 82941, USA

ABSTACT Wyoming has unparalleled wildlife populations. From moose and elk to bald eagles and cutthroat trout, more than 800 species call the state home. These species provide countless benefits to Wyoming communities and represent a priceless legacy for future generations. Wyoming enjoys unparalleled wildlife populations thanks, in large part, to agriculture. The state's working lands not only provide vital habitats for most species, but also critical links through which they must move to survive. The vast majority of the state's species use different habitats at various times in their lives. For some, like the spotted frog, these habitats lie relatively close together. For others, like the pronghorn antelope and wolverine, they lie hundreds of miles apart. The ability to travel safely between these habitats often means the difference between life and death. Disconnected habitats isolate, and eventually suffocate, species' diversity and abundance. Development threatens wildlife's ability to move. Development degrades, fragments, and restricts habitat, increases interspecies competition for scarce resources, decreases connectivity, eliminates prey base, and removes what we have before we know it's gone. Developments like subdivision, fencing, roads, and commercial centers cause 8 of the 13 major threats to wildlife identified by the Wyoming Game and Fish Department in its Comprehensive Wildlife Conservation Strategy. Balancing this development with healthy wildlife populations represents a significant challenge - and opportunity - for the state. The Green River Valley Land Trust's (GRVLT) Corridor Conservation Campaign addresses this challenge by maintaining viable migration routes for Wyoming's wildlife and connecting habitats these species need to survive. GRVLT is a private, nonprofit organization that works with landowners to conserve Wyoming's natural and agricultural resources. Since 2000, GRVLT has worked with more than 45 families to conserve nearly 30,000 acres of working ranchland, wildlife habitat, and scenic views in western Wyoming. GRVLT is one of the Top 100 land trusts in the country in terms of acreage conserved, and one of the first accredited land trusts in nation. Through the Corridor Conservation Campaign, GRVLT and its partners are working to make 500 miles of existing fencing in key western Wyoming wildlife migration routes wildlife- and livestock-friendly at no cost to landowners. Wildlife- and livestock-friendly fences are generally no more than 42 inches tall. They have a smooth bottom wire at least 16 inches off the ground so pronghorn can easily "scoot under." They have at least 10, but preferably 12 inches between the top 2 wires so deer and other animals can jump the fence without catching their hind legs.

GRVLT's Campaign works by:

1. Identifying key wildlife migration routes based on sound-science;
2. Inventorying existing fences within those routes with landowner permission to determine whether and to what extent the fences impede migration;
3. Talking with each landowner about modifications to make their fences passable for wildlife and functional for the landowner's needs;
4. Hiring fencing contractors to modify the fences <u>at no cost to landowners</u>; and
5. Monitoring the modified fences with game cameras to ensure that animals can easily negotiate them.

GRVLT's Campaign employs prudence, balance, and common sense to achieve on-the-ground results efficiently, effectively, and immediately. In 2009, the Campaign worked with landowners to modify 75 miles of existing fence in the historic "Path of the Pronghorn" migration route between Grand Teton

National Park and southern Sublette County. Pronghorn have used this route to move between summer and winter range for more than 6,000 years. Their migration stands as the longest terrestrial animal migration in the 48 contiguous states and the 3rd longest non-avian migration in the world. Going forward, the Campaign will work with landowners to modify approximately 200 miles of fence along a key migration route for mule deer and other big game at the foot of the Wind River Mountains. GRVLT intends the Corridor Conservation Campaign to serve as a model for collaborative efforts throughout the Northern Rockies. The Campaign has brought together a host of non-traditional partners to implement a concrete, affordable, on-the-ground solution that landowners and others can use to maintain the state's migration routes if they choose.

Location Density at a Landscape Level Scale in Montana

ANDREW JAKES, Faculty of Environmental Design, University of Calgary, Calgary, AB, T2N 1N4, CA
ERIN POOR, Master's Candidate, *Duke University*, Durham, North Carolina, 27706, USA
COLBY LOUCKS, Deputy Direct of Conservation Science, *World Wildlife Fund*, 1250 24th Street North West, Washington D.C., 20037-1193, USA
CORMACK GATES, Faculty of Environmental Design, *University of Calgary*, Calgary, AB, T2N 1N4, CA

ABSTRACT It is believed that barbed and woven wire fences, common structures across North American western prairies, sage steppes and rangelands, act as impediments to pronghorn daily and seasonal movements. Furthermore, fencing may influence pronghorn habitat selection. Because of these potential impacts to pronghorn, we felt it was essential to include fences in both pronghorn movement and habitat selection models across our study area. At this time, no geospatial fencing data is available at landscape level scales. As such, we constructed a fence model using a series of land tenure assumptions for Blaine, Valley and Phillips counties, an area of approximately 37,589 km^2, in north central Montana. Field data was collected in summer 2009. Randomized 3.2 km long transects (n=738) on both paved and unpaved roads were driven to collect information on habitat, fence densities and fence type. GPS locations were recorded at every interior fence convergence to roads and where roadside fencing changed in presence/absence or fence type. Using GIS, the initial fence model consisted of parcel boundaries which were then merged and/or split depending on ownership, size, neighboring parcels and township boundaries. Local knowledge of land ownership and land use assisted in improving the final model. Using fence GPS locations, the model was validated for fence presence/absence accuracy using four buffer sizes: 15 meters, 25 meters, 50 meters and 100 meters. Fence presence accuracy was greater than 96% at the 100 meter distance, and greater than 82% at the 15 meter distance. We believe the high correspondence between the modeled fencing and field survey data indicate that using similar techniques will assist in creating robust fence layers across a broad, landscape level scale. A fence layer benefits both wildlife and land managers to assess effects to pronghorn at various scales. In addition, management practices could be prioritized by identifying high fence densities along migratory pathways, an ecological necessity to sustaining pronghorn populations at the periphery of their range.

Internal Parasite Concentrations of Pronghorn in Trans-Pecos, Texas

BILLY TARRANT, Texas Parks and Wildlife Department, Alpine, TX 79830, USA
LOUIS A. HARVESON, Borderlands Research Institute-Natural Resource Management, Sul Ross State University, Alpine, TX 79832, USA
SHAWN GRAY, Texas Parks and Wildlife Department, Alpine, TX 79830, USA
KENNETH WALDRUP, Texas Department of State Health Services Zoonosis Control, El Paso TX 79901, USA

ABSTRACT Texas Parks and Wildlife Department (TPWD) Wildlife Division staff survey pronghorn annually to document population structure and issue harvest permits to landowners. In the Trans-Pecos region of Texas, pronghorn population fluctuations have typically been associated with precipitation patterns and associated habitat conditions. In 2008, a die-off of approximately 2,500 animals was documented in the Marfa Plateau area, after an extended dry period and unseasonably late freeze in May. In 2009, despite improved range conditions, TPWD biologists recorded only 9.4 fawns per hundred does in the herd units most affected by the previous year's die-off. Personnel from TPWD and the Borderlands Research Institute - Natural Resource Management (Sul Ross State University) sampled 102 hunter-harvested pronghorn to analyze for internal parasites, selenium serum concentrations, and blood and liver copper concentrations. Copper blood levels averaged 0.67 ppm, and copper liver levels averaged 7.8 ppm. Selenium serum levels averaged 133.8 ppb. Entire abomosal contents and fecal samples were examined for internal parasite loads. Fecal egg counts were determined using a standard fecal flotation technique, and counts (*Haemonchus spp*.) averaged 57.8 eggs per slide. Eighty two abomasums were examined and 78 (95%) were found to contain *Haemonchus spp*. The average number of individual *Haemonchus spp*. counted per pronghorn abomasum was 552.4, with a range of 0-4,080 worms per sample. Based on these results, we believe that *Haemonchus spp.* may be an additional factor affecting population dynamics of pronghorn in Trans-Pecos region of Texas. Further research and surveillance is needed to determine parasite significance and make appropriate management recommendations.

