Proceedings of the Nineteenth Biennial Pronghorn Antelope Workshop

2001

Hosted by:
Centro de Investigaciones Biológicas del Noroeste, S. C.
La Paz, Baja California Sur, México.
March 14-17, 2000

PROCEEDINGS

of the

NINETEENTH BIENNIAL

PRONGHORN ANTELOPE WORKSHOP

Edited by Jorge Cancino

La Paz, Baja California Sur, Mexico

March 13 – 17, 2000

Chair
Jorge Cancino

TABLE OF CONTENTS

Posters and Abstracts

PREFACE

The Northwest Biological Research Center and the Dirección General de Vida Silvestre of the National Institute of Ecology hosted the 19th Pronghorn Antelope Workshop in La Paz, Baja California Sur, Mexico during March 13-17, 2000. A total of 42 persons participated in the workshop. The representation was as follows: 28 came from United States and 14 were from Mexico. There were 15 participants from state agencies, 11 from non-governmental organizations, 9 from federal agencies, and 7 from universities. Unfortunately, there were no Canadian or tribal representatives.

There was vast support from personal of the Arizona Game and Fish Department, especially with the status reports and with the workshop correspondence in the United States.

There was no record kept of questions and discussion after the presentations or at the business meeting. These proceedings are mainly in the format of each paper, however, the editor assumes full responsibility for minor changes in the transcriptions.

The 20th Biennial Pronghorn Antelope Workshop will be held in the spring of 2002 in Kearney, Nebraska (tentative location). Jeff Abegglen, Wildlife Biologist with the US Forest Service is the Chairperson. The workshop will be Co-sponsored by the Nebraska Game & Parks Commission and the U.S. Forest Service.

Jorge Cancino.
Chair.

SUMMARY OF PRONGHORN WORKSHOPS HELD TO DATE

Meeting dates and Locations	Number attending	Chairperson	Host Agency
April 14-16, 1965 Santa Fe, NM	18	W. Huey	New Mexico Department of Fish and Game
February 16-17, 1966 Denver, CO	32	G. D. Bear	Colorado Game, Fish and Parks Department
February 5-6, 1968 Casper, WY	97	J. L. Newman	Wyoming Game & Fish Commission
January 27-28, 1970 Scottsbluff, NE	85	K. I. Menzel	Nebraska Game & Parks Commission
June 19-22, 1972 Billings, MT.	85	H. O. Compton	Montana Fish & Game Department
February 19-21, 1974 Salt Lake City, UT	52	D. M. Beale	Utah Division of Wildlife Resources
February 24-26, 1976 Twin Falls, ID	68	R. Autenreith	Idaho Department of Fish and Game
May 2-4, 1978 Jasper, Alberta	84	M. W. Barret	Alberta Fish & Wildlife Division
April 8-10, 1980 Rio Rico, AZ	64	J. S. Phelps	Arizona Game & Fish Department
April 5-7, 1982 Dickinson, ND	69	J. V. McKenzie	North Dakota Game & Fish Department
April 10-12, 1984 Corpus Cristi, TX	45	C. K. Winkler	Texas Parks & Wildlife Department
March 11-13, 1986 Reno, NV	43	M. Hess	Nevada Department of Fish & Wildlife
May 31- June 2, 1988 Hart, Mt., OR	43	D. Eaestman	Oregon Department of Fish & Wildlife
May 22-24, 1990 Silver Creek , CO	45	T. M. Pojar	Colorado Division of Wildlife
June 8-11, 1992 Rock Springs, WY	91	P. Riddle	Wyoming Game & Fish Department
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 & Fish Department
Marzo 13-17, 2000 La Paz, Baja California Sur, México	42	J. Cancino	Centro de Investigaciones Biológicas del Noroeste – Dirección General de Vida Silvestre

Attendance register

Jeffrey S. Abegglen
Wildlife Biologist
Pine Ridge Ranger District
Nebraska National Forest
Oglala National Grassland
Chadron, NE (308) 432-4475

Patryce Avsharian
Department of Biological Sciences
University of Idaho
Moscow, ID 83844-3051

Danae Azuara
Unidos para la Conservación
Prado Norte 324
Lomas de Chapultepec
México, 11000, D. F.

Jose Bernal Stoopen
Dirección General de Vida Silvestre
Instituto Nacional de Ecolgía
Av. Revolución 1425
Col. Tlacopac
Del. Alvaro Obregón
México, D. F.

Kim Brinkley
Animal keeper
Los Angeles Zoo
534 W Doran St
Glendale, CA 91203

Jorge Cancino
Centro de Investigaciones Biológicas del Noroeste
Mar Bermejo195
Col. Playa Palo de Santa Rita
La Paz, 23090, Baja California Sur
México

Matt Carling
Department of Biological Sciences
University of Idaho
Moscow, Id 83844-3051

Ramón Castellanos
Reserva de la Biosfera El Vizcaíno
Dom. Conocido: Casa de la Fauna
Guerrero Negro, Baja California Sur
México

Wendy Clark
Wildlife Biologist
Yellowstone National Park
Ycr. Box 168
Yell. Nat. Park, WY 82190

Dalia A. Conde
Unidos para la Conservación
Prado Norte 324
Lomas de Chapultepec
México, 11000, D. F.

Jim deVos
Chief of Research
Arizona Game and Fish Dept.
2221 W Greenway Rd
Phoenix, AZ 85023

Steve Flinders
Utah Division of Wildlife
1594 W. North Temple
Salt Lake City, Utah 84114

Steve Friedland
Zoological Society of San Diego

Mike Gregg
Wildlife Biologist
U.S.F.W.S.
P.O. Box 111
Lakeview, OR 97630

Enrique Guadarrama
Unidos para la Conservación
Prado Norte 324
Lomas de Chapultepec
México, 11000, D. F.

Jim Heffelfinger
Arizona Game and Fish Dept
555 N Greasewood
Tucson, AZ 85745

John Hervert
Arizona Game and Fish Department
9140 East County 10 ½ Street
Yuma, AZ 85365

Robb D. Hitchcock
North American Pronghorn Foundation
1905 CY Ave.
Casper, WY 82604

Jeff Holland
Los Angeles Zoo
5333 Zoo Drive
Los Angeles, CA 90027

William Jensen
North Dakota Game and Fish Dept.
100 N Bismarck Expressway
Bismarck, ND 58501

Carlos Manterola
Unidos para la Conservación
Prado Norte 324
Lomas de Chapultepec
México, 11000, D. F.

Lorie Mc Cracken
Pronatura,
Presa 206 -8, San Jerónimo
México, 10200, D.F.

William H. McLean
Arizona Antelope Foundation
8896 E. Shasta Dr.
Gold Canyon, AZ 85219

Rodrigo Medellín
Instituto de Ecología
Universidad Nacional Autónoma de
México. Circuito Interior s/n
Ap. Postal 70-275
México, 04510, D. F.

John R. Morgart
U.S. Fish and Wildlife Service
Cabeza Prieta N.W.R.
1611 North Second Avenue
Ajo, AZ 85321

Richard Ockenfels
Arizona Game and Fish Deptment
2221 W Greenway Rd
Phoenix, AZ 85023

Thomas Pojar
Colorado Division of Wildlife
317 W Prospect Rd.
Ft. Collins, CO 80526

Mary Robinson
University of Idaho
1315 Linda Lane #3
Moscow ID 83843

José María Reyes Gómez
Dirección General de Vida Silvestre
Instituto Nacional de Ecolgía
Av. Revolución 1425
Col. Tlacopac
Del. Alvaro Obregón
México, D. F.

Olin E. Rhodes, Jr.
Department of Forestry & Natural Resources
Purdue University
West Lafayette, IN 47909

William Rudd
Wyoming Game and Fish Department
351 Astle Ave.
Green River, WY 92935

Oliver Ryder
Center for Reproduction of Endangered Species
Post Office Box 551
San Diego, Ca 92112

Victor Sánchez
Reserva de la Biosfera El Vizcaíno
Dom. Conocido: Casa de la Fauna
Guerrero Negro, Baja California Sur
México

Cindy Ticer
Arizona Game and Fish Department
3701 N Lynx Lake Dr
Prescott Valley AZ 86314

Donald Tiller
U.S. Fish and Wildlife Service
Cabeza Prieta N.W.R.
1611 North Second Avenue
Ajo, AZ 85321

Jim Torland
Oregon Department of Fish & Wildlife
3701 West 13th
The Dalles OR 97058

Liliana Valle
SEMARNAP- Chihuahua
Melquiades Alanis 5645
Col. Porfirio Díaz
Cd. Juárez, 32320, Chihuahua.

Manuel Valdez
Unidos para la Conservación
Prado Norte 324
Lomas de Chapultepec
México, 11000, D. F.

Don Whittaker
Oregon Depart. of Fish and Wildlife
P.O. Box 59
2501 SW First Ave
Portland OR 97207

Jason E. Zimmer
University of Wyoming
460 ½ North 11th St.
Laramie, WY 82072

Manuscript Reviewers

Gerardo Ceballos
Instituto de Ecología
Universidad Nacional Autónoma de México.

Andrew DeWoody
Institute of Environmental and Human Health
Texas Tech University
Lubbock, TX 79409-1163

Sue Fairbanks
Department of Biology
University of Nebraska
Omaha, NE 68182-0040

Oz Garton
Fish and Wildlife Resources
University of Idaho
P.O.Box 4411
Moscow, ID 83844-1136

Jim Heffelfinger
Arizona Game and Fish Deptment
555 N Greasewood
Tucson, AZ 85745

Paul Krausman
The University of Arizona
Tucson, AZ 85721

Scott L. Kronberg
Animal and range Sciences
South Dakota State University
Brookings, SD 57007

Thomas E. Lee Jr.
Department of Biology
Abilene Christian University
Abilene, TX 79699

Raymond M. Lee.
Foundation for North American Wild Sheep.
720 Allen Ave.
Cody, Wyoming, 82414.

Eric Mellink
Centro de Investigación Científica y de Educación Superior de Ensenada
Ensenada, Baja California.

Dennis Murray
Depart. of Fish and Wildlife Resources
University of Idaho
Moscow, ID 83844

Richard Ockenfels
Arizona Game and Fish Deptment
2221 W Greenway Rd
Phoenix, AZ 85023

Thomas Pojar
Colorado Division of Wildlife
317 W Prospect Rd.
Ft. Collins, CO 80526

James R. Purdue
Illinois State Museum
1011 East Ash Street
Springfield, Il 62703

Ricardo Rodríguez Estrella
Centro de Investigaciones Biológicas del Noroeste
Apdo. Postal. 128
La Paz, 23000, Baja California Sur.
México

Harley G. Shaw
P. O. Box 370
Chino Valley
Arizona 86323

SR. DIRECTOR DEL CIBNOR, Dr. Mario Martínez García
SR. DELEGADO DE LA SEMARNAP EN B. C. S., Lic. Carlos Fernando Aceves García
SR. PRESIDENTE DE LA FUNDACIÓN NORTEAMERICANA DEL BERRENDO, Robb Hitchcock
DISTINGUIDOS INVESTIGADORES Y REPRESENTANTES DE LAS AGENCIAS ESTATALES

SEÑORAS Y SEÑORES:

Agradezco la hospitalidad de nuestros amigos de Baja California Sur y a todos quienes han hecho posible que hoy nos encontremos aquí en La Paz con motivo de la realización de la **XIX Reunión Bianual del Berrendo**.

En México, hace algunos meses tuvimos el gusto de participar en la presentación de un libro del autor Lane Simonian, titulado **"La Defensa de la Tierra del Jaguar**: **Una Historia de la Conservación en México".** En esta historia de la conservación, México, Estados Unidos y Canadá han desarrollado esquemas de cooperación para la conservación de más de 65 especies compartidas. Una de estas especies, sin duda alguna, es el berrendo.

El berrendo para el caso específico de México y sus poblaciones de las 3 subespecies reconocidas, localizadas actualmente en pequeños grupos aislados en los estados de Coahuila, Chihuahua, Sonora y Baja California Sur, representan un patrimonio invaluable y con varias potencialidades para su manejo y recuperación.

Como todos ustedes saben, las poblaciones del berrendo en México han experimentado una alarmante disminución. Por ejemplo, para el caso del berrendo mexicano sus poblaciones se han reducido en un 81.9 %, principalmente en lo que corresponde al Altiplano Central Mexicano, con ambientes como las zonas áridas con tipos de vegetación de pastizal y matorral espinoso de los estados de Coahuila y Durango extendiéndose hacia el sur hasta Tehuacán, Puebla; en la actualidad, solo se cuenta con registros de su distribución en 10 regiones de Chihuahua y tanto en el "Valle de Colombia" y rancho "El Novillo", Coahuila, dada la exitosa reintroducción que realizó la agrupación Sierra Madre y Unidos para la Conservación en coordinación con la Dirección General de Vida Silvestre y el New México Game a Fish Department.

Por otra parte, se cuenta con un hato reproductivo de 21 ejemplares del berrendo peninsular, 7 de ellos ya nacidos en cautiverio durante este ciclo. Cabe destacar que este proyecto esta vinculado a las acciones de conservación incluidas en el Plan de Manejo de la Reserva de la Biosfera "El Vizcaino", en el que participan también el CIBNor, Ford Motor Company y el Nuevo Centro de Población Ejidal "Lagunitas"

Así también, el IMADES ha desarrollado proyectos de investigación sobre la ecología de las poblaciones del berrendo sonorense en la Reserva de la Biosfera "El Pinacate y Gran Desierto de Altar", en los que participa el Arizona Game and Fish Department.

Actualmente la Dirección General de Vida Silvestre, desarrolla esquemas de participación social para el desarrollo sustentable con base a la evaluación de las poblaciones del berrendo sonorense en coordinación con el Centro Cinegético Integrado.

Desde hace más de 10 años, diversas autoridades federales y estatales, academia, iniciativa privada, así como organizaciones no gubernamentales, han buscado evitar la extinción del berrendo por medio de acciones de investigación científica, reintroducciones, conservación del hábitat y manejo, aún cuando sus esfuerzos han sido un tanto aislados y sus logros con diversos grados de éxito.

En un afán de integración y ordenamiento de conocimientos, recursos y esfuerzos, se convocó a una reunión de trabajo para el establecimiento de bases sobre Conservación, Investigación y Manejo del Berrendo, que tuvo verificativo en 1999, en la Unidad de Manejo Integral de la Vida Silvestre "San Cayetano", Estado de México, participando autoridades federales y estatales, iniciativa privada, organizaciones no gubernamentales, instituciones de investigación y de enseñanza superior.

Resultado de esta reunión, se logró la conformación de un grupo de trabajo que aprobó el **Proyecto para la Conservación, Manejo y Aprovechamiento del Berrendo en México (PREP del Berrendo**), que en breve presentaremos en México y se formalizo asimismo el "**Subcomité Técnico Consultivo para la Conservación, Manejo y Aprovechamiento del Berrendo en México".**

Estimados Señores y Señoras, amigos invitados, la constitución de éste Subcomité y su Programa de Trabajo, contribuyen cabalmente al cumplimiento de una de las tres grandes estrategias de trabajo de nuestra institución, la cual está orientada a alcanzar una efectiva contención del deterioro del medio ambiente y su biodiversidad.

Los enormes retos que implican el dar respuesta exitosa a esta estrategia, reconocemos que solo será posible en la medida en que los diversos sectores de la población se comprometan y hagan causa común en temas, que en consenso, estimemos son prioritarios para su atención. Por ello, el trabajo realizado anteriormente sobre el tema berrendo, sirve hoy de base para el lanzamiento de esta importante iniciativa, la cual es producto de una amplia consulta y participación social.

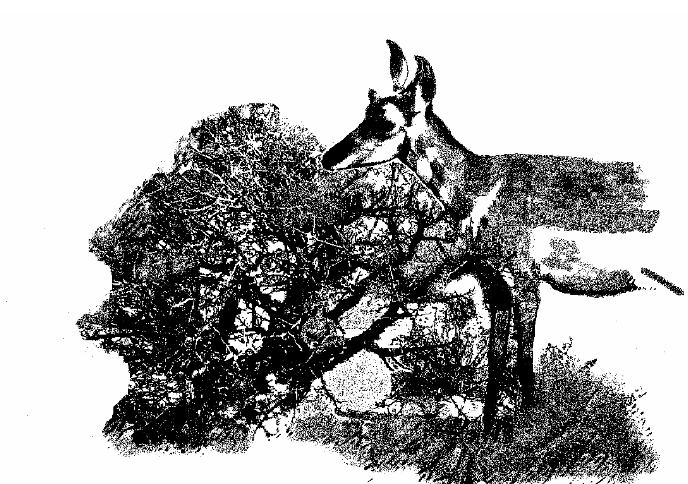
Es de destacar, que esta participación, se ha realizado de manera desinteresada y mediante recursos, en la mayoría de las veces propios, por lo tanto, deberemos diseñar los mecanismos que nos permitan establecer un fondo financiero, administrado por el mismo Subcomité, con el cual se atiendan y desarrollen proyectos y acciones prioritarias encaminadas al cumplimiento de los objetivos y metas planteadas.

Esto nos alienta y estimula por cuanto sabemos, que estamos todos comprometidos en una tarea de largo plazo, ya que los procesos ambientales y la permanencia de las especies de flora y fauna silvestre, no reconocen ni obedecen a tiempos administrativos. Por eso, hago un llamado a todos ustedes para que hagan suya esta y otras iniciativas semejantes para asegurar la continuidad y el éxito.

Una señal de que todos habremos cumplido con nuestra tarea, será ver correr en el altiplano y pastizales de México al Berrendo.

Agradezco a todos ustedes su entusiasmo, confianza y participación desinteresada. Estoy seguro que los resultados de este 19 Taller Bianual sobre Berrendos nos será de estimulo para continuar las tareas que nos permitan transitar hacia un desarrollo sustentable.

Biol. José María Reyes Gómez



Vizcaino Desert, Baja California Sur, Mexico.

Dr. Mario Martínez, Director of CIBNOR
Lic. Carlos Fernando Aceves García, SEMARNAP Delegate
Distinguished Researchers and State Agency Representatives
Ladies and Gentlemen

I thank the hospitality of our friends of Baja California Sur and all of those that have made possible our encounter here in La Paz, to celebrate the XIX Biannaul Pronghorn Workshop.

Some months ago, we had the pleasure in México to participate in the presentation of Lane Simonian´s book "The Defense of the Land of the Jaguar: A History of the Conservation in Mexico". In this conservation history, México, the United States and Canada have developed joint collaborative efforts for the conservation of more than 65 shared species. One of this shared species, is the pronghorn, indeed.

The pronghorn, and its 3 recognized subspecies in Mexico, currently located in small and isolated groups in the states of Coahuila, Chihuahua, Sonora and Baja California Sur, represent an invaluable heritage for our country, an inheritance with strong posibilities for its management and recovery.

As we all know, pronghorn populations in Mexico have dramatically decreased. For example, the numbers of A. a. mexicana have decreased 81.9%, mainly throughout the Mexican central plains, which are characterized by arid areas with thorny bushes and grasslands in the states of Coahuila and Durango, extending south down to Tehuacán, Puebla. Presently, this subspecies is reported in only 10 locations of Chihuahua and in the "Valle de Colombia" and in "El Novillo" Ranch, in the state of Coahuila, as a result of a successfull reintroduction coordinated by Sierra Madre and Unidos para la Conservación with the Dirección General de Vida Silvestre and the New México Game a Fish Department.

On the other hand, there is a captive breeding herd of 25 individuals of the peninsular pronghorn, 7 of them born in captivity during this cycle. This breeding project is entailed with the conservation actions included in the Management Plan of the Biosphere Reserve "El Vizcaíno", in which CIBNor, Ford Motor Company and the New Population Center Ejidal "Lagunitas", are participating actively.

IMADES has also developed long-term studies concerning the population ecology of the sonorensis subspecies in the "El Pinacate y Gran Desierto de Altar" Biosphere Reserve, in which the Arizona Game and Fish Department is involved.

The Dirección General de Vida Silvestre is developing social opportunities for the sustainable use of the pronghorn based on evaluations of the populations of the sonorensis subespecies in coordination with the Centro Cinegético Integrado.

During the last decades, several federal and state agencies, the academia, the private sector and different non-governmental organizations, have worked together to prevent the pronghorn extinction. Numerous scientific studies, habitat conservation and management activities and reintroductions, have been developed and, although they have been somewhat isolated, they have showed different levels of success.

In 1999, a workshop for the Conservation, Research and Management of the Pronghorn in Mexico was conducted at the San Cayetano Wildlife Station, in the State of México with the participation of several representatives from federal and state agencies, the private sector, non-governmental organizations, universities and research centers. The goal of this workshop was to integrate and organize the available knowledge, human and economic resources and conservations efforts developed for the pronghorn in Mexico.

This workshop was extremely successful. First, a working group approved the **Conservation, Management and Sustainable Use Project for the Pronghorn in Mexico**, a national recovery strategy that will soon be officially presented in Mexico. Secondly, during the meeting, the **Technical Advisory Subcommittee for the Conservation, Management and Sustainable Use of the Pronghorn in Mexico,** was established.

Dear Ladies and Gentlemen, invited friends, the creation of this subcommittee and the approval of its Working Program, fully meets one of the three major working strategies of our institution, which is oriented towards stoping effectively the deterioration of the environment and the biological diversity.

We recognize that the accomplishment of this strategy will only be possible through the strong commitment and active participation of the diferent sectors of our society. Based on this fact, the different initiatives that have been developed for the pronghorn set the basis for the release of an important initiative that could only result from a wide public consultation and strong social participation.

It is extremely important to akcnowledge that this participation has been developed taking only into consideration the continuity of the species and that in most cases has been supported through the resources of each institution. Because of this, it is necessary to identify an effective mechanism to create a finantial trust to be administered by the pronghorn subcomittee, which will help to develop successfully the priority actions in order to accomplish the project´s goals and objectives.

This encourages and stimulate us, because we are all committed to a long term goal, because the environment processes and the survival of the flora and fauna , do not recognize, nor obey administrative periods. This is why I urge you to participate actively in this and other initiatives to assure their continuity and success.

We will succeed in our efforts when we see the running free through the plains and through the pasture grounds of Mexico.

I wish to thank your enthusiasm, trust and willing participation. I am sure that the results of this 19th Biannual Workshop of the Pronghorn will stimulate all of us to continue the tasks that will allow us to accomplish the conservation of our natural resources through sustainable development programs.

Translator: Lorie Mc Cracken

PRONGHORN PROVINCE AND STATE STATUS REPORT

CINDY L. TICER, Research Branch, Arizona Game and Fish Department, 2221 W. Greenway Road, Phoenix, AZ 85023-4312, USA

JAMES, C DEVOS, JR., Research Branch, Arizona Game and Fish Department, 2221 W. Greenway Road, Phoenix, AZ 85023-4312, USA

Abstract: We sent standardized questionnaires to 19 western states in the United States, 3 Canadian provinces, and Mexico to collect 1999 pronghorn (*Antilocapra americana*) population, survey, and hunt information. We received responses from 18 of the 19 western U. S. states, 1 Canadian province, and 2 from Mexico. We clarified information over the phone and summarized information by topic and management strategy.

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19: 7-18

Key words: *Antilocapra americana*, data, hunt, management strategies, population, questionnaires, survey.

INTRODUCTION

The Western Association of Fish and Wildlife Agencies (WAFWA) sanctions the Biennial Pronghorn Workshop to advance management and research on pronghorn (*Antilocapra americana)*. To ensure that data pertaining to pronghorn survey and harvest are recorded in a consistent, retrievable manner, a standardized questionnaire was developed and sent to 19 U. S. states, 3 Canadian provinces, and contacts in Baja California Sur, Sonora, and Chihuahua. Eighteen U. S. states, 1 province, and 2 entities in Mexico responded.

POPULATION ESTIMATES AND SURVEY METHODOLOGY

Population estimates ranged from 150 in Baja California Sur, Mexico to 450,000 in Wyoming (Table 1). Alaska, Hawaii, and Washington reported that they have no pronghorn. With the exception of Chihuahua, Mexico, which used ground surveys exclusively, most surveys were conducted using fixed-wing aircraft. Idaho and Nevada used helicopter surveys in conjunction with fixed-wing surveys and Nevada, Oregon, Utah, Wyoming, and Baja California Sur used both ground and fixed-wing surveys (Table 1). The most common survey method used was line transects, however, California, Nevada, Montana, and Chihuahua, Mexico used direct counts and New Mexico used a strip transect (Table 1). Most states used survey counts and/or population models to derive population estimates (Table 1). Observation rates varied by method and by state and ranged from “unknown” in Colorado, Montana, and Oregon to 100% in North Dakota, Texas, and Chihuahua, Mexico (Table 1).

HARVEST SUMMARY

We used harvest data and population estimates to estimate percent population harvested for each respondent (Table 2). The mean percent of pronghorn populations harvested ranged from 5% in Arizona and Texas to ~29% in Montana (Table 2). Pronghorn are not hunted in Baja California Sur and Chihuahua, Mexico. Arizona, Texas, and Alberta were the only respondents that did not harvest does/fawns (Table 2). Where does and fawns were harvested, the percent harvest ranged from 3 to 50%.

Except for the states in Mexico, all respondents offered rifle hunts with at least a 64% hunter success rate (Table 3). Wyoming rifle hunt success can be >100% because more than 1 pronghorn may be harvested by a hunter. Only 5 states (Arizona, Colorado, New Mexico, Oregon, and Wyoming) offered muzzleloader-only hunts. Wyoming had a very short muzzleloader season, but no harvest data were provided, Kansas and Alberta did allow muzzleloaders to be used during the general rifle season. Muzzleloader hunter success ranged from 64% in Arizona to 87% in New Mexico (Table 4). Most respondents offered archery-only hunts; percent success ranged from 11% in Oregon and South Dakota to 50% in Alberta (Table 5).

We asked the respondents to provide an estimate of pronghorn harvest for 1989 and 1999. In those jurisdictions with the largest harvest (>1,000) all experienced a sharp decline in harvest. Idaho, North Dakota, and Alberta had harvest declines >50%. Wyoming and Montana had the greatest decline with Wyoming having a decline of nearly 25,000 animals harvested (Figure 1). States with smaller populations and harvest (<1,000) were more stable with some showing slight increases in populations. Total hunter numbers and total hunter days trends were similar in most states.

SEASON STRUCTURE

Hunt season structure varied by jurisdiction (Table 6). Many muzzleloader hunts occurred in conjunction with rifle or archery hunts and/or had their own season following the rifle hunt. Most archery hunts opened prior to firearm hunts, with the exception of Oregon whose archery hunt opened following their firearm hunt and Oregon whose archery hunt occurred just before and following the firearm hunt.

MANAGEMENT STRATEGIES

Non-resident hunters

Most respondents (81%) imposed pronghorn hunt restrictions on non-resident hunters, New Mexico promoted non-resident hunters, and the remaining jurisdictions neither promoted nor restricted non-resident hunters (Table 7). Restrictions varied from a maximum of 3% - 22% of the tags allocated to non-residents. North Dakota offers an archery-only season for non-residents.

Partnership programs

Most respondents had a partnership program to address wildlife-landowner conflicts. Arizona, Colorado, New Mexico, and Wyoming developed habitat partnership committees and programs comprised of agency personnel and stakeholders to foster communication, enhance cooperation with beneficial projects, and to reduce conflict. In addition, New Mexico designed a landowner sign-up system that distributed 3,380 permits to 800 participating landowners, opening 3 million acres of private land to public hunters.

Several states have landowner compensation programs. California, through their Private Lands Management Program, issues tags (21 in 1999) to landowners that market them. Colorado uses 5% of their pronghorn license revenue to fund The Wildlife Ranching Program where a landowner signs a contract with the Division of Wildlife agreeing to improve habitat for wildlife on their private property. In return, the landowners are issued permits for times outside the regular hunt pronghorn season. Harvest quotas are established and the landowner and agency personnel agree on license numbers. Applications for 60% of the licenses are given to the landowner to market. Kansas has a Walk-In-Hunting Program in which they lease private land and landowners are also provided half-priced permits. Nevada's Landowner Compensations Tag Program provides each landowner with 1 buck tag for every 50 pronghorn on their private land. Utah developed a big game habitat program that generates habitat authorization fees through a license. Wyoming reimburses landowners for damage on their private lands and also provides them with coupons worth $11.00/pronghorn harvested on their property.

Special Tags

Arizona, California, Nevada, Texas, Utah and Wyoming offered special tag programs to generate revenue for pronghorn management (Table 8). All states, but Wyoming offer these tags through auctions or raffles. Wyoming raises the cost of 30% of authorized tags by $100.00 each, with the proceeds (varied from $7,000 - $200,000 in 1999; Table 8) designated to pronghorn management. Hunters are restricted to specific areas in California, Texas, Wyoming, and some of the tags in Utah. Hunters in the remaining states can hunt statewide. Arizona, California, Nevada, and Utah provide for longer hunts with special tags; Texas and Wyoming restrict special tag hunts to the general season.

Harvest Pressure Management

All respondents limit opportunity to harvest pronghorn. Arizona uses pre-hunt buck:doe and fawn:doe ratios to establish harvest quotas. Generally, permits decrease when pre-hunt buck:doe ratios are < 25:100 and doe:fawn ratios are < 30:100; and increase if buck:doe ratios are > 30:100 and fawn:doe ratios are > 40:100. New Mexico varies permits to maintain a buck:doe ratio (20:100), but also consider landowner tolerance. Oregon used their summer fawn:doe ratio and population trend data, Utah used buck:doe:fawn ratios, and Nevada used only buck:doe ratios to establish quotas. Idaho used harvest trend data and age structure of harvested animals whereas Kansas used population trend data. California (6% of winter population size), Montana, and Alberta used population estimates to determine harvest levels.

Predator Control Programs

Arizona, Montana, Utah, Baja, and Chihuahua conducted some form of predator control program for pronghorn. Although Alberta did not have an organized control program they encourage coyote control through liberal trapping and hunting seasons. Arizona provided $23,000 in a contract with USDA-APHIS for predator control via aerial gunning of coyotes prior to fawning season. Montana also aerially guns coyotes in selected areas prior to fawning season. Utah conducts predator control in certain units when deemed necessary. Baja conducts coyote control around their captive pronghorn management facilities during fawning season and Chihuahua use depredation control.

Current Research

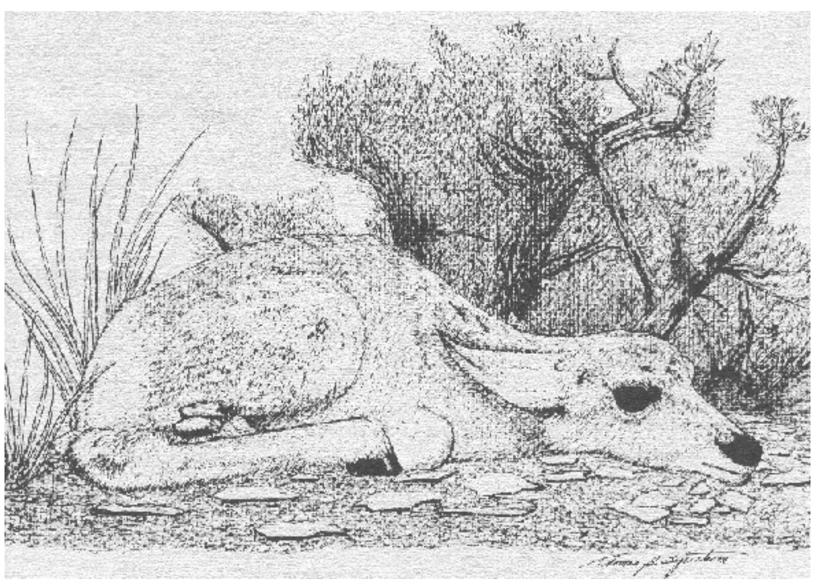
Arizona, California, Colorado, North Dakota, Wyoming, and Baja California Sur were currently conducting pronghorn research projects. In northern Arizona, there were 2 separate projects identifying habitat limitations of pronghorn. These projects are pre-treatment studies to evaluate the effects of fenceline modification on pronghorn movements. Arizona is also conducting taxonomic, disease, and mineral requirement studies. The U. S. Fish and Wildlife Service has funded studies on the effects of military overflights on Sonoran pronghorn behavior and fawning on the Barry Goldwater Experimental Range. Research on Sonoran pronghorn in southwestern Arizona continued relative to forage enhancement and pronghorn habitat use on disturbed military sites.

California has been investigating survey methodology and seasonal pronghorn distribution. Colorado has been evaluating the habitat selection and population dynamics of a pioneering pronghorn population. North Dakota has been developing a descriptive analysis of pronghorn range and habitat use.

Wyoming is conducting 2 research projects with a 3rd slated to begin in 2000. The first is a study designed to identify movement corridors of a small pronghorn population that summers within Teton National Park, but migrates >330 km to winter. The second is a fawn mortality study in central Wyoming to identify the cause of fawn losses to identify how mortality patterns change with time and are linked to habitat conditions. The 3rd study will occur on Warren Air Force Base in Cheyenne to provide information about pronghorn that live on the base. Baja California Sur has ongoing research on Peninsular pronghorn nutritional requirements, habitat, and health status.

Other Management Programs

Nevada is attempting to improve pronghorn water availability as a step towards improving habitat for transplants. Oregon has been evaluating their aerial line transect for estimating abundance. Kansas has been investigating human dimensions and landowner desires related to pronghorn. In Wyoming, a statewide Wyoming Game and Fish working group was formed in 1999 to bring more management attention to pronghorn. This internal group is made up of interested biologists and wardens and its purpose is to help guide research and management. The group is currently working on a rewrite of the pronghorn techniques manual, evaluating differential fawn sex ratios observed in harvest and trapping data, reviewing and updating population model parameters, and identifying research needs.



Frontispiece of the Proceedings of the
Tenth Biennial Pronghorn Antelope Workshop

Table 1. 1999 pronghorn population estimates and survey methodology of western states, Alberta, and Mexico, 2000.

