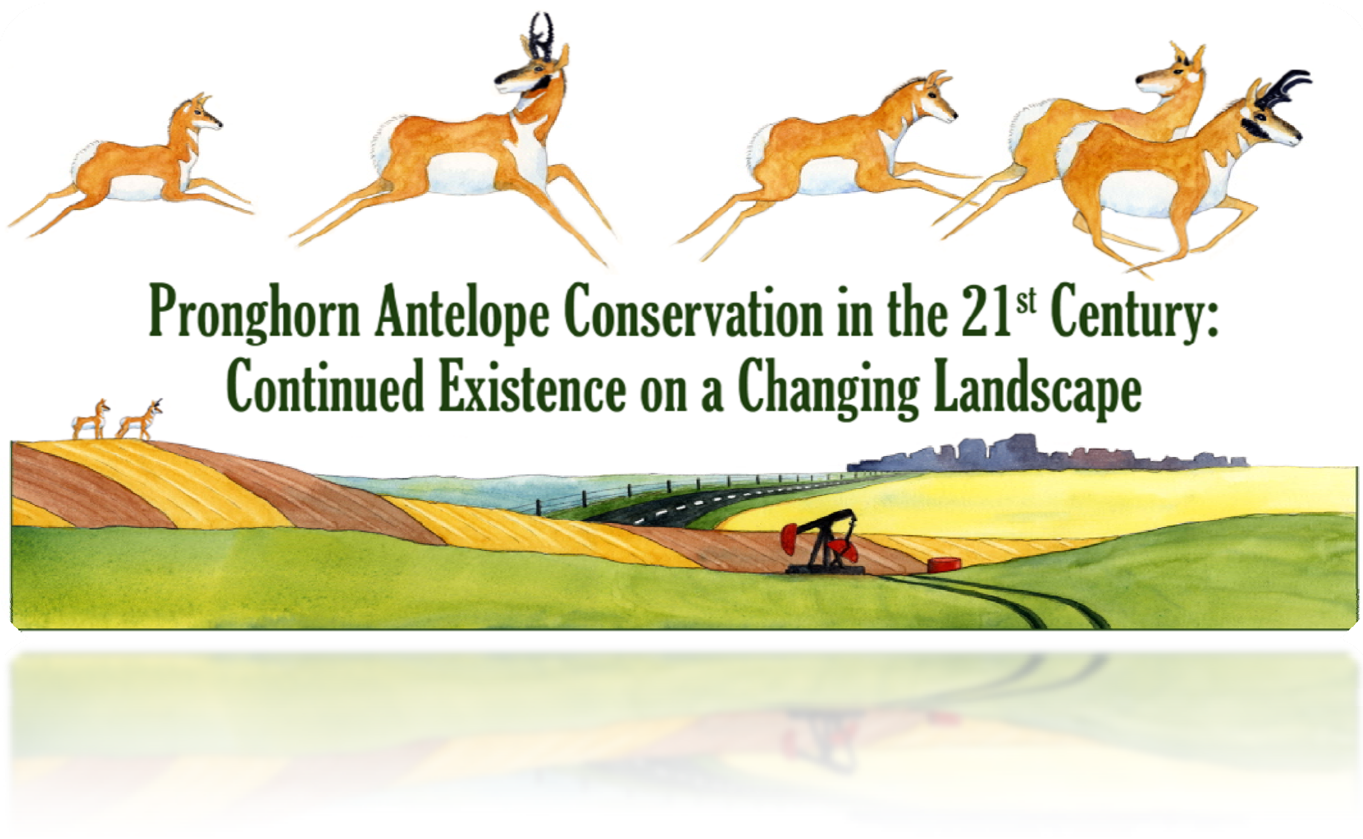
Proceedings of the
23rd Biennial Pronghorn Workshop

2008



May 13 – 16, 2008
Canmore, Alberta

PROCEEDINGS

of the

TWENTY-THIRD BIENNIAL

PRONGHORN ANTELOPE WORKSHOP

2008

Edited by Darren Bender

Canmore, Alberta, Canada

May 13 – 16, 2008

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Section I Workshop Agenda

Tuesday, May 13

6:00 – 9:00 PM	**Registration**
7:00 – 9:00 PM	**Social (sponsored by Lotek Wireless Inc)**

Wednesday May 14

7:00 – 8:00 AM	**Breakfast Buffet**: sponsored by Alberta Sustainable Resource Development: Fish and Wildlife Division
7:00 – 8:00 AM	**Registration**
8:00 – 8:20 AM	**Welcome to the 23rd Biennial Pronghorn Workshop** Kim Morton – Alberta Fish and Wildlife
8:20 – 8:45 AM	**Welcome to Alberta** Jim Allen – Alberta Sustainable Resource Development Todd Zimmerling – Alberta Conservation Association Cormack Gates – University of Calgary
8:45 – 9:00 AM	**Opening Remarks** Dr. Morley Barrett

Pronghorn Antelope Management (Session Host: Joel Nicholson)

9:00 – 9:25 AM	**Ducks Unlimited Canada: Helping Enhance Biodiversity on the Canadian Prairies.** Morley Barrett*and David Kay.
9:25 – 9:50 AM	**Maintaining the Balance: Management for Range Sustainability at Canadian Forces Base Suffield.** Delaney Boyd*.
9:50 – 10:15 AM	**Coffee Break:** sponsored by Shell Canada
10:15 – 10:40 AM	**Landowner Knows Best: Local Ecological Knowledge of Pronghorn Antelope Habitat Use in Southern Alberta.** Paul Jones*, Mike Grue and Julie Landry-DeBoer.

10:40 – 11:05 AM **Province and State Status Report on Pronghorn Antelope – 2008.**
Kim Morton, Paul Jones and John Taggart*.

11:05 – 11:30 AM **Pronghorn Captive Management: Why, When, and Where.**
Kim Brinkley* and Jorge Cancino.

11:30 – 1:30 PM **Lunch and Business Meeting:** lunch sponsored by the Alberta Conservation Association

Migration of Pronghorn Antelope (Session Host: Robert Anderson)

1:30 – 1:55 PM **Role of Population Phenotype in Ensuring Resilient, Abundant Populations of Pronghorn Antelope.**
Michael J. Suitor*, C. Cormack Gates, Paul Jones, Kyran Kunkel, Mike Grue and Julie Landry-DeBoer.

1:55 – 2:20 PM **Pronghorn Movements and Site Fidelity in Southwestern North Dakota.**
Jesse L. Kolar*, Joshua J. Millspaugh and Bruce A. Stillings.

2:20 – 2:45 PM **Identified Pronghorn Migration Corridors on Anderson Mesa, Arizona.**
Richard A. Ockenfels*, C. Richard Miller, Scott C. Sprague and Sue R. Boe.

2:45 – 3:10 PM **A Spatial Approach to Classifying Pronghorn Movement Behaviour.**
Paul Knaga* and Darren Bender.

3:10 – 3:30 PM **Coffee Break**: sponsored by Canadian Natural Resources Ltd.

Habitat Selection (Session Host: Mike Suitor)

3:30 – 3:55 PM **Winter Habitat Selection by Pronghorn Antelope at Multiple Scales in Southern Alberta.**
Paul F. Jones*, Mike Grue, Julie Landry-DeBoer, Mike Suitor, Cormack Gates, Dale Eslinger and Kim Morton.

3:55 – 4:20 PM **Recent Changing Vegetation Conditions and Pronghorn Populations Near Elko, Nevada.**
Jim Yoakam*, Ken Gray and Merlin McColm.

4:20 – 4:30 PM **End of Session and Workshop Announcements**

Thursday May 15

7:00 – 8:30 AM **Breakfast Buffet**: sponsored by Alberta Sustainable Resource Development: Fish and Wildlife Division

7:00 – 8:30 AM **Registration**

Pronghorn Antelope Conservation in the 21st Century: Continued Existence on a Changing Landscape (Session Host Cormack Gates)

8:00 – 8:45 AM **Alberta's Changing Prairie Landscape: Addressing Cumulative Effects.**
Ian Dyson*.

8:45 – 9:30 AM **Conservation Challenges for Pronghorn in a Changing Landscape.**
Jim Yoakum*.

9:30 – 10:15 AM **Pronghorn as a Focal Species for Coordinated Wildlife and Land Management in the Transboundary Region of the Northern Sagebrush Steppe.**
Cormack Gates*, Dale Eslinger, Pat Gunderson and Sean Burke.

10:15 – 10:45 AM **Panel Discussion** (Moderator: Cormack Gates)

10:45 – 11:00 AM **Coffee Break:** sponsored by EnCana

Field Trip to Banff National Park: Bag lunch provided by Alberta Conservation Association

11:00-11:30 AM **Consilience and Ecological Restoration in Banff National Park, Canada.**
Clifford A. White* and Jesse Whittington.

11:30-12:00 PM **Effects of Human Activity and Restoration Actions on Animal Movements.**
Jesse Whittington*, Marco Musiani, Tony Clevenger and Cliff White.

12:00 – 4:00 PM Field Trip to Banff

Banquet, Awards and Entertainment: sponsored by Petro-Canada

5:30 – 6:30 PM **Social**

6:30 PM **Dinner Served**

7:30 – 8:30 PM **Awards Ceremony** (Host: Dale Eslinger)

8:30 – 9:30 PM **Entertainment**

Friday May 16

7:00 – 8:30 AM **Breakfast Buffet:** sponsored by Alberta Sustainable Resource Development: Fish and Wildlife Division

7:00 – 8:30 AM **Registration**

Fawn Survival and Physiology (Session Host: Doug Manzer)

8:30 – 8:55 AM **Survival Patterns of Newborn Pronghorn Fawns on Hart Mountain National Antelope Refuge, Oregon, 1996–2007.**
Banks, H., M. Bennett, M. Gregg, G. H. Collins, C. Foster and D. G. Whittaker*.

8:55 – 9:20 AM **Blood Chemistry, Mineral, and Whole Blood Parameters for Newborn Pronghorn Fawns on Hart Mountain National Antelope Refuge, Oregon, 1996–2007.**
Banks, H., M. Bennett, M. Gregg, G. H. Collins, C. Foster and D. G. Whittaker*.

9:20 – 9:45 AM **Potential Factors Affecting Pronghorn Fawn Survival and Predation in Arizona.**
Stanley C. Cunningham, Kirby D. Bristow* and Richard O. Ockenfels.

9:45 – 10:00 AM **Coffee Break:** sponsored by Shell Canada

Population Ecology (Session Host: John Taggart)

10:00 – 10:25 AM **Pronghorn and Habitat Management for Fifty Years on the Hart Mountain National Antelope Refuge: A Review and Assessment.**
Jim D. Yoakum*.

10:25 – 10:50 AM **Environmental Conditions as a Precursor of Pronghorn Horn Size Throughout Life.**
David E. Brown* and E.D. Edwards.

10:50 – 11:15 AM **Comparison Between Pronghorn Age and Horn Size in Southern Alberta**.
Kim Morton*, Paul F. Jones and Mike Grue.

11:15 – 11:30 PM **End of Workshop and Announcements.**

Province and State Status Report on Pronghorn Antelope 2008

KIM MORTON, *Alberta Sustainable Resource Development – Fish & Wildlife Division, 530-8th S. S., Lethbridge, AB T1J 2J8, Canada*

PAUL F. JONES, *Alberta Conservation Association, 530-8th S. S., Lethbridge, AB T1J 2J8, Canada*

JOHN TAGGART, *Alberta Sustainable Resource Development – Fish & Wildlife Division, 346 – 3rd Str. S.E., Medicine Hat, AB T1A 0G7, Canada*

ABSTRACT

A requirement of the host jurisdiction for every biennial Pronghorn Workshop is to provide a status update on pronghorn management in jurisdictions throughout North America. Early in 2008, a standardized questionnaire was sent electronically to jurisdictions within current pronghorn range. A total of 18 responses were received back from 19 jurisdictions contacted. Responses were received from the United States, Mexico and Canada. From figures provided by the 18 jurisdictions, the North American pronghorn population is estimated to be 1.1 million animals. Wyoming supports about half of the North American population with 564,580 animals. Montana and South Dakota have populations of 216,632 and 74,434 animals respectively. In other jurisdictions, population estimates range from 2 in Manitoba to 45,000 in New Mexico. Buck: doe ratios vary across jurisdictions, ranging from 31:100 in Oregon to 76:100 in Wyoming. Reproduction varies across North American Pronghorn range as well, with fawn: doe ratios as low as 22:100 in Arizona to 102:100 in South Dakota. Based on questionnaire results we provide recommendations to assist future host organizations and to further promote the transfer of knowledge between jurisdictions.

KEY WORDS pronghorn, *Antilocapra americana*, Management, North America, status report

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 jurisdictions known to have free ranging pronghorn antelope and provide a summary of that data at the workshop. In early 2008, Alberta Sustainable Resource Development (ASRD) and the Alberta Conservation Association (ACA) and sent out a standardized questionnaire electronically to all jurisdictions within current pronghorn range. A total of

18 responses were received back from 19 jurisdictions in the United States, Mexico and Canada.

Pronghorn populations and management vary across North America. While each jurisdiction managing pronghorn keeps various records for their own management purposes, this status report summarizes standardized information from across the continent. Each jurisdiction provided data from the past year (2007) and 10 years previous (1997), if available. The results have been summarized below with specific information available in Appendix I.

SURVEY METHODOLOGY AND POPULATION ESTIMATES

Pronghorn survey methods varied greatly among jurisdictions. Helicopter surveys were used by 5 jurisdictions, fixed-wing aircraft were used by 15, and ground surveys were used by 9. While some jurisdictions used more than 1 survey type, other jurisdictions did not survey for pronghorn. Of the jurisdictions using aerial surveys, 7 used strips, 8 used lines, 5 used targeted areas, 1 used a random aerial survey methodology, and 1 used a stratified random survey. Only 3 jurisdictions stratified habitat prior to aerial surveys with all stratification based on native vs. agricultural land cover. During aerial surveys, 9 jurisdictions reported using some type of sightability correction on survey results, while 8 did not correct for sightability. Most ground surveys were focused on concentration areas (n=9), with three as trend routes, and 1 was reported as a pre-hunt composition survey. Regardless of survey type, most pronghorn surveys occurred during the post fawn period (n=18 jurisdictions), followed by winter (n=7 jurisdictions), pre-fawn (n=6 jurisdictions) and fall (n=2 jurisdictions). Of 18 jurisdictions responding, 10 reported they were satisfied with their survey methods. Five jurisdictions reported dissatisfaction regarding the surveys they conducted or their lack of survey. Comments from jurisdictions on how surveys could be improved are listed in Table 1.

Across North America, there were approximately 1.1 million pronghorn in 2006-2007. Population estimates ranged from 2 pronghorn observed by a landowner in Manitoba, Canada to 564,580 pronghorn estimated to be in Wyoming (2006 estimate). The core pronghorn area is Wyoming, Montana, Colorado and South Dakota. Over 80% of the continents pronghorn can be found in these four states, with population estimates becoming smaller as we move to the edges of continental pronghorn range (Figure 1).

Herd composition data showed a wide range of recruitment patterns. The number of fawns per 100 does ranged from 22 to 102 (Figure 2). Straight comparison of fawn:doe ratios is difficult, however, because different jurisdictions conducted their surveys at different times of the year. Fawn mortality is quite high in most areas, so a difference of only a month or two in survey times can result in large differences in fawn:doe ratios.

Table 1. Suggested survey improvements by state/provincial pronghorn managers.

Jurisdiction	Summary of comments
AB	Need for inclusion of sightability and the development of confidence intervals. Also, better stratification based on vegetation.
OR	Oregon would benefit from better funding to allow for designed surveys.
MT	Exploring new protocol.
ND	Incorporating detection rate into population estimates.
SD	Switching to aerial line transect survey.
CA	Need more repeatable flights over more time frames.
NV	More biologists (not probable)- attempt a heli-survey every 5 years over large areas which have limited ground surveys to confirm and correct biases in fawn/buck ratios. This survey would also provide vegetation and water availability and assist in addressing issues.
NM	Current technique provides reasonable estimate of pre-hunt bucks in areas. The technique does not provide adequate recruitment or population trends. Fall surveys would obtain post hunt and fawn data, and sight bias would be nice to have, though not critical.
TX	Discontinue survey of traditional quadrats in panhandle and switch to biennial survey of entire herd. Develop sightability model to account for rough / green / sunny / shrub / terrain.
ID	Increase funding and a reliable survey method and results

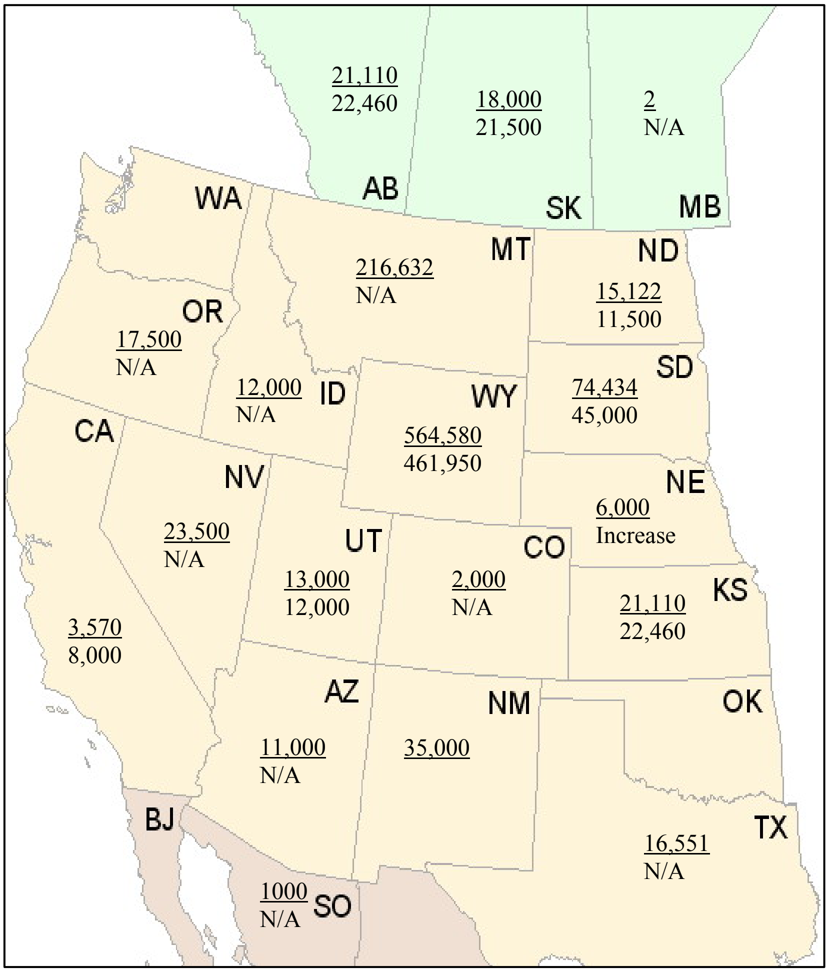

Figure 1. Pronghorn population estimates by jurisdiction in North America in 2007. Values in the numerator represent the population estimate and values in the denominator represent the population goal for each jurisdiction.

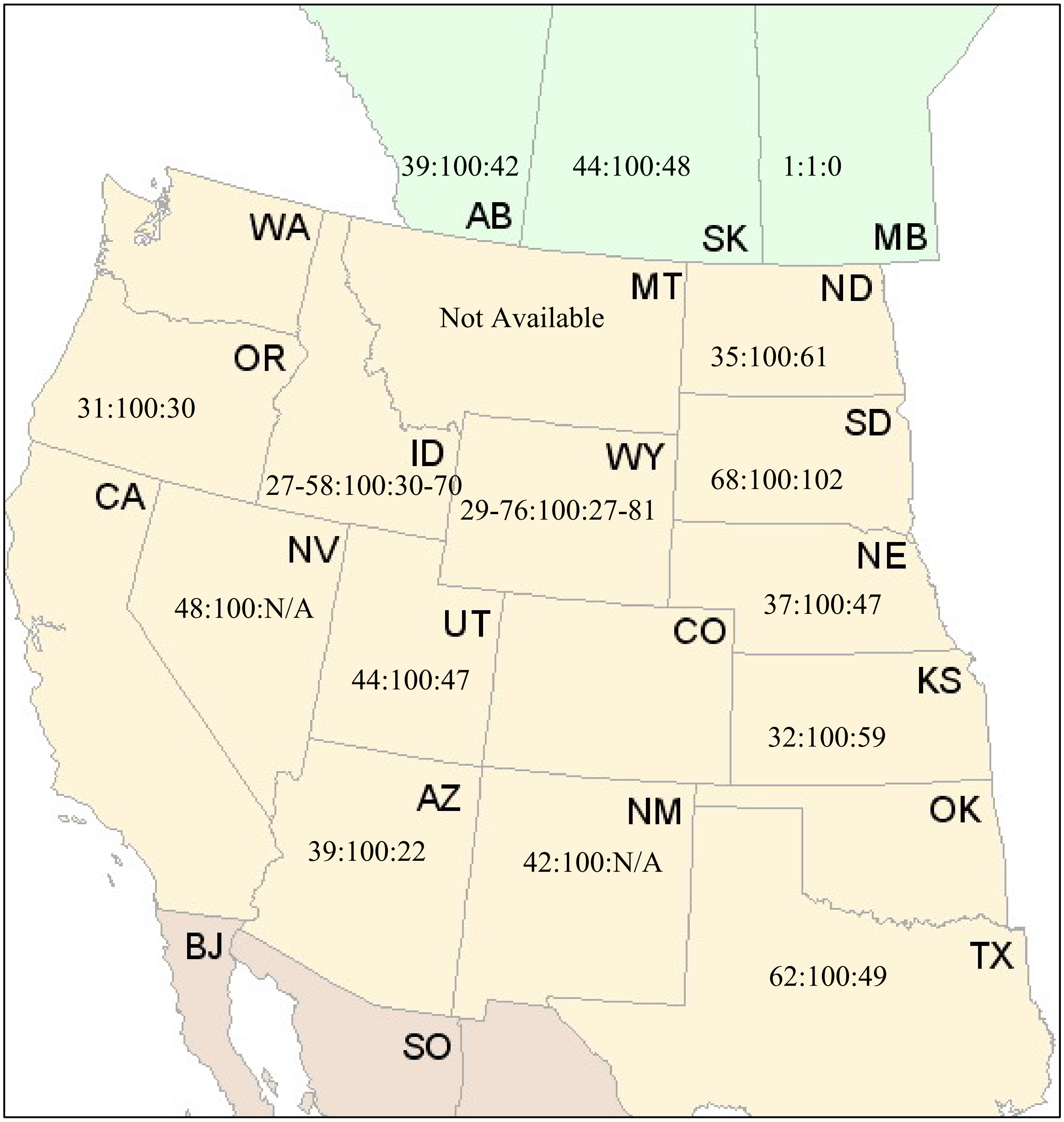

Figure 2. Pronghorn buck:doe:fawn ratios by jurisdiction in North America in 2007.

HUNTING SEASON STRUCTURE

Pronghorn hunting is very popular across most of the current range. One of the drivers behind pronghorn management is to provide a sustainable surplus to allow for hunting opportunities to residents and non-residents. Hunting seasons available in each jurisdiction are listed in Table 2. Season lengths vary from the 3 day rifle season in New Mexico to the 102 day archery season in Nebraska. While most jurisdictions provide pronghorn hunting opportunity for non-residents (16 of 17). The approach for accommodating non-resident hunting varies among jurisdictions. In jurisdictions such as New Mexico and Texas, non-resident opportunities may be actively promoted. In jurisdictions such as Idaho and California, while non-residents do have opportunity, they are cited as "benignly ignored" with respect to management. The majority of jurisdictions report having limited non-resident opportunity, usually designated by a proportion of total licenses available.

Table 2. Pronghorn antelope hunting season availability and length (# of days) by jurisdiction across North America in 2007.

Jurisdiction	Rifle Season	Muzzleloader Season	Archery Season
AB	12	0	20
SK	11	27	53
OR	9	9	30
MT	29	0	56
ND	16.5	0	37.5
SD	16	0	59
WY	60	30	45
NE	16	16	109
CA	17	0	9
NV	15	0	20
UT	11	0	28
KS	4	8	28
AZ	10	10	14
NM	3	4	9
TX	9	9	9
OK	13	0	0
ID	30	30	32

HARVEST SUMMARY

Harvest data was collected in a variety of ways, from mandatory registration to voluntary check stations. Questionnaires are the most used method for collecting harvest information, and they were used in various ways by 16 jurisdictions. Harvest data is important for providing feedback to population models and for comparing harvest projections to actual harvest to determine if management objectives are being met. In 2007, over 65,500 bucks and 47,000 does were harvested. Figure 3 illustrates estimated total harvest by jurisdiction.

PREDATOR CONTROL

One of the largest sources of mortality on pronghorn is predation of young. The main predator in most jurisdictions is the coyote. Jurisdictions were asked to report whether they implemented any predator control measures directed at coyotes. While 8 jurisdictions reported having some form of predator control, in most cases, it was not used as a pronghorn management tool. It was most often done in association with livestock programs. Table 3 summarizes jurisdictional responses to predator control efforts.

Table 3. Predator control measures by jurisdiction across North America in 2007.

Jurisdiction	Predator control measures
SK	Trapping - price driven
MT	Occasional aerial gunning of coyotes in concert with APHIS/Livestock
SD	Trapping, aerial gunning and targeted trapping
WY	County management boards conduct control activities for pronghorn if meets criteria/objectives
NV	USDA by herd basis primarily in prescription/research areas
UT	Wildlife service contract
AZ	Aerial gunning in targeted units with low fawn survival
TX	Private landowners

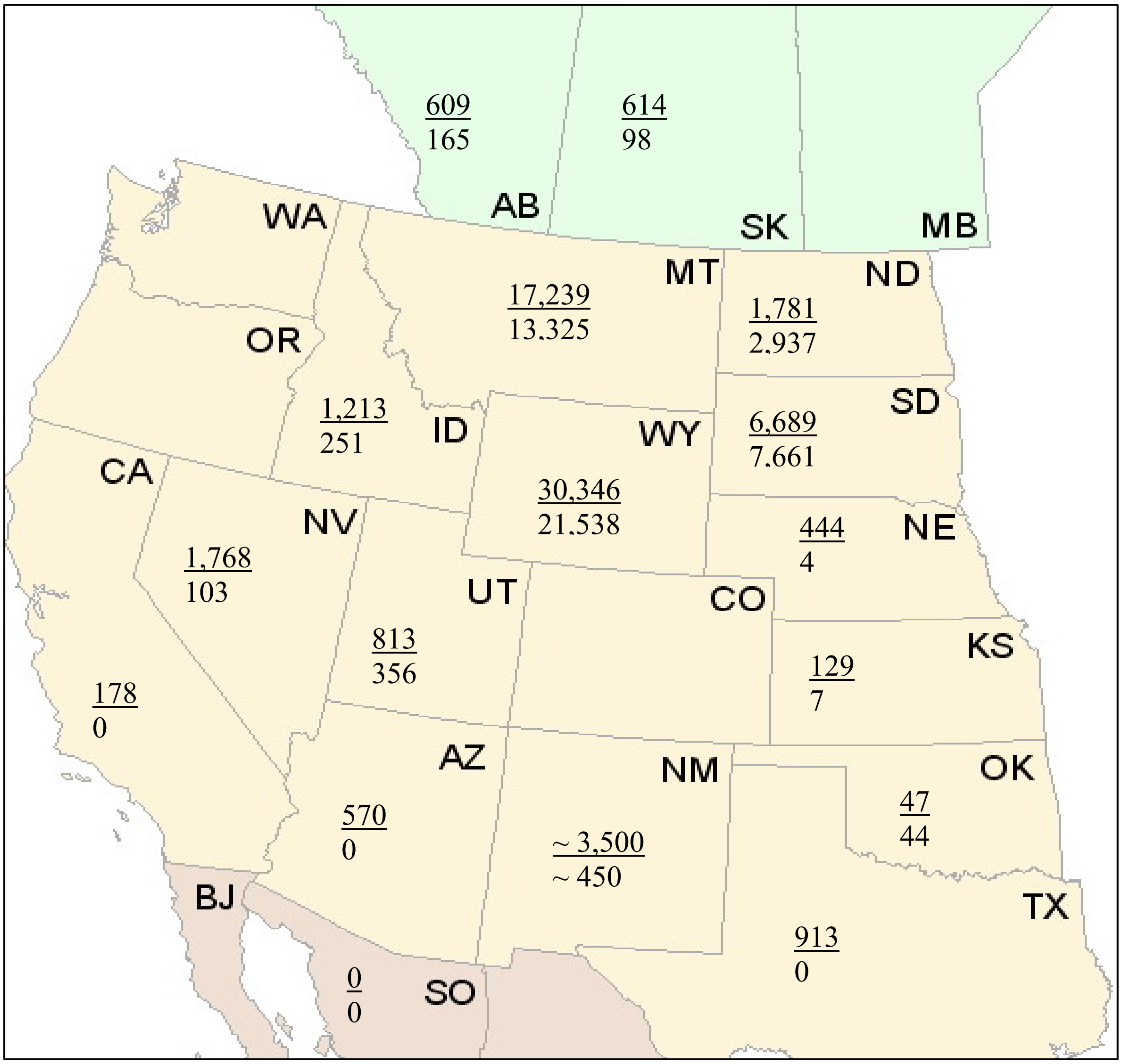

Figure 3. Estimated pronghorn harvest by jurisdiction across North America in 2007. Values in the numerator represent buck harvest and values in the denominator represent doe harvest.

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 the continued existence of pronghorn throughout its range, as landscapes face many changes and multiple uses that are not always complimentary to long-term pronghorn survival. Table 4 lists current research being undertaken by different jurisdictions. For any information on these programs, the host jurisdiction should be contacted directly. In some jurisdictions, it has been necessary to transplant pronghorn from healthy populations in other jurisdictions. Table 5 lists transplants that have been conducted in different jurisdictions.

Table 4. Current pronghorn research by jurisdiction across North America in 2007.

Jurisdiction	Research activity
AB	Habitat selection and connectivity, movement and migration, age & horn characteristics.
OR	MSc student evaluating movements and habitat utilization of pronghorn in the Owyhee region of SE OR.
MT	Habitat identification and use.
ND	Determine home range, survival rates and habitat use of adult does and bucks.
AZ	Identifying movement corridors and effectiveness of highway mitigation features.
TX	A Landscape Evaluation of Pronghorn Antelope Habitats and Management Units in Trans-Pecos Texas.
MEX	Movements, home range and habitat use via GPS radio collars.

Table 5. Pronghorn transplants by jurisdiction across North America in 2007.

Jurisdiction	Pronghorn transplants
MT	Full distribution - some transplants in the past.
WY	Provides fawns to Mexico for research.
NV	Transplant throughout the state: 2903 since 1950.
UT	High elevation herd on Parker Mountain is productive and they take animals from this herd to supplement other herds since 2001 (when necessary).
AZ	In areas with below carrying capacity following habitat improvements.

NM	100/year of nuisance and depredated animals, moved to good habitat and desire for animals. 100-400 for 2008-9 to Reserves and Mexico.
TX	Private landowners through Trap/transport/transplant program.
OK	Mid 90's 25 pronghorn from Wyoming.
MEX	Occasional transplant to a Sonoran captive breeding program in Arizona.
ID	Augmented a few herds with Utah pronghorn a few years ago.

DISCUSSION

The questionnaire used for the 2008 status report was based on the questionnaire used historically with a few minor changes. Based on the responses from the various jurisdictions, there is a wide range of survey methods and protocols being used currently. Standardization of data collection and reporting (i.e. definition for line versus strip transect) would assist in comparison of results among the jurisdictions. Additionally, if each jurisdiction were to provide a contact list (minimum of 2 individuals) to the host organization, the completion of questionnaire summary report would be facilitated.

Ackerman (2006) indicated that the 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 jurisdictions would assist the host agency with reporting the status of pronghorn across North America as well as allowing for the analysis of long-term trends in populations. In addition, the pronghorn workshop should consider the establishment of a pronghorn working group under WAFWA similar to mule deer group. This would further facilitate the transfer of information among jurisdictions.

LITERATURE CITED

Ackerman, B. B. 2006. Pronghorn state and province status report. Proceedings Pronghorn Workshop, 23:7-23.

Appendix I: Population estimates and estimation methods by state and province in 2007.

State / Prov	Population Estimate	Population Goal	Percent Observed	Pre-season B:D ratio	Pre-season F:D ratio	Survey Type			Frequency of aerial coverage		Frequency of ground coverage		Survey Method		Time of Year	
						Helicopter	Fixed-wing	Ground	Specific Area	Entire Range	Specific Area	Entire Range	Aerial	Ground	Aerial	Ground
AB	21,100	22460	17%	39	42	X			Annually	Annually	N/A	N/A	Line Transect	N/A	Post-Fawn	N/A
AZ	11,000		50%	34	22		X		Annually	Annually	N/A	N/A	Strip Transect	N/A	Post-Fawn & Winter	N/A
CA	3,570	8,000					X		Biennially	N/A	N/A	N/A	Targeted search & Count	N/A	Winter	N/A
ID	12,000			27-58	30-70	X	X	X	Variable	Annually	Annually	Never	Line Transect / Targeted Search & Count / Stratified Random Quadrat Sampling	Trend Routes / Target Concentrated Areas	N/A	N/A
KS	2,000		60%	32	59		X		Annually	N/A	N/A	N/A	Line Transect	N/A	Post-Fawn & Winter	N/A
E.U.M	1,000		89%				X		Biennially	Biennially	N/A	N/A	Line Transect	N/A	Winter	N/A
MT	216,632		variable				X		variable	variable	N/A	N/A	Strip Transect / Targeted Search & Count	N/A	Post-Fawn	N/A
NE	6,000	Increase	30%	37	47		X	X	Annually	Never	Annually	Never	Line Transect	Target Concentrated Areas	Post-Fawn	Winter
NV	23,500		32%	48		X		X	Biennially	Annually	Never	Never	Targeted search & Count	Target Concentrated Areas	Fall	Fall
NM	35-45,000	N/A	50-=60%	42			X		Every 1-3 years	Never	N/A	N/A	Strip Transect	N/A	Pre-Fawn	N/A
ND	15,122	7,500-11,500	96%	35	61		X		Annually	years	N/A	N/A	Strip Transect	N/A	Post-Fawn	N/A
OK							No Surveys									
OR	17,500	None	U/K	31	30	X	X	X	Annually	Annually	Annually	Annually	Targeted Search & Count / Random Search & Count	Trend Routes / Targeted Concentration Areas	Post-Fawn & Winter	Post-Fawn & Winter
SK	18,000	21,500	75%	44	48		X	X	Every 3 years	Never	1-2 years	Never	Line Transect	Targeted Concentration Areas	Pre-Fawn / Post Fawn	Post-Fawn
SD	74,434	45,000	33%	68	102		X		Every 1-2 years	Every 1-2 years			Strip Transect	Targeted Concentration Areas	Pre-Fawn / Post Fawn	
TX	16,551		69%	62	49		X	X	Every 1-2 years	Panhandle (every 2-3 years).	Every 1-2 years		Strip Transect	Targeted Search & Count	Post-Fawn	Post-Fawn
UT	13,000	12,000 min.	75%	44	47		X	X	Annually	Annually	Annually	Annually	Line Transect	Targeted Concentration Areas	Pre-Fawn	Post-Fawn
WY	564,580 (2006)	461,950	Varies	29-76	27-81		X	X	Every 3 years	Annually	Never		Line Transect	Pre-hunt herd composition	Pre-Fawn	Post-Fawn

Section III Submitted Papers

Ducks Unlimited Canada: Helping to Enhance Biodiversity on the Canadian Prairies

MORLEY BARRETT, *Box 11, Site 8, RR3, Rocky Mountain House, Alberta*

DAVID KAY, *Ducks Unlimited Canada, Edmonton, Alberta*

ABSTRACT Nearly half of the North American duck population breeds on the Canadian prairies and consequently, since 1938 Ducks Unlimited Canada (DUC) has focused much of their habitat conservation programs on the prairies. In addition, DUC has been the primary Canadian delivery agent for the North American Waterfowl Management Plan (NAWMP) that was launched in 1986. This paper examines the goals, guiding principles and programs of DUC and reviews key habitat elements and accomplishments of the NAWMP program from 1986 to 2006, as reported by the Prairie Habitat Joint Venture (PHJV). The PHJV secured over 3.6 million acres of habitat at a cost of $641 million. Prior to 1986, DUC and other conservation partners secured an additional 1.8 million acres of waterfowl habitat on the prairies. Some important habitat accomplishments included conservation and restoration of wetlands, conservation of large tracts of native uplands, conversion of annual cropland to perennial cover and a myriad of other on-farm conservation programs with landowners, including the development of grazing systems. In addition, DUC has actively worked with key government stakeholders to help develop more beneficial water, wetland and agricultural policies. We discuss how these collective achievements contribute to increased waterfowl productivity and to the improvement of biodiversity on the prairies. Some of the ongoing challenges facing the maintenance of biodiversity in the prairie ecosystem are reviewed. Finally, this paper summarizes how DUC, through its diverse partnerships and programming, enhances biodiversity on the Canadian prairies, benefiting waterfowl and other wildlife, including pronghorn (*Antilocapra americana)*.

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KEY WORDS biodiversity, conservation, Canadian prairies, Ducks Unlimited, habitat conservation, landscape management

The Canadian prairies is the single most important waterfowl breeding area in North America and thus has been the focus for agencies like Ducks Unlimited Canada (DUC) that are committed to improving prairie landscapes for the sustainable, high production of waterfowl (Figure 1). We contend that the programs delivered by DUC contribute not only to the long-term benefit of waterfowl but also contribute to the enhancement of biodiversity on the Canadian prairies. DUC has been active on the Canadian prairies since 1938 and we examine this organization's principles, goals, and programs to determine how its accomplishments have helped maintain biodiversity on the prairies. For reporting purposes, emphasis is placed on the 20-year interval from 1986-2006, which is the first 20 years of the North American Waterfowl Management Program (NAWMP).

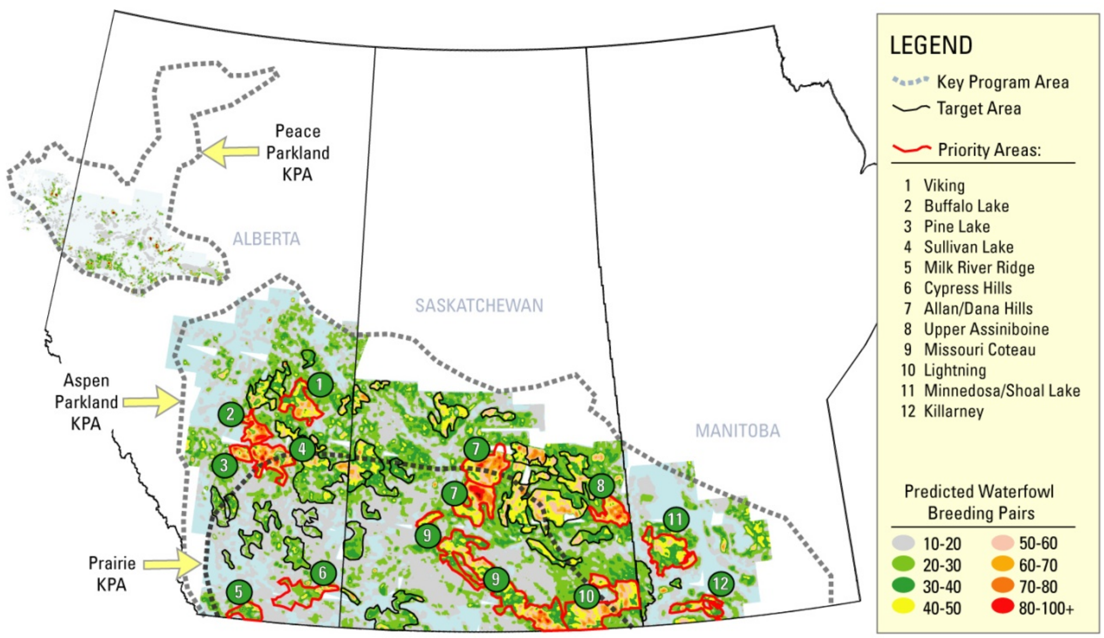

Figure 1. Key target areas for delivery of waterfowl conservation programs on the Canadian prairies. Areas below the bottom dotted line closely depict the distribution of pronghorn in Canada.

The NAWMP, an international conservation program involving Canada, the United States and Mexico, was first signed in 1986 (NAWMP 2008). The objective of this program was to restore waterfowl populations in North America to the levels of the 1970s. The NAWMP established waterfowl population goals for each species and identified key habitat areas that became the focus for habitat restoration and protection activities. The key habitat area on the Canadian prairies became the Prairie Habitat Joint Venture (PHJV) an area originally encompassing Alberta, Saskatchewan and Manitoba. As a partner within NAWMP and the subunit PHJV, DUC delivers the majority of habitat programs on the prairies and provides leadership in planning, science, policy and partnership development, and funding. Since the authorization of NAWMP in 1986, DUC has dedicated nearly 100% of its habitat programs and staffing resources to the delivery of this international program. This has allowed DUC to capture greater partnership and NAWMP program funding in addition to its internal funding. Consequently, there is a strong overlap in the programming by DUC and NAWMP on the Canadian prairies and all agencies use the same tracking system to record achievements. In this paper, we present the 20-year accomplishments of the PHJV as summarized in 2006, as the appropriate proxy for waterfowl programming on the prairies. We acknowledge the contributions from provincial, federal, NGO and international parties that formed or funded the PHJV and share in these accomplishments.