Physical and Chemical Capture of Pronghorn

TERRY J. KREEGER, Supervisor Veterinary Services Branch, Wyoming Game and Fish Department, 2362 Hwy 34, Wheatland, WY 82201, USA

ABSTRACT Pronghorn are physically captured either by net guns or corral traps. Individual pronghorn can easily be captured using net guns. Net gunning requires an experienced helicopter crew and can be extremely dangerous. Injuries to pronghorn are not uncommon with net gunning, but mortalities are usually low (< 3%). Costs can exceed several hundred dollars per animal. Corral traps can catch large numbers of pronghorn, but require significant planning to site and several hours to erect. Additionally, successful trapping requires the use of a helicopter and large numbers of personnel. Injuries, mortalities, and overall costs can be high. Chemical immobilization of pronghorn is not common because, under most circumstances, free-ranging pronghorn cannot be approached close enough for successful darting. Chemical immobilization is the most successful when pronghorn have grown accustomed to human activity (e.g., urban settings, military bases, golf courses, etc.) and be closely approached using a vehicle or other device with which the pronghorn are familiar. Although cyclohexane drugs (ketamine, tiletamine) combined with potent alpha-adrenergic sedatives (xylazine, medetomidine) have been used to chemically immobilize pronghorn, their overall efficacy is poor. The preferred drugs are the potent opioids (carfentanil, thiafentanil, sufentanil) with or without alpha-

adrenergic sedatives. Per animal cost using chemical capture is usually the lowest of the capture methods, but still can be several hundred dollars. Medical problems using either physical or chemical capture include hyperthermia, respiratory depression, capture myopathy, shock, and wounds.

POSTER PRESENTATION ABSTRACTS

Surgical Sterilization of Coyotes offers a Non-Lethal Alternative

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ERIC M. GESE, USDA/APHIS/WS/National Wildlife Research Center, Department of Wildland Resources, Utah State University, Logan, Utah
MARY M. CONNER, Department of Wildland Resources, Utah State University, Logan, Utah

ABSTRACT Trends in public opinion demonstrate a need for non-lethal alternatives when managing wildlife, but practical solutions can be challenging to deliver. Concerns have stimulated research into sterilization of wildlife to attenuate problem situations. Surgical sterilization of coyotes (*Canis latrans*) has been shown to reduce predation on domestic sheep. A similar model which could be utilized to reduce predation on pronghorn (*Antilocapra americana*) fawns may be important for wildlife managers when lethal control of coyotes is not an option. We investigated whether sterilizing coyotes would reduce predation on pronghorn neonates in southeastern Colorado. From May 2006 to March 2008, we radio-collared 71 pronghorn fawns to determine survival rates. During the first year of the study, all coyotes were intact. During the second year, we surgically sterilized coyotes in the southern half of the study area, while coyotes in the northern half were given sham sterilizations. In addition, we surveyed the availability of alternative prey on fawn survival. Using the known fate model structure in Program Mark, we constructed models that included a treatment effect, plus year, area, alternative prey, and individual covariates to estimate fawn survival. Fawn survival was higher for fawns captured in sterile coyote home ranges than for fawns captured in intact coyote home ranges. Lagomorph abundance was not influential on fawn survival, nor was rodent abundance, but increased vegetation may have impaired prey detection probabilities. Our results indicate that surgical sterilization of coyotes may offer a practical alternative for wildlife managers to reduce coyote predation on pronghorn fawns.

Horn Growth and Age in Harvested Wyoming Pronghorn

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THOMAS J. RYDER, Lander Wildlife Management Coordinator, Wyoming Game and Fish Department, 260 Buena Vista, Lander, WY 82520
WILLIAM J. RUDD, Assistant Division Chief, Wildlife Division, Wyoming Game and Fish Department, 5400 Bishop Blvd, Cheyenne, WY 82001

ABSTRACT Biologists recently evaluated relationships among numerous variables potentially affecting pronghorn horn growth; including genetics, age, precipitation, and nutrition. Given the abundance of pronghorn in Wyoming, the Wyoming Game and Fish Department investigated the relationship of age versus horn growth to add to the body of knowledge concerning this subject.

During 2004 and 2005 hunting seasons, Department personnel measured a total of 574 pronghorn bucks using standard Boone and Crockett (B&C) scoring. Results suggest age and horn growth patterns are consistent with those reported in four similar studies, wherein maximum horn growth is found among age classes 2-4, followed by a leveling off until age 7+. Scores did not differ significantly among ages 4 – 6 (P<0.01), but did differ significantly between age 1 and ≥ 2, between 2-3, and between 3-4 (P<0.01). Maximum score fell slightly in older aged pronghorns (≥7). Scores ≥ minimum B&C (80 inches) were documented in each age class from 2-6, with the greatest number occurring in age 5. Pronghorn bucks exceeding B&C minimum represented 3% of the total sampled population. These results suggest season structures that support older-aged class males may be conservative if maximum trophy yield is desired.

Factors Influencing Pronghorn in the Chihuahuan Desert of White Sands Missile Range, South-central New Mexico

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ABSTRACT The pronghorn (*Antilocapra americana)* population on White Sands Missile Range (WSMR) is in decline. WSMR is located in the Chihuahuan Desert of the Tularosa Basin of south-central New Mexico between the Sacramento Mountains to the east and the San Andreas and Organ Mountains to the west. It is one of the largest military landholdings in the United States, constituting an area of about 800,000 ha. Habitat characteristics that impact pronghorn populations include precipitation, forage, predation (mainly on fawns), and human disturbances. Thus, the goal of this research is to determine if quality of available forage is providing required nutrients for pronghorn survival and productivity in the Chihuahuan Desert on WSMR. The objectives of this research were to (1) relate precipitation to pronghorn productivity and recruitment within 2 reproductive seasons through intensive monitoring of pronghorn during conception and lactation and (2) characterize forage availability and nutrient composition through forage harvesting and frequency, and diet composition through fecal microhistological analysis, and digestibility by Fecal N and Fecal DAPA. Research results to date demonstrate forage quality and quantity profoundly affect pronghorn recruitment. Research will be presented describing the results of microhistological analysis, and recruitment of one reproductive season. The research will result in recommendations as to how managers can increase the quality and quantity of forage available to pronghorn populations throughout WSMR.

The Good, the Bad and the Ugly; Fences are More Than Barriers to Movement

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CARLA KOENIG, *Alberta Conservation Association,* 1603 3rd Ave South, Lethbridge, Alberta, Canada, T1J 0L1.

ABSTRACT The dawn of fences on the grasslands at the turn of the century was one of the factors that almost resulted in the extinction of pronghorn (*Antilocapra americana*). Pronghorn numbers have

recovered significantly since the early 1900's, their inability to deal with fences remains. It is widely understood that poorly constructed fences can hinder or restrict movement by pronghorn resulting in mortalities, but it is not well known what actual physical harm occurs. Using Reconyx© cameras at known fence crossings, and photos and GPS relocations from marked study animals, we have documented additional negative effects of fences on pronghorn including scarring, hair loss, behavioral avoidance, and entanglement. Going forward, we will be mapping fences in Alberta and evaluating a number of fence enhancement techniques to rank their success in fostering movement and reducing harmful physical damage to pronghorn. Results from these projects will be used to prioritize and implement stewardship actions with provincial, federal, municipal, and private land owners.

Pronghorn Age and Horn Size in Southern Alberta

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PAUL F. JONES, Alberta Conservation Association, 1609 3rd Ave. S., Lethbridge, Alberta T1J 0L1, Canada
MICHAEL G. GRUE, Alberta Conservation Association. 1609 3rd Ave. S., Lethbridge, Alberta T1J 0L1, Canada

ABSTRACT In Alberta, pronghorn antelope (*Antilocapra americana*) provide one of the most sought after trophy hunts (approximately 17,000 applicants annually), with one of the lowest draw applicant success rates (3.6%). Recently public concerns were raised that pronghorn management practices had resulted in fewer bucks in older age classes, which would result in fewer large bucks being harvested. From 2005-2009, staff collected incisor teeth (I-1) and horn measurements (Boone and Crockett scores) from 626 harvested male pronghorn. The mean age of harvested pronghorn was 3.21 +/- 0.05 (SE) and ranged from 1-10 years old. Mean score for all years combined was 68.27 +/-0.26 (SE) with the highest mean scores for 4 year old (71.42 +/- 0.45 SE) and 5 year old (71.09 +/- 0.92 SE) bucks. We discuss the management implications of our results.