Province/ State	Population Estimate	Survey Vehicle	Survey Method	Estimate Method	Percent Observed
United States					
AZ[a]	12,000	Fixed-wing	Line transect	Model POP DYN	80
CA	6,100	Fixed-wing	Visual obs.	Count	95
CO	60,750	Fixed-wing	Line transect	Computer Simulations	Unkn.
ID	10,500	Fixed-wing Helicopter	Line transect	Count	<60
KS	2,000	Fixed-wing	Line transect	Count	~60
MT	~120,000[c]	Fixed-wing	Visual obs.	Count	Unkn.
NV	15,000	Fixed-wing Helicopter Ground	Visual obs.		48±10
NM	35,000	Fixed-wing	Strip	Count	
ND	5100	Fixed-wing		Indices	Usu. 100
OK[b]	700	Fixed-wing	Line transect	Count	50
OR[a]	12,367	Fixed-wing Ground	Line transect	Count	Unkn.
SD	19,900	Fixed-wing	Line transect	Count	~33
TX	10,000	Fixed-wing	Line transect	% change	100
UT		Fixed-wing Ground	Line transect	Count	50-90
WY	450,000	Fixed-wing Ground	Line transect	Model POP II	<50
Canada					
Alberta[a]	14,000	Helicopter	Line transect		20
Mexico					
Baja Calif. Sur	150	Fixed-wing Ground			50
Chihuahua	160	Ground	Visual obs.	Count	100

[a] 1998 data.
[b] 1992 data.
[c] Estimate based on harvest data.

Table 2. 1999 pronghorn harvest data of western states and Alberta, 2000.

State/ Province	Population estimate	Total harvest	Total % Harvest	No. bucks harvested	% bucks harvested	No. does/fawns harvested	% does/fawns harvested
AZ	12,000[a]	574	5	574	100	0	0
CA[a]	6,100	347	6	243	70	104	30
CO	60,750	8259	14	4,314	52	3,945	48
ID	10,500	1147	11	843	74	304	26
KS	2,000	165	8	136	82	29	18
MT[b]	~120,000[c]	34,463	~29	17,281	50	17,183	50
NV	15,000	1,061	7	1,028	97	33	3
NM	35,000	3,269	9	3,053	93	216	7
ND	5100	748	15	386	52	362	48
OK	700[d]	55	8	49	89	6	11
OR[a]	12,367	1,086	9	914	84	172	16
SD	19,900	2,696[e]	14	1,940[e]	72	756[d]	28
UT[a]		1,094		532	49	562	51
TX[a]	10,000	490	5	490	100	0	0
WY	450,000	27,022	6	18,595	69	8,427	31
Alberta	14,000	406	3	406	100	0	0
TOTAL	773,417	82,882		50,784		32,099	

[a] 1998 data.
[b] 1995 data.
[c] Estimate based on harvest data.
[d] 1992 data.
[e] 1998 archery data, 1999 rifle data.

Table 3. 1999 pronghorn rifle harvest and percent success for western states and Alberta, 2000.

State/ Province	Buck Harvest	Doe/fawn harvest	Total Harvest	% hunter success
AZ	420	0	420	84
CA[a]	234	103	337	64
CO[a]	4,232	3,803	8,035	70
ID	843	304	1,147	70
KS	124	22	146	75
MT[b]	17,019	17,084	34,103	69
NV	989	33	1,022	81
NM[a]	2,821	216	3,037	87
ND	314	329	643	85
OK	49	6	55	68
OR[a]	863	168	1,031	68
SD	1,882	745	2,627	72
TX[a]	490	0	490	82
UT[a]	532	562	1,094	86
WY	21,632	9,109	30,741	93
Alberta[a]	358	0	358	81
TOTAL	52,802	32,484	85,286	

[a] 1998 data.
[b] 1995 data.

Table 4. 1999 pronghorn muzzleloader harvest and percent success for western states, 2000.

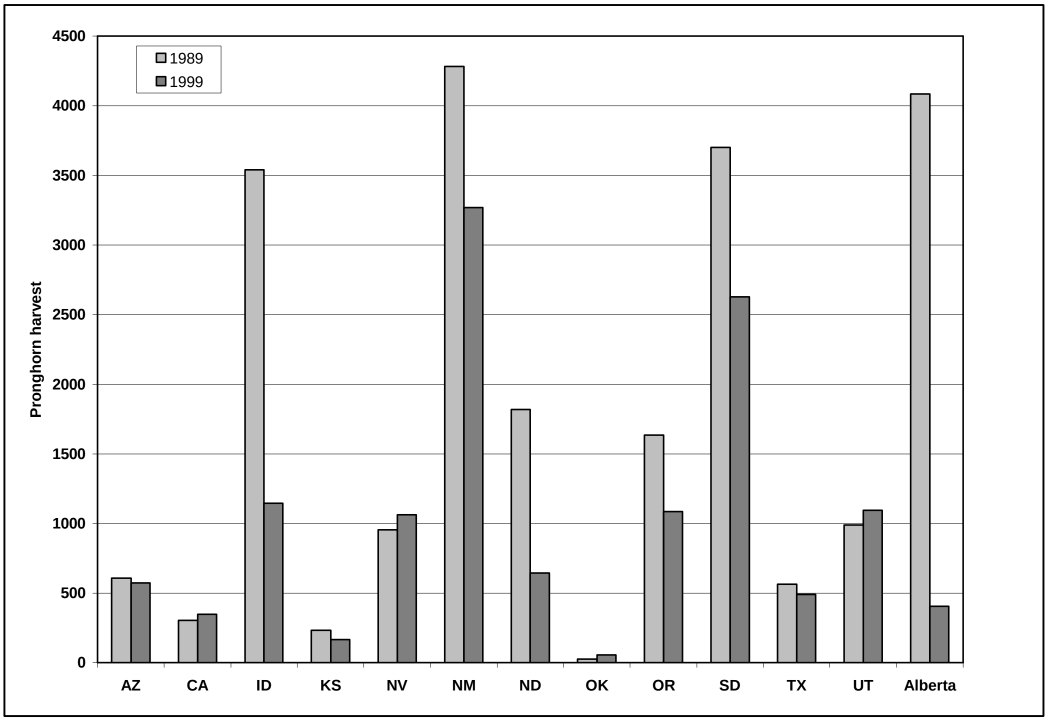
State/ Province	Buck Harvest	Doe/fawn harvest	Total Harvest	% hunter success
AZ	57	0	57	64
CO[a]	4,232	3,803	8,035	70
NM[a]	2,821	216	3,037	87
OR[a]	863	168	1,031	68
TOTAL	7,973	4,187	12,160	

[a] 1998 data.

Table 5. 1999 pronghorn archery harvest and percent success for western states and Alberta, 2000.

State/ Province	Buck Harvest	Doe/fawn harvest	Total Harvest	% hunter success
AZ	97	0	97	17
CA[a]	9	1	10	29
CO[a]	341	33	374	20
ID	*	*	60	18
KS	12	7	19	13
MT[b]	262	99	361	28
NV	39	0	39	26
NM[a]	116	0	116	20
ND	72	33	105	20
OR[a]	41	4	45	11
SD	58	11	69	11
WY	*	*	896	40
Alberta[a]	48	0	48	50
TOTAL	1,095	188	2,239	

[a] 1998 data.
[b] 1995 data.
* No data for sex.



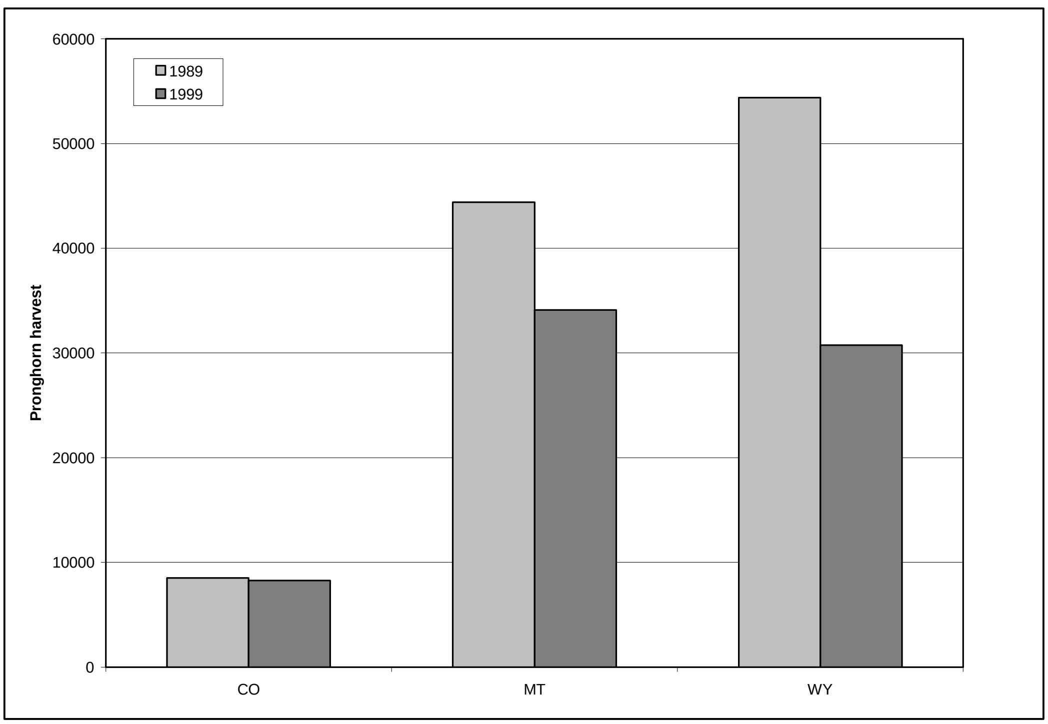


Figure 1. 10-year total pronghorn harvest data from 15 western states and Alberta, 2000.

Table 6. Pronghorn hunt season structures for 15 western states and Alberta, 2000.

State/ Province	Rifle opening day	Season length (days)	Muzzleloader opening day	Season Length (days)	Archery opening day	Season length (days)	Special Status Hunt
AZ	Sept. 24-27 or Oct. 1-6	4-6	Sept. 24-27 Sept. 24-29	4-6	Aug. 27-Sept. 9	14	Juniors only (eligible throug year of 15th birthday)
CA	Aug. 19-27	9	Aug. 19-27	9	Aug. 5-13	9	Junior (12-16 years.) fund-raising
CO	Sept. 25-Oct. 1 or Oct. 2-8	7	Oct. 21-24	9	Aug. 15-Sept. 20	37	Wildlife Ranching
ID	Sept. 25-Oct. 24	30	Aug. 1, Sept. 25-Oct. 24.	30-55	Aug. 15-Sept. 15	31	
KS	Oct. 1 (1st Friday in Oct.)	4	Oct. 1 (during rifle hunt)	4	Sept. 20	9	
MT	Oct. 8-Nov. 5	29			Sept. 2-Oct. 7	36	
NV	Aug. 26-Sept. 4	10			July 29-Aug. 13	16	Depredation (either sex) Doe
NM	Aug. 28-30 (NE) Sept. 18-19 (SE)	3 2	Aug. 14-17 (NE) Sept. 25-26 (SE)	4 2	Aug. 14-18	5	Youth (12-17 yr.) Handicapped Military (unit 2
ND	1st Friday in Oct.	16.5				45	
OK	Buck: last Thursday in Sept. Doe: 3rd weekend in Dec.	4 4					
OR	Aug. 14-22	9	Sept. 4-12	9	Sept. 4-12	9	
SD	Oct. 2-10	9			Aug. 21-Oct. 1 Oct. 11-31	63	
TX	Oct. 2-10	9					
UT	Sept. 9-26	18			Aug. 19-Sept. 8	21	
WY	Sept. 18 & Oct. 1	14-34 (var.)	Aug. 20-Sept. 1	19	Aug. 15 or Sept. 1 (variable)	15-31 (var.)	
Alberta	Sept. 28- Oct. 24	12			Sept. 9-26	16	Trophy Doe/Fawn

Table 7. Non-resident pronghorn hunter restrictions for 15 western states and Alberta, 2000.

State/ Province	Restrictions Present (yes/no)	Restrictions
AZ	No	
CA	Yes	Fund-raising tags (1 of ~21 PLM tags).
CO	No	
ID	Yes	No archery limits. 1 tag/<10 permit hunts. 10% of >10 permit hunts.
KS	Yes	Prohibited by state law.
MT	Yes	10% of tags available
NV	Yes	5% of tags available
NM	Yes	22% of tags available No limits on private lands.
ND	Yes	Archery only.
OK	No	
OR	Yes	3% of tags available
SD	Yes	8% in good years.
TX	Yes	Landowner controlled.
UT	Yes	10% of tags available
WY	Yes	20% and leftovers.
Alberta	Yes	% varies

Table 8. Pronghorn Special Tags in 6 western states, 2000.

State	Program	$	Permitted hunt areas	Season Length
AZ	Auction/Raffle 2 tags	36,000	Statewide	Longer
CA	Auction 4 tags	12,000-16,000	Restricted	Longer
NV	Auction	~7,000	Statewide	Longer
TX[a]	Grand Slam	200,000+	Restricted	General hunt season
UT	Auction/Raffle	~10,000-20,000	Statewide/ Restricted	Longer
WY	Higher priced tags	134,292	Restricted	General hunt season

[a] Pronghorn is 1 of 4 species hunted by the person who wins the Grand Slam hunt.

SONORAN PRONGHORN RECOVERY: HABITAT ENHANCEMENTS TO INCREASE FAWN SURVIVAL

JOHN J. HERVERT, Arizona Game & Fish Dept., 9140 E. 28th Street, Yuma, AZ 85365

JILL L. BRIGHT, Arizona Game & Fish Dept., 9140 E. 28th Street, Yuma, AZ 85365

LINDEN A. PIEST, Arizona Game & Fish Dept., 9140 E. 28th Street, Yuma, AZ 85365

MARK T. BROWN, Arizona Game & Fish Dept., 9140 E. 28th Street, Yuma, AZ 85365

ROBERT S. HENRY, Arizona Game & Fish Dept., 9140 E. 28th Street, Yuma, AZ 85365

Abstract: Sonoran pronghorn (*Antilocapra americana sonorensis*) are listed as endangered. From 1994 to1998, fawn recruitment has varied from zero fawns in 1996 and 1997 to 33 per 100 does in 1998. Fawn mortality occurs during 2 time periods: late spring and summer. Recruitment is correlated with the amount and timing of rainfall. During the spring, nutritious forage is necessary for increased energy demands of lactating females and newly weaned fawns. When winter rains are above normal, and corresponding forage conditions are good, fawns survive at least through spring. The second period of high fawn morality was noted during July and August. This is most likely due to increasingly higher temperatures, reduction and desiccation of forage, and increased water needs of fawns. Recruitment of fawns is key to recovery of Sonoran pronghorn. In this paper, we outline our proposal to provide additional and longer lasting forage through habitat manipulations and irrigation. Increased nutritious forage and supplemental water at critical times, when does are lactating and fawns are foraging for themselves, may increase fawn recruitment.

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19:27

Key words: *Antilocapra americana sonorensis,* fawn recruitment, habitat manipulations, rainfall, recovery, Sonoran pronghorn.

INTRODUCTION

Sonoran pronghorn *(Antilocapra americana sonoriensis)* are 1 of 5 subspecies of pronghorn antelope and are found only in southwestern Arizona and parts of west-central Sonora, Mexico. Sonoran pronghorn were listed as endangered in

1967 by the U.S. Fish and Wildlife Service. Current estimates indicate there are < 142 individuals in the United States (U.S.) (Bright et al. 1999). In the U.S., they inhabit the harsh Sonoran Desert where summer temperatures often exceed 40^{o} C and rainfall averages < 130 mm. Sonoran pronghorn habitat consists of the wide, flat, alluvial valleys dominated by creosote (*Larrea tridentata*) and bursage (*Ambrosia spp*.) and the more complex bajadas on lower slopes of mountains. Small ephemeral washes bordered by paloverde (*Cercidium spp.*) and ironwood (*Olneya tesota*) flow from the bajadas into the valleys and provides forage resources and thermal protection. In Arizona, Sonoran pronghorn are found on the Cabeza Prieta National Wildlife Refuge (CPNWR), Organ Pipe Cactus National Monument (OPCNM), Barry M. Goldwater Range (BMGR), and some adjacent public and state lands south of Interstate 8.

Their historical range has been altered and fragmented by human activities, such as damming and diverting large rivers for agriculture, construction of highways and fences, livestock grazing, settlement, recreation and some military activities (USFWS 1998). Low-level Border Patrol flights relative to illegal immigration may also impact pronghorn. These types of activities have reduced the amount and quality of habitat available to Sonoran pronghorn, possibly leading to low population levels.

Although Sonoran pronghorn range has been reduced by numerous past and ongoing human activities (construction of roads, recreation, etc.), available data indicate that reproductive success and fawn survival are largely governed by environmental factors, not by current land-use practices. No differences in mortality rates were detected between the heavily use BMGR and the largely protected CPNWR / OPCNM area (Hervert et al. 2000). However there are significant correlations between fawn mortality and the amount and timing of rainfall (Hervert et al. 2000). Availability of nutritious forage for lactation and young fawns, which is dependent on rainfall, is critical.

Sonoran pronghorn diet has been studied through microhistological analysis of fecal pellets collected from 1994 through 1998. These analyses have shown that forbs and shrubs make up the majority of Sonoran pronghorn diets (Hervert et al. 2000). Forbs are selected when they are available, such as in wet summers. Browse makes up the main component of their diet when forbs are not available, such as during droughts. Nutritional analysis indicate that forbs contain large amounts of protein, as well as being highly digestible and providing preformed water, while shrubs are high in fat (Hughes and Smith 1990, Fox 1997). Numerous studies of pronghorn feeding habits in other parts of the country confirm that nutritious forbs are the most selected forage items for pronghorn when they are available (Beale and Smith 1970, Yoakum 1990).

Availability of preferred food items for pronghorn is dependent on the timing and amount of rainfall. All desert plants respond to moisture input, but annual plants are triggered by rainfall. Normal periods of rainfall in the Sonoran desert follow a bimodal pattern, occurring as convective thundershowers in the summer and long cyclonic storms in the winter. Winter storms are the primary stimulant of plant productivity, much of it in the form of winter ephemeral plant growth (Patten 1978). Adequate winter rains are needed to sustain winter annuals into spring and early summer, when females need nutritious forage for the high energy demands of lactation and weaned fawns need quality forage for growth.

Additionally, a good summer monsoon season is needed to produce sufficient quantities of summer annuals and promote new growth on perennials, without which fawns will be unable to maintain body weight and will subsequently die. Summer monsoons also provide ephemeral sources of free standing water.

Sonoran pronghorn use certain areas of the BMGR on a much more frequent basis than surrounding areas (deVos 1989; Hervert et al. 1997*a*, 2000). These are areas that have been disturbed by military activities (e.g. HE Hill, targets, and runways), creating a more open habitat, favorable to pronghorn. In addition, the disturbed soil surface, which holds water runoff better than surrounding flat areas, promotes increased herbaceous plant growth preferred by pronghorn. Availability of late season quality forage and free standing water, which collects in clay bottomed bomb craters, allow pronghorn to occupy these areas longer and in larger groups than otherwise expected (Hervert et al. 1997*b*). Additionally, more fawns were associated with the pronghorn groups occupying the BMGR than were observed in other areas (unpubl data).

Using what we have learned through observations of pronghorn use and fawn survival on the disturbed areas on the BMGR, and knowledge of pronghorn behavior, feeding habits and nutritional requirements, we propose, through habitat manipulations, to provide areas favorable to pronghorn, during periods critical to fawn survival. By creating open habitats, with plentiful food and water, we expect to increase fawn survival.

PROPOSED METHODS

SITE SELECTION

Habitat enhancement sites will be located within current pronghorn range based on several factors. The main considerations for locating sites are: 1) areas that pronghorn are known to favor during winter and spring; 2) areas with soil types conducive to forb growth; 3) areas with existing road accessibility; and 4) areas without land use conflicts, such as military use or wilderness (Table 1).

Sonoran pronghorn are nomadic animals, covering > 900 km^2 throughout the year (Hervert et al 2000). Using the last 5 years of radio telemetry data, areas that pronghorn typically use during the winter and spring months will be determined. In addition, habitat enhancement sites may be placed in areas that pronghorn normally pass through enroute to their preferred summer habitats, such as at the base of bajadas or near chain-fruit cholla (*Opuntia fulgida*) areas. Additional sites in summer habitats may be considered during droughts.

In addition to selecting areas that pronghorn should frequent, habitat enhancement sites must also be in soils that are conducive to forage growth and persistence. Sandy soils allow deeper penetration of moisture and allow roots to penetrate farther underground. Tevis (1958) found that the onset of wilting and drying of ephemeral forage was delayed by 2 weeks in areas of sandy dunes compared to adjacent heavier soiled flat areas. Even a slight piling of windblown sand in the flat areas produced better conditions of water penetration and retention.

HABITAT MANIPULATIONS

Most habitat enhancement sites will typically cover an area of 1 km^2, which is based on the size of the disturbed areas preferred by pronghorn on BMGR. Some areas are designed along existing roads and will only be 500-m long and approximately 30-m wide on one side of the road.

<u>Creosote Thinning:</u> Creosote bush has increased in the Sonoran and Chihuahuan deserts from 1910 to 1950 and continues to increase in density and area (Buffington and Herbel 1965, Herbel et al. 1985). As creosote and associated woody species increase, forage production decreases (Anderson et al. 1957). Likewise, when woody plant populations are removed or thinned, forage production increases (Scifres et al. 1979, Jacoby et al. 1982, Morton et al. 1990, Morton and Melgoza 1991).

In addition, studies of pronghorn habitat cite visually open areas with low vegetative structure averaging < 64 cm and < 35% shrub cover as optimal for pronghorn (Yoakum 1974, 1980; O'Gara and Yoakum 1992, Ockenfels et al. 1994, Lee et al. 1998). Sonoran pronghorn use creosote flats less than expected based on availability during dry years and as expected in wet years (Hervert et al. 2000). Pronghorn may avoid creosote flats because visibility is restricted and forage is limited in this vegetation type (Arizona Game and Fish Department 1981). Duerr et al. (1999) found that Sonoran pronghorn selected areas with less cover of large shrubs than was generally available and that they seemed to avoid the dominant large shrub, creosote bush, on the tactical ranges.

Thinning large creosote bushes in the habitat enhancement sites is expected to make the areas more structurally preferable for pronghorn and to increase forage production from both natural rainfall and watering. Creosotes would not be removed in desert washes, on desert pavement terraces, or in areas where they are already sparse. Creosote will be removed by burning individual plants using a propane torch. Brown and Minnich (1986) found that creosote bushes are poorly adapted to relatively low intensity fire, as evidenced by limited sprouting and reproduction. Many creosote shrubs with living foliage after burning died later as a result of basal cambium damage.

Annual Forage Irrigation: Water will be trucked to each site receiving this treatment or a well will be drilled. Wells will be drilled on the northeastern edge of the Mohawk Dunes site and the western edge of the Granite Mountain site. These 2 areas are far from good roads, and pronghorn are expected to use the sites for long periods of time. A water truck will serve the three Aztec Hills plots. A pipeline and sprinkler system will be used to convey the water from the well or a holding tank, to each irrigated plot. Water will be applied frequently enough to promote forage growth and keep existing forage alive as long as possible while pronghorn are in the area or until summer rains relieve the need for watering. Depending on natural rainfall, watering could begin in November, and continue through May or June. Additional watering may be necessary in July and August if summer drought conditions prevail and the pronghorn stay near the plots. We anticipate applying up to 13 cm of water throughout the watering cycle. Approximately 0.75 ha within each plot (10 plots total) will receive this treatment. Watering will be done at night, when evaporation loss will be minimized and pronghorn are least likely to be disturbed.

This additional water should promote growth and sustain production of winter annuals into late spring and early summer while pronghorn are in the general area. Mortality of winter annuals is not associated with the onset of reproduction, but occurs when moisture reserves in the soil are depleted, through high temperatures and evaporation (Forseth et al. 1984). Given heavy rains from late season storms, vegetative and reproductive growth may continue for extended periods, and some annuals can "perennate" and live for 2 years (Forseth et al. 1984). Tevis (1958) found that when 5 cm of water was sprinkled on a dying population of mature ephemerals, all living individuals revived completely and resumed extensive growth and flowering.

Perennial Forage Irrigation: Preferred perennial forage species such as white ratany (*Krameria grayi*), wire lettuce (*Stephenomeria spp.*) and silverbush (*Ditaxis spp*.) will be irrigated with the same sprinkler system used to grow annuals. These perennial shrubs sustain pronghorn when annual forage is not available, and given additional water, they may stay green and more palatable. Existing plants will be watered and additional perennials may be established from seed (local sources only).

Free Standing Water: In addition to forage improvements, we propose to provide a temporary supply of free standing water at some habitat enhancement sites during the time pronghorn are using the area and water use is deemed beneficial for fawn survival. The water would be stored underground in a single length of buried polyvinyl chlorine (PVC) pipe, 61 cm in diameter and 6.5-m in length. The pipe would have a capacity of 1700 liters. The pipe would be filled by water truck and would be connected to a 76 cm deep walk-in drinker. The entire system would be buried 76 cm in the ground. There would be a valve between the PVC pipe and the walk-in trough allowing the system to be turned off.

Table 1. Proposed habitat enhancement sites and potential treatments.

Site name	Potential treatments[1]	Size (km^2)	UTM coordinate (northwest corner)
1. Mohawk Pass	C-A-W	1.0	3611000 N 262000 E
2. Mohawk Dune	C-A	1.0	3609000 N 264000 E
3. Granite Mountains #1	C-A-P-W	1.0	3592500 N 277000 E
4. Granite Mountains #2 (NW)	C-A-P	1.0	3593000 N 276000 E
5. Granite Mountains #3 (SE)	C-A-P	1.0	3592000 N 278000 E
6. Aztec Hills #1	C-A-P-W	1.0	3624700 N 277900 E (north end; 1.7-km long X 580-m wide along road)
7. Aztec Hills #2	C-A-P	0.015	3622784 N 281073 E (south end; 500-m NE along road, 30-m wide)
8. Aztec Hills #3	C-A	0.015	3622000N 282200 E (north end; 500-m south along road, 30-m wide)
9. Point of the Pintas	C-A-P-W	1.0	3592000 N 250000 E
10. Point of the Pintas #2	C-A-P	1.0	3591500 N 251000 E

[1] Treatments: C = creosote removal; A = annual forb irrigation; P = perennial forage irrigation; W = free standing water.

CONCLUSION

Fawn survival is the most critical component of the population dynamics of Sonoran pronghorn. Small changes in the recruitment level of fawns can have dramatic influences on population size and the probability of extinction (Hosack 1996). Recently fawn recruitment has been critically low, with no known recruitment in 3 of the last 5 years (Hervert et al. 2000). The key to recovery of this endangered subspecies is through the recruitment of fawns into the population.

If, as we hypothesize, a lack of nutritional forage and water resources are limiting fawn recruitment, providing quality forage and water in habitats favorable to pronghorn should increase fawn recruitment. Since the Sonoran pronghorn was listed as endangered in 1967, virtually no proactive management has taken place. Over that 33-year period, pronghorn have failed to recover on their own, and there is no reason to expect they will in the future. In order to ensure their continual survival, meaningful habitat management strategies are needed now.

LITERATURE CITED

ANDERSON, D., L.P. HAMILTON, H.G. REYNOLDS AND R.R. HUMPHREY. 1957. Reseeding desert grassland ranges in southern Arizona. (Revised) Arizona Agricultural Experiment Station Bulletin 249.

ARIZONA GAME AND FISH DEPARTMENT. 1981. The Sonoran Pronghorn. Special Report Number 10. Arizona Game and Fish Department, Phoenix, AZ. 55 pp.

BEALE, D.M. AND A.D. SMITH. 1970. Forage use, water consumption, and productivity of pronghorn antelope in western Utah. Journal of Wildlife Management 34:570-583.

BRIGHT, J.L., J.J. HERVERT, L.A. PIEST, R.S. HENRY AND M.T. BROWN. 1999. Sonoran pronghorn 1998 aerial survey summary. Nongame and Endangered Wildlife Program Technical Report 152. Arizona Game and Fish Department, Phoenix, AZ.

BROWN, D.E. AND R.A. MINNICH. 1986. Fire and changes in creosote bush scrub of the western Sonoran desert, California. American Midland Naturalist 116(2):411-422.

BUFFINGTON, L.C. AND C.H. HERBEL. 1965. Vegetation changes on a semidesert grassland range. Ecological Monographs 35:139-164.

DUERR, A., M.A. MCLEOD AND E.L. SMITH. 1999. Sonoran pronghorn use of 2 tactical ranges on the Barry M. Goldwater Range. Luke Air Force Base Contract Number F41624-94-D-8016.

DEVOS, J.C. 1989. Evaluation of Sonoran Pronghorn movements around military activity sites on the Barry M. Goldwater Air Force Range. Arizona Game and Fish Department, Phoenix, Arizona.

FORSETH, I.N., J.R. EHLERINGER, K.S. WERK AND C.S. COOK. 1984. Field water relations of Sonoran desert annuals. Ecology 65(5):1436-1444.

FOX, L.M. 1997. Nutritional content of forage in Sonoran pronghorn habitat, Arizona. M.S. Thesis, Univ. Arizona, Tucson. 228pp.

HERBEL, C.H., H.L. MORTON AND R.P. GIBBENS. 1985. Controlling shrubs in the arid southwest with tebuthiuron. Journal of Range Management 36:149-151.

HERVERT, J.J., J.L. BRIGHT, M.T. BROWN, L.A. PIEST AND R.S. HENRY. 2000. Sonoran Pronghorn Population Monitoring: 1994-1998. Nongame and Endangered Wildlife Program Technical Report 162. Arizona Game and Fish Department, Phoenix, AZ.

HERVERT J.J., L.A. PIEST, W. BALLARD, R.S. HENRY, M.T. BROWN AND S. BOE. 1997a. Sonoran Pronghorn Population Monitoring: Progress Report. Nongame and Endangered Wildlife Program Technical Report 126. Arizona Game and Fish Department, Phoenix, AZ.

HERVERT, J.J., R.S. HENRY, AND M.T. BROWN. 1997b. Preliminary investigations of Sonoran pronghorn use of free-standing water. Proceedings of a Symposium on Environmental, Economic and Legal Issues Related to Rangeland Water Development. The Center for the Study of Law, Science and Technology, Arizona State University, Tempe, Arizona. Pp. 126 – 137.

HOSACK, D.A. 1996. Population Viability Analysis Workshop for the Endangered Sonoran Pronghorn (*Antilocapra americana sonoriensis*) in the United States. Draft. 22pp.

HUGHES, K.S. AND N.S. SMITH. 1990. Sonoran pronghorn use of habitat in southwest Arizona. Final Report 14-16-009-1564 RWO #6. AZ. Coop. Fish & Wildl. Research Unit, Tucson, AZ. 58 pp.

JACOBY, P.W., R.D. UECKERT, AND F.S. HARTMAN. 1982. Control of creosotebush (*Larrea tridentata*) with pelleted tebuthiuron. Weed Science 30:307-310.

LEE, R.M., J.D. YOAKUM, B.W. O'GARA, T.M. POJAR, AND R.A. OCKENFELS, eds. 1998. Pronghorn Management Guides. 18th Pronghorn Antelope Workshop, Prescott, AZ. 110pp.

MORTON, H.L. AND A. MELGOZA. 1991. Vegetation changes following brush control in creosotebush communities. Journal of Range Management 44(2):133-139.

MORTON, H.L., F.A. Ibarra-F, M.H. Martin-R and J.R. Cox. 1990. Creosotebush control and forage production in the Chihuahuan and Sonoran Deserts. Journal of Range Management 43(1):43-48.

OCKENFELS, R.A., A.A. ALEXANDER, C.L. DOROTHY TICER AND W.K. CARREL. 1994. Home ranges, movement patterns and habitat selection of pronghorn in central Arizona. Arizona Game and Fish Department Technical Report 13. 80 pp.

O'GARA, B.W. AND J.D. YOAKUM, editors. 1992. Pronghorn management guides. Proceedings Pronghorn Antelope Workshop 15 (suppl.) 101 pp.

PATTEN, D.T. 1978. Productivity and production efficiency of an upper Sonoran desert ephemeral community. American Journal of Botany 65(8):891-895.

SCIFRES, C.J., J.L. MUTZ AND W.T. HAMILTON. 1979. Control of mixed brush with tebuthiuron. Journal of Range Management 32:155-158.

TEVIS JR., L. 1958. A population of desert ephemerals germinated by less than one inch of rain. Ecology 39(4):688-695.

U.S. FISH AND WILDLIFE SERVICE. 1998. Final Revised Sonoran Pronghorn Recovery Plan. Albuquerque, New Mexico. 70 pp.

YOAKUM, J.D. 1974. Pronghorn habitat requirements for sagebrush-grasslands. Proceedings Pronghorn Antelope Workshop 6:16-24.

YOAKUM, J.D. 1980. Habitat management guides for the American pronghorn antelope. U.S. Bureau of Land Management Technical Note 347. Denver, CO. 78 pp.

YOAKUM, J.D. 1990. Food habits of the pronghorn. Proceedings Pronghorn Antelope Workshop 14:102-110

RELATIONSHIPS BETWEEN DIET QUALITY AND FECAL NITROGEN, FECAL DIAMINOPIMELIC ACID AND BEHAVIOR IN A CAPTIVE GROUP OF PRONGHORN.

MARY ROBINSON, Department of Biological Sciences, University of Idaho, Moscow, ID 83844-3051.

MARGARET WILD, Colorado Division of Wildlife, 317 W. Prospect, Fort Collins, CO 80526.

JOHN BYERS, Department of Biological Sciences, University of Idaho, Moscow, ID 83844-3051.