DUC CONSERVATION PROGRAM APPROACH, PRINCIPLES AND GOALS

DUC's conservation program focuses on four broad areas of activity in delivering their program on the prairies.

The Approach

Habitat Projects.— These are the on-the-ground projects or activities that help restore and conserve wetlands and associated uplands for the benefit of waterfowl, other wildlife, and people. Generally these activities are done in conjunction with the landowner and often there is both an agricultural and wildlife benefit. These programs and activities have typically consumed the bulk of DUC's resources on the prairies and have established the identity of the company in the eyes of the public. A more specific examination of DUC's programming and achievements on the prairies will provide insight into whether or not these actions are likely to promote biodiversity. In particular, we examine whether or not the benefits of this programming are narrowly focused on waterfowl or have more broad-sweeping impacts.

Science and Research.— DUC's management programs and approach are guided by science through the Institute for Wetland and Waterfowl Research a science arm of DUC. A series of comprehensive research programs has helped to assess the efficacy of different types of conservation programs relative to waterfowl benefits. The nature of the management action, the design of programs, and the evaluation of success is subject to scientific evaluation in a continuous adaptive-management context.

Industry and Government Relations.— DUC recognizes the abilities of governments and their agencies to positively or negatively influence conservation actions on private and public lands. For this reason, DUC is dedicated to working with provincial, federal, and municipal governments to promote policies and regulations that promote sustainable land and water use. A more specific examination of DUC's programming on the prairies will provide insight into whether or not its benefits are narrowly focused on waterfowl or have more broad-sweeping effects on biodiversity. DUC and its partners work with all levels of government to develop and adopt environmentally-friendly policies and programs. In recent years, the promotion of ecological goods and services as a valid product of agriculture has been the subject of much debate and lobbying. The thesis is that by rewarding landowners for restoring and maintaining wetlands and other important habitat types, the habitat base will be conserved and stabilized. DUC understands that large landscapes or habitat types can be positively or negatively impacted by government action, but many examples exist to show how beneficial policies can help promote biodiversity.

Education.— The need to promote awareness and appreciation of important wildlife habitats and the dependent relation between these habitats, wildlife populations, and society, presents an ongoing need and challenge in an increasingly urbanized society. DUC provides environmental content, particularly on wetlands, for inclusion in school curricula, in addition to a wide variety of educational material for the general public. DUC also maintains a network of outdoor education and interpretive centers across the prairies. Education and knowledge are seen as the key to future political strength as the population becomes more aware and supportive of the need to maintain our natural capital.

Principles

DUC's conservation programs are intended to benefit both wildlife and people and are particularly focused on wetland conservation. Below are a number of principles that DUC uses to guide their programs.

- Habitat ***programs focus on those areas with the greatest potential*** to benefit waterfowl nesting success.
- Conservation programs emphasize actions that provide ***permanent protection of functional native*** and naturalized habitats.
- Preserving or ***restoring the ecological function*** of landscapes is a high priority.
- DUC ***works cooperatively with landowners*** to improve the productive ability of entire landscapes for waterfowl.
- Conservation initiatives should contribute to the overall health of the land and ***benefit both people and wildlife***.
- Broader impacts are achieved through ***collaborative partnerships*** with others.
- There is a commitment to the ***constant evaluation and adaptation of programs*** through scientific research, new information, and circumstance.

Goals

DUC has established four conservation goals that help characterize its conservation values and program approaches. Some people will argue that these goals are unrealistic and unattainable, but they provide an unequivocal statement of values for DUC. These goals provide broad direction to staff for the habitat projects and conservation program undertaken by DUC.

Goal 1. **No loss of wetlands** with value to waterfowl.

Goal 2. **Restore wetlands** to support waterfowl.

Goal 3. **No loss of upland cover** with value to waterfowl.

Goal 4. **Restore upland cover** to improve habitat conditions for waterfowl.

RESULTS: HABITAT ACHIEVEMENTS AND BIODIVERSITY

Land Securement-Preserving the Best of the Best

Since 1938, DUC has been working on the Canadian prairies to restore and conserve waterfowl habitat. Throughout this period there has been an effort to acquire and permanently preserve high priority waterfowl habitat. These areas have typically been complexes with both wetlands and permanent cover and securement typically has been accomplished through fee simple purchase. With the more recent establishment of legislation to support conservation easements (CEs), this tool has been used across the Canadian prairies to conserve priority areas of habitat on a perpetual basis.

DUC has used the CE tool alone and with partners to secure large tracts of land, particularly in the ranching country of southern Saskatchewan and Alberta. Typically, DUC has paid between 20-25% of fair market value to establish perpetual CEs on all or a portion of a property. These CEs have specific registered activities that are allowed or prohibited on the land. In general these CEs are designed to maintain the traditional ranching culture but prohibit the breaking of grasslands and the draining of wetlands. In many cases, there is also a provision that allows DUC to restore lost or drained wetlands on the ranch.

Throughout the history of DUC, there has been a history of benevolent supporters donating land to DUC. More recently, CEs have been donated as well and the current Canadian tax laws have created a favorable environment for the donation of ecologically-significant lands to a qualified conservation organization like DUC. Donors typically appreciate and identify with the high wildlife values of the land and want to see these areas maintained in their natural state in perpetuity.

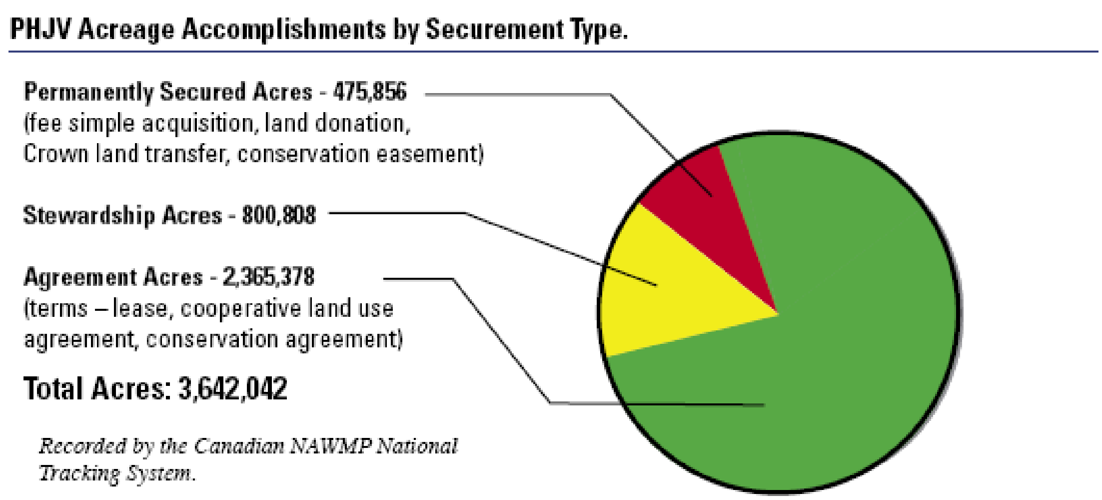

Figure 2. Accomplishments by DUC and their NAWMP partners from 1986-2006 DUC in conjunction with its PHJV partners have permanently *secured in excess of 475,000 acres* of quality habitat to date as part of the NAWMP program (Figure 2).

Restoring Function on Priority Landscapes

DUC employs a science-based approach to determine factors within a landscape that limit waterfowl nesting success and subsequent management actions to address them. In practical terms, DUC tries to address habitat changes on a landscape basis and work where returns on effort are potentially maximized. Targeting is accomplished through a Geographic Information System (GIS) based model that predicts the distribution of wetlands and waterfowl pairs and depicts them on a “thunderstorm” map. This allows for the selection of critical landscapes for the delivery of direct habitat conservation programs. These landscapes typically contain more that 40 pairs of all duck species or 6 pairs of pintails per square mile. Twenty-two of these high priority target landscapes have been identified on the Canadian prairies (Fig. 1).

Using the Waterfowl Productivity Model, a state of the art modeling tool developed within the PHJV, current land cover is compared to that from the 1970s, and subsequent gains or losses in waterfowl productivity are determined for this period (PHJV 2006a). If a deficit in waterfowl productivity currently exists, then further model runs will indicate how productivity could be improved if specific habitat actions are taken. Through successive model runs, the most cost-effective and beneficial actions in a given landscape are identified. These results inform DUC’s delivery staff and management plans are subsequently developed.

Not all priority landscapes require the same management action. For example, an area with high pond numbers but little permanent cover may attract a lot of breeding birds but nest success will be low. Programs that establish more permanent cover in the vicinity of the wetlands will yield improved nest success. This scenario is often seen in Saskatchewan. In contrast, some landscapes, particularly in Alberta, may have substantial upland cover but most of the historical wetlands have been drained. By restoring these wetlands and improving the presence of both wetlands and permanent cover, the productivity of both types of landscapes is improved. Each of the 22 priority landscapes have to be examined independently and the best mix of programs for each area determined through successive model runs.

Habitat Management Programs

There has been a long history of DUC working with landowners and governments to deliver site specific habitat programs. Programs like establishing cover plantings, developing wetland complexes and large marshes and having agreements to limit agricultural use of specified areas have been common. The PHJV update on achievements (PHJV 2006b) indicated that over 1,158,000 acres had been delivered using these programs (Table 1). Typically there are long term agreements in place associated with these programs.

Table 1. Prairie Habitat Joint Venture (PHJV) habitat acres accomplishments using intensive programs.

Intensive Program	Acres
Cover Plantings	195,383
No Agricultural Use	232,831

Wetland Complex	219,348
Large Marsh	509,622
Total Acres	1,158,069

Data from Canadian North America Waterfowl Management Program tracking systems (Prairie Habitat Joint Venture data from 1986 – 2006).

Similarly, a large number of acres has been delivered using extensive programs like modified agriculture use, grazing systems, flushing bars (to reduce mortality to nesting birds from hay cutting), and conversion to perennial cover. In total, the PHJV (2006b) delivered 2,483,000 acres using this suite of actions (Table 2). While these programs may provide long-term land use change there is usually no long-term legal agreement in place for many of these actions.

Table 2. Prairie Habitat Joint Venture (PHJV) habitat acreage accomplishments using extensive programs.

Extensive Program	Acres
Grazing Systems	1,297,010
Delayed Hay	83,272
Flushing Devices	228,588
Conversion to Perennial	66,961
Land Use Exchange	6,382
Stewardship	800,808
Total Acres	2,483,021

Data from Canadian North America Waterfowl Management Program tracking systems (Prairie Habitat Joint Venture data from 1986 – 2006).

Policy Achievements

DUC, in conjunction with NAWMP partners, has many successes to show for its commitment to policy work with governments. The benefits from these changes include increased acres converted from croplands to hay lands and pastures, increased conservation of native habitats, increased payments for agricultural beneficial management practices and increased tax credits for conservation practices (PHJV 2006c).

DUC and its partners have been particularly active in the development of policies for wetlands in each of the prairie provinces. These policies have the potential to be wide reaching in their ability to conserve tens of thousands of existing wetlands. Other specific examples of policy successes include the Saskatchewan Wildlife Habitat Protection Act which protects 3.4 million acres of uplands and wetlands through provincial legislation. In addition, the Saskatchewan Agriculture Conservation Cover Program led to the conversion of over a million acres of permanent cover from cropland. DUC and its partners participated vigorously in the development and adoption of these programs.

DUC has been particularly active in working with the Canadian government in the development of environmental components of federal policies and programs. Consequently, the National Soil Conservation Program promotes adopting winter wheat and other practices that benefit waterfowl and other wildlife. DUC has been the primary supporter of research to develop new ecovars of winter wheat suitable for the Canadian prairies and now nearly all farmers growing winter wheat in western Canada use these ecovars. Similarly, work with Agriculture and Agri-Food Canada (AAFC) led to the creation of the Permanent Cover Program which has converted 1.2 million acres of cultivated land to permanent cover in priority waterfowl areas on the prairies (PHJV 2006c). The ongoing work with AAFC on the Agricultural Policy Framework (Canada-Alberta Farm Stewardship Program 2006) has yielded great returns to date with over 35% of prairie farmers participating in the program. The development of environmental farm plans and the ability to access a suite of Beneficial Management Practices, some dealing with biodiversity and wildlife planning, speak well for the benefits from this program. These Beneficial Management Practices are cost-shared by the landowner and the government. The next phase of this program, called Growing Forward will be announced and implemented later in 2008 and DUC is working to promote even larger environmental benefits from this program.

DISCUSSION-CONTRIBUTING TO BIODIVERSITY

The evolution of the prairie grassland biome has been shaped by fire and limited precipitation. It is relatively simple in structure but is home to a large number of species. The prairie grasslands are arguably the most impacted habitats in Canada and the impacts of agriculture and resource development are ubiquitous. An estimated 70% of wetlands have been lost on the prairies and this loss continues (DUC 2008a). Thirty-four species of mammals, birds, fish, reptiles, and plants combined are listed as endangered, threatened or species of special concern on the Canadian grasslands (Natural Resources Canada 2008). Competing land uses are the norm in today's prairie landscapes and the pressure from agriculture, gas and oil extraction, corridor development, and urban sprawl is unprecedented (Praxis 2007). Consequently, the loss of biodiversity is an insidious process whereby important habitat is simply destroyed or degraded by competing land use activities and much of the remaining habitat is often fragmented.

Most provincial jurisdictions in Canada are developing strategies or implementation plans to address the loss of biodiversity and to support the Canadian Biodiversity Strategy that was completed in 1995. Some of the most urgent needs are to protect and restore wetlands, particularly those important as sources of fresh water, address fragmentation of habitats, protect native habitats, retain larger habitat units to ensure ecological function, and promote best management plans to reduce industrial and agricultural impacts.

DUC Programming and Biodiversity

Preserving and Restoring Native Habitats.—If you consider some of the critical needs to stem the loss of biodiversity on the Canadian prairies then one could conclude whether or not the programs delivered by DUC in conjunction with its partners, are of significance in enhancing biodiversity. Resource development and cultivation have altered most of the prairie grasslands and fragmented much of the remaining native habitats. DUC has acknowledged in its goals and principles the need to protect native habitats and restore ecological function of large landscapes. DUC has effectively responded to this charge by giving priority in its acquisition program to the securement through purchase and CEs, of primarily large tracts on native rangelands. The majority of the more than 475,000 acres of secured land is native rangelands with most of it occurring in southern Saskatchewan and Alberta. Clearly this action alone is important to a variety of grassland species including pronghorns on the prairies.

On cultivated quarters purchased, DUC has on many occasions reseeded the land to native plants. DUC established the Native Plant Solutions program to provide science-based solutions and products for managing and establishing native plants in disturbed upland and wetland areas. DUC initiated the first large-scale sale of native plants in Canada over 20 years ago and has planted more native grass than any organization in Canada (DUC 2008b). Native Plants Solutions remains the industry leader and has established more than 100,000 acres of native grass to date.

Native rangelands provide a number of needs for DUC including prime nesting habitat for grassland-nesting species like the pintail (*Anus acuta*). Secondly, there are a large number of grassland-dependent species that are adapted for the prairie grasslands that benefit from this action. The pronghorn would be one species with direct benefit. Furthermore, native habitats while productive require minimum annual maintenance and are therefore a cost-effective option as well. Prairie biodiversity clearly benefits from DUC's focus on preserving and restoring native habitats.

Wetland Preservation and Restoration.—The one historic focus and identity of DUC relates to its commitment as an agency to conserve and restore wetlands. This commitment has included the preservation of large prairie wetlands that serve as important migratory stops and the PHJV (2006b) reported that 509,000 acres of large marshes were preserved from 1986-2006 alone (see Table 1). In the early decades of DUC, this wetland development program included large numbers of engineered wetlands and complex dyke systems but those projects, while important, were costly and maintenance-rich.

In the past 20 years, DUC has focused more on securing and restoring large numbers of small wetlands and their associated upland habitats. DUC science has indicated that the greatest need of waterfowl continentally was to increase the breeding success on the prairies and this meant the all important small wetland complexes were of paramount importance. The PHJV progress report indicated that 219,000 acres of wetland complexes were secured from 1986-2006. Furthermore, DUC has conducted a survey of drained wetlands in much of prairie Canada and is actively in negotiations with governments and landowners to restore these wetlands that number in the hundreds of thousands. Restoration in these cases is a process whereby simple ditch plugs are placed to re-establish the historical contour and recreate a low-cost, low-maintenance wetland. When DUC secures land through purchase or conservation easement, the historical wetlands are typically restored.

One additional opportunity is worth mentioning. In Alberta in particular, DUC is recognized by the provincial government as a qualified wetland specialist and as such acts as an agent to restore wetlands as mitigation for wetlands lost through development. Developers, particularly around large urban communities, destroy wetlands as part of their building process. They are required to provide mitigation for these losses (often 5-7 times the wetland area lost) and typically negotiate with DUC to develop other wetlands in waterfowl productive areas as mitigation. Government agencies sign-off on approved mitigation replacement projects as part of their legislative requirement.

Wetlands are among the most productive ecosystems in the world and this would be particularly true within a prairie grassland ecotype. The securement and restoration of wetlands represent the single-most important step in promoting biodiversity on the prairies. The work by DUC with respect to wetlands is unparalleled in Canada and, in particular, on the Canadian prairies.

Management Agreements and On-Farm Support.—DUC and its partners help maintain prairie biodiversity on the Canadian prairies through a large number of smaller, on-farm activities over the years. The planting of cover, developing flood irrigation systems, provision of stock water, exchanging land to preserve important wildlife habitat, conversion of cropland to perennial cover, and a myriad of stewardship programs all add up over decades. From 1986-2006, the PHJV (2006b) accomplishments included 195,000 acres of plantings, 1,297,000 acres of planned grazing systems, 83,000 acres of delayed haying, and 66,000 acres of conversion to perennial cover (see Table 2). In addition, DUC and its partners secured an additional 1,803,000 acres of land under various programs before NAWMP began in 1986. These programs collectively represent over three million acres of on-farm habitat retention or improvement that all contribute to the maintenance of biodiversity on the Canadian prairies.

Work with the irrigation districts in southern Alberta represents another unique area of programming. Irrigation districts and DUC (often include a provincial government partner) have jointly developed large-scale landscape plans to develop wetland complexes and preserve native grasslands on the prairies. These prairie oases are biodiversity-rich and productive for a wide array of wildlife and also promote cattle ranching. Through these major agreements many thousands of acres of prairie landscape have been preserved and protected from the onslaught of pivot irrigation systems and the plough.

A new program illustrates the commitment of DUC to advancing biodiversity. Under the Agricultural Policy Framework, a farmer is required to complete an Environmental Farm Plan before qualifying for federal funding to implement Beneficial Management Practices (BMPs) under that program (Canada-Alberta Farm Stewardship Program 2006). DUC staff provides a free service to landowners that inventory the existing wildlife habitat and the potential to enhance it. A comprehensive plan based on GIS and air photo technology is provided to the farmer. The farmer in return can use this plan to access cost share funding to implement the various biodiversity enhancing BMPs of the federal program.

CONCLUDING PERSPECTIVES

DUC has been active on the Canadian prairies since 1938 and arguably has put more programs on the ground, particularly wetland related projects, than any other agency in the country. The capacity of DUC became significantly enhanced in 1986 with the authorization of the NAWMP. Federal, provincial, NGO and international funding supported the plan and DUC became the primary delivery agency on behalf of the many partners. Building on the nearly 50 years of operation in Canada, DUC in conjunction with its NAWMP partners in the PHJV, put millions of acres of programming on the ground since 1986. The achievements under NAWMP have earned it the title of the most successful wildlife habitat program ever conceived.

There can be no doubt about the importance of the DUC/NAWMP programming enhancing the biodiversity on the Canadian prairies (Table 3). The emphases on preserving native uplands, particularly in large tracts, helps support the many species adapted to this threatened ecotype. Furthermore, the priority to preserve and restore wetlands in large numbers provides the most powerful element in any effort to boost biodiversity on arid grasslands. Similarly, the work with landowners to increase permanent cover and stabilize habitat on a seasonal and yearly basis further contributes to enhanced prairie biodiversity.

Table 3. A summary of programming by DUC and its partners and a conclusion on its probable value to maintaining biodiversity on the Canadian prairies.

Steps Needed to Promote Prairie Biodiversity	DUC Score Card
Offset Continuing Habitat Losses	Yes
Preserve Native Habitats	Yes
Preserve and Restore Wetlands	Yes
Increase Productivity of Existing Habitats	Yes
Influence Public Policy to Promote Habitat Maintenance	Yes

Despite the efforts by DUC and a host of other agencies, there continues to be grave concern for the future of prairie habitats. The demand for land and the pace of development is unprecedented on the prairies and there is every reason to expect it to continue. Watmough and Schmoll (2007) have continued to document the progressive loss of wetlands and native grasslands within the PHJV waterfowl target areas. Existing development combined with new pressures like high commodity prices, the demand for bio-fuels and coal bed methane will likely increase the rate of habitat loss. The intensive DUC and NAWMP programming from 1986 to 2006 resulted in 35,000 more hatched nests annually, a 3.3% gain over what would have been the case without PHJV programming (Devries 2008). Devries estimated the total number of hatched nests on the prairies in 2006 to be 1,047,874. The continuing loss of wetlands represents the most significant obstacle in trying to restore waterfowl productivity to that of the 1970s (Devries 2008). Local results where programming was concentrated had a greater positive benefit but overall the results confirm that relentless negative pressure continues to erode biodiversity. The waterfowl habitat improvements and other programming only managed modest gains after offsetting the negative pressures of development. To keep pace, the wildlife community will need to find new tools and vehicles to enhance biodiversity on the Canadian prairies.

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Landowner Knows Best: Local Ecological Knowledge of Pronghorn Antelope Habitat Use in Southern Alberta

PAUL F. JONES, *Alberta Conservation Association, 2nd Floor YPM Place, 530 – 8th Street South, Lethbridge, Alberta, Canada, T1J 2J8* paul.jones@ab-conservation.com

MIKE GRUE, *Alberta Conservation Association, 2nd Floor YPM Place, 530 – 8th Street South, Lethbridge, Alberta, Canada, T1J 2J8*

JULIE LANDRY-DEBOER, *Alberta Conservation Association, 2nd Floor YPM Place, 530 – 8th Street South, Lethbridge, Alberta, Canada, T1J 2J8*

ABSTRACT In Alberta pronghorn antelope (*Antilocapra americana*) exist at the northern most part of their range and as such their population levels fluctuate in response to winter severity. This suggests that winter habitat may play a major role in the persistence of pronghorn in Alberta. Wildlife managers, sportsman and landowners have recently noticed that some wintering herds of pronghorn are remaining in agricultural areas suggesting a shift in selection from native habitat. In the initial phase of a multipart habitat study, we examined winter habitat selection by pronghorn antelope in Alberta through an assessment of local ecological knowledge. Two hundred and forty-four landowners identified 3,545 quarter sections containing pronghorn antelope at least once, during a winter from December 1997 to January 2002. When the data were pooled across the 8 Antelope Management Areas (AMA), pronghorn selected for class 1 (76-100% native prairie), against class 4 (1-25% native prairie) and used the 3 remaining classes, including class 5 (agricultural land) in proportion to their availability. When looking at individual AMA's results were variable. For example, in AMA F pronghorn selected for class 5 and against class 1, while the opposite occurred in AMA D. Based on these results there does appear to be variability in selection patterns between AMA prompting quantification with empirical data.

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KEY WORDS pronghorn, *Antilocapra americana*, grassland natural area, habitat, local ecological knowledge, Alberta

The pronghorn antelope is considered to be an obligate grassland species (Barrett 1982, Wood 1989, Yoakum 2004) found throughout North America. Pronghorn prefer flat or rolling terrain with a mixture of grasses, forbs and shrubs (Yoakum 2004). They will avoid areas of steep terrain, dense woody vegetation, and certain agricultural crops (Yoakum 2004). In Alberta, pronghorn antelope exist at the northern most part of their range, and as such their population levels fluctuate in response to winter severity. This phenomenon suggests that winter habitat plays a major role in the persistence of pronghorn in Alberta. Barrett (1974), during the winters of 1971-72 and 1972-73, found that over 60% of all pronghorn observed were on a sagebrush vegetation type. Mitchell (1980) analyzed rumen contents from 112 pronghorn in the Newell and Ronalane areas of Alberta from 1962 to 1965 and found that 82% of the winter diet consists of silver sagebrush (*Artemesia cana*) and pasture sage (*Artemesia frigida*). The relative importance of native prairie habitat is reflected in the changes on the landscape. From the 1970's to 1983 there was a 20% increase in agricultural lands within the range of pronghorn in Alberta, with the majority being found in the northern portions of their range (Hagg 1986). Hagg (1986) also identified large tracts of native prairie in the Milk River Ridge, Milk River, and Lodge Creek pronghorn winter ranges that were suitable for conversion to agriculture if current land use trends continued. Conversion to agricultural land would be detrimental for pronghorn which are native grassland obligates.

In Alberta, pronghorn antelope management is based on a plan developed in 1990 (Alberta Fish and Wildlife 1990). The plan identified four major issues needing to be addressed. They were 1) optimizing public use, 2) maintaining and enhancing habitat, 3) enhancing survey methods to provide more precise pronghorn population estimates, and 4) managing herds at acceptable levels to ensure crop damage caused by pronghorn was kept to a minimum (Alberta Fish and Wildlife 1990). A workshop held in 2001 identified three current issues facing pronghorn conservation in Alberta. They were 1) low fawn recruitment (based on results of aerial surveys), 2) loss of habitat due to unprecedented levels of land use activities throughout the grasslands, and 3) pronghorn were being observed more frequently in agricultural lands. Sheriff (2006) addressed the first issue by modeling temporal and spatial variation in pronghorn antelope population dynamics in Alberta. The second issue is being examined under a larger project within the Northern Sagebrsuh Steppe initiative, where the effects of energy development on pronghorn are being investigated. We examined the issue from wildlife managers, sportsman, and landowners that some wintering herds of pronghorn are remaining in agricultural areas year-round by conducting a survey of local ecological knowledge.

We determined winter habitat selection by pronghorn antelope in Alberta through an assessment of local ecological knowledge. The objective for this study was to assess habitat selection by pronghorn antelope during the winter based on the observations of landowners throughout the Antelope Management Areas (AMA) of Alberta. Landowners were chosen because of their intimate knowledge of their surroundings and because they are on the landscape during all times of the year. We also assessed the overall feeling landowners had towards pronghorn antelope and whether there were any perceived conflicts, in particular associated with agricultural lands.

STUDY AREA

The study area for which landowners were surveyed was the 8 Antelope Management Areas (Alberta Fish and Wildlife 1990), which fall within the Grasslands Natural Region (GNR) of Alberta. We did not include the Canadian Forces Base (CFB) Suffield management area in our study. The GNR of Alberta comprises approximately 14% of the province extending from the Saskatchewan border to the Rocky Mountains and from the southern edge of the Parklands to Montana. About 10 million acres (4 million ha) or 43% of the 24 million acres (9.7 million ha) comprising the GNR remain in a native state (Prairie Conservation Forum 2000). Seven million acres (2.9 million ha) of native grasslands are under public ownership, while 4.5 million acres (1.8 million ha) are privately owned (Prairie Conservation Forum 2000). Our study area falls within 3 of the 4 GNR sub-regions; dry mixed-grass, mixed-grass, and northern fescue. The dry mixed-grass is characterized by western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), and spear grass (*Stipa comata*), with brown chernozems and solonetzic soils, and few Chinooks (Alberta Environmental Protection 1997). The mixedgrass subregion is characterized by northern wheat grass (*Agropyron dasystachyum*) and porcupine grass (*Stipa curtiseta*), dark brown chernozem soils, and is cooler and moist (Alberta Environmental Protection 1997). The northern fescue sub-region is characterized by oatgrass (*Danthonia* sp.), rough fescue (*Festuca campestris*) and Idaho fescue grasses (*F. idahoensis*), dark brown and black chernozem and few solonetzics soils, with milder winters (Alberta Environmental Protection 1997). Historically the primary cause of habitat loss has been conversion for cultivation. Pressures on the remaining native grasslands include increasing conversion for cultivation, grazing, energy field development, roads and pipelines, rural acreage development, and urban expansion (Alberta Environmental Protection 1997). Most native grasslands in the GNR are used for livestock grazing. Public lands are leased to livestock producers who manage grazing intensity under a grazing lease agreement and leases are subject to inspection by Alberta Sustainable Resource Development (Lands Division).

METHODS

We conducted landowner surveys during the winter of 2002 with landowners being chosen at random within the Antelope Management Areas. Each landowner was asked to identify quarter sections that have been used by pronghorn antelope in any of the winters from December 1997 to January 2002. Data were also collected on the approximate number of antelope, duration of use, type of habitat (agricultural crop type, native grass, etc.), weather conditions, and comments, but was not used in the analysis due to the general nature of the responses. In most cases too much time had passed for the landowner to recall more details beyond the presence of pronghorn in the area.

Statistical Analysis

Using the Grassland Native Prairie Vegetation Inventory (GNVI) database (Resource Data Branch 1995), we classified the quarter sections being used by pronghorn antelope, as identified by landowners, into one of five native prairie vegetation (NPV) classes (Table 1). The GNVI assigns a percentage value of native prairie vegetation for each partial or whole quarter section to the nearest 5% based on interpretation of 1992 and 1993 aerial photography (Resource Data Branch 1995). Habitat availability was determined as the number of quarter sections in each of the NPV classes at the individual AMA level and across all AMA's combined. We determined whether pronghorn antelope used each NPV class in proportion to its availability within each AMA and across all AMA's using a chi-square (χ^2) test (Neu et al. 1974). If the null hypothesis that pronghorn antelope were using the NPV classes in proportion to their availability was rejected, a Bonferroni *Z* statistic was calculated for each NPV class to determine which were used more or less than expected (Neu et al. 1974). All analysis was completed in Microsoft Excel®.

Table 1. Native prairie cover classes based on the Province of Alberta's NativePrairie Vegetation Inventory.

Native Prairie Cover Class	Percent Native Prairie
1	75 – 100%
2	50 – 74%
3	25 – 49 %
4	1 – 24%
5	0%

RESULTS

A total of 244 landowners were surveyed during the winter of 2002 across the AMA's of Alberta. They were receptive to the interview process and seemed genuinely concerned regarding perceived declines in the pronghorn population. They did not view pronghorn as a detrimental species, as compared to deer, and also indicated that they thought vehicle collisions with pronghorn antelope were not that common.

Habitat availability was determined for each AMA and for all combined (Table 2). Antelope Management Area A had 158 quarter sections identified by landowners as having winter use by pronghorn. Pronghorn in AMA A did not select habitat in proportion to its availability (χ^2 = 16.04, P = 0.003). Native prairie class 1 was used greater than available while class 4 was used less than expected (Table 3).

Antelope Management Area B had 679 quarter sections identified by landowners as having winter use by pronghorn. Pronghorn in AMA B did select habitat in proportion to its availability (χ^2 = 5.39, P = 0.25; Table 3).

Antelope Management Area C had 374 quarter sections identified by landowners as having winter use by pronghorn. Pronghorn in AMA C did not select habitat in proportion to its availability (χ^2 = 12.53, P = 0.01). Native prairie class 5 was used less than available while the remaining classes were used in proportion to their availability (Table 3).

Antelope Management Area D had 346 quarter sections identified by landowners as having winter use by pronghorn. Pronghorn in AMA D did not select habitat in proportion to its availability (χ^2 = 43.11, P < 0.01). Native prairie class 1 was used greater than available while class 5 was used less than available (Table 3).

Antelope Management Area E had 60 quarter sections identified by landowners as having winter use by pronghorn. No analysis could be performed for Area E due to low sample size.

Antelope Management Area F had 448 quarter sections identified by landowners as having winter use by pronghorn antelope. Antelope in AMA F did not select habitat in proportion to its availability (χ^2 = 29.19, P < 0.01). Native prairie class 1 was used less than available while class 5 was used greater than available (Table 4).

Antelope Management Area G had 794 quarter sections identified by landowners as having winter use by pronghorn antelope. Antelope in AMA G did not select habitat in proportion to its availability (χ^2 = 11.06, P = 0.03). Native prairie class 1 was used greater than available while the remaining classes were used in proportion to their availability (Table 4).

Antelope Management Area H had 483 quarter sections identified by landowners as having winter use by pronghorn antelope. Antelope in AMA H did not select habitat in proportion to its availability (χ^2 = 9.80, P = 0.04). Native prairie class 2 was used less than available while the remaining classes were used in proportion to their availability (Table 4).

For all Antelope Management Areas combined, landowners identified 3,302 quarter sections as having pronghorn antelope use. For all management areas combined antelope did not select habitat in proportion to its availability (χ^2 = 39 P < 0.01). Native prairie class 1 was used greater than available while class 4 was used less than available (Table 4).

Table 2. Percentage of the native prairie vegetation classes found within the Antelope Management Areas of Alberta.

	Native Prairie Vegetation Class				
Antelope Management Area	1	2	3	4	5
A	33%	3%	6%	20%	38%
B	13%	2%	3%	9%	73%
C	85%	3%	3%	3%	6%
D	35%	3%	3%	7%	52%
E	57%	3%	5%	8%	27%
F	45%	6%	8%	13%	28%
G	58%	5%	5%	10%	22%
H	41%	7%	9%	25%	18%
ALL	45%	4%	6%	14%	31%

Table 3. Habitat selection by pronghorn antelope based on landowner surveys conducted during the winter of 2002 in Antelope Management Areas A, B, C and D.

NPC Class	**Used**	**Expected**	**X^2**	**Lower Limit**	**Upper Limit**	**Use**
Antelope Management Area A						
1	71	53	6.42	0.347	0.551	Greater
2	3	5	0.74	-0.009	0.047	**Equal**
3	12	9	1.18	0.022	0.130	Equal
4	16	31	7.37	0.039	0.163	**Less**
5	56	61	0.34	0.256	0.452	Equal
Total	158	158	16.05			

Antelope Management Area B						
1	102	91	1.27	n/a	n/a	Equal
2	11	14	0.64	n/a	n/a	Equal
3	18	19	0.10	n/a	n/a	Equal
4	47	61	3.26	n/a	n/a	Equal
5	501	493	0.12	n/a	n/a	Equal
Total	679	679	5.39			
Antelope Management Area C						
1	323	315	0.18	0.818	0.909	Equal
2	7	10	1.15	0.001	0.037	Equal
3	15	12	0.84	0.014	0.066	Equal
4	19	13	2.81	0.022	0.080	Equal
5	10	23	7.55	0.005	0.048	**Less**
Total	374	374	12.53			
Antelope Management Area D						
1	161	121	12.86	0.396	0.533	**Greater**
2	14	12	0.32	0.013	0.067	Equal
3	18	12	2.87	0.021	0.082	Equal
4	37	24	6.58	0.064	0.149	Equal
5	116	176	20.28	0.270	0.399	**Less**
Total	346	346	43.11			

Table 4. Habitat selection by pronghorn antelope based on landowner surveys conducted during the winter of 2002 in Antelope Management Areas F, G, H and all combined.

NPC Class	Used	Expected	X^2	Lower Limit	Upper Limit	Use
Antelope Management Area F						
1	173	203	4	0.327	0.445	**Less**
2	21	25	1	0.021	0.073	Equal
3	28	36	2	0.033	0.092	Equal
4	47	57	2	0.068	0.142	Equal
5	179	128	21	0.340	0.459	**Greater**
Total	448	448	29			
Antelope Management Area G						
1	498	459	3	0.583	0.624	**Greater**
2	38	36	0	0.028	0.065	Equal
3	44	42	0	0.035	0.074	Equal
4	72	79	1	0.064	0.127	Equal
5	142	177	7	0.144	0.261	Equal
Total	794	794	11			
Antelope Management Area H						
1	226	199	4	0.409	0.526	Equal
2	21	32	4	0.020	0.067	**Less**
3	41	46	0	0.052	0.118	Equal
4	120	119	0	0.198	0.299	Equal
5	75	87	2	0.113	0.198	Equal
Total	483	483	10			
All Antelope Management Areas Combined						
1	1576	1481	6	0.455	0.500	**Greater**
2	112	148	9	0.026	0.042	Equal
3	178	203	3	0.044	0.064	Equal
4	372	463	18	0.098	0.127	**Less**
5	1064	1008	3	0.301	0.343	Equal
Total	3302	3302	39			

DISCUSSION

The intent of this study was to determine overall receptiveness of landowners to pronghorn and to use their local ecological knowledge to assess winter habitat use as a means of quantifying the notion that pronghorn had shifted resource selection patterns to incorporate agricultural lands as primary habitat. We used a social science approach to understand the attitudes and values (Bath and Enck 2003) landowners across southern Alberta had toward pronghorn, and in particular their understanding of pronghorn's use of the landscape. We assessed landowners affective (whether they liked or disliked a species) and cognitive (beliefs about a species that may or may not be true) attitudes (Bath and Enck 2003) toward pronghorn. Based on responses from landowners, they were interested and concerned about pronghorn and did not view them in the same light as deer, the later being seen in a negative or conflict context.

Based on the knowledge of local landowners there does not appear to be a shift in habitat use and for the most part pronghorn are still using native prairie habitat in greater proportion than its availability. That said, there does seem to be variability in use at the AMA level and in fact certain individuals or groups are using agricultural land, particularly in AMA F. Our results of winter habitat selection by pronghorn based on observations of landowners are as we expected. Barrett (1982) found that pronghorn use of cultivated land was <15% in all months except October and November when it increased to approximately 25%. Based on the observations of landowners, pronghorn predominately used agricultural lands in winter in approximately equal proportion to availability, except for AMA's C and D where they used it significantly less than available and AMA F where use was significantly greater than available. It is not surprising that it was used less than available in AMA C as this is the management unit with the greatest percent of native prairie cover and a key wintering area for pronghorn. It is interesting to note that for AMA F agricultural lands are used in greater proportion to their availability. AMA F does have a number of irrigated pivots along the South Saskatchewan River and in the Seven Persons area and this could be attracting pronghorn to use the agricultural areas greater than their availability. Also it may be an artifact of the landowners interviewed in this area, as the ranches tend to be large and access to the native pastures in winter is limited. Further investigation into the habitat selection patterns of pronghorn residing in AMA F is recommended.

Overall pronghorn in Alberta use native prairie–sagebrush communities 85-90% of the time (Barrett 1982, Sheriff 2006). Sherriff (2006) found a very strong relationship between the percent native prairie composition in the AMA's and the corresponding density of pronghorn within the AMA. A similar pattern occurred in Saskatchewan where over 72% of pronghorn observed were on sagebrush-grassland community types (Wiltse 1978). Barrett (1982) emphasized the need to conserve sagebrush rangelands in Alberta to maintain critical winter habitat. Although there was some variability in selection among individual AMAs, generally our results reiterate the importance of native prairie habitat for pronghorn.

MANAGEMENT IMPLICATIONS

The use of social science in the ecology field is slowly gaining in popularity. We used social science methods to assess habitat use by pronghorn as a means to initially substantiate the idea of pronghorn use of agricultural fields from wildlife managers, sportsman and landowners. Our results should be viewed in the context of a landowner's perspective and potential biases. Results are likely influenced by each landowner's time spent in proximity to their residence and memories are likely better associated to areas close to home. Phase II of our multipart program will quantify our local ecological knowledge results using data from individually collared (GPS units) pronghorn does. Our results serve as baseline information to compare to those obtained from the collar data as a means of assessing the accuracy of using local ecological data for conservation purposes. The locations provided by landowners, in particular those in agricultural areas, will provide starting points for searching for animals to be captured and collared to determine if pronghorn are, in fact, using agricultural areas year round.

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Pronghorn Captive Management: Why, When, and Where

JORGE CANCINO, *Centro de Investigaciones Biologicas del Noroeste, Apartado Postal 128, La Paz, 23000, Baja California Sur, MEXICO* cancino04@cibnor.mx

KIM BRINKLEY, *Los Angeles Zoo. 5333 Zoo Drive, Los Angeles, CA 90027, USA* pronghorngirl@sbcglobal.net

ABSTRACT The captive management of pronghorn (*Antilocapra americana*) has a long history. This paper documents this history and some of its characteristics. Two surveys were conducted, one with ten questions for facilities that currently hold pronghorn, and one with five questions for facilities that once held but no longer hold pronghorn. The surveys were sent to facilities including zoos, parks, and reserves. We received over 60 responses from five countries: Canada, Japan, Mexico, South Africa, and the United States. Additional countries emerged from the literature and supplemental information was obtained from the internet. Captive pronghorn have been used for multiple purposes including restoration, research, and public exhibition. This paper summarizes facilities where pronghorn have been held captive, numbers held captive, problems encountered with captive animals, and public attitude toward pronghorn. The oldest reference to a captive pronghorn is at the Philadelphia Zoo (1874) and the newest is the San Juan de Aragon Zoo in Mexico City, which received its animals in 2007. Currently, there are at least 48 places holding this species in captivity or semi-captivity. Numbers of captive animals range from one to several hundred. There are a number of institutions holding just one animal, such as the San Diego Zoo, versus El Vizcaino Biosphere Reserve, which has almost 300 pronghorn. The most common medical problem noted was self-inflicted trauma, with "lumpy jaw" the second most common medical problem. Public attitude towards this species ranges from apathy to great interest. Management of captive pronghorn includes housing, diet, raising of offspring, prophylactic and emergency medical care, etc. A comprehensive list of institutions now holding and those that once held pronghorn is included.