Modeling Pronghorn Migration Corridors in the Northern Great Plains

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COLBY LOUCKS, Deputy Direct of Conservation Science, *World Wildlife Fund*, 1250 24th Street North West, Washington D.C., 20037-1193, USA
DEAN URBAN, Professor of Landscape Ecology, *Duke University*, Durham, North Carolina, 27706, USA
ANDREW JAKES, Faculty of Environmental Design, *University of Calgary*, Calgary, AB, T2N 1N4, CA

ABSTRACT While terrestrial seasonal migrations worldwide continue to decline, the migrations of pronghorn antelope (*Antilocapra americana*) in the Northern Great Plains remain poorly studied. Development due to energy exploration and extraction within this region has recently increased, possibly placing restrictions on pronghorn movement. In this study, we used two habitat modeling methods, maximum entropy and Analytical Hierarchy Process (AHP), to identify suitable pronghorn habitat, and two corridor modeling methods, circuit theory and least cost paths, to identify seasonal migration corridors. We used pronghorn locations during the 2008 spring and fall migration seasons to identify which habitat and corridor models perform the best based on pronghorn occupancy and area included in the corridor. The maximum entropy model performed better than AHP, resulting in

corridors that included more pronghorn locations than those created using AHP. Additionally, corridors derived from circuit theory included more pronghorn locations within a smaller area than those created using the least cost path method. We recommend using the maximum entropy cost surface and the circuit theory corridor at the 15% habitat suitability level for future management actions. Without further study and conservation efforts built on this new knowledge, pronghorn populations may eventually decline and the functioning and biodiversity of the Northern Great Plains may be greatly impaired.

Effects of Fence Type on Pronghorn Movement in North Central Montana

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ANDREW JAKES, Ph.D Student, Faculty of Environmental Design, University of Calgary, Calgary, AB, T2N 1N4, CA
ADAM G. HART, School of Natural and Social Sciences, University of Gloucestershire, Cheltenham, England, GL50 4AZ, UK

ABSTRACT Pronghorn are endemic to North American grasslands and prairies and are considered prairie obligates. They utilize grassland, agriculture and shrub-steppe habitats at large temporal and spatial scales, and have been recorded to undertake long distance migrations. This study investigates the effects of fence structure type on pronghorn movements in North Central Montana, covering Blaine, Phillips and Valley Counties. For this study, daily relocations (n=6) from five GPS collared female pronghorn were collected over one year and analyzed. Of these five pronghorn, two were classified as migratory and three as residential. Field data was collected in summer 2009. Randomized 3.2 km long transects (n=738) on both paved and unpaved roads were driven to collect information on habitat, fence densities and fence structure type. GPS locations were recorded at every interior fence convergence to roads and where roadside fencing changed in presence/absence or fence structure type. At each site where a GPS location was taken, fencing was given a 'permeability code' of 0-6, dependant on fencing structure and how difficult pronghorn would find it to cross. Using ArcGIS, fence structure type and permeability code were recorded at each location a pronghorn crossed a road transect over one year (n=748) and pooled results across all five individuals. At over 89% of instances where pronghorn crossed road transects, there was either no fencing or it was the two most permeable codes, with 55% of that being no fencing. 10% of crossings were through low, well made fences, and <1% through woven wire fencing. There was a clear, significant correlation (Spearman's rank; r= .929, p=.003) between fence type and pronghorn crossings, showing that pronghorn select to move through areas with either no fences or highly permeable fences. This is significant for pronghorn conservation as barbed and woven wire fences, common across western North America, act to impede movement. As such, impermeable fencing may lower nutritional foraging opportunities for pronghorn and may influence migratory movements, an important strategy at the periphery of their range. Land and wildlife managers may choose where to prioritize on the ground conservation actions, based on fence structure types.

An Assessment of Fifty-five Years of Predator Influences on Pronghorn Neonates

JIM D. YOAKUM, Western Wildlife, Post Office Box 369, Verdi, Nevada, 89439

ABSTRACT Factors affecting pronghorn production and survival in the Hart Mountain area of south-central Oregon have been reported for >55 years. Management agencies during the 1950s alluded to

predation of neonates as a major agent contributing to low fawn recruitment. Consequently predator control practices were often intensively conducted. In addition research was accomplished, however, radio telemetry techniques had not been fully developed and little quantitative data was obtained. Reports substantiated that high numbers of permitted, trespass, and feral livestock grazed the area and competed heavily for pronghorn preferred nutritious herbaceous forage. Pronghorn numbers continued to be stressed. Then during the 1990s, a research project using radio telemetry mortality techniques was accomplished that established neonate losses were indeed high. Some year's predation accounted for 70 to 90 percent mortality loss, while for the 10-year study the average was 49 percent. Final conclusions indicated that although pronghorn herds for this site maintained fawn recruitment rates of around 50 percent for a decade, the herds experienced a continued increase in numbers until apparently a new carrying capacity was established. Since then, the population has maintained population levels of some 2,000 animals, the highest long-term average for >60 years. This case history indicates that studies of predation on pronghorn neonates should to be conducted over long-term periods, and that other ecological agents need to be concurrently investigated. Thus, mortality agents such as varying weather conditions, inadequate nutritious herbaceous forage, and predator losses can be assessed and the primary trigger(s) responsible for herd numbers can be more accurately determined and reported.

Business Meeting
24th Biennial Pronghorn Workshop
Business Meeting Minutes
May 19, 2010

1. **Business Meeting called to Order:** Business meeting was called to order by Workshop representative Tom Ryder at 12:16 pm.

2. **Roll Call for jurisdictional representative:** Tom Ryder asked for a representative of each attending State, Province, and Country. Each representative was identified and introduced (members are listed below):

Jim Hinkle	Arizona
Matt Peek	Kansas
Shawn Gray	Canada
Tom Donham	North Dakota
Darrel Weybright	New Mexico
Lizardu Cruz	Mexico
Bill Miller	Arizona State University
Andy Holland	Colorado
Mindi Avery	USGS, Arizona
Anis Aoude	Utah
Bruce Trindle	Nebraska
Luke Meduna	South Dakota
Andrew Jakes	Montana
Mark Zornes	Wyoming

3. **Review and adopt 23rd Workshop Business Minutes:** The 23rd Workshop Business meeting minutes had already been reviewed, ratified, adopted, and sent to WAFWA.

4. **Old Business from past Workshops:**

   A. <u>Awards</u> **–** Richard Ockenfels explained that he had developed a set of Standard Operating Procedures (SOP) or guidelines for the Pronghorn Hall of Fame, Special Recognition, and Berrendo Awards. Within these guidelines, the host agency of future workshops will select and provide an awards committee, which will be responsible for developing and sending out a nomination announcement. For the Berrendo Award, the committee will select two previous award winners which will be responsible for selecting the current workshop award winner. Wyoming was selected to send out the Standard Operating Procedures, developed by Ockenfels, to all States/Providences asking for comments with a deadline of July 1, 2010. However, Lizardu Cruz (Mexico) made a motion to except the Awards Standard Operating Procedures as is. This was 2nd by Mindi Avery (USGS). There was no discussion, and the motion carried unanimously.

B. Standard Operating Procedures for the Workshop – It was discussed that SOP's should be developed for the Pronghorn Workshops in order for hosting States/Providences/Countries to have guidelines to follow when developing and organizing Workshops. Tom Ryder volunteered to contact Kevin Hurley (WAFWA Bighorn Sheep Working Group chair) to obtain a copy of their SOP's. Tom will then develop simple SOP's for the Pronghorn Workshop using the same framework as those used for the Bighorn Sheep Workshop. It was also decided to include financial support information and available monies into these SOPs to help with future Workshops. Tim Thomas (WY Chapter Wildlife Society) will provide a short financial summary to include in the draft SOP.