***Abstract*:** Both behavior and fecal indices have been suggested as measures of diet quality of wild ruminants; however, their accuracy and applicability in measuring the diet quality of pronghorn have not been evaluated. We investigated the fecal and behavioral response of 10 captive pronghorn females (*Antilocapra americana*) to reductions in the availability of high quality forage. Low quality forage, consisting of over 98% mature cheatgrass brome (*Bromus tectectorum*), was available in excess at all times. Intake of high quality forage was reflected in the total fecal output by the group and by the concentration of N and DAPA (diaminopimelic acid) in the feces. Fecal N and DAPA did not accurately reflect changes in body weight. However, fecal N and DAPA may be useful in monitoring trends in the diet quality of pronghorn. The rate of aggressive interactions was inversely related to diet quality. However, the relationship between the time devoted to feeding and the availability of high quality forage was more complex.

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19:28-44

***Key words*:** aggression, *Antilocapra americana*, behavior, nitrogen, DAPA, forage quality, forage quantity, pronghorn.

Changes in body condition measures, such as body weight, are expressions of energy and matter balances and reflect attempts by animals to use resources to the best advantage (Gates and Hudson 1981). An accurate measure of diet quality for free-ranging ruminants has proved ellusive (Leslie and Starkey 1985; Irwin et al. 1993; Wehausen 1995; Kucera 1997). Considerable effort has been directed towards the development of indices between population condition and diet and fecal nutrient levels (Holechek et al. 1982; Leslie and Starkey 1985).

Fecal nitrogen (N) is correlated with various measures of diet quality such as dietary N, energy, and intake and has been used to assess the quality of diets of wild ruminants (e.g., Erasmus et al. 1978; Wofford et al. 1985; Osborn and Jenks 1998). However the reliability of fecal N as an index of diet quality may be compromised by secondary plant compounds such as tannins (Rhoades and Cates 1976; Zucker 1983; Freeland et al. 1985; Robbins et al. 1987) which can decrease N absorption and hence elevate fecal N.

Another fecal index is diaminopimelic acid (DAPA). DAPA is an amino acid found almost exclusively in bacterial cell walls (Work and Dewey 1953; Purser and Buechler 1966) and its concentration increases in the rumen pool as a function of increasing bacterial mass (Leslie et al. 1989). Low levels of dietary energy in the diet may limit microbial growth and hence should be detected by decreases in fecal DAPA. Fecal DAPA has been found to vary with season (Mauty et al. 1976; Kie and Burton 1984; Kucera 1997), species of ruminant (Leslie et al. 1989), and intake (Hodgman et al. 1996). Unlike fecal N, fecal DAPA is not thought to be compromised by factors such as secondary plant compounds (Nelson and Davitt 1984).

Implicit in the use of fecal indices is the assumption that daily fecal output is constant or that changes do not affect the concentration of the index in the feces (Leite and Stuth, 1990). However fecal progesterone concentrations in baboons (*Papio cynocephalus cyncocephalus*) have been shown to be inversely related to the total fecal output (Wasser et al. 1993). Changes in total fecal output may occur due to either changes in diet composition or forage availability. In the presence of such changes, fecal indices may over- or underestimate dietary quality (Belonje and Van den Berg 1980; Leite and Stuth 1990; Miller et al. 1991; Kucera 1997). No information exists regarding the effect of total fecal output on the concentrations of N or DAPA in the feces of pronghorn (*Antilocapra americana*). Before the accuracy of fecal indices in measuring diet can be fully evaluated more knowledge relative to fecal output is required (Leite and Stuth 1990).

Social and non-social interactions may also influence or be influenced by nutrition. Any organism has a limited amount of resources and time available to devote to foraging, growth, maintenance and reproduction (Pianka 1994). Several researchers have reported increases in foraging behavior (and corresponding decreases in rumination and other behaviors) in various ruminants in response to decreases in forage availability (Arnold 1960a,b 1962; Miller 1971; Geist 1971) and quality (Arnold 1960b, Forchhammer 1995; Kronberg and Malechek 1997). The relationships between feeding and diet quality in pronghorn are largely unknown.

The primary interactions among pronghorn females involve assertions of dominance or aggressive takeover of feeding sites (Byers 1997). In the presence of seasonal variations in food abundance, the rate of agonistic interactions seems to be held constant in pronghorn groups through the modification of group sizes (Byers 1997). If this is the case, then in pronghorn groups of constant size, with temporally varying food abundance, we would expect to see changes in the rate of agonistic interactions. In other species, under less than optimal conditions, it is often the low ranking animals which first show signs of impaired function such as lowered disease resistance or greater weight loss (Rowell 1966; Demarest et al. 1997). However among pronghorn females no significant fitness advantages of high social rank have been detected (Byers 1997; Dennehy 1997).

The possibility exists that in a species such as pronghorn, in which predation of healthy adults is low (Byers 1997), predator avoidance strategies may have a negligible effect on activity and therefore activity may accurately reflect habitat quality and population health.

The specific questions addressed by this study were: 1) are changes in the availability of high quality forage by pronghorn females reflected in changes in total fecal output, 2) are N and DAPA levels in feces good measures of diet quality in pronghorn females, 3) does the time devoted to feeding by pronghorn females vary inversely with the quality of their diet, 4) does diet quality influence the occurrence of other behaviors in pronghorn females, and 5) does social rank influence the quality of a female's diet?

METHODS

We conducted the study during June, July, and August 1998, at the Foothills Wildlife Research Facility, Fort Collins, Colorado. Ten captive female pronghorn were kept together in a 1.5ha pasture containing a wooden shelter, water and a trace mineral block. The animals ranged in age from seven to three years. All were bottle-raised in captivity. None of the animals were pregnant or had bred in the previous year. The animals' normal diet consisted of ad libitum alfalfa hay (approx. 0.35kg/animal/day) and a pelleted ration (approx. 1kg/animal/day; Baker and Hobbs 1985) fed at 0800h and distributed between 3 and 10 feeding troughs respectively. The pasture vegetation was composed almost entirely of mature cheatgrass brome (Bromus tectectorum), and was specifically chosen for its unpalatable forage to provide as little additional nutrients as possible while allowing the animals, as far as is possible in captivity, the expression of their full suite of behaviors. The animals had been housed in the pasture in previous years and were allowed to adapt to the pasture for 3 days prior to the commencement of the study and to remove any palatable vegetation.

For sampling purposes, we divided the summer into 5 two-week periods or diets. The study consisted of two restricted feeding levels (75%, 50%) preceded and followed by ad libitum feeding. We measured the intake of alfalfa and pellets during the first ad libitum feeding and used it to calculate, by weight, the 75% and 50% feeding levels. The first week of each diet was an adjustment period (the first adjustment period was shortened to 3 days as the only change in their normal diet/lifestyle involved a change of pasture and the increased presence of a keeper in the field) and the second week was the sampling period during which time we measured, as described below, the forage composition, each animal's body weight and behavior, and daily fecal output by the group. We also collected fecal samples from each animal.

We monitored the composition and abundance of pasture vegetation at weekly intervals using the canopy cover method (Daubenmire 1959). Forty 20 x 30cm plots were evenly spaced throughout the pasture and marked by tent pegs driven level with the ground. We then estimated the area of each plot, and hence the total pasture area, occupied by bare ground, cheatgrass, and non-cheatgrass forages.

The animals had previously been trained to stand on a platform for weighing and were weighed between 0500 and 0600h on the first day of the study and on the final day of each diet.

We collected samples of alfalfa and pellets in the middle of each sampling week and froze them for future analysis of nitrogen in the Wildlife Habitat Laboratory at Washington State University. We analyzed nitrogen levels using the Kjeldahl method according to AOAC guidelines (1990). We estimated dietary nitrogen (N) for the group each day based on the N content of the pellets and alfalfa. No estimate could be made of the contribution of pasture vegetation to dietary N intake.

We collected fecal samples during each sampling week. During observation periods, defecation by individuals was recorded and, after the animal had moved a sufficient distance away to prevent undue disturbance, we collected approximately 20 grams of feces using forceps or latex gloves. The samples were stored in plastic Whirl Pak™ bags at -20°C within 4 hours of collection and later analyzed for nitrogen and DAPA (according to Davitt and Nelson 1984). Where possible, one fecal sample was collected per animal per day and only the last 3 fecal samples collected per diet from each animal were analyzed.

We monitored the daily total fecal output of the group by hand collecting and weighing all feces in the pasture prior to feeding the animals at 0800h. To test the accuracy of total fecal output estimates, an independent observer, at times unknown to the collector, watched the animals defecating and on a diagram noted the position of the sample in the pasture. The following morning, after the collection of feces from the pasture was completed, the number of missed samples was recorded. We calculated the total amount of N and DAPA excreted by the group per day by multiplying the mean fecal N or DAPA concentration (g/kg) for a particular day by the total amount of feces (kg) collected on that day.

We collected activity budget data during sampling weeks between 0600 and 2100h using instantaneous point sampling at 5-minute intervals for 1hour periods (Altmann 1974). Over the course of each sampling week a total of 45 hours of observations were collected and these consisted of three replicates of each hour (e.g., data was collected between 1500 and 1600h 3 times during each sampling week). The total time spent Feeding, Reclining, and engaged in Other activities was measured. Feeding was further divided into feeding on alfalfa, pellets, or pasture vegetation. Other was further divided into moving, standing, interacting with others, and miscellaneous behaviors such as drinking and using the salt-lick.

All occurrence sampling of social interactions followed protocols established by Byers (1997). We noted the identity of animals involved in interactions and the loser was determined as the animal which conceded the resource in dispute or moved away. We recorded the form of the interaction as either nudge, spar, or butt and the interaction as either bedded, feeding, or simple displacement. Bedded displacement was recorded if an animal was forced to rise from reclining by another animal. Feeding displacement was recorded if an animal was forced to cease feeding by another animal. Simple displacement was recorded if no resource appeared to be contested.

We first calculated the dominance rank for each animal based on the percent of interactions won by each animal. However the dominance rank of an animal, calculated in this manner, may be elevated if she avoids interactions with animals dominant to her (Byers 1997). Hence we used a second method in which we ranked each animal depending on the number of animals which were subordinate to her minus the number which were dominant over her (DeVries 1993). We then evaluated the observed relationship between adjacent animals and if it was contradicted by that of the ranking scheme the position of the adjacent animals was switched. We compared the two resulting ranking schemes and the ten animals were then categorized as either high, intermediate, or low ranking animals.

Our analysis was limited by the fact that some variables could only be measured per animal (e.g., body weight, behavior) and some only for the entire group of animals per day (e.g., intake of high quality forage, dietary N, total fecal output, total fecal N, total fecal DAPA). Some variables could be calculated either per day or per animal (fecal N, fecal DAPA). We used Duncan's multiple range test to test for differences in each variable between diets. Unless otherwise stated a significance level of ? = 0.05 was used. We examined plots of residuals to ensure that data met the statistical assumptions. We used backward stepwise regression procedures of SAS (1990) to determine the combination of independent variables that best explained variation in the dependent variables. Variables were left in the models at a significance level of 0.1 unless otherwise stated. It should be remembered that the same animals were sampled repeatedly during the study. Therefore the p-values obtained in these analyses may be overly liberal i.e. significant relationships may be found where none exist. Spearman's correlation coefficient was used to test the relationship between the social rank of an animal and her age.

RESULTS

Relationship between Intake and Output

Daily intake of high quality forage (pellets and alfalfa) and dietary N by the group of ten animals during the last 3 days of each diet differed significantly among all diets (Table1; Fig 1). The proportion of fecal samples missed by the collector was found to be <1.5% (N = 42 pellet groups). Daily fecal output by the group also differed significantly with diet (Table 1; Fig 1). Daily fecal output (Output) by the group was related to their daily high quality forage intake (Intake) by the equation: Estimated Output = 3.01 + 0.507 Intake, (R^2 = 0.569, P = 0.0012, N = 15). Intake of pasture vegetation could not be measured during the study and hence its contribution to dietary N and fecal output remain unknown. However, from our observations, the animals only ingested very small quantities of the pasture vegetation with non-cheatgrass forages being preferred. We estimated that non-cheatgrass forages accounted for less than 0.5% of the total pasture area and less than 0.6% of the total vegetation cover in all diets, except in the first ad libitum when non-cheatgrass forages accounted for 6.5% of the total pasture area and 7.2% of the total vegetation. Throughout the study, bare ground and cheatgrass accounted for >10% and >75% of the total pasture area, respectively.

Diet Quality and Fecal N, DAPA

All but two animals lost weight during the 75% diet. By the end of the second ad libitum diet only two animals were more than 0.6 kg lighter than at the start of the study. All others were within 0.6 kg of their original weight (first ad libitum) or had exceeded it. By the end of the third ad libitum diet, all animals had regained weight lost during the 50% diet and all were heavier than at the commencement of the study.

Duncan's multiple range test identified significant differences in dietary N and in the mean fecal N and DAPA levels per animal per diet (Table 1; Fig 2). Body weight was only very poorly (r^2 = 0.085 P = 0.1251 N= 50) described by the equation: Estimated Body weight = 37.643 + 4.222 * (fecal N) – 8.934 * (fecal DAPA). We calculated mean daily fecal N and DAPA concentrations for the group for each of the last 3 days of each diet. We also calculated the total amount of fecal N and DAPA excreted, on those days (Fig 2). Caution should be used when interpreting mean daily values because it was not always possible to collect a fecal sample from each animal every day, hence the mean fecal N and DAPA levels for some days are based on samples from 7, 8, or 9 animals instead of 10. The best fitted line for daily dietary N (r^2 = 0.194 P = 0.0014 N= 15) using the variables measured per day, fecal N, fecal DAPA, total fecal N, and total fecal DAPA was found to be: Estimated Dietary N = - 4.97 + 2.264 * (fecal N) + 0.04387 * (fecal DAPA), where variables were left in the model at a significance level of ? = 0.05.

Table 1. Duncan's multiple range tests for significant differences in behavior and fecal indices with diet.

	Ad. Lib.1	75%	Ad. Lib. 2	50%	Ad. Lib. 3	Sample size	d.f.
Intake	A	B	C	D	E	N= 15	8
Dietary N	A	B	C	D	E	N= 15	8
Output	A	A	B	A	C	N= 15	8
Body weight	A	B	A	B	C	N=50	36
Fecal N [a]	A	B	A	B	A	N=50	36
Fecal DAPA [a]	A	B	A	C	B	N=50	36
Fecal N [b]	A	B	A	C	A	N=15	8
Fecal DAPA [b]	A	B	C	D	B,C	N=15	8
Total fecal N [b]	A	A	B	A	C	N=15	8
Total fecal DAPA [b]	A	A	B	A	C	N=15	8
Feeding	A,B	B,C	C	A	A,B	N=50	36
Reclining	A	A	A	A	B	N=50	36
Other	C	B	A	C	A,B	N=50	36
Feeding (pasture)	A	A	B	C	A	N=50	36
Other (standing)	A	B	C	D	C	N=50	36
Interactions	A,B	B	B	B	A	N=50	36

[a] measured per animal, [b] measured per day.
N=50 Fecal N etc. values of all 10 animals * number of diets
N=15 Mean fecal N etc. on each of 3 days of each diet * the number of diets.

Significantly different diet means are assigned different letters

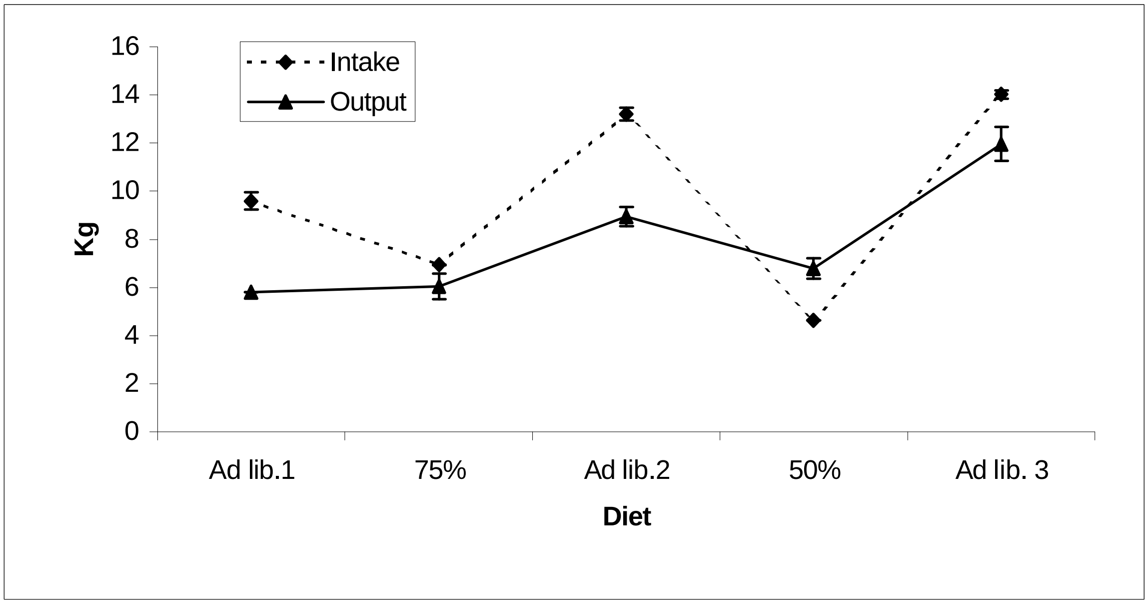


Figure 1: Mean daily fecal output and mean daily intake of high quality forage (pellets and alfalfa) with diet. Bars represent standard errors.

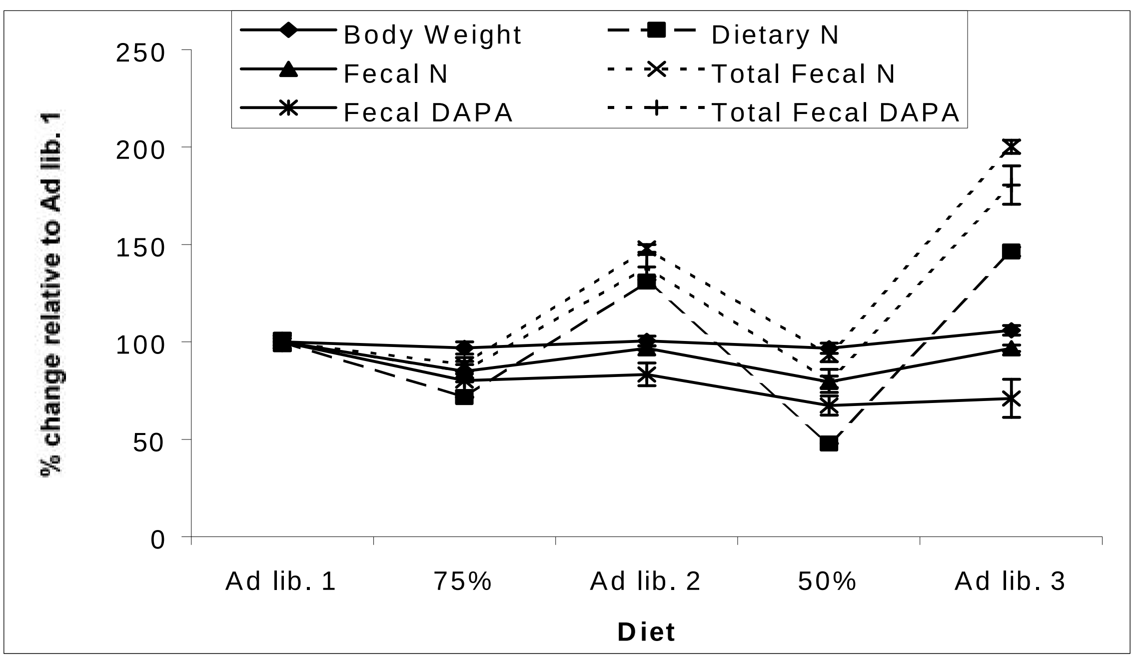


Figure 2: Measures of diet quality in pronghorn compared. All measures, except body weight, were calculated as the mean daily values for the group per diet. Body weight is the mean body weight of the group at the end of each diet. Bars represent standard errors.

Feeding, Reclining, and Other activities

Feeding on pasture vegetation accounted for over 51% of total feeding in all diets except during the second ad libitum diet when feeding on pasture decreased to 30%. Feeding and Other activities differed significantly with diet (Table 1; Fig 3).

Standing accounted for over 63% of Other activities during all diets. Feeding, Other, and Reclining activities were related by the equation: Estimated Feeding = 12.05 - 1.01 * (Other) – 1.01* (Reclining), (r^2 = 0.998 P = 0.0001 N = 50). Differences in body weight, fecal N per animal, and fecal DAPA per animal did not explain variation in Feeding, Other, or Reclining activities, as all were removed from the model at the significance level of ? = 0.1.

The total number of interactions in the third ad libitum diet was significantly lower than all other diets except ad libitum 1 (Table 1; Fig 4). Simple displacement was most often the cause of interactions (51%), while feeding displacement (44%) and bed displacement (5%) accounted for the remainder. Interactions most often took the form of nudging, which accounted for over 75% of all interactions. Of the three diet quality measures, dietary N, fecal N, and fecal DAPA, only the relationship between the total number of interactions per animal and fecal N approached significance: Estimated total interactions = 85.669 – 19.227 * (fecal N), (r^2 = 0.14, P = 0.079, N = 50).

Effects of Dominance

We found close agreement in the dominance ranking schemes identified by the two methods used. Dominance status was unrelated to age (Spearman's correlation coefficient P> 0.38, N=10), social and non-social behaviors, body weight, fecal N, and fecal DAPA (Repeated measures ANOVA, P > 0.05, N = 50).

DISCUSSION

Ad libitum intake increased during the study. Several possible reasons exist for this. First, the duration of the second and third ad libitum diets may have been insufficient to allow full recovery of the animals from the preceding restriction diets. However, body weight changes do not seem to support this conclusion as almost all animals had regained, or added to, their pre-restriction weight. Alternately the increase observed could have been a reaction by the animals to the sudden unpredictability of high quality forage availability.

A second possibility is that pasture vegetation may have contributed more to the diet than initially thought. Non-cheatgrass forages were in greatest abundance during the first ad libitum diet. Hence ad libitum intake of pellets and alfalfa during the first diet may have been depressed. However, non-cheatgrass forages remained at negligible levels for the remainder of the study and therefore cannot explain the differences seen in ad libitum intake.

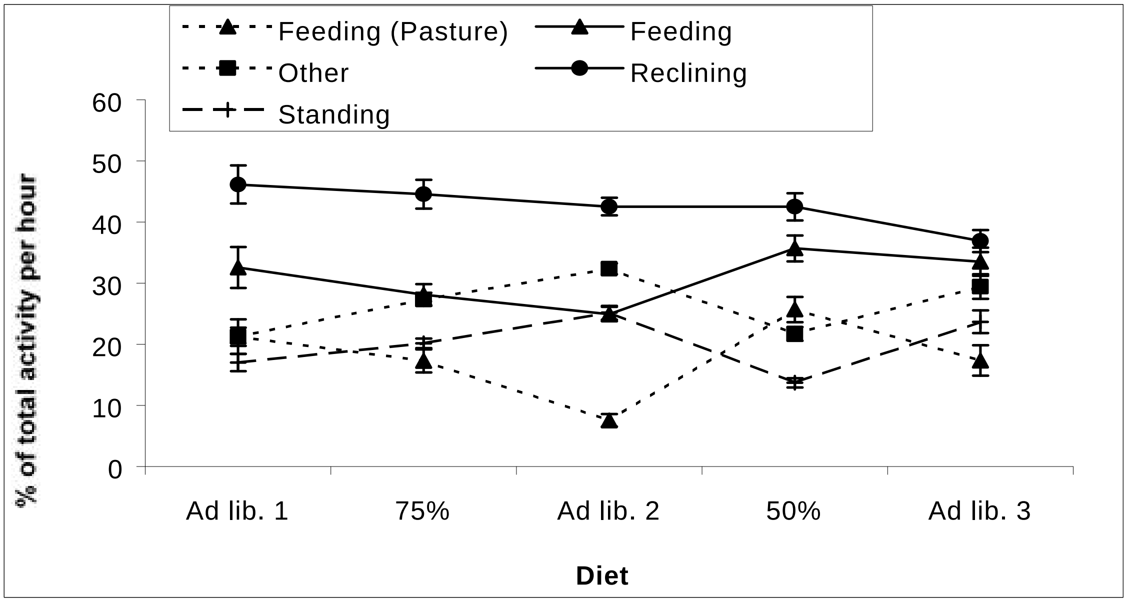


Figure 3: Change in non-social behaviors with diet. Bars represent standard errors.

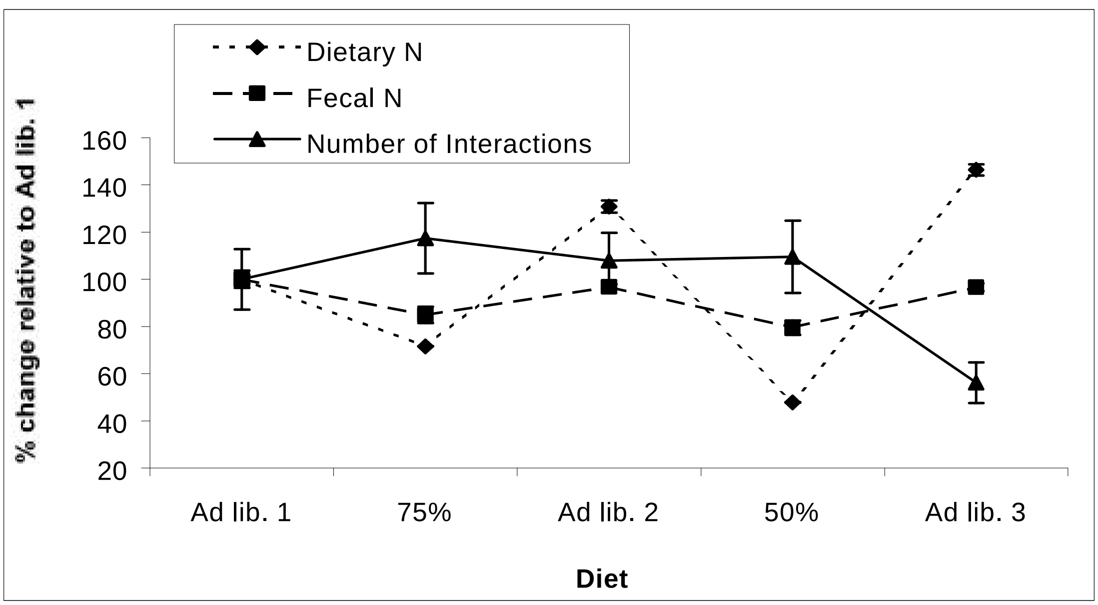


Figure 4: Change in rate of interations with diet. Bars represent standard errors.

Third, daily temperature may have influenced intake. High summer temperatures have been shown to reduce intake in captive white-tailed deer (Wheaton and Brown 1983). Daily temperature means for each of the diets were 63.5, 72, 75, 69, 79^0 F respectively. As the first ad libitum diet coincided with the coolest mean temperature and the third ad libitum diet with the highest, if temperature influenced intake, we would expect the opposite relationship to that observed. Hence temperature is not thought to be responsible for the changes seen in intake.

Fourth, seasonal variations in intake and body weight have been documented in many ruminant species (e.g. Ozoga and Verme 1970; Loudon 1991), even in captivity where food is provided ad libitum in pens (Moen 1978; Wheaton and Brown 1983; Wild unpublished data). Intake for non-reproducing female white-tailed deer has been shown to reach a minimum in early June and peak in December (Moen 1978). Therefore, dietary intake may have increased over the summer as part of normal seasonal variation.

We found a significant relationship between daily fecal output and intake of high quality forage. In this study the availability of high quality forage was limiting but at no time were the animals limited in their access to forage per se due to the presence of pasture vegetation. Palatability of forages has been shown to influence intake, and limitations to intake, due to palatability, are known to differ between animal species (Dynes 1996). Therefore, in pronghorn, forage palatability, and not simply its availability, may be of greater importance and hence fecal output may be more variable in pronghorn than in less descerning ruminants. A cholesterol metabolite, cholestanone, in the feces of female baboons is positively correlated with dietary fiber and Wasser et al (1993) suggested that, in the presence of profound variations in dietary fiber, it may be appropriate to express fecal progestogens, and presumably other fecal measures, by cholestanone concentrations. We did not test for the presence of cholestanone in pronghorn feces.

Fecal N and DAPA levels were poor predictors of body weight but moderately good predictors of daily dietary N. The inability of fecal N and DAPA to monitor body weight agrees with findings by Kucera (1997). Kucera (1997) suggested that fecal indices reflect what an animal ate recently and body condition measures, such as body weight, reflect dietary and energetic factors over months or even between seasons. Therefore, it may be naive to expect fecal indices measured over short periods of time to reflect population condition at that time. Kucera (1997) did find that fecal N and DAPA reflected growth of vegetation and this seems to be supported by our findings that fecal N and DAPA are related to dietary N. We may have found a stronger relationship between dietary N and fecal N and DAPA had the contribution of pasture vegetation been included in our estimates of dietary N. Expressing fecal N and DAPA levels as the total amount excreted by the group did not improve the predictive equations. This may suggest that N and DAPA excretion rates change in response to changes in fecal output and hence their concentrations in the feces are independent of changes in fecal output.

We hypothesized that the time devoted to feeding would be inversely related to the availability of high quality forage. This however was not the case. The time devoted to feeding during the 75% diet appears to have been limited by the time devoted to standing. One possibility for this limitation is that the 75% diet coincided with the fourth of July celebrations. Events such as a hot air balloon race and fireworks may have lead to a heightened alertness among the animals resulting in them spending more time standing and alert. Alternately, when on the 75% diet, the best energetic strategy for the animals may have been to conserve energy. The 50% diet may have been sufficiently severe that they could not conserve enough energy by standing and so were forced to forage resulting in the feeding/standing pattern observed. The results of this study suggest that there is a threshold level of nutrition at which feeding behavior is modified.

In wild pronghorn groups, interaction rates appear to be relatively constant (Byers 1997). We found that the total number of interactions did appear to vary with diet and were best described by fecal N levels ($p = 0.079$). Similar to findings by Byers (1997) high ranking females appear to have slightly, although non-significantly, elevated rates of interactions relative to subordinates. This suggests that subordinates may avoid interactions and/or dominant animals may seek interactions. No clear relationship occurred between rank and body weight, dietary N, or fecal indices. This suggests that high social status does not confer greater fitness on the individual and agrees with results of previous studies (Byers 1997; Dennehy 1997).

MANAGEMENT IMPLICATIONS

The results of this study suggest that the assumption of constant total fecal output, in selective feeders such as pronghorn, may be invalid. Further research should focus on measuring more fully the relationship between intake and fecal output levels, the existence of such a relationship in the wild, and the influence of this relationship on specific fecal indices. Based on the results of this study it appears that fecal N and DAPA may be useful in monitoring diet quality in pronghorn. However, the resultant effects of diets of varying quality on the health of wild pronghorn populations requires further study.

The rate of energy intake (or feeding) has been suggested as a measure of the relative fitness of a forager (Hanks 1981; Morse and Fritz 1987). If, as suggested by the results of this study, there is a threshold level of nutrition at which feeding behavior is modified then the measurement of feeding or any other behavior as an index of diet quality may only be possible where extreme or sudden changes in diet quality occur.

ACKNOWLEDGEMENTS

We would like to thank Tom Pojar, Dan Baker, N. Thompson Hobbs, and Liz Wheeler for assistance during the design and implementation of the study. We would also like to thank Bruce Davitt, and Chris Williams for assistance with fecal sample and data analysis. Thanks also to Sue Fairbanks for reviewing an early draft of this manuscript and to the Max McGrath Wildlife Foundation grant for funding this study.

LITERATURE CITED

ALTMANN, J. 1974. Observational study of behavior: sampling methods. Behavior 49:225-265.

AOAC (ASSOCIATION OF ANALYTICAL CHEMISTS). 1990. Official methods of analysis of official analytical chemists. Assocation of Analytical Chemists Arlington, Virginia.

ARNOLD, G.W. 1960a. The effect of the quantity and quality of pasture available to sheep on their grazing behaviour. Australian Journal of Agricultural Research 11:1034-1043.

ARNOLD, G.W. 1960b. Selective grazing by sheep of two forage species at different stages of growth. Australian Journal of Agricultural Research 11:1026-1033.

ARNOLD, G.W. 1962. The influence of several factors in determining the grazing behavior of Border Leicester X Merino sheep. Journal of British Grassland Society 17:41-51.

BAKER, D.L. AND N.T. HOBBS. 1985. Emergency feeding of mule deer during winter: Tests of a supplemental ration. Journal of Wildlife Management 49:934-942.

BELONJE,P.C. AND A. VAN DEN BERG 1980a. The use of fecal analysis to estimate the phosphorus intake by grazing sheep. I. The use of pool instead of individual samples. Onderstepoort J. Vet. Res. 17:163-167.

BYERS, J.A. 1997. American Pronghorn:Social adaptations & the ghosts of predators past. University of Chicago Press, Chicago.

DAUBENMIRE, R. 1959. A canopy-coverage method of vegetation analysis. Northwest Science 33: 43-61.

DAVITT, B.B. AND J.R. NELSON. 1984. Methodology for the determination of DAPA in feces of large ruminants. In Proceedings of the Western States and Provinces Elk Workshop, (Ed. by R.W. Nelson) Edmonton, Alberta. Pp.133-147.

DEMAREST, D.W., R.M. KAMINSKI, AND L.A. BRENNAN 1997. Body-mass, survival, and pairing consequences of winter-diet restriction in wood ducks. Journal of Wildlife Management 61:822-832.

DENNEHY J.J.1997. Influence of Social Dominance Rank on Diet Quality Pronghorn Females. Behavioral Ecology 12:177-181.

DEVRIES, H., W.J. NETTO, AND P.L.H. HANEGRAAF. 1993. Matman: a program for the analysis of sociometric matrices and behavior transition matrices. Behaviour 125:157-175.