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KEY WORDS captive management, exhibit, pronghorn, *Antilocapra americana*, zoo.

The history of holding pronghorn (*Antilocapra americana*) captive goes back over 100 years, to 1874, with the first reference to captive pronghorn at the Philadelphia Zoo (Holland 2004). Here, we present a comprehensive list of facilities with captive and semi-captive pronghorn including, but not limited to, zoos. We consider a captive situation to be an entirely closed situation where there was absolutely no chance of animals leaving or entering by choice. Zoo exhibits are considered closed, regardless of their size. Semi-captive situations include facilities that are enclosed by a fence line, but have some areas where animals can come and go freely. Semi-captive situations may occur due to breaches or faults in the fence line itself (i.e., fence line too low or too high in areas, damaged areas, etc.), or to areas within the facility that are impossible to entirely close off (i.e., railroad tracks, military style entrances). An example of such a facility is F.E. Warren Airforce Base in Cheyenne, Wyoming. Some places, such as the Hart Mountain National Antelope Refuge, had pronghorn herds in fenced areas, although the fences were intentionally built to keep cattle and wild horses out, not to keep pronghorn in; i.e., the fences allow pronghorn to go in and out as they choose (M. Bennett, U.S. Fish and Wildlife Service, personal communication). Finally, there were many places (e.g., state and national parks, and refuges) where pronghorn roam freely but where people may frequently encounter and observe them.

The management of captive pronghorn has evolved to include a wide range of practices. Captive animals were used for exhibition, research, or as part of some recovery plans. The Sonoran pronghorn (*A. americana sonoriensis*) and Peninsular pronghorn (*A. americana peninsularis*) recovery plans (Anonymous 1998 and Cancino 2005, respectively) are recent examples of how captive animals are used to help re-populate areas where herd numbers have been decimated for a variety of reasons. However, this practice is not new and there are earlier references in the literature about captive animals being used for re-population purposes (Nelson 1925, Einarsen 1948, Mitchell 1980). This topic was discussed in the 2006 edition of the Pronghorn Management Guide (Autenrieth et al. 2006).

Pronghorn are not the only ungulate to be managed and studied under captive conditions. Some examples of other hoofed mammals for which captive management has been used in their recovery plans include Pere David's deer (*Elaphurus davidianus*) (IUCN 2006), Arabian oryx (*Oryx leucoryx*) (Fisher 1999), and Prezwalski's horse (*Equus ferus przewalskii*) (CRES 2008). There are some places, such as the National Bison Range (NBR), with special conditions conducive to developing research projects. Byers states that "…animals are habituated to vehicles and can be observed at close range…" and "The NBR is large enough (30 sq mi) to allow the animals to act naturally" (J. Byers, University of Idaho, personal communication). Olney et al. (1994) and Kleiman et al. (1996) cite additional examples of other species for which captive management has been used as a tool in their conservation plans. The research of Pojar and Miller (1984) on pronghorn estrus cycles is an example of the type of studies that could only be done with captive animals. Thus, the study of captive animals is important to both the conservation and research of pronghorn and other ungulates. In this paper we seek to summarize historical and current holdings of pronghorn identify key issues arising from management of captive and semi-captive populations of the species.

METHODS

Two surveys were prepared, one with ten questions for facilities that currently hold pronghorn, and one with five questions for facilities that once held but no longer hold pronghorn. The surveys were sent to facilities including zoos, parks, and reserves. We received over 60 responses from five countries: Canada, Japan, Mexico, South Africa, and the United States. Additionally, the available literature was reviewed and any pertinent information on the internet was consulted to locate additional facilities/locations holding captive or semi-captive pronghorn. There are at least two pronghorn studbooks, which we also consulted. One is for the peninsular subspecies (Castellanos and Holland 2001) and the second is for the North American pronghorn populations held in zoological institutions (Holland 2004). The North American studbook summarizes information from more than one century: 1874 to 2004. To date, there is no studbook for the Sonoran captive animals (J. Hervert, personal communication). There are some papers that focus on this issue (e.g., Moore 1982) but most of the information is disperse. The main source for determining holding locations was the North American Pronghorn Regional Studbook (Holland 2004).

RESULTS

Locations and Facilities Holding Pronghorn

We located 161 facilities that historically held pronghorn, 48 of which still hold pronghorn today. Even though the pronghorn is endemic to North America (i.e. three countries) (O'Gara and Yoakum 2004), the total number of countries that have had the species, at one time or another, is 10: Belgium (BE), Canada (CA), France (FR), Germany (DE), India (IN), Japan (JP), Mexico (MX), Netherlands (NL), South Africa (ZA), and the United States of America (US). The oldest reference is for the Philadelphia Zoo (1874) (Holland 2004), and the newest is the San Juan de Aragón in Mexico City (2007). There are several large places where pronghorn can be observed and/or studied; some, such as the National Bison Range, in Montana and the El Vizcaino Biosphere Reserve, in Baja California Sur, Mexico, are included in the appendix. Not included in the appendix are facilities such as Custer State Park, Sheldon Range Wild Horses, and the already mentioned Hart Mountain National Antelope Refuge, where the pronghorn are not at all limited in their movements by the fences. Charles M. Russell National Wildlife Refuge and Yellowstone National Park are without fences but have pronghorn that can sometimes be observed.

Regardless of the reason for the captive situation, the most common subspecies is the American pronghorn (*A. americana americana)*. Some zoos have Mexican pronghorn (*A. americana mexicana*) for their exhibits, but the Los Angeles Zoo is the only one that has peninsular animals. The main states or province that were sources of animals for several zoos are (alphabetically) Alberta, Arizona, Colorado, Kansas, Montana, Nebraska, Nevada, New Mexico, Texas, Utah, and Wyoming.

Captive Rearing

Not all institutions that exhibit pronghorn are breeding them. Some are only holding males, some only females, some only a single animal, and one institution (Living Desert Zoo) uses a contraceptive feed during the breeding season to curtail reproduction (Holly Payne, General Curator, Living Desert Zoo, personal communication). Many institutions choose not to breed their pronghorn because finding adequate homes for the male fawns can be a problem, and because the person-hours used in caring for fawns can be overwhelmingly expensive.

The method by which captive pronghorn fawns are reared depends upon the type of facility they are born at, and ultimately on where they will live out their lives. Institutions that have animals for public exhibition, such as zoos, need to decide whether or not to breed their animals and also whether to hand-rear or not. For pronghorn held in zoos and zoo-type facilities, hand-rearing the fawns seems to work best (Holland 2004). Of survey respondents, 52% stated that they always hand-rear their fawns to keep them more tractable and to reduce the stress that comes with the constant, up-close presence of people and vehicles. Those animals that are destined for release as part of a recovery effort should be mother-reared to help keep them wary of people and away from vehicles. The Peninsular Pronghorn Recovery Program hand-reared all captive fawns for the first few years because these animals were used as the initial breeding animals and were not going to be released. They also hand-reared any fawns that have been designated by the studbook to be exported to zoos. All others were mother-reared since they were potential candidates for release.

Surveys indicated that a variety of diets are offered at facilities holding pronghorn, including a "sub-variety" in some kinds of feeds (Table 1). Some facilities, other than zoos (e.g., El Vizcaino Biosphere Reserve, Baja California Sur, Mexico), supplement the diet of natural vegetation due to such factors as the time of year, weather conditions, and enclosure size.

Table 1. Foods offered to the captive pronghorn. Facility numbers correspond to the number of the facility in Appendix 1.

Type of food	Facility	Total No. Places
Alfalfa hay	4, 32, 41, 42, 57, 60, 65, 68, 74, 75, 80, 96, 105, 107, 108, 110, 117, 119, 120, 129, 133, 135, 139, 146, 155	25
Other types of hay[a]	11, 16, 24, 26, 31, 41, 57, 65, 68, 74, 75, 117, 120, 132, 161	15
Alfalfa pellets	8, 16, 40, 60, 110,132, 155	7
Herbivore pellets[b]	4, 11, 24, 31, 32, 41, 53, 57, 65, 68, 74, 75, 80, 95, 96, 107, 117, 119, 120, 129, 132, 135, 139, 146, 154, 161	26
Other grains[c]	11, 16, 24, 26, 31, 40, 108, 132, 155	9
Produce[d]	75, 117, 129, 132, 155	5
Miscellaneous supplements[e]	16, 26, 32, 41, 42, 57, 60, 65, 68, 75, 105, 108, 110, 119, 135, 155, 161	17
Natural vegetation	6, 42, 48, 84, 105, 133, 139, 154	8
Browse (provided)	8, 11, 16, 24, 26, 31, 57, 65, 68, 75, 96, 107, 110, 119, 120, 132, 135, 155	18
Exhibit grass	4, 8, 11, 16, 26, 31, 40, 60, 65, 68, 74, 80, 95, 96, 108, 110, 132, 161	18

[a] Alfalfa/brome mix, grass hay, timothy, brome hay, grass mix hay, clover hay, prairie grass hay, gramma grass hay, sudan hay.
[b] Mazuri ADF-16 ™, Mazuri ADF-25 ™, Blue Seal Trotter ™, deer pellets.
[c] Blue Seal Charger ™, rolled barley, cracked corn with molasses, rolled oats, Purina Omolene 10 ™, sweet feed, pressed oats.
[d] Apples, carrots, dried fruit.
[e] Beet pulp, Marion Leaf- eater- gorilla size, Blue Seal Sunshine Plus ™, Purina Animax ™, calcium, salt blocks (plain and/or trace mineral), Allivet ™ Clovite, vitamins, copper sulfate.

Figure 1. Although the captive management of some animals is useful, it should be noted that there are some alterations in their behavior. Photo: Patricio Robles Gil.

Some zoos kept their animals in mixed-species exhibits. Hoofed species sharing enclosures with pronghorn in zoos included bison (*Bison bison*), white-tailed deer (*Odocoileus virginianus*), mule deer (*O. hemionus*), fallow deer (*Dama dama*), elk (*Cervus canadensis*), and blackbuck (*Antilope* cervicapra). In addition, wild turkey (*Meleagris gallopavo*), sandhill crane (*Grus canadensis*), emu (*Dromaius novaehollandiae*), Bolson tortoise (*Gopherus flavomarginatus*), and trumpter swan (*Cygnus buccinator*) were also reported as sharing exhibit space with pronghorn; and, there were several zoos that reported having more than one additional species living with their animals. The National Bison Range is a good example of a non-zoo facility that has numerous species to observe together with the pronghorn.

There is potential for problematic interactions when housing pronghorn with other species. During the rut, male pronghorn have been known to pick fights with bison, and one facility reported that their pronghorn male actually ran a whitetail buck to death. Moore (1998) describes this kind of problem in the Burnet Park Zoo. Sexually mature pronghorn males will fight amongst themselves when housed together, especially during the breeding season. Keepers need to be careful when entering an exhibit with a rutting male, particularly a hand-reared one.

Numerous medical problems were reported by survey respondents (Table 2). Miscellaneous problems recorded included trauma due to chemical immobilization, mange, West Nile virus, enlarged liver, hair loss from *Haemonchus*, rain scald, intestinal complications or obstructions, abscesses from cactus spines, respiratory fungus, congenital spinal cord defect, fibro-sarcoma, urethral urolithiasis, distocia, papaloma virus, interdigital infections, meningitis, food poisoning, epizootic hemorrhagic disease, and surgical intervention needed as a result of accidents. Predation on fawns was also reported.

Table 2. Medical problems reported in the survey. Facility numbers correspond to the number of the facility in Appendix 1.

Problem	Facility*	Total No.
Trauma- self inflicted	1, 4, 5, 21, 23, 27, 30, 31, 32, 35	10
Lumpy Jaw or oral abscesses	3, 4, 10, 14, 21, 23, 34, 36, 38, 39	10
Pneumonia	16, 18, 21, 42, 43	5
Parasites	8, 9, 11, 20, 24, 26	6
Copper deficiency	21, 30	2
Diarrhea	16, 21, 42, 43	4
Malnutrition	4, 37	2
Abnormal horn growth	5, 33	2
Miscellaneous	1, 3, 6, 8, 12, 16, 17, 19- 22, 25, 27-31, 33, 37, 41, 43	21

*Names and locations of facilities are provided in Appendix I.

Some of the health problems are related to the number of animals kept together, with the type of fencing used and even with the size of the enclosure. The general range for the number of pronghorn held is from a single animal to several hundred. The San Diego Zoo is an example of a zoo that holds just one pronghorn versus El Vizcaino Biosphere Reserve that holds more than 300 captive peninsular pronghorn. The types of fencing used in the different t facilities were: woven wire, chain link, chicken wire, wood, stone, smooth wire (for interior fences), barbed wire, and two double fences: woven wire with electric fence, and chain link with bamboo fence. Enclosure size varied a lot, with the smallest being approx. 13.7 x 13.7 m in a zoo, versus more than approximately 24,000 ha for the largest in a National Park.

The surveys asked facilities for the reasons they were no longer holding pronghorn, if that was the case. The responses were: use of space for other species, space restrictions, medical issues, importation difficulties, difficulties with raising animals in captivity, cost too high, persistence is difficult east of the Mississippi River due to humidity, and restrictions on personnel.

DISCUSSION

The public's attitude towards pronghorn varies depending upon the kind of place that is visited. Even though they may occur in their own state, some people are not aware that pronghorn exist at all until they visit a particular zoo. Other people purposefully visit special places, such as the National Bison Range, just to see this species. The internet hosts hundreds of sites for those people interested in obtaining information on the species, in fact, some zoo sites have information on pronghorn even though they no longer have, or never had them in their collections.

Despite some facilities no longer holding pronghorn, there still remain many places where the public can view them. Zoo and zoo-type facilities are not holding nor breeding the numbers that they once were, but pronghorn are abundant in many of **the** national parks, refuges, open areas and some other places **outside** of the United States. The care and feeding of captive animals has advanced as science and experience has advanced. However, keeping pronghorn in captivity offers many challenges. Members of the public often fail to recognize and appreciate pronghorn for the uniquely special animals they are and view them as just another kind of "deer". For those who care **about** pronghorn, the challenge is to learn how to better keep them in captivity and to better educate the public to appreciate these North American symbols of a bygone era.

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APPENDIX I. HISTORICAL LIST OF PRONGHORN HOLDERS – PAST AND PRESENT.

Name of Facility	Location	Country*	Number**	Present holder
Abilene Zoological Gardens[a]	Abilene, Texas	US	1	
Alameda Park Zoo[a]	Alamogordo, New Mexico	US	2	
Alaska Zoo	Cantwell, Alaska	US	3	
Amarillo Zoo[a]	Amarillo, Texas	US	4	X
Animals International[b]	Riverside, California	US	5	
Antelope Island[a,c]	Salt Lake City, Utah	US	6	X
Arizona-Sonora Desert Museum	Tucson, Arizona	US	7	
Assiniboine Zoo[a]	Winnipeg, Manitoba	CA	8	X
Banks, John[b]	Eddy, Texas	US	9	
Bear Country US	Rapid City, S. Dakota	US	10	
Beardsley Zoo[a]	Bridgeport, Connecticut	US	11	X
Bergen County Zoo	Parasmus, New Jersey	US	12	
Binghamton Zoo	Binghamton, New York	US	13	
Bioparque Estrella[a]	Montemorelos, Nuevo Leon	MX	14	
Boise Zoo	Boise, Idaho	US	15	
Bramble Park Zoo[a]	Watertown, S. Dakota	US	16	X
Brit Spaugh Zoo[a]	Great Bend, Kansas	US	17	
Bronx Zoo[a]	New York, New York	US	18	
Brookfield Zoo	Chicago, Illinois	US	19	
Brooks/Seville Aviaries	Parkland, Florida	US	20	
Buena Vista Exotic Animal Paradise[b]	Stafford, Missouri	US	21	
Calgary Zoo[a]	Calgary, Alberta	CA	22	
Caldwell Zoo[a]	Tyler, Texas	US	23	
Cape May Zoo[a]	Cape May Court House, New Jersey	US	24	X
Centro Ecologico de Sonora[a]	Hermosillo, Sonora	MX	25	
Chahinkapa Zoo[a]	Wahpeton, N. Dakota	US	26	X
“Charlie Blazier” Farm[c]	Brooks, Alberta	CA	27	
Cheyenne Mountain Zoo[a]	Colorado Springs, Colorado	US	28	
Cincinnati Zoo	Cincinnati, Ohio	US	29	
Cleveland Zoo	Cleveland, Ohio	US	30	
Columbus Zoo[a]	Columbus, Ohio	US	31	X
Dakota Zoo[a]	Bismarck, N. Dakota	US	32	X
Dallas Zoo[a]	Dallas, Texas	US	33	
Darby Dan Farm	Columbus, Ohio	US	34	
Delhi National Zoological Park	New Delhi	IN	35	
Denver Zoo	Denver, Colorado	US	36	
Detroit Zoo	Royal Oak, Michigan	US	37	
Dickerson Park Zoo	Springfield, Missouri	US	38	
El Bonito (UMA)[a,c]	Acuña, Coahuila	MX	39	X
Elmwood Park Zoo[a]	Norristown, Pennsylvania	US	40	X
El Paso Zoo[a]	El Paso, Texas	US	41	X
El Tulillo (UMA)[a,c]	Mazapil, Zacatecas	MX	42	X
Emporia Zoo[a]	Emporia, Kansas	US	43	

Name of Facility	Location	Country*	Number**	Present holder
Foothill Game Farm	Oregon House, California	US	44	
Foothills Wildlife Research Facility[a,c]	Fort Collins, Colorado	US	45	X
Fort Worth Zoo[a]	Fort Worth, Texas	US	46	
Fouts Zoological Park	Loveland, Colorado	US	47	
Francis E. Warren Airforce Bas	Cheyenne, Wyoming	US	48	X
Franklin Park Zoo	Boston, Massachusetts	US	49	
Ghost Ranch Museum	Abiquiu, New Mexico	US	50	
Grand Canyon Deer Farm[a]	Williams, Arizona	US	51	
Grants Farm	St. Louis, Missouri	US	52	
Great Plains Zoo[a]	Sioux Falls, S. Dakota	US	53	X
Grindstone Valley Zoo	Chatham, Illinois	US	54	
Hannover Zoo	Hannover	DE	55	
Hemker Wildlife Park[a]	Freeport, Minnesota	US	56	X
Heritage Park Zoo[a]	Prescott, Arizona	US	57	X
Hillcrest Park Zoo	Clovis, New Mexico	US	58	
Hogle Zoo[a]	Salt Lake City, Utah	US	59	
Hutchinson Zoo[a]	Hutchinson, Kansas	US	60	X
International Animal Exchange[b]	Royal Oak, Michigan	US	61	
International Zoological Distributors[b]	Laval, Quebec	CA	62	
IPSCO Wildlife Park	Regina, Saskatchewan	CA	63	
Jackson Zoo	Jackson, Mississippi	US	64	
Kanazawa Zoo[a]	Yokohama	JP	65	X
Lake Superior Zoo	Duluth, Minnesota	US	66	
Lamkin Wildlife Co.[b]	Amarillo, Texas	US	67	
Lee Richardson Zoo[a]	Garden City, Kansas	US	68	X
Lewis, Brad[b]	Live Oak, Florida	US	69	
Lincoln Municipal Park Zoo	Lincoln, Nebraska	US	70	
Lincoln Park Zoo	Chicago, Illinois	US	71	
Little Ponderosa Livestock Co.[b]	Winchester, Illinois	US	72	
Little Rock Zoo[a]	Little Rock, Arkansas	US	73	
Living Desert Zoo[a]	Carlsbad, New Mexico	US	74	X
Los Angeles Zoo[a]	Los Angeles, California	US	75	X
McRoberts Game Farm[b]	Gurley, Nebraska	US	76	
Mesker Park Zoo	Evansville, Indiana	US	77	
Metro Richmond Zoo	Richmond, Virginia	US	78	
Milwaukee Zoo	Milwaukee, Wisconsin	US	79	
Minnesota Zoo[a]	Apple Valley, Minnesota	US	80	X
Moose Jaw Zoo	Moose Jaw, Saskatchewan	CA	81	
Montgomery Zoo	Montgomery, Alabama	US	82	
Mt. Gozaisho Serow Center	Gozaisho, Mie Prefecture	JP	83	
National Bison Range[a,c]	Moiese, Montana	US	84	X
National Zoo	Washington, D.C.	US	85	
National Zoological Gardens of South Africa[a]	Pretoria	ZA	86	
National Zoological Gardens of South Africa[a]	Lichtenburg	ZA	87	
Navajo Nation Zoo[a]	Window Rock, Arizona	US	88	
N.B.J. Park	Bulverde, Texas	US	89	
Northland Wildlife[b]	Bovey, Minnesota & Grand Rapids, Michigan	US	90	

Name of Facility	Location	Country*	Number**	Present holder
Northwest Trek[a]	Eatonville, Washington	US	91	
Novack, Ed[b]	Cairo, New York	US	92	
Oglebay's Good Zoo	Wheeling, W. Virginia	US	93	
Okanagan Game Farm	Penticton, British Columbia	CA	94	
Oklahoma City Zoo[a]	Oklahoma City, Oklahoma	US	95	X
Omaha's Henry Doorly Zoo[a]	Omaha, Nebraska	US	96	X
Orange County Zoo	Irvine, California	US	97	
Oregon Wildlife Foundation[a,b]	Sheridan, Oregon	US	98	
Oregon Zoo	Portland, Oregon	US	99	
Oxbow Park/Zollman Zoo[a]	Byron, Minnesota	US	100	
Palmer, Red[b]	Douglasville, Georgia	US	101	
Papanack Park Zoo	Wendover, Ontario	CA	102	
Paramount's King's Island Wild Animal Habitat	King's Island, Ohio	US	103	
Paris Zoo	Paris	FR	104	
Peninsular Pronghorn Recovery El Vizcaino Biosphere Reserve	Mulegé, Baja California Sur	MX	105	X
Philadelphia Zoo	Philadelphia, Pennsylvania	US	106	
Phoenix Zoo[a]	Phoenix, Arizona	US	107	X
Pine Grove Zoo[a]	Little Falls, Minnesota	US	108	X
Pittsburg Zoo	Pittsburg, Pennsylvania	US	109	
Pocatello Zoo[a]	Pocatello, Idaho	US	110	X
Pueblo Zoo[a]	Pueblo, Colorado	US	111	
Queens Zoo	New York, New York	US	112	X
Rand Park Zoo	Keokuk, Iowa	US	113	
Red McCombs Wildlife[b]	Johnson City, Texas	US	114	
Red River Zoo	Fargo, N. Dakota	US	115	
Rio Grande Zoo[a]	Albuquerque, New Mexico	US	116	
Riverside Zoo[a]	Scottsbluff, Nebraska	US	117	X
Rockton-African Lion Safari Park	Cambridge, Ontario	CA	118	
Roger Williams Park Zoo[a]	Providence, Rhode Island	US	119	X
Rolling Hills Wildlife[a]	Salina, Kansas	US	120	X
Rosamond Gifford Zoo[a]	Syracuse, New York	US	121	
Roosevelt Park Zoo[a]	Minot, N. Dakota	US	123	
Ruhe, Louis[b]	New York & Philadelphia	US	124	
Safari West[b]	Santa Rosa, California	US	125	
San Antonio Zoo	San Antonio, Texas	US	126	
San Diego Wild Animal Park	Escondido, California	US	127	
San Diego Zoo[a]	San Diego, California	US	128	X
San Juan de Aragon Zoo[a]	Mexico City	MX	129	X
Saskatoon Zoo	Saskatoon, Saskatchewan	CA	130	X
Seabold, Paul L.[b]	Keokuk, Iowa	US	131	
Sedgwick County Zoo[a]	Wichita, Kansas	US	132	X
Sonoran Pronghorn Recovery Program Cabeza Prieta National Wildlife Refuge[a,c]	Ajo, Arizona	US	133	X
Southwick's Zoo/Wild Animal Farm, Inc.	Blackstone, Massachusetts	US	134	
Spring River Zoo[a]	Roswell, New Mexico	US	135	X
St. Louis Zoo	St. Louis, Missouri	US	136	
St. Paul's Como Zoo	St. Paul, Minnesota	US	137	

Name of Facility	Location	Country*	Number**	Present holder
Sunset Zoo[a]	Manhattan, Kansas	US	138	
Sybille Wildlife Research Center[a,c]	Wheatland, Wyoming	US	139	X
Tanganyika Wildlife Co.[b]	Wichita, Kansas	US	140	
Tatum, Earl[b]	Holiday Island, Arkansas	US	141	
Theodore Roosevelt National Park[a,c]	Medora, N. Dakota	US	142	X
The Wilds[a]	Cumberland, Ohio	US	143	
Thompson, Frank[b]	Bradenton, Florida	US	144	
Tiller, Wally[b]	Bellview, Nebraska	US	145	
Topeka Zoo[a]	Topeka, Kansas	US	146	X
Toronto Zoo[a]	Toronto, Ontario	CA	147	
Tulsa Zoo[a]	Tulsa, Oklahoma	US	148	
Valley Zoo	Edmonton, Alberta	CA	149	
Van den Brink, Frans[b]	Soest	NL	150	
Vivo Animales[b]	Lorena, Texas	US	151	
Wheeler National Wildlife Refuge[c]	Decatur, Alabama	US	152	
Wildlife Safari[a]	Winston, Oregon	US	153	
Wildlife West Nature Park[a]	Edgewood, New Mexico	US	154	X
Willow Park Zoo[a]	Logan, Utah	US	155	X
Wind Cave National Park[a,c]	S. Dakota	US	156	X
Woodland Park Zoo[a]	Seattle, Washington	US	157	
Zoo Antwerp	Antwerp	BE	158	
Zoological Animal Exchange[b]	Natural Bridge, Virginia	US	159	
Zoo Montana	Billings, Montana	US	160	
Zoo Sauvage[a]	Quebec	CA	161***	X

* The official short names in English are following the ISO 3166.
** This number is the one used in the previous tables.
X Present pronghorn holder.
[a] Survey answered
[b] Animal dealers
[c] Other places / institutions that are not zoos.
(UMA) Unidad de Manejo, conservación y Aprovechamiento de la vida silvestre: Wildlife management unit for conservation and harvest.
*** There are other places referred to in the North American Pronghorn Regional Studbook (Holland 2004), but, because of obscure abbreviations we were not successful at identifying them.

Winter Habitat Selection by Pronghorn at Multiple Scales in Southern Alberta

PAUL F. JONES, *Alberta Conservation Association, 2nd Floor YPM Place, 530 – 8th Street South, Lethbridge, Alberta, Canada, T1J 2J8 paul.jones@ab-conservation.com*

MIKE GRUE, *Alberta Conservation Association, 2nd Floor YPM Place, 530 – 8th Street South, Lethbridge, Alberta, Canada, T1J 2J8*

JULIE LANDRY-DEBOER, *Alberta Conservation Association, 2nd Floor YPM Place, 530 – 8th Street South, Lethbridge, Alberta, Canada, T1J 2J8*

MIKE SUITOR, *University of Calgary, 2500 University Drive NW, Calgary, Alberta, Canada, T2N 1N4*

CORMACK GATES, *University of Calgary, 2500 University Drive NW, Calgary, Alberta, Canada, T2N 1N4*

DALE ESLINGER, *Alberta Fish and Wildlife, Room 301, Provincial Building, 346 3rd Street SE, Medicine Hat, Alberta, Canada, T1A 0G7*

KIM MORTON, *Alberta Fish and Wildlife, 2nd Floor YPM Place, 530 – 8th Street South, Lethbridge, Alberta, Canada, T1J 2J8*

ABSTRACT Among the diversity of prairie wildlife in North America, the pronghorn (*Antilocapra americana*) is the most specialized and representative free-roaming, large mammal. Pronghorn are considered to be an obligate grassland species across their range. Though pronghorn in Alberta will experience high mortality due to severe winters and low fawn recruitment, their fate is directly linked to land use practices. Since the late 1970's, little research has been done on pronghorn in Alberta, particularly about land use practices and its influence on resource selection by pronghorn. We used global positioning system data collected from collared female pronghorn across Alberta to quantify habitat selection patterns across multiple scales. We applied a hierarchical framework for habitat use by investigating the selection of a winter seasonal range within the study area (landscape level) and selection of patches within the winter seasonal range (stand level) by pronghorn. At the landscape level, pronghorn habitat selection was evident in the winter of 2007 but not in 2006. At the stand level, selection by pronghorn occurred during both winters. We discuss the implications of our results and provide recommendations for future research.

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Resource or habitat selection has been defined as the adaptive response of animals attempting to meet life requirements and ultimately to increase fitness (Johnson 1980, Thomas and Taylor 1990, Manly et al. 1993). Habitat selection patterns are modified accordingly in response to energy and thermal requirements, reproductive needs, intra- and inter-specific competition, as well as avoidance of predators. To understand selection patterns, Johnson (1980) defined 4 levels or scales of selection: 1) selection of a physical or geographical range, 2) selection of a home range within the geographical area (hereafter called landscape level), 3) selection of attributes or components within the home range (hereafter called stand level) and 4) selection of food items at a feeding site (hereafter called site level). The last level of selection has since been expanded to include the selection of areas for feeding, bedding, reproduction, and predator avoidance (Lofroth 1993, Jones and Hudson 2002). Selection patterns have varied by species, with certain species selecting at the landscape level (Hansen et al. 1993) to others selecting only at the site level (Pearson 1993). Alternatively, selection may occur at multiple levels with selection at different scales being complementary or selection at one level explaining why it occurs at another (Lofroth 1993, Pedlar et al. 1997, Jones and Hudson 2002). For pronghorn, habitat selection at multiple scales has not been extensively examined to date.

Previous pronghorn habitat selection studies have been focused either at the geographic or site level. At the geographical level, pronghorn are considered prairie obligates being found in ecosystems containing grasses, forbs and shrubs (Yoakum 2004), whereas at the site level pronghorn predominately forage on forbs and shrubs for rangelands in Alberta (Mitchell and Smoliak 1971). Additionally, at the site level anthropogenic features such as highways, fences, and residential development can alter habitat use, cause fragmentation, and block or restrict movement by pronghorn (Berger 2004, Yoakum 2004, Sheldon 2005, Gavin and Komers 2006, Brown and Ockenfels 2007).

Little research has examined selection patterns of pronghorn at the landscape and stand level (Ockenfels et al. 1996). We examined habitat selection patterns of pronghorn at the landscape and stand level during the winters of 2005-2006 (hereafter 2006) and 2006-2007 (hereafter 2007) using global positioning system (GPS) technology. At the landscape level, we compared the native prairie composition and anthropogenic features of winter seasonal ranges used by female pronghorn to available winter habitat within the Antelope Management Areas (AMA) of Alberta as designated by Alberta Fish and Wildlife Division. At the stand level, we compared the percent native prairie and distance to anthropogenic features for the pronghorn used points to available points within the individual's winter seasonal range.

STUDY AREA

We used the boundaries of the 9 Antelope Management Areas (Alberta Fish and Wildlife 1990) as our study area which covers an area of approximately 63,000 km^2. Our study area falls within the Grassland Natural Region which comprises approximately 14% of the province, extending from the Saskatchewan border to the Rocky Mountains, and from the southern edge of the Parklands to Montana (Alberta Environmental Protection 1997). Our study area falls within 3 of the 4 subregions; dry mixedgrass, mixedgrass and the northern fescue. The dry mixedgrass is characterized by western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), and spear grass (*Stipa comata*), with brown chernozems and solonetzic soils, and few Chinooks (Alberta Environmental Protection 1997). The mixedgrass subregion is characterized by northern wheatgrass (*Agropyron dasystachyum*) and porcupine grass (*Stipa curtiseta*), dark brown chernozem soils, and is cooler and moist (Alberta Environmental Protection 1997). The northern fescue subregion is characterized by oatgrass (*Danthonia* sp.), rough fescue (*Festuca campestris*), and Idaho fescue grasses (*F. idahoensis*), dark brown and black chernozem and few solonetzics soils, with milder winters (Alberta Environmental Protection 1997). Historically, the primary cause of habitat loss for pronghorn has been conversion for cultivation and increased fencing associated with domestic grazing (Mitchell 1980, Alberta Environmental Protection 1997). Pressures on the remaining native grasslands include increasing conversion for cultivation, livestock grazing, energy field development, roads and pipelines, rural acreage development, and urban expansion (Alberta Environmental Protection 1997). Most native grasslands in the Grassland Natural Region are used for commercial livestock grazing.

METHODS

Based on the results of Grue and Jones (2004), and a visual assessment of the landscape comprising the Grassland Natural Region, we subdivided the study area into areas with a high proportion of native habitat, areas with a high proportion of agricultural farmland, and areas with a mixture of native and agricultural land. We attempted to capture pronghorn within each of these different habitat compositions. Over a 2-year period, our intent was to determine the distribution and movements of 50 pronghorn females using GPS collar technology. Pronghorn does were captured in March 2005 (n = 25) and March 2006 (n = 25) (Jones and Grue 2006). Each captured animal was fitted with a Lotek GPS3300 collar (Lotek Wireless Fish & Wildlife Monitoring©) and Keflex ear tag. The collars were programmed to record a location every 4 hours and were fitted with a timed drop-off scheduled to release after 50 to 52 weeks.

We determined start and end dates for seasonal ranges by examining the mean consecutive 4-hour movement rates per week, pooling data across animals for each year separately. We visually interpreted the graphic depiction of weekly population-level movement rates to determine start and end dates for different seasons on an annual basis (e.g., Winter 2006, Winter 2007), acknowledging published literature describing seasonal pronghorn ecology (Barrett 1981, Alberta Fish and Wildlife 1990).

Statistical Analysis

We defined landscape-level habitat selection as the selection of a winter seasonal range within AMA's. The variables listed in Table 1 were determined for each female pronghorn's 95% fixed kernel winter seasonal range. Available habitat was determined by constructing random seasonal ranges equal in size to the average of the 95% fixed kernel for the pronghorn winter seasonal ranges. The available ranges were randomly placed within the AMA boundary. The same variables listed in Table 1 were summarized for the available winter seasonal ranges. We compared the means for each variable in Table 1 for the used winter seasonal ranges versus the available winter seasonal ranges using the Mann-Whitney U-test (Zar 1984). We completed the analysis at the population level by using the animal as the sample unit and pooling data for individuals separately.

Table 1. Habitat and anthropogenic variables used to compare pronghorn winter ranges to available ranges at the landscape level in Alberta, 2006-2007.

Variable	Definition	Units
Native Prairie	Percent native prairie composition of the winter/available range.	%
Express Highway	Density of high speed through fare with controlled access intersections within the winter/available range.	km/km^2
Arterial Road	Density of major through fare with medium to large traffic capacity within the winter/available range.	km/km^2
Collector Road	Density of minor through fare dedicated to providing access to properties within the winter/available range.	km/km^2
Well Sites	Density of well sites within the winter/available range.	#/km^2

We defined stand-level habitat selection as the selection of components within the winter seasonal ranges of pronghorn in Alberta. Locations contained within an individual female pronghorn's minimum convex polygon (MCP) winter seasonal range were classified into the habitat and anthropogenic variables listed in Table 2. We determined habitat availability using the random point method described by Marcum and Loftsgaarden (1980). We generated an equal number of random points to used locations for each animal within each animals' MCP winter seasonal range using Hawth's Analysis Tools Version 3.09 for ArcGIS (www.spatialecology.com). The habitat and anthropogenic variables in Table 2 were also determined for each random point. We used the Mann-Whitney test to compare the means for the used locations to random points, as the data were not normally distributed (Zar 1984). We completed the analysis at the population level by using the animal as the sample unit and pooling data for those individuals for each winter separately. Significance level for all tests was 0.05. All analysis was preformed using SPSS® version 11.0 (SPSS 2001).

RESULTS

Based on analysis of mean 4-hour movement data we identified the winter period for 2006 and 2007 as 2 December 2005 to 16 February 2006 and 8 December 2006 to 28 February 2007, respectively. The end dates for both winters corresponded to the end of data collection by the collars. We were able to complete analysis for 18 and 19 pronghorn for the winters of 2006 and 2007, respectively.

The variable means for the pronghorn winter seasonal ranges were predominately significantly different than the means for the available winter seasonal ranges for 2007 variables, but not for 2006 (Table 3). In 2007, the mean percent native prairie for the pronghorn winter seasonal ranges was significantly greater than the available winter seasonal ranges. The density of express highways and arterial roads was greater in the 2007 available winter seasonal ranges than the pronghorn winter seasonal ranges, while there was no significant difference for collector roads in either year. There was a significantly greater density of wells within the 2007 pronghorn winter seasonal ranges than the available winter seasonal ranges.

Table 2. Habitat and anthropogenic variables used to compare pronghorn winter locations to available locations at the stand level in Alberta, 2006-2007.

Variable	Definition	Units
Native Prairie	Percent native prairie within the quarter section that the used or random point falls within.	%
Express Highway	Distance to the nearest express highway (high speed through fare with controlled access intersections) from the used or random point	km
Arterial Road	Distance to the nearest arterial road (major through fare with medium to large traffic capacity) from the used or random point	km
Collector Road	Distance to the nearest collector road (minor through fare dedicated to providing access to properties) from the used or random point.	km
Well Sites	Distance to the nearest well site from the used or random point.	km

The selection patterns by pronghorn at the stand level varied between years (Table 4). There was no difference in mean percent native prairie between the pronghorn locations and available points for either year. In 2007, mean distance to express highways was less for pronghorn points than for available points, whereas there was a significant difference between 2006 and 2007 for arterial roads. For both years, pronghorn locations were further from collector roads than available points. Pronghorn locations were further from well sites than available points in 2006, whereas in 2007 there was no significant difference between pronghorn points and available points.

Table 3. Landscape level mean attributes for pronghorn ranges and available ranges for the winters of 2006 and 2007 in southern Alberta.

Variable	Year	Used			Available			Mann-Whitney Value	*P* –Value
		Pronghorn	Mean	S.E	Pronghorn	Mean	S.E		
Percent Native Prairie	2006	18	62.55	9.92	18	57.71	7.04	135	0.393
(%)	2007	19	87.90	4.25	19	49.42	7.21	56	<0.001
Express Highway Density	2006	18	0.004	0.003	18	0.019	0.01	122	0.082
(km/km^2)	2007	19	0.000	0.000	19	0.04	0.01	104.5	0.002
Arterial Density	2006	18	0.03	0.01	18	0.05	0.01	137.5	0.395
(km/km^2)	2007	19	0.01	0.01	19	0.03	0.01	100	0.003
Collector Density	2006	18	0.49	0.04	18	0.38	0.05	128	0.282
(km/km^2)	2007	19	0.39	0.04	19	0.43	0.05	166	0.672
Total Well Density	2006	18	3.16	0.52	18	1.80	0.50	105	0.071
($\#/km^2$)	2007	19	4.10	0.40	19	1.53	0.47	46	<0.001

Table 4. Stand level mean attributes for the pronghorn locations and the available points for the winters of 2006 and 2007 in southern Alberta.

Variable	Year	Used			Available			Mann-Whitney Value	P – Value
		Points	Mean	S.E	Points	Mean	S.E		
Percent Native Prairie	2006	6348	65.47	0.56	6348	66.80	0.54	19955788	0.324
(%)	2007	9074	86.22	0.31	9074	88.84	0.25	40995140	0.585
Distance to Express Highway	2006	6348	19.74	0.18	6348	19.61	0.17	20030120	0.566
(km)	2007	9074	25.58	0.13	9074	26.33	0.13	39569804	<0.001
Distance to Arterial Roads	2006	6348	13.72	0.13	6348	14.85	0.13	18514932	<0.001
(km)	2007	9074	16.07	0.09	9074	16.51	0.09	39826600	<0.001
Distance to Collector Roads	2006	6348	0.95	0.01	6348	0.79	0.01	17373472	<0.001
(km)	2007	9074	1.14	0.01	9074	0.96	0.01	35237568	<0.001
Distance to Well Site	2006	6348	0.40	0.004	6348	0.38	0.004	19275804	<0.001
(km)	2007	9074	0.32	0.002	9074	0.31	0.002	40559732	0.084

DISCUSSION

The selection patterns by pronghorn at the 2 levels we examined varied between the 2 years. At the landscape level, there were significant differences in selection patterns in 2007 but not in 2006, while at the stand level significant differences were found for the anthropogenic variables but not the percent native prairie for both years. The variability at the landscape level between the 2 years may be an artifact of the different individuals than actual selection patterns. The results for the winter of 2006 may be because the sample of pronghorn had a higher percentage of animals in an agricultural setting and when pooled with animals from a native prairie setting are representative of the landscape in Alberta and hence no apparent selection. In the winter of 2007 we had a high percentage of pronghorn (~75%) that wintered on Canadian Forces Base (CFB) Suffield. This landscape is not representative of other ranges in Alberta because CFB Suffield contains predominately intact native prairie habitat. The use of this area by collared pronghorn in 2007 may have biased tests resulting in significant differences because of a lack of variance in sampling.