C. 24th Workshop Proceedings - It was decided the deadline to submit final papers and posters for the workshop proceedings will be June 15, 2010. The final version of each paper and poster for the proceedings will only be "peer edited". The proceedings will also include the Awards SOP, previous award winners, meeting attendees, and Workshop Bylaws.

D. Pronghorn Management Guidelines – Dave Brown suggested by 2012 a revision needs to occur for these guidelines and that a revision should occur every five years. Also, total publications should be reduced to 100-150 copies. A suggestion was made to go with a 7 year revision requirement. No action was carried forward. Jim Yoakum stated the revisions of this publication need to include the most current and updated information. Jim Yoakum volunteered to chair a committee for the next revision with the following people: Jorge Cancino (MX), Mark Zornes (WY), Mindi Avery (MSU), and a Canadian representative. Recognition was given to Jorge Cancino for translating the latest version of the Guidelines into Spanish.

E. Pronghorn Bibliography – The current Pronghorn Bibliography notebook was developed, but needs to be updated. All States, Providences and Mexican representatives will be responsible for updating the bibliography. Jim Yoakum made a motion to have the current representatives update and publish the revised bibliography. The motion was seconded and carried forward unanimously.

F. 2012 Pronghorn Workshop – Jorge Cancino offered to host the 2012 Workshop in northern Mexico. The group accepted, but felt a backup location is needed. New Mexico offered to host 2012 if Mexico has to step down . Texas offered to host in 2014. Motion was made to except the offers The motion was seconded and carried unanimously.

5. New Business – No new business was initiated.

6. Resolutions – No resolutions were initiated or suggested.

24th Business Meeting was adjourned at 1:25pm.

24th Biennial Pronghorn Workshop

Hosted by the Wyoming Game & Fish Department and
The Wyoming Chapter of The Wildlife Society
Hilton Garden Inn and University of Wyoming Conference Center
Laramie, Wyoming
May 18 - 21, 2010

AWARDS NOMINATIONS

Through the Biennial Pronghorn Workshop, pronghorn biologists and managers recognize individuals and organizations that have made significant contributions toward pronghorn conservation. These special awards fall into three categories: The Berrendo Award, Special Recognition Award, and Hall Of Fame. Now is the time to nominate our peers who have dedicated a part of their life to the betterment of pronghorn. **Please read these award criteria and nominate persons you know are deserving of this recognition by April 30, 2010.**

Berrendo Award

This award is the most significant award offered through the Western Association of Fish & Wildlife Agencies sanctioned Pronghorn Workshop. One award per workshop is given to an individual or a group of collaborators who have made great contributions to management or research for pronghorn. The award is named for a desert pronghorn, an animal that epitomizes the difficulty of being a pronghorn.

Nomination Criteria

1. An individual, organization, or group of collaborators that has gone well beyond normal job expectations in a project related to pronghorn.
2. These contributions need to afford significant scientific advances in the management or research of pronghorn.
3. These contributions can represent a single event or a long-term commitment to pronghorn.

Previous Winners:
2002 Jim Yoakum
2004 Bart O'Gara (deceased)
2006 Tom Pojar
2008 Richard Ockenfels

Special Recognition Award

Many people or organizations make significant contributions that aid in the management of pronghorn. These can include projects that are oriented to pronghorn management or research. The Special Recognition Award is a certificate recognizing the accomplishments of an individual or group. Up to 4 awards can be presented per Workshop.

Nomination Criteria

1. The individual, organization, or group of collaborators nominated should have made an important contribution to aid in management of pronghorn.
2. The contribution can be a single event or the accumulation of long-term contributions.

Previous Winners:	2002:	Karl Menzel, NE, Jorge Cancino, BCS, MX, Bill Rudd, WY, and Richard Ockenfels, AZ
	2004:	Rich Guenzel, WY, Alice Koch, CA, John Hervert, AZ, and Arizona Antelope Foundation
	2006:	Rick Danvir, UT, Fred Lindzey, WY, and Rick Miller, AZ
	2008:	Morley Barrett, AB, David Brown, AZ

Hall Of Fame

The Berrendo and Special Achievement Awards are relatively new recognitions, having been instituted at the 20th Biennial Pronghorn Workshop in 2002. This is some 40 years after the first conference. Pronghorn managers today owe much to the efforts of pronghorn biologists, managers and other conservationists whose contributions preceded the opportunity to be formally recognized by the Biennial Pronghorn Workshop. The Hall Of Fame awards are an ongoing effort to recognize the careers and long-term contributions of our predecessors. Although formal criteria are evolving, the 24th Biennial Pronghorn Workshop provides the opportunity to nominate individuals for inclusion in the Hall Of Fame.

Preliminary Nomination Criteria

1. The individual should have made numerous important contributions over his or her career that advanced the management and conservation of pronghorn.
2. All recipients of the Berrendo Award are automatically included in the Hall Of Fame.

Submit nominations either in hard copy or e-mail to:

Mark Zornes (Co-chair and Awards Committee Chair)
Wyoming Game and Fish Department
351 Astle
Green River, WY 82935 USA
or mark.zornes@wgf.state.wy.us

Awards Nomination Form

Please review above criteria for award category

This nomination is for the (check one):
Berrendo Award ___X__ Special Recognition Award ________Hall Of Fame______

Name of nominee : Richard J. Guenzel
Phone: 307.745.5180 xtn 231 Email: Rich.Guenzel@wgf.state.wy.us
Address: Wyoming Game and Fish Dept. Laramie Region
528 S. Adams
Laramie, WY 82070

Nominated by Mark Zornes/Tom Ryder/Bart Kroger
Phone: 307.875.3223 Email: mark.zornes@wgf.state.wy.us
Address: Wyoming Game and Fish Dept. Green River Region
321 Astle Ave
Green River, WY 82935

Submit nominations either in hard copy or e-mail by **APRIL 30, 2010** to:
Mark Zornes (Co-chair and Awards Committee Chair)
Wyoming Game and Fish Department
351 Astle
Green River, WY 82935 USA
or mark.zornes@wgf.state.wy.us

Nomination justification

We respectfully nominate Richard J. Guenzel for the 2010 Borrendo Award. Over a career spanning nearly three decades, Rich has maintained a passion for the biology, management and research of pronghorns. He is recognized as one of the world's authorities regarding wildlife survey design and protocol, particularly for pronghorns. His contribution to the body of scientific knowledge of this subject has been significant, and Rich's many works are some of the most often cited regarding wildlife survey techniques.

Rich pioneered and refined the use of aerial line transect surveys for pronghorns, which has contributed significantly to the day-to-day management of the species in Wyoming and other parts of this species range. Wyoming uses this technique as the backbone of our management system for pronghorns, and Rich has gone above and beyond to act as the Department trainer and expert in this subject, on top of his very busy position as a regional wildlife biologist. However, Rich has not been content to rest on his laurels regarding pronghorn survey techniques, and is constantly striving to improve the technique to provide better estimates. He has done an admirable job remaining current with all potential technological advances, and adjusts to meet new challenges annually. Rich has also successfully linked the use of Cyber Tracker software to Wyoming's survey technique.

Rich has been involved with numerous other pronghorn research and management projects throughout his career. He was instrumental in assisting Mexico with their captive rearing program and continues to act as a liaison between the Wyoming Game and Fish Department and Mexico. Rich's efforts have led to additional translocation efforts to other states, including Texas and Oklahoma. He has contributed significantly to research ranging from population estimation, impacts of energy development on pronghorn, pronghorn migration, pronghorn fawn survival, herd composition survey techniques, and analyses of age and horn growth. He has been an outspoken advocate for the species and other sagebrush obligates in Wyoming in the face of ever-increasing and unprecedented energy development and increasing barriers to migration. Rich regularly serves in an advisory capacity to all desiring his vast knowledge on pronghorn. He is particularly helpful to students working on this species and works closely with the Wyoming Chapter and Wyoming Student Chapter of The Wildlife Society.