DYNES, R.A.. 1996. The animal: options for managing intake. Australian Journal of Agricultural Research 47:277-287.

ERASMUS, T., B.L. PENZHORN, AND N. FAIRALL. 1978. Chemical composition of faeces as an index of veld quality. South African Journal of Wildlife Research 8:19-23.

FORCHHAMMER, M.C. 1995. Sex, age, and seasonal variation if the foraging dynamics of muskoxen,*Ovibos moschatus*, in Greenland. Canadian Journal of Zoology 73:1344.

FREELAND, W.J., P.H. CALCOTT, AND D.P. GEISS. 1985. Allochemicals, minerals and herbivore population size. Biochemistry and Systems Ecology 13:195-206.

GATES, C.C., AND R.J. HUDSON. 1981. Weight dynamics of Wapiti in the boreal forest. Acta Theriologica 26:467-518.

GEIST, V. 1971. Mountain Sheep: a study in behavior and evolution. University of Chicago Press, Chicago, IL.

HANKS, J. 1981. Characterization of population condition. Pages 47-74 *in* C.W. Fowler and T.D. Smith editors. Dynamics of large mammal populations. A Wiley-Interscience publication, New York.

HODGMAN,T.P., B.B. DAVITT, AND J.R. NELSON, 1996. Monitoring mule deer diet quality and intake with fecal indices. J. Range. Manage. 49(3):215-222.

HOLECHEK, J.I., M.V. VAVRA, AND R.D. PIEPER, 1982. Botanical composition determination of range herbivore diets: a review. Journal of Range Management 35:309-315.

IRWIN, L.L., J.G. COOK, D.E.MCWHIRTER, S.G. SMITH, AND E.B. ARNETT. 1993. Assessing winter dietary quality in Bighorn Sheep via fecal nitrogen. Journal of Wildlife Management 57:413-421.

KIE, J.G. AND T.S. BURTON. 1984. Dietary quality, fecal nitrogen and 2,6 diaminopimelic acid in black-tailed deer in Northern California. USDA Forest Service, Res. Note PSW-364. Berkeley, Calif.

KRONBERG, S.L. AND J.C. MALECHEK. 1997. Relationships between nutrition and foraging behavior of free-ranging sheep and goats. Journal of Animal Science 75:1756-1763.

KUCERA, T.E. 1997. Fecal indicators, diet, and population parameters in mule deer. Journal of Wildlife Management 61:550-560.

LEITE, E.R. AND J.W. STUTH, 1990. Value of multiple fecal indices for predicting diet quality and intake of steers. Journal of Range Management 43:139-143.

LESLIE, D.M. JR., AND E.E. STARKEY, 1985. Fecal indices to dietary quality of cervids in old-growth forests. Journal of Wildlife Management 49:142-146.

_______, J.A. JENKS, M. CHILELLI, AND G.R. LAVIGNE. 1989. Nitrogen and diaminopimelic acid in deer and moose feces. Journal of Wildlife Management 53:216-218.

LOUDON, A.S.I. 1991. Nutritional physiology of some Asian ruminants. Pages 403-425 *in* Proceedings of the 7th International Symposium on Ruminants: Physiological aspects of digestion and metabolism in ruminants.

MAUTY, W.W., H. SILVER, J.B. HOTTER, H.H. HAYES, AND W.E. ARBON JR. 1976. Digestibility and related nutritional data for seven northern deer browse species. Journal of Wildlife Management 40:630-638.

MILLER, D.R. 1971. Seasonal changes in the feeding behavior of Barren-ground Caribou on the Taiga winter Range. *In* V. Geist and F. Walther editors. The behavior of ungulates and its relation to management 24:744-755

MILLER, M. W., HOBBS, N. T., AND M.C. SOUSA. 1991. Detecting stress responses In Rocky Mountain bighorn sheep (Ovis canadensis canadensis): reliability of cortisol concentrations in urine and feces. Canadian Journal of Zoology 69:15-24.

MOEN, A.N. 1978. Seasonal changes in heart rates, activity, metabolism, forage intake in white-tailed deer. Journal of Wildlife Management 42:715-738.

MORSE,D.H. AND FRITZ, R.S.1987. The consequences of foraging for reproductive success. In: Foraging Behavior (Ed. by Kamil, A.C., Krebs, J.R., & Pulliam, H.R.), pp. 443-455. New York; Plenum Press.

NELSON, J.R. AND B.B. DAVITT. 1984. A regional cooperative DAPA research and development program. Pages 148-163 *in* R.W.Nelson. Proceedings of the Western States and Provinces Elk Workshop. Edmonton, Alberta.

OSBORN, R.G. AND J.A. JENKS. 1998. Assessing dietary quality of white-tailed deer using fecal indices: effects of supplemental feeding and area. Journal of Mammalogy 79:437-447.

OZOGA, J.J. AND L.J. VERME. 1970. Winter feeding patterns of penned white-tailed deer. Journal of Wildlife Management 34:431-439.

PIANKA, E.R. 1994. Evolutionary ecology. Fifth edition. HarperCollins College Publishers.

PURSER, D.B., AND S.M. BUECHLER. 1966. Amino acid composition of rumen organisms. Journal of Dairy Science 49:81-84.

RHOADES, D.F. AND R.G. CATEY 1976. Toward a general theory of plant antiherbivore chemistry. Pages168-213. J.W. Wallace and R.L. Mansell editors. Vol. 10 Biochemical interactions between plants and insects: Recent advances in phytochemistry. Plenum New York, New York.

ROBBINS, C.T., T.A. HANLEY, A.E. HAGERMAN, O.HJELJORD, D.L. BAKER, D.L. SCHWARTZ, AND W.W. MAUTZ. 1987. Role of tannins in defending plants against ruminants: reduction in protein availability. Ecology 68:98-107.

ROWELL, T.E. 1966. Social organisation of primates. *In* Morris. Primate Ecology. London.

STATISTICAL ANALYSIS SYSTEMS 1990. Procedures guide for personal computers, Sixty third edition. Statistical Analysis Systems Institute, Cary, N.C.

WASSER, S.R., R. THOMAS, P.P. NAIR, C. GUIDRY, J. SOUTHERS, J. LUCAS, D.E. WILDT, AND S.L. MONFORT. 1993. Effects of dietary fibre on fecal steroid measurements in baboons (*Papio cynocephalus cynocephalus*). Journal of Reproduction and Fertilization 97:569-574.

WASSER, S.R., R. THOMAS, P.P. NAIR, C. GUIDRY, J. SOUTHERS, J. LUCAS, D.E. WILDT, AND S.L. MONFORT. 1993. Effects of dietary fibre on fecal steroid measurements in baboons (*Papio cynocephalus cynocephalus*). Journal of Reproduction and Fertilization 97:569-574.

WEHAUSEN, J.D. 1995. Fecal measures of diet quality in wild and domestic ruminants. Journal of Wildlife Management 59:816-823.

WHEATON, C. AND R.D. BROWN. 1983. Feed intake and digestive efficiency of south Texas white-tailed deer. Journal of Wildlife Management 47:442-450.

WOFFORD, H., J.L. HOLECHEK, M.L. GALYEAN, J.D. WALLACE, AND M. CARDENAS. 1985. Evaluation of fecal indices to predict cattle diet quality. Journal of Range Management 38:450-455.

WORK, E. AND D.L. DEWEY. 1953. The distribution of 2,6 diaminopimelic acid among various micro-organisms. Journal of General Microbiology 9:394-406.

ZUCKER, W.V. 1983. Tannins: does structure determine function? An ecological perspective. American Naturalist 121:335-365.

ANALYSIS OF REINTRODUCED PRONGHORN POPULATIONS IN ARIZONA USING MITOCHONDRIAL DNA MARKERS

OLIN E. RHODES, JR., Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN 47907, USA

ERIN P. REAT, Department of Forestry and Natural Resources, Purdue University, West Lafayette, IN 47907, USA

JAMES R. HEFFELFINGER, Arizona Game and Fish Department, 555 North Greasewood Road, Tucson, AZ 85745, USA

JAMES C. DEVOS, JR., Arizona Game and Fish Department, 2221 W. Greenway Road, Phoenix, AZ 85023, USA

Abstract: Genetic diversity was examined in pronghorn (*Antilocapra americana*) to assess relationships among Arizona populations sharing common reintroduction or translocation sources. Ninety-seven Arizona pronghorn were analyzed for mitochondrial DNA (mtDNA) haplotype variation via restriction enzyme analysis and four composite haplotypes were revealed. Comparative analyses of Arizona pronghorn populations that shared founders from Montana, Wyoming, Texas, or central Arizona were performed. In addition, analyses of differences in haplotype frequency were performed specifically for populations in the northwestern and southeastern sections of the state because these populations are thought to be composed entirely of reintroduced pronghorn. Tests for differences in haplotype frequencies among populations sharing founders were performed using Monte Carlo simulation. Populations which received translocated animals from Texas, Wyoming, or Montana showed no significant variability in haplotype frequencies. Haplotype frequencies were significantly different among populations that received reintroductions from central Arizona only when a population which also received pronghorn from Montana, was included in analyses. Overall, populations in southeastern Arizona differed significantly from each other in haplotype frequencies. However, populations within southeastern Arizona with common reintroduction sources (e.g., Texas or central Arizona only) were not different in haplotype frequencies. Populations sampled in northwestern Arizona were not different from each other in haplotype frequencies despite the wide array of sources (central Arizona, Montana, Wyoming, Colorado, and Utah) used to restock that region. Our results suggest that whenever possible, genetic data should be used to plan future reintroductions of pronghorn in Arizona.

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19:45-54

Key Words: *Antilocapra americana*, mitochondrial DNA, polymerase chain reaction, reintroduction.

Numerous genetic studies of reintroduced organisms document increased colonization success by individuals that most closely resemble the original genetic stocks of the region (Ellsworth et al. 1994, Leberg et al. 1994, Rhodes et al. 1995, Nedbal et al. 1997, Serfass et al. 1998). Thus, selection of source populations which closely correspond to current or historical genetic stocks of recipient populations could increase the probability of successful restocking events and may help to preserve remnants of native stocks. To manage wildlife populations at this level of resolution, baseline data on genetic diversity of potential source populations and existing remnant populations are needed (Avise 1989, Serfass et al. 1998, Williams et al. 2000).

Declines in pronghorn numbers around the turn of the century both isolated and extirpated populations and stimulated the Arizona Game and Fish Department (AGFD) to initiate a series of pronghorn reintroductions beginning in the 1920s. Continuing through the present, these reintroductions were designed to help bolster small populations and to repopulate historic pronghorn ranges. Pronghorn used in Arizona reintroductions came from central Arizona, as well as from other states such as Montana, Wyoming, Colorado, Utah, and Texas (Lee 1988).

Although successful in reestablishing pronghorn populations in Arizona, these reintroductions may have compromised the phylogeographic relationships of pronghorn throughout the state. For example, pronghorn north of the Grand Canyon (northwestern Arizona; Game Management Units [GMU] 12A, 12B, 13A & 13B; Figure 1) are believed to have been extirpated by the early twentieth century and repopulated with reintroductions from central Arizona, Colorado, Wyoming, Montana, and Utah (Alexander 2000). All present-day pronghorn within northwestern Arizona are believed to be direct descendents from these translocations. Likewise, pronghorn are believed to have been extirpated from southeastern Arizona by the early 1930s, and all pronghorn populations in this region of the state were established through reintroductions from Texas and central Arizona (Hoffmeister 1986).

Reat et al. (1999) examined mitochondrial haplotype diversity of 389 pronghorn distributed across the southeastern, central, and northern portions of their range in Arizona. Their research indicated that Arizona pronghorn exhibited 4 haplotypes, 3 observed previously in North American pronghorn and 1 unique to Arizona. In addition, their research revealed that 1 haplotype, which occurs at a relatively low frequency throughout most of the United States, was the common haplotype in Arizona. The research presented herein is an extension of the work of Reat et al. (1999) with emphasis on reintroduced pronghorn populations in Arizona. Our goal was to determine whether reintroduced Arizona pronghorn populations that shared a common source (either from a reintroduction or translocation) differed in their haplotype distributions. Additionally, we examined regional pronghorn populations in the northwestern and southeastern portions of the state to determine whether haplotype distributions in these population could be explained by their reintroduction history.

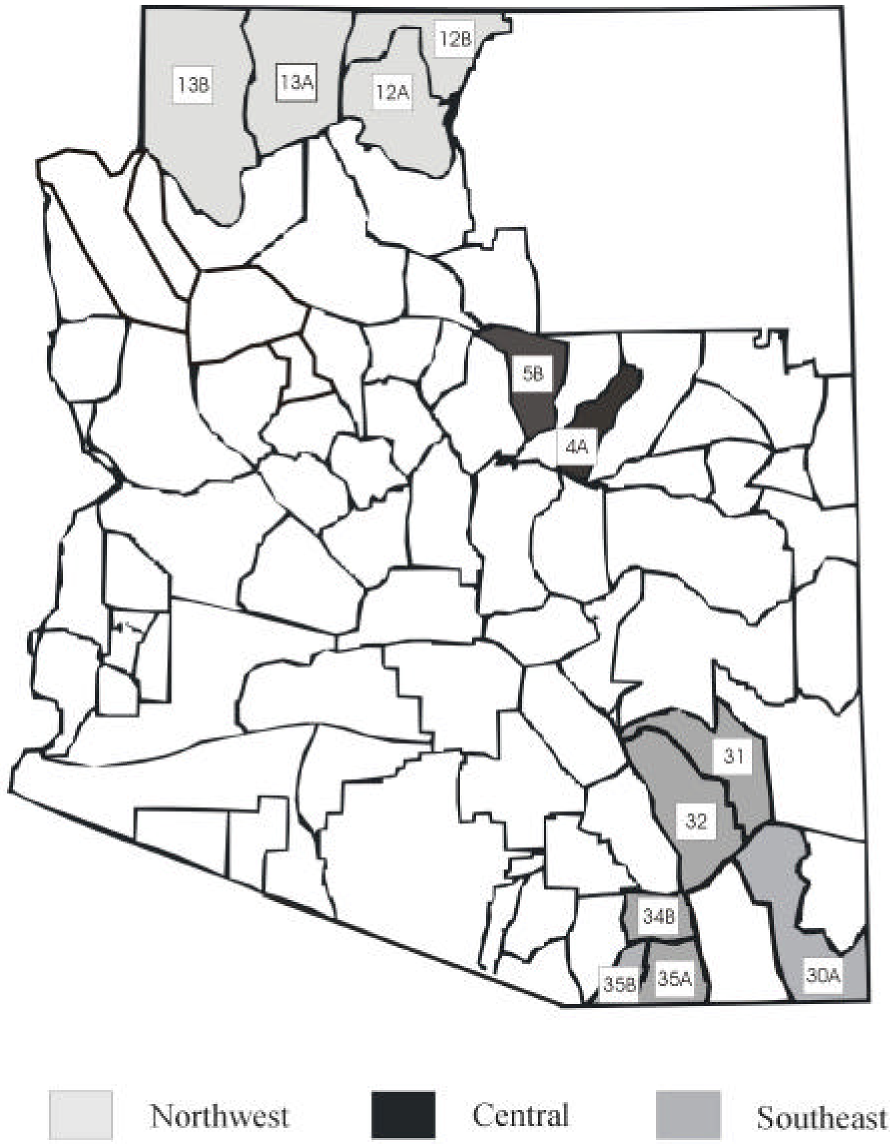


Figure. 1. Pronghorn samples were obtained from 10 Game Management Units in northwestern, central, and southeastern Arizona during the 1996 and 1997 hunting seasons. Game management unit numbers are provided within regions.

STUDY AREA AND METHODS

Collection kits, consisting of sample bags and instructions for tissue collection, were mailed to hunters that obtained permits to harvest pronghorn in Arizona during the 1996 and 1997 hunting seasons. In 1996, 755 kits were mailed to hunters throughout the state. In 1997, 334 kits were mailed to hunters that drew tags for areas under-represented in the 1996 sampling effort. The hunters were asked to collect liver and muscle tissue in the field and place the samples on wet ice. Hunters then dropped the samples off at collection stations located throughout Arizona at major highway intersections. In addition to roadside collections, samples were collected at AGFD regional offices and by Wildlife Managers in the field. Archived samples from the AGFD were also used to bolster sample numbers from critical areas. Following collection, samples were cataloged and placed in liquid nitrogen for storage until they could be transported to Purdue University, where they were stored at -75ºC until analysis.

Following genomic DNA extraction, mitochondrial DNA (mtDNA) was analyzed for haplotype variation using a technique whereby a 2290 base-pair (bp) segment of the ND-2 gene region was amplified using standard polymerase chain reaction (PCR) protocols (Saiki et al. 1988, Lee et al. 1994). Cycling times and temperatures were as follows: 1) initial denaturation for 2 min at 95ºC, 2) denaturation for 1 min at 95ºC, 3) annealing for 1 min at 52ºC, 4) extension for 2.5 min at 72ºC, 5) final extension for 7 min at 72ºC, and 6) soak at 4ºC. Steps 2-4 were repeated 40 times. Each fragment was amplified using the primers 562 (5´ TAA GCT ATC GGG CCC ATA CC 3´) and 452 (5´ ACT TCA GGG TGC CCA AAG AAT CA 3´; Lee et al. 1994).

The resulting amplified DNA fragments were digested to completion according to manufacturer's recommendations using 1 unit of each of the following restriction enzymes: *Aci*-I, *Bsp*-1286, *Hha*-I, *Hinf*-I, *Rsa*-I, *Ssp*-I . The digested fragments were then electrophoresed on 1%-2% agarose gels (Sambrook et al. 1989), separating the fragments according to size, and producing a scorable pattern. An *EcoR*-I, *Hind*-III-digested lambda DNA marker was used for size determination on each agarose gel. Gels were stained with ethidium bromide, and a permanent electronic record of these patterns was stored using a Stratagene Eagle-Eye II™ gel documentation system.

Data were analyzed for population haplotype frequency differentiation among sampling locations using the Monte Carlo simulation (Roff and Bentzen 1989) program found in the Restriction Enzyme Analysis Package (REAP, McElroy et al. 1992). Each Monte Carlo simulation was run with 1,000 iterations to test the hypothesis that differences in haplotype frequencies among populations were different than would be expected under random conditions. Significance values were based on an alpha of ??0.05 and critical probability values were adjusted to P ??0.004 to account for multiple comparisons using the Dunn-Sidak method. To assess the impact of past relocations, populations were grouped for analysis based on known reintroduction histories. These analyses were employed for: 1) populations that had reintroductions from Wyoming, Montana, or Texas; 2) populations that received reintroductions from central Arizona [GMU 5B; Figure 1]; 3) populations in southeastern Arizona; and 4) populations in the northwestern Arizona (Figure 1; Table 1).

RESULTS

During the 1996 and 1997 collection efforts, 405 individual pronghorn were sampled throughout the state of Arizona (1996, n = 351; 1997, n = 54). This represented approximate return rates of 46.5% in 1996 and 16.2% in 1997, based on the number of collection kits mailed to hunters. Of the 405 samples collected, 97 were used in analyses of haplotype frequency differentiation among GMUs which had received pronghorn reintroductions. Samples were analyzed from: GMU 4A (n = 13), GMU 5B (n = 15), GMU 12A (n = 1), GMU 12B (n = 2), GMU 13A (n = 13), GMU 13B (n = 6), GMU 30A (n = 22), GMU 31 and 32 (n = 15), GMU 34B (n = 4), and GMU 35A/B (n = 7) (Figure 1).

All restriction enzymes proved informative, except *Rsa*-I which was monomorphic. *Aci*-I , *Bsp*-1286, *Hha*-I, and *Hinf*-I each resulted in 2 distinct fragment patterns; *Ssp*-I produced 3 distinct fragment patterns (Reat et al. 1999). From these individual fragment patterns, 4 composite haplotypes were observed in Arizona's pronghorn, including 1 haplotype (K)**,** that has not previously been described. The remaining 3 haplotypes (A, C, J) were observed previously in North American pronghorn (Lee 1992, Lee et al. 1994).

Populations that received translocated animals from Texas, Wyoming, or Montana showed no significant variability in haplotype frequencies (Table 1). Populations which received pronghorn from Colorado (GMUs 12A & 13B) could not be tested for haplotype differentiation, as only 1 individual was collected from GMU 12A (Table 2). Haplotype frequencies were significantly different among GMUs that received reintroductions from central Arizona (GMU 5B) only when GMU 13A, which also received pronghorn from Montana, was included (Table 1). Likewise, of those populations that received pronghorn from central Arizona, only the GMU 13A population was significantly different in haplotype frequency from its source. Overall, populations in southeastern Arizona differed significantly in haplotype frequencies (Table 1). However, populations within southeastern Arizona that shared reintroduction sources (e.g., Texas or central Arizona) were not different from each other in haplotype frequencies. Populations sampled in northwestern Arizona were not different in haplotype frequencies despite the wide array of sources (central Arizona, Montana, Wyoming, Colorado, and Utah) used to restock the region (Table 1).

DISCUSSION

Our data indicated that, in general, pronghorn populations that shared a common source were similar in haplotype frequency. For example, subsets of Arizona pronghorn populations that received reintroductions from either Montana, Wyoming, or Texas were similar in haplotype frequencies. Our comparisons of haplotype frequencies among populations that shared central Arizona as a source indicated that for all comparisons, except those in which pronghorn from

Table 1. Monte Carlo simulations with 1,000 iterations were used to compare haplotype frequency distributions among pronghorn populations in Arizona. Comparisons were made between pairs of reintroduced populations (GMUs) that shared a common source from Montana, Wyoming, Texas, or Arizona. Comparisons also were made between the central Arizona population used as a source (GMU 5B) and those populations founded from that source. Additionally, comparisons of haplotype frequencies were made among the reintroduced populations that reside in the southeastern and northwestern regions of Arizona.

Comparison	*P*-value[5]
Montana reintroductions	
GMU 13A[1], 13B[2]	0.080
Wyoming reintroductions	
GMU 4A, 13B	0.135
Texas reintroductions	
GMU 34B, 30A	0.239
Arizona reintroductions	
GMU 13A, 31/32	<0.001
GMU 13A,35A/B	0.004
GMU 31/32,35A/B	0.068
Game Management Unit 5B	
GMU 13A, 5B	<0.001
GMU 31/32, 5B	0.270
GMU 35A/B, 5B	0.850
Southeast[3]	
GMU 31/32, 30A, 34B, 35A/B	0.003
Northwest[4]	
GMU 13A, 12A, 12B, 13B	0.162

[1] reintroductions also from central Arizona
[2] reintroductions also from Wyoming and Colorado
[3] reintroductions from central Arizona and Texas
[4] reintroductions from central Arizona, Montana, Wyoming, Colorado, and Utah
[5] Dunn-Sidak Corrected significance level is P?0.004

Table 2. Composite haplotype frequencies based on PCR-RFLP analysis of the 2.3 kb ND-2 gene region of mtDNA in Arizona pronghorn populations. Sample sizes (*n*) are provided for each of 10 Game Management Units analyzed in Arizona. Data were collected during the fall hunting seasons of 1996 and 1997.

GMU	*n*	A	C	J	K
4A	13	0.615	0.308	0.000	0.077
5B	15	0.533	0.200	0.000	0.267
12A	1	1.000	0.000	0.000	0.000
12B	2	0.000	1.000	0.000	0.000
13A	13	0.000	1.000	0.000	0.000
13B	6	0.167	0.667	0.167	0.000
30A	22	0.500	0.500	0.000	0.000
31/32	14	0.852	0.000	0.000	0.143
34B	4	0.000	1.000	0.000	0.000
35A/B	7	0.430	0.285	0.000	0.285
Average	9.7	0.410	0.496	0.016	0.076

GMU 13A were included, haplotype frequencies were similar among populations. Additionally, of those populations that were established using pronghorn from central Arizona, only the pronghorn population residing in GMU 13A was significantly different from its source in haplotype frequency. The aberrant haplotype frequencies in GMU 13A are most likely due to the high frequency of the C haplotype (common in non-Arizona pronghorn) and the total absence of the K haplotype (unique to Arizona) in pronghorn from that GMU (Table 2).

The southeastern and northwestern regions of Arizona are considered to be inhabited totally by reintroduced stock. Thus, significant differences in haplotype frequencies among pronghorn populations in southeastern Arizona are likely a consequence of differences between the Texas (K haplotype absent) and central Arizona (K haplotype present) source populations used to restock the region. Pairwise comparisons of populations sharing the same sources in the southeastern region of the state (i.e., central Arizona stock versus Texas stock) were non-significant. Differences in haplotype frequencies within the southeastern region populations are probably a consequence of historic differences between reintroduction sources (i.e., Texas versus Arizona), despite the evidence that the (A) haplotype is the common haplotype for both sources. Alternatively, the wide variety of sources and ubiquitous placement of pronghorn used to restock the Arizona Strip, as well as low samples sizes in GMUs 12A and 12B, probably contributed to the lack of observable differentiation among pronghorn populations sampled in that region.

Several researchers have used genetic tools to assess the colonization success of reintroduced populations relative to the success of remnant populations residing in their vicinity (Ellsworth et al. 1994, Leberg et al. 1994, Nedbal et al. 1997). In some instances, remnant genetic material has clearly been maintained even in the presence of repeated translocations of individuals with different genetic characteristics (Ellsworth et al. 1994). In other cases, there is evidence that reintroduced populations have maintained the genetic characteristics of their source populations, even many generations after the reintroduction event (Leberg et al. 1994). Our analysis of reintroduced pronghorn populations indicate that Arizona populations sharing a common source do retain the genetic characteristics of those sources, despite the effects of sampling error (founder effect) during the translocation events and random changes in gene frequencies over time (genetic drift) after establishment.

Our results may not seem surprising given that many of the focal study populations were established in areas where pronghorn were assumed to have been extirpated. However, our data do serve to support the premise that pronghorn were extirpated in northwestern and southeastern Arizona. In particular, the absence of the K haplotype in northwestern Arizona (which received no intraArizona translocations) and, the presence of the K haplotype in all GMU's in southeastern Arizona except GMUs 30A and 34B (which received pronghorn from Texas only) suggest that the current genetic distributions of these regional populations were primarily influenced by their reintroduction sources.

MANAGEMENT IMPLICATIONS

Data on regional gene frequency distributions offer wildlife managers the opportunity to select source populations for reintroduction programs that are appropriate to their management goals. For instance, our data suggest that a genetic legacy of past reintroductions is maintained in Arizona's current pronghorn populations. Thus, it is clear that decisions pertaining to pronghorn sources have long lasting genetic impacts and that pronghorn reintroductions have probably changed the distribution of genetic diversity in the Arizona population. Alternatively, Arizona has a unique opportunity to preserve pronghorn stocks native to the state (e.g., K haplotype) as they make decisions regarding source populations for future translocations. In addition, using the haplotype frequency data generated in this research, Arizona biologists can make informed decisions regarding future translocations of pronghorn in the state.

ACKNOWLEDGEMENTS

Thanks to all the volunteers from Arizona Game and Fish Department, Arizona State University, University of Arizona, Northern Arizona University, Yavapai College, Grand Canyon University, Pima Community College, and the Arizona Antelope Foundation who helped operate the sample collection stations, especially R. Barkhurst, J. Beals , D. N. Cagle, A. Fuller, J. Galaway, J. Goodwin, J. Hanna, B. Henry, J. Hervert, C. A. Jones, M. A. McKenzie, R. M. Lee, A. Munig, J. B. Pickrell, P. Shaw, J. Simmons, J. Vassel, B. F. Wakeling, and many others. The Southern Arizona Bowhunting Chapter of Safari Club International provided funding for necessary field supplies. We thank Purdue University for providing funding in support of this research and we express our appreciation to B. Shen for his assistance with laboratory analyses. Our appreciation goes to all the Arizona Game and Fish Department Employees who went out of their way to collect samples from far reaching areas. We also thank Richard Ockenfels for information on pronghorn movements and population fragmentation. Arizona pronghorn hunters played an integral role in sample collection, sometimes going far out of their way to return samples in good condition. This is a contribution of the Federal Aid in Wildlife Restoration Act Project W-53-M and W-78-R of the Arizona Game and Fish Department.

LITERATURE CITED

ALEXANDER, A. 2000. History of pronghorn transplants in Arizona. Proceedings of the 17th Biennial Pronghorn Antelope Workshop:112-113

AVISE, J. C. 1989. A role for molecular genetics in the recognition and conservation of endangered species. Trends in Ecology and Evolution 4:279-281.

ELLSWORTH, D. L., R. L. HONEYCUTT, N. J. SILVY, J. W. BICKHAM, AND W. D. KLIMSTRA. 1994. Historical biogeography and contemporary patterns of mitochondrial DNA variation in white-tailed deer from the southeastern United States. Evolution 48:122-136.

HOFFMEISTER, D. F. 1986. Mammals of Arizona. Arizona Game and Fish Department and University of Arizona Press. Tucson, USA.

LEBERG, P. L., P. W. STANGEL, H. O. HILLESTAD, R. L. MARCHINTON, AND M. H. SMITH. 1994. Genetic structure of reintroduced wild turkey and white-tailed deer populations. Journal of Wildlife Management 58:698-711.

LEE, R. M. 1988. Arizona state report. Proceedings of the 13th Biennial Pronghorn Antelope Workshop. 13:5-11.

LEE, T. E., JR. 1992. Mitochondrial DNA and allozyme analysis of pronghorn populations on North America. Dissertation, Texas A&M University, College Station, USA.

______, J. W. Bickham, and M. D. Scott. 1994. Mitochondrial DNA and allozyme analysis of North American pronghorn populations. Journal of Wildlife Management 58:307-318.

McElroy, D., P. Moran, E. Bermingham, and I. Kornfeld. 1992. REAP: An integrated environment for the manipulation and phylogenetic analysis of restriction data. Journal of Heredity 83:157-158.

Nedbal, M. A., R. L. Honeycutt, S. G. Evans, R. M. Whiting, Jr., and D. R. Dietz. 1997. Northern bobwhite restocking in east Texas: a genetic assessment. Journal of Wildlife Management 61:854-863.

Reat, E. P., O. E. Rhodes, Jr., J. R. Heffelfinger, and J. C. deVos, Jr.. 1999. Regional genetic differentiation in Arizona pronghorn. Proceedings of the 18th Biennial Pronghorn Antelope Workshop 18: 25-31.

Rhodes, O. E., Jr., D. J. Buford, M. Miller, and R. S. Lutz. 1995. Genetic structure of reintroduced Rio Grande turkeys in Kansas. Journal of Wildlife Management 59:771-775.

Roff, D., and P. Bentzen. 1989. The statistical analysis of mitochondrial DNA polymorphisms: ?^{2} and the problem of small samples. Molecular Biology and Evolution 6:539-545.

Saiki, R. K., D. H. Gelfand, S. Stoffel, S. J. Scharf, R. Higuchi, G. T. Horn, K. B. Mullis, and H. A. Erlich. 1988. Primer-directed enzymatic amplification of DNA with a thermostable DNA polymerase. Science 239:487-491.

Sambrook, J., E. F. Fritsch, and T. Maniatis. 1989. Molecular cloning: a laboratory manual. Cold Spring Harbor Laboratory Press. Plainview, New York, USA.

Serfass, T. L., J. M. Novak, P. E. Johns, R. P. Brooks, and O. E. Rhodes, Jr. 1998. Genetic variation among river otter populations in North America: Considerations for reintroduction projects. Journal of Mammalogy 79:736-746.

Williams, R. N., O. E. Rhodes, Jr., and T. L. Serfass. 2000. Assessment of genetic variance among source and reintroduced fisher populations. Journal of Mammalogy 81:895-907.

Sensitivity analysis as a guide for population management of pronghorn

PATRYCE AVSHARIAN, Department of Biological Sciences, University of Idaho, Moscow, ID 83844-3051, USA.

JOHN A. BYERS, Department of Biological Sciences, University of Idaho, Moscow, ID 83844-3051, USA.

Abstract: Sensitivity analysis can be a valuable tool for management and conservation of declining pronghorn populations. Calculation of elasticities is a type of sensitivity analysis which measures proportional effect of vital rates on the finite rate of increase (?). We calculated elasticity associated with each age-specific vital rate over 500 replicates of a leslie matrix population model. Vital rates were chosen randomly for each replicate within predetermined bounds derived from empirical life table data. Fawn survival was associated with the highest elasticity in all 500 replicates. Yearling and 2-yr old survival had the second and third highest elasticities, respectively. For all age classes, survival was associated with higher relative elasticity than reproductive rate. The results of this analysis support the hypothesis that fawn survival is the most important factor affecting ? of pronghorn populations.

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19:55-62

KEY WORDS: Elasticity, Leslie matrix, pronghorn, sensitivity analysis, survival, reproduction.

INTRODUCTION

Pronghorn (*Antilocapra americana*) range across much of western North America, but current populations are scattered and fragmented (Byers 1997). Although some populations have stabilized, others continued to decline (Yoakum 1978). To guide conservation efforts, managers can benefit from knowing which life stages or vital rates have the greatest effect on population growth. Several studies used sensitivity analyses to investigate the relative importance of age- or stage-specific vital rates (Maguire et al. 1995, Schmutz et al. 1997, Wisdom and Mills 1997) to changes in the finite rate of increase (?).

Sensitivity analysis can be used to calculate the elasticity of ? associated with each vital rate (Caswell 1989, Wisdom and Mills 1997). Elasticities are proportional sensitivities which can take values between 0 and 1. By considering the proportional effects of vital rates on ?, individual components of a population matrix sum to 1, making comparison among different types of vital rates possible (de Kroon et al. 1986). This approach can identify age-classes and vital rates which should be targeted by managers to affect population growth most effectively. Using a Leslie matrix approach, we test the hypothesis that fawn survival will have a larger effect on ? than adult survival or fertility.