Pronghorn are found within the short-grass and mixed-grass vegetative communities of the grassland biome, the sagebrush/grass, mesquite/grass, oak/grass and juniper/grass vegetative communities of the shrubsteppe biome as well as the hot desert biome (Yoakum 2004). The use of these communities and biomes would represent the selection at the geographical level. Looking at our results for 2006 only, there was no evidence of selection for native prairie habitat at either the landscape or stand level. This may indicate that selection is occurring at the geographical level, and that Alberta's native prairie is still intact enough to support pronghorn populations. Alternatively, selection by pronghorn may be occurring at the site level. Bruns (1977) found that pronghorn in Alberta selected micro-sites that had lower wind velocities, less snow and softer snow during the winter. Further investigation is required to test the competing hypothesis that selection occurs at multiple scales or that selection at one level explains the pattern at other levels for pronghorn.

Pronghorn movements, behavior and habitat selection can be influenced by roads and fences (O'Gara 2004, Sheldon 2005, Brown and Ockenfels 2007). Ticer et al. (1999) found that pronghorn in Arizona avoided roads in the 0-400m class while Gavin and Komers (2006) found that pronghorn in Alberta were more vigilant and foraged less in habitats containing high traffic volumes. The density of express highways and arterial roads were low throughout our study area and we consider the results of our analysis as statistically significant but not biologically significant. At the stand level the mean distance from a pronghorn location to the nearest express highway or arterial road were between 20-25km and 12-14km respectively. This suggests these two categories of roads are not influencing habitat selection patterns. The results for the collector roads are more consistent with published literature. At the landscape level pronghorn are not able to select winter seasonal ranges to avoid high densities of collector roads because these roads are pervasive and evenly distributed in most of southern Alberta. Our stand level results suggest that pronghorn are modifying their habitat selection patterns within their winter seasonal range to avoid the collector roads.

A recent focus of pronghorn research has been to examine the effects of land use or energy development on pronghorn habitat use and movement (Beckmann et al. 2006, Berger et al. 2006). Based on preliminary results, Berger et al. (2006) found that pronghorn in Wyoming avoided concentrated gas fields once a threshold of well and infrastructure density was exceeded. Alberta has invested heavily in the energy sector and the density of wells in our study area is high, precluding pronghorn from selecting a winter seasonal range that avoids highly developed areas. At the stand level in 2006 pronghorn locations were further from wells, suggesting that their selection patterns may be influenced by energy development. The selection pattern during the winter of 2007 was not what we expected, with pronghorn having a higher density of wells within their winter seasonal range than found across the landscape. By occupying a winter range with such a high density of wells, pronghorn may not have been as capable of selecting areas at a distance from wells than in ranges with lower well densities. The unexpected selection pattern may also be explained by the atypical nature of the wells in the 2007 winter range, where there are few surface wells and an usually high number of buried well heads; this may have potentially reduced the stimulus to which pronghorn respond when they selected habitats. Further, as stated earlier, the 2007 winter ranges of many pronghorn fell within CFB Suffield. Other landscape features (e.g. low fence densities) are associated with this landscape and we were not able to account for them, which may explain this discrepancy in our results.

The importance of CFB Suffield to pronghorn in Alberta is underscored by this analysis and previous research. The base has been identified as one of the key wintering areas in Alberta for pronghorn (Barrett 1982, Alberta Fish and Wildlife 1990). CFB Suffield is used as a military training area predominantly in the summer months for Canadian and British troops. It covers an area of approximately 2,700 km^2 and is composed of predominately native prairie. It also contains 13,354 wells (predominately oil or gas), equating to a density of 4.95 wells/km^2, though most are buried below ground and may not be acting as a disturbance source to pronghorn. Barrett (1984) indicated that the future of pronghorn in Alberta is directly linked to land-use practices and the conservation of quality habitat. Pronghorn that are wintering on the base are likely making a trade off between the high quality of habitat available and the density of wells. High quality habitat on the base is maintained by a regular fire regime caused by live fire exercises as well as prescribed burns (Courtney 1989, Seagel 2007). Previous work has shown pronghorn to seek out these burned areas during particular periods of the year to forage on plains prickly pear cactus (*Opuntia polyacantha*) that have had there spines burned off (Stelfox and Vriend 1977, Courtney 1986, 1989). In addition there are very few fences on the base, being predominantly confined to the east side and the perimeter. This allows free movement by pronghorn across large contiguous areas of native prairie as reported for other locations by O'Gara (2004) and Brown and Ockenfels (2007). The significance of CFB Suffield to the pronghorn population of Alberta still needs to be quantified, as it appears to be the center of activity for pronghorn in the province. However, initial results appear to indicate that CFB Suffield a key area for Alberta pronghorn (Alberta Pronghorn Working Group, unpublished data).

MANAGEMENT IMPLICATIONS

The management plan for pronghorn in Alberta identifies a number of recommendations of which the continued delineation of winter seasonal range is one

(Alberta Fish and Wildlife 1990). Our results provide a basis for this delineation as well as helping to understand the selection patterns of pronghorn during the winter. Improving the habitat layer from the quarter section resolution of the Native Prairie Vegetation Inventory layer to one currently being developed from Landsat 7 ETM+ imagery (Agriculture and Agri-Food Canada 2008) with a 30m resolution will further refine our results and allow for modeling pronghorn habitat use. Completing the analysis at an individual level will also allow us to identify different traits and ensure these traits are conserved. For example, we know that some individuals in our sample used agricultural areas for the entire winter but this fact is lost when the data is pooled between individuals. Pooling also creates greater variance within models reducing their ability to discriminate selection for particular habitat characteristics at the population level. Additionally, similar analysis reported here should be completed for the fawning and summer periods to help wildlife managers understand the needs of pronghorn in Alberta during other seasons.

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Potential Factors Affecting Pronghorn Fawn Survival and Predation in Arizona

STANLEY C. CUNNINGHAM, *Wildlife and Restoration Ecology, Arizona State University Polytechnic Campus, 7001 E. Williams Field Road, Mesa, AZ 85212, USA Stanley.Cunningham@asu.edu*

KIRBY D. BRISTOW, *Arizona Game and Fish Department, 5000 W. Carefree Highway, Phoenix, AZ 85086, kbristow@azgfd.gov*

RICHARD O. OCKENFELS, *PO Box 326, Mayer, AZ 86333*

ABSTRACT A 20-year statewide decline in Arizona pronghorn (*Antilocapra americana*) numbers has been primarily attributed to low fawn survival. Two factors consistently listed as affecting pronghorn fawn survival are predation by coyotes and habitat changes that increase fawn vulnerability to predators. From 2002-2004, we estimated coyote density, availability of vegetation suitable for hiding pronghorn fawns, and the number of trees/ha which could aid predators in approaching pronghorn at 8 sites. We used univariate and multivariate regression to examine how fawn:doe ratios estimated from aerial surveys conducted in July-August of each year varied with coyote density determined through April-May scat indices, vegetation cover measured at 5 height intervals (0-10 cm, 11-20 cm, 21-30 cm, 31-40 cm, and >40 cm) during fawning, and tree density. Because we collected data during and after a severe 7-year drought, we also examined the effect of precipitation on fawn:doe ratios. None of the independent variables potentially contributing to predation were strongly associated with fawn:doe ratios; all correlations were weak and only 2 were significant. The percentages of forb cover from 21-30 cm ($r2 = 0.20$, $P = 0.04$) and 31 –40 cm ($r^2 = 0.17$, $P = 0.05$) were weakly correlated with fawn:doe ratios, but we suspect these correlations reflect potential diet quality rather than hiding cover. Similarly, precipitation from October-April preceding pronghorn surveys was positively correlated with fawn:doe ratios ($r^2 = 0.38$; $P = 0.02$), which is likely related to diet. We present conclusions based on our findings, and explain why our results differ from those previously documented for coyote density, fawn hiding cover selection, and fawn recruitment.

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KEY WORDS *Antilocapra americana*, Arizona, bed site, coyote, fawn cover, fawn:doe ratio, precipitation, pronghorn, recruitment, tree density.

North American pronghorn (*Antilocapra americana*) range from the prairies of southern Canada to the grasslands and shrub steppe plains of the western U.S. and south to the deserts of northern Mexico (Lee et al. 1998). However, suitable pronghorn habitat has been reduced by more than 70% since European settlement (Lee et al. 1998), and numbers have declined by more than 99% due to habitat loss, fencing, dietary overlap with livestock, and year-round hunting near the turn of the 20th century (Yoakum 1968). Management efforts initiated in the 1920's increased pronghorn numbers to an estimated 1 million throughout their range (Lee et al. 1998). However, pronghorn in Arizona have begun to decline in the last 20 years. In 1987, the Arizona pronghorn population was estimated at 12,000 animals, but by 2000 the population had declined to less than 8,000 (AZGFD 2001). Causes for decline have varied. Lee et al. (1998) suggested that human development, predators, restrictive fences, dietary overlap, water availability, disease, and nutritional deficiencies all contributed to the recent decline. Fawn recruitment into the population is the primary determinant of Arizona pronghorn numbers (Ockenfels et al. 1992) and may be susceptible to several of these interrelated factors. Two factors that are consistently listed as influencing pronghorn fawn survival are coyote (*Canus lupus*) predation and habitat changes that increase fawn vulnerability to coyotes (O'Gara and Shaw 2005).

A major cause of fawn mortality is coyote predation. Telemetry studies have recorded mortality rates of 25-80% for fawns during their first 6 months (Vriend and Barrett 1978, Ockenfels et al. 1992, Rothchild et al. 1994). In a review of 18 telemetry studies of fawns, O'Gara and Shaw (2005) found that 702 of 995 (71%) fawns died within their first 2 months of life; a minimum of 528 (76%) of these mortalities were due to predation. Fawns are most vulnerable within their first 3 weeks (neonatal period; Neff and Woolsey 1979, Barrett 1984, O'Gara and Malcom 1988, Gregg et al. 2001). Cover around fawn bed sites may be critical to avoid predation (Barrett 1981, 1984; Autenrieth 1982; Canon and Bryant 1997). Pronghorn fawns spend approximately 90% of their time bedded during the neonatal period (Barrett 1981), and use the "hider strategy" to avoid predators by selecting vegetation that provides better visual obstruction than surrounding areas (10-40 cm, Alldredge et al. 1991). Conversely, fawns >3 weeks old were found in areas of shorter vegetation and topographic characteristics that provided better visibility (Barrett 1981, Ticer and Miller 1994, Ticer 1998.). Ticer and Miller (1994) suggested fawns >3 weeks old use the same "see and flee" response as adults because the type of cover fawns selected changed as fawns aged.

Vegetation selected by bedding pronghorn fawns varies between geographic locations and with fawn age (Bodie 1978, Barrett 1981, Tucker and Garner 1983, Autenrieth 1984, Alldredge et al. 1991). In Idaho, Autenrieth (1982, 1984) found that fawns selected high shrub density at heights of 32-59 cm, and Pyrah (1987) found decreased fawn survival in areas with decreased shrub cover in Montana. Alldredge et al. (1991) found that pronghorn fawns in Wyoming selected areas of higher shrub cover than random, but they avoided areas with the highest shrub density. In Texas, Tucker and Garner (1983) found that shrubs were not selected by bedding fawns, and although mean vegetation was 19 cm around beds, they selected areas of taller grass (38-52 cm) than surrounding areas. In Alberta, fawns primarily selected small vegetation patches with high forb density, not shrubs (Barrett 1984). In semi-desert grassland, Ticer and Miller (1994) found that both neonates and post-neonates selected areas where grass was 29 cm high and forbs were 12 cm high.

Bed site selection can also involve other factors. Both Alldredge et al. (1991) and Autenrieth (1984) noted the importance of adequate cover to reduce environmental extremes and reduce disease exposure. In arid areas, such as Arizona, fawns were most often located <1 km from permanent water sources (Ockenfels et al. 1992, Ticer and Miller 1994).

Tree and tall shrub (>1 m) density can affect the ability of fawns and adults to detect predators. Lee et al. (1998) reported tree diversity and density were low in suitable habitat. Alexander and Ockenfels (1994) found that pronghorn avoided areas of high tree density in Arizona pinyon juniper habitats. High-use areas for pronghorn averaged 4.7 trees/ha, whereas non-use areas contained 155 trees/ha. Yoakum (1978) stated that pronghorn rarely inhabit areas with ponderosa pine (*Pinus ponderosa*) or juniper (*Juniperus* spp.), and that they prefer low vegetation heights (25-46 cm) and avoid areas where vegetation is >63 cm.

Our goal was to determine how variation in coyote density, fawn hiding cover, tree density, and precipitation influence pronghorn fawn recruitment in Arizona. We used fawn:doe ratios (FDR) from July-September to estimate fawn survival. Based on the results of previousstudies, we expected higher coyote density to negatively affect FDR. We also hypothesized that vegetation cover could influence this relationship, with higher FDR correlated with higher cover from 10-40 cm and with increasing rainfall. If cover was abundant, coyote density would not affect FDR. We also expected higher tree density to negatively affect FDR. Because we collected data during and after one of the worst 7-year droughts in recorded Arizona history (Ni et. al 2002, Kipfmeuller et al. 2004), we examined the effect of precipitation on fawn survival and coyote density. Three pronghorn studies have found juvenile survival rates were positively correlated with winter rainfall in some locations (Brown et al. 2002, Hossack et al. 2002, McKinney et al. *In Press*). Rainfall during winter strongly influenced production of forbs the following spring, as well as production, productivity, and recruitment of other large desert herbivores (Beatley 1974, Smith and LeCount 1979, Brown 1984, McKinney et al. 2001).

STUDY AREA

We collected data on coyote density, cover, tree density and precipitation at 8 sites in 7 game management units (GMUs) containing pronghorn across 4 separate geographic areas of Arizona (Fig. 1). Within 3 of the 4 areas, we measured these 4 variables from 2002-2004 in areas where FDR had been measured as high (>25:100 does) and low (<15:100 does) from 1991-2001. In the 2 sites in central Arizona, we collected data in 2003-2004 and previous FDR were similar. Within each GMU, we limited data collection to areas rated as moderate to high quality habitat (Ockenfels et al. 1996) and where field observations confirmed pronghorn were present. We estimated <100 pronghorn in each subset of GMUs where we collected data. We only collected coyote index and fawn cover data during location-specific parturition periods. Tree density data was not collected during any specific time period.

In central Arizona, we collected data at 2 sites in GMU 19A. The Fain Ranch site encompassed approximately 11,687 ha of short-grass prairie bordered on the west by Prescott Valley (elevation 1,700 m). The Lonesome Valley site encompassed approximately 23,871 ha of short-grass prairie near the town of Chino Valley (1,550 m). Dominant vegetation was short-grass prairie with some interior chaparral. Both sites were grazed by cattle. 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*). Long-term minimum and maximum daily temperature at Chino Valley in January averaged -6 and 11° C, respectively. July temperatures averaged 15 to 33° C. Annual rainfall averaged 30 cm.

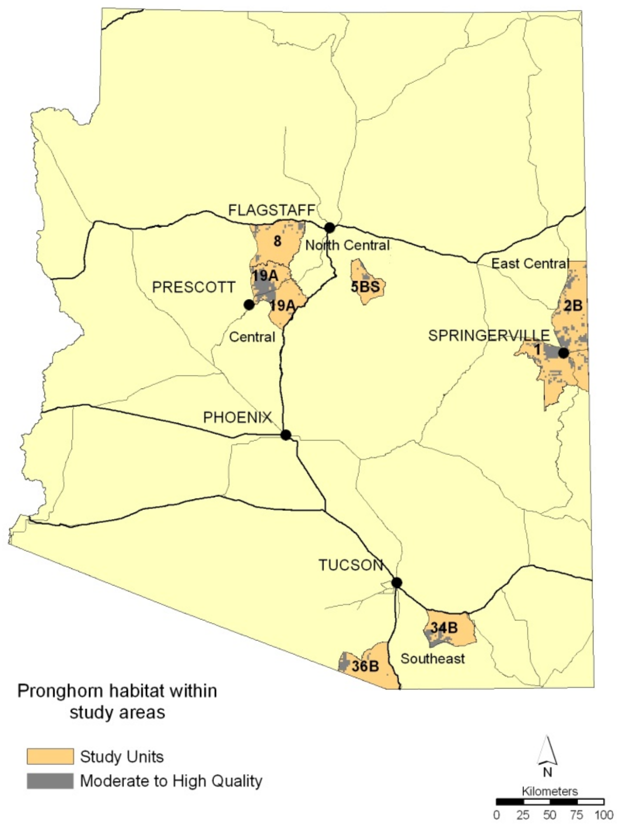

Figure 1. Geographic location of the 8 study sites in 7 game management units in Arizona, 2002-2004.

In northeastern Arizona, we collected data across 13,761 ha in GMU 1, approximately 7-15 km northwest of Springerville (2,070 m), and across 14,626 ha in GMU 2B 4-20 km north of Springerville. Both sites were grazed by elk (*Cervus elaphus*) and cattle while pronghorn were present. Predominant vegetation in the northeastern study sites was Great Basin grasslands with sections of Petran montane conifer forest and Great Basin conifer woodland (Brown 1994). Dominant grasses included blue gramma, Arizona fesque (*Festuca arizonica*), and squirreltail (*Sitanion hystrix*). Dominant forbs included silver sage (*Artemesia ludoviciana*), cuman ragweed (*Ambrosia psilostachya*), and rayless gumweed (*Grinlis aphanactis*). Dominant shrubs were rabbitbrush (*Chrysothamnus nauseosus*), wax currant (*Ribes cereum*), and skunkbush sumac (*Rhus trilobata*). Long-term minimum and maximum mean temperatures at Springerville in January averaged –9.3 to 8.6° C, respectively. July temperatures averaged 10.6 to 27.9° C. Despite close proximity and similarities in climate, habitat quality differed between the two northeastern study sites (Ockenfels et al. 1996); the 10-year mean pronghorn FDR has been greater in GMU 1 (25.9 fawns/100 does) than in GMU 2B (15.7 fawns/100 does).

In north-central Arizona, we gathered data across 4,430 ha in GMU 8 at Garland Prairie (2,072 m) 7.2 km south of Parks, and across 14,155 ha in GMU 5B on Anderson Mesa 11 km east of Mormon Lake (2,194 m). Both sites were grazed by elk and cattle. Great Basin grassland was the predominate vegetation type in these study sites with patches of Great Basin conifer woodland (Brown 1994) also present. In GMU 5B, dominant forb species included silver sage, aspen fleabane (*Erigeron macranthus*), common fleabane (*E. oreophilus*), red root eriogonum (*Eriogonum racemosum*), fleshy mullen (*Verbascum thapsus*), brickella (*Brickella* spp.), and goldeneyes (*Viguiera longifolia*). Dominant grasses included western wheatgrass (*Elymus smithii*) and blue grama. The most common shrub species were rabbitbrush and broom snakeweed. In GMU 8, silver sage, aspen and common fleabane, and red root eriogonum were the most common forb species. Western wheatgrass, blue grama, squirreltail, and Arizona fescue were the most common grass species. The most abundant shrub species in GMU 8 were the same as those in 5B. Stands of ponderosa pine were common in both sites. In GMU 5B, long-term minimum and maximum temperatues at Flagstaff in January ranged from –9 to 5.9° C, respectively. July temperatures ranged from 10.2 to 27.7° C. In GMU 8, long-term minimum and maximum temperatures at Williams in January averaged -7 and 7.3° C, respectively. July temperatures averaged 11.7 to 28.7° C. Mean precipitation was 54 cm in GMU 8 and 53 cm in GMU 5B, and mean annual snowfall was greater in GMU 5B (248 cm) than in GMU 8 (73.5 cm). The 10-year mean pronghorn FDR has been greater in GMU 8 (37.1 fawns/100 does) than in GMU 5B (11.7 fawns/100 does).

Southeastern Arizona study sites included sections on 16,009 ha of the Empire Ranch (GMU 34B) 8.2 km from Greaterville (1,462 m), and 8,885 ha in Buenos Aires National Wildlife Refuge (BANWR, 1,096 m) in GMU 36B, 97 km southwest of Tucson. GMU 34B was grazed by cattle but BANWR was not. Semi-desert grasslands dominated the sites, with some remnants of Sonora savannah grassland in GMU 36B (Brown 1994). Predominant grasses included bush muhly (*Muhlenbergia porteri*), blue gramma, sideoats gramma (*Bouteloua curtipendula*), Lehmann lovegrass, (*Eragrostis lehmanniana*), and Arizona cottontop (*Trichacne californica*). Predominant forbs included doveweed (*Croton pottsii*), Arizona blue eyes (*Evolvulus arizonica*), Arizona poppy (*Kallstroemia grandiflora*), sida (*Sida procumbens*), and western ragweed (*Ambrosia confertiflora*). Predominant shrubs included shrub form mesquite (*Prosopis velutina*), catclaw acacia (*Acacia greggii*), false mesquite (*Calliandra humilis*), fairy duster (*Calliandra eriophylla*), and shrubby buckwheat (*Eriogonum wrightii*). Long-term minimum and maximum daily temperature at Tombstone in January averaged 1.5 and 15.6° C, respectively. July temperatures averaged 18.6 to 34° C. Mean precipitation was 50 cm in 34B and 44 cm at 36B. Mean FDR from 1991-2001 was greater in 34B (23.2 fawns/100 does) than 36B (12.9 fawns/100 does).

Arizona experienced a severe 7-year drought from 1996-2002 (Ni et. al 2002), which affected all of our study sites. The first year of our study (2002) was the worst drought year in the last 1,400 years of Arizona's history; 2000 was the fourth worst year (Ni et. al. 2002, Kipfmeuller et al. 2004). Precipitation records indicated 2003 and 2004 were near normal or exceeded normals in all study sites except GMU 5B. With respect to both total and winter precipitation (October-April) from 1996-2002, each site in central Arizona was below normal in 5 of 7 years; in north central Arizona GMU 5B was below normal each year and GMU 8 was below normal 6 of 7 years; east central Arizona was below normal 4 of 7 years, and southern Arizona was below normal 5 of 7 years.

METHODS

Pronghorn survey.— The Arizona Game and Fish Department has conducted standard, nonrandom census surveys of pronghorn during July-August each year since 1946 using fixed-wing aircraft (Neff 1986, Ockenfels et al. 1996, Rabe et al. 2002). We flew a grid system at 16 to 30 m over pronghorn habitat with lines separated by no more than 1.0 km, and counted all groups classifying each animal as buck, doe, or fawn. We compared FDR observed only in the areas of the GMU where we collected data between study sites among years, and vice versa, using ANOVA and a Tukey's multiple comparison test when values were significant at the alpha=0.05 level. We used a Student's t-test to investigate differences between mean FDR from 1991-2001 and those measured during our study.

Coyote indices.— We indexed coyote abundance on 20-24 1-km scat transects in each of the 8 study sites in May-June of each year. Clark (1972), Davison (1980), Stoddart (1984), and Cunningham et al. (*In Press*) all used scat deposition rates to index carnivore populations in their study areas. Scat deposition rates were highly correlated (r^2 = 0.97) with 4 estimates of coyote density derived from "mark-recapture" experiments involving radioactive feces tagging (Pelton and Marcum 1975, Davison 1980), suggesting this technique might be sensitive to changes in coyote abundance. However, Knowlton (F. F. Knowlton, Denver Wildlife Research Center, U.S. Department of Agriculture APHIS, unpublished report) suggested possible biases associated with scat transects might be: (1) removal of scats from transects might slightly reduce the number of scats deposited in subsequent days (old scats motivate deposition of new scats); (2) observer variability is relatively low; and (3) scat persistence is inversely related to the amount of vehicular traffic. The most important bias involves failure to detect scats while walking transects.

We cleared all transects by walking routes twice (once in each direction) to reduce failure to detect scats. All permanent scat transects were $\geq$1 km in length and located only on unmaintained roads or hiking trails to limit the effect of vehicular traffic on scat deposition. We walked each transect twice after 10 to 21 days and counted scats again. We calculated a coyote abundance index (CAI) as the number of scats divided by the number of nights of scat accumulation times 100 per km (F. F. Knowlton, Denver Wildlife Research Center, U. S. Department of Agriculture APHIS, unpublished report). We used visual characteristics by Murie (1954; size, shape, and width) and Danner and Dodd (1982) to identify scats.

We compared CAI among years using ANOVA and a Tukey's multiple comparison test when comparisons were significant at the 0.05 level. We compared CAI among years within the same season to reduce biases due to seasonal differences in defecation rates (Andelt and Andelt 1984). We compared CAI in study sites considered areas of high FDR versus low FDR using a students *t*-test. We used linear regression with CAI as the independent variable and FDR as the dependent variable to measure the correlation between these variables in all years on all study sites. We also used linear regression to investigate a possible correlation between winter preciptitation and CAI.

Fawn cover availability.— We measured vegetation cover at 5 height intervals at 60 random points <1 km from a water source using a modified line-intercept method (Bristow and Ockenfels 2002) during pronghorn fawning. At each site, we measured cover at 10 random points derived with a Geographical Information System (GIS) around 6 waterholes. In 2002, drought forced us to measure 20 random points around 3 waterholes in 2 sites. At each point a series of 4 to 12.5m transects, perpendicular to each other, were established at 0.5 m intervals. Ordination of the first transect was determined from a random numbers table. We measured cover by vegetation type (grass, forb, shrub, cacti, tree, all vegetation types) at the following height intervals: 0-10 cm, 11- 20 cm, 21-30 cm, 31-40 cm, and >40 cm tall. Both alive and decadent vegetation was recorded.

We used ANOVA to examine differences in cover among study sites and years within each height category. A Tukey's multiple comparison test was used when ANOVA results were significant (P < 0.05). We used both univariate and multivariate regression to determine the association between vegetation cover by height interval and FDR over all 3 years. In the univariate analysis, we regressed each independent height interval against the dependant FDR. In multi-regression analysis, we used the following combinations of height intervals of vegetation cover (0-20 cm, 0-30 cm, 0-40 cm, 0->40 cm, 11-20 cm, 11-30 cm, 11-40 cm, 11->40 cm, 21-30 cm, 21-40 cm, 21->40 cm, 31->40 cm) and FDR over all years. We used Student's *t*-tests ($\alpha < 0.05$) to assess possible differences among the 5 measures of vegetation cover by height interval in paired study sites. We used a Bonferroni correction method for multiple comparisons with *t*-tests to adjust $\alpha = 0.05$ to $\alpha = 0.01$ (Hochberg and Tamhane 1987).

Precipitation.— Selection of gauging stations for each site was based on average annual precipitation isopleths (Sellers and Hill 1974). We obtained total monthly rainfall data from national weather service summaries for the 5 sites (National Oceanic and Atmospheric Administration 2005). Most winter storms in Arizona occur during October-March, with occasional extensions into April (Sellers and Hill 1974), so we summarized precipitation data between October-April at each location. We used linear regression with the previous winter's precipitation and observed FDR (dependent variable) to analyze the relationship between seasonal rainfall and pronghorn FDR. We also regressed winter precipitation against CAIs indices, but not fawn cover since decadent vegetation was considered cover.

RESULTS

Estimated survival (FDR) varied across all sites and years from 0 to 79%, with mean survival of 26% (S.D. = 19.1). Over our 3-year study period, 31.8% of the FDR values were considered low (<15%), whereas 36.4% of the ratios were considered high (>25%; Fig. 2). Mean FDR across all sites differed among years ($F = 11.33$, $P = 0.001$), and FDR in 2004 FDR ($\bar{x}$ = 43.4%) was the highest (*P* < 0.001). The FDR in 2004 was higher than the 10-year average FDR for all sites (*t* = -4.03, *P* = 0.001), and the highest value in all sites except GMU 1 in east central Arizona. Mean FDR was lowest in 2002 ($\bar{x}$ = 8.5%), and mean FDR in 2003 was 23.2%. FDR was similar between 2003 and 2004 for sites in east-central Arizona, whereas FDR increased between these years for all other sites. During our 3-year study, mean FDR values did not differ among sites we originally classified as high or low fawn FDR sites (*t* = –0.47, *P* = 0.64).

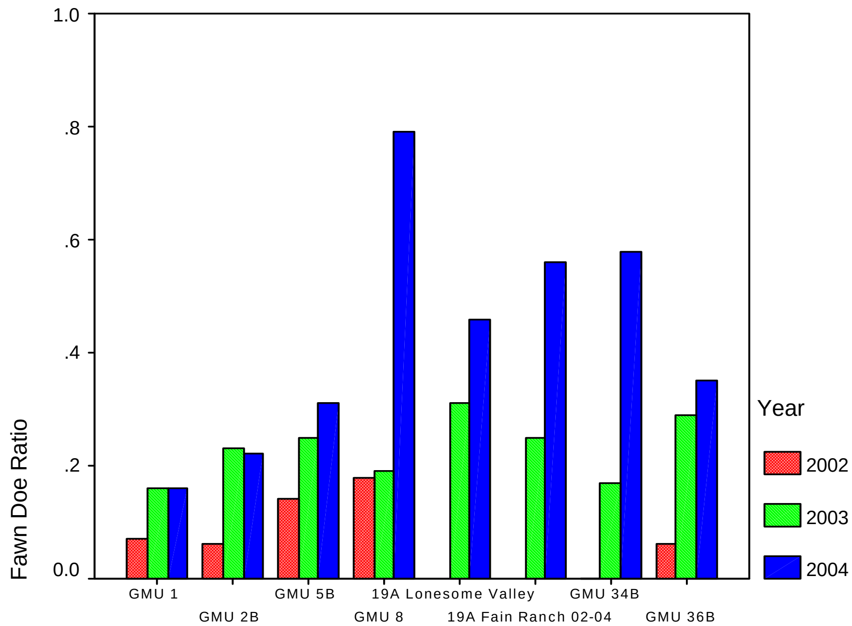

Figure 2. Fawn doe ratios for 8 study sites in 7 game management units (GMUs) in Arizona, 2002-2004.

Coyote indices.— Coyote density (CAI) varied significantly among years and study sites (Table 1). Southern Arizona sites had significantly higher (*P* < 0.001) CAI each year except for GMU 2 in east-central Arizona in 2004. Coyote density was similar in the southern sites among years, however 5 study sites did vary in density among years (*P* < 0.05). In east-central Arizona, CAIs were highest in 2004, but in north-central Arizona they were highest in 2002. There was no difference in mean CAIs between areas originally classified as high or low recruitment (*t* =0.63, *P* =0.54).

Linear regression between annual CAI and FDR in all sites showed the 2 variables were not significantly correlated (r^2 = 0.002, *P* = 0.86). Within geographic regions, there was no significant relationship between CAI and FDR for either the southern or north-central sites (r^2 = 0.002 and 0.15, respectively). In east-central Arizona, however, there was a weak correlation between CAI and FDR (r^2 = 0.55, *P* = 0.09). There was no significant correlation between winter precipitation and CAI (r^2 = 0.09, *P* = 0.19).

Table 1. Coyote abundance indices by study site and year collected in 8 sites in Arizona, 2002-2004.

Study site	2002	2003	2004
East-Central Arizona			
GMU 1	2.3	1.8	**7.2**
GMU 2B	3.5	**8.0**	**13.0***
North-Central Arizona			
GMU 5B	**8.3**	0.9	**7.0**
GMU 8	**2.7**	0.2	0.3
Central			
GMU 19A Lonesome Valley	na	5.2	5.6
GMU 19A Fain	na	4.0	**9.0**
Southern Arizona			
GMU 34B	29.0*	20.3*	25.0*
GMU 36B	25.4*	34.7*	22.5*

GMU = Game management unit
Bold-type values indicate a significant (P < 0.05) difference among years within the same study site
* indicates a significant (P < 0.05) difference among study sites within the same year

Fawn Cover.— Percent vegetation cover by height interval varied significantly in each site among years. Generally, the highest cover within each height category >10 cm was in southern Arizona (Table 2). Mean values for 3 years for 0-10 cm differed between sites (F = 11.9, P < 0.001) and ranged from a low of 46% in GMU 8 in north-central Arizona to 73.4% at Fain in central Arizona. At 11-20 cm, north-central sites had the lowest values at 6.4 and 10.9% (F = 103.4, P < 0.001) and 36B in southern AZ was the highest (39.6%). GMU 36B also had the highest cover values (F > 101.8, P < 0.001) at height intervals from 21-30 and 31-40 cm (25.9 and 17.2%, respectively), while GMU 5B in north-central Arizona was the lowest (1.1 and 0.7%).

In 2002, vegetation cover was significantly greater in southern sites in all categories from 0-40 cm (F > 29.1, P < 0.001), north central sites had the lowest cover >11 cm. In 2003, central sites and GMU 1 in east central Arizona had the highest ground cover from 0-10 cm (F = 41.6, P < 0.001), but southern units had the greatest cover from 11->40 cm (F > 29.8, P < 0.001). In 2003, north-central sites had the lowest cover values (P < 0.05) for vegetation >11 cm. In 2004, central sites again had the highest ground cover at 0-10 cm, and GMU 36B in southern Arizona had significantly higher cover values than any other site from 11->40 cm (F > 30.7, P < 0.001).

In Southern sites, GMU 36B had higher cover values than 34B (P < 0.05, Table 2) in all height intervals in all years, except 0-10 cm in 2002. Central units were similar, except cover at 11-30 cm in Lonesome Valley was higher in 2004. In north central sites, GMU 8 had higher cover from 0–30 cm in 2002, but sites were similar in 2003. In 2004, GMU 5B was higher from 0-10 cm and GMU 8 was higher from 21-40 cm. In east-central Arizona, both sites were similar in 2002, and nearly all in 2003 (0-10 cm excepted). In 2004, GMU 1 was highest from 0-40 cm. Mean cover at 0-10 cm was significantly higher (F = 5.54, P = 0.01) at sites and years when FDR was >25% than when FDR was <15% (Table 3). All other height classes had similar means and ranges of values.

Table 2. Percent vegetation cover (all classes combined) by height interval in 8 study sites in Arizona measured from 2002-2004.

		Height interval (cm)				
Study Site	Year	0-10	11-20	21-30	31-40	>41
Southern Arizona						
GMU 36B[L]	2002	51.1	41.5	30.8*	20.9*	15.5*
	2003	56.8*	34.9*	18.7*	11.7*	17.2*
	2004	59.6	42.7*	28.4*	19.1*	24.3*
GMU 34B[H]	2002	62.6*	38.8	21.2	12.1	8.15
	2003	47.9	19.1	10.1	9.4	9.4
	2004	55.1	13.6	8.4	5.7	5.0
Central Arizona						
GMU 19A Lonesome Valley	2003	78.2	7.4	1.8	0.9	0.5
	2004	64.1	26.1*	10.1*	3.2	0.4
GMU 19A Fain	2003	77.6	9.6	2.7	1.2	0.7
	2004	69.1	16.0	3.7	1.3	0.7
North-Central Arizona						
GMU 5B[L]	2002	28.3	6.0	1.8	1.7	3.7
	2003	49.9	5.9	1.1	0.2	4.1
	2004	61.2*	7.1	0.32	0.1	4.3
GMU 8[H]	2002	37.6*	19.1*	9.4*	3.8	1.6
	2003	46.8	5.3	1.6	0.6*	1.5
	2004	54.7	6.3	2.9*	1.4*	2.3
East-Central Arizona						
GMU 2B[L]	2002	20.7	9.6	3.4	1.5	1.3
	2003	67.8	18.2	6.6	2.1	0.9
	2004	49.4	8.5	1.6	0.4	1.0
GMU 1[H]	2002	32.1	16.8	6.7	2.2	2.3
	2003	79.7*	15.3	4.2	1.1	0.3
	2004	57.1*	19.1*	8.2*	4.0*	2.6

[L] indicates an area with a mean fawn:doe ratio < 15:100 from 1992-2001.
[H] indicates an area with a mean fawn:doe ratio > 25:100 from 1992-2001.
* indicates a height interval that was significantly higher ($P < 0.01$) than the height interval in the unit in the same geographic area the same year

All univariate regression analyses between vegetation cover at different height intervals (0–>40 cm) and FDR at the 8 study sites from 2002 –2004 (Table 4) were weak ($r^2 \leq 0.2$), and all but 2 were not significant. The strongest univariate relationship for cover with FDR was forb cover at 21-30 cm ($r^2 = 0.2$, $P = 0.04$) and 31-40 cm ($r^2 = 0.17$, $P = 0.05$). Correlation values for shrubs 0–10 cm ($r^2 = 0.15$, $P = 0.08$) suggested the two might be related.

We found no combination of cover heights with all plant types combined (Table 5) or by plant type that had a significant correlation with FDR. From stepwise entry, 0-10 cm had the most effect on the correlation value (Table 4), but all values were small and not significant.

Table 3. Descriptive statistics of vegetation cover (all plant types combined) by height interval of sites with fawn survival <15% (n = 6), 16–25% (n = 7), >25% (n = 9) in 8 study sites in Arizona, 2002-2004.

Vegetation height (cm)	Fawn Survival	Mean Cover	Standard Deviation	Minimum	Maximum
0-10	<15%	40.5	15.9	20.7	62.6
	16-25%	56.5	13.9	37.6	79.7
	>25%	63.2	9.9	49.9	78.2
11-20	<15%	21.9	14.9	6.0	41.5
	16-25%	17.2	9.5	5.3	34.9
	>25%	15.0	12.2	5.9	42.7
21-30	<15%	12.3	11.3	1.8	30.8
	16-25%	7.2	5.9	1.6	18.7
	>25%	6.6	8.8	0.3	28.4
31-40	<15%	7.3	7.7	1.5	20.9
	16-25%	3.6	6.1	0.4	11.7
	>25%	3.4	3.9	0.1	19.1

Table 4. Univariate regression models correlating vegetation cover by different height intervals and plant type with pronghorn fawn recruitment in 8 study sites in Arizona, 2002-2004.

Vegetation type	Vertical height intervals	r^2	*P* value
All classes combined	0-10 cm	0.11	0.13
	11-20 cm	0.04	0.34
	21-30 cm	0.04	0.36
	31-40 cm	0.03	0.42
	> 40 cm	0.01	0.71
Grasses	0-10 cm	0.05	0.34
	11-20 cm	0.02	0.51
	21-30 cm	0.02	0.57
	31-40 cm	0.01	0.75
	> 40 cm	0.01	0.73
Forbs	0-10 cm	0.03	0.43
	11-20 cm	0.13	0.1
	21-30 cm	0.20	0.04
	31-40 cm	0.17	0.05
	> 40 cm	0.15	0.08
Shrubs	0-10 cm	0.15	0.08
	11-20 cm	0.01	0.58
	21-30 cm	0.02	0.49
	31-40 cm	0.02	0.55
	> 40 cm	0.02	0.55

Table 5. Multivariate regression models correlating vegetation cover (all plant types combined) by different height intervals with pronghorn fawn recruitment in 8 study sites in Arizona, 2002-2004.

Percent cover at vertical height intervals	r^2	*P* value
0-10, 11-20 cm	0.18	0.16
0-10, 11-20, 21-30 cm	0.20	0.26
0-10, 11-20, 21-30, 31-40 cm	0.20	0.40
0-10, 11-20, 21-30, 31-40, > 40 cm	0.24	0.50
11-20, 21-30 cm	0.05	0.60
11-20, 21-30, 31-40 cm	0.06	0.76
11-20, 21-30, 31-40, >40 cm	0.07	0.85
21-30, 31-40 cm	0.06	0.56
21-30, 31-40, >40 cm	0.07	0.71
31-40, >40 cm	0.06	0.34

We arbitrarily examined correlations between vegetation cover at different height intervals when CAI was greater or less than 5.0 or 10.0 (Table 6); none of these correlations was significant. Density indices (CAIs) with values >10.0 represented data from all years in southern Arizona and GMU 2B in 2004 only.

Tree Density.— The number of trees of each type differed by geographic area (Table 7). The highest number of ponderosa pine was found in north-central Arizona, and mesquite trees in southern Arizona. The highest number of pinyon juniper trees were found in east-central Arizona, and GMU 5B in north central Arizona. There was no correlation between FDR and any species of tree or shrub (r^2 = 0.01 to 0.24, P >0.1).

Table 6. Correlations between vegetation cover at different height intervals and fawn:doe ratios at study sites with different coyote index values in Arizona 2002-2004. (*P* values are shown in parentheses.)