Rich is one of the most passionate advocates for pronghorns it has been our pleasure and honor to know. His dedication to the species is not only professional; he regularly contributes from his own pocket to benefit pronghorns and other wildlife species. This, coupled with the many contributions he has made to our knowledge of pronghorn and their management during his distinguished career, make him more than deserving of this prestigious award.

Respectfully submitted by:

Mark Zornes
Wildlife Management Coordinator, Green River Region
Wyoming Game and Fish Department
Chairman, WGFD Pronghorn Working Group

Bart Kroger
Worland Wildlife Biologist
Wyoming Game and Fish Department
Co-Chairman, WGFD Pronghorn Working Group

Tom Ryder
Wildlife Management Coordinator, Lander Region
Wyoming Game and Fish Department
President-elect, The Wildlife Society

Rich Guenzel

2010 Borrendo Award Recipient

Wyoming Game and Fish Department Wildlife Biologist

Summary of Pronghorn Workshops Held to Date

Meeting Dates and Locations	Number Attending	Chairman	Host Agency
April 14-16, 1965 Santa Fe, NM	18	W. Huey	New Mexico 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 and Fish Commission
January 27-28, 1970 Scottsbluff, NE	85	K.I. Menzel	Nebraska Game and Parks Commission
June 19-22, 1972 Billings, MT	85	H.O. Compton	Montana Fish and Game Departmetn
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. Autenrieth	Idaho Department of Fish and Game
May 2-4, 1978 Jasper, Alberta	84	M.W. Barrett	Alberta Fish and Wildlife Division
April 8-10, 1980 Rio Rico, AZ	64	J.S. Phelps	Arizona Game and Fish Department
April 5-7, 1982 Dickinson, ND	69	J.V. McKenzie	North Dakota Game and Fish Department
April 10-12, 1984 Corpus Christi, TX	45	C.K. Winkler	Texas Parks and Wildlife Department
March 11-13, 1986 Reno, NV	43	M. Hess	Nevada Department of Fish and Wildlife
May 31-June 2, 1988 Hart Mt., OR	43	D. Eastman	Oregon Department of Fish and Wildlife
May 22-24, 1990 Silver Creek, CO	45	I.M. Pojar	Colorado Division of Wildlife
June 8-11, 1992 Rock Springs, WY	91	P. Riddle	Wyoming Game and 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
March 23-27, 1998 Prescott, AZ	92	R.A. Ockenfels	Arizona Game and Fish Department

March 14-17, 2000 La Paz, Baja California Sur Mexico	42	J. Cancino	Centro de Investigaciones Biologicas del Noroeste – Direccion General de Vida Silvestre
March 17-20, 2002 Kearney, NE	85	J.S. Abegglen	Nebraska Game and Parks Commission, U.S. Forest Service, Nebraska National Forest
May 2-4, 2004 Bismarck, ND	76	B. Jensen B. Stillings	North Dakota Game and Fish Department, U.S. Forest Service, Bureau of Land Mngt
May 16-19, 2006 Idaho Falls, ID	143	B. Compton D. Toweill	Idaho Department of Fish and Game
May 13-16, 2008 Canmore, Alberta	57	D. Eslinger K. Morton	Alberta Sustainable Resource Development Alberta Conservation Association
May 18-21, 2010 Laramie, WY	77	M. Zornes	Wyoming Game and Fish Commission

2010 Workshop Attendees

Courtney	Amerine	Wyoming	Field Organizer
Anis	Aoude	Utah	Big Game Program Coordinator
Mindi	Avery	New Mexico	Graduate Research Associate
Brad	Banulis	Colorado	Terrestrial Biologist
Jon	Beckmann	Montana	Conservation Ecologist
Justin	Binfet	Wyoming	Wildlife Biologist
Kim	Brinkley	California	Animal Keeper (Retired)
David	Brown	Arizona	Adjunct Professor
Patrick	Burke	Wyoming	Wildlife Biologist
Jorge	Cancino		
Lew	Carpenter	Colorado	Regional Representative
Ivonne	Cassaigne		DVM
Dean	Clause	Wyoming	Wildlife Biologist
Terry	Creekmore	Wyoming	Wildlife Management Coordinator
Julie	Cummings	New Mexico	Manager
Eric	Dahl	Wyoming	Executive Vice President
Dustin	Darveau	Nebraska	Wildlife Biologist
Tom	Donham		
Scott	Gamo	Wyoming	Staff Biologist
Shawn	Gray	Texas	
Mike	Grue	Alberta	

Rich	Guenzel	Wyoming	Senior Wildlife Biologist
Heather	Halbritter	Colorado	Terrestrial Biologist
John	Hart	Wyoming	Principal Biologist
Stan	Harter	Wyoming	Wildlife Biologist
Therese	Hartman	Wyoming	Biologist
Curtis	Hendricks	Idaho	Wildlife Biologist
Kent	Hershey	Utah	Big Game Project Leader
Greg	Hiatt	Wyoming	Wildlife Biologist
Martin	Hicks	Wyoming	Wildlife Biologist
Jim	Hinkle	Arizona	Big Game Program Supervisor
Rob	Hitchcock	Wyoming	President
Pat	Hnilicka	Wyoming	Biologist
Andy	Holand	Colorado	Terrestrial Bioloigst
Lynn	Jahnke	Wyoming	Wildlife Management Coordinator
Andrew	Jakes	Alberta	Ph.D. Student
Paul	Jones	Alberta	Senior Biologist
Ed	Juno	Wyoming	
Renee	Keleher	Texas	Research Assistant
Rick	King	Wyoming	Game Warder
Alice	Koch	California	
Bart	Kroger	Wyoming	Wildlife Biologist
Tom	Krolikowski	Nebraska	Biologist II
Dan	McDonald	Florida	District Biologist

Dwayne	Meadows	Wyoming	Public Land Organizer
Luke	Meduna	South Dakota	Resource Biologist
William	Miller	Arizona	Associate Professor
Clare	Mix	Colorado	Graduate Student
Heather	O'Brien	Wyoming	Wildlife Biologist
Richard	Ockenfels	Arizona	Wildlife Biologist
Tom	Pojar	Colorado	Researcher (retired)
Erin	Poor	North Carolina	Masters Candidate
Jake	Powell	Idaho	
Tom	Rudd		
Tom	Ryder	Wyoming	Wildlife Management Coordinator
Rebecca	Schilowsky	Wyoming	Wildlife Biologist
Keith	Schoup	Wyoming	Terrestrial Habitat Biologist
Will	Schultz	Wyoming	Wildlife Biologist
Jeff	Short	Wyoming	Wildlife Biologist
Ana	Soler		Director
Julie	Stiver	Colorado	Terrestrial Biologist
Billy	Tarrant	Texas	District Leader
Chad	Taylor	Nebraska	Wildlife Biologist
Tim	Thomas	Wyoming	Senior Wildlife Biologsit
Melanie	Tluczek	Arizona	Student
Stephen	Torbit	Colorado	Regional Exective Director
Bruce	Trindle	Nebraska	Big Game Research Manager

Jordan	Vana	Wyoming	Director of Conservation
Mark	Vieira	Colorado	Wildlife Biologist
Allen	Vitt	Colorado	Terrestrial Biologist
William	Voelker	Oklahoma	Executive Director
Ryan	Walker	New Mexico	Northeast Area Game Manager
Brad	Weinmeister	Colorado	Wildlife Biologist
Darrel	Weybright	New Mexico	Big Game Supervisor
Jim	Yoakum	Nevada	Wildlife Biologist
Jeff	Yost	Colorado	Terrestrial Biologist
Mark	Zornes	Wyoming	Wildlife Management Coordinator

24th Biennial Pronghorn Workshop
FIELD TRIP
May 20, 2010

We will be traveling northwest of Laramie through a variety of pronghorn habitats, ranging from short-grass prairie near Laramie, saltbush-greasewood areas, and Wyoming big sagebrush-grassland types. We will probably see a few pronghorn along the route (better keep count!). Our stops will take us to a wind farm, a Hunter Management Area, and to a Wyoming Game and Fish Department's Wildlife Habitat Management Area. Presentations will be brief and informal with many opportunities for questions. Our time will be limited at each stop. We will make about a 150 mile loop. In order to return on time, please be prompt in getting back on the buses.