METHODS

Parameter Estimation

We used data from the literature to estimate pronghorn age-specific survival and reproduction. To encompass the range of possible values, we selected the highest and lowest estimate available for each vital rate. Age-specific survival (S_x) was obtained from life table data compiled by Byers (unpublished data) and Mitchell (1980) from a total of four populations. We defined S_x as the finite rate of survival during the age interval x to x+1, where $S_x = (n_x - d_x)/n_x$. Although reports of age-specific adult S_x in the literature were limited, estimates of fawn survival were more abundant (Ellis 1972, Pyrah 1976, Beale 1978, Vriend and Barret 1978, Neff and Woolsey 1980). However, as a large proportion of fawn mortality occurs within the first few weeks after birth (Barrett 1978, Autenrieth 1980), we did not use estimates of fawn mortality based on mid-summer surveys. Only fawn counts conducted within a few days of birth provide accurate measures of early post-natal fawn survival.

Reproductive effort in ungulates is generally high (Case 1978, Robbins 1993), and may reach an extreme in pronghorn (Byers and Moodie 1990). Byers (1997) found that fecundity of pronghorn on the National Bison Range in Montana is invariant, with all females producing twins each year. Studies of other populations reported fawning rates as low as 1.8 - 1.9 fawns/adult female (Ellis 1972, Beale 1978). We defined age-specific reproduction (R_x) as the number of female fawns/female/year. Since considerable data suggest a 1:1 sex ratio in pronghorn (Edwards 1958, Pyrah 1976, Mitchell 1980, Byers 1997), we obtained R_x by multiplying the total number of fawns/female by 0.5.

To establish the upper and lower bounds of vital rates, we used the highest and lowest estimates available from the literature (Table 1). After defining the bounds of R_x and S_x, We used these values to parameterize the elements of age-specific fertility (F_i) and survival (P_i) in a Leslie matrix population model (Table 2). Wisdom and Mills (1997) recommended this procedure to evaluate elasticity over a realistic range of vital rates.

Model description.

To determine elasticities of each vital rate, we used ELASTIC6, a DOS-based program written by L. S. Mills. Parameter estimates from the literature were used to specify the upper and lower bounds on vital rates, incorporating possible variation between populations and environmental conditions (Table 1). Randomly selected values from within the specified bounds were parameterized in a post-birth pulse Leslie matrix model (Caswell 1989, Wisdom and Mills 1997). The top row matrix elements contained age-specific fertilities (Fi), which were

Table 1. Demographic components, range of values, associated vital rates and Leslie matrix elements used to calculate elasticities of lambda for pronghorn. Low and high values were used to establish the bounds of vital rates, and to parameterize the elements of age-specific fertility (F_i) and survival (P_i) in a Leslie matrix population model.

Demographic component	Range of values (source)	Vital rate	Matrix element
Number of female Fawns/ female/year[a]	0.9 (Beale 1978) to 1.0 (Byers 1997)	R_1 through R_{15}	F_1 through F_{15}
Fawn (age 0) survival	0.113[a] to 0.326[b]	S_0	P_0, F_0[c]
Adult (age 1) survival	0.409[b] to 1.0[a]	S_1	P_1, F_1
Adult (age 2) survival	0.968[a] to 1.0[b]	S_2	P_2, F_2
Adult (age 3) survival	0.447[b] to 0.967[a]	S_3	P_3, F_3
Adult (age 4) survival	0.617[b] to 1.0[a]	S_4	P_4, F_4
Adult (age 5) survival	0.460[b] to 0.957[a]	S_5	P_5, F_5
Adult (age 6) survival	0.327[b] to 0.952[a]	S_6	P_6, F_6
Adult (age 7) survival	0.727[b] to 0.971[a]	S_7	P_7, F_7
Adult (age 8) survival	0.320[b] to 0.936[a]	S_8	P_8, F_8
Adult (age 9) survival	0.200[b] to 0.958[a]	S_9	P_9, F_9
Adult (age 10) survival	0.0[b] to 1.0[a]	S_{10}	P_{10}, F_{10}
Adult (age 11) survival	0.0[b] to 0.786[a]	S_{11}	P_{11}, F_{11}
Adult (age 12) survival	0.0[b] to 0.857[a]	S_{12}	P_{12}, F_{12}
Adult (age 13) survival	0.0[b] to 0.600[a]	S_{13}	P_{13}, F_{13}

[a] J. Byers, unpublished data.
[b] Mitchell 1980:141-142.
[C] Fawn reproduction assumed to be zero (Byers 1997), thus F_0 was also assumed to be zero.

calculated as the product of $(R_x)(S_{x-1})$. The off-diagonal matrix elements equaled female probability of surviving the previous time step (P_i). We generated 500 replicates, with each composed of a different set of randomly selected vital rates from within the given range. For each replicate, ? was calculated, and the mean elasticities associated with each vital rate among the replicates were determined. Vital rates associated with the highest elasticity values represented the rates with the largest effects on ?.

Table 2. Estimates of the lower (a) and upper (b) bounds on age-specific fertility (Fi) and survival (Pi) for pronghorn. Estimates are organized in a post-birth pulse Leslie matrix, with Fi along the top row and Pi down the sub-diagonal. Lower-bound matrix (a) contains values of 0 for columns 11-15.

a

0	0.368	0.871	0.402	0.555	0.414	0.294	0.654	0.288	0.180
0.113	0	0	0	0	0	0	0	0	0
0	0.409	0	0	0	0	0	0	0	0
0	0	0.968	0	0	0	0	0	0	0
0	0	0	0.447	0	0	0	0	0	0
0	0	0	0	0.617	0	0	0	0	0
0	0	0	0	0	0.460	0	0	0	0
0	0	0	0	0	0	0.327	0	0	0
0	0	0	0	0	0	0	0.727	0	0
0	0	0	0	0	0	0	0	0.320	0
0	0	0	0	0	0	0	0	0	0.200
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

b

0	1.000	1.000	0.967	1.000	0.957	0.952	0.971	0.936	0.958	1.000	0.786	0.857	0.600	0.330
0.326	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1.000	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1.000	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0.967	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1.000	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0.957	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0.952	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0.971	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0.936	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0.958	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	1.000	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0.786	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0.857	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0.600	0

RESULTS

Fawn survival (S_0) showed the highest elasticity across the range of vital rates (Figure 1), and had the highest elasticity for all 500 replicates. Age-specific survival (S_x) had consistently higher associated elasticities than did age-specific reproduction (R_x) for every age-class (Figure 1). The second-highest elasticity was associated with yearling survival (S_1), and the third-highest elasticity was associated with 2-yr old survival (S_2). Relative ranking of the three highest elasticities was consistent for all 500 replicates. The distribution and range of ? showed these elasticities were applicable across variable population growth rates (Figure 2).

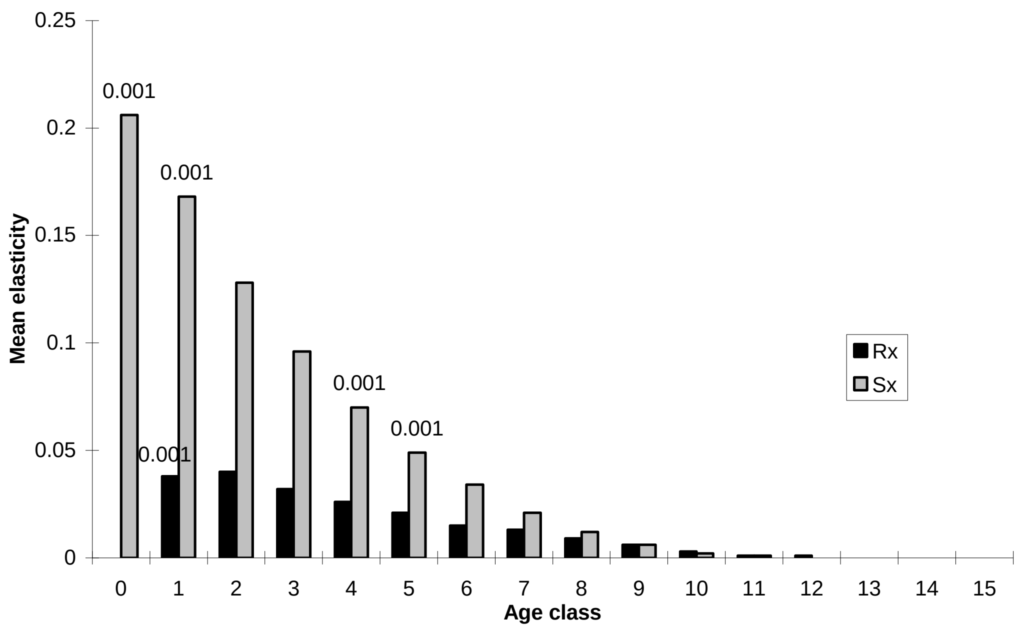


Figure 1. Mean Elasticities of age-specific survival (Sx) and reproduction (Rx) for pronghorn calculated from 500 replicates of a Leslie matrix population model. Shown with all SE values that were > .0001.

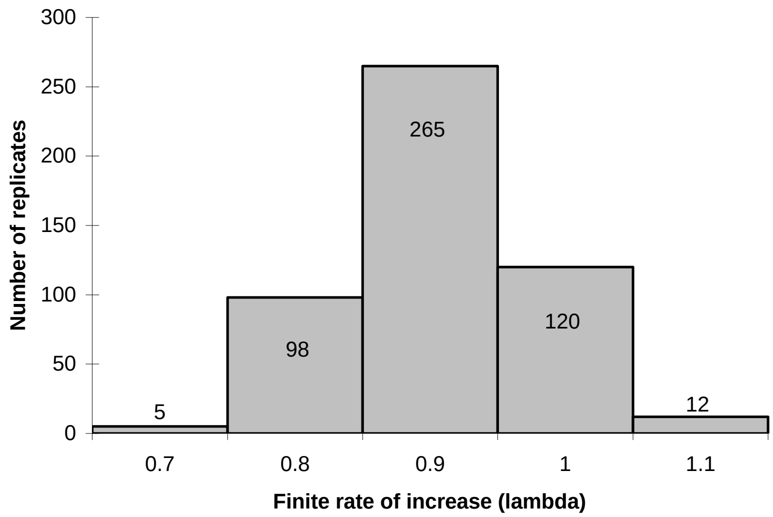


Figure 2. Distribution and range of the finite rate of increase (lambda) for pronghorn based on 500 replicates of a Leslie matrix population model

DISCUSSION

To promote the recovery and stability of pronghorn populations, managers can benefit from knowing how changes in survival and reproduction would affect ?. The results of our sensitivity analysis suggest that fawn survival is the most important factor contributing to changes in ?, followed by yearling and 2-yr old survival. The importance of fawn survival and recruitment has been emphasized in the literature (Vriend and Barrett 1978). The majority of fawn mortality is typically due to predation by coyotes, bobcats, and golden eagles, and predator control effected pronghorn population increases in multiple cases (Barrett 1978, O'Gara and Malcolm 1988, Byers 1997).

In addition to fawn survival, yearling and 2-yr old survival rates were associated with relatively high elasticities. These results may reflect the large potential variance in adult survival due to hunter harvest. The lowest estimates of S_1 and S_2 were obtained from a hunted population (Mitchell 1980). In hunted populations, reduction of early age-class-harvest combined with predator control would be the most effective way to increase population growth. Low elasticities associated with older age classes ($S_{x?6}$) suggest that harvest of older individuals would not significantly affect ?.

Before changing management plans to incorporate the results of elasticity analysis, it is important to consider the underlying assumption that vital rates are measured accurately (Schmutz et al 1997). In our analysis of pronghorn, the range of possible vital rates may have been underestimated due to scarcity of demographic data. In particular, fecundities of pronghorn under poor environmental conditions are not known, but are currently under investigation (M. Robinson, pers. comm). With accurate estimation of vital rates, sensitivity analysis is a valuable tool for managers that can guide allocation of future management and research efforts.

ACKNOWLEDGMENTS

We thank E.O. Garton for useful suggestions during the preparation of this mnuscript. We are grateful to L.S. Mills fir the use if his computer program for data analyses

LITERATURE CITED

AUTENRIETH, R. 1980. Vulnerability of pronghorn fawns to predation. Proc Biennial Pronghorn Antelope Workshop. 9:77-79.

BARRETT, M. W. 1978. Pronghorn fawn mortality in Alberta. Proc. Biennial Pronghorn Antelope Workshop. 8:429-444.

BEALE, D. M. 1978. Birth rate and fawn mortality among pronghorn antelope in western Utah. Proc. Biennial Pronghorn Antelope Workshop. 8:445-448.

BYERS, J. A. 1997. American pronghorn: social adaptations and the ghosts of predators past. University of Chicago Press, Chicago. 300pp.

BYERS, J. A. AND J. D. MOODIE. 1990. Sex-specific maternal investment in pronghorn, and question of a limit on differential provisioning in ungulates. Behav. Ecol. Sociobiol. 26:157-64.

CASE, T. J. 1978. On the evolution and adaptive significance of postnatal growth rates in the terrestrial vertebrates. Q. Rev. Biol. 53:243-82.

CASWELL, H. 1989. Matrix population models. Sinauer Publishers, Sunderland, Mass. 328pp.

DE KROON, H., A. PLAISIER, J. VAN GROENENDAEL, AND H. CASWELL. 1986. Elasticity: the relative contribution of demographic parameters to population growth rate. Ecology. 67:1427-1431.

EDWARDS W. C. 1958. A study of the reproductive potential and ovarian structures in the pronghorn antelope, *Antilocapra americana* (Ord.) in Wyoming. M.S. Thesis. University of Wyoming. 63pp.

ELLIS. J. 1972. Observations of pronghorn population dynamics. Proc. Antelope States Workshop. 5:55-65.

MAGUIRE, L. A., G. F. WILHERE, AND Q. DONG. 1995. Population viability analysis for red-cockaded woodpeckers in the Georgia Piedmont. J. Wildl. Manage. 59:533-542.

MITCHELL, G. J. 1980. The pronghorn antelope in Alberta. Alberta Department of Lands and Forests Fish and Wildlife Division. 165pp.

NEFF, D. J. AND N. G. WOOLSEY. 1980. Coyote predation on neonatal fawns on Anderson Mesa, Arizona. Proc. Biennial Pronghorn Antelope Workshop. 9:80-97.

O'GARA, B. W., AND MALCOLM, J. 1988. Pronghorn fawn mortality related to limited coyote control on the National Bison Range. Proc. Biennial Pronghorn Antelope Workshop. 13:61-70.

PYRAH, D. 1976. Pronghorn population characteristics in central Montana. Proc. Biennial Pronghorn Antelope Workshop 7:54-61.

ROBBINS, C. T. 1993. Wildlife feeding and nutrition, Second Edition. Academic Press, New York.

SCHMUTZ, J.A., R. F. ROCKWELL, AND M. R. PETERSEN. 1997. Relative effects of survival and reproduction on the population dynamics of emperor geese. J. Wildl. Manage. 61:191-201.

VRIEND , H. G. AND M. W. BARRETT. 1978. Low pronghorn recruitment- is it an issue? Proc. Biennial Pronghorn Antelope Workshop. 8:360-379.

WISDOM, J. J., AND L. S. MILLS. 1997. Sensitivity analysis to guide population recovery: prairie-chickens as an example. J. Wildl. Manage. 61:302-312.

YOAKUM, J. D. 1978. Pronghorn. Pages 103-121 *in* J. L. Schmidt and D. L. Gilbert, eds. Big game of North America, ecology and management. Stackpole Books, Harrisburg. 494pp.

A VALIDATION OF ARIZONA'S LANDSCAPE-LEVEL PRONGHORN HABITAT MODEL

CINDY L. TICER, Research Branch, Arizona Game and Fish Department, 2221 W. Greenway Road, Phoenix, AZ 85023-4312, USA

RICHARD A. OCKENFELS, Research Branch, Arizona Game and Fish Department, 2221 W. Greenway Road, Phoenix, AZ 85023-4312, USA

Abstract: Results of an earlier pronghorn (*Antilocapra americana*) habitat analysis (Ockenfels et al. 1996*a*) indicated that a model developed to evaluate landscape-scale pronghorn habitat identified useable pronghorn habitat. The model separated relative levels of quality with reasonable consistency, however, its ability to discern higher quality from more moderate habitat was low. Assessment of the habitat model in a different area of the state seemed necessary to determine reliability. We were able to validate the model during a project in a shortgrass prairie of northern Arizona, using locations from 29 radiocollared pronghorn acquired during a 2-year period. We compared proportion of pronghorn locations in each habitat rating class with proportion of the study area in each rating class. Non-random use of rated sections (2.6 km^2) by pronghorn occurred ($P < 0.001$); 82% of locations occurred in sections evaluated as moderate quality habitat. Sections rated as moderate or higher were sections pronghorn used above availability, whereas sections rated as lower quality than moderate were used less than available. The model is appropriate for identifying suitable habitat at a landscape level.

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19:63-70

Key words*: Antilocapra americana*, habitat analysis, habitat, landscape, model, pronghorn, shortgrass prairie.

Habitat loss, particularly loss of movement corridors from fences used to control livestock movements within pastures and along highways, and habitat degradation from long-term vegetative community changes due to livestock overuse and fire suppression have greatly impacted pronghorn populations (Ockenfels et al. 1994). In fact, as a result of habitat loss and degradation, some Arizona pronghorn populations have been extirpated (Nelson 1925, Knipe 1944, deVos 1999), or isolated.

The Arizona Game and Fish Department has identified and mapped Arizona pronghorn populations since the early 1920s (Nelson 1925, Knipe 1944) and has conducted aerial surveys since 1946. However, an assessment of pronghorn habitat quality, occupied and potential, was not systematically evaluated until 1994-96 (Ockenfels et al. 1996*b*) when a landscape-level habitat model was developed. This Statewide Pronghorn Habitat Evaluation Model used

5 key pronghorn habitat variables (topographic ruggedness, vegetative structure and species richness, water availability, human disturbance, and fence density and structure) to determine statewide habitat quality of potential pronghorn habitat. Potential pronghorn habitat was determined using slope (<20%) and general vegetation type (i.e., grasslands). Accuracy of this model was tested in 4 state Game Management Units (GMU) where pronghorn locations were overlaid onto an evaluated map of each GMU. Most (73.3%, 92.0%, 98.5%, and 95.6%) pronghorn locations occurred in sections rated as high, moderate, or low quality classes. Furthermore, using this evaluation method, we were able to identify habitat factors that decreased the quality of potential pronghorn habitat.

In 1997, we initiated a 2-year study in northern Arizona to evaluate the utility of this model in another area using radiomarked pronghorn. Also, it was important to establish validity of the model in this area because we needed to refer to the habitat factors identified as problems during the evaluation as a starting point to make habitat enhancement recommendations for another aspect of this project.

If the model was valid, we predicted that radiomarked pronghorn would use high-quality sections more than they were available and would avoid sections evaluated as low quality. If the model was invalid, we predict that no relationship between pronghorn use and habitat rating would occur. Establishing validity of the model in this area was necessary to confirm and further determine habitat quality enhancement recommendations for the area.

STUDY AREA

The study area was located on the Colorado Plateau in north-central Arizona at an elevation of 1,676-1,829 m and included 2 adjacent ranches that comprised approximately 182 km^2 of predominantly private land. The southern end of the study area consisted of mixed sections of state and private lands.

This area was typically arid; precipitation averaged <19cm and ranged from <25 - 51 cm annually, most of which occurred during summer (July - September) monsoons (Thybony and Thomas 1998). Terrain consisted of flats and gentle, rolling hills bisected longitudinally by steep-walled Cataract Canyon, a major drainage to the Colorado River.

Vegetation was predominately Shortgrass Plains Grassland integrating with Great Basin Grassland (Brown 1994: 115-119). Blue grama (*Bouteloua gracilis)* and ring muhly (*Muhlenbergia torreyi*) were dominant grasses. Salt-bush (*Atriplex* spp.), buckwheat (*Eriogonum* sp.), winter-fat (*Eurotia lanata*), rabbitbrush *(Chrysothamnus* spp.), and snakeweed (*Gutierrezia sarothrae*) were common shrub species. Extensive stands of rabbitbrush or snakeweed dominated poorer-condition sites. Big sagebrush (*Artemisia tridentata*) dominated much of the northern periphery. Tall shrubs, such as mexican cliffrose

(*Cowania mexicana*) and mountain mahogany (*Cercocarpus montanus*), and juniper (*Juniperus* spp.) trees occurred along Cataract Canyon. Southern and eastern boundaries consisted mainly of juniper woodlands.

Using the landscape-level model, the majority of this study area was evaluated as moderate quality pronghorn habitat. Problems identified in this area included high densities of low- to-the-ground (<40.6cm) fences, low vegetative diversity, dense tall shrub stands, and inaccessible water sources.

METHODS

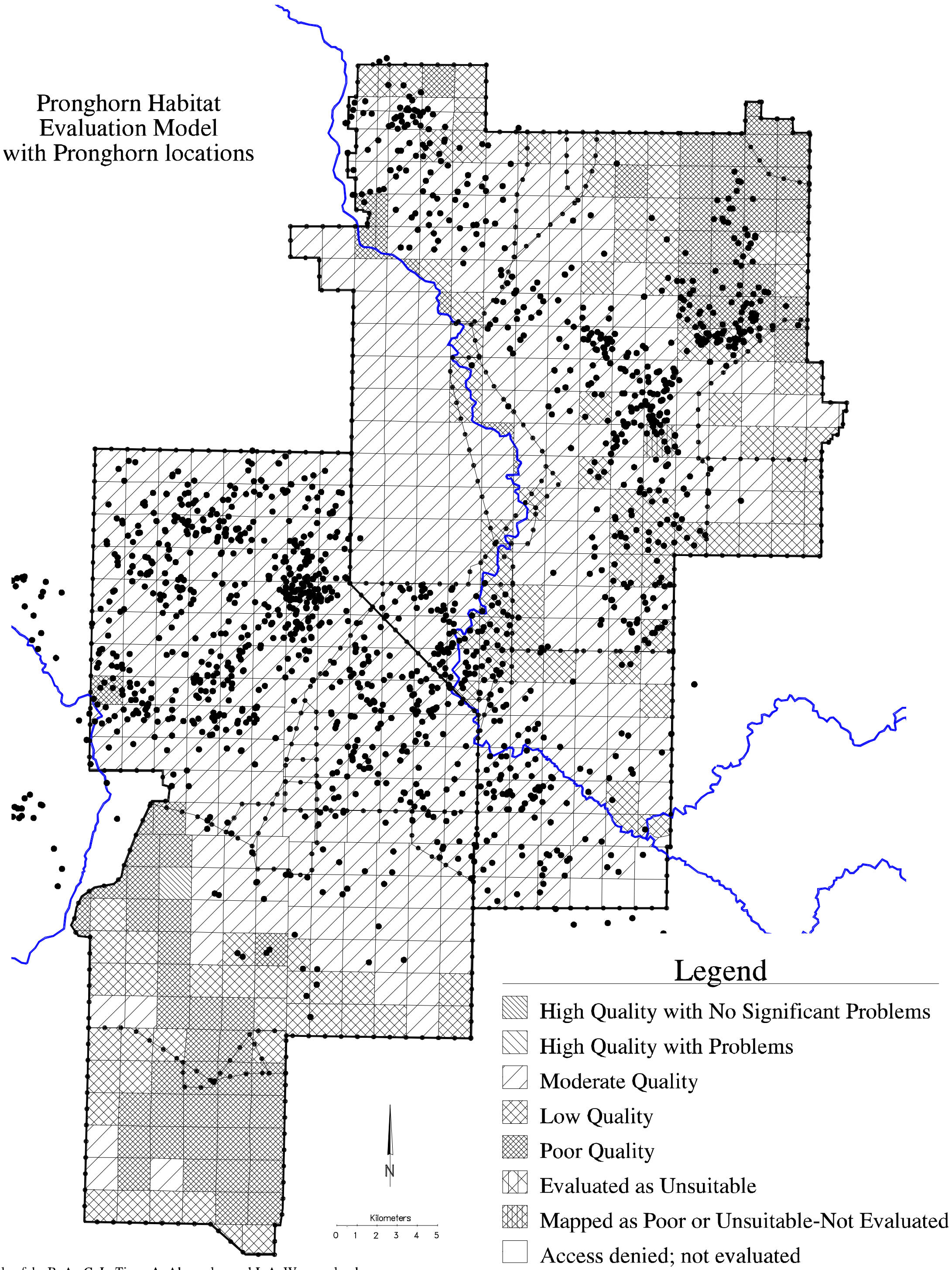
We captured, radiocollared, and eartagged adult pronghorn in March 1997, November 1998, and February 1999, using a net-gun fired from a helicopter (Firchow et al. 1986). During the first year, we aerially located pronghorn weekly during fawning season (March-July) and twice monthly the remainder of the year. Following the first year, 04/ pronghorn twice monthly using a hand-held receiver. Locations were plotted on U.S. Geological Survey (USGS) 7.5-min topographic maps. Universal Transverse Mercador (UTM) coordinates were recorded to the nearest 0.1 km for each location. Aerial and ground locations were combined and their coordinates transferred into a geographic information system (GIS).

We used GIS technology to assess pronghorn use of the evaluated habitat types. First, we extracted the study area from the 1996 statewide habitat evaluation database, determined km^2, and calculated percent area of each habitat quality class present. Next, we overlaid a GIS-developed cover of pronghorn locations onto the study area map (Fig. 1). We then calculated proportion of locations within each habitat quality class as our measure of pronghorn use.

We compared proportion of locations in each habitat quality rating class against availability with Chi-square contingency table analysis. We used a contingency table rather than goodness of fit analysis because we only estimated the expected distribution (Thomas and Taylor 1990). When the contingency table indicated a significant difference between the 2 distributions, Bonferroni simultaneous confidence intervals were calculated to determine which rating classes were selected or avoided (Neu et al. 1974, Byers et al. 1984). If selection or avoidance was determined for a cell, we used a Jacobs' *D* to indicate direction and magnitude of nonrandom use for that rating score (Jacobs 1974).

RESULTS

We captured, radiocollared, and eartagged 29 adult pronghorn (11F, 6M-1997, 7F-1998, and 5F-1999). We acquired 1,647 locations between March 1997 and March 1999.



Ockenfels, R. A., C. L. Ticer, A. Alexander, and J. A. Wennnerlund. 1996. A landscape-level pronghorn habitat evaluation model for Arizona. Ariz. Game and Fish Dep. Tech. Rep. 19, Phoenix. 50pp.

Non-random (X^2 = 140.52, df = 2, n = 1,220) use by pronghorn of available sections occurred (Table 1). Sections rated as moderate quality or high quality with problems were used more than available, whereas sections rated as low or poor quality were used less than available**.** In this study area, 94.5% of pronghorn locations occurred in sections rated as moderate (82%) or low (11.6%), quality classes (Fig. 1). We did not document pronghorn use of high quality with no significant problems habitat class probably because only 1 section of such habitat existed within this study area. Only 18.8% of pronghorn locations occurred in habitat evaluated as low and poor quality classes.

DISSCUSSION

We conclude that the statewide pronghorn habitat evaluation model adequately evaluated potential pronghorn habitat in shortgrass prairie of northern Arizona, at a landscape level. Similar to pronghorn habitat use in a shortgrass prairie of central Arizona (Ockenfels et al. 1994, 1996*a*), pronghorn in this study selected for habitat evaluated as moderate or better and avoided habitat evaluated lower than moderate quality.

We found that pronghorn use of habitat evaluated as poor was likely a combination of individualistic animal use and scale of the evaluation. Only 2 of 29 collared pronghorn used the Poor quality habitat in the northeastern portion of the study area. These pronghorn were often located in juniper woodlands, tall (>46cm) sagebrush shrublands, and small grassy openings within this area. Pronghorn also occasionally used peripheral areas of poor quality habitat, which may have been location measurement scale error. We visually examined 3 of these low and poor quality areas where locations appeared most numerous and clustered. We found the vegetation and terrain to be suitable for pronghorn since the vegetation was a grassland without tall (>45.7cm) shrubs and terrain was gentle (<10%). However, low (<40.6cm), to-the-ground fences and mixed vegetation within the scale of the experimental unit (i.e., 2.6 km^2) resulted in a reduced overall evaluation score of many sections. A to-the-ground, woven-wire fence ran along the periphery of several sections, resulting in a decreased evaluation score of these sections. Juniper woodlands and sagebrush flats that occurred in the northeastern corner of the study area were dissected by a series of finger-like grassy draws. We determined that 2 collared pronghorn used these draws for access. However, many locations from these 2 pronghorn also were located in the woodlands and shrublands.

We believe this model can be used as a management tool to conduct landscape-scale assessments of potential pronghorn habitat. The model will assist land managers in identifying landscape-scale habitat problems of an area currently occupied by pronghorn or by aiding in identification of unoccupied pronghorn habitat area for possible re-introduction.

Table 1. Pronghorn use of habitat sections previously rated by Statewide Habitat Evaluation Model (Ockenfels et al. 1996*a*,*b*) in northern Arizona, 1997-99.

Habitat quality	No. of locations	% of locations	Bonferroni 90% CI	km^2 available	% of area	No. of Locations expected	Jacobs' *D*
High/no problems	0	0.0		2.6	0.0	3.2	
High/problems	0	0.0		0.0	0.0	0.0	
Moderate	1370	83.1	81.2 - 85.1	887.2	66.1	1088.7	0.43
Low	187	11.4	9.7 - 13.0	261.5	19.5	321.2	-0.31
Poor	90	5.5	4.3 - 6.7	190.5	14.2	233.9	-0.48
	1647	100.0		1341.8	100.0	1647.0	

ACKNOWLEDGEMENTS

Babbitt Ranches, Inc., President Billy Cordasco graciously provided us opportunity to conduct this study on deeded and leased lands. David W. Hunt coordinated aerial support for pronghorn captures. John Hervert, Bob Birkeland, Amber A. Munig, Wade Zarlingo, Larry Phoenix, Billy Cordasco, James D. Babbitt, Mark McCullough, and Lee Leudecker assisted with capture operations. Volunteers Dr. Robert Kreycik and Dr. Clancy Gansberg provided veterinary assistance during captures. Bob Birkeland, Neil Lawson, Wade Zarlingo, Heather Whitlaw, MariAnn Koloszar, Andi Rogers, and student interns Phil James and Carl Daniels assisted in data collection. Bill Carrel and MariAnn Koloszar provided aerial location support. Sue Boe provided GIS and technical support. James C. deVos Jr., Ted McKinney and Amber A. Munig reviewed this manuscript.

Funding for this project was provided by Babbitt Ranches Inc., and Federal Aid in Wildlife Restoration Act Project F-78-R of the Arizona Game and Fish Department.

LITERATURE CITED

ARIZONA GAME AND FISH DEPARTMENT. 1996. Wildlife 2000. Arizona Game and Fish Department, Phoenix, USA.

BROWN, D. E., editor. 1994. Biotic Communities: southwestern United States and northwestern Mexico. University of Utah Press, Salt Lake City.

BYERS, C. R., R. K. STEINHORST, AND P. R. KRAUSMAN. 1984. Clarification of a technique for analysis of utilization-availability data. Journal of Wildlife Management 48:1050-1053.

DEVOS, J. C., JR. 1999. Status and management needs of pronghorn in Arizona. Pronghorn Antelope Workshop Proceedings 18:7-15.

FIRCHOW, K. M., M. R. VAUGHN, AND W. R. MYTTON. 1986. Evaluation of the hand-held net gun for capturing pronghorns. Journal of Wildlife Management 50:320-322.

JACOBS, J. 1974. Quantitative measurements of food selection. Oecologia 14:413-417.

KNIPE, T. 1944. The status of the antelope herds of northern Arizona. Arizona Game and Fish Commission Federal Aid Project Report, Phoenix, Arizona, USA.

NELSON, E. W. 1925. Status of the pronghorn antelope: 1922-1924. U.S. Department of Agriculture Bulletin 1346, Washington, D.C., USA.

NEU, C. W., C. R. BYERS, AND J. M. PEEK. 1974. A technique for analysis of utilization-availability data. Journal of Wildlife Management 38:541-545.

OCKENFELS, R. A., A. ALEXANDER, C. L. DOROTHY TICER, AND W. K. CARREL. 1994. Home ranges, movement patterns, and habitat selection of pronghorn in central Arizona. Arizona Game and Fish Department Technical Report 13, Phoenix, Arizona, USA.

_____, C. L. TICER, A. ALEXANDER, AND J. A. WENNERLUND. 1996a. A landscape-level pronghorn habitat evaluation model for Arizona. Arizona Game and Fish Department Technical Report 19, Phoenix, Arizona, USA.

_____, C. L. TICER, A. ALEXANDER, AND J. A. WENNERLUND. 1996b. Statewide evaluation of pronghorn habitat in Arizona. Arizona Game and Fish Department Federal Aid Final Report, Phoenix, USA.

THOMAS, D. L., AND E. J. TAYLOR. 1990. Study designs and tests for comparing resource use and availability. Journal of Wildlife Management 54:322-330.

THYBONY, S., AND K. THOMAS. 1998. Coconino Plateau Babbitt Ranches Biological Assessment.

NEW STRATEGIES FOR PRONGHORN FOOD HABIT STUDIES

MICHAEL C. HANSEN[1], Oregon Cooperative Fish & Wildlife Research Unit, 104 Nash Hall, Oregon State University, Corvallis, OR 97331-3803, USA

JAMES D. YOAKUM, Western Wildlife Consultants, P.O. Box 369, Verdi, NV 89439-0369, USA

WILLIAM H. PYLE[2], U.S. Fish and Wildlife Service, P.O. Box 111, Lakeview, OR 97630, USA

ROBERT G. ANTHONY, Oregon Cooperative Fish & Wildlife Research Unit, U.S. Geological Survey, Oregon State University, Corvallis, OR 97331-3803, USA

Abstract: A food habits project was conducted on pronghorn (*Antilocapra americana*), mule deer (*Odocoileus hemionnus*), bighorn sheep (*Ovis canadensis*), feral horses (*Equus caballlus*) and feral burros (*Equus assinus*) on 2 national wildlife refuges, one in Oregon and one in Nevada from 1993 to 1995. We report findings emphasizing pronghorn diet and the relationship with the other 4 ungulates. Diet composition varied considerably among seasons and between years for 3 native ungulates. Digestibility correction factors were employed for the first time in pronghorn diet studies and provided a more accurate assessment of forage consumed. Pronghorn and mule deer primarily alternated use between forbs and shrubs, while bighorn alternated between grass and forbs. Both feral equids foraged on grasses with some seasonal forb use. Diet quality for all ungulate species at both refuges varied seasonally with the highest quality generally during spring when forbs were used most heavily. Lowest quality occurred during winter when forage was generally senescent. Apparent relationships of diet quality indices with weather, particularity temperature and precipitation were noted. Based on results of this project, we recommend future diet studies for pronghorn consider using digestibility correction factors, forage quality indices and correlation of diet composition with weather patterns.