Height Category (cm)	<5 df = 7	>5 df = 13	<10 df = 14	>10 df = 6
0-10	0.08 (0.48)	0.14 (0.19)	0.16 (0.14)	0 (0.97)
0-20	0.26 (0.46)	0.23 (0.24)	0.17 (0.33)	0.29 (0.51)
0-30	0.66 (0.19)	0.23 (0.44)	0.18 (0.52)	0.54 (0.46)
0-40	0.66 (0.39)	0.04 (0.57)	0.18 (0.71)	0.78 (0.39)
>40	0.05 (0.59)	0.04 (0.49)	0.01 (0.7)	0.0 (0.99)

Table 7. Mean number of trees and shrubs in good to moderate pronghorn habitat in 8 sites in Arizona, 2002-2004.

Study site	Ponderosa Pine	Pinyon Juniper	Mesquite	Shrubs <2 m tall
Southern Arizona				
36B[L]	0	0	17.11	1.16
34B[H]	0	0	3.75	9.11
Central Arizona				
Lonesome Valley	0	0.3	0	2.5
Fain	0	.02	0	3.2
North-Central Arizona				
5B[L]	12.21	5.34	0	3.79
8[H]	26.62	0.6	0	8.34
East-Central Arizona				
2B[L]	0.1	2.6	0	6.67
1[H]	0.9	4.4	0	4.4

[L] indicates an area with a mean fawn:doe ratio < 15:100 from 1992-2001
[H] indicates an area with a mean fawn:doe ratio > 25:100 from 1992-2001

Precipitation.— We found that FDR was positively correlated with precipitation during the previous winter during our period of study (r^2 = 0.38, P = 0.002; Fig. 3). The correlation was strongest when winter precipitation was <10 cm (r^2 = 0.82, P = 0.001), and was weaker when precipitation increased by just 2.5 cm to 12.5 cm (r^2 = 0.59, P = 0.004). There was no correlation between FDR and precipitation when FDR was >12.5 cm (r^2 = 0.04, P = 0.55). When winter precipitation was <12.5 cm, FDR averaged 15%, whereas when winter precipitation was >12.5 cm FDR was significantly higher (41%; t = –4.4, P = 0.002).

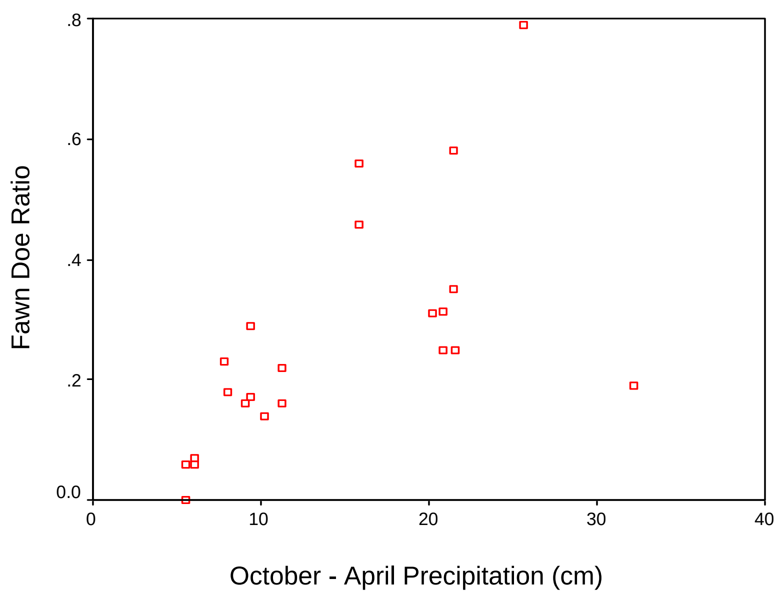

Figure 3. Scatterplot of October-April precipitation and fawn:doe ratios (FDR) for 8 study sites in 7 game management units in Arizona, 2002-2004.

DISCUSSION

None of our hypotheses on factors affecting predation correlated with FDR in our study. When working with multiple factors that can control predation, and thus fawn survival, the interactions may be too complex to be separated by existing research methods (Connolly 1981). However, given previous evidence on the positive effects on fawn survival that reducing coyote density had, and the strong selection for cover in fawn bed site studies we expected to see more explained by the factors measured than we did.

Coyote density.— Coyote density (CAIs) was much higher in southern Arizona than in central and northern areas of the state. Even though there is little coyote harvest because trapping on public lands illegal, CAIs were very low in some sites, particularly GMU 8. The highest FDR (78:100) was observed in GMU 8 in 2004 where the CAI (0.3) was the lowest measured that year. In 2003, GMU 8 had the lowest CAI as well (0.2), but the FDR was only 19:100.

Our hypothesis that FDR would be correlated with coyote density was not supported, although the correlation in east-central Arizona suggested coyote density might have an effect on FDR. Because 2002 was the lowest rainfall year in 1,400 years, it may not be realistic to assume we observed typical ecological relationships that year. However, CAIs were not affected by winter precipitation, and the correlation for CAIs and FDR for 2003 and 2004 was insignificant ($r^2 = 0.02$, $P = 0.98$, $df = 14$).

There may be several reasons we did not see a correlation between CAI and FDR: 1) our index method may not be sensitive enough to pick up a difference in the minimum number of coyotes that affects FDR, particularly in small pronghorn populations; 2) coyote behavior may change when they are actively hunting fawns, and a reduction in road travel may skew indices low; 3) we did not measure alternate prey species, and an increase in alternate prey could shift coyote diet emphasis from pronghorn fawns (Beale 1986); or 4) coyote density does not affect FDR, at least not during the 3 years we studied the 8 Arizona sites.

We tried to reduce previously cited biases with CAIs, and given that 3 studies found a high correlation with scat indices and a mark-recapture index (Pelton and Marcum 1975, Davison 1980), we felt this index was the best method to use in smaller (<30,000 ha) study areas. However, this index still may not have been sensitive enough to distinguish the number of coyotes needed to affect FDR, particularly where populations were estimated at <100 animals. In some of our populations, only 20 to 30 does may have been present that year, and only 3-5 coyotes may affect a small population easily. A slight increase of coyote numbers (2-3) is probably not noticeable with our method. Lee et al. (1998) felt that coyote predation was likely to have the greatest impact in small populations or marginal habitats, and O'Gara and Shaw (2005) noted that predation of fawns by a limited number of coyotes would have much greater effects in small populations. We were not able to identify a coyote index threshold where we started to see FDR change, as we did with precipitation.

The majority of predation on pronghorn fawns primarily occurs within 1 month of parturition, and coyotes can frequently be seen following and actively hunting pronghorn (O'Gara and Shaw 2005). We surveyed each site just after fawns were born, but do not know how this might change coyote movements with respect to traveling roads and scat deposition rate. An increase in meat without as much hair, such as a fawn versus rodents, often results in diarrhea and unidentifiable scat (Ackerman et al. 1984).

Our data, as collected, indicated that coyote density had little to no effect on FDR. In the low coyote densities we observed in most sites, coyote density may not affect fawn survival when compared to other sources of mortality. Alternatively, a low index still represent enough coyotes to affect a small pronghorn population FDR. However on Anderson Mesa (GMU 5B), 3 research projects (Arrington and Edwards 1951, Neff and Woolsey 1979, Smith et al. 1986) found strong correlations between coyote control with a reduction in coyote density resulting in an increase in fawn survival. Similar results have been found in Oregon (Einarsen 1948 , Willis 1988) Utah (Udy 1953), Montana (O'Gara and Malcolm 1988), Texas (Canon 1993), and Nebraska (Menzell 1992). From a critical review of the literature, O'Gara and Shaw (2005) concluded that reducing coyote density will increase fawn survival, but the effect may be very temporary and coyote control costly to continue. Given the amount of evidence that coyote density can influence FDR, we feel that low coyote density, small pronghorn populations, and/or study design errors may have masked the effect CAIs had on FDR.

Fawn Cover.— We found 2 significant, but weak correlations (r^2 = 0.2 and 0.17) with forbs from 21-30 cm and 31-40 cm, respectively. Barrett (1984) and Ticer (1998) found that fawns selected areas of higher forb diversity than random sites. However, because correlations between all vegetation classes and those height intervals were low (r^2 = 0.04 and 0.03), we suspect this may be indicative of better diet quality affecting fawn survival, even though we recorded decadent vegetation. Because the presence of forbs responsible for the significant correlation were also included under the combined classes category, we cannot see how these values reflect a response to cover. Forbs could not provide cover other species could not.

Since pronghorn survivability is thought to be dependent on the selection of adequate cover around the bed site to provide protection from predators (Autenrieth 1982, 1984; Beale 1973; Bromley 1978; Neff and Woolsey 1979; Barrett 1981) we expected greater correlation with FDR. Our hypothesis was higher FDR in areas with high cover from vegetation heights 10-40 cm, such as we found in southern Arizona. The highest correlation in multivariate analysis was 0->40cm (r^2 = 0.24), but was not significant (P = 0.5) and revealed little. Deleting the 0-10 cm category from the analysis dropped all r^2 values to 0.18 ($P<0.07$). Thus, we may have underestimated the importance of lower vegetation cover. Ticer (1998) found that fawns selected areas with grass >15 cm, but shrubs <15 cm in our central Arizona sites when fawn survival was consistently one of the highest in the state.

There was a difference in vegetation at 0-10 cm when we compared areas with a FDR ratio < 0.15 ($\bar{x}$ = 40.5 %) versus >0.25 ($\bar{x}$ = 63.2%), but all other height classes were essentially equal. A distribution of vegetation heights of > 6% at 11-20 cm, > 0.5 % at 21-30 cm, and > 0% at 31-40 cm appear adequate for fawn survival to be > 25%.

Previous research indicates that fawns also select bed sites where they might be better able to see predators (Barrett 1984, Ticer and Miller 1994, Canon and Bryant 1997, Ticer 1998) and not necessarily taller vegetation. Bodie (1978) found a negative correlation between fawn survival and shrub cover, believing taller shrubs (>76 cm) provided hiding cover for predators, and that fawn survival was higher in areas where shrub height averaged 20-25 cm. Both Rothchild et al. (1994) and O'Gara et al. (1986) felt that the amount of movement by fawns had more affect on their survival than the ability to conceal themselves in the local habitat. In central Arizona, Ticer (1998) found that fawns selected grass and forbs averaging 15 cm in height. Pronghorn fawns also selected topographic features which helped with visibility and concealment such as slopes on hillsides (Rothchild et al. 1994, Ticer and Miller 1994, Canon and Bryant 1997, Ticer 1998), rocks (Tucker and Garner 1983, Canon and Bryant 1997), and small depressions (Autenrieth 1982, 1984; Barrett 1981).

We did not measure fawn bed sites, rather we estimated the availability of adequate fawn cover by measuring vegetation and examined correlations between these measures and FDR. Our line intercept method may not have been sensitive enough to distinguish small patches of cover such as Barrett (1984) found were selected, especially in short grass situations. Also, our hypothesis of 10-40 cm being optimal may have been an overestimate. Ticer (1998) found 15 cm was adequate in our central Arizona sites for a FDR of 62:100. A bedded fawn in a prone position would be approximately 10 cm tall at the head, and vegetation of 15 cm of height would be sufficient enough to provide camouflage (Ticer 1998). This height would also allow fawns visibility, particularly with non bunch grass species or single stem forbs common in our central and northern Arizona grasslands. Measurements at 5 cm heights may have been more revealing than 10 cm intervals.

We tried to determine if fawn cover was more important at high CAIs, such as southern Arizona, but we found no significant correlations with height interval. We also tied to determine if fawn cover was not as important when CAIs were low, but again there were no significant correlations.

Our data indicate that FDR is not related to fawn cover at the height intervals we measured. However, given evidence on the importance of fawn survival, it is difficult to understand how a neonate behavior to bed in areas of higher cover than randomly available would be selected for, without having some survival advantage.

Tree density.— We did not find a relationship between tree density and FDR in areas rated as moderate to good habitat (Ockenfels et al. 1996). However, the definition of moderate to good habitat restricted the number of trees we could count to <20% cover. This prevented us from directly measuring the relationship between the number of trees and FDR. It was interesting to note that GMU 8 in north central Arizona had the highest number of trees and shrubs (>27 trees and 8 shrubs/ha), and also had the highest mean survivorship of any study site. The number of trees may have more impact on adult predation by species such as mountain lions (*Puma concolor;* Ockenfels 1994), which could actually increase the FDR.

Precipitation.— The correlation we found with winter precipitation further documents the relationship between pronghorn productivity, and winter rainfall at landscape levels in Arizona. Hosack et al. (2002) hypothesized an extended period of below-average rainfall in southwestern Arizona might explain low juvenile recruitment into a pronghorn population. Brown et al. (2002) suggested pronghorn juvenile survival rates were positively correlated with winter rainfall in some locations, but effects of other limiting factors may be more important in some areas. McKinney et al. (*In Press*) found winter precipitation was a major factor affecting total pronghorn, number of adults, production, and productivity, although these variables were independent of winter precipitation in some locations. Rainfall during winter strongly influences production of forbs the following spring, as well as production, productivity, and recruitment of other large desert herbivores (Beatley 1974, Smith and LeCount 1979, Brown 1984, McKinney et al. 2001). Forbs generally provide a major food source for pronghorn (Stephenson et al. 1985, Lee et al. 1998), and rainfall, diet quality, and production of forbs may be key factors affecting juvenile pronghorn survival (Schwartz et al. 1977, Stephenson et al. 1985, Brown et al 2002, Hosack et al. 2002).

Our results are consistent with a hypothesis that winter precipitation is a critical limiting factor affecting pronghorn populations in Arizona, but suggest additional limiting factors likely play an important role in pronghorn population dynamics. We also advise caution in the interpretation of these results, as sources of precipitation were as far as 130 km from the study site.

MANAGEMENT IMPLICATIONS

There appears to be a threshold value of precipitation near 10 to 12.5 cm. When winter precipitation was >12.5 cm, there was no longer a correlation between precipitation and FDR, but all ratios were >25%. The predictive value of this threshold would seem to indicate there is little wildlife managers can do, unless winter precipitation is >10 cm. If a consistent long-term threshold relationship is established, it could serve as an important "alarm" for needed investigations and management action when fawn survival is low when rainfall would seem sufficient. We suggest longer term monitoring with more sensitive methods to determine coyote density and more discriminatory vegetation heights to determine their possible effects on fawn survival.

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Environmental Conditions as a Precursor of Pronghorn Horn Size throughout their Life

DAVID E. BROWN, *Arizona State University, School of Life Sciences, P O Box 874501, Tempe, AZ 85287 USA debrown@imap3.asu.edu*

ABSTRACT Previous studies on the Armendariz Ranch in southwestern New Mexico have shown that variations in pronghorn (*Antilocapra Americana*) horn size, as measured by "green" Boone and Crockett scores, are related to the animal's age and environmental conditions prior to and during horn growth. These conditions include both winter temperature minima and forage growth as measured by either the previous summer's precipitation or July Palmer Drought Severity Indices. Genetics and environmental conditions at the time of the buck's birth also appear to play a role in horn size as mean annual BC scores is significantly correlated with the May Palmer Drought Severity Index during the male's natal year ($r^2 = 0.42$; $P<0.02$).

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KEY WORDS pronghorn age, horn size, environmental conditions, Boone and Crockett scores, winter temperature, forage growth

Arizona has long been famous for trophy-sized pronghorn (Allen 1877, Einarsen 1948, Seton 1953, Hoffmeister 1984, Brown et al. 2006). The conventional explanation for this phenomenon was that pronghorn lived longer in Arizona due to the state's mild winters (O'Connor 1961), a conclusion shown to be faulty when studies in Montana showed that the longest horns and greatest Boone and Crockett (BC) scores were from animals 2 to 4 years old (Mitchell and Maher 2001, 2004). Moreover, a study on Ted Turner's Armendariz Ranch in southern New Mexico (Brown et al. 2002), showed that the horns of bucks >7 years old had significantly smaller BC scores than those of younger animals ($P < 0.03$). Considering the effects of pronghorn age alone, the horn sheaths of hunted animals on this ranch decreased by an average of 0.28 cm (0.11 in) of length and 0.53 BC points for every year of age.

Because pronghorn are unique in having horn sheaths that grow mostly during the winter months (O'Gara 2004), and because southern states produce a disproportionate number of trophy animals compared to northern states and provinces, I reasoned that winter temperatures might influence horn size. Indeed, a comparison of mean January temperatures close to each state and province's pronghorn population center showed a significant relationship with the number of pronghorn trophies per 1,000 bucks harvested according to BC and Safari Club International record books ($r^2 = 0.35$; $P < 0.01$; Brown and Mitchell 2005).

Picard et al. (1994) suggested an explanation for this phenomenon when they concluded that horns were a major source of heat loss when growing. To further test the assumption that pronghorn horn growth was negatively influenced by low winter temperatures, I compared winter temperature data with mean annual BC scores of pronghorn harvested on the Armendariz Ranch in southern New Mexico. Although the annual variation in horn size on the Armendariz Ranch was not very large, the mean "green" BC scores for all pronghorn age classes negatively correlated with the numbers of days having temperatures ≤0º C during the previous winter ($r^2 = 0.33$; $P < 0.06$).

Other environmental factors also appeared to be involved. Although winter precipitation amounts had no significantly positive effect on horn growth, adding April through August rainfall amounts received prior to the winter horn sheath growing season significantly improved the fit of the correlation in a multiple regression equation ($r^2 = 0.64$; $P < 0.02$; Brown and Mitchell 2005). Further comparison showed that there was also a significant relationship ($r^2 = 0.63$; $P<0.02$) between the July Palmer Drought Severity Index (PDSI) for southwestern New Mexico and pronghorn horn size on the Armendariz Ranch the following year (Brown and Mitchell 2005). The PDSI is a regional monthly water balance index that considers both local precipitation and temperature data to determine relative dryness, and thus plant growth and forage conditions. An index value of 0 is considered normal, a –2 is a moderate drought, –3 a severe drought, and –4 an extreme drought (Palmer 1965). Comparisons with winter temperatures and July PDSI values for Flagstaff, Arizona also showed a significant relationship when compared with the number of trophy pronghorn per 1,000 animals annually harvested in Arizona (Brown et al. 2006). I therefore concluded that pronghorn horn growth not only varied with location but by year, and that the amount of this variation was determined in part by environmental factors, i.e., winter temperatures and moisture conditions prior to horn growth. But one question remained. Because all of the pronghorn harvested on the Armendariz Ranch are aged, I attempted to determine if the conditions that prevailed during the year a buck was born would influence horn growth in later life.

STUDY AREA

Data were obtained from the privately owned Armendariz Ranch, a former land grant that is now managed by Turner Enterprises, Inc. Pronghorn habitat elevations range from 1,375 to 1,525 m, and the mean annual precipitation is <250 mm. Approximately 105,220 ha of the ranch are classified as pronghorn habitat, in which the primary vegetation is semi-desert grassland characterized by such grasses and shrubs as black grama (*Bouteloua eriopoda*), palmilla (*Yucca elata*), and Mexican tea (*Ephedra torreyana*). The latter species, along with mesquite (*Prosopis torreyana*), sand sage (*Artemisia filiforma*), and cacti represent the only significant browse plants in pronghorn habitat. Most of the ranch's remaining vegetation is Chihuahuan desertscrub where the climate is warm-temperate with an average of 213 frost-free days per year (Truth or Consequences, New Mexico).

Bison are the only livestock; other large herbivores are restricted to an increasing number of gemsbok (*Oryx gazella)* and small populations of mule deer (*Odocoileus hemionus*) and desert bighorn sheep (*Ovis canadensis*). The pronghorn population is subject to climate-induced variations but was estimated to number between 800 to 1,000 animals after winter surveys were conducted in 2000. Limited archery hunting for buck pronghorn is permitted in late August and a rifle hunt is conducted in September.

Relatively few permits are issued each year and the pronghorn harvest never exceeds 10% of the available bucks. Most wildfires are allowed to burn and no prescribed coyote control is conducted.

METHODS

An important assumption of my comparisons was that hunters generally select the largest male pronghorn available. Annual harvests are limited to between 10 and 25 males, and hunters are encouraged to take the largest animal they and their outfitters can find. Each animal harvested is checked, weighed, and measured before leaving the ranch, and ranch personnel measure the animal's horns according to the scoring procedures described by BC. Two incisors are extracted from each animal and sent to Marston's Laboratory in Montana for sectioning and ageing. Only those animals providing a readable age in years were included in the analysis.

I obtained PDSI information for southwestern New Mexico from the Western Regional Climate Data Center (2005), an internet site sponsored by the National Oceanic and Atmospheric Administration. The May index was selected as the month most closely approximating conditions present at the time of the animal's birth. Comparisons were made between each year's May PDSI and the mean BC score and horn lengths of the animals born that year. Similar comparisons were made between the October PDSI and the mean scores and horn lengths of yearlings to test whether conditions during the first year of significant horn growth continued throughout the animal's life.

RESULTS

The mean horn lengths and BC scores of the bucks harvested are arranged according to the May PDSI of their birth year and the October PDSI of their yearling year in Table 1. Although annual variations in horn size were small, and there were no significant relationships between the PDSI values and horn length, there was a significant correlation between May PDSI values and BC scores ($r^2 = 0.42$; $P < 0.02$; Fig. 1).

DISCUSSION

I interpret my results as indicating that bucks born in years having good moisture conditions have a propensity for larger horn mass throughout life. Pronghorn horn size, and horn mass, is therefore dependent not only on the male's age, environmental conditions preceding and during horn growth, and genetic propensity, but also on the conditions present at the time of its natality.

Table 1. Mean pronghorn horn lengths and scores arranged according to birth year.

Year of Birth	*n*	May PDSI (birth year)	Mean horn length	Mean BC Score
2002	5	-2.99	15.63	74.125
2001	12	0.27	14.49	74.4
2000	14	-3.69	14.97	75.78
1999	11	-2.37	14.31	72.03
1998	11	-0.25	14.54	76.01
1997	23	1.03	15.41	77.75
1996	13	-3.49	14.84	76.92
1995	17	2.89	15.6	77.26
1994	8	-1.37	14.83	75.06
1993	8	7.47	15.52	80.48
1992	11	11.35	14.95	78.02
1991	16	3.38	14.92	75.27
1990	11	-1.7	14.85	75.16

Abbreviations: PDSI = Palmer drought severity index; BC = Boone & Crockett (see text).

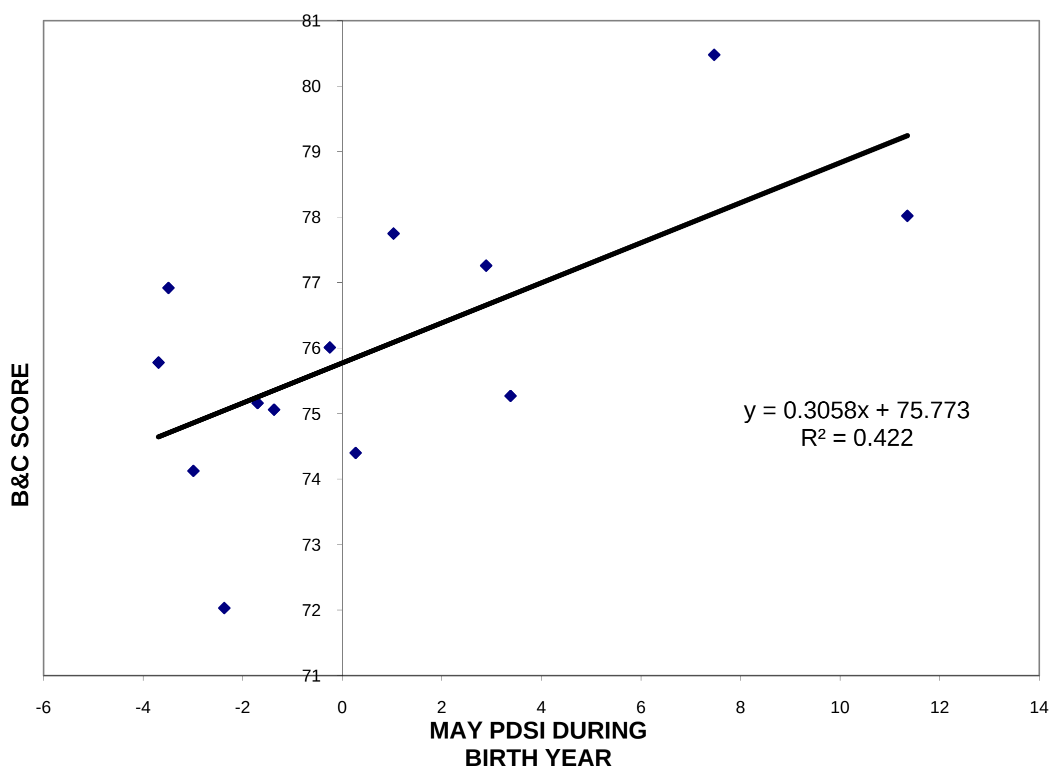

Figure 1. Mean pronghorn Boone and Crockett (B&C) scores vs. May Palmer drought severity index (PDSI) at birth year.

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Comparison Between Pronghorn Age and Horn Size in Southern Alberta

KIM MORTON, *Alberta Sustainable Resource Development – Fish & Wildlife Division, 530-8th S. S., Lethbridge, Alberta, Canada T1J 2J8 Kim.Morton@gov.ab.ca*

PAUL F. JONES, *Alberta Conservation Association, 530-8th S. S., Lethbridge, AB T1J 2J8, Canada*

MIKE GRUE, *Alberta Conservation Association, 530-8th S.S., Lethbridge, AB T1J 2J8, Canada*

ABSTRACT: In Alberta, pronghorn antelope (*Antilocapra americana*) provide one of the most sought after trophy hunts (approx 17,000 applicants annually), with one of the lowest draw applicant success rates (3.6%). In 2004, concerns were raised that the current management regime of maximum sustained yield was resulting in fewer animals in older age classes, which could mean fewer 'large' bucks. During antelope hunting seasons from 2005 through 2007, staff collected incisors (I-1) and horn measurements (Boone & Crockett scores) from over 300 pronghorn harvested by recreational hunters. The mean age of pronghorn harvested was 3.01 years, with 70% of animals being 2 or 3 years of age. Analysis of the data indicates that while the mean B&C score peaked for animals 4 and 5 years old, there was no positive correlation between age and trophy quality after pronghorn had reached 3 years of age. Under Alberta's current allocation system, trophy quality animals are still available while providing opportunity for 'large' pronghorn buck harvest.

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KEY WORDS: *Antilocapra americana*, pronghorn, age, horn size, hunting, Alberta

In 1958, limited entry draws were introduced by the Alberta government to protect pronghorn from overharvest. Limited entry draws for both archery and rifle seasons for trophy (>5 inch horn) and non-trophy pronghorn still exist today based on a maximum sustainable yield (MSY) harvest model (Fish & Wildlife 1990). The model allows for high harvest levels, maximizing recreational opportunity for resident and non-resident hunters. Harvest levels calculated under the MSY model are expected to, over time, lower the average age of harvested bucks and crop off older age classes within the population (Figure 1). The effect on harvest quality was not understood at the time when the MSY model was adopted in Alberta.

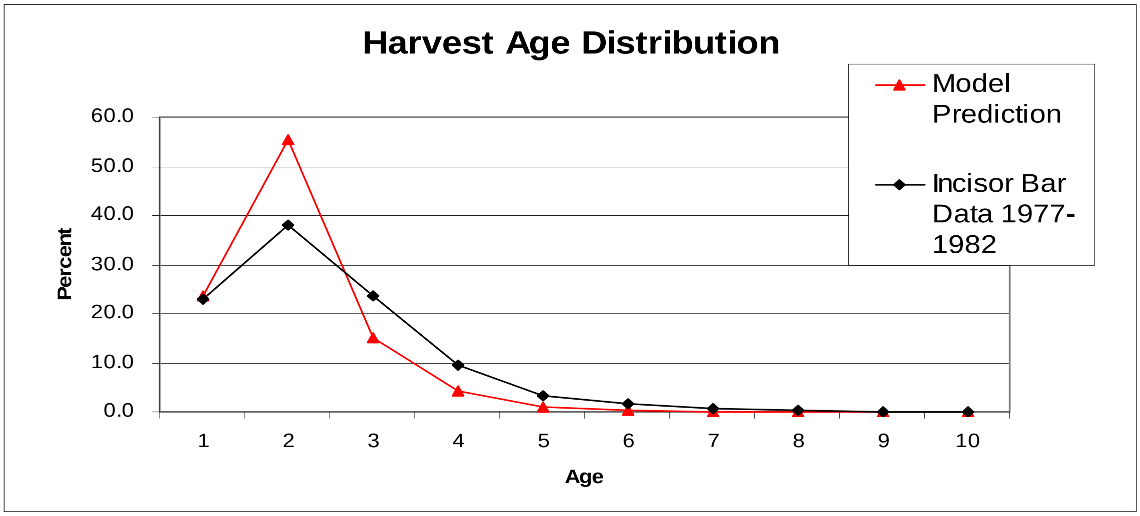

Figure 1. Predicted population age distribution under MSY harvest model for pronghorn antelope in Alberta

Understanding the relationship between age and horn characteristics would allow Alberta pronghorn managers to evaluate the impacts that harvest levels under the MSY model may have on male pronghorn antelope age, distribution and trophy quality. It would also allow pronghorn managers to address stakeholder concerns related to trophy pronghorn availability. In 2003, following a hunting season with relatively high harvest rates, members of the guide/outfitter community in Alberta communicated concerns that there were no older bucks left and therefore no 'large' bucks. At the time, both Montana and New Mexico were conducting work on horn size relative to animal age suggesting that after two years of age, there is no correlation between age and Boone & Crockett score (Mitchell and Maher 2001, Brown et al. 2002). These results and stakeholder concerns led Alberta Sustainable Resource Development (ASRD) and the Alberta Conservation Association (ACA) to initiate a project to look at the relationship between the age of harvested bucks and the trophy quality of those animals.

The objectives of this paper are to determine if there was a yearly difference in age and horn characteristics for bucks harvested between 2005 and 2007, if there were differences in age and horn characteristics of bucks harvested in the north versus the south portions of the study area, and finally, if there exists a general relationship between age and horn characteristics. We collected harvest information on horn characteristics and collected incisors for aging of harvested animals taken in Alberta between 2005 and 2007 through the use of hunter check stations.

STUDY AREA

Southeast Alberta is hot and dry and is comprised of brown and dark brown chernozemic soils (AAFRD 2005). Alberta's pronghorn population is distributed across the southeast part of the province (Figure 2). Within pronghorn range, irrigated and dry land farming is primarily in the northern and western portions, with some dry land farming scattered throughout. Native short grass prairie, used for cattle grazing, is the predominant landscape in the southeast portion of pronghorn range, but is found in small patches throughout pronghorn range.

Pronghorn range in Alberta is divided up into 9 areas, based on Wildlife Management Unit (WMU) borders. There are 8 provincial Antelope Management Areas (AMA's) plus the lands of Canadian Forces Base Suffield (Department of National Defence). Figure 2 outlines the 8 AMA's (A –H) in relation to each other. For our study, AMA's G, D and C were the focus for data collection (though some hunters from other AMA's did attend voluntary check stations to participate in the program). These AMA's offered good central locations for hunter check stations and had relatively high numbers of permits available. This allowed us to maximize use of manpower and resources during the short pronghorn hunting season (6 days).

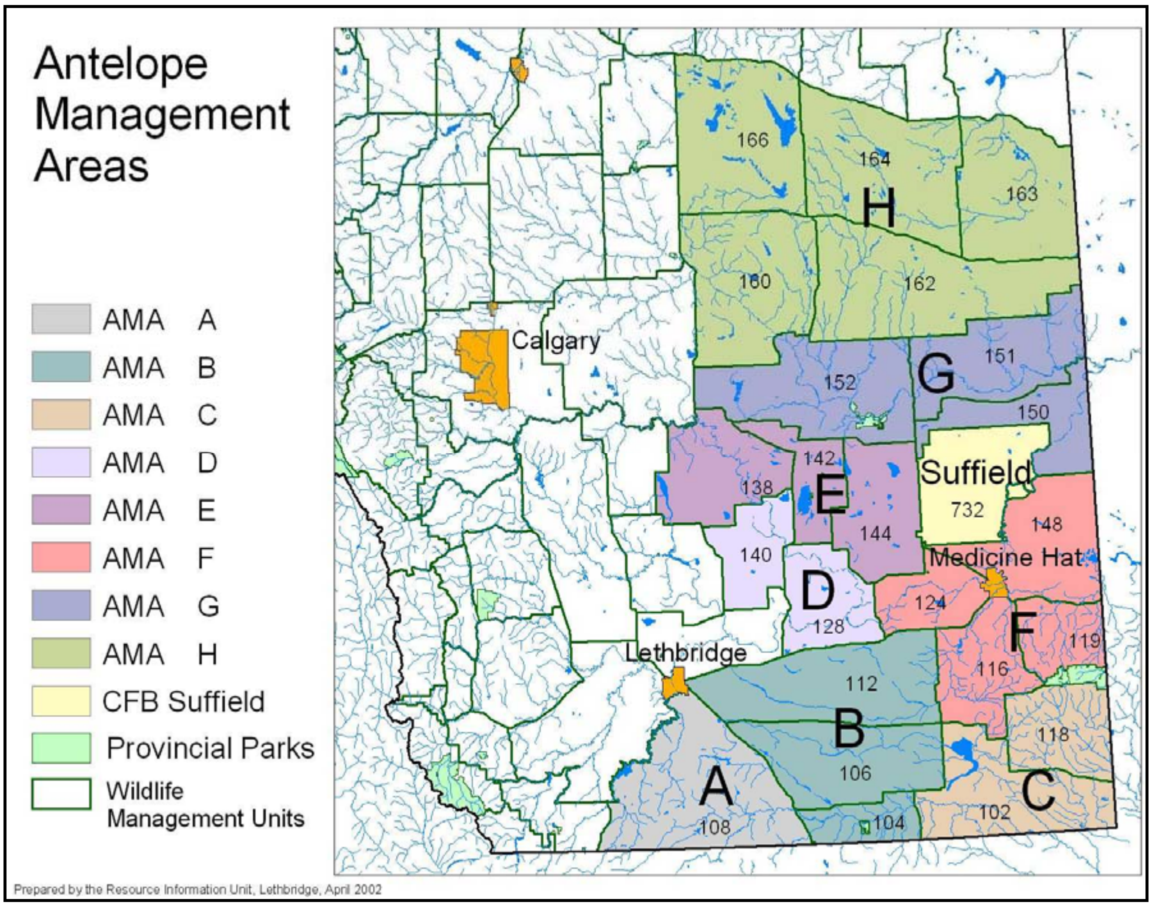

Figure 2. Southern Alberta antelope Management areas.

METHODS

Prior to the hunting season, all successful applicants for trophy pronghorn in targeted AMA's were mailed a letter outlining the intent to collect data on harvested animals and requesting voluntary cooperation from hunters. Check station locations were identified as well as times of operation. Hunters were encouraged to visit a check station with any pronghorn harvested. Field crews were equipped with data sheets, maps of the AMA, pliers and screwdrivers for tooth extraction and measuring tapes for horn measurements. Hunters coming to check stations or stopped out in the field were introduced to the project and then asked if they would be willing to participate. Any animal harvested by a hunter willing to participate was measured and had both first incisors (I-1) extracted for aging.

Horn Measurements and Aging

We used the Boone & Crockett (B&C) score sheet to collect horn measurement data (Appendix 1). The method is recognizable by hunters, is easy to do in the field and allowed us to provide hunters with a green B&C score of their animal. We trained staff on measurements using mounted heads in the Lethbridge office prior to setting up check stations. We collected hunter information (name, Wildlife Identification Number, area harvested).

SRD Senior Wildlife Technician Leo Dube measures a Pronghorn at the check station as the hunter watches.

For most cloven-hoofed mammals, the I-1 is the preferred tooth to be collected for cementum age analysis (Matson's 2004). Dental elevators, screwdrivers and pliers were used to extract teeth from harvested animals. The screwdriver was pushed into the gum all around both I-1's, separating teeth from surrounding tissue. The teeth were then loosened and extracted with pliers. Once extracted, teeth were cleaned of excess bone and tissue and placed inside a small envelope attached to the B&C score sheet. At the time of tooth extraction, an age estimate was recorded, based on permanent tooth eruption (Giles 1969). When hunting season was over, all teeth collected were separated, cleaned and given a unique sample number, and were packaged and shipped to Matson's Laboratories for aging.

Statistics

We compared the means for age, Boone and Crockett score, horn length, horn base and symmetry from data derived from the B&C score sheet. We used the B&C score as a measure of trophy quality. The horn length and base were calculated as the mean of the left and right horn measurements. The B&C score sheet contains a column reflecting the difference between the left and right horn for each measurement. We used the sum of these differences as a metric of horn symmetry. We first grouped the data across all AMA's by year to determine if data could be pooled. A Kruskal-Wallis test was used to determine significant differences among the three years. If a significant difference was detected we used a post-hoc Mann-Whitney U-test to determine which years were significantly different from each other. We used the Mann-Whitney test to determine if differences between mean age and horn characteristics were significant for male pronghorn harvested in the northern AMA (AMA G) and the southern AMA's (AMA's D and C separately). Lastly, we used linear regression to examine whether there was a relationship between age and B&C score. We used SPSS® to complete all analysis except the regression which was performed using Microsoft Excel®.

RESULTS

We collected and analyzed data from over 300 male pronghorn harvested in Alberta between 2005 and 2007 (Table 1). Boone & Crockett scores calculated from harvested trophy pronghorn ranged from 46 to 85, with animals ranging in age from 1 to 10 years of age. Bucks harvested at 4 years of age had the highest average horn size, but bucks from 2 years to 5 years of age were represented in the top 10 B&C scores of animals measured (Table 2).

Table 1. Summary of number of harvested trophy pronghorn in Alberta measured by AMA and Year.

	YEAR			
AMA	**2005**	**2006**	**2007**	**Total**
A	1	1		2
B		7	5	12
C	1	53	59	113
D	20	2		22
E		1		1
F	6	7		13
G	50	55	50	155
H	1	1	1	3
Total	79	127	115	321

Results in Table 3 showed the 2005 data were significantly different from both 2006 and 2007 data, except for symmetry which was only different between 2005 and 2006. Data from 2006 and 2007 were similar and pooled for further analysis. Horn and age characteristics of pronghorn harvested in northern and southern AMA's were then compared to determine any geographical effects. Between AMA D and G horn base and age were the only variables significantly different (Table 4) while for AMA C and G the only significantly different variable was symmetry (Table 5). The relationship between age and B&C score was not linear but in fact was non-linear, with score increasing with age until 4 years and then declining for older bucks (Figure 3). It should be noted that sample sizes were small for harvested bucks 5 years and older.

Table 2. Top ten Boone & Crockett scores recorded for male pronghorn harvested in Alberta between 2005 and 2007.

Number	Year Harvested	AMA Harvested In	AGE	SCORE
1	2007	G	5	85
2	2006	H	3	83 2/8
3	2007	G	4	80 4/8
4	2005	G	4	80 4/8
5	2006	G	3	79 4/8
6	2007	G	4	79 2/8
7	2006	D	3	79 2/8
8	2005	G	2	78 4/8
9	2007	H	5	77 6/8
10	2006	C	3	77 4/8

Table 3. Differences between the age and horn characteristics of male pronghorn harvested in Alberta between 2005 and 2007.

Variable	2005 (n=79)	2006 (n=127)	2007 (n=115)	Significance
Age	2.77 ± 0.13^{a}	3.07 ± 0.11^{b}	3.09 ± 0.11^{b}	0.026
Score	64.91 ± 0.72^{a}	69.28 ± 0.52^{b}	67.98 ± 0.60^{b}	<0.001
X_Length	12.25 ± 0.17^{a}	13.14 ± 0.14^{b}	13.09 ± 0.16^{b}	<0.001
X_Base	5.64 ± 0.05^{a}	5.80 ± 0.04^{b}	5.74 ± 0.04^{b}	0.011
Symmetry	1.22 ± 0.06^{a}	1.02 ± 0.06^{b}	$1.13 \pm 0.06^{a\,b}$	0.012

[a,b] Means with different letter are significantly different

Table 4. Differences between the age and horn characteristics of male pronghorn harvested in Alberta in 2005 between AMA D and AMA G.

Variable	AMA D (n=22)	AMA G (n=50)	Significance
Score	66.36 ± 1.39	63.68 ± 0.94	0.046
X_Base	5.80 ± 0.09	5.56 ± 0.06	0.008
Age	2.86 ± 0.25	2.60 ± 0.16	0.253
X_Length	12.24 ± 0.38	12.07 ± 0.22	0.582
Symmetry	1.13 ± 0.08	1.17 ± 0.08	0.946

Table 5. Differences between the age and horn characteristics of male pronghorn harvested in Alberta in 2006 and 2007 between AMA C and AMA G?