A couple of orientation maps and other information are appended to this Field Trip guide.

Be sure to use the restroom before getting on the bus, and bring your box lunch (provided) and beverage with you. We will eat lunch en route to our first stop (bring cameras, binoculars, sunscreen, raincoat, etc.).

11:00 AM - DEPART HILTON GARDEN INN, LARAMIE

We head northwest along US Highway 30/287. We will be driving through shortgrass prairie for a ways. Off to the west you can see the **Snowy Range** in the Medicine Bow Mountains (Medicine Bow Peak is the high point at just over 12,000' above sea level). There is abundant public land up on the Medicine Bow –Routt National Forest in those mountains. In addition to pronghorn along the base, these mountains are home to elk, mule deer, moose and a few bighorn sheep along with mountain lions, black bears, pine marten, blue grouse, goshawks, boreal owls, pikas and a lot of other neat critters.

The lower mountains to the east are part of the **Laramie Range**, which is an extension of Colorado's Front Range. There is very limited public access in this portion of the range. Some pronghorn migrate east across the Laramie Range. Elk, mule deer, a few moose and a few bighorn sheep occur in the range.

About 18 miles north of Laramie, we come to the **junction with Wyoming Highway 34**. You can see that Wyoming big sagebrush is more dominant. Some of our prime greater sage-grouse habitat in Albany County occurs in this area east of US 30/287. It includes one of our designated **Sage-grouse Core Areas**, which receive greater protections from development. Our **Tom Thorne/Beth Williams Wildlife Research Center** is located farther down along Highway 34 in Sybille Canyon. Public access is very limited in this area. We do have 3 Walk-in Areas for pronghorn hunting near Highway 34. The **Laramie River Hunter Management Area** is located to your west. About 6 miles east of the junction, Highway 34 bisects crucial pronghorn winter range. Right-of-Way fences tend to be restrictive to pronghorn movements along the western part of the highway. The Wyoming Department of Transportation has installed a few opposable gates and a small stretch of **electric fence** to facilitate pronghorn crossing the highway in winter

Just past the US 30/287 and Highway 34 junction, we cross the Laramie River, which flows out of the Snowy Range and through the Laramie Mountains to the North Platte River. As we come up the hill, we go through the remnants of **Bosler** (anyone looking for a fixer-upper?). As we travel beyond, you will notice some more arid habitats with saltbush-greasewood complexes in the low-lying areas. The terrain starts to get more rugged, with rocky ridges and other landforms becoming more frequent.

As with travel along the Pine Ridge, wind farms become more dominant on the landscape. **Elk Mountain** (>11,000' elevation) is the tall mountain to our west that is somewhat isolated from the rest of the Medicine Bow Mountains. The Overland Trail and Interstate Highway 80 run along the north end of the mountain.

The Marshall Road goes north of US 30/287 a few miles past the town of **Rock River**. The large ridge to the west is **Como Bluff**, an extremely important site for dinosaur excavation. The Marshall Road drives up through our **Como Bluffs Hunter Management Area**. Just after we cross the Albany/Carbon County line, a small cabin sits on the north side of the highway near the base of Como Bluff. The cabin is made from dinosaur bone fragments.

We shortly cross the Medicine Bow River and drive on through the town of **Medicine Bow**. Medicine Bow is famous as the setting for Owen Wister's novel, The Virginian. The tall hotel in town is named after the book. To the south of town are a few wind turbines. They are at the site of the original Medicine Bow Wind Energy Project and the first commercial turbines in the state. **Dr. Archie Reeve** did some of his doctoral research on pronghorn as part of the baseline work for the project. Also to our south is the **Medicine Bow River Hunter Management Area**.

We pass by the junction with Wyoming Highway 487, which goes through **Shirley Basin** and the heart of the Medicine Bow Pronghorn Herd, eventually taking people through **Bates Hole** (an important area for pronghorn habitat monitoring that **Daryl Lutz** discussed) and on into Casper. **Jason Zimmer** and **Ron Grogan** did part of their pronghorn survival studies up in Shirley Basin. About 15 miles north of Medicine Bow is the **Dunlap Ranch Wind Project**. At our first stop, we will be hearing about the recently initiated pronghorn research for that wind project.

~12:30 PM - STOP 1 – THE SEVENMILE HILL WIND FARM (~30 minutes)

About 10 miles west of Medicine Bow, we turn north into the **Sevenmile Hill Wind Farm**. This is our first stop. Representatives of **Pacificorp** will tell us about the project. **Scott Gamo** will introduce the Wyoming Game and Fish Department's Wildlife/Wind Recommendations and coordination. **Jordan Ongstad** will review the ongoing pronghorn monitoring for the **Dunlap Ranch** Wind Project that he and **Dr. Jeff Beck** of the University of Wyoming are conducting. **Chad Lebeau,** a student of Dr. Beck's will discuss his sage-grouse study for the Sevenmile area. The Sevenmile project occurs within a Sage-grouse Core Area. Recently, the U.S. Fish and Wildlife Service elevated the greater sage-grouse to a Candidate species under the Endangered Species Act.

The **Shirley Mountains** are off to the north of the Sevenmile project. Looking off to the south toward Elk Mountain and the Snowy Range, we can see **Simpson Ridge**. Just to the east lies the ruins and cemetery of the old town of **Carbon** and an old coal mining area.

~1:15 PM – STOP 2 – HANNA (Restrooms ~15 minutes)

We drive on west to the town of **Hanna**. We will be making a ***brief*** restroom break at the Hanna Recreation Center. *Please return to the buses as soon as you can*.

Hanna is an energy town. Originally an old **coal mining** district (after Carbon played out), Hanna has seen the boom and bust of surface and underground coal mining, coal gasification, and Coal Bed Methane development. You can see the tipple, drag lines, and reclaimed slopes to the north of the town. A variety of reclamation projects can be found in the area, based upon the laws governing the mining at the time. Today, the area is desirable for wind energy, but new coal mining operations occur to the south.

~1:45 PM – STOP 3 – SIMPSON RIDGE HUNTER MANAGEMENT AREA/HABITAT (~30 minutes)

We will drive south of Hanna on Wyoming Highway 72 for a few miles. We'll stop along the side of the road to discuss the Wyoming Game and Fish Department's **Hunter Management program**, and specifically the **Simpson Ridge HMA** (a map and ranch rules are attached). **Brian Olsen** described the WGFD's **Private Land Public Wildlife Program** (PLPW) on Wednesday, for which HMAs are a component. **Mr. Burt Palm** will give a landowner's perspective on the HMA program and specifically the Simpson Ridge Area, as well as comment on issues landowner/agricultural producers face in this area of mixed public and private lands. **Jason Sherwood**, Laramie Region PLPW coordinator for WGFD, will discuss the administration of the PLPW program at the local level.

Grant Frost, WGFD Habitat Biologist, will discuss some of his **habitat monitoring**, and specifically issues and concerns for the Medicine Bow Pronghorn Herd and its management.

As we drive south along Highway 72, you can see **Simpson Ridge** to the east. Several wind energy projects have been proposed for the area. As we come to the south end of the ridge, you will see an example of a **vertical wind turbine** as part of a project by Terra Moya Aqua. Watch for the **electric right-of-way fencing** along the highway. Originally, much of the ROW fencing along this highway restricted pronghorn movements. The electric fence was originally placed as part of a research project. With landowner cooperation, the restrictive fencing has largely been replaced by a more wildlife-friendly design when it was reconstructed. As we approach Interstate Highway 80, you can see the pattern in sagebrush treatments that were done over 20 years ago. We will head east along Interstate Highway 80 to our next stop.