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19:71-94

Key words: *Antilocapra americana*, diet selection, digestibility correction factors, food habits, forage quality, plant nutritional values, pronghorn, weather patterns.

---

[1]Present address: Oregon Department of Fish and Wildlife, 65495 Alder Slope Road, Enterprise, OR 97828, USA.
[2]Present address: Kodiak National Wildlife Refuge, 1390 Buskin River Road, Kodiak, AK 99615, USA.

Literature on pronghorn diets has spanned close to 200 years. During the historic Lewis and Clark expedition across America from 1803 to 1806, Lewis reported anecdotal observations of plants consumed by pronghorn (Moulton 1987). Rouse (1941) documented the earliest quantified diet composition for pronghorn. More than 250 diet studies of pronghorn diet have been conducted during the last 50 years (Sundstrom et al. 1973, Yoakum 1990). Pronghorn food habit studies originally used observation methods, then changed to rumen analyses, and more recently, fecal analyses (Yoakum 1990). Fecal analysis for pronghorn diets has been used since the 1970s (Jacobs 1973, Schwartz and Nagy 1976, Sneva and Vavra 1978). Procedural techniques have been standardized with few changes.

The project was initiated during the development of an Environmental Impact Statement/Comprehensive Management Plan for the Hart Mountain National Antelope Refuge (HMNAR) in Oregon (U.S. Fish and Wildlife Service 1994). Diet composition data for the HMNAR were more than 40 years old for pronghorn, did not exist for other wild and domestic ungulates, and lacked nutritional values for plants. Similar information was needed to meet management objectives on the nearby Sheldon National Wildlife Refuge (SNWR) in Nevada (Yoakum 1992). This study represents the first use of digestibility correction factors for pronghorn diets, as well as forage quality indices and the correlation of diets with weather patterns.

Our paper focuses on the portions of the study (Hansen and Anthony 1999) pertaining to pronghorn diets and diet overlap of pronghorn with other ungulates. Our specific objectives were to:

1. Determine diet composition for all ungulates (corrected for differential digestion for pronghorn), and preference ratios for pronghorn
2. Determine diet quality indices
3. Correlate diet information with weather patterns
4. Calculate dietary overlap between pronghorn and other ungulates.

STUDY AREA

The HMNAR contains approximately 88,000 ha in southcentral Oregon and the nearby SNWR encompasses some 120,000 ha in northwestern Nevada--all within the Great Basin ecoregion (Figure 1). Elevations ranged from 1,400 m on the SNWR to 2,400 m on the HMNAR. Average annual precipitation was 25 to 35 cm with most received as rain and snow during winter and spring. Both refuges are in the shrubsteppe biome with vegetative communities dominated with sagebrush (*Artemisia spp.*), rabbitbrush (*Chrysothamnus spp.*), and western juniper (*Juniperus occidentalis*). Predominate grasses included bluegrass (*Poa secunda*), bluebunch wheatgrass (*Agropyron spicatum*), and at higher elevations, fescue (*Festuca spp.*).

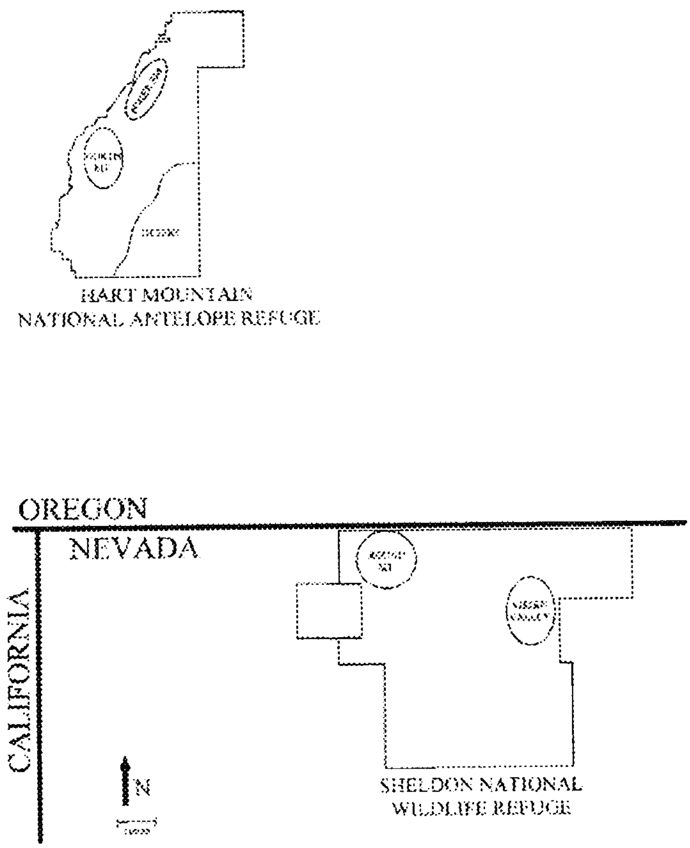


Fig. 1. Map of Hart Mountain National Antelope Refuge and Sheldon National Wildlife Refuge showing study areas.

A large diversity of annual and perennial forbs grow in various vegetative communities on both refuges.

METHODS

The study commenced in October 1993 and terminated in June 1999. Field collections of biological samples were conducted by U.S. Fish and Wildlife personnel between October 1993 and September 1995. Determination of diet composition and quality were accomplished by the Wildlife Habitat Laboratory at Washington State University, Pullman, Washington.

Sample Collections.--Fecal samples were collected from pronghorn, bighorn sheep, mule deer and feral horses on both refuges, and from feral burros on the SNWR. Two sample locations on the SNWR and 3 on the HMNAR (see Figure 1) were established because they represented typical plant communities on each refuge, exhibited maximum species overlap, multi-season use, and presence of feral burros and horses that were of special interest. We attempted to collect fecal samples from all ungulates inhabiting each collection site on each refuge. Thus, during some sample periods, fecal samples were collected from the same ungulate species in up to 3 locations on the HMNAR, but only 1 location for another ungulate species. Occasionally some ungulate species could not be located within designated locations; consequently, samples were collected in the closest adjacent area where animals were found and the vegetative community was similar.

Fecal samples were collected by observing specific animals (or groups of animals) until they defecated. Information on sex and age of the animals was recorded. For pronghorn, fecal samples were predominantly collected from adult females. Sample collection times were concentrated during periods when the diversity of plant species was high and the change in plant phenology was rapid (April, May, June), then equally spaced during the remainder of the year (August, October, and January). Sample sizes were increased when plant species diversity was high (Davitt and Nelson 1984): 15-20 samples/month in the spring and summer and 10 samples/month during the autumn and winter. Two years of diet information were collected in an attempt to establish how diets varied between years with differing weather conditions.

Diet Composition.--Determination of dietary components was done by microhistological analysis. Composite samples were obtained for each refuge, sampling period, and were available for each sample location by compositing 1 gm of fecal material from each individual sample to remove bias due to pellet size (Jenks et. al. 1989). Two hundred microscope fields per composite sample were inspected for identifiable plant species using methods of Davitt and Nelson (1980). However, uncorrected diet composition data does not account for the effect of differential digestibility of the various forage plants consumed, especially forbs (Dearden et al. 1975, Vavra and Holechek 1980, Holechek and Valdez 1985, Hansen 1996). Therefore, concurrent with collection of additional fecal samples in the second year, specimens of important forage plants were collected. *In-vitro* digestion trails on these plants were used to determine correction factors for species with differential digestibility. These factors were then applied to the diet composition data from both years to give a more accurate estimation of the relative quantity of each plant species actually consumed by the animals.

All plant species were grouped into three forage classes (grasses, forbs and shrubs) commonly used in pronghorn food habit studies (Yoakum 1990); consequently, it was possible to compare results of this study with similar studies in the Great Basin, and to calculate dietary overlap for each forage class. Sedges and rushes were included with grasses--moss was listed with forbs.

Forage preference ratings (PR) were calculated as: PR=D/R, where D was the percentage of forage class in diet composition and R was the percentage forage class in vegetative production (Krueger 1972). Plants rating greater than 1.0 were preferred. Vegetative production data were obtained for the low sagebrush community during spring/summer 1993 and 1995 (Crawford and Coggins 1997).

Dietary overlap refers to the degree of similarity in use of food sources among different animal species occupying the same rangeland, whether concurrently or not (Schoener 1970, McCullough 1980). It is high when both animals ingest the same or similar proportions and kinds of forage and nonexistent when none or small quantities are consumed.

Diet Quality.--Fecal nitrogen in forage plants was assessed using the Kjeldahl technique, a simple chemical procedure that measures the percent by weight of nitrogen in a sample. Diaminiopimelic acid (DAPA) was assessed with techniques reported by Davitt and Nelson (1984). Both quality indices were measured on an individual sample basis in which each individual defecation was considered 1 sample, and on an organic matter basis to remove confounding effects of ingestion of soil or other minerals (Wehausen 1995).

Statistical Analysis.--For statistical comparisons of diet composition and quality, we combined monthly values of grass, forb and shrub consumption, FN, and DAPA into a spring season (April, May, June) and a winter season (December, January and February), and applied standard ANOVA techniques. Factors used in ANOVA models for each of the independent variables (shrub, forb, grass, FN, and DAPA) were animal species, refuges, year, and season/month. Seasons used were winter (December, January, and February) when diet quality was at its lowest and spring (April, May, and June) when diet quality peaked for the year.

Standard multiple linear regression techniques were used to explore the relationships between diet quality and weather variables. In these analyses, FN and DAPA were the dependent variables and minimum, maximum, and mean daily temperature and precipitation were the independent variables. All statistical comparisons were performed using SYSTAT software (Wilkinson 1996).

RESULTS

Diet Selection.-- Pronghorn ate 52 plant species on the HMNAR and 51 species on the SNWR (Table I). Before digestibility corrections were made grasses and shrubs made up more of the total diet than forbs (Table, 2, 3: Figure 2, 3). Forb use was greater on HMNAR than on SNWR. However, when correction factors were applied, forbs were selected over shrubs by 17% on HMNAR. On SNWR, where there is less diversity of forbs, pronghorn still consumed a higher percentage (65%) of shrubs than forbs (25%), after digestibility corrections. Pronghorn and mule deer

Table 1. Number of forage taxa consumed by three wild and two feral ungulates on the Hart Mountain National Antelope Refuge (HMNAR) and the Sheldon National Wildlife Refuge (SNWR) from 1993 to 1995.

Forage Class	Number of Plant Taxa in Forage consumed								
	Pronghorn		Mule Deer		Bighorn Sheep		Feral Horses		Feral Burros
	HMNAR	SNWR	HMNAR	SNWR	HMNAR	SNWR	HMNAR	SNWR	SNWR
Grass	13	13	16	13	15	18	17	23	15
Forb	27	27	29	31	34	32	10	9	11
Shrub	12	11	14	13	12	7	11	10	7
Total	52	51	59	57	61	57	38	42	33

Table 2. Diet composition of pronghorn by microhistological analyses of feces from the Hart Mountain National Antelope Refuge, Oregon from October 1993 to September 1995.

Forage	Percent Diet Composition									
Class	Uncorrected					Corrected				
	Spring	Summer	Autumn	Winter	Annual	Spring	Summer	Autumn	Winter	Annual
Grass	21.8	3.9	12.6	11.8	12.5	14.0	2.2	10.2	5.5	8.0
Forb	38.4	30.6	28.8	49.0	36.7	47.8	31.1	47.2	71.0	49.3
Shrub	39.8	65.5	58.6	39.2	50.8	38.2	66.7	42.8	23.5	42.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.2	100.0	100.1

Table 3. Diet composition of pronghorn by microhistological analyses of feces from the Sheldon National Wildlife Refuge, Nevada from October 1993 to September 1995.

Forage	Percent Diet Composition									
Class	Uncorrected					Corrected				
	Spring	Summer	Autumn	Winter	Annual	Spring	Summer	Autumn	Winter	Annual
Grass	6.5	6.4	9.0	21.7	10.9	3.0	4.6	8.2	24.1	10.0
Forb	33.2	17.2	20.4	13.2	21.0	38.5	14.8	28.1	17.4	24.7
Shrub	60.3	76.4	70.6	65.1	68.1	57.5	80.6	63.7	58.5	65.1
Total	100.0	100.0	100.0	100.0	100.0	99.0	100.0	100.0	100.0	99.8

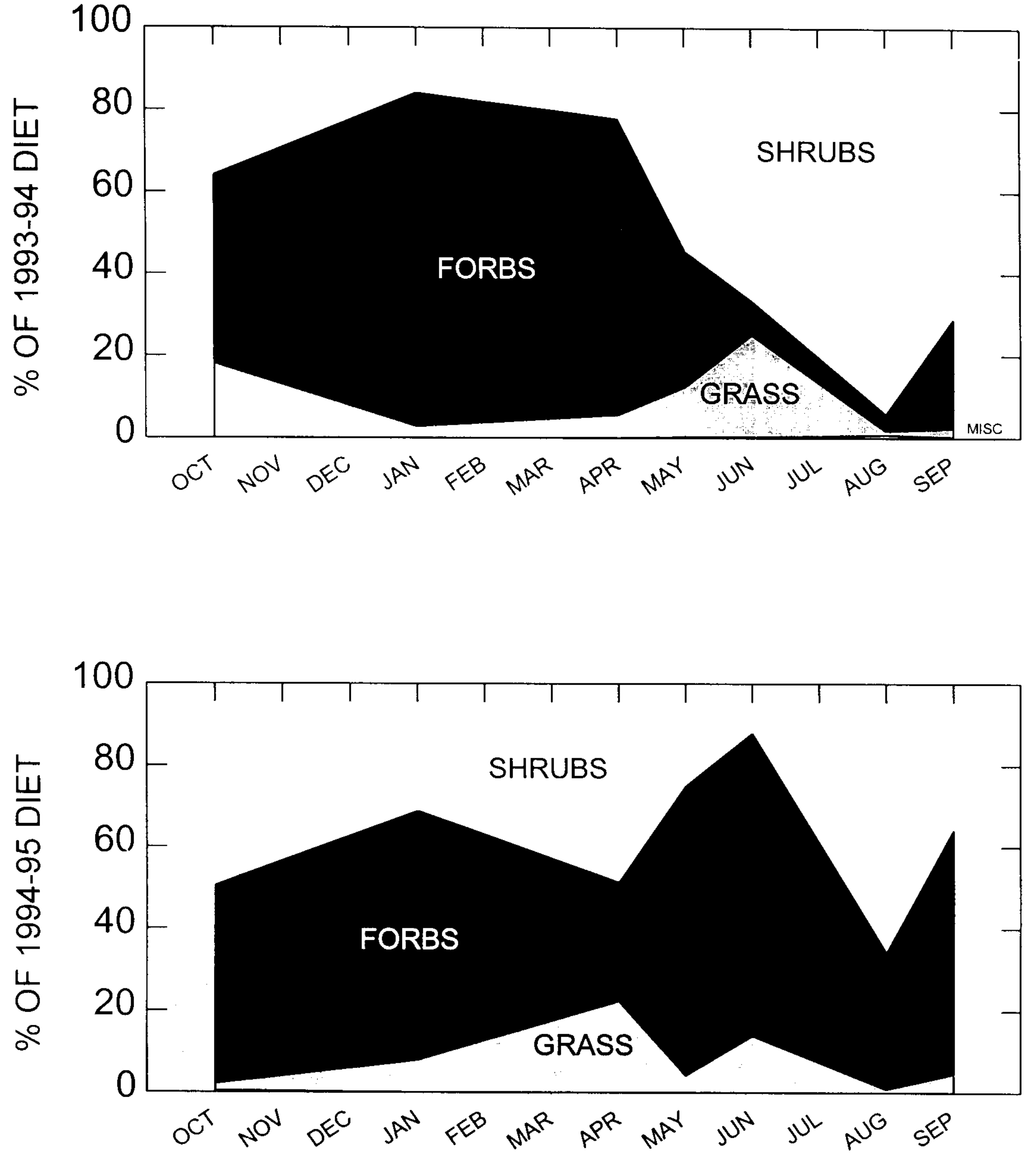


Fig. 2. Corrected plant composition of pronghorn diets measured by microhystological analysis of feces from HMNAR from October 1993 to September 1995.

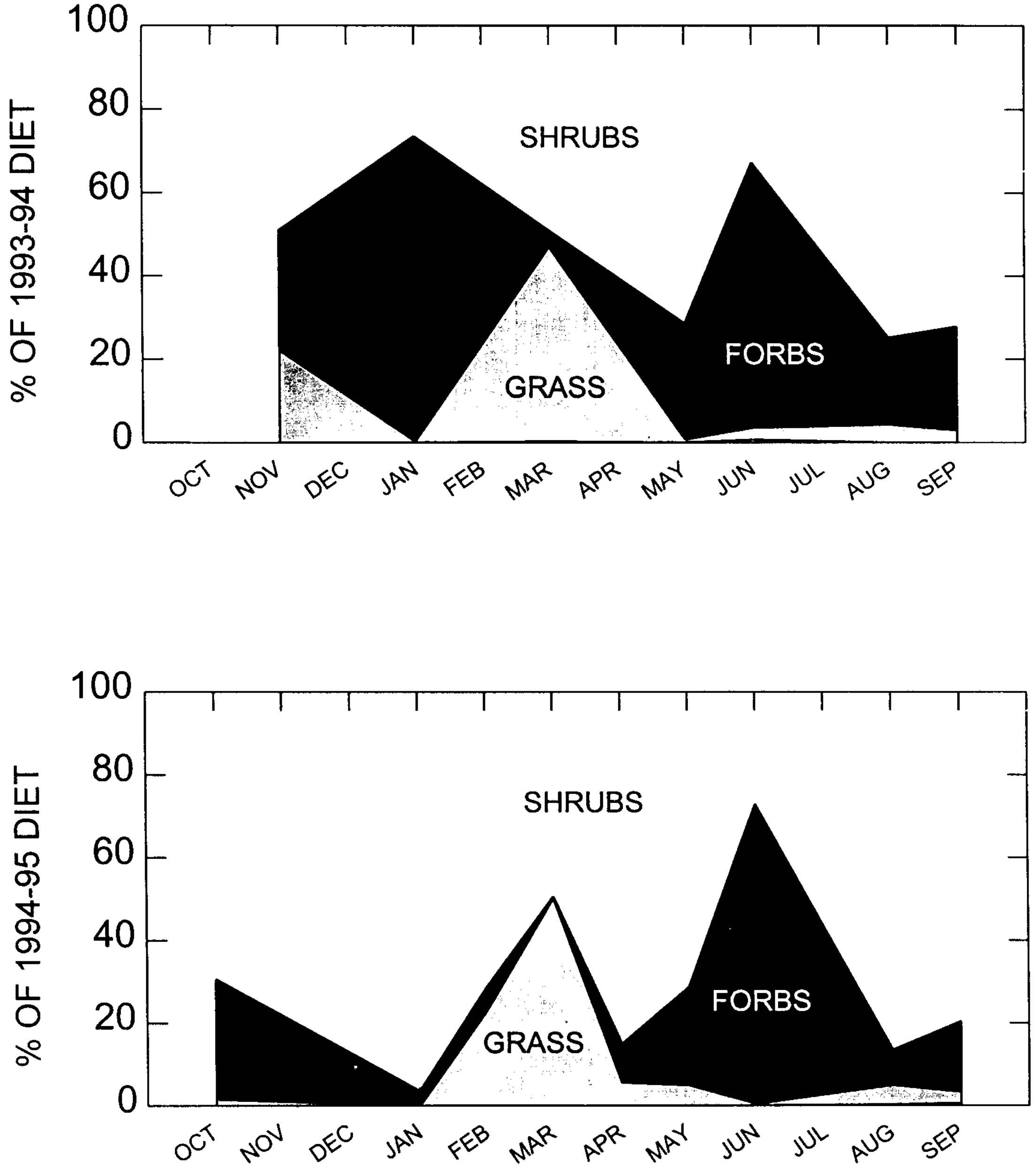


Fig. 3. Corrected plant composition of pronghorn diets measured by microhystological analysis of feces from SNWR from October 1993 to September 1995.

Table 4. Annual diet composition for wild and feral ungulates on the Hart Mountain National Antelope Refuge and the Sheldon National Wildlife Refuge from October 1993 to 1995.

Species	Forage Class	Hart Mt. National Antelope Refuge		Sheldon National Wildlife Refuge	
		Uncorrected Percentages	Corrected Percentages	Uncorrected Percentages	Corrected Percentages
Pronghorn	Grass	12.5	7.9	10.9	9.9
	Forb	36.7	49.3	21.0	25.0
	Shrub	50.8	42.8	68.1	65.1
Mule Deer	Grass	12.9	9.4	10.8	11.8
	Forb	46.0	50.1	24.9	34.0
	Shrub	41.1	40.5	64.3	54.2
Bighorn Sheep	Grass	70.5	59.0	74.4	70.0
	Forb	21.9	32.4	20.8	26.5
	Shrub	7.6	8.6	4.8	3.5
Feral Horse	Grass	88.9	83.7	91.5	90.6
	Forb	8.3	13.0	6.0	7.1
	Shrub	2.8	3.3	2.5	2.3
Feral Burro	Grass	No burros on Refuge	No burros on Refuge	88.8	84.4
	Forb			4.8	6.8
	Shrub			6.4	8.8

foraging percentages were similar, but depicted some variability seasonally (Table 4). For equids on both refuges, the corrected diets showed greater use of forbs than did uncorrected diets. Horses consumed 13% forbs during winter on the HMNAR.

Dietary overlap was calculated for all ungulates on both refuges. Overlap was the highest (about 95%) with mule deer because both species consumed approximately equal percentages of forbs and shrubs (Table 5). Overlap of pronghorn with bighorn sheep was close to 50% with the greatest overlap on forbs. Yearlong dietary overlap with feral horses averaged 20% and feral burros 25%. Forage preference ratings (Figure 6) for pronghorn on the HMNAR indicate that they preferred forbs (1.6) over shrubs (.9), while grasses are nonpreferred (.3).

Diet Quality Indices,--The general ANOVA models relating FN and DAPA to various factors indicated that ungulate species, season, and the interaction between species and season had the greatest effects on diet quality. The overall effects of year and refuge, as well as interactions were not significant ($P > 0.05$) for this analysis.

For pronghorn, the lowest fecal nitrogen (FN) occurred in winter ($\bar{x}$ =1.52%, SD=0.11), and the highest occurred in spring ($\bar{x}$ =3.12%, SD=0.34). Similarly, DAPA values were low in winter ($\bar{x}$ = 0.51 mg/g, SD=0.10) and highest in spring ($\bar{x}$ + 0.94 mg/g, SD=0.16), Fecal nitrogen values for pronghorn were similar at the 2 refuges during spring (df=1, F=1.782, P=0.185) and winter (df= 1, F=0.259, P=0.612) (Figure 4).

Effect of Weather.-- Monthly weather data available for HMNAR (Oregon Climate Service 1995) indicated the 1994-95 season was colder than in 1993-94, but there were only small differences in precipitation between these 2 years (Figure 5). Multiple regression analyses indicated that mean daily temperature and precipitation during the current month explained 84% of the variation in pronghorn FN ($P<0.0001$) and 81% of the variation in DAPA ($P<0.001$) (Table 6).

DISCUSSION

Diet Composition.-- Our data document that forbs and shrubs were a staple for pronghorn during most seasons of the year. When succulent forbs and grasses were available, together they made up 80-90% of pronghorn diets. *Phlox* and/or *Leptodactylon*, low growing perennial forbs, were apparently selected in winter over the ubiquitous and taller sagebrush when not covered by snow. Grasses were usually the earliest plants to green-up in spring, which explains their appearance in pronghorn diets in February, March and April. Other investigators are consistent in showing that forbs are highest, shrubs intermediate, and grasses lowest in concentrations of crude protein, phosphorus, and cell solubles (Houston et al, 1981, Krysl et al. 1984, Holechek et al. 1998). Although forb selection was yearlong, it was more pronounced when more available during spring and summer.

Table 5. Dietary overlap determined by diet composition studies using digestibility factors for pronghorn and sympatric wild and domestic ungulates on the HMNAR and SNWR, 1993-1995.

Refuge and Ungulate	Forage Class			
	Grass	Forb	Shrub	Total
Hart Mountain National Antelope Refuge				
Mule deer	7.9	49.3	40.5	97.7
Bighorn sheep	7.9	32.4	8.6	48.9
Horses, feral	7.9	13.0	3.3	24.2
Sheldon National Wildlife Refuge				
Mule deer	9.9	25.0	54.2	89.1
Bighorn sheep	9.9	25.0	3.5	38.9
Horses, feral	9.9	7.1	2.3	19.3
Burros, feral	9.9	6.8	8.8	25.5

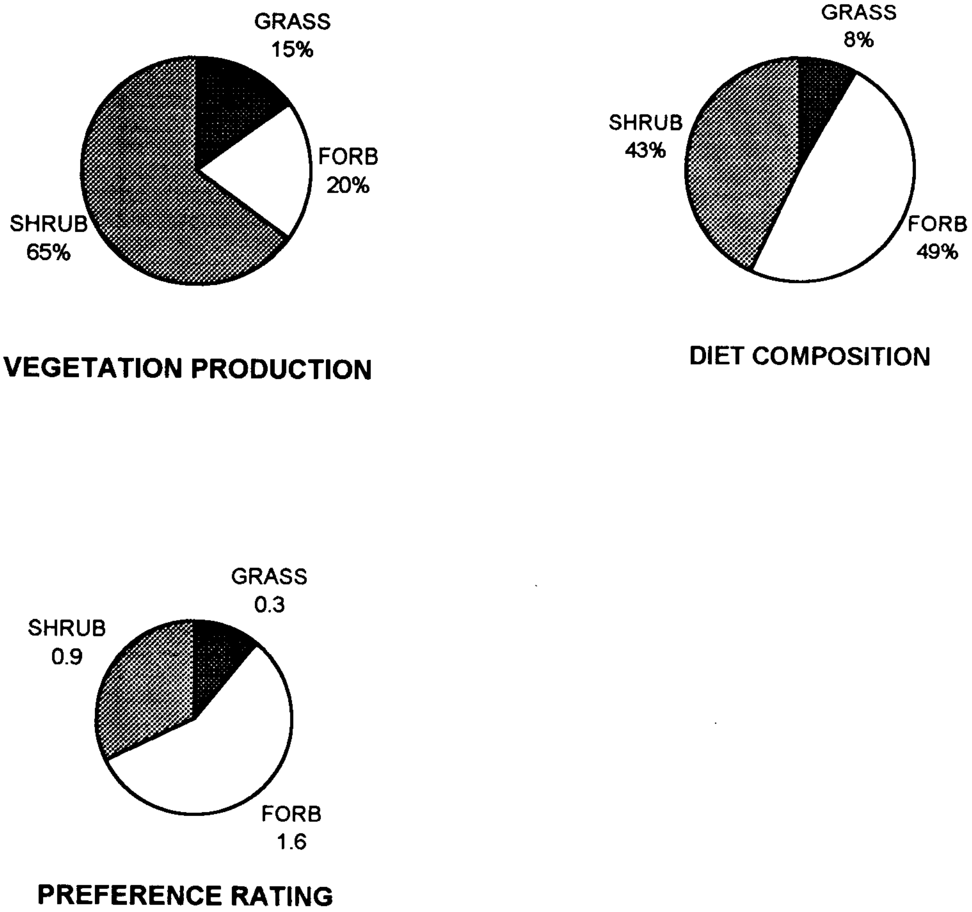


Fig.4. Percent composition of vegetation production, pronghorn diet composition corrected for differential digestibility, and preference rating.

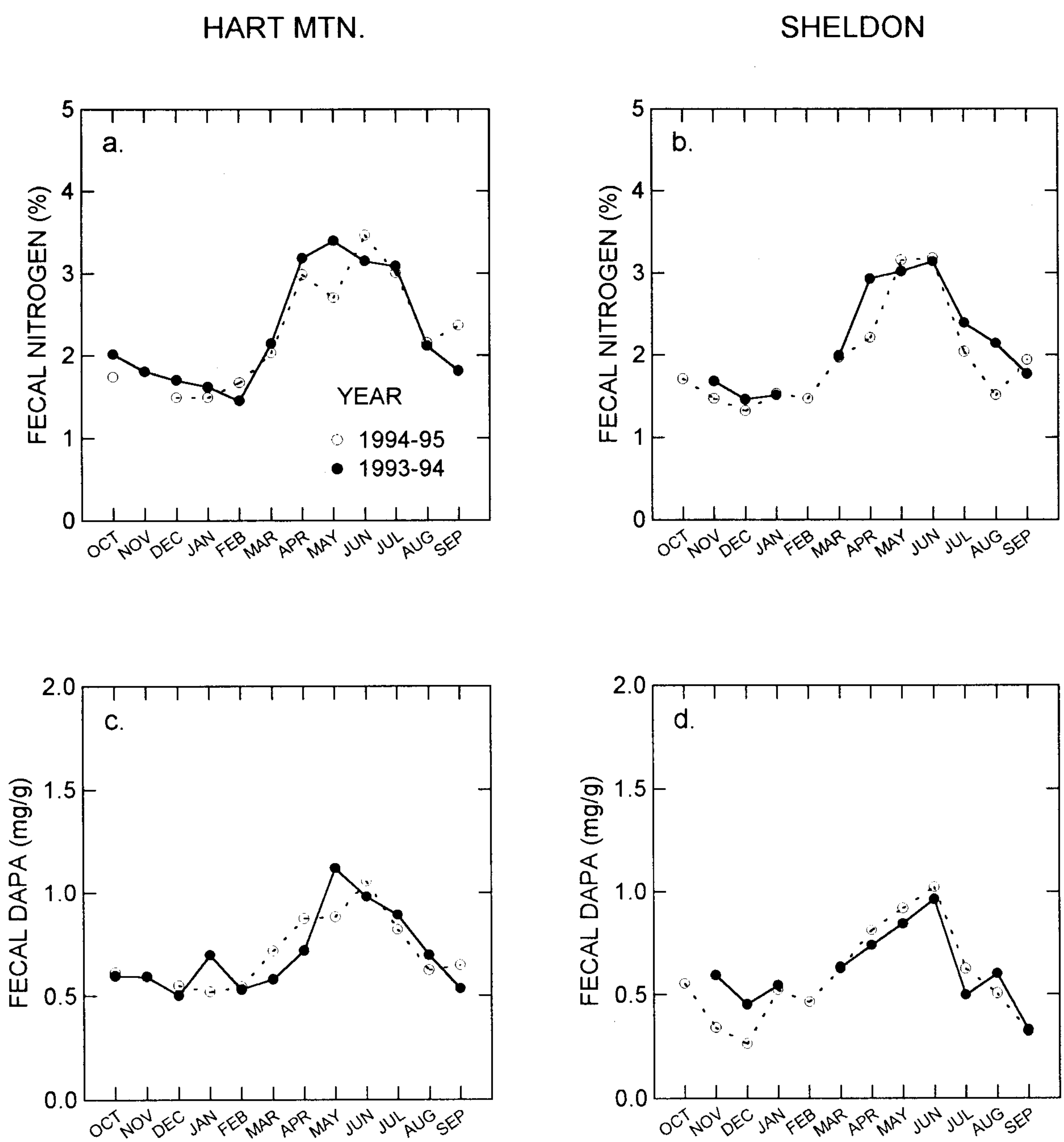


Fig. 5. Fecal nitrogen and fecal DAPA measurements from pronghorn at HMNAR and SNWR from October 1993 to September 1995.