Variable	AMA C (n=111)	AMA G (n=105)	Significance
Symmetry	1.22 ± 0.07	0.93 ± 0.05	0.001
X_Length	12.95 ± 0.17	13.21 ± 0.13	0.755
X_Base	5.76 ± 0.04	5.76 ± 0.04	0.994
Age	3.06 ± 0.12	3.10 ± 0.12	0.976
Score	68.09 ± 0.60	68.74 ± 0.55	0.972

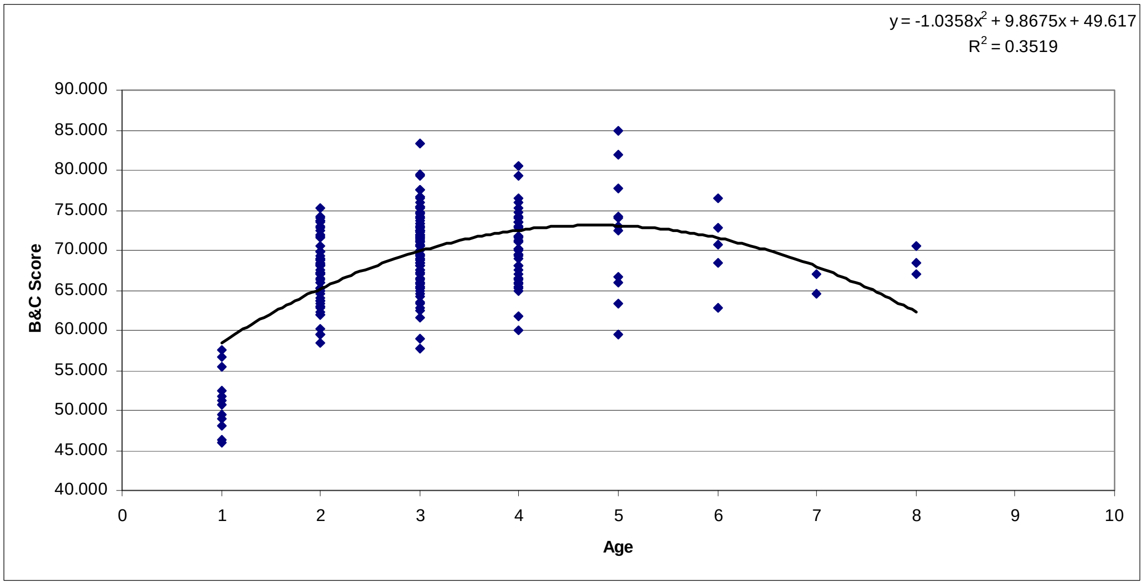

Figure 3. Relationship between age and Boone and Crockett score for pronghorn harvested in Alberta between 2006 and 2007.

DISCUSSION

We addressed stakeholder concerns that few "trophy" antelope were left in Alberta as a consequence of the management system by looking at the age and horn characteristics of male pronghorn harvested between 2005 and 2007. As in other jurisdictions, it appears older does not mean bigger for pronghorn bucks harvested in Alberta. Significant differences in mean age and mean B&C score in 2005 compared to 2006 and 2007 are a result of very high harvest rates on male and female pronghorn for 3 to 5 years prior to the 2005 season. Similar results for 2006 and 2007 indicate that lower harvest levels in the 2005 season resulted in an increase in the mean age and mean B&C score. In Alberta, there are 3 to 5 year old bucks still present on the landscape providing quality trophy harvest opportunities.

We found that once an adult male reaches 2 years of age, it has the ability to provide a high quality trophy, with the highest B&C scores observed in animals 3 to 5 years old. This is consistent with findings in other jurisdictions in the United States. Both Mitchell and Maher (2001) and Brown et al. (2002) found that harvested pronghorn attained the highest mean B&C scores between the ages of 2 to 6. From data on pronghorn harvested between 2005 and 2007 in Alberta, the top ten trophy animals include bucks from 2-5 years in age.

One might hypothesize that if high harvest rates removed all of the large bucks, genetic selection would result in decreasing B&C scores over time. There does not appear to be a decrease in trophy quality in Alberta pronghorn based on 2005-2007 harvest data. For example, three of the top 4 trophy bucks listed in the Alberta Pronghorn Antelope Top 10 (APOS 2007) were harvested in the last seven years. A more important factor in determining trophy quality of a pronghorn throughout its life may be forage quality and availability during the first year of horn sheath development (Brown and Edwards 2008).

Continued data collection on harvested pronghorn in Alberta will allow us to investigate the importance of forage quality and availability on trophy quality.

The question still remains whether older bucks have smaller horn size because they are continually passed over by hunters? Brown et al. (2002) discuss the possibility of harvest selection focused on large bucks being a factor in explaining the lower scores of older (>7 years) pronghorn males. Collecting horn measurements over multiple years on the same animal would address this issue. However, this would be difficult to conduct in a population receiving high harvest pressure and no way to ensure year-to-year survival of study animals.

MANAGEMENT IMPLICATIONS

Trophy pronghorn are defined in the Alberta Hunting Regulations as a "male pronghorn antelope that has a horn at least 12.6 cm (5 in.) in length" (ASRD 2008). Trophy quality, as defined by the individual hunter is more subjective. Pronghorn managers try to balance the desire for 'trophy' opportunities with the high demand for recreational opportunity. Current pronghorn management in Alberta is focused on maintaining a provincial population goal, while at the same time, allowing for recreational harvest. This has led to restrictions on both trophy and non-trophy harvest of pronghorn. As a result, the age class distribution of harvested trophy pronghorn has not reflected the predicted increase in younger age classes being over represented in annual harvest and the loss of some of the older age classes based on the MSY model (Figure 4). Current harvest levels have allowed for older age classes to be represented in the population while maintaining recreational opportunities and trophy quality. Continuing the collection of data will allow Alberta pronghorn managers to better understand the impacts of mortality factors (i.e. severe winter events, exceedingly high harvest or low recruitment) on the age distribution within the provincial population. Additional data collection will also strengthen conclusions regarding the relationship between age and B&C score, particularly as it relates to older age classes (>5years).

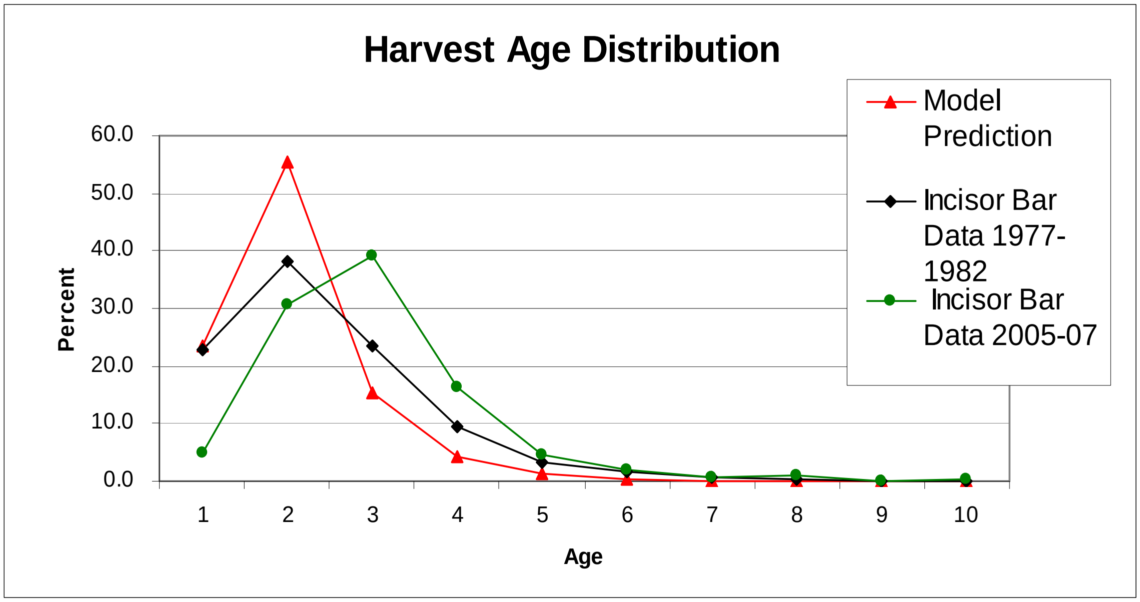

Figure 4. Age distribution of pronghorn bucks harvested from 2005-07 Compared to bucks harvested from 1977-82 and to MSY model predictions.

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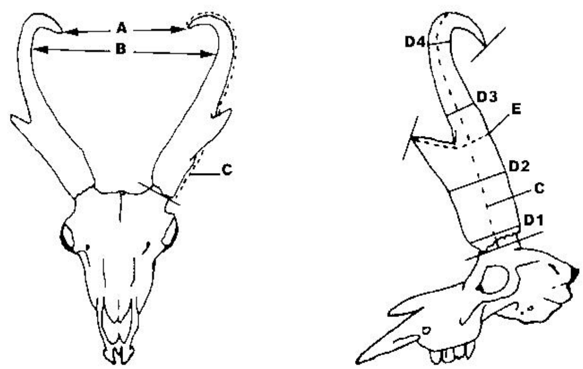
APPENDIX I

BOONE AND CROCKETT CLUB®

OFFICIAL SCORING SYSTEM FOR NORTH AMERICAN BIG GAME TROPHIES

MINIMUM SCORES	
AWARDS	ALL-TIME
80	82

PRONGHORN



SEE OTHER SIDE FOR INSTRUCTIONS	COLUMN 1	COLUMN 2	COLUMN 3
A. Tip to Tip Spread	Right Horn	Left Horn	Difference
B. Inside Spread of Main Beams			
C. Length of Horn			
D-1. Circumference of Base			
D-2. Circumference at First Quarter			
D-3. Circumference at Second Quarter			
D-4. Circumference at Third Quarter			
E. Length of Prong			
TOTALS			

ADD	Column 1		Exact Locality Where Killed:
	Column 2		Date Killed: Hunter:
	Subtotal		Owner: Telephone #:
SUBTRACT Column 3			Owner's Address:
FINAL SCORE			Guide's Name and Address:
			Remarks: (Mention Any Abnormalities or Unique Qualities)

Official Boone & Crockett Pronghorn Score Sheet.

Pronghorn (*Antilocapra americana*) Food Habits on a Semidesert Grassland Range in Arizona

DAVID E. BROWN, *School of Life Sciences, Arizona State University, P.O. Box 874501, Tempe, AZ 85287, USA debrown@imap3.asu.edu*

DANA WARNECKE, *Arizona Game and Fish Department, Region VI, 7200 E. University, Mesa, AZ 85207, USA*

ALBERT SILLAS, *Prescott National Forest, Verde Ranger District, PO Box 670, Camp Verde, AZ 86322, USA*

DEBORRAH SMITH, *Cascabel Range Consultants, 4963 N. Cascabel Road, Benson, AZ 85602, USA*

ABSTRACT We conducted a microhistological analysis of pronghorn (*Antilocapra americana*) pellets in a semidesert grassland region east of Cordes Junction, Arizona. Monthly diet comparisons over a two-year interval encompassed both a drought and a wet period. Forbs comprised the most important dietary items with two perennial species, *Eriogonum wrightii* and a species of *Artemisia* being present every month. Seasonal forbs varied from 21 to 66% of the diet depending on season and drought conditions, these plants being least common in mid-winter. Woody browse plants never compromised more than a third of the diet, and were most often taken during the fall and winter months. Grasses comprised a small portion of the diet and were largely limited to spring and early summer. Cacti were taken during the summer drought of 2003 and during the fall and winter months when *Opuntia* fruits were common. Changes in the percentage of forbs taken between drought and wet years were not especially great, and it appeared that pronghorn changed pastures rather than diet when desirable foods became scarce.

Proceedings Pronghorn Workshop 23: 000-000

KEY WORDS Agua Fria National Monument, *Antilocapra americana*, buckwheat, diet, drought, *Eriogonum wrightii*, food habits, livestock competition, nutrition, Prescott National Forest, pronghorn**,** sage, semidesert grassland.

Semidesert grasslands comprise large areas of pronghorn habitat in west Texas, southern New Mexico, southeast Arizona, and northern Mexico (Brown 1994). Pronghorn food habit studies in this biotic community are largely limited to Texas and New Mexico, (e.g., Büechner 1950, Russell 1964, Hailey 1979) with Arizona data limited to observations made by Wallmo (1951) more than a half century ago. Given this lack of information, and an intensive investigation being conducted by Warnecke and Brunner (2006) into the status of pronghorn in a semidesert grassland east of Cordes Junction, we attempted to determine which forage plants were used by pronghorn during different times of the year and under varying circumstances.

STUDY AREA

We conducted our study in Game Management Unit 21 in west-central Arizona (Arizona Game and Fish Department 2006). This area east of Cordes Junction contains an isolated pronghorn population of approximately 150 to 300 animals, ranging in elevations from 1,050 to 1,250 m (Ockenfels et al. 1994, Warnecke and Brunner 2006). Nearly all pronghorn habitat is semidesert grassland with tobosa (*Hilaria mutica*) and thorny legumes such as mesquite (*Prosopis velutina*), catclaw acacia (*Acacia greggi*) and mimosa (*Mimosa biuncifera*) providing important vegetative cover. Precipitation averages ca. 380 mm per annum with a mean of 213 frost-free days (Cordes Junction). Approximately 700 km^2 of the unit is classified as pronghorn habitat (Ockenfels et al., 1994), which is managed by the Bureau of Land Management (Agua Fria National Monument), Prescott National Forest, and Tonto National Forest intermixed with small parcels of state and private land. Nearly all pronghorn habitat is subject to cattle grazing with mule deer *(Odocoileus hemionus*), white-tailed deer (*O. virginianus*), and javelina (*Pecari tajacu*) present in below-average numbers (Arizona Game and Fish Department 2006). Black-tail jack rabbits (*Lepus californicus*) and various rodents also appeared to be present in low numbers, probably because of a drought that characterized the first half of the study period. Brush encroachment is an ongoing problem often causing pronghorn to forage in sub-optimum habitats (Ockenfels et al. 1994).

METHODS

Once each month, from February 2003 through December 2005, we collected samples of >16 individual pronghorn droppings from 6 or more pellet groups from 1 or more pastures containing pronghorn. Various volunteers assisted in these efforts, which were assisted by monthly survey flights conducted by the Arizona Game and Fish Department. During survey flights, pronghorn were classified and their locations recorded through the use of a global positioning system (GPS). Although we initially wanted to alternate samples between the northern and southern portions of the unit, this strategy was modified to target known pronghorn locations given that pronghorn often changed pastures. Although most collections consisted of fresh pellets taken from observed animals, some samples may have been up to 30 days old and more representative of the previous month’s diet.

All of the samples, most of which consisted of >80 pellets, were refrigerated and sent to Cascabel Range Consultants, Benson, Arizona, for microhistological identification (Sparks and Malechek 1968). Monthly diet samples were then arranged by plant species occurrence and percent species composition. Because we were primarily interested in diet selection, we used the percent species composition in our analysis, and tabulated the plant material identified into seasonal forb, perennial forb, browse species, grass, and cacti/succulent categories (Appendix I). Monthly comparisons were precluded for April, May, and June 2004 when the samples were lost, and the sample for September 2004 was combined with one collected in August 2004.

The National Climatic Data Center in Ashville, North Carolina, provided monthly precipitation for Cordes Junction and regional Palmer Drought Severity Indices (PDSI) for west-central Arizona. The monthly PDSI is a water-balance index standardized to local climates, which considers both precipitation and temperature data to determine relative dryness (Palmer 1965). An index value of 0 is considered normal, –2 is a moderate drought, –3 is a severe drought, and –4 is an extreme drought.

RESULTS

A minimum of 41 plants were identified in the pellet samples, comprising >16 species of seasonal forbs, 9 perennial forbs, 7 browse species, 5 grasses, and several succulents. The percentage of each species in each category is shown with that month's PDSI index in Appendix I. The study encompassed a severe drought that began in 2003 with a February PDSI of –3.75 and persisted through August 2004 when the PDSI was –4.88. This period was followed by an exceptionally wet winter during which 59.6 cm of precipitation fell at Cordes Junction between September 2004 and February 2005 resulting in a February 2005 PDSI of 5.75 (Appendix I).

Despite the great variance in drought conditions, dietary percentages followed the typical pattern consisting primarily of forbs followed by shrubs, succulents, and grasses (Yoakum 2004). Seasonally available (soft, mostly annual) forbs composed the largest dietary percentage (41%; Appendix I), comprising from 55 to 67% of the spring (March) diet, with mid-summer percentages being essentially the same during July 2003 and July 2004. Seasonal forb use was lowest in midwinter, comprising only 21% of the diet in December 2003 and 9% in December 2004 (Fig. 1). Seasonal forbs of principal importance when available were borages (*Cryptantha*, *Amsinckia*, *Plagiobothrys* sp., etc.), filaree (*Erodium* spp.), Indian wheat (*Plantago* sp.) and wild alfalfa or medick (*Medicago* sp).

Perennial forbs were taken throughout the study and constituted significant percentages (*ca*. ≥25%) of the diet nearly every month (Appendix I, Fig. 1). Two species were selected in particular, Wright's buckwheat (*Eriogonum wrightii*) and an *Artemisia* (*A. ludoviciana* or *A. dracunculoides*). Another perennial forb that was prevelant when available was globe mallow (*Sphaeralcea* spp.). The percentages of such plants as vetch (*Vicia* sp.), hibiscus (*Hibiscus coulteri*), and green and yellow pea (*Lotus* sp) may have been larger had these plants been more common. Together, seasonal and perennial forbs comprised up to 99 % of the monthly diet, these two categories averaging about 80% of the monthly intake (Fig. 1).

Browse species were taken mostly in mid-winter, although woody plants constituted 13% of the diet in June 2003. Unlike more northern locales (e.g., Yoakum 2004), these plants did not show up as large percentages in this warm temperate study area (Appendix I). An exception was immediately after the drought during the fall and early winter of 2004 when samples contained measurable percentages of *Ephedra viridis*. This plant, which has only been observed in one locality in the study area, has been shown to be an important browse species during drought conditions (Brown and Shaw 2006).

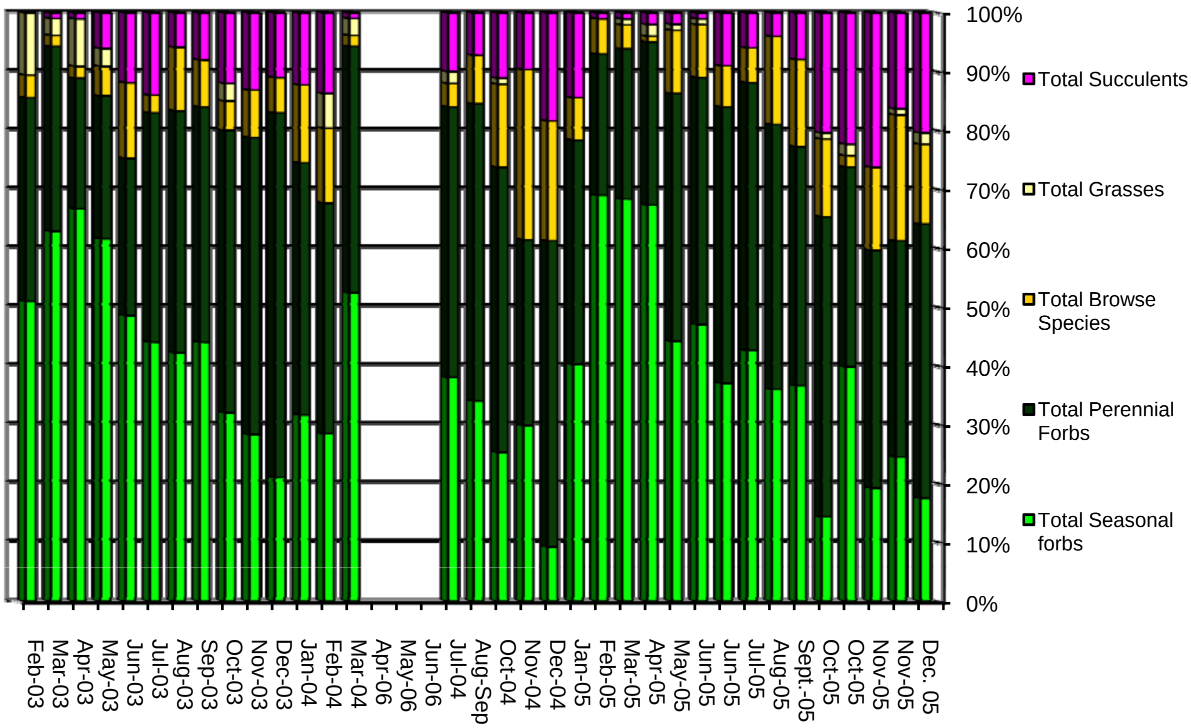


Figure 1. Percent forage type by month.

Grasses were mostly taken in late winter or early spring. This group of plants was infrequent in the diet of pronghorn and rarely comprised > 5% of the monthly total. Grasses appeared to be less frequently taken when seasonal forbs were abundant, and the highest percentages were recorded during the dry Februarys of 2003 and 2004 when 11 and 6% of the respective diets were composed of *Bromus* and *Aristida* spp. (Fig. 1).

Succulents were taken from midsummer through midwinter (Appendix I, Fig. 1) and were represented by both plant stems and fruits, the most common species in the study area being Engelmann prickly-pear (*Opuntia phaeacantha*), clock-face prickly-pear (*O. chlorotica*), and Whipple cholla (*O. whipplei*). Unlike desert pronghorn, which took cacti mostly during dry summers (Arizona Game and Fish Department 1981, Hughes and Smith 1990, Hervert et al. 2000), the highest consumption of succulents in this study was during the fall and winter of 2004 when pricklypear fruits were abundant and cacti comprised >25% of the November diet. By way of contrast, cacti comprised <14 % of the pronghorn's diet during the dry June and July of 2003.

The frequency and percentage of plant use was generally comparable in both the northern and southern portions of the unit in July 2005. Other samples collected in different pastures during the same month varied little with the exception of October 2005 when one pasture (Black Mesa) was noticeably deficient in plant variety despite pronghorn being present there.

DISCUSSION

Nearly 40% of the pronghorn diet was seasonally available forbs and <6 forb species constituted the majority of this plant group used during both dry and wet months. Such a large percentage of such a small variety of seasonal forbs would have been cause for concern if perennial forbs had been lacking. However, the large presence of such perennial species such as *Eriogonum wrightii* and *Artemisia* spp. resulted in forbs comprising >60% of the diet every month. As in most studies, grasses constituted a small part of the annual diet and were largely limited to the winter-spring period (e.g., Büechner 1950, Russell 1964, Hervert et al. 2000, Yoakum 2004).

Diet diversity was nonetheless limited when compared to other food habit studies in the southwest. Although the methodologies are not comparable, the greater variety of food items (160 forbs, 53 browse plants, and 15 grasses) noted by Büechner (1950) in Trans-Pecos Texas, and Russell (1964) in Chaves County, New Mexico (>50 forbs, 12 shrubs, 2 succulents, and 3 grasses), might indicate a lower variety of nutritious vegetation in this unit compared to other semidesert grassland sites. In northern Arizona's Intermountain grasslands, Miller and Drake 2005) found 47 species of food plants in their pellet samples on Garland Prairie, 14 less than the 33 species recorded on Anderson Mesa, which they considered to be in poorer condition for pronghorn. As in our area, diets in Garland Prairie were consistently dominated by forbs (66-83%), followed by shrubs (12-30%), and lastly grasses (1-7%). In contrast, diets on Anderson Mesa were more variable, with forbs declining from 61% of the total to as low as 25% as forage conditions deteriorated (Miller and Drake 2005).

A more informative comparison may be Wallmo's (1951) study in southern Arizona, which found the following species to be important in the diets of pronghorn: *Brickellia* spp., *Artemisia ludoviciana*, *Eriogonum wrighti*i, *Astragulus nothoxys*, *Boerhaavia caribaea*, *Lactuca graminifolia*, with moderate use of *Aster* spp., *Dalea formosa*, *Heterotheca subaxillaris*, *Ipomoea* sp. *Agastache rupestris*, *Lotus greenie*, and *Oenothera* sp. We therefore regard the prolonged use of forbs by pronghorn in Arizona's semidesert grasslands, however limited in variety, to be indicative of food availability rather than food deprivation.

With the exception of some late fall and winter samples collected during the relatively wet years of 2004 and 2005, browse species never comprised more than 15% of the monthly diet and the highest use of woody browse plants during the drought period was 13% during June 2003 (Fig. 1). Although most food habit studies show pronghorn switching to browse plants during winter months when forbs become unavailable (Büechner 1950, Russell 1964, Gay 1984, Hervert et al. 2000, Yoakum 2004, Miller and Drake 2005), several studies in the southwest have shown an increase in the use of browse species during drought periods (Hailey et al. 1966, Howard et al. 1982, Stephenson et al. 1985, Hervert et al. 2000). Beale and Smith (1970) working in western Utah, and Brown and Shaw (2006) studying pronghorn diets in southern New Mexico, also considered palatable browse plants to be important for sustaining pronghorn during drought. Hailey et al. (1966) noted that a pronghorn population in Presidio County, Texas, declined 60% between June 1964 and June 1965 when drought forced malnutritioned animals to feed almost entirely on such poor quality browse plants as tarbush (*Flourensia cernua*), creosote (*Larrea tridentate*), and snakeweed (*Amphiachyris* *dracunculoiedes*). It appears that pronghorn switch to browse plants only when nutritious forbs are unavailable.

The relatively low frequency of use of succulents, particularly during the drought period, was somewhat surprising. Although low in protein, chain-fruit cholla (*Opuntia fulgida*) fruits contain up to 85% water, and Hughes and Smith (1990) found that these plants constituted up to 53% of the diet of pronghorn in the Sonoran Desert during the dry season. Hervert et al. (2000), in their comprehensive study of desert pronghorn, found that this plant was selected for in all seasons with the highest consumption (14.2%) occurring during the dry summer months.

Because quality forbs were usually present in the diet, and because large percentages of browse and succulents were lacking, we concluded that pronghorn forage conditions east of Cordes Junction were never as critical as those experienced by Hailey et al.(1966) in New Mexico, Brown and Shaw (2006) in New Mexico, or even Miller and Drake (2005) on Anderson Mesa. We nonetheless believe that pronghorn in the study area suffered losses during the drought of 2002-2003 as measured by a doe mortality rate of ca. 33% (Brown et al. 2006) and a reduction in survey observations (Warnecke and Brunner 2006). Although no dead animals were reported suffering from malnutrition, we observed pronghorn abandoning several pastures during the drought period, especially those heavily impacted by livestock. We therefore speculate that these movements resulted in increased stress and mortality as the pronghorn had to travel distances >40 km and cross numerous fences and other barriers to obtain the forage plants that comprised their usual diet.

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APPENDIX I

Table 1. Percent composition of plants in pronghorn diets east of Cordes Junction, Arizona (February 2003 – March 2004).

Plant species	**Occurrence**	**Feb 2003**	**Mar 2003**	**Apr 2003**	**May 2003**	**Jun 2003**	**Jul 2003**	**Aug 2003**	**Sep 2003**	**Oct 2003**	**Nov 2003**	**Dec 2003**	**Jan 2004**	**Feb 2004**	**Mar 2004**
Allium macropetalum	Seasonal	1	3	3	3	1	0	0	0	1	0	0	0	2	0
Ambrosia spp.	Seas. abund.	1	1	5	5	5	6	10	10	5	5	0	2	4	1
Amsinkia spp.	Seas. comm.	6	4	5	6	6	1	1	1	2	3	3	2	4	6
Aster spp.	Seas. comm.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baileya multiradiata	Seasonal	0	5	5	3	1	2	4	4	2	2	0	0	0	2
Borage spp.	Seas. abund.	16	14	13	13	12	9	4	4	5	4	8	13	7	10
Brassica spp.	Seas. comm.	0	2	5	4	3	2	1	1	3	1	0	0	0	3
Brodia. sp.	Seasonal	0	2	0	0	1	0	0	0	0	0	0	0	0	1
*Cirsium*sp.	Not uncom.	0	1	2	1	2	1	4	2	2	2	0	0	0	0
Erodium spp.	Seas. abund.	5	16	13	10	4	4	5	12	4	2	0	0	2	11
Geranium spp.	Seas. uncom	2	2	0	1	0	0	1	1	0	0	0	1	0	1
Lupinus spp.	Seas. comm.	4	1	1	1	1	0	0	2	0	0	0	0	1	2
Malva spp.	Seas. abund.	2	3	5	4	4	5	4	1	2	1	2	3	2	3
Medicago hispida	Seas. uncom	2	4	3	4	5	10	0	1	1	0	1	5	0	3
Plantago spp.	Seas. abund.	8	5	4	5	1	2	4	1	0	0	0	5	3	5
Sisymbrium irio	Seas. abund.	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Misc. forbs	Seas. abund	6	3	2	1	3	2	5	4	5	8	6	0	4	6
Total Seasonal forbs		**53**	**66**	**66**	**61**	**49**	**44**	**43**	**44**	**32**	**28**	**21**	**31**	**29**	**55**
Artemisia spp.	Uncommon	12	8	5	3	5	5	12	13	18	14	29	14	12	9
Castilleja spp.	Not common	3	2	1	1	1	1	2	1	1	2	0	0	2	2
Erigeron sp.	Not uncom.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eriogonum wrightii	Abundant	18	12	7	10	8	20	16	13	17	28	22	23	21	19
Hibiscus coulteri	Not common	0	0	0	0	0	0	0	0	0	0	0	0	0	
Lotus	Uncommon	1	1	3	1	2	1	5	2	1	0	0	5	2	3

Plant species	Occurrence	Feb 2003	Mar 2003	Apr 2003	May 2003	Jun 2003	Jul 2003	Aug 2003	Sep 2003	Oct 2003	Nov 2003	Dec 2003	Jan 2004	Feb 2004	Mar 2004
Senecio sp.	Not common	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphaeralcea spp.	Abundant	1	7	4	8	10	11	5	10	10	6	11	0	3	8
Taraxicum officinale	Not common	1	3	2	1	1	1	2	1	1	0	0	0	0	3
Total Perennial Forbs		**36**	**33**	**22**	**24**	**27**	**39**	**42**	**40**	**48**	**50**	**62**	**42**	**40**	**44**
Acacia greggi	Abundant	0	0	1	3	5	1	1	0	0	0	0	0	0	0
Ephedra viridis	Rare	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Juniperus monosp.	Common	1	0	0	0	0	0	1	0	1	3	4	5	4	0
Krameria parvifolia	Common	3	2	1	2	3	1	1	2	4	5	2	5	7	2
Prosopis velutina	Abundant	0	0	0	0	5	1	8	6	0	0	0	0	0	0
Quercus, Salix, etc.	Common	0	0	0	0	0	0	0	0	0	0	0	3	2	0
Total Browse Species		**4**	**2**	**2**	**5**	**13**	**3**	**11**	**8**	**5**	**8**	**6**	**13**	**13**	**2**
Aristida spp.	Common	2	1	1	0	0	0	0	0	1	0	0	0	0	0
Avena sp.	Seas. comm.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bromus sp.	Seasonal	9	2	7	3	0	0	0	0	2	0	0	0	6	3
Hordeum sp.	Seasonal	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tobosa mutica	Abundant	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Grasses		**11**	**3**	**8**	**3**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**0**	**6**	**3**
Opuntia spp.	Abundant	0	1	0	4	10	13	5	8	12	13	11	12	14	1
Yucca baccata	Not uncommon	0	0	1	2	2	1	1	0	0	0	0	0	0	0
Total Succulents		**0**	**1**	**1**	**6**	**12**	**14**	**6**	**8**	**12**	**13**	**11**	**12**	**14**	**1**
PDSI		-3.75	-3.39	-3.23	-3.21	-3.39	-3.77	-3.31	-3.62	-3.99	-3.35	-3.45	-3.74	-3.45	-3.92

Table 2. Percent composition of plants in pronghorn diets east of Cordes Junction, Arizona (July 2004 – December 2005).

Plant species	Occur-rence	Jul 04	Aug Sep *04*	Oct 04	Nov 04	Dec 04	Jan 05	Feb 05	Mar 05	Apr 05	May 05	Jun 05 North	Jun 05 South	Jul 05	Aug 05	Sept 05	Oct 05 New Mill	Oct 05 B. Mesa	Nov 05 North	Nov 05 South	Dec 05
Allium macropetalum	Seasonal	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	0	0	0	0	0
Ambrosia spp.	Seas. abund.	2	1	0	0	0	0	7	6	3	6	6	5	6	5	2	1	5	0	0	0
Amsinkia spp.	Seas. comm.	0	0	0	0	0	0	1	2	0	0	1	0	0	0	1	0	0	4	0	0
Aster spp.	Seas. comm.	3	2	8	9	0	0	0	0	0	2	2	6	3	1	0	1	1	1	1	0
Baileya multiradiata	Seasonal	1	2	0	0	0	0	0	0	8	2	2	1	2	3	7	0	0	0	0	0
Borage spp.	Seas. abund.	4	2	3	2	0	9	16	14	0	8	6	6	6	5	8	4	7	4	3	0
Brassica spp.	Seas. comm.	0	0	0	0	0	0	0	1	0	0	1	1	1	0	0	0	1	0	1	0
Brodia. sp.	Seasonal	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
*Cirsium*sp.	Not uncom.	2	0	0	0	0	0	2	3	0	0	0	2	3	1	3	1	9	0	0	1
Erodium spp.	Seas. abund.	13	11	7	13	4	20	20	15	17	9	8	3	4	5	5	6	9	6	10	11
Geranium spp.	Seas. uncom	0	0	0	0	0	0	0	1	1	0	1	0	0	0	1	0	1	0	0	0
Lupinus spp.	Seas. comm.	0	0	0	0	0	0	0	2	2	1	2	0	0	1	0	0	0	0	0	0
Malva spp.	Seas. abund.	6	9	2	2	1	1	2	2	2	0	1	1	6	5	4	0	1	1	3	3
Medicago hispida	Seas. uncom	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Plantago spp.	Seas. abund.	0	0	0	0	0	0	10	10	5	5	5	3	2	2	0	0	0	0	0	0
Sisymbrium irio	Seas. abund.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
Misc. forbs	Seas. abund	7	6	5	8	4	9	10	11	30	10	9	9	9	7	6	2	7	3	6	3

Plant species	Occur-rence	Jul 04	Aug Sep *04*	Oct 04	Nov 04	Dec 04	Jan 05	Feb 05	Mar 05	Apr 05	May 05	Jun 05 North	Jun 05 South	Jul 05	Aug 05	Sept 05	Oct 05 New Mill	Oct 05 B. Mesa	Nov 05 North	Nov 05 South	Dec 05
Total Seasonal forbs		**38**	**33**	**25**	**34**	**9**	**39**	**69**	**67**	**68**	**45**	**47**	**37**	**43**	**36**	**37**	**14**	**41**	**19**	**24**	**18**
Artemisia spp.	Uncommon	5	8	13	9	19	16	3	1	0	1	2	4	3	4	6	13	0	12	10	12
Castilleja spp.	Not common	4	3	0	0	0	0	0	0	2	6	3	6	4	1	0	0	0	0	0	1
Erigeron sp.	Not uncom.	1	3	10	8	8	5	3	4	5	3	2	3	4	5	6	9	9	0	3	3
Eriogonum wrightii	Abundant	14	15	14	13	19	15	15	13	10	11	12	10	11	11	11	19	9	19	18	24
Hibiscus coulteri	Not common	2	1	0	0	0	0	1	1	2	5	4	6	5	3	4	0	0	3	3	4
Lotus	Uncommon	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	1
Senecio sp.	Not common	4	5	3	3	1	1	1	0	0	0	0	3	3	10	4	0	0	0	0	1
Sphaeralcea spp.	Abundant	16	14	8	3	4	0	1	1	6	15	15	13	15	10	10	8	12	2	2	2
Taraxicum officinale	Not common	0	0	0	0	0	0	0	4	3	1	4	2	1	1	0	1	5	0	0	0
Total Perennial Forbs		**46**	**49**	**48**	**36**	**51**	**37**	**24**	**25**	**28**	**43**	**42**	**47**	**46**	**45**	**41**	**50**	**35**	**40**	**36**	**48**
Acacia greggi	Abundant	0	0	0	0	0	0	0	0	0	5	5	5	1	1	0	0	0	1	1	1
Ephedra viridis	Rare	2	2	11	15	16	7	3	1	0	0	0	0	0	1	1	3	0	0	4	3
Juniperus monosp.	Common	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Krameria parvifolia	Common	0	0	3	9	3	0	3	3	1	2	2	1	1	1	3	6	0	11	9	8
Prosopis velutina	Abundant	2	6	0	9	1	0	0	0	0	4	0	1	4	12	10	4	1	0	7	2
Quercus, Salix, etc.	Common	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	1	1	0	0
Total Browse Species			**4**	**8**	**14**	**33**	**20**	**7**	**6**	**4**	**1**	**11**	**9**	**7**	**6**	**15**	**15**	**13**	**2**	**14**	**21**
Aristida spp.	Common	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Avena sp.	Seas. comm.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Plant species	Occur-rence	Jul 04	Aug Sep *04*	Oct 04	Nov 04	Dec 04	Jan 05	Feb 05	Mar 05	Apr 05	May 05	Jun 05 North	Jun 05 South	Jul 05	Aug 05	Sept 05	Oct 05 New Mill	Oct 05 B. Mesa	Nov 05 North	Nov 05 South	Dec 05
Bromus sp.	Seasonal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hordeum sp.	Seasonal	1	0	0	0	0	0	0	1	0	1	1	0	0	0	0	1	2	0	1	2
Tobosa mutica	Abundant	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Grasses		**2**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**2**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**2**	**0**	**1**	**2**
Opuntia spp.	Abundant	8	5	11	11	18	14	1	1	2	0	0	5	4	3	6	20	22	26	16	21
Yucca baccata	Not uncomm.	2	2	0	0	0	0	0	0	0	2	1	4	2	1	2	0	1	0	0	0
Total Succulents		**10**	**7**	**11**	**11**	**18**	**14**	**1**	**1**	**2**	**2**	**1**	**9**	**6**	**4**	**8**	**20**	**23**	**26**	**16**	**21**
PDSI		-4.59	-4.85	1.85	2.91	3.3	4.51	5.75	5.12	4.89	4.87	4.75	4.75	3.99	3.76	2.66	2.5	2.5	1.64	1.64	0.69

Population Productivity and Pronghorn Nutrition During Lactation

TIM SMYSER, *Department of Forestry and Natural Resources, Purdue University, Forestry Building, 195 Marstellar St., West Lafayette, IN 47907 tjsmyser@purdue.edu*

ABSTRACT Predators, specifically coyotes (*Canis latrans*), often are thought to limit pronghorn (*Antilocapra americana*) populations, yet few studies have investigated the potential role of nutrition as a limiting factor for this species. We used fecal nitrogen (FN) and 2,6 diaminopimelic acid (DAPA) to quantify nutrition during the lactation season for 5 pronghorn populations in Idaho. We assessed the relationship between these nutritional indices and population productivity with linear regression models evaluated with AICc. Weighted mean FN was the best model explaining 47% of the variation in fawn:doe ratios although the null model was competitive (ΔAICc <3). These results support the hypothesis that the nutritional quality of summer forage can limit fawn recruitment for pronghorn populations in Idaho.

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KEY WORDS pronghorn, *Antilocapra americana*, coyote, *Canis latrans*, predator-prey dynamics, population regulation, productivity, fawn recruitment, nutrition

Simple predator-prey models provide a theoretical framework under which predators may hold prey populations below environmental carrying capacity (see review in Berryman 1992). With the introduction of alternative prey items, these predator-prey models can be extended to predict population-level responses in more complex predator-prey systems such as those involving ungulate species. In general, these more complex models predict that bolstering predator densities with alternative prey will lead to greater reductions in the abundance of primary and secondary prey species (Seip 1992, Pech et al. 1995). Empirical examples in which predators in single or multi-prey systems strongly limit or regulate prey abundance can be drawn from a variety of ungulate systems (moose [*Alces alces*], Van Ballenberghe and Ballard 1994; caribou [*Rangifer tarandus*], Seip 1992).

It has been hypothesized that predators, most commonly coyotes (*Canis latrans*), maintain pronghorn (*Antilocapra americana*) populations below carrying capacity through high rates of fawn predation (Trainer et al. 1983). Such predation was the proximate cause of mortality for ≥54% of radio-marked fawns in O'Gara and Shaw's (2004) summary of 18 neonatal telemetry studies representing 995 fawns; in this summary coyotes accounted for 67% of confirmed predatory losses. Dunbar et al. (1999) concluded that coyote predation contributes additively to fawn mortality as coyotes kill "apparently regardless of fawn health."

Corroborative evidence for the hypothesis that predators limit pronghorn populations can be drawn from the success of coyote eradication programs in eliciting positive population responses in studied populations. For example, a predator removal program on Anderson Mesa in Arizona increased fawn:doe ratios at weaning to 57:100 in years with predator treatment as compared to 31:100 in years ≥4 years post-coyote control (Smith et al. 1986). Improved recruitment following coyote removal was accompanied by increased abundance as the herd grew 136% (Smith et al. 1986). Similar positive population responses associated with coyote control have been observed elsewhere (southeast Oregon, Willis 1988; National Bison Range, Montana, O'Gara and Malcolm 1988, Byers 1997b; west Texas, Canon 1993).