~2:30 PM – STOP 4 – WICK/BEUMEE WILDLIFE HABITAT MANAGEMENT AREA (Restrooms - ~30 minutes)

We will travel east along Interstate 80 to the Wagonhound Rest Area for a presentation and a restroom stop. We again cross the Medicine Bow River near the town of Elk Mountain. The Wyoming Game and Fish Department's **Wick/Beumee Wildlife Habitat Management Area** occurs on both sides of the highway. The highway is a formidable barrier to pronghorn migrations although mule deer cross under through underpasses along **game-proof fences** along the highway while elk cross over the lower-fenced areas. The Wyoming Department of Transportation intends to extend game-proof fencing to reduce wildlife collisions. A proposal to construct an **overpass** (mainly for elk) near Arlington to the east was not funded. The **Foote Creek Rim Wind Plant** (Wyoming's first commercial plant) can be seen to the east.

We will be able to look over the Wick Unit from the rest area. The Wick Unit provides winter range for several species, especially elk. Several habitat treatments including range pitting, fertilization, livestock grazing for weed control, and clear cutting have been done to help direct elk onto the Unit to minimize damage to adjacent ranches. We have a seasonal closure in effect to minimize human disturbance on the winter range on the south side of the highway. Elk Mountain Game Warden **Jordan Kraft** will discuss management of the Unit and other wildlife issues in the vicinity. The nearby **Overland Trail** and **Pass Creek Basin HMAs** provide pronghorn hunting opportunities nearby.

~3:00 PM – DEPART FOR LARAMIE

We will head back east to Laramie, traveling along Interstate 80. We will cross over Rock Creek near the town of **Arlington** at the base of the Foote Creek Rim Wind Farm. You may notice a lot of dead trees as we pass near the mountains. Much of the mortality is due to an epidemic of mountain pine beetles in the Lodgepole Pine forest.

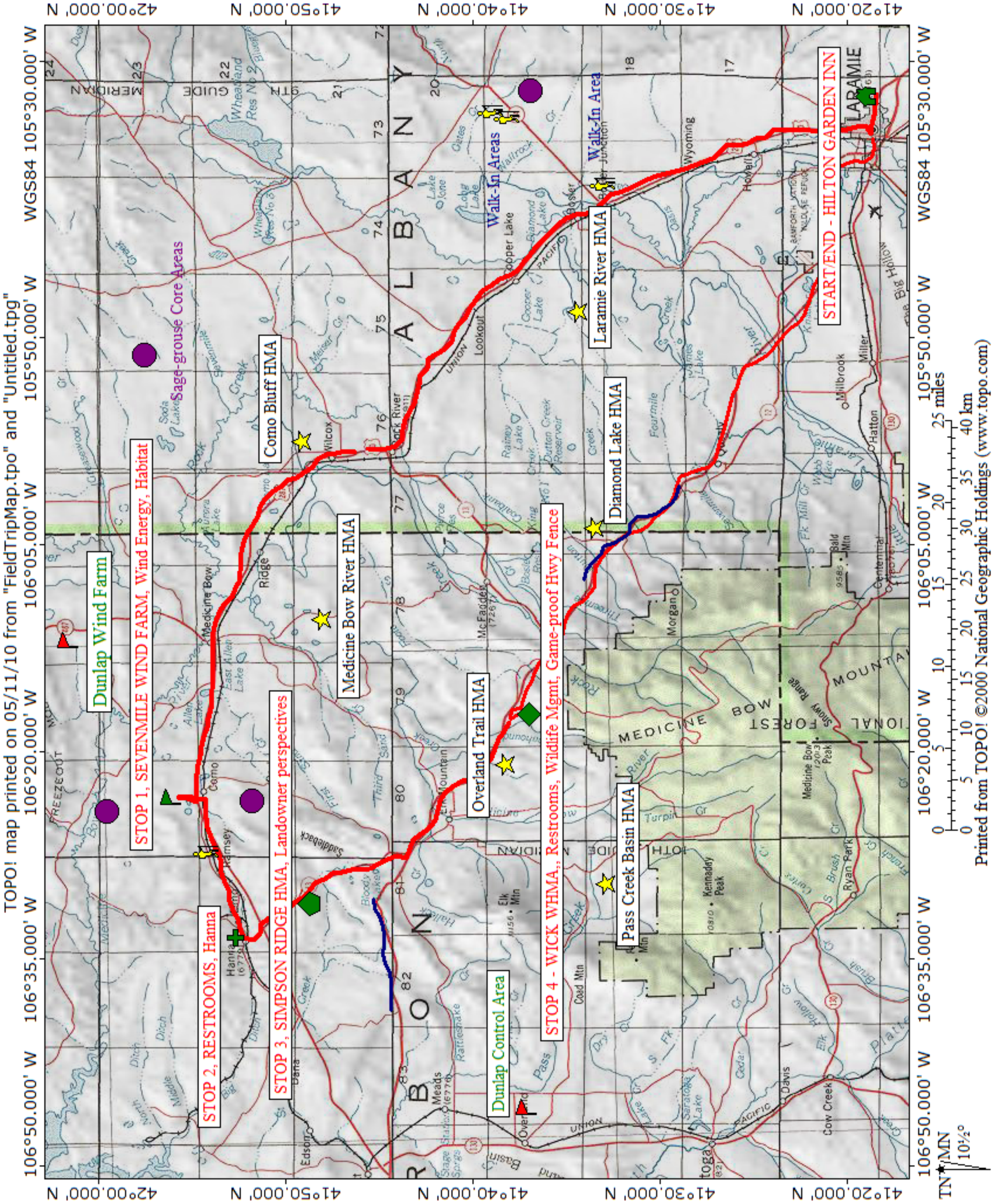
As we travel southeast to Laramie, we will go through **Cooper Cove**. You will notice game-proof fencing and a grave on the side of **Bengough Hill** on the north side of the highway. The **Diamond Lake HMA** occurs on the north side of the highway and the **Strouss Hill HMA** is on the south side. Both are extremely important for pronghorn hunting in their respective hunt areas.

We will pass sections of tall **game-proof fencing** along the way. You may have noticed that the only other Right-of-Way fencing along the Interstate Highway consists of **woven-wire** with top strands of barbed wire. This type of fencing restricts pronghorn from crossing the highway. Periodically along the game-proof fences are **ramp features** with a perpendicular wing fence to help big game animals cross back out of the Right-of-Way.

As we get closer to Laramie, the habitat is largely a shortgrass prairie that is common in the Laramie Basin.

~4:00 PM – RETURN TO HILTON GARDEN INN, LARAMIE

So how many pronghorn did you count?