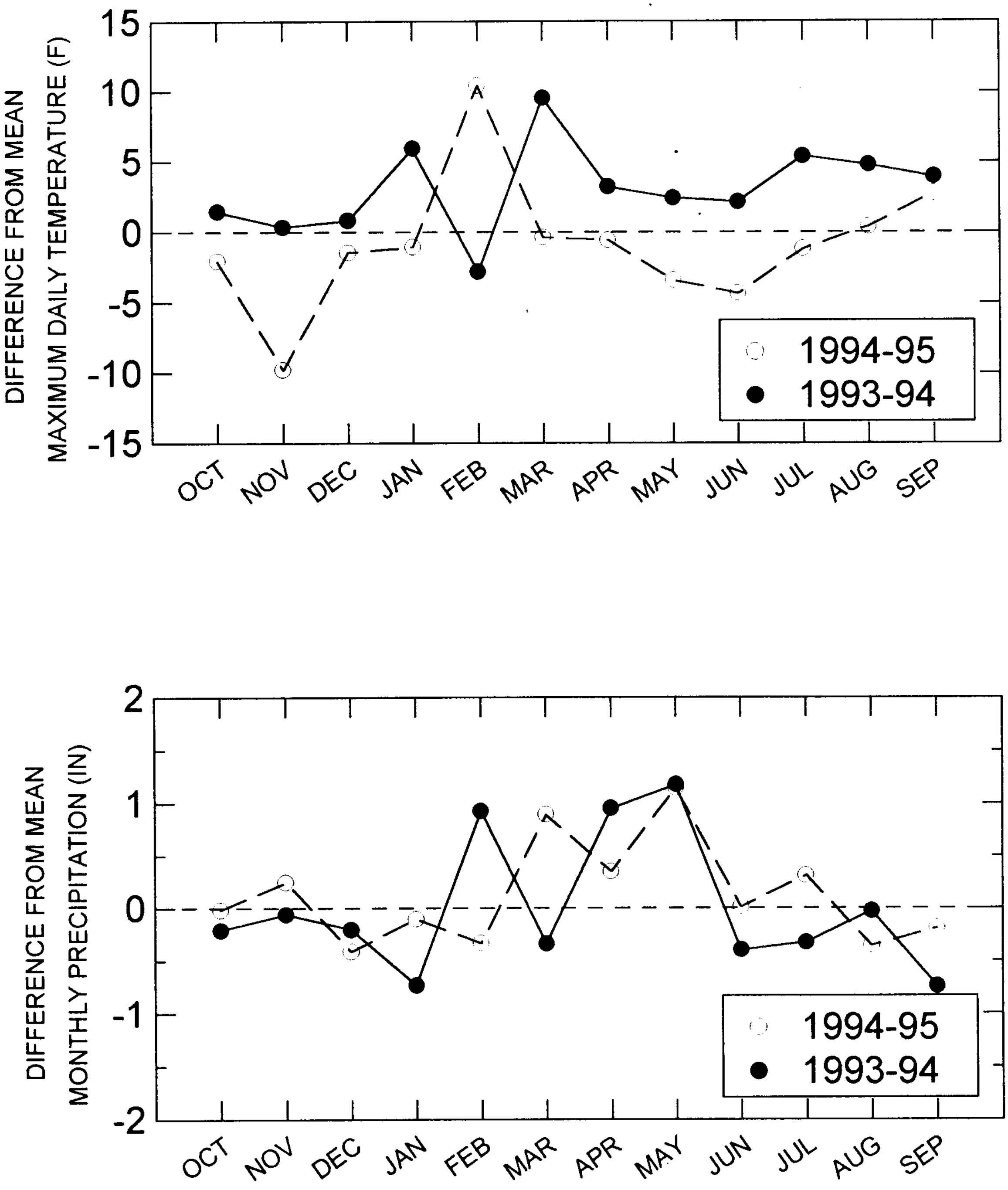


Fig. 6. Difference from mean maximum daily temperature (F) and mean monthly precipitation (in) for each month between October 1993 and September 1995 on the HMNAR.

Compared to previous studies (Mason 1952, Sneva and Vavra 1978, Hanley and Hanley 1982, Hansen 1982, McInnis 1984), pronghorn consumed a high percentage (71% on HMNAR) of forbs during winter (Table 2). Wildlife and range managers often assume forbs "dry up and blow away" during winter, but pronghorn consume greater quantities of forbs when available during winter than previously believed.

The value of digestibility correction factors has been investigated for mule deer (Holochek and Valdez 1985) and Dall's sheep (Hansen 1996), but were not used for pronghorn prior to this project. These correction values are especially important for ungulates, such as pronghorn, that consume large quantities of forbs. The only pronghorn diet study on HMNAR prior to this project was conducted more than 40 years earlier by Mason (1952) when the technique of digestibility correction factors was not in use for wild ungulate diet studies. While our uncorrected data are similar to Mason's (1952), the digestibility correction process suggests that pronghorn selected considerably more forbs than previously accepted.

The greater use of forbs at HMNAR may have resulted from 1 or more factors. First, rangelands may have been in better vegetative condition than the SNWR as a result of longer rest from cattle grazing. Second, more of the rangeland at HMNAR has been burned by wild and prescribed fires which promotes greater abundance of herbaceous vegetation. And third, HMNAR offers greater elevation relief, allowing pronghorn access to plants in early phenological stages for an extended time by moving with the seasons. Further research could help distinguish which of these factors are most important.

Early publications pertaining to pronghorn food habit studies emphasized the importance (forage composition, nutritional values) of shrubs for pronghorn survival during severe winters with deep snow (Sundstrom et al. 1973). Later studies documented the importance (preference, succulence, nutritional values) of forbs for fetal development and lactation (Ellis 1970, Yoakum 1990). Our study indicates that forbs are highly preferred and nutritious forage. We found that when forbs were available during winter, pronghorn used this forage class for as much as 70% of their diet. Some of these forbs were perennial and maintained higher digestibility and nutritional values than other forage classes (Barnett and Crawford 1994, Vrba and Schaller 2000). Forbs are of greater importance to pronghorn for all seasons of the year because they have high nutritional value. Pronghorn are predominantly forb consumers and our results indicate forbs may be even more important than previously thought; consequently, managers need to consider enhancing forb production and diversity on pronghorn habitat.

Most of the annual variations in diet probably resulted from differences in weather between years. The early, heavy snowpack in 1994-95 prevented pronghorn access to the lower growing forbs, so pronghorn compensated by consuming more shrubs. Conversely, the large increase in forb use in summer

Table 6. Weather factors that influenced (P<0.05) quality indices of monthly pronghorn diets on Hart Mountain National Antelope Refuge, 1993-1995.

Diet Index	N	Factor	Parameter Estimate	SE	t	P
FN	23	Precipitation in prior month	0.370	0.081	4.541	<0.0001
		Mean temperature	0.027	0.005	5.696	<0.0001
		Interaction of mean Temperature and current Precipitation	0.007	0.002	3.825	0.001
DAPA	23	Precipitation in prior month	0.113	0.024	4.706	<0.0001
		Mean temperature	0.006	0.001	3.917	0.001
		Interaction of mean Temperature and current Precipitation	0.002	0.001	3.491	0.002

Uncorrected diets were similar to those reported for pronghorn and other ungulates on the SNWR (Hansen 1982). One of the most apparent differences was the relatively slow changes in use among forage classes reported by Hansen (1982) compared with rapid shifts among forage classes in our study that were probably related to rapid changes in weather. Further, Hansen (1982) tracked diets for 1 year and was not able to address the annual variation reported in this project. Finally, consumption rates reported for forbs and grasses during our study often were larger than reported by Hansen (1982) as a result of the digestibility correction employed. Use of forbs and grasses in this study also was higher than reported for studies of pronghorn in other Great Basin environments (Vavra and Sneva 1978, Hanley and Hanley 1982, McInnis 1984, Yoakum 1990).

1995 over summer 1994 for pronghorn at HMNAR was due to increased availability of forbs during the winter season.

At times diet overlap can appear minimal when data are summed over the four seasons and several years. This may have been the case for pronghorn and feral horses on HMNAR for winter. Feral horses consumed 13% forbs during winter--a season when pronghorn were likewise seeking and consuming large quantities (71%) of many of the same forbs. Forbs are not abundant on certain Great Basin pronghorn habitats, especially during winter (Ellis 1970). A horse can consume 6 times as much forage daily as a pronghorn (Heady and Child 1994). Consequently, large numbers of horses on winter habitats with low biomass of forbs, could compete with pronghorn.

Pronghorn consume large amounts of shrubs known to contain nitrogen binding compounds, rendering FN less useful. DAPA is a relatively new index and little information is available to relate it with nitrogen requirements of pronghorn. Therefore, FN and DAPA are not especially useful for determining whether diets are deficient in protein. They are useful for within season comparisons among years, or increases of similar diet composition among areas (Leslie and Starkey 1987).

Seasonal trends in DAPA followed FN closely, but DAPA measurements exhibited more variation within each month so that it was more difficult to determine whether differences were significant. It may be that DAPA was the most accurate diet quality measure and that FN was elevated in summer by nitrogen binding compounds (Leslie and Starkey 1987, Robbins et al. 1987).

Goldsmith (1988) working with pronghorn in a Great Basin shrubsteppe in Adobe Valley, California, also found DAPA and FN varied seasonally with plant phenology, and had the lowest levels during winter and early spring.

Weather Factors.-- Diet quality for pronghorn is largely a function of plant species composition, nutritional values and phenology. Therefore, seasonal and annual weather variation, elevation and other topographic influences, as well as vegetation status and forage competition can affect diet quality. Region-wide weather phenomena, such as heavy snow and low precipitation, affect diet quality in ways that are difficult for pronghorn to compensate. Diet quality was related to weather, especially temperature and precipitation. Lower pronghorn diet quality in the winter of 1994-95 compared to 1993-94 was likely a result of colder 1994-95 temperatures. The greatest differences in diet quality between the 2 study years occurred from September to November and again in May, which coincide with 2 critical times of year for pronghorn reproduction--conception and parturition. Reductions in maternal diet quality can reduce maternal weight, birth weight of fetuses, and milk production in pronghorn and other ungulates (Ellis 1970, Oftedal 1985). Neonatal survival is reduced by low maternal diet quality, and reductions in diet quality for longer durations closer to parturition and early lactation have the greatest effect (Price and White 1985). Consequently, our diet quality data suggest that pronghorn recruitment in 1995 should have been lower than in 1994, which was confirmed (U.S. Fish and Wildlife Service 1996). More years of data are needed to refine the relationships between weather, diet quality and pronghorn recruitment.

We obtained limited snowfall timing or snow depth records for HMNAR. Snowfall and snow depth are functions of temperature and precipitation, and during the winter may be more closely related to diet quality than either temperature or precipitation. Such information could improve the predictive ability of our regression equations.

Management and Research Implications.-- This project was designed to provide basic information on the diets of pronghorn, bighorn sheep, mule deer, feral horses and burros to measure future change in refuge management practices. We sampled from 2 separate years with different weather patterns and found variable diet composition and quality between the years. While this variation gives managers a good indication of the range of diet composition and quality possible, it may make it difficult to discern small changes that result from applying varying management programs.

Our analysis disclosed that diet quality was related to temperature and precipitation for these 2 years. We recommend the relationship between annual changes in weather, corresponding vegetation production, and ungulate production be studied further.

Acknowledgments.-- We thank Mike Gregg and other staff members of the HMNAR and SNWR for logistical and fiscal support. The long hours L. Bastion, R. Huddleston, G. Lorton, G. Reynolds, and other volunteers spent in field collection of plant and fecal samples were the backbone of the project. Funding for the laboratory analyses came from Nevada Wildlife Diversity federal appropriations, the Western Section and Nevada Chapter of The Wildlife Society, and the North American Pronghorn Foundation. Tom Pojar and Harley Shaw reviewed and provided suggestions for improvement of the final manuscript.

LITERATURE CITED

BARNETT,J.K. AND J.A. CRAWFORD. 1994. Pre-laying nutrition of sage grouse hens in Oregon. Journal Range Management 47:114-118.

CRAWFORD, J.S. AND K.A. COGGINS. 1997. Habitat selection and reproductive success of nesting sage grouse in altered habitats and climatic conditions of southeastern Oregon. Department Fisheries and Wildlife, Oregon State University, Corvallis, Oregon USA.

GOLDSMITH, A. E. 1988. Behavior and ecology of pronghorn after reintroduction to Adobe Valley, California. Dissertation, University of California, Berkeley, California, USA.

DAVITT,B.B. AND J.R. NELSON. 1980. A method of preparing plant epidermal tissue for use in fecal analysis. Circular 0678. College Agriculture Research Center, Washington State University, Pullman, Washington, USA.

_____ and _____. 1984. Methodology for the determination of DAPA in feces of large ruminants. Proceedings Western States and Provinces Elk Workshop, Alberta, Canada, USA.

DEARDEN,B.L., R.E. PEGAN AND R.M. HANSEN. 1975. Precision of microhistological estimates of ruminant food habits. Journal Wildlife Management 39:402-407.

ELLIS, J. 1970. A computer analysis of fawn survival in the pronghorn antelope. Dissertation, University California, Davis, California, USA.

HANLEY, T.A. AND K.A. HANLEY. 1982. Food resource partitioning by sympatric ungulates on Great Basin rangeland. Journal Range Management 35:152-158.

HANSEN, M.C. 1982. Diets of mule deer, pronghorn antelope, California bighorn sheep, domestic cattle and feral horses in northwestern Nevada. U.S. Fish and Wildlife Service, Lakeview, Oregon, USA. Administrative report.

______. 1996. Foraging ecology of female Dall's sheep in the Brooks Range, Alaska. Dissertation, University Alaska, Fairbanks, Alaska, USA.

______. AND R.G. ANTHONY. 1999. Diet composition and quality of pronghorn antelope, mule deer, bighorn sheep, feral horses, and feral burros on Sheldon-Hart Mountain National Wildlife Complex. Oregon Cooperative Wildlife Research Unit, Corvallis, Oregon, USA.

HEADY,H.F. AND P.D. CHILD. 1994. Rangeland ecology and management. Western Press, San Francisco, California, USA.

HOLECHEK,J.L. AND R. VALDEZ. 1985. Evaluation of in vitro digestion for improving botanical estimates of mule deer samples. Journal Mammalogy 66:574-577.

HOLECHEK, J.L., R.D. PIEPER AND C.H. HERBEL. 1998. Range management: Principles and practices. Third edition. Prentice Hall, Upper Saddle River, New Jersey. USA.

HOUSTON, J.L., B.S. RECTOR, L.B. MERRILL AND S.B. INGDALL. 1981. Nutritive value of range plants in the Edwards Plateau region of Texas. Bulletin 1357. Texas Agriculture Experiment Station, College Station, Texas, USA.

IRWIN, L.L., J.G. COOK, D.E. MCWHIRTER, S.G. SMITH, AND E.B. ARNETT. 1993. Assessing winter dietary quality in bighorn sheep via fecal nitrogen. Journal Wildlife Management 57:413-421.

JACOBS, J. 1973. A microtechnique index to pronghorn diet and sagebrush digestion coefficients. Thesis, University Wyoming, Laramie, Wyoming, USA.

JENKS, J.A., D.M. LESLIE, R.L. LOCHMILLER, M.A. MCLCHIORS AND W.D. WARDS. 1989. Effects of compositing samples on analysis of fecal nitrogen. Journal Wildlife Management 53:213-215.

KRUEGER, W.D. 1972. Evaluating animal forage preference. Journal Range Management 25:471-475.

KRYSL,L.J., F.B. SOWELL, M.E. HUBBERT, G.E. PLUMB, J.K. JEWETT, M.A. SMITH AND J.W. WAGGONER. 1984. Horses and cattle grazing in the Wyoming Red Desert II. Dietary quality. Journal Range Management 37:252-256.

LESLIE,D.M. AND E.E. STARKEY. 1987. Fecal indices to dietary quality of cervids in old-growth forests. Journal Wildlife Management 49:142-146.

MASON, E. 1952. Food habits and measurements of Hart Mountain antelope. Journal Wildlife Management 16:387-389.

MCCULLOUGH,Y.B. 1980. Niche separation of seven North American ungulates on the National Bison Range, Montana. Dissertation, University Michigan, Ann Arbor, Michigan, USA.

MCINNIS, M.L. 1984. Ecological relationships among feral horses, cattle, and pronghorn in southeastern Oregon. Dissertation, Oregon State University, Corvallis, Oregon, USA.

MOULTON,G.E. 1987. The journals of the Lewis and Clark expedition: April 7-July 27, 1805. Volume 4. Nebraska University Press, Lincoln, Nebraska, USA.

OFTEDAL,O.T. 1985. Pregnancy and lactation. Pages 215-238 *in* R.D. Hudson and R.G. White, editors. Bioenergetics of wild herbivores. CRC Press, Boca Raton, Florida, USA.

OREGON CLIMATE SERVICE, 1995. Climate data. Oregon Climate Service Internet Web Site, (www.ocs.orst.edu), Oregon State University, Corvallis, Oregon, USA.

PRICE,M.A. AND R.G. WHITE. 1985. Growth and development. Pages 183-213 *in* R.J. Hudson and R.G. White, editors. Bioenergetics of wild herbivores. CRC Press, Boca Raton, Florida, USA.

ROBBINS, C.T., T.A. HANLEY, A.E. HAGERMAN, O. HJELJORD, D.L. BAKER, C.C. SCHWARTZ AND W.W. MANTZ. 1987. Role of tannins in defending plants against ruminants: reduction in protein availability. Ecology 68:98-107.

ROUSE, C.H. 1941. Notes on winter foraging habits of antelope in Oklahoma. Journal Mammalogy 22:57-60.

SCHOENER, T.W. 1970. Nonsynchronous spacial overlap of lizards in patchy habitats. Ecology 51:408-418.

SCHWARTZ, C.C. AND J.G. NAGEY. 1976. Pronghorn diets relative to forage availability in northeastern Colorado. Journal Wildlife Management 40:469-478.

SNEVA, F.A. AND M. VAVRA. 1978. Botanical composition of feces from antelope grazing the Oregon high desert. Proceedings Pronghorn Antelope Workshop 8:78-93.

SUNDSTROM, C., W.O. HEPWORTH AND K.L. DIEM. 1973. Abundance, distribution, and food habits of pronghorn. Bulletin 12. Wyoming Game and Fish Commission, Cheyenne, Wyoming, USA.

U.S. FISH AND WILDLIFE SERVICE. 1994. Final environmental impact statement: Hart Mountain National Antelope Refuge comprehensive management plan. Two volumes. U.S. Fish and Wildlife Service, Portland, Oregon, USA.

U.S. FISH AND WILDLIFE SERVICE. 1996. Annual narrative report for the Hart Mountain National Antelope Refuge. U.S. Fish and Wildlife Service, Lakeview, Oregon, USA.

VAVRA,M. AND J.L. HOLECHEK. 1980. Factors influencing microhistological analysis of herbivore diets. Journal Range Management 33:371-374.

_____ AND F. SNEVA. 1978. Seasonal diets of five ungulates grazing the Cold Desert Biome. Proceedings Pronghorn Antelope Workshop 8:435-437.

VRBA,E.S. AND G.B. SCHALLER. 2000. Antelopes, deer, and relatives: Fossil record, behavioral ecology, systemactics and conservation. Yale University Press, New Haven, Connecticut, USA.

WEHAUSEN, J.D. 1995. Fecal measures of diet quality in wild and domestic ruminants. Journal Wildlife Management 59:816-823.

WILKINSON, L. 1996. SYSTAT: The system for statistics. SASS, Chicago, Illinois, USA.

YOAKUM,J.D. 1990. Food habits of pronghorn. Proceedings Pronghorn Antelope Workshop 14:102-111.

_____. 1992. Proposal for: Food habit study of wild and domestic ungulates on the Hart Mountain National Antelope Refuge, Oregon. Administrative Report. U.S. Fish and Wildlife Service, Lakeview, Oregon, USA.

PRONGHORN (*Antilocapra americana mexicana*) POPULATIONS IN CHIHUAHUA, ESTIMATED BY AERIAL SURVEYS.

DANAE AZUARA, Instituto de Ecología, Universidad Nacional Autónoma de México, Ap. Postal 70-275 C. P. 04510

RODRIGO A. MEDELLIN, Instituto de Ecología, Universidad Nacional Autónoma de México, Ap. Postal 70-275 C. P. 04510 México D.F.

CARLOS MANTEROLA, Unidos para la Conservación A.C. Prado Norte 324, Lomas de Chapultepec, C.P. 11000, México D.F.

MANUEL VALDES, Unidos para la Conservación A. C. Prado Norte 324, Lomas de Chapultepec, C. P. 11000, México D.F.

Abstract: The ongoing survey of the remaining pronghorn populations in Mexico is a solid basis to plan actions and to assess priorities for the National Pronghorn Recovery Program. The state of Chihuahua contains at least 50% of the total Mexican pronghorn. Aerial surveys of Pronghorn antelope in Chihuahua have been carried out the last three years by Unidos para la Conservación in collaboration with the Instituto de Ecología, Universidad Nacional Autónoma de México. The aerial surveys were carried out following a fixed strip transect method. Our estimates vary from 282 to 564 pronghorn for Chihuahua depending on different opinions on the method's detection reliability. The groups were found in three main areas that are isolated form each other. Most of the pronghorn were in the large central area, the remainder in two small regions, La Perla and Casas Grandes. La Perla, which we recognized as an important breeding area since the onset of the study, and has continuously been monitored from 1997 to 1999, shows fewer antelope every year, namely 57, 34 and 26 individuals. The monitoring of these populations, habitat studies, usage of GIS, and so on, will soon provide us with the necessary information to plan a conservation and management strategy that will allow the species to escape from local extinction.

Proceedings Pronghorn Antelope Workshop 19:95-105

Key Words*:* Mexican pronghorn, distribution, population size, population structure, endangered species, game species, Chihuahua.

Pronghorn populations originally extended from southeast Alberta and Saskatchewan, to the north of Valle de México, California and Baja California, occupying the big flat lands in western North America (Hall 1981).

Before the arrival of Spanish conquerors, pronghorn populations reached approximately 50 million individuals. By 1929 its populations were drastically reduced to barely 20,000 individuals (Yoakum 1980). The main causes for this reduction were habitat loss and fragmentation, and overexploitation through hunting (O'Gara 1978). During that year in the United States of America, programs to manage and recover this species began and have been very successful.

In Mexico, pronghorn populations distributed from the northernmost states, where they were very abundant, to the flatland north of the Valle de México (Leopold 1959). Nowadays Mexican pronghorn is naturally distributed in three areas: Vizcaíno desert in Baja California, Pinacate desert in Sonora and other (southeastern) areas in Sonora and in the state of Chihuahua.

Surveys carried out in 1984 estimated minimal Mexican pronghorn populations as follows: 307 individuals in Chihuahua, 63 eastwards to Sierra del Pinacate Sonora, and 64 in El Vizcaíno in Baja California. National population did not exceed 434 pronghorn (González-Romero & Lafón, 1993) and, as a result, the species is now officially labeled as endangered (Diario Oficial de la Federación, 1994). González Romero and Lafón T. (1993) report that Mexican pronghorn population has decreased its size in approximately 82% in the last sixty years, due to loss and fragmentation of habitat caused by urbanization, agriculture advance, overgrazing and illegal hunting.

Compared to the other pronghorn sites, the state of Chihuahua contains the greatest proportion of Mexican pronghorn, being of major importance to the conservation of this species. In order to establish a properly planned conservation strategy, the populations in Chihuahua are being studied. The main objective of this study is to find out its current distribution, size, and structure.

METHODS

The potential area of distribution in which we carried out the surveys was obtained using the most recent records, information provided by ranch owners, vegetation maps, and a survey flight done in 1995 in collaboration with the Secretaría de la Defensa Nacional (SEDENA).

To estimate Chihuahua's pronghorn population size we used data from aerial surveys carried out from 1997 to 1999 in three different areas (Fig. 1 and 2). i) La Perla (surveyed in 1997, 1998 and 1999). ii) The Central Area (part of it, El Sueco Corridor was flown in 1997, and the area was surveyed almost completely in 1999), and iii) Casas Grandes (surveyed in 1997). The surveys were done following the New Mexico Department of Game and Fish strip transect method, (Tom Sansom, *pers. com.*) which consists in flying approximately at 250ft. above ground, at a 90 – 100 miles/hr speed, for three to four hours beginning at sunrise or late in the afternoon when sun rays fall slanted on the ground. The flights are done in a north-south, south-north direction (ondulated pattern) always with the sun on the side. To avoid double counting we flew areas as large as possible, trying to delimit the transects with barriers such as highways or Sierras, so the probability of animals moving from one survey area to another would be reduced. All observations were georeferenced and later mapped. If we counted identical or very similar groups in near areas in consecutive flights, we eliminated one of the groups from the analysis. Flights were not performed when conditions were cloudy, windy or very hot, to avoid resulting biases (Lee et al., 1998). Most surveys were done in September or October when fawn were young enough to be easily recognized, yet old enough to be running with their mothers.

To estimate the population size we considered different scenarios: 1) The animals we counted represent a 100% of the animals present in the surveyed area (Tom Samson *pers. com.*). 2) The counted antelope represent 50% of the actual number for the surveyed area (Raymond Lee, *pers. com.*). We used the 1997 count of the Sueco area with lower density and more surveyed area being confident of not overestimating the numbers.

RESULTS

Geographic distribution.
In “La Perla” animals were found in all three years between Rancho La Palma and Rancho Mesteñas, most of them being found in ranches El Mimbre and El Liberal. In the “Casas Grandes” area, they were found in the ranch called El Cuervo. The largest numbers of pronghorn were found in the Central area in four sites: “El Sueco Corridor”, “El Veinticuatro”, “Tres Castillos” and “Tosesihua” (Fig. 2).

Some not quantified impacts and barriers to pronghorn movements were recognized, which help us explain the fragmented pronghorn distribution and understand part of the problematic these populations are suffering. Some human and natural impacts, were identified during field work (Fig. 3) like:

- Menonites agriculture, which transform and reduce pronghorn habitat and represent barriers for their movements.
- Ejidos, that are, in Chihuahua, small properties with a higher density of fences and human population than big private properties.
- Sheep presence, that some authors consider to be pronghorn competitors (Lee *et. al.* 1998).
- Salt flats in which almost no vegetation grows and get flooded.
- An Ejido called Julimes that we have been informed by land owners poaches pronghorn.
- Predators like coyotes were seen in most of the flights, and we were informed about the presence of mountain lions in these areas, both of which represent threats to fawns.

o Finally, highways like the one from Chihuahua City to Ciudad Juaréz and the border contribute to fragment the area.

Populations size and structure.

The lowest estimated population of pronghorn in Chihuahua, taking in account the data from 1997, 98 and 99 is 282. If we consider that only fifty percent of the real number of animals was detected, we would have an estimated population size of 564. There are still some areas not surveyed in which more pronghorn are likely to be found. For example, due to time constrains, 15% of the Central Area was not surveyed.

The number of bucks, does, fawns, not identified and total pronghorn found in each area are shown in figure 4. The area with the highest number of sighted pronghorn is by far “El Sueco Corridor” with 137, registered in 1997. In 1999, when only about 45% of the Sueco corridor was surveyed, we counted 64 animals. We assumed that the population in this area has not changed because the calculated densities do not vary significantly between years (approximately 0.033 / km^2 in 1997, and 0.035 / km^2 in 1999).

El Sueco, Tosesihua and La Perla were the sites that had the largest numbers of fawns. However, the proportion of fawns in El Sueco, in relation to the total pronghorn observed, was very small (0.06 fawns per doe).

Since 1997, we identified “La Perla” as an important breeding area, and monitored it for three years. During this period the population seemed to be decreasing from 61, to 3 4 and 26. Buck numbers have consistently decreased each year. The number of does was the same the first two years and in 1999 that figure decreased to almost half of what was observed in prior years. Fawn numbers decreased in 1998 and increased again in 1999 to almost one half of the 1997 count. (Fig. 5.)

The fawn:doe:buck ratio (Table 1) suggests that all areas have poor, very poor or no recruitment rate except for La Perla in 1997 (0.83 fawn per doe, considered good) and 1999 (0.62 fawn per doe considered fair) (sensu Trueblood 1971). The average fawn: doe ratio of 0.32, for the three years, at La Perla is higher than ratios calculated in 1977 and 1998 for the same area, in 1977 and 78, 0.17 and 0.11, respectively (Treviño 1978).

For maximum recruitment a 1:4 buck:doe ratio is suggested (Lee et al. 1998). In the Tosesihua area the ratios are close to that one, while in Casas Grandes, El Veinticuatro and La Perla 1999 the relation is near 1:2. The ratios for El Sueco and Tres Castillos were approximately 1:3 and 1:7 respectively.

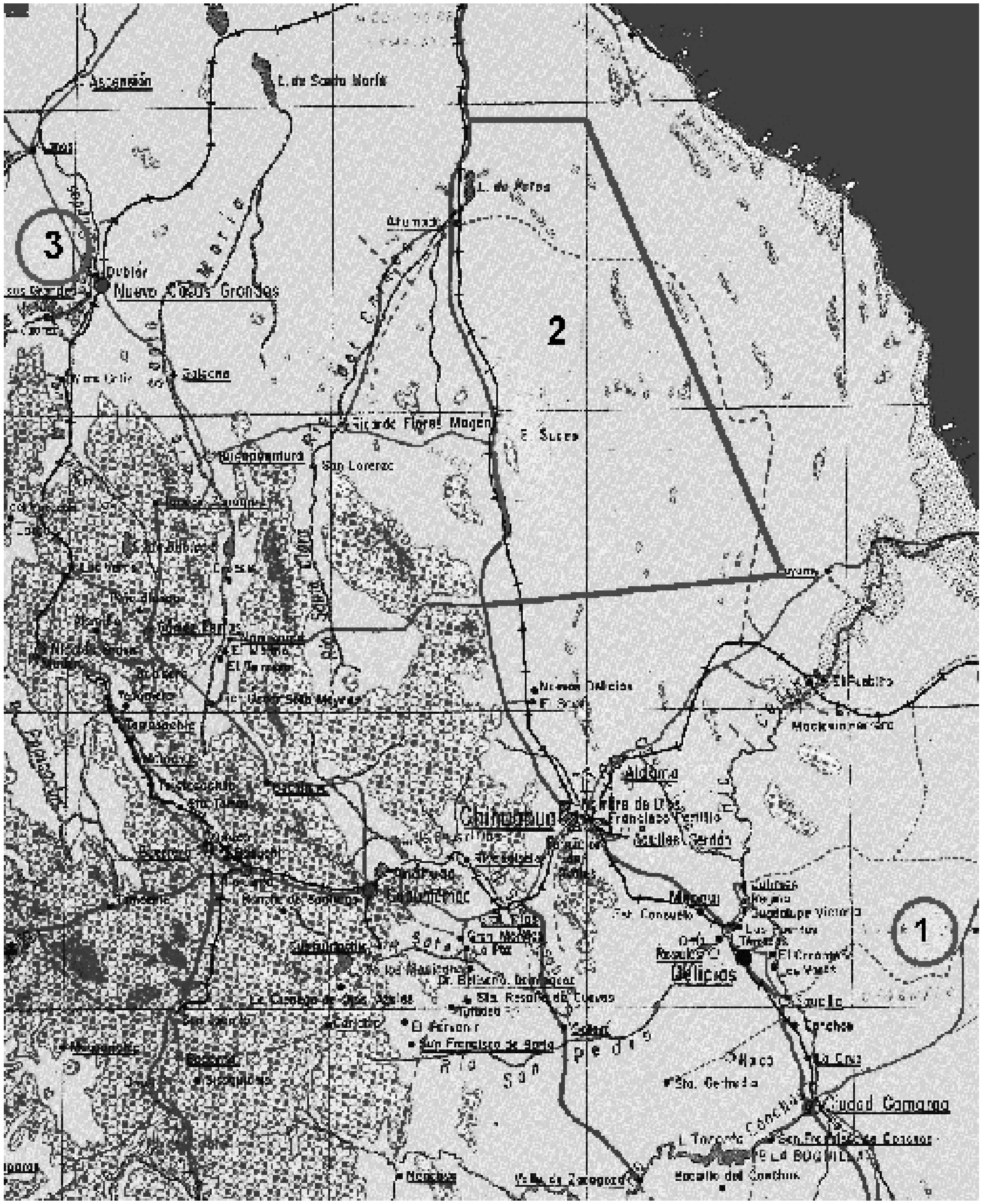


Fig. 1. This map of part of the Mexican State of Chihuahua contains the three study areas: 1.- La Perla. 2.- Central Area. 3.- Casas Grandes.

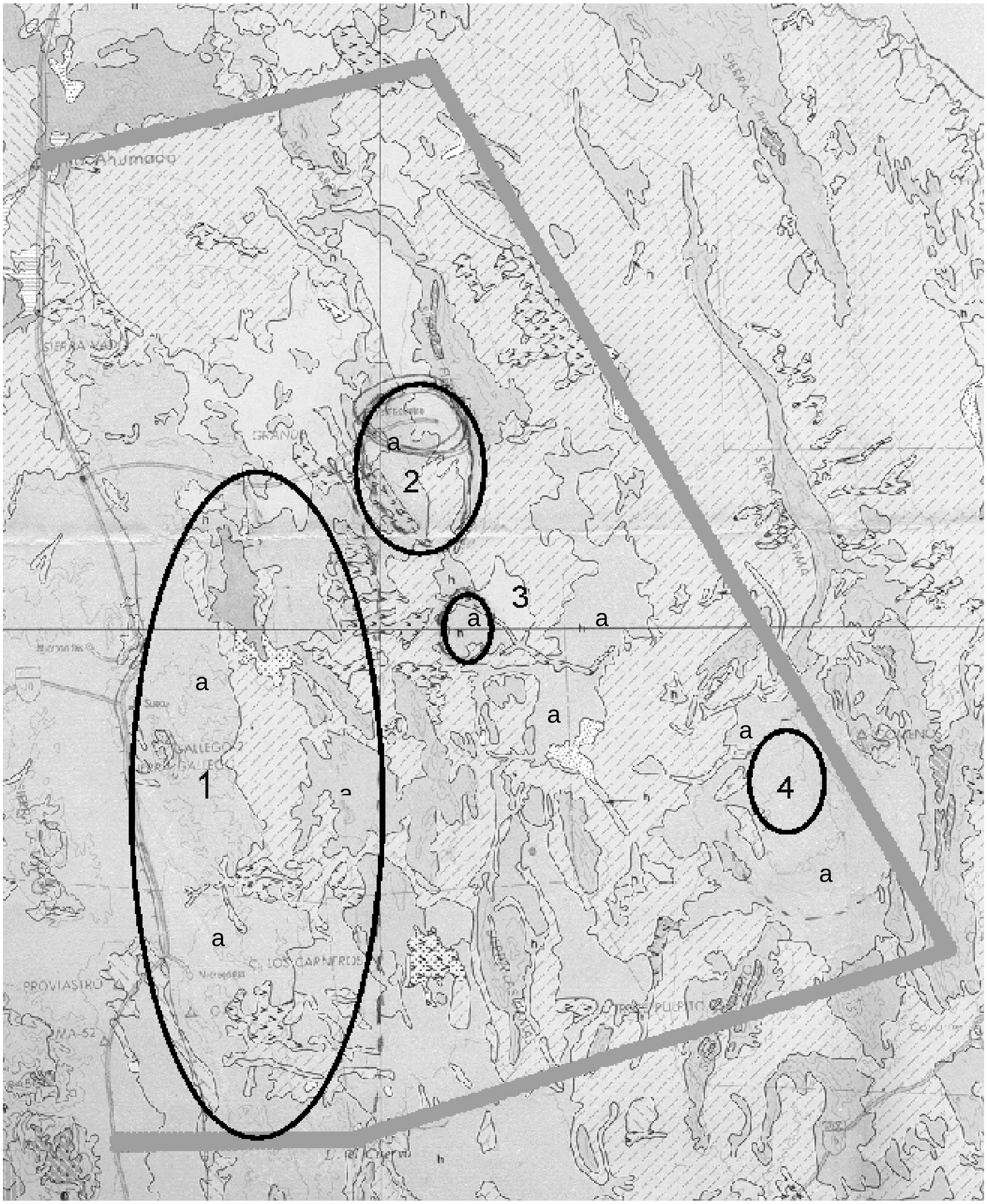


Fig. 2. This map shows the four areas of natural grasslands in which pronghorn were found inside the Central area of study. We called these areas. 1.- Sueco corridor. 2.- El Veinticuatro. 3.- Tres Castillos. 4.- Tosesihua. Most pronghorn were found in natural grassland areas (marked with letter a).