Although evidence for predator control of pronghorn populations may superficially appear overwhelming, more complex habitat-related factors also may serve as limiting factors to pronghorn productivity. A widespread conclusion from ungulate population studies is that forage-limited, density dependence can effectively control populations (e.g., caribou, Post and Klein 1999; elk [*Cervus elaphus*], Singer et al. 1997; mule deer [*Odocoileus hemionus*], Pojar and Bowden 2004, Bishop et al. 2005; white-tailed deer [*O. virginianus*], Patterson et al. 2002). Reduced juvenile survival often is among the first population parameters to reflect resource limitation (Eberhardt 1977) and is commonly observed among stable or declining pronghorn populations (O'Gara and Shaw 2004). Stress as a result of forage resource limitation, the ultimate cause of mortality, may be revealed through the proximate mechanism of increased predation rates, particularly on young, vulnerable age classes (Bishop et al. 2005).

As in other ungulate systems, a growing body of evidence suggests that processes other than simply fawn predation limit pronghorn recruitment and population abundance. Forage-limited density dependence, manifested through variation in fawn survival, has been shown to regulate pronghorn populations in shrubsteppe habitats of Utah; experimental habitat manipulations designed to improve summer forage quality increased recruitment rates and population abundance (Aoude and Danvir 2004). Providing corroborative evidence for the hypothesis of forage-limited, density dependence, observed pronghorn recruitment rates in Utah and Arizona populations were inversely related with population size (Aoude and Danvir 2004, O'Gara and Shaw 2004).

A more careful examination of the role predators play in limiting pronghorn fawn survival suggests predation rates reflect a response to nutritionally driven processes. The nutritional condition of gravid females as they enter winter affects gestation length and birth weight of the ensuing fawn crop as gestation length increased and birth weight decreased from wet to dry years (Byers and Hogg 1995). Relating these observations to population processes, heavier fawns at birth had a greater probability of survival to weaning (Fairbanks 1993). Similarly, fawns born during the peak fawning period realized higher survival rates to weaning (Gregg et al. 2001). Therefore, poor nutritional condition, which reduces birth weights and prolongs gestation, may disrupt birth synchrony and, subsequently, lead to increased predation risk for pronghorn fawns.

The nutritional condition of lactating pronghorn likely continues to influence fawn survival after birth through a cascade of ecological interactions. Pronghorn fawns depend on a hiding strategy to avoid predators during their first weeks of life (Byers 1997a). Fawns grow rapidly during this period (Martin and Parker 1997) as they transition from hiders to followers, ultimately achieving a speed refuge in which fawns can outrun terrestrial predators. The response of fawn growth rates to a range of both natural and artificial levels of energy and protein intake suggests nutrition rather than physiology constrains the rate of fawn development (Martin and Parker 1997). Poor forage quality may depress milk production by lactating does thereby reducing fawn growth rates and prolong the period over which fawns remain vulnerable to terrestrial predators.

Although researchers have identified nutritional limitations within pronghorn herds (Dunbar et al. 1999) and have quantified substantial variation in the quality of forage conditions among habitats occupied by different herds (Trainer et al. 1983), poor recruitment or population declines in these herds have been attributed primarily to coyote predation (Trainer et al. 1983, Dunbar et al. 1999). While predation and nutrition likely interact in shaping population processes, little research has addressed the contribution of nutritional quality, specifically during the lactation season, to pronghorn recruitment. It is imperative that such relationships be elucidated before conclusions regarding the role of predation as a primary mechanism limiting pronghorn population growth can be clearly evaluated. We sought to explore the relationship between nutritional condition during the lactation season and recruitment rate for pronghorn populations within the shrubsteppe bioregion. Five pronghorn populations across Idaho were selected to represent the range of variation observed within the state in both the nutritional quality of pronghorn habitat and population productivity. Our objectives were to: 1) evaluate nutritional condition of pronghorn across the lactation season and 2) explore the relationship between nutritional condition and population-level productivity. We used fecal indicators to quantify variation in nutritional condition both among populations and across the lactation season. Subsequently, we evaluated the relationship between indices of nutritional condition and pronghorn recruitment rate as assessed through post-weaning fawn:doe ratios.

STUDY AREA

This study was conducted in 5 disjunct pronghorn populations located in southern and southeastern Idaho. The Eastern Owyhee (EO) study site typified resident pronghorn populations persisting in desert habitats. The area fell within Owyhee and Twin Falls counties: delineated on the east by Salmon Falls Creek, the west by the Bruneau/Jarbidge Canyons, and the south by the Nevada border and the foothills of the Jarbidge Mountains (Fig. 1). To the north, we truncated the EO study area at 42° 36’ because cheat grass (*Bromus tectorum*) increased in dominance and pronghorn densities decreased precipitously beyond that latitude. Based on Idaho’s GAP analysis land cover classification (Scott et al. 2002), basin and Wyoming big sagebrush (*Artemisia tridentata tridentata* and *A. t. wyomingensis*) were the dominant cover types of EO, accounting for >60% of the study area. Perennial grasses composed another 25% of the area with the remaining landscape a mix of low sagebrush (*Artemesia arbuscula*), bitter-brush (*Purshia tridentata*), and rabbit brush (*Chrysothamnus* spp) communities. Eastern Owhyee was a multi-use landscape with much of the area grazed by cattle and sheep for at least part of the year. The towns of Roseworth (which had limited irrigated agriculture, <3% of EO) and Three Creek fell within the study area. Many of the wet meadows occurring in the EO study area were fenced and hayed in July and August. Average annual precipitation across the site was 32.8 cm (National Oceanic and Atmospheric Administration, Western Regional Climate Center, Three Creek, Idaho 1940-1987). The precipitation regime was characterized by hot, dry summers with precipitation spread evenly through fall, spring, and winter. The mean monthly low temperature within EO occurred in January (−11.4° C) and the mean monthly maximum temperature occurred in July (30.1° C).

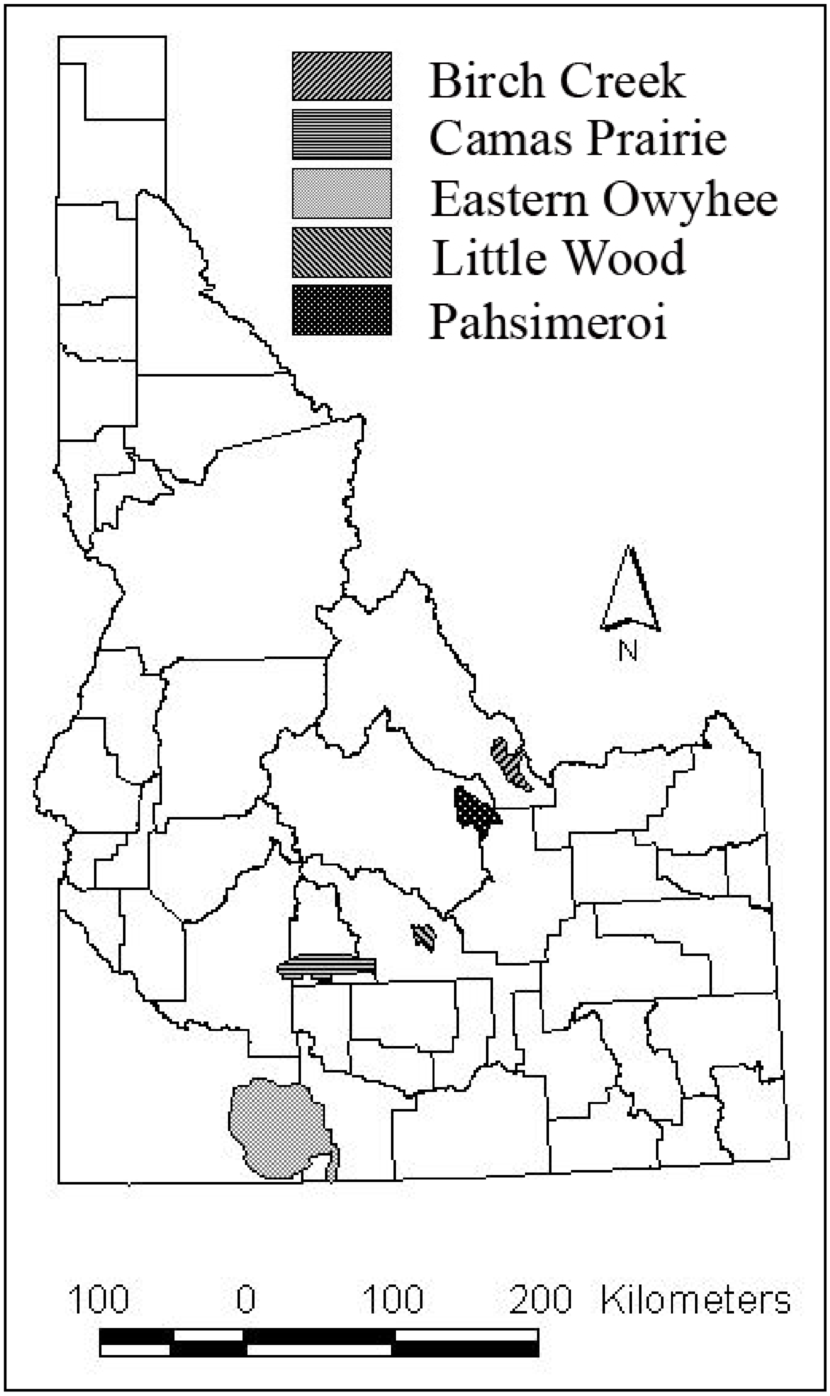

Figure 1. Study populations within the state of Idaho were geographically isolated from one another through the lactation season. Study sites were selected to represent the breadth of pronghorn habitat types and population productivities encountered in Idaho.

The second study site, Camas Prairie (CP), was selected to characterize migratory pronghorn populations persisting largely on agricultural lands through summer months. This site was bounded to the north by the Soldier Mountains (Sawtooth National Forest) and to the south by the Bennett Hills. The majority of the study area fell within Camas County with a small portion in Elmore County (Figure 1). The towns of Fairfield and Hill City fell within the study area. Camas Prairie was bisected by state highways 20 and 46 with secondary roads established along most section lines. The majority (52%) of the study area was under agricultural cultivation of which 81% was dryland and 19% was irrigated. Alfalfa was the dominant crop (54% of agricultural area) followed by barley (13%) and grass hay (11%), in addition to pasture or conservation reserve program (CRP) lands (17%; Kinder 2004). Perennial grass (21% of the study area) and basin and Wyoming big sagebrush communities (18%) persisted in Bureau of Land Management and state held lands. Average annual precipitation across CP was 38.2 cm with a periodicity of dry summers and wet winters (National Oceanic and Atmospheric Administration, Western Regional Climate Center, Fairfield Ranger Station, Idaho 1948 - 2004). The mean low monthly temperature within CP occurred in January (−14.9° C) and the mean high monthly temperature occurred in July (29.7° C).

The third study site was the Little Wood (LW) area, selected to characterize migratory pronghorn populations on native shrubsteppe range. This foothills habitat was bordered to the north by the Pioneer Mountains and to the south by the eastern expanses of the Big Desert. The study area fell within Blaine County (Figure 1). Local ranches grazed cattle, sheep, and horses throughout the area. Basin and Wyoming big sagebrush comprised the dominant vegetation type, covering 73% of the study area. Agricultural lands accounted for 6% of the study area and irrigated alfalfa was available to pronghorn. The remainder of the study area was composed of mountain big sagebrush (*A. t. vaseyana*), perennial grasslands, and bitter-brush. Average annual precipitation for the area was 32.6 cm characterized by dry summers with precipitation spread evenly through the remainder of year (National Oceanic and Atmospheric Administration, Western Regional Climate Center, Picabo, Idaho 1958 - 2004). The mean low temperature within LW occurred in January (−13.7° C) and the mean high temperature occurred in July (30.2° C).

Two pronghorn populations inhabiting mountain valley habitats were included in the study. These migratory populations likely overwintered together on the Big Desert (Hoskinson and Tester 1980), but were isolated by the Lemhi Mountain Range during summer. The first, encompassing the Lemhi and Birch Creek valleys (BC), fell within Lemhi County (Figure 1). Low sagebrush was the dominant vegetation community, comprising 51% of the study area. Mountain, basin, and Wyoming big sagebrush accounted for another 40% of the study area. The area had limited agriculture (4%) and interspersed forest stands (4%). Average annual precipitation for the area was 20.1 cm (National Oceanic and Atmospheric Administration, Western Regional Climate Center, Leadore, Idaho 1965 - 2004). The mean low monthly temperature within BC occurred in January (−15.7° C) and the mean high monthly temperature occurred in July (29.1° C).

The second mountain valley habitat fell within the Little Lost and Pahsimeroi (PAH) valleys in Custer and Butte counties (Figure 1). Mixed stands of mountain big sagebrush and low sagebrush dominated the study area (>60%). Basin and Wyoming big sagebrush accounted for 23% of the study area. Patches of Douglas-fir (*Pseudotsuga menziesii*) and subalpine fir (*Abies lasiocarpa*) persisted in higher, mesic microsites. Agriculture accounted for <2% of the total land area. Average annual precipitation for the area was 21.1 cm (National Oceanic and Atmospheric Administration, Western Regional Climate Center, May, Idaho 1948 – 2004, Howe, Idaho 1948 - 2004). Mean low temperature within PAH occurred in January (−14.0° C) and mean high temperature occurred in July (30.1° C).

METHODS

Forage Quality

Pronghorn are highly mobile and selective feeders, such that relative abundance of preferred forage items does little to reflect the ability of pronghorn to meet dietary requirements (Byers 1997a). Therefore, we used 2 fecal indicators, fecal nitrogen (FN) and 2,6 diaminopimelic acid (DAPA), to depict the response of populations to their nutritional environment, incorporating elements of both forage abundance and competition. The utility of FN and DAPA to reflect changes in nutritional plane has been demonstrated through feeding trials with captive pronghorn (Robinson 2001) and applied to free-ranging pronghorn to track changes in seasonal diet quality (Dunbar et al. 1999, Dennehy 2001, Hansen et al. 2001), to compare diet quality between populations (Hansen et al. 2001), and to evaluate differences in diet quality associated with social dominance (Dennehy 2001). Robbins et al. (1987) caution that FN is not a precise indicator of either dietary nitrogen content or dry matter digestibility as this metric lacks the ability to distinguish contributions from dietary crude protein content, non-digested fiber-bound protein, metabolic fecal protein, and tannin-bound protein. The protein-precipitating effects of tannins in some forage items can greatly inflate nitrogen levels observed in feces and distort the relationship between FN and protein and energy available to the herbivore (Robbins et al. 1987). However, with a large portion of pronghorn summer diets composed of generally high-protein, low-tannin forbs (Hansen et al. 2001), FN is an appropriate measure of diet quality and energy intake during the lactation season.

Fresh fecal samples were collected throughout the lactation season (24 May – 30 July) from CP and EO in 2003 (CP03 and EO03) and from all sites in 2004 (BC04, CP04, EO04, LW04, PAH04). Pronghorn groups were observed from roads using spotting scopes and binoculars. Groups were monitored until defecation was observed, at which time an observer remaining at the road would direct a second observer to the location of the fecal sample using 2-way radios. Each study site was visited during 4 sampling periods (time) corresponding roughly to 2-week intervals spread evenly throughout the lactation season [1) 24 May – 13 June; 2) 14 – 26 June; 3) 27 June – 11 July, 4) 12 – 30 July]. Within each sampling time period, we spatially segregated fecal samples in order to avoid resampling the same pronghorn group and to obtain samples representative of the entire population. Without the benefit of marked individuals, groups, but not necessarily individuals, were potentially resampled in subsequent 2-week intervals. Given the correlation in plant communities encountered by a group foraging together, we considered the group to be our sampling unit. Therefore, in the event that more than a single fecal sample was located from a group site, additional pellet groups were collected independently and equal weights from each pellet group were homogenized in the laboratory. For purposes of chemical fecal analysis, composite samples produce a value equal to the mean of the represented individuals (Jenks et al. 1989). All samples were dried in a drying oven at 40° C for 2 days or until dry, and ground prior to analyses. Samples were sent to Washington State University's Wildlife Habitat Lab for chemical analysis. Fecal nitrogen was extracted according to the Kjeldahl method and expressed as percent fecal nitrogen (Horowitz 1980); DAPA was extracted according to Nelson and Davitt (1984) as expressed as mg DAPA/g feces. Values for both fecal indicators were evaluated on an oven dried basis.

Aerial Survey Methods

Aerial herd composition surveys were conducted during the period between the conclusion of weaning and the start of harvest (28 July – 11 August) from either a Bell 47 Soloy helicopter or a Maule M-6-235 fixed-wing aircraft. Surveys were conducted by a pilot and 2 observers experienced in pronghorn aerial surveys. Flights were carried out prior to 1200 and after 1800 to maximize the proportion of individuals not bedded. For each population, the extent of the area inhabited by pronghorn was delineated and divided into search subunits. With the navigational assistance of a Global Positioning System, rough transects were flown within each subunit in an effort to census each population. When large groups of pronghorn were encountered, the task of classifying bucks and fawns was divided between observers with the number of does in the group identified as the total group size, less the number of bucks and fawns. In smaller groups, the observers reached a consensus on group size and sex and age composition.

While fawn:doe ratios represent the additive effect of both fecundity and survival, ratios are an appropriate measure of pronghorn population productivity. Pregnancy rates have been shown to be uniformly high across pronghorn populations (O'Gara 2004) with the exception of years following severe winters (Barrett 1982), conditions which were not observed during the time frame of our study.

Statistical Analysis

We used multivariate analysis of variance (MANOVA) to evaluate differences in assessed values of FN and DAPA among sites, among sampling time periods, as well as differences within sites across sampling time periods (Proc GLM, SAS Inst. Inc. 1999). Where statistical differences were identified with MANOVA, we used canonical variables to quantify the influence of each response variable (FN and DAPA) on the significant outcome. Subsequent univariate analysis of variance (ANOVA) and Tukey's pairwise comparisons were used to identify between site differences in FN and DAPA, using an alpha value of 0.05 (Proc GLM, SAS Inst., Inc. 1999).

We used multiple regression to evaluate the relationship between nutritional condition and pronghorn productivity across the 5 populations surveyed (Proc REG, SAS Inst., Inc. 1999). Given the potential for dramatic variation across years for both recruitment and forage conditions, we treated values observed in CP and EO as independent observations (CP03, CP04, EO03, EO04). Large mammal population dynamics are influenced by the integration of environmental conditions over a long time period (Picton 1984) and fawns remain vulnerable until weaning. Therefore, we evaluated the relationship between fawn:doe ratios and the grand mean from the 4 sampling periods (weighting each sampling period equally despite differences in sample size) selected to depict nutritional conditions experienced through the entire lactation season within each population.

Alternatively, assuming nutrition has a constant importance for fawn survival from birth to weaning may be an oversimplification of biological processes. Protein and energy demands on a lactating pronghorn female can change over a short time period; the lactational energy demands of captive females decreased from a high of 141.7 KJ/kg/day during the first 2 weeks of lactation to 22.3 KJ/kg/day at 74 days post-parturition (Martin 1995). Therefore, to reflect the relative importance of changes in milk energy expenditures, we also conducted a second set of regression analyses in which we averaged milk energy expenditure within intervals corresponding to our sampling periods, and weighted observed fecal values to reflect the differences in milk energy expenditures among the sampling periods. We then evaluated the relationship between fawn:doe ratios and the weighted average from the 4 sampling periods.

For each set of regression analyses, we used an information theoretic approach employing Akaike's Information Criterion corrected for sample size (AIC_c) to evaluate three competing models (FN, DAPA, FN + DAPA) against the null, intercept-only model (Burnham and Anderson 2002).

RESULTS

A total of 953 uniquely identifiable scat samples were collected from 467 groups of pronghorn across the 2 years of sampling. The average number of scats collected from a group of pronghorn was 2.04 (SD = 2.17, range = 1 − 22), although the distribution of scats collected was strongly skewed to the right (Skewness = 4.51). Within samples, FN and DAPA were significantly positively correlated ($P < 0.0001$, $r = 0.5028$). Average FN values for sites by time ranged from 2.00% (SD = 0.23) in EO04 during the third sampling time period to 3.49% (SD = 0.41) in CP03 during the first sampling time period (Table 1). These same sites and time periods had the lowest and highest DAPA values with EO04 having a mean of 0.30 mg/g (SD = 0.15) during the third sampling time period and CP03 having a mean of 0.77 mg/g (SD = 0.36) during the first sampling time period (Table 2).

Significant differences in fecal indicators were identified across sites with the multivariate test (Wilks' Lambda = 0.4342, $P < 0.0001$). Differences among sites were largely attributable to variation in FN (1^{st} canonical axis: proportion of the variance described = 0.9225, standardized coefficients = 1.3327*FN + 0.2716*DAPA). Significant differences in fecal indicators also were identified over the sampling time periods (Wilks' Lambda = 0.8550, $P < 0.0001$); differences observed among sampling time periods again were largely attributable to the general decline in FN values across the lactation season (1^{st} canonical axis: proportion of the variance described = 0.9972, standardized coefficients = 1.5722*FN – 0.3890*DAPA). A statistically significant interaction term (Wilks' Lambda 0.8823, $P = 0.0128$) in the multivariate analysis indicated fecal indicators varied independently by site across time with differences among sites and times more strongly attributable to FN (1^{st} canonical axis: proportion of the variance described = 0.8033, standardized coefficients = 1.1554*FN + 0.4882*DAPA).

Table 1. Mean percent fecal nitrogen (% FN) values for 5 populations of pronghorn (BC04, Birch Creek 2004; CP03, Camas Prairie 2003; CP04, Camas Prairie 2004; EO03, Eastern Owyhee 2003; LW04, Little Wood 2004; and PAH04, Pahsimeroi 2004) collected in shrubsteppe habitats in Idaho during the 2003 and 2004 lactation seasons. Means are divided by sampling time frames distributed throughout the lactation season. Standard deviations associated with the means are expressed within the brackets with the number of groups sampled listed on the line below.

Site	**24 May – 13 Jun**	**14 – 26 Jun**	**27 Jun – 11 Jul**	**12 – 30 Jul**
BC04	2.69 (0.4) n = 30	2.26 (0.42) n = 8	2.37 (0.32) n = 8	2.47 (0.3) n = 16
CP03	3.49 (0.41) n = 13	3.2 (0.41) n = 22	3.05 (0.41) n = 17	2.82 (0.36) n = 21
CP04	3.05 (0.45) n = 29	3.34 (0.47) n = 17	3.09 (0.54) n = 14	2.69 (0.26) n = 16
EO03	2.27 (0.32) n = 9	2.11 (0.3) n = 21	2.12 (0.39) n = 17	2.06 (0.32) n = 23
EO04	2.43 (0.48) n = 24	2.29 (0.34) n = 20	2 (0.23) n = 14	2.05 (0.3) n = 18
LW04	2.94 (0.45) n = 15	2.73 (0.25) n = 16	2.52 (0.27) n = 17	2.51 (0.36) n = 28
PAH04	2.43 (0.36) n = 9	2.55 (0.16) n = 5	2.14 (0.18) n = 9	2.06 (0.22) n = 11

Table 2. Mean 2,6 diaminopimelic acid (mg/g DAPA) values for 5 populations of pronghorn (BC04, Birch Creek 2004; CP03, Camas Prairie 2003; CP04, Camas Prairie 2004; EO03, Eastern Owyhee 2003; LW04, Little Wood 2004; and PAH04, Pahsimeroi 2004) collected in shrubsteppe habitats in Idaho during the 2003 and 2004 lactation seasons. Means are divided by sampling time frames distributed throughout the lactation season. Standard deviations associated with the means are expressed within the brackets with the number of groups sampled listed on the line below.

Site	**24 May – 13 Jun**	**14 – 26 Jun**	**27 Jun – 11 Jul**	**12 – 30 Jul**
BC04	0.49 (0.12) n = 30	0.35 (0.14) n = 8	0.43 (0.15) n = 8	0.53 (0.22) n = 16
CP03	0.77 (0.36) n = 13	0.67 (0.22) n = 22	0.68 (0.29) n = 17	0.64 (0.2) n = 21
CP04	0.47 (0.24) n = 29	0.59 (0.28) n = 17	0.57 (0.16) n = 14	0.49 (0.14) n = 16
EO03	0.4 (0.17) n = 9	0.38 (0.11) n = 21	0.49 (0.09) n = 17	0.42 (0.1) n = 23
EO04	0.38 (0.14) n = 24	0.31 (0.13) n = 20	0.3 (0.15) n = 14	0.32 (0.11) n = 18
LW04	0.41 (0.19) n = 15	0.52 (0.15) n = 16	0.49 (0.17) n = 17	0.5 (0.15) n = 28
PAH04	0.47 (0.1) n = 9	0.5 (0.15) n = 5	0.43 (0.06) n = 9	0.45 (0.13) n = 11

In accord with the results from the multivariate test, the univariate analysis of FN indicated significant effects associated with study site, sampling time period, and the interaction of site and time ($F_{27, 439} = 21.91$, $P < 0.0001$). The statistically significant time effect is attributable to the general declined through the lactation season (Fig. 2). The significant site*time interaction term indicates that changes across the sampling time periods were not consistent across sites. Given that time contributed significantly to the univariate analysis, we used least-squares means for the pairwise comparisons among sites as sample sizes varied across the four sampling time periods (Table 1). Pairwise comparisons of least-squares means identified a number of significant differences between sites (Table 3). Fecal nitrogen values observed in Camas Prairie (CP03, CP04) across both years were significantly greater than all other sites. Little Wood (LW04) and BC04 fecal nitrogen values were of an intermediate range. Values from PAH04, EO03, and EO04 were similarly low relative to other observations.

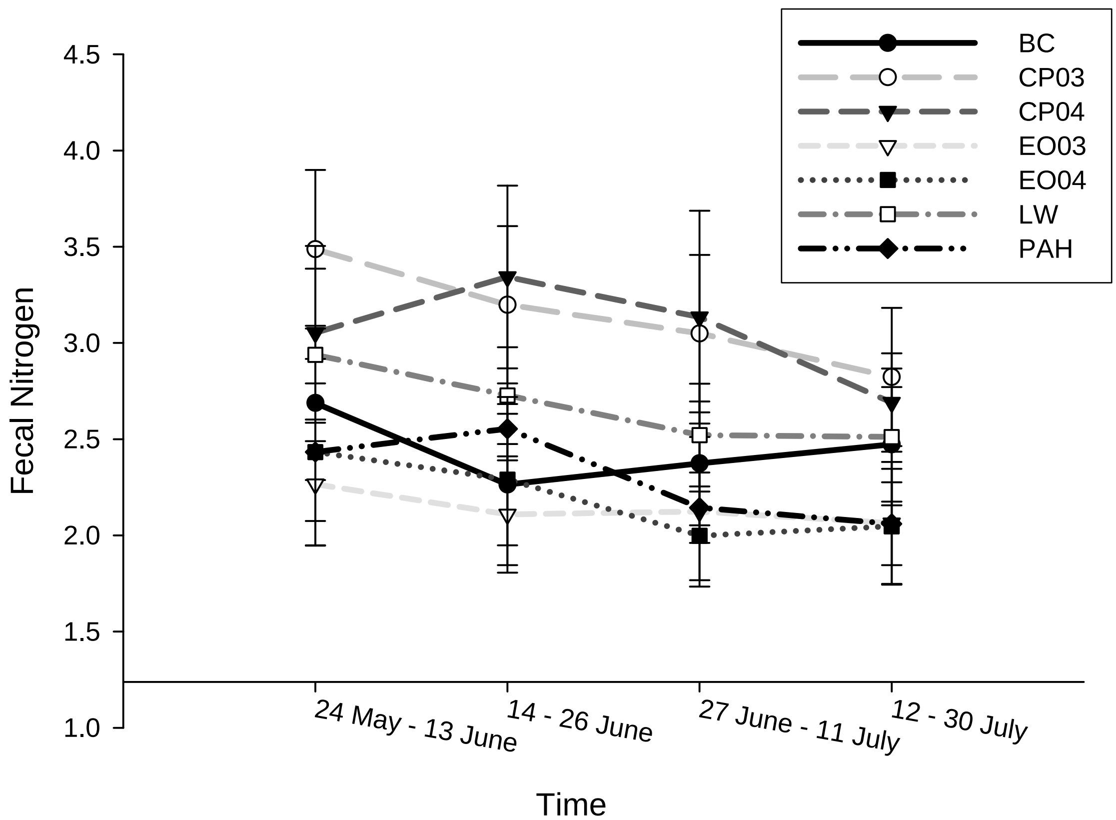

Figure 2. Mean percent fecal nitrogen values for pronghorn across the lactation season for Idaho populations: Birch Creek (BC), Camas Prairie (CP03, CP04), Eastern Owyhee (EO03, EO04), Little Wood (LW), and Pahsimeroi (PAH). Error bars depict standard error.

Table 3. *P*-values for Tukey's pairwise comparisons for 2,6 diaminopimelic acid (below the diagonal) and fecal nitrogen (above the diagonal) for 5 pronghorn populations in Idaho. Fresh fecal samples were collected from groups of pronghorn throughout the lactation season (24 May – 30 July) in 2003 and 2004. Pronghorn populations represent Birch Creek (BC), Camas Prairie (CP03, CP04), Eastern Owyhee (EO03, EO04), Little Wood (LW), and Pahsimeroi (PAH).

	BC04	**CP03**	**CP04**	**EO03**	**EO04**	**LW04**	**PAH04**
BC04		<.0001	<.0001	0.0004	0.0045	0.0244	0.5705
CP03	<.0001		0.8258	<.0001	<.0001	<.0001	<.0001
CP04	0.1919	<.0001		<.0001	<.0001	<.0001	<.0001
EO03	0.9929	<.0001	0.0128		0.9843	<.0001	0.4592
EO04	0.0054	<.0001	<.0001	0.0263		<.0001	0.8347
LW04	0.9704	<.0001	0.6156	0.5719	<.0001		<.0001
PAH04	1	<.0001	0.5143	0.9748	0.0097	0.9985	

Diaminopimelic acid levels showed similar patterns among sites with less pronounced trends across the season (Fig. 3). The univariate analysis of DAPA indicated significant differences by site and time with differences associated with the site*time interaction approaching statistical significance ($F_{27, 439} = 6.94$, $P < 0.001$, Type III SS site*time $P = 0.0763$), and therefore, the full model was used for between site comparisons to adjust for unequal sample sizes across sampling rotations. Pairwise comparisons between sites indicated DAPA values for CP03 were significantly greater than all other sites including CP04 (Table 3). A number of sites including CP04, LW04, PAH04, BC04, and EO03 had similar DAPA values. Diaminopimelic acid values observed in EO04 were significantly lower than other sites observed.

Regression analysis of population productivity relative to both simple and weighted means of fecal indicators identified the models incorporating FN as the AIC_c best model (Table 4, Fig. 4). Weighting observations to correspond with changing energy demands of lactating does improved the strength of the relationship only slightly ($R^2 = 0.46$, 0.47 for simple versus weighted regression). Although models including the variable FN were the best models, the null model was competitive in both model sets ($\Delta AIC_c < 3$; Table 4). The strength of the relationship between population productivity and DAPA values was not as strong, explaining only 16% and 15% of the variation in fawn:doe ratios for the simple and weighted models, respectively (Table 4, Fig. 5).

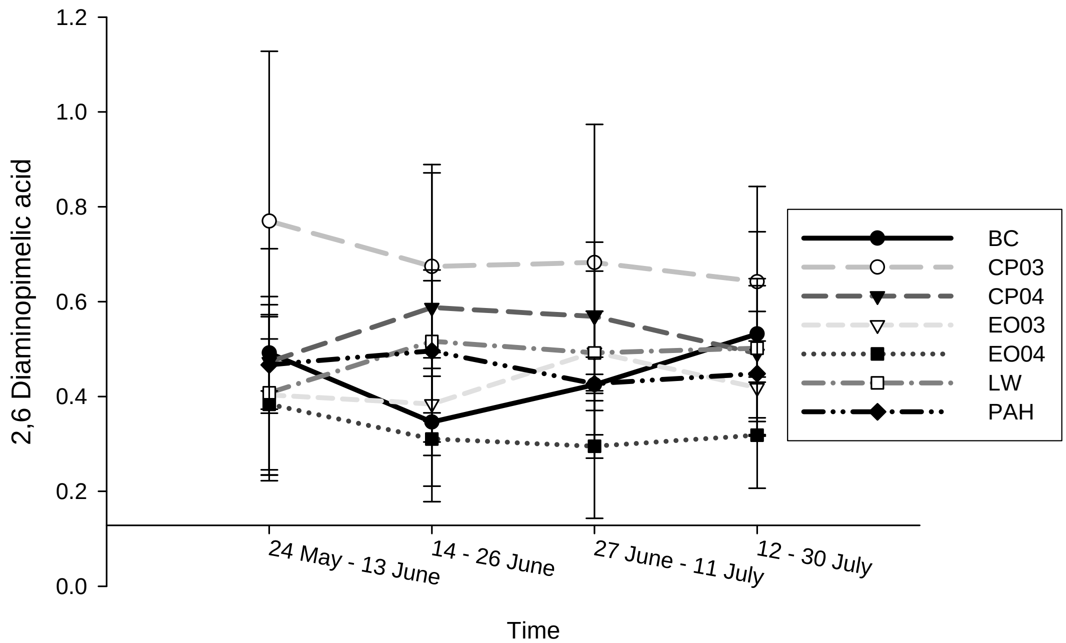

Figure 3. Mean pronghorn fecal 2,6 diaminopimelic acid (DAPA; mg/g) values across the lactation season for five sites in Idaho: Birch Creek (BC), Camas Prairie (CP03, CP04), Eastern Owyhee (EO03, EO04), Little Wood (LW), and Pahsimeroi (PAH). Error bars depict standard error.

Table 4. Linear regression models evaluating relationship between the fecal indicators, fecal nitrogen (FN) and fecal 2,6 diaminopimelic acid (DAPA), and preharvest fawn:doe ratios (f:d). Simple regression models evaluated the relationship between mean fecal values across the lactation season (24 May – 30 July) while the weighted regression emphasized observed fecal values relative to milk energy expenditure by lactating does (Martin 1995). Fecal samples were collected from 5 sites in Idaho: Birch Creek, Camas Prairie, Eastern Owyhee, Little Wood, and Pahsimeroi, during 2003 and 2004.

Simple Regression				
	AIC_c	ΔAIC_c	Regression equation	R-square
FN	-14.12	0.00	f:d = -0.77 + 0.55*FN	0.46
Null	-13.96	0.16	f:d = 0.64	0.00
DAPA	-10.99	3.13	f:d = 0.08 + 1.17*DAPA	0.16
FN DAPA	-9.25	4.86	f:d = -1.06 + 1.07*FN - 2.18*DAPA	0.60
Weighted Regression				
	AIC_c	ΔAIC_c	Regression equation	R-square
FN	-14.20	0.00	f:d = -0.76 + 0.54*FN	0.47
Null	-13.96	0.24	f:d = 0.64	0.00
DAPA	-10.87	3.33	f:d = 0.12 + 1.08*DAPA	0.15
FN DAPA	-9.96	4.24	f:d = -1.09 + 1.10*FN - 2.34*DAPA	0.64

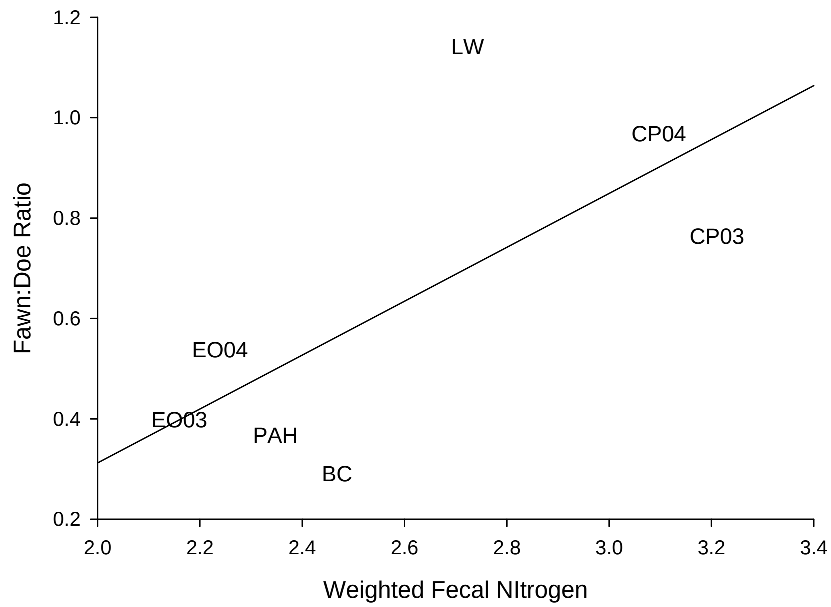

Figure 4. Pronghorn fawn:doe ratios from five populations in Idaho [Birch Creek (BC), Camas Prairie (CP03, CP04), Eastern Owyhee (EO03, EO04), Little Wood (LW), and Pahsimeroi (PAH)] relative to weighted mean fecal nitrogen (FN) values from the lactation season. Values (Wt FN) were weighted to reflect changes in milk energy expenditures by lactating does (Martin 1995).

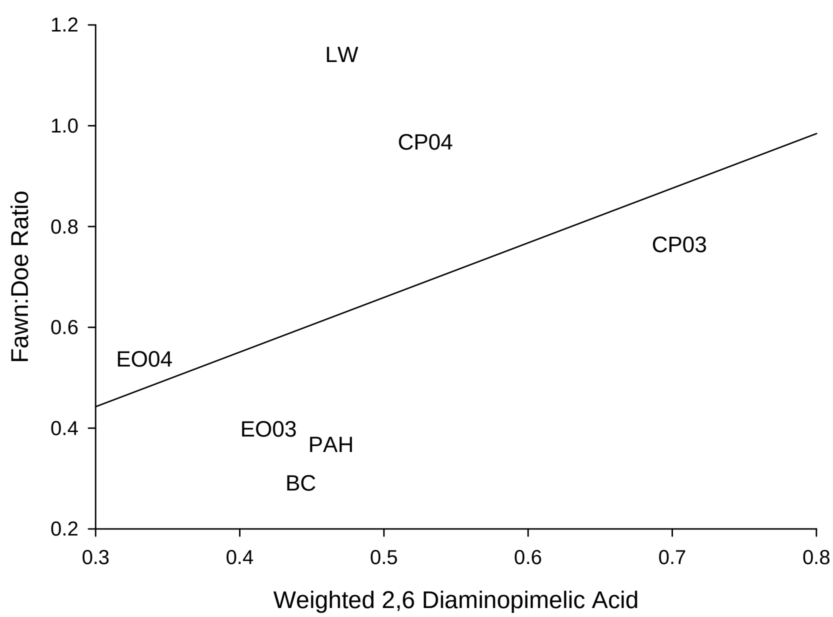

Figure 5. Pronghorn fawn:doe ratios from populations in Idaho [Birch Creek (BC), Camas Prairie (CP03, CP04), Eastern Owyhee (EO03, E004), Little Wood (LW), and Pahsimeroi (PAH)] relative to weighted fecal diaminopimelic acid (DAPA mg/g). 2, 6 diaminopimelic acid values were weighted to reflect changes in milk energy expenditures by lactating does (Martin 1995).

DISCUSSION

This study demonstrated FN and DAPA are well suited to resolve both statistical and biological differences in nutrition among pronghorn populations and changes in nutritional quality across the lactation season. Across sites, FN generally declined through the lactation season. As preferred forage items senesce with progression of the lactation season, pronghorn may switch to high-tannin sagebrush, which would decouple the relationship between FN and digestible energy and protein. We did not observe this hypothesized FN spike, indicating FN was an appropriate metric to evaluate pronghorn nutrition through the lactation season. While the pattern of between-site differences observed in FN was generally reflected in DAPA, DAPA values did not show a strong trend across the lactation season.

Both FN and DAPA have unique ranges for different ungulate species and may vary with forage types. By placing our observations in context with other pronghorn studies, we gain perspective and can begin to qualitatively characterize Idaho's summer range. Fecal nitrogen and DAPA were used by Hansen et al. (2001) to quantify nutritional condition of pronghorn in Sheldon National Wildlife Refuge and Hart Mountain National Antelope Refuge, Oregon, during the summers of 1994 and 1995. Mean FN values observed across the lactation season in Oregon were similar to native range sites in Idaho. Alternatively, DAPA values in Oregon were substantially greater than any of the sites observed in Idaho. Similar to values observed in Oregon, DAPA values from females at the National Bison Range, Montana, in 1996 (Dennehy 2001) were substantially greater than those observed in Idaho. These results suggest Idaho populations are not able to obtain the digestible energy intake available in other shrubsteppe ecosystems. The ability to draw meaningful inference from FN and DAPA values will continue to improve with the application of these tools to free-ranging pronghorn across levels of habitat quality, net primary productivity, seasonal time frames, and various intensities of intra- and interspecific competition.