TOPO! map printed on 05/11/10 from "FieldTripMap.tpo" and "Untitled.tpg"
STOP 1, SEVENMILE WIND FARM, Wind Energy, Habitat
STOP 2, RESTROOMS, Hanna
STOP 3, SIMPSON RIDGE HMA, Landowner perspectives
STOP 4 - WICK WHMA., Restrooms, Wildlife Mgmt, Game-proof Hwy Fence
START/END - HILTON GARDEN INN
Dunlap Wind Farm
Dunlap Control Area
Sage-grouse Core Areas
Como Bluff HMA
Medicine Bow River HMA
Overland Trail HMA
Pass Creek Basin HMA
Diamond Lake HMA
Laramie River HMA
Walk-In Areas
Walk-In Area
LARAMIE
MEDICINE BOW NATIONAL FOREST
ALBANY
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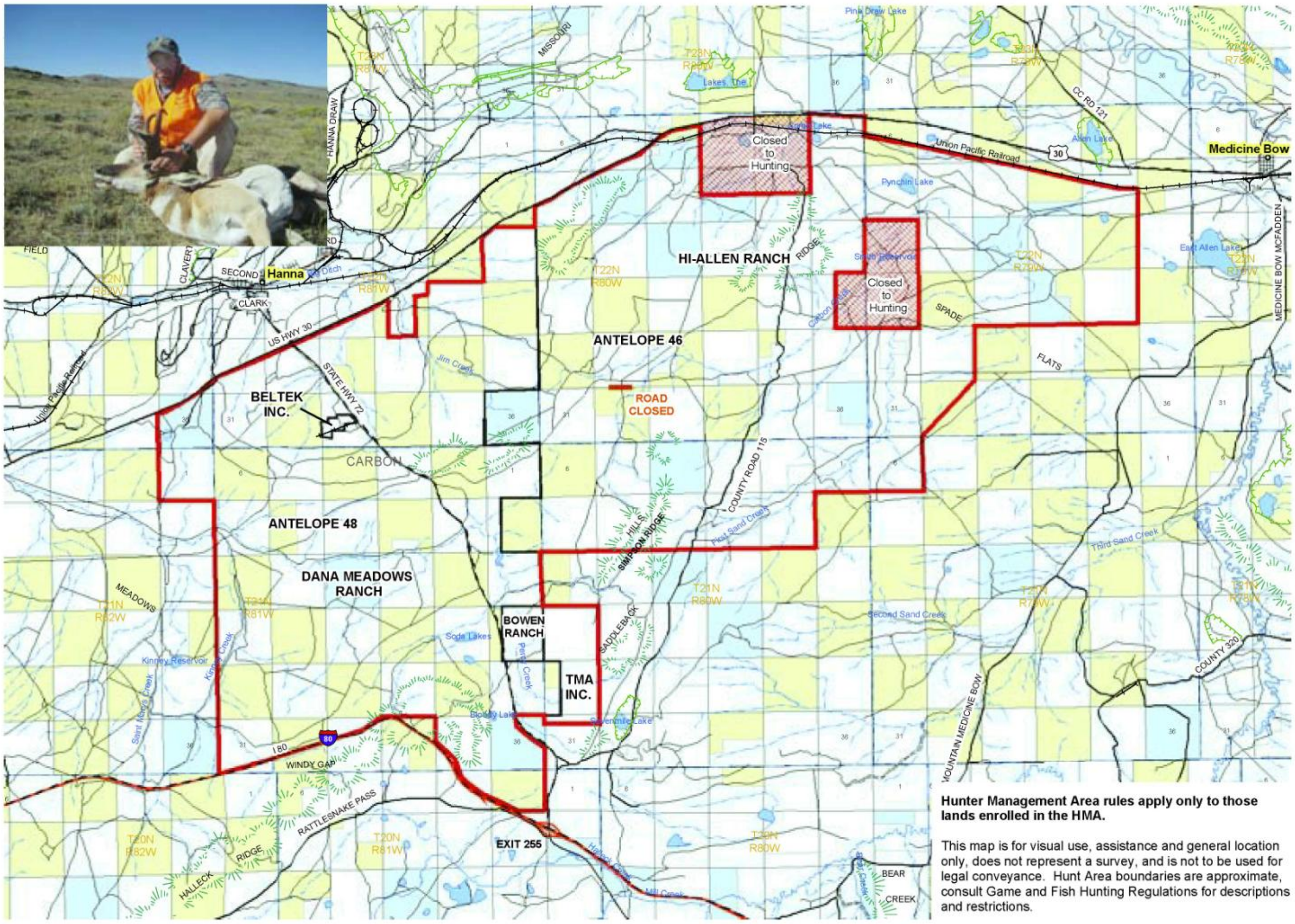
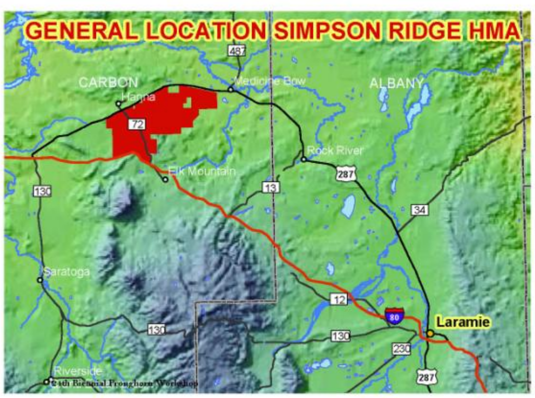


Hunter Management Area rules apply only to those lands enrolled in the HMA.

This map is for visual use, assistance and general location only, does not represent a survey, and is not to be used for legal conveyance. Hunt Area boundaries are approximate, consult Game and Fish Hunting Regulations for descriptions and restrictions.

Access to these private lands for any commercial activity must be gained by contacting the individual landowner(s) directly.



LEGEND

- PRIVATE LAND
- BLM LAND
- STATE LAND
- PRIVATE - NO ACCESS
- HUNTER MANAGEMENT AREA BOUNDARY
- RANCH BOUNDARY
- HUNT AREA BOUNDARY

N

0 1 2
SCALE IN MILES

173

Simpson Ridge Hunter Management Area

Simpson Ridge Hunter Management Area provides access to hunt antelope in Hunt Areas 46 & 48, from August 15 - October 31, 2009. Four hundred (400) permission slips (250 for Hunt Area 46 and 150 for Hunt Area 48) will be issued via a random drawing.
SEE RANCH RULES.

Simpson Ridge 2009

The **Simpson Ridge Hunter Management Area** provides access to hunt **antelope only** in Hunt **Areas 46 & 48** during the specific species season as published in the current Game and Fish Commission Regulations and with the following limitations:

- **Antelope** Hunting Access (**Archery <u>and</u> Firearm Hunters**)
  - **Hunt Area 46**
    - Two hundred-fifty (250) permission slips will be issued for <u>August 15-October 31</u>.
  - **Hunt Area 48**
    - One hundred-fifty (150) permission slips will be issued for <u>August 15-October 31</u>.
    - Hunters are reminded Type 7 licenses are not valid in this portion of Area 48.
  - **All Simpson Ridge HMA permission slips are issued by a random drawing.**
- **Persons may not scout or trespass** prior to their designated access period!
- **Each hunter** must have **a permission slip** and a **vehicle pass** to the specific hunter management area and species they are hunting. **Anyone without Department permission shall be subject to trespass charges.**
- Non-hunting/ non-permitted persons may assist in game retrieval on the HMA as long as they are accompanying a permitted hunter and do not possess a firearm.
- **You may apply for <u>either</u> a Medicine Bow River or a Simpson Ridge HMA permission slip, not both!**
- Due to the limited number of water sources, <u>archery hunters</u> are urged to coordinate with one another by sending an email to **simpsonridge@yahoo.com** or a letter with your hunting plans and telephone number to the Hi-Allen Ranch (see below) as far in advance of your hunt as possible.
- Hunting is by foot and horseback ONLY.
- Motorized travel is allowed on **established roads ONLY**. When roads are wet or muddy, motorized access is limited to highways and county roads.
- Leave all gates closed. Abide by all signs and posted areas.
- No overnight camping on private land, except with landowner's written permission. Camping is prohibited on state trust lands.
- Do not litter, it is against the law.
- No dogs allowed on the hunter management area.
- Do not shoot in the direction of livestock, buildings, roads, windmills, stock tanks, or any object other than the animal you are hunting.
- Do not damage fences, range improvements, or harass livestock. Livestock has the right of way.
- **Report any wildlife violations 1-877-WGFD-TIP (1-877-943-3847).** Future hunting opportunities depend on hunter compliance with all ranch rules as well as Game and Fish laws and regulations.
- **If you harvest an animal on deeded land, deposit the landowner coupon in the drop box or mail to:**

Hi-Allen Ranch
PO Box 96
Medicine Bow, WY 82329

Dana Meadows Ranch
PO Box 857
Saratoga, WY 82331

Bowen Ranch
County Road 402
Elk Mountain, WY 82324

Beltek Inc.
Beltek Drive and 3rd Street
Hanna, WY 82327

TMA Inc.
2020 Carey Ave.
Cheyenne, WY 82003

PRONGHORN HUNT AREAS IN THE VICINITY OF THE FIELD TRIP (route shown in red)