Within the observed distribution of DAPA values, the tight clustering of BC04, CP04, EO03, LW04, and PAH04 suggests these populations obtain similar levels of digestible energy. In contrast, DAPA values observed in EO04 were significantly lower than other sites in Idaho and were the lowest observed in pronghorn (Dennehy 2001, Hansen et al. 2001). Recruitment into EO during the 2004 season may have been energetically limited.

In BC04, EO04, LW04, and PAH04, we observed an increase in DAPA levels between the third (27 June - 11 July) and fourth (12 - 30 July) sampling rotation. We believe this late season increase was caused by changes in foraging behavior associated with senescence of preferred forage items. Pronghorn responded to the curing of forage in late summer by concentrating activity around more mesic habitats. At LW, pronghorn groups were observed at higher frequencies in irrigated alfalfa and wet meadows with the progression of the growing season. In EO, the most heterogeneous site included in the study, most of the groups identified from aerial surveys in August were associated with wet meadow habitats.

With ungulate protein demands during the peak of lactation at 5 times those of maintenance levels (Spalinger 2000), it is likely that the low values of FN observed in some populations are potentially limiting dam milk production and, subsequently, fawn growth. The identification of the FN regression model as the best model supports this conclusion. A commonly observed peak in fawn mortality within the first three weeks of life (Beale and Smith 1973, Bodie and O'Gara 1980, Trainer et al. 1983, Barrett 1984, Dunbar et al. 1999) suggests nutritional difference may have the greatest effects early in the fawn's life or during gestation. Because of the preponderance of early mortality and high protein and energy demands of late gestation, future research may find it prudent to broaden the sampling frame to include the third trimester of gestation.

Our minimal data set limited analysis to linear regression. Given that the relationship between dietary protein and apparent digestibility is curvilinear (Robbins 1983), it is likely that the relationship between nutritional plane and recruitment is similarly non-linear. Above threshold levels, fetal growth and milk production are likely limited by behavioral and physiological constraints of the dam. Additional improvements in diet quality above these thresholds have diminishing returns. It is not known whether nutritional condition experienced within any of our study sites had reached a level of physiological limitation, although the substantially greater metrics of nutritional quality observed elsewhere (National Bison Range, Dennehy 2001; Oregon, Hansen 2001) suggested lactating females would seek out a higher quality diet if available.

While our data offers support for the hypothesis that summer range quality limits pronghorn populations, it is not sufficient to refute the importance of other mortality factors such as predation. As growing fawns take on adult proportions, they enter a speed refuge at approximately 45 days of age with the ability to evade most terrestrial predators (Byers 1997a). Nutrition likely interacts with predation during this window of fawn vulnerability as fawns benefitting from a high nutritional plane may be rapidly ushered into an adult survival class while poor nutrition may prolong the period of heighten predation risk (Martin and Parker 1997). The true influence of nutrition on fawn recruitment is likely to increase with understanding of the interaction between nutritional level, fawn growth rates, the attainment of adult running speeds, and associated predation risk.

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Section IV Abstracts

Maintaining the Balance: Management for Range Sustainability at Canadian Forces Base Suffield.

Delaney Boyd

Canadian Forces Base Suffield comprises 2,690 km^2 of uncultivated native prairie within Southeastern Alberta. For decades, the area has been recognized for its environmental sensitivity and value for wildlife, with more recent research confirming its importance as vital pronghorn habitat. The Base has developed a Range and Training Area Management System (RTAMS) to monitor and mitigate the impacts of varying land uses including military training, oil and gas development, and domestic cattle grazing. This presentation will outline the approach used by the Base to recognize and manage its lands for environmental sustainability and wildlife conservation while fulfilling its primary mandate to provide sustainable military training opportunities.

Delaney Boyd, G3 Range Biologist, Canadian Forces Base Suffield, PO Box 6000 Stn Main, Medicine Hat, Alberta T1A 8K8 Canada boyd.dp@forces.gc.ca

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Role of Population Phenotype in Ensuring Resilient, Abundant Populations of Pronghorn Antelope

Michael J. Suitor*, C. Cormack Gates, Paul Jones, Kyran Kunkel, Mike Grue and Julie Landry-DeBoer.

Large mammal migration is an increasingly rare component of biodiversity and is threatened globally. For populations exhibiting partial migration, where individuals may migrate seasonally or remain as residents, the loss of migration could substantially decrease population resilience and abundance. Reductions in migrants could indicate landscape level pressures detrimental to the whole population. While the conservation community has implicated truncation of migration routes by anthropogenic barriers and landscape change as two leading threats to migratory populations, we suggest there are differences in movement patterns within populations that make some individuals more sensitive to these pressures. We demonstrate that pronghorn antelope on the Northern Sage Steppe (NSS) of Alberta, Saskatchewan, and Montana have developed several strategies to deal with environmental and landscape variability, including three behavioural phenotypes: long distance (LD) migrants, short distance (SD) migrants, and residents. Movements during migration periods and while on seasonal range were different between these phenotypes. LD migrants moved 451 km (SE = 177) including

one of the longest recorded round-trip migration movements by the species (831 km). SD migrants moved 74 km (SE = 41). LD migrants occupied winter home ranges greater in size than the other two phenotypes, even when occupying the same general area. Pronghorn were more abundant where all phenotypes were present, generally in areas where large tracts of native vegetation were still available. The apparent loss of LD migration in the highly altered landscape in the western portion of the study area indicates LD migrants are the most sensitive phenotype to landscape change. The NSS is a highly stochastic environment where anthropogenic pressures are incrementally reducing the capacity of its landscapes to support populations. We argue if managers wish to maintain resilient and abundant populations of pronghorn, it is necessary to develop land use plans based on the habitat and movement requirements of its most sensitive phenotype, LD migrants.

**Michael J. Suitor, Faculty of Environmental Design, University of Calgary, 2500 University Drive, Calgary, Alberta T2N 1N4, Canada mjsuitor@ucalgary.ca*

Pronghorn Movements and Site Fidelity in Southwestern North Dakota

Jesse L. Kolar*, Joshua J. Millspaugh and Bruce A. Stillings.

Evidence for large-scale movements of pronghorn (*Antilocapra americana*) in North Dakota has been based on anecdotal information. Wildlife managers need empirical data about pronghorn movements in North Dakota because harvest quotas are based on results of a mid-summer survey, which might not represent the spatial distribution of pronghorn during the hunting season. We initiated a project in 2004 to study pronghorn movements in southwestern North Dakota with the objective of quantifying distance and direction of seasonal migration, timing of migration, and seasonal site fidelity to better understand the extent of seasonal movements. We radio-collared 121 pronghorn with VHF radio-transmitters and assessed broad-scale pronghorn movements and migration patterns for collared animals surviving two or more seasons. We measured the distance and direction between summer and winter ranges to quantify migration distances, and the distance between consecutive summer ranges and consecutive winter ranges to assess site fidelity. Pronghorn exhibited two primary migration patterns: 1) movement > 15 km between discrete summer and winter ranges (45%); and 2) movement < 15 km between summer and winter ranges (55%). Of the pronghorn that moved > 15 km, 81% moved north and/or east (between 337.5° and 112.5°) in the spring and 77% moved south and/or west (between 157.5° and 292.5°) in the fall. The mean date for pronghorn to begin migrating in spring was 20 March (SD = 20 days) and 22 October (SD = 17 days) in the fall. Nearly all pronghorn (97%) returned to within 15 km of their previous summer range, whereas only half of the pronghorn returned to within 15 km of their previous winter range. Failure to establish well-defined winter ranges might have been due to mild weather. Most pronghorn moved across hunting unit boundaries (70%) and survey unit

boundaries (75%), but only 7 (10%) fall migrations occurred between the aerial survey and the hunting season. While some pronghorn (37) made long movements into South Dakota and Montana (e.g. 60 km into MT), none of our collared pronghorn moved to Wyoming (105 km from the southwest corner of ND). Our research showed that about half of the pronghorn in our study site migrate in the spring, which is more than previously understood; however most movements take place before the aerial survey and at the end of or after the October hunting season. Therefore the mid-summer survey accurately reflected the distribution of pronghorn for the fall hunting season during our years of study.

Jesse L. Kolar, University of Missouri, 1317-B Anthony St., Columbia, Missouri, USA JesseKolar@mizzou.edu

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Identified Pronghorn Migration Corridors on Anderson Mesa, Arizona

Richard A. Ockenfels*, C. Richard Miller, Scott C. Sprague and Sue R. Boe

Anderson Mesa has long been considered premier pronghorn (*Antilocapra americana*) summer range in Arizona, but the herd has recently been in one of its numerous decline phases. Major habitat restoration efforts have been undertaken to assist in the recovery of the herd. To guide in the planning of the restoration efforts, we captured and equipped 15 pronghorn (14F, 1M) with GPS-equipped radiotelemetry collars in 2 capture efforts in November 2003 and 2004. Collars were programmed to record a location 1-2 per day, based on the season of year, for 2 years. Over 8,200 locations were usable for the period between 2003 and 2006. Location data were transferred to a Geographic Information System (GIS) for analyses. Ocular assessment of the plotted locations on 2- and 3-D topography covers indicated 4 likely migration corridors off/on the higher elevation mesa to adjacent winter range. Field investigations of the 4 candidate corridors resulted in identification of pronghorn hair on barbed-strands on fences along the mesa rim at 2 of the 4 sites. We put up remotely-triggered cameras (film, digital) in an attempt to capture pronghorn use of the corridors. A single pronghorn was detected (9 Nov 2004) in still pictures using the corridor off Olin Tank, between Yeager and Grapevine canyons, at the site of a gate. Tracks in recent snow were detected at both the Chavez Pass and Olin corridors. The Olin corridor was an old road bed through dense Pinyon-Juniper (*Pinus-Juniperus* spp.) woodlands along the rugged mesa rim. Elk (*Elaphus canadensis*) use of the Olin corridors exceeded pronghorn use. Restoration treatment strategies for the corridors themselves are being discussed with landowners. Tree thinning and removal at both ends of corridors has already been undertaken to reduce the time pronghorn are in dense woodland habitat.

**Richard A. Ockenfels, PO Box 326, Mayer, AZ 86333, USA sboe@azgfd.gov*

A Spatial Approach to Classifying Pronghorn Movement Behavior

Paul Knaga* and Darren Bender

Global Positioning Systems (GPS) technology provides a unique advantage in the study of animal behavior due to its ability to continuously track wildlife species. Through the use of a Geographic Information System (GIS), GPS data can be used to analyze movement shape and patterns. This project is a feasibility study on the ability to extrapolate behavior from movement data. In 2003, the Alberta Conservation Association (ACA), in conjunction with a long-term pronghorn antelope (*Antilocapra americana*) population monitoring program in south-eastern Alberta, equipped female pronghorns with Lotek© 3300 Global Positioning System (GPS) collars. Two types of pronghorn were examined in this study: pronghorn that exhibit large, broad scale migratory behavior, and pronghorn that exhibit small yearly movements. Since movement behaviors are inherently spatial, they were derived from movement-based metrics: velocity, net displacement ratios, fractal dimensions, turning angles, evenness of habitat patch residency times, and number of habitat patches visited. Behaviors were classified using a K-means optimization clustering and were applied to a classification tree analysis, using a v-fold cross validation to select an appropriate classification tree. Metrics such as fractal dimensions were weak in differentiating behavior groups, while habitat richness was excluded from this analysis altogether based on collinearity issues. Evenness, net displacement ratios and turning angles successfully classify movement steps into statistically different behavior categories. For both pronghorns, the habitat evenness index provided the first movement decision rule in the classification tree. Additionally, migrant and resident pronghorn appear to be interacting with the landscape differently, which can be seen in the spatial ethogram behavior frequencies. These results show that integrating GIS into movement studies can provide additional information regarding movement behavior, and that certain movement metrics are stronger in classifying pronghorn movement habits then others.

*Paul Knaga, Western and Northern Service Centre, Parks Canada Agency, 1550, 635-8th Ave SW, Calgary, AB T2P 3M3, Canada paul.knaga@pc.gc.ca

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Recent Changing Vegetation Conditions and Pronghorn Populations Near Elko, Nevada

Jim Yoakam*, Ken Gray and Merlin McColm.

During recent decades, pronghorn (*Antilocapra americana*) numbers have accelerated near Elko, Nevada. Factors affecting pronghorn population dynamics (e.g., inclement weather, predation, disease, forage competition, harvest, and others) apparently have remained relatively static except for wildfires and their influence on vegetation. Wildfires have increased in numbers and acreage during the last 30 years. Prior to these accelerated burns, much of this Great Basin rangeland was dominated with late successional stages of shrubs and scant herbaceous plants. However, natural wildfires have for eons acted as an ecological disturbance agent changing vegetation seral stages to mixed communities with greater quantities of herbaceous plants and decreased shrub densities. These changes resulted in 2 habitat characteristics beneficial for pronghorn: (1) increased nutritious, preferred, and succulent herbaceous forage during critical fawning and winter seasons, and (2) decreased shrub structure resulting in less hiding cover for mammalian predators. Apparently, certain plant community characteristics prior to recent accelerated burns were less favorable for meeting pronghorn habitat requirements—thus, some recent wildfires acting as a natural ecological disturbance, may have been a contributing factor changing vegetation composition and structure to enhance pronghorn production, survival, and increased numbers.

Jim D. Yoakum, Western Wildlife, Post Office Box 369, Verdi, Nevada 89439-0369, USA

Alberta's Changing Prairie Landscape: Addressing Cumulative Effects

Ian W. Dyson

The prairie environment, like other parts of the province, is experiencing the consequences of Alberta's hot economy. But current pressures are coming from a 'base' where the prairie landscape has already been historically subject to major anthropogenic modification. We still have much environmental richness in our prairies, but we likely don't have the luxury of time to demonstrate a societal capacity to make far sighted choices. In response to unprecedented growth pressures of development on the environment, the Government of Alberta has developed an new approach to address the impacts of development on air, land, water and biodiversity, by setting regional environmental outcomes that all human activities on the landscape must conform to. Alberta Environment is leading development of a system to manage cumulative effects, linked to the Land Use Framework process. A crucial component of this task is to get a better understanding of the regional environmental state of our prairies and the likely environmental responses to changing human pressures. But ultimate success will depend on a collective ability to develop and deliver desired outcomes using both regulatory and non regulatory approaches.

Ian W. Dyson, Alberta Environment, Provincial Building, 220-5th Ave South, Lethbridge, T1J 4L1, Canada ian.dyson@gov.ab.ca

Conservation Challenges for Pronghorn in a Changing Landscape

Jim Yoakum

Pronghorn (*Antilocapra americana*) during the last century have experienced major changes in occupied habitats and vegetation conditions primarily because of landscape alternations accelerated by modern mankind. This relationship continues today and is a challenge for the future; consequently, these changes need to be recognized and incorporated in pronghorn conservation programs. It is estimated that more than 60 percent of historic occupied rangelands are no longer available pronghorn habitat because of human occupation or landscape modifications that fail to provide suitable biotic characteristics to meet pronghorn requirements. For much of the current remaining occupied habitat, the vegetation quality has been deteriorated, thus decreasing ecological carrying capacities resulting in lower fawn recruitment rates and decreased population densities. Populations within the past 5 decades experiencing increased numbers have healthy vegetation communities, whereas decreased populations have been associated with unhealthy vegetation conditions. Management programs to help bring about a new thrust of maintaining wild pronghorn on western rangelands are provided for international, national, regional, and local entities. There is a greater need to encourage collaboration efforts regarding financial, political, research and management support with sportsman organizations, conservation groups, and the general public—for pronghorn belong to all the people. To fulfill the goal of perpetuating abundant wild pronghorn on western rangelands, the primary management strategies need to be the perpetuation of existing habitats in quality condition—all other factors are secondary.

**Jim D. Yoakum, Western Wildlife, Post Office Box 369, Verdi, Nevada 89439-0369, USA*

Pronghorn as a Focal Species for Coordinated Wildlife and Land Management in the Transboundary Region of the Northern Sagebrush Steppe

Cormack Gates*, Dale Eslinger, Pat Gunderson and Sean Burke.

In 2007, an M.O.U. concerning coordinated management of focal wildlife species was signed by the directors of wildlife for Montana, Alberta and Saskatchewan under the umbrella of the Western Association of Fish and Wildlife Agencies (WAFWA). The agreement provided for cooperation among participating state, provincial and federal land and wildlife management agencies in the conservation and management of grassland and

sagebrush habitats and sagebrush-dependent wildlife in the contiguous ecosystem referred to as the Northern Sagebrush Steppe (NSS). The NSS is under accelerating cumulative land use pressures that could impair ecological integrity and biodiversity. Pronghorn, greater sage grouse and mule deer were specifically identified as focal species serving as indicators for the ecosystem. The M.O.U. committed the parties to maintaining regional landscape scale ecological processes spanning the borders between jurisdictions, and viable, socio-economically valuable populations, requiring conservation and land use planning at appropriate scales. Emerging knowledge about the ecology of pronghorn and sage grouse in this area provides a compelling rationale for coordinated management and planning in this transboundary region of the continent. Coordinated management will require appropriate organizational structures, planning processes, and technical support from applied research organizations.

**Cormack Gates, Faculty of Environmental Design, University of Calgary, 2500 University Drive, Calgary, Alberta T2N 1N4, Canada ccgates@nucleus.com.*

Consilience and Ecological Restoration in Banff National Park, Canada

Clifford A. White* and Jesse Whittington.

Ecosystem management in Banff National Park (BNP) was initially premised on providing economic benefits through tourism, followed by a period of natural regulation with minimal planned human interference or restoration. More recently, park management has followed a paradigm of ecological integrity and long-term range of variability to restore ecosystems. The ecosystem-management process involved four broad components: 1) developing ongoing collaboration groups comprising a wide range of stakeholder interests; 2) providing groups with multidisciplinary knowledge; 3) decision making based on interdisciplinary understanding (consilience) provided through collaborative input to managers; and 4) implementation of actions through an adaptive-management approach. Application of this process is described for restoring the montane ecosystem where indicators included human dimensions (economic and social), and distribution and densities of humans, grizzly bear (Ursus arctos), black bear (U. americanus), wolf (Canis lupus), cougar (Felix americanis), elk (Cervus elaphus), beaver (Castor canadensis), trembling aspen (Populus tremuloides) and willow (Salix spp.). Restoration actions included prescribed burning, mitigating highway effects with fences and wildlife-crossing structures, and restoring wildlife corridors through facility relocation and human-use management. The synergy created by a diverse and interested citizenry, well-informed with knowledge from a variety of sources and interacting with scientists and managers, was essential to adaptive management and innovative ecological restoration in BNP. We describe a recent example of applying this process to the management of a predator-driven, hyper-abundant elk herd near Banff town site.

*Clifford A. White, Parks Canada, Box 900, Banff, AB T1L 1K2, Canada Cliff.White@pc.gc.ca

Effects of Human Activity and Restoration Actions on Animal Movements

Jesse Whittington*, Marco Musiani, Tony Clevenger and Cliff White.

Human activity has potential to affect wildlife populations through direct mortality, habitat degradation, habitat fragmentation, and altered predator-prey relationships. Banff National Park and the Province of Alberta have implemented numerous large-scale management actions to minimize the effects of human activity on wildlife. A large portion of the Trans-Canada Highway was twinned and fenced to reduce wildlife-vehicle collisions. Overpasses and underpasses were constructed to facilitate wildlife movements across the highway. Formalized wildlife corridors were created to help carnivores travel around the towns of Banff and Canmore. Most wildlife species have responded in positive ways to restoration actions. The success of restoration actions depended on the species, spatial context, and variability in individual behaviour. We will discuss how human activity affects the movement behaviour of wary carnivores and ungulates and how those animals respond to ecosystem-based management actions.

*Jesse Whittington, Parks Canada, Box 900, Banff, AB, T1L 1K2, Canada Jesse.Whittington@pc.gc.ca.

Survival Patterns of Newborn Pronghorn Fawns on Hart Mountain National Antelope Refuge, Oregon, 1996–2007

Banks, H., M. Bennett, M. Gregg, G. H. Collins, C. Foster, and D. G. Whittaker*

A total of 462 newborn pronghorn fawns were captured and marked with eartag radio-transmitters between 1996–2007 on Hart Mountain National Antelope Refuge to evaluate factors affecting survival and recruitment. Annual sample size ranged from 20–52 animals with an average age at sampling of 26.7 hr. Annual survival ranged between 0.03–0.91 and 0.00–0.73 for females and males, respectively. Survival patterns were compared to indices of general health, weather patterns, predator abundance, and small mammal abundance (lagamorphs and rodents). Implications for management and conservation will be discussed.

*Donald G. Whittaker, Oregon Department of Fish and Wildlife, 3406 Cherry Avenue NE, Salem, OR 97303, USA don.whittaker@state.or.us

Blood Chemistry, Mineral, and Whole Blood Parameters for Newborn Pronghorn Fawns on Hart Mountain National Antelope Refuge, Oregon, 1996–2007

Banks, H., M. Bennett, M. Gregg, G. H. Collins, C. Foster, and D. G. Whittaker*

Blood samples were collected from 462 newborn pronghorn fawns on Hart Mountain National Antelope Refuge between 1996–2007 to assess general health status. Annual sample size ranged from 20–52 animals with an average age at sampling of 26.7 hr. We report normal value ranges for nutritional indices, diagnostic indices, whole blood parameters, and mineral values. Comparisons with other reported studies of blood parameters will be discussed.

*Donald G. Whittaker, Oregon Department of Fish and Wildlife, 3406 Cherry Avenue NE, Salem, OR 97303, USA don.whittaker@state.or.us

Pronghorn and Habitat Management for Fifty Years on the Hart Mountain National Antelope Refuge: A Review and Assessment

Jim D. Yoakum*

Pronghorn (*Antilocapra Americana*) population dynamics and habitat conditions were investigated for more than 50 years on the Hart Mountain National Antelope Refuge (HMNAR), Oregon. Population estimates have fluctuated from <300 in the early 1950s to >2,700 in 2006; consequently, pronghorn numbers increased more than 1,300 percent during the last half century with greatest trend increases during the last 2 decades. Studies of factors influencing herd trends included: weather conditions, diseases, natural accidents, predation, forage competition, vegetation alterations, harvests, diet selection, and others. These factors had various affects on population numbers but none were isolated as limiting long-term densities. A 12-year study of neonate mortality identified an average predation loss of around 50 percent while the herd doubled in size. Diseases were studied for fawn and adult health, and no specific malady was reported for limiting numbers. However, one factor appeared correlated with pronghorn herd increases—changes in vegetation quantity and quality. As preferred, succulent, nutritious forage was

increased during the pronghorn pregnancy and lactation periods, fawn recruitment improved and population numbers increased. Increased forb availability after elimination of domestic and feral livestock coupled with implementation of vegetation alteration strategies, appeared to have triggered more recent rapid pronghorn increases. Several pronghorn and refuge management plans were developed over the years evaluating agents influencing pronghorn production and survival. Based on experiences with ecological carrying capacities, it appeared that free-living pronghorn on the HMNAR may have accelerated numbers following management programs that enhanced vegetation conditions.

**Jim D. Yoakum, Western Wildlife, Post Office Box 369, Verdi, Nevada 89439-0369, USA*

Section V Business Meeting

23rd Biennial Pronghorn Antelope Workshop

Business Meeting Minutes
May 14, 2008

1. Business Meeting called to order by Workshop Co-chair Dale Eslinger at 12:15 pm.

Alberta acknowledged the 2 students that were attending the workshop by giving them each a set of O'Gara and Yoakum's *Pronghorn Ecology and Management* (signed by Jim Yoakum) and the companion, *Prairie Ghost*.

Two students were: Jesse Kolar, University of Missouri, Missouri
Mike Suitor, University of Calgary, Alberta

2. Roll Call for jurisdictional representatives:

States/Provincial Jurisdictions

Alberta	Kim Morton
Arizona	Brian Wakeling
Baja CS	Jorge Cancino
Idaho	Brad Compton
Montana	Mark Sullivan
North Dakota	Bruce Stillings
Oregon	Don Whittaker
Saskatchewan	Sean Burke
South Dakota	Andy Lindbloom
Texas	Calvin Richardson
Utah	Anis Aoude
Wyoming	Roger Bredehoft

Universities Represented

University of Calgary, Alberta	Mike Suitor
University of Missouri, Missouri	Jesse Kolar

No other agencies came forward to be identified when the call went to the floor.

3. **Review of 2006 Business Meeting minutes:**

Idaho moved to accept the minutes as recorded.
Oregon seconded the motion. All in favour. Motion carried.
Minutes from 2006 meeting adopted as presented.

4. Old Business Items from 2006 Workshop:

A. Pronghorn Hall of Fame

Dave Brown was identified to address this issue, but he was not in attendance. It was pointed out that guidelines were adopted at the 22nd Workshop; as nominations come forward, they are accepted or rejected by the Awards Committee set up for that particular workshop.
No action taken on this issue.

B. Berrendo and Special Recognition Awards

The awards were initiated to recognize individuals who have contributed significantly to Pronghorn Management. By doing it at the business meeting, it is captured in the meeting minutes. Each jurisdiction hosting will put the list of past winners and also the background on the current winners. In this way, the acknowledgement is captured permanently.

It was suggested that the award winner selection be patterned after the Mule Deer award (Wallmo). The host jurisdiction would get a package of past winners with all the relevant information on the winners. They would then use this information to base their selection for award winners from the list of nominations put forward that year.

An attempt was made to initiate discussion on standardizing awards and criteria to help future workshop hosts. There was no discussion and no action taken.

No action taken. Provided as information only.

C. Pronghorn Workshop Bank Account (via WAFWA)

Brad Compton indicated that there was $7090.00 in the Pronghorn account held by WAFWA. It was surplus from the 22nd Workshop in Idaho. It was left as seed money for jurisdictions hosting future Pronghorn Workshops that may require some seed money. This money would be available as a loan to be paid back to the account.

The question was asked whether this money could be used for student scholarship that would facilitate student attendance at future workshops. It was indicated that requests of this nature could be made through the WAFWA directors. If approved, there would be no repayment required.

5. Pronghorn Hall of Fame Nominations

Oregon made a motion to adopt a list of nominees to the Hall of Fame as read.

Discussion:

- this seems cumbersome with no formal structure, do we want to keep it like this?
- write up on past winners was completed by Dave Brown and Richard Ockenfels.
- is the list all or nothing? The list put forward by the awards committee is as was read. Any changes would require an amendment.
- we have no way of weighting nominations, no standard guidelines for deciding who is eligible, purely subjective, up to the current workshops awards committee.

Oregon re-iterated motion to adopt the entire list, as read.
Arizona seconded the motion.

More discussion:

- reference back to Wallmo award, there is only 1 winner, chosen from all nominees, based on some criteria (not known at this time).
- again reference to the need for some type of standardized workbook or "how-to" for awards for future Workshop hosts.
- is there a past list? No, the current list of nominees was put together by Richard and Dave to cover all 'past' important people that had played a role in furthering Pronghorn knowledge. Capture their legacy before it is forgotten. As well, all Berrendo award winners would be automatically included in the Hall of Fame. This list would bring everything up to date. Future nominee lists would presumably be much shorter.
- is there structure for the Berrendo Award? It has been done similar to the Wallmo award, with the current host awards committee receiving nominations, rating them and choosing a winner, but very informal.

Idaho made a motion to amend Oregon's existing motion as follows:
"Adopt the entire list as read and in addition add Bart O'Gara and form a committee to work with Richard Ockenfels to establish guidelines and procedures for determination of winners for Berrendo, Special Recognition and Hall of Fame awards. "

Comment: Bart O'Gara will automatically go in as a past Berrendo award winner.

Motion to amend put forward as stands again by Idaho
Wyoming seconded the motion.
All in favor. Motion carried.

The amended motion initially put forward by Oregon was re-read.
Comment: the Hall of Fame list as read will bring us up to date.
Vote was finally taken on the amended initial motion to adopt list as read.
All in favour. Motion carried.

6. **Student Support:**

Student participation is critical to continued advancement of pronghorn research, conservation and management. The workshop provides a forum to facilitate knowledge transfer, data sharing and partnership opportunities to further these studies. As the host jurisdiction, we would like to propose that funds be made available to support student attendance and participation at future workshops.

Discussion

- is this proposal to use the WAFWA account or funds from the 23rd Workshop? It is to decide if there is the possibility of setting up an account to accommodate promoting student participation in future workshops. Possibly using some of the existing money and also money from the 23rd Workshop raised specifically for that purpose.
- this can become onerous, determining who is eligible, how much, etc. A large task to put on future hosts.
- is it even legal to take public (WAFWA) money to give as gifts? If hosts want to encourage students, they can cut registration costs as they see fit.
- can outside donations be used? Can do anything with non-public money, just not with public money. Can be onerous burden on hosts, particularly in the mid-USA jurisdictions, as there may be a large number of students attending, requiring a large amount of funding to be secured to provide meaningful help to students.
- leave it up to host jurisdiction to help if they want (i.e. cutting registration).

No motion was presented. It is left up to the host jurisdiction if they want to help students attend and then find ways to make that possible.

7. **Workshop Proceedings**

Darren Bender discussed procedures and timelines for the preparation of the 2008 proceedings.

Discussion:

- WAFWA requires completion within one year, with copies to all WAFWA participating agencies and also a report at the next WAFWA meeting (July 2008). This report can be submitted or presented in person at the meeting.
- regarding peer review, comment was made that papers are to be peer edited.
- use Journal of Wildlife Management format as a guide for papers submitted for proceedings.
- deer/elk workshop looked at putting PowerPoint presentations in proceedings instead.

Conclusion is that we'll stick with past format, as there is no clear rationale or desire for any change.

Action Item: Darren Bender will pursue getting the proceedings on the WAFWA website.

8. Workshop and Awards Guidelines

Discussion already held previously (see items 4 and 5 above).
Action Items: 23rd Workshop awards committee will document our decision making process and pass it on to 2010 host to use if desired.

9. **Pronghorn Ecology and Management Book** – *O'Gara and Yoakum.*

- 32 years to put together.
- 1st edition in 2004 was sold out the first year.
- worked on it two more years and re-published in 2006. There are currently less than 120 copies for sale. There are no plans to re-print.

10. North American Pronghorn Science and Cultural Center

There is an interest in past books, paintings, etc. Jim Yoakum's thoughts were that possibly there could be a center focused on Pronghorn similar to ones for bighorn sheep and elk. Does the workshop wish to appoint a committee to pursue/investigate this?

No motion. No action taken or required based on lack of discussion.

11. Next Meeting Location

Jorge Cancino offered to host the 2010 Workshop in Zacatecas, Mexico.
Roger Bredehoft offered to host the 2010 or 2012 Workshop in Wyoming.

Discussion:

- issue with having 2 workshops in a row where international travel is required for majority of jurisdictions. See lower attendance. If we go to a central U.S. location, perhaps we can get attendance up again. We don't want the Workshop to lose relevance by decreased attendance in the long-term.
- Mexico can get Federal and State support under current government. That support may not be available in 2012

Vote – Mexico hosting 2010 and Wyoming hosting 2012: For – 3 Against – 8.
Vote - Wyoming hosting 2010 and Mexico possibly 2012: For – 8 Against – 0.

Wyoming is selected to host the 2010 – 24 Biennial Pronghorn Workshop.

Meeting was adjourned at 1:33 pm.

Awards

Awards Presented at the 23rd Biennial Pronghorn Workshop, Canmore, Alberta

SPECIAL RECOGNITION AWARDS

Morley Barrett

Our recipient was among the first to document pronghorn/habitat relations for North America's most northern pronghorn populations. These investigations resulted in the first publications to provide science-based data regarding the influences of severe winters on pronghorn population dynamics. Findings relative to capture myopathy were recorded together with recommendations for winter supplemental feeding--valued data for wildlife managers.

Our honoree first attended a Pronghorn Workshop in 1972. Since then, he presented six technical reports at Workshops, all of which were printed in the Workshop Proceedings. In total, he has authored more than 19 scientific reports over eight years of study on pronghorn.

He completed more than 30 years of service with the Government of Alberta in a number of postings where he continued to work with pronghorn and other wildlife. His past positions have included a long list of leadership positions, including Head, Wildlife Biology Branch, Alberta Environment Centre, Executive Director, North American Waterfowl Management Program, Director of Fisheries, Fish and Wildlife Division, and Assistant Deputy Minister, Fish and Wildlife Division.

The Pronghorn Workshop appreciates the professional wildlife service of a Canadian who has, and continues to accomplish, a long-term productive career of research and management for pronghorn and other wildlife; and therefore, grants in 2008 a "Special Recognition Award" to Morley W. Barrett.

David Brown

Our recipient has had a distinguished career as a pronghorn biologist, with many notable achievements to his credit. He was the founding member (charter) of the Arizona Antelope Foundation in 1992-1993, of which he has been a Member of the Board ever since, and also a Past President (1997). He is well known for his contributions to pronghorn management. For example, he is recognized for formulating the first transplant guidelines for pronghorn antelope in Arizona. He was also a lead co-author on revising and recompiling the Pronghorn Management Guides (2006).

Our honoree has also made numerous contributions to the science of pronghorn. He has published numerous scientific articles on pronghorn, including research on three of the recognized subspecies: American, Sonoran, and Peninsular. He is also lead author on the new pronghorn book for Arizona: "Arizona's Pronghorn Antelope: A Conservation Legacy" (Arizona Antelope Foundation, Phoenix, AZ, 2007).

Our recipient has been a familiar face at Pronghorn Workshops since 1982. He has attended and presented papers at numerous meetings. He has also served on the Awards Committee in recent years, and most notably he authored the criteria for the Pronghorn Workshop "Hall of Fame Award" to recognize significant figures from the past.

For his service to the science and management of pronghorn, and his dedication to the Pronghorn Workshops, we present the "Special Recognition Award" to

BERRENDO AWARD – RICHARD OCKENFELS

The arid southwest has produced a champion for pronghorn. He is a wildlife research biologist that has conducted long-term pronghorn investigations specializing in population dynamics and habitat monitoring techniques.

Ever since 1990, our honoree has attended and participated in all Pronghorn Workshops. In 1998, he organized and chaired the successful 19th Pronghorn Workshop in Arizona. He contributed to three editions of the "Pronghorn Management Guide". In addition, he was a leader in developing and implementing the Pronghorn Workshop Awards Program for six years.

Because of his long-term expertise in research and management, he has cooperated in pronghorn programs with provincial/state and federal agencies. Also, he provided professional technical support to wildlife managers in Mexico. He developed new GIS inventory procedures for pronghorn habitat that are a model for current management. In addition, he has provided pronghorn management counseling to the Arizona Wildlife Federation and the Arizona Antelope Foundation.

However, one of the recipient's major contributions to pronghorn management has been conducting field research investigations, and then making the findings available to the wildlife society through scientific literature. Consequently, he has authored more than 37 reports on pronghorn of which 15 were printed in the Pronghorn Workshop Proceedings or Pronghorn Management Guides. Topping all this, last year he coauthored the first and only book on pronghorn in Arizona. This book contains a wealth of historic an d extant information written in a style that is enjoyable reading for the public and wildlife biologists alike.

Our recipient has dedicated much of his life to pronghorn, for he is a wildlife biologist, a wildlife researcher, a wildlife manager—a "*berrendo afectionado*". he has visited Africa to observe and enjoy the numerous antelope species there. He has traveled to the western rangelands of Canada, Mexico and the United States to study pronghorn ecosystems. Our honoree retired this spring after more than 30 years of employment with the U.S. Fish and Wildlife Service and the Arizona Game and Fish Department, but he undoubtedly will never retire from a wildlife career. He personifies a "Professional Pronghorner". His services were recognized in 2002 when he was recipient of one of our first "Special Recognition Awards". Today, we present him the premier Berrendo Award; consequently, he is the first and only wildlifer to date to receive the Pronghorn Workshop's two honorary awards. Therefore, the 23rd Pronghorn Workshop hereby grants for a lifetime professional career of distinguished service to pronghorn—the Berrendo Award to Richard Ockenfels.

HALL OF FAME AWARD – T. PAUL RUSSELL

T. Paul Russell was the Project Leader responsible for New Mexico's pronghorn management program under Federal-Aid Project W-84D. During the period 1937-1963, Mr. Russell conducted studies into the distributions, habitat requirements, food habits, and diseases peculiar to New Mexico's pronghorn. Even more importantly, Mr. Russell pioneered pronghorn survey and capture techniques that proved so successful that they became model procedures for Texas and other western states. Earlier efforts having largely failed, it was the capture methodologies developed by Mr. Russell and his co-workers using wild, adult animals that finally succeeded in making pronghorn translocations a reality throughout North America. Realizing that his accomplishments should be in print, T. Paul Russell authored the *Antelope of New Mexico*, published by the New Mexico Department of Game and Fish in 1964.

So successful was the trapping and transplanting program led by Russell in New Mexico that more than 4,400 new Mexican pronghorn were translocated into historic habitats in 30 New Mexico counties between 1937 and 1956. During this time, the estimated numbers of antelope, as he insisted on calling these animals, rose from 3000 to between 20,000 and 25,000, thus ensuring New Mexico's position ever after as one of the top 5 pronghorn states and provinces. For his outstanding contributions, we posthumously award T. Paul Russell with the Pronghorn Workshop Hall of Fame Award.

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 Department
February 19-21, 1974 Salt Lake City, UT	52	D.M. Beale	Utah Division of Wildlife Resources
February 24-26, 1976 Twin Falls, ID	68	R. 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	T.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 Management
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

2008 Workshop Attendees

Name	Affiliation	Country
Jim Allen	Alberta Sustainable Resource Development	Canada
Robert Anderson	Alberta Conservation Association	Canada
Anis Aoude	Utah Division of Wildlife Resources	U.S.A.
Morley Barrett	Ducks Unlimited Canada (Retired)	Canada
Darren Bender	University of Calgary	Canada
Delaney Boyd	Department of Nat. Defence CFB Suffield	Canada
Roger Bredehoft	Wyoming Game & Fish Dept.	U.S.A.
Kim Brinkley	Los Angeles Zoo	U.S.A.
David Brown	Arizona Antelope Foundation, Arizona State Univ.	U.S.A.
Shawn Burke	Fish and Wildlife Branch, Ministry of Environment	Canada
Jorge Cancino	Centro de Investigaciones Biologicas del Noreste	Mexico
Grant Chapman	Fish and Wildlife - ASRD	Canada
Brad Compton	Idaho Fish and Game	U.S.A.
Todd Cornia	Deseret Land and Livestock Ranch	U.S.A.
Rob Corrigan	Wildlife Management Branch - ASRD	Canada
Roger Creasey	Shell Global Solutions (Canada)	Canada
Rick Danvir	Deseret Land and Livestock Ranch	U.S.A.
Dave Depape	Fish and Wildlife - ASRD	Canada
Leo Dube	Fish and Wildlife - ASRD	Canada
Dale Eslinger	Fish and Wildlife - ASRD	Canada
Doug Etherington	Fish and Wildlife - ASRD	Canada
Sean Fontaine	Petro-Canada	Canada
Cormack Gates	University of Calgary	Canada
Mike Grue	Alberta Conservation Association	Canada

Name	Affiliation	Country
Richard Guenzel	Wyoming Game & Fish Dept.	U.S.A.
Pat Gunderson	Montana Fish, Wildlife and Parks	U.S.A.
Karlyn Haas		U.S.A.
Kent Hersey	Utah Division of Wildlife Resources	U.S.A.
Paul Jones	Alberta Conservation Association	Canada
Paul Knaga	Parks Canada	Canada
Alice Koch	California Dept. of Fish & Game	U.S.A.
Jesse Kolar	University of Missouri	U.S.A.
Cheryl Le Drew	Lotek Wireless Inc.	Canada
Andy Lindbloom	South Dakota Game, Fish & Parks	U.S.A.
Doug Manzer	Alberta Conservation Association	Canada
Luke Meduna	South Dakota Game, Fish & Parks	U.S.A.
Kim Morton	Fish and Wildlife - ASRD	Canada
Joel Nicholson	Fish and Wildlife - ASRD	Canada
Gordon Nijboer	Lotek Wireless Inc.	Canada
Richard Ockenfels	Arizona Game & Fish Dept.	U.S.A.
John Pogorzelec	Fish and Wildlife Branch, Ministry of Environment	Canada
Brian Ratliff	Oregon Department of Fish and Wildlife	U.S.A.
Kevin Redden		Canada
Trevor Rhodes	Fish and Wildlife - ASRD	Canada
Calvin Richardson	Texas Parks and Wildlife Dept.	U.S.A.
Darlene Sakires	Canadian Natural Resources Limited	Canada
Bruce Stillings	North Dakota Game & Fish Dept.	U.S.A.
Michael Suitor	Student - University of Calgary	Canada
Mark Sullivan	Montana Fish, Wildlife and Parks	U.S.A.
John Taggart	Fish and Wildlife - ASRD	Canada
Alan Violette	Alberta Sustainable Resource Development	Canada
Brian Wakeling	Arizona Fish and Game Department	U.S.A.
Catherine Watson	EnCana Corporation	Canada
Don Whittaker	Oregon Department of Fish and Wildlife	U.S.A.
Neal Wilson	Antelope Creek Ranch	Canada
Jim Yoakum	Western Wildlife	U.S.A.
Todd Zimmerling	Alberta Conservation Association	Canada