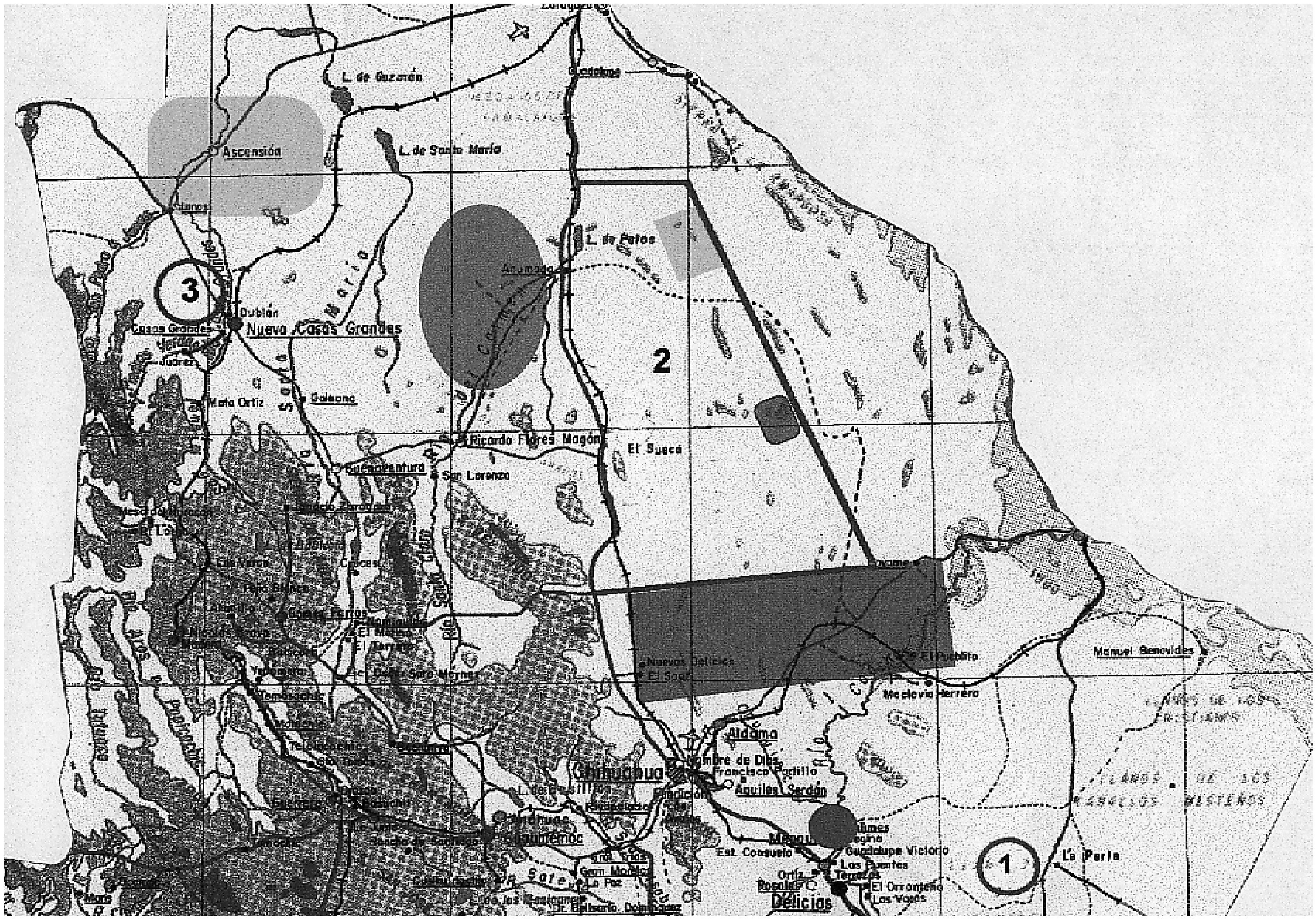


Fig 3.- This map shows the three study areas and some of the human activities and natural conditions that have effect on pronghorn populations distribution and sizes.

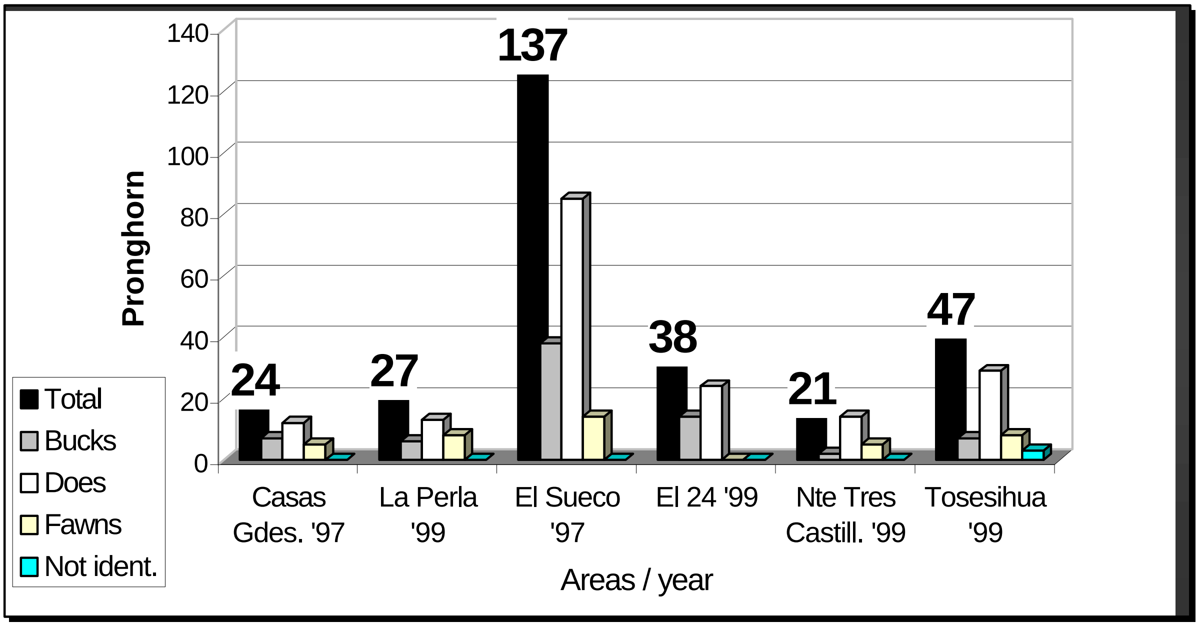


Fig. 4. Number of pronghorn counted in each area, bucks, does, fawns, not identified and total numbers are presented.

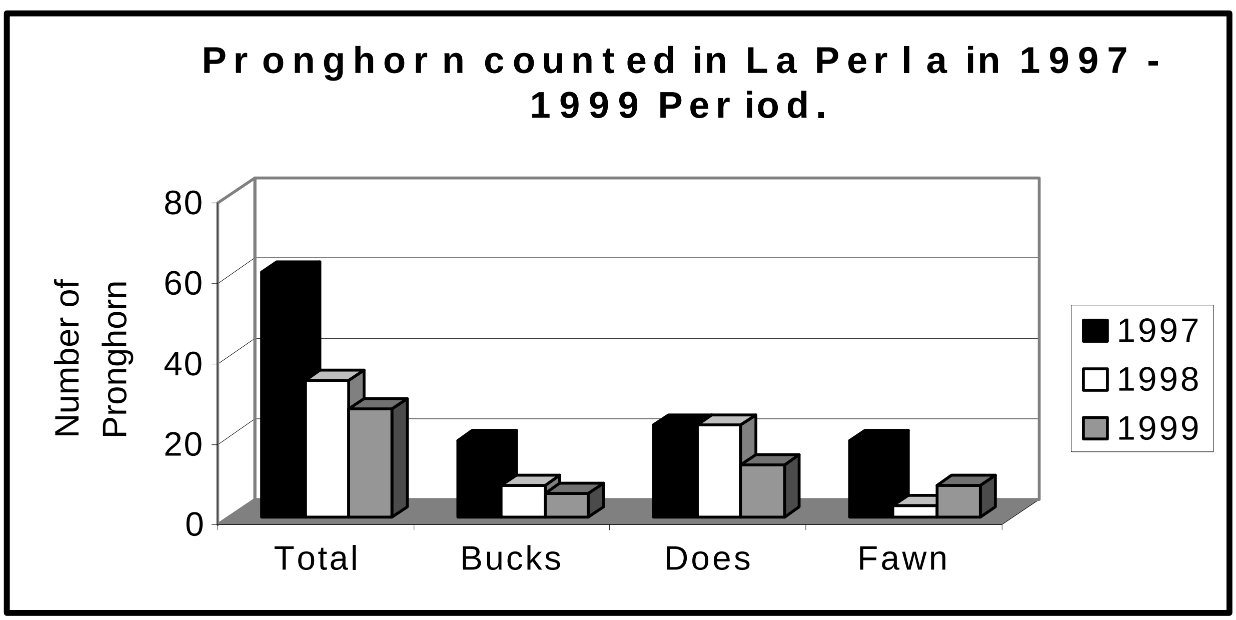


Fig. 5. Number and buck, doe, fawn structure of pronghorn counted in La Perla area in 1997, 1998 and 1999.

TABLE 1. Buck:doe:fawn ratios found in the study areas rated with Trueblood's standards. Three ratios are given for La Perla area that have been monitored for three consecutive years.

AREA	BUCK:DOE:FAWN	TRUEBLOOD 1971 RATING
Casas Grandes	0.58 : 1 : 0.42	Poor
El Veinticuatro	0.5 : 1 : 0.0	---------
Tres Castillos	0.14 : 1 : 0.36	Very Poor
Tosesihua	0.27 : 1 : 0.27	Very Poor
El Sueco	0.33 : 1 : 0.06	----------
La Perla 97	0.072 : 1 : 0.83	Good
La Perla 98	0.13 : 1 : 0.35	Very poor
La Perla 99	0.46 : 1 : 0.62	Fair

DISCUSSION

The Casas Grandes area is very vulnerable; it is a small isolated area that supports a small population that in 1997 appeared to have a poor recruitment rate. La Perla is also a small isolated area, but it seems to have the best recruitment rate for Chihuahua. The pronghorn conditions in La Perla are also not so critical because conservation efforts carried out in this area, by means of an educational campaign.

In the fall the big central area had pronghorn groups in different partially isolated areas. We believe that the animals recorded in this area do not face considerable barriers that limit their movements within it. Pronghorn in this area were found precisely in the areas classified as natural grassland by the INEGI (1974).

The great central area, in which we found the highest numbers of pronghorn, seems to be the one with the greatest chance to conserve the species in the state. Nevertheless, we have to take in account that it is already surrounded by highways, agriculture and other disturbances; predators, competitors like sheep, and poachers are present in this area, all this endangering the continuity of the population by reducing, fragmenting and transforming its habitat and directly reducing its population numbers.

The lowest estimate of pronghorn for the state is 282, being a conservative estimation. If we consider a 50% reliability for our survey method we could estimate a population about 564 animals, not far from the estimation that Treviño (1978) gave for 1977 and 1978 (561 and 533 respectively).

The number of pronghorn counted in La Perla seems to be falling from one year to the next. It could be that the first year was a very good one for the population in this place, because of the presence of researchers studying them (all through the breeding season) and a good year in terms of precipitation. The next two years there was no presence of researchers to "passively defend" the area from poachers and predators.

Recruitment rates found are quite low, but higher in average to the ones found by Treviño in 1977 and 1978. It may be that natural recruitment in Chihuahua is not as good as in other areas or that it is very variable according to climatic conditions and both studies were carried out in poor rain years.

RECOMMENDATIONS.

Management practices for Chihuahua's state pronghorn populations should urgently seek to increase the number of animals recruited each year, and also try to reach a buck:doe relation that improves the population growth rate. Specific short-term plans and recommendations include:

- Implement active vigilance programs in fawning areas such as the rolling hills areas in: La Perla, the southern part of El Sueco Corridor, Tosesihua, Tres Castillos and El Veinticuatro.
- Survey the rest of pronghorn potential areas in Chihuahua like Janos and Benavides.
- Monitor in other seasons (spring, summer or winter) or use telemetry to find out how pronghorn move throughout the year.
- Monitor as many populations as possible, at least La Perla and the parts of the central area in which we have found pronghorn.
- Start habitat evaluations.
- Usage of GIS to study agriculture and desertification expansion, population dynamics, and so on; as a tool to justify conservation decision-making processes.
- Evaluate the need of predator control in fawning areas.
- Promote educational projects among local inhabitants.
- Carry on constant informative meetings with ranch owners.
- Reevaluate the objectives and methods, considering new information.

All these points are part of the National Pronghorn Recovery Program that aims at building a long-term and efficient conservation and recovery strategy for Mexican pronghorn populations.

ACKNOWLEDGEMENTS

We would like to thank CEMEX, Fondo Mexicano para la Conservación de la Naturaleza, World Wildlife Fund, Eduardo Iñigo, Dirección

General de Vida Silvestre, Felipe Ramírez, Tom Sansom, Santiago Gonzales, NMDG&F, Asociación Sierra Madre, Ranch Owners, Sandy Lanham, Alberto Lafón, Dalia Conde, for their support, and Eric Mellink and Gerardo Ceballos for their comments and suggestions.

LITERATURE CITED

DIARIO OFICIAL DE LA FEDERACIÓN. 1994. Norma Oficial Mexicana NOM-159-ECOL-1994 que determina las especies y subespecies de flora y fauna silvestres terrestres y acuáticas en peligro de extinción, amenazadas, raras y las sujetas a protección especial, y que establece especificaciones para su protección. Lunes 16 de mayo, 1-60.

González-Romero A. y A. Lafón. 1993. Distribución y estado actual del berrendo (*Antilocapra americana*) en México. Pp. 409-420. En: Medellín R. A. y G. Ceballos (eds). Avances en el estudio de los mamíferos de México. Publicaciones Especiales, Vol. 1, Asociación Mexicana de Mastozoologia, A.C. México, D. F.

Hall, E. R.. 1981. The mammals of North America. John Wiley and Sons, New York.

Instituto Nacional de Estadística Geografía e Informática (INEGI). 1974. Carta de uso de suelo y vegetación, Chihuahua, Escala 1:1000,000.

Lee, R. M., J. D. Yoakum, B. W. O'Gara, T. M. Pojar and R. A. Ockenfels, (eds.) 1998. Pronghorn Management Guides. 18th Pronghorn Antelope Workshop, Prescott, Arizona. 110 pp.

Leopold, A. S. 1959. Wildlife of Mexico. The University of California Press, Berkeley, 568pp.

O'Gara B. W. 1978. Antilocapra americana. *Mamm. Species*. 90: 1-7.

Treviño J. C. 1978. Numbers and distribution of Pronghorn-Antelope in Chihuahua. Master Diss. New Mexico State University, Las Cruces, Nuevo México, 58 pp.

Trueblood, R. W. 1971. Statewide wildlife survey and inventory. Pittman-Robertson Job Prog. Rep., W-130-R-2. Montana. Fish and Game Dep., Helena. 26 pp.

Yoakum, J. 1980. Habitat Management guides for the American Pronghorn Antelope. U.S. Department of Interior Bureau of Land Management, Denver Service Center, Denver, Colorado.

GENETIC VARIATION AMONG PRONGHORN (A*ntilocapra americana*) POPULATIONS.

DALIA AMOR C. Unidos para la Conservación, A.C., México City.

OLIVER A. RYDER, Center for Reproduction of Endangered Species, Zoological Society of San Diego, CA, U.S.A.

ROB RAMEY, University of Colorado Boulder, CO, 80309-0334, U.S.A.

RODRIGO A. MEDELLIN, Instituto de Ecología, U.N.A.M., Mexico City

Abstract: Mexican pronghorn populations have been declining drastically in the last century as a result of habitat fragmentation and loss, predation and poaching. The latest census data indicates there are approximately 1000 individuals representing three subspecies. Of the three, the peninsular pronghorn subspecies is the most threatened, comprising only 10% of the total number of pronghorn present in Mexico. In order to ensure the survival of this species, conservation management of the remaining populations is necessary. One key element to contribute towards this management is the analysis of genetic variation found among pronghorn subspecies and populations. This will help to understand their recent demographic history, the effects of range reduction on gene flow and genetic variation. To accomplish this goal, we compared genetic variation between Mexican and USA populations using the mitochondrial d-loop control region as a molecular marker. The majority of DNA samples from México that were obtained for these studies were extracted from horns, bone marrow, old tissue, hair, and feces, all of which were collected by non-invasive methods. Oligonucleotide primers designed to amplify the d-loop control region were used in PCR reactions to produce a 500 base pair product. The sequence from 93 individuals from México and USA was obtained including representatives of all five subspecies. We found 29 haplotypes, which indicates a high level of variation, suggesting that reported severe population bottlenecks during the last Century did not strongly reduce the genetic variability within the species. We have found a low level of genetic differentiation between the populations. The data that we obtain in this study shows signs of a rapid population explosion of the pronghorns populations, as a result of the extinction of many of their predators and competitors during the megafauna extinction, and the prairie expansion during the Holocene. The results obtained from this study will help to understand the recent evolutionary history of the pronghorn populations, and will be valuable for making management decisions designed to reestablish populations of the endangered subspecies in Mexico.

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19:106

***Key words*:** Molecular genetics, subspecies, population biology, bottleneck, management, mitochondrial DNA.

HISTORY AND MANAGEMENT OF YELLOWSTONE NATIONAL PARK PRONGHORN

WENDY E. CLARK. Wildlife Biologist Yellowstone Center for Resources P.O. Box 168, Yellowstone National Park, WY 82190

Abstract: Unregulated commercial hunting outside the Yellowstone National Park (YNP) boundary was largely responsible for extirpating pronghorn from the area north of the park by the early 1920's and isolating the Yellowstone population at the upstream limit of its former distribution. Increased protection from poaching within the park, along with favorable climatic conditions and predator control actions allowed pronghorn and other ungulates to increase in number during the first half of the century. These increases resulted in an apparent reversal of National Park Service (NPS) management policy, which had stressed full preservation and protection of all ungulate species. Between the 1940's and the late 1960's, park managers, concerned about impacts of increasing ungulate numbers on habitat, attempted to maintain the pronghorn population between 125 and 150 animals by shooting and by trapping and transplantation. Pronghorn from Yellowstone were used to augment or re-establish decimated pronghorn populations in several western states. In 1968 the NPS again implemented a policy change, ceasing its program of aggressive population control, and allowing all wildlife populations to exist without human interference to the maximum extent possible. The Yellowstone pronghorn population at this time numbered less than 200 animals, and remained so until 1983 when it began to increase. After reaching a high of nearly 600 animals in 1991, the population has declined in recent years to around 200 pronghorn. Human activity, intraspecific competition, habitat changes, and predators have all been suggested as possible contributing factors to the recent decline. The NPS has recently initiated a cooperative research effort to examine the factors influencing pronghorn numbers. These studies are intended to form the beginning of a comprehensive evaluation of the factors influencing the Yellowstone pronghorn population and an estimation of the likelihood of persistence of the population. This information will also be used to review the potential effectiveness of various proposed management strategies.

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19:107

CAPTURE, HAND REARING AND CAPTIVE MANAGEMENT OF PENINSULAR PRONGHORN.

JORGE CANCINO. Centro de Investigaciones Biológicas del Noroeste. La Paz, 23000, Baja California Sur, Mexico.

RAMÓN CASTELLANOS. Reserva de la Biosfera “El Vizcaíno”. Guerrero Negro, 23940, Baja California Sur, Mexico

VICTOR SÁNCHEZ. Reserva de la Biosfera “El Vizcaíno”. Guerrero Negro, 23940, Baja California Sur, Mexico

Abstract. Capture and hand rearing of peninsular pronghorn fawns was carried out early 1998 (2 males: 3 females), 1999 (3 males: 1 female), and 2000 (5 males: 2 females),. After these, captive management include since transfer of the first weaned youngsters, to care and to observe the animals, general complement feeding, coyote control, irrigation system, training some animals, and to capture wild adults. All these activities are developed in a large enclosure ranging 1,400x1,850m. There is a division with a double fence (wire netting and electric) and other single wire fences for pronghorn handling. The facilities includes a 405 m^3 water storage, an observation tower and cabins. Some of the activities are described with detail. Nowadays there are 33 captive peninsular pronghorns: 18 males and 15 females. First captive births of peninsular pronghorn were early 2000, including triplets.

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19:108

Key words: Capture, hand rearing, captive management, peninsular pronghorn.

ALTERNATIVE CAPTURE TECHNIQUE FOR THE PENINSULAR PRONGHORN.

RAMÓN CASTELLANOS. Reserva de la Biosfera “El Vizcaíno”. Guerrero Negro, 23940, Baja California Sur, Mexico

JORGE CANCINO. Centro de Investigaciones Biológicas del Noroeste. La Paz, 23000, Baja California Sur, Mexico.

VICTOR SÁNCHEZ. Reserva de la Biosfera “El Vizcaíno”. Guerrero Negro, 23940, Baja California Sur, Mexico

Abstract. Capture of wild peninsular pronghorn adults is described. The technique used was supported by a irrigation system, captive hand reared fawns and an observation tower. The main structure of the trap consists of a divided fence (1400x1850m) installed for capturing wild adults and captive reproduction. One side of this fence can be opened or closed as needed, in a mayor dimension than a door. A general diagram is included. There are two main “baits” used: a) Green vegetation yearlong promoted by the irrigation system, and b) the hand-reared captive animals. Other important element is the use of the tower to spot the entrance of wild pronghorn to the trap, and to coordinate the capture action. Obviously optic and radio equipment was unavoidabl**e**.

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19:109

Key words: Capture, fence, peninsular pronghorn, irrigation system.

REINTRODUCCIÓN Y MONITOREO DE BERRENDOS EN EL ESTADO DE COAHUILA.

ENRIQUE GUADARRAMA, Asesorías Biológicas. A.C., Museo de la Fauna en Monterrey N. L.

Abstract: Unidos para la Conservación A. C. (U.P.C.) inicia el Programa "El Retorno del Berrendo" en 1993, año en que inicia pláticas con el New México Department of Game & Fish para establecer un programa de colaboración internacional para reintroducir la especie al estado de Coahuila. Después de la evaluación de las áreas de captura y trasplante, se eligió el Valle Colombia, en el NW de Coahuila, que ocupa un área aproximada de 230,000 hectáreas y en el cual se estimó una superficie de pastizales para el manejo del Berrendo de 55,743 ha. En 1996 se realizó la primera traslocación de 65 Berrendos procedentes de Carrizoso, Nuevo México y se estableció un programa de monitoreo para observar su adaptación y distribución en el área de liberación. Debido al éxito de ésta, se realizó una segunda traslocación de 85 Berrendos. Actualmente se da seguimiento a los grupos de Berrendos establecidos dentro del Valle Colombia mediante monitoreos terrestres y aéreos para evaluar el éxito de las traslocaciones y el proceso de dispersión de algunos grupos fuera del Valle.

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19:110

"UNIDOS PARA LA CONSERVACIÓN" PRONGHORN RESCUE PROGRAM IN THE STATES OF CHIHUAHUA AND COAHUILA.

Carlos Manterola, Unidos para la Conservación A. C.

Abstract: Unidos para la Conservaci6n, A.C. (UPC), is a Mexican non-profit private association founded in August 7, 1992, with the goal to preserve Mexican natural resources, to assist and develop programs that would allow their continuity by applying an efficient financial and scientific structure, as well as it's promotion."The Return of the Pronghorn", is the name of UPC's program for the conservation of the pronghorn in Mexico. This program started giving support to other projects already existing such as the one in the state of Baja California Sur with the Centro de Investigaciones Biologicas del Noroeste and the Reserve of El Vizcaino; and the other in Sonora, with the Centro Ecologico de Sonora. In February 1996 and January 1998, with the support of the New Mexico Department of Game and Fish, UPC reintroduced this species to Coahuila with herds from the south of New Mexico. Since then this herd has been monitored by air and land. In collaboration with the UNAM and some landowners, during 1997, 1998 and 1999 air and land monitoring has been carried out in Chihuahua obtaining information of the status of the pronghorn populations and its habitat. We are also collaborating with the UNAM in the genetic study of the introduced animals and the pronghorns surviving in Chihuahua, Sonora and El Vizcaino in Baja California Sur. This study will let us establish new alternatives for the management of this species. All these actions have been carried out with the support of different institutions and companies.

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19:111

SONORAN PRONGHORN HOME RANGES AND HABITAT USE

JILL L. BRIGHT, Arizona Game and Fish Dept., 9140 E County 10 1/2 Street, Yuma, AZ 85365

JOHN J. HERVERT, Arizona Game and Fish Dept., 9140 E County 10 1/2 Street, Yuma, AZ 85365

LINDEN A. PIEST, Arizona Game and Fish Dept., 9140 E County 10 1/2 Street, Yuma, AZ 85365

MARK T. BROWN, Arizona Game and Fish Dept., 9140 E County 10 1/2 Street, Yuma, AZ 85365

ROBERT S. HENRY. Arizona Game and Fish Dept., 9140 E County 10 1/2 Street, Yuma, AZ 85365

Abstract: The current range of Sonoran pronghorn (Antilocapra americana sonoriensis) in the United States is limited to southwestern Arizona. Vegetation is described as either the Lower Colorado River Valley or Arizona Upland subdivisions of the Lower Sonoran Desert Life Zone (Brown 1982). We studied home ranges and habitat use of radio-collared Sonoran pronghorn from 1994 - 1999. Habitat was classified primarily by topographic features into 5 categories: flats, bajadas, hills, washes and other. Habitat associations of pronghorn were recorded on weekly aerial telemetry flights. We used estimates of the expected proportions of habitat types from Wright and DeVos's (1986) study in the same area, which were derived by plotting random points. Seasons were based on local temperature and precipitation patterns. Observed use was compared to expected use by seasons using chi-square tests. We also mapped the distribution of chain-fruit cholla (Opuntia fulgida) and compared use of these areas to areas lacking this species. The results of these analyses will be presented.

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19:112

***Key words*:** Sonoran pronghorn, habitat, bajada, chain-fruit cholla, home range.

BIOTIC AND ABIOTIC FACTORS AFFECTING THE QUALITY AND QUANTITY OF HABITAT OF THE PENINSULAR PRONGHORN (*Antilocapra americana peninsularis*) IN THE BIOSPHERE RESERVE "EL VIZCAINO', BAJA CALIFORNIA SUR, MEXICO.

FERNANDO GONZÁLEZ SALDÍVAR. . Facultad de Ciencias Forestales, U.A.N.L. Apdo. Postal 41. 67700. Linares, Nuevo León.

JORGE CANCINO. Centro de Investigaciones Biológicas del Noroeste. Apdo. Postal 128. La Paz, 23000, Baja California Sur, México.

Abstract: Some biotic and abiotic factors were evaluated. Canfield line and quadrants were used to record the vegetation data. The information obtained is in the following tables. The main anthropogenic activities include: agriculture, cattle raising, infrastructure developments (aqueduct and roads), and poaching. Human population and habitat fragmentation also are important factors.

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19:113-114

Table 1. Number of quadrants per vegetation type.

Dune shrub	Halophilous vegetation	Microphila vegetation	Microphila - halophilous vegetation
12	8	9	9

Table 2. Vegetal composition per vegetation type.

Vegetation Type.	Shrubs (%)	Forbs (%)	Grasses (%).
Dune shrub	**63**	35	2
Halophilous vegetation	37	**45**	18
Microphila vegetation	**60**	20	20
Microphila - halophilous vegetation	**55**	27	18

Table 3. Number of species per vegetation type.

Vegetation Type.	**Shrubs**	**Forbs**	**Grasses**	**Total**
Dune shrub	**8**	6	1	15
Halophilous vegetation	7	**9**	3	19
Microphila vegetation	**10**	3	2	15
Microphila – halophilous vegetation	**11**	4	2	17

Table 4. Biomass estimated per vegetation type.

Vegetation Type.	Maximum production (Kg/ha)	Minimum production (Kg/ha)	Medium production (Kg/ha)
Dune shrub	256.08	140.23	192.56
Halophilous vegetation	534.5	196.0	333.9
Microphila vegetation	276.5	217.5	247.0
Microphila – halophilous vegetation	593.9	315.7	454.8

EFFECT OF BIRTH DATE ON PREDATION OF NEONATAL PRONGHORN IN THE NORTHERN GREAT BASIN.

MICHAEL A. GREGG, U.S. Fish and Wildlife Service, Sheldon National Wildlife Refuge Complex, Biological Investigations Unit, P.O. Box 111, Lakeview, OR 97630, USA

MARTIN BRAY, U.S. Fish and Wildlife Service, Hart Mountain National Antelope Refuge, P.O. Box 111, Lakeview, OR 97630, USA

KEVIN M. KILBRIDE, U.S. Fish and Wildlife Service, Vancover Field Station, 9317 Hwy 99, Suite D, Vancouver, WA 98665 USA

MICHAEL R. DUNBAR, U.S. Fish and Wildlife Service, Sheldon National Wildlife Refuge Complex, Biological Investigations Unit, P.O. Box 111, Lakeview, OR 97630, USA

Abstract: The northern Great Basin represents an important area of the pronghorn (*Antilocapra americana*) range. However, limited information exists about factors influencing fawn survival. Birth date can affect fawn survival of other ungulates, but it has not been examined in pronghorn. We investigated causes and timing of fawn mortality and the effect of birth date on survival at Hart Mountain National Antelope Refuge in southeastern Oregon during 1996-99. One hundred forty-nine fawns (<1 to 7 days old at capture) were marked and monitored from mid-May to mid-July during the 4-year study. We estimated survival of marked fawns with the Kaplan-Meier estimator modified for staggered entry and used the Weibull survival model to identify factors related to fawn mortality. Eighty-six percent (128/149) of the marked fawns died during the monitoring period. Average age at death was 7.3 days and 124 (97%) of the fawns that died were <21 days old. Predation accounted for 82% (105/128) of the fawn deaths. Coyote (*Canis latrans*) predation was the greatest single cause of mortality each year. Disease and starvation were minor factors and accounted for only 6 deaths. No mortalities attributed to exposure were diagnosed during the 4-year study. Female fawns lived longer than male fawns (P = 0.048). Birth date affected fawn survival where fawns born during the peak parturition period lived longer than those born during the non-peak period (P = 0.0001). Of 21 surviving fawns, 17 (81%) had birth dates during peak parturition. Results suggest that birth synchrony in pronghorn may be an important factor in fawn survivability.

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19:115

Key words: birth date, birth synchrony, coyote, fawn, Great Basin, mortality, predation, pronghorn, sex, survival.

EVALUATION OF AERIAL LINE TRANSECT FOR ESTIMATING PRONGHORN POPULATIONS IN OREGON.

DONALD G. WHITTAKER. Oregon Department of Fish and Wildlife, 2501 SW First Avenue PO Box 59, Portland, OR 97207, USA.

WALKER A VAN DYKE. Oregon Department of Fish and Wildlife, 3814 Clark Blvd., Ontario, OR 97914, USA.

STUART L. LOVE. Oregon Department of Fish and Wildlife, 3814 Clark Blvd., Ontario, OR 97914, USA.

ABSTRACT: We evaluated the use of Aerial Line Transect, Wyoming method, for estimating pronghorn antelope abundance in Oregon. Surveys were conducted in 2 Oregon big game units during May 1998 and 1 unit during May 1999. Data were collected according to protocols developed by Wyoming Game and Fish (Guenzel 1997) and analyzed using DISTANCE (Buckland et al. 1993). We found this technique provided reasonable estimates of population size for the density range found in Oregon, which is much lower than found in other states already utilizing the technique. However, confidence intervals around estimates were larger than desired. In addition, application in lower density areas was more expensive compared to traditional survey methods because additional effort was required to obtain adequate sample size for desired precision estimates. Comparison with historic trend counts and management implications will be discussed.

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19:116

Key words**:** aerial transect, *Antilocapra americana*, low density, Oregon, pronghorn, survey

MONITORING A PRONGHORN *(Antilocapra americana mexicana)* POPULATION REINTRODUCED TO THE NORTHEASTERN OF MEXICO

E. PAOLA MIRANDA ALMAZÁN. Facultad de Ciencias Forestales, U.A.N.L. Apdo. Postal 41. 67700. Linares, Nuevo León.

ALFONSO MARTÍNEZ MUÑOZ. Facultad de Ciencias Forestales, U.A.N.L. Apdo. Postal 41. 67700. Linares, Nuevo León.

Abstract: The pronghorn (*Antilocarpra americana mexicana*), an endemic ruminant species of North America is classified as an endangered species. This study covering three years (1995-1998) was conducted to evaluate the factors determining the success of reintroduction of pronghorn in the Mexican State of Coahuila. Vegetation characteristics, botanical composition of the pronghorn diet and birth and mortality rates were monitored. One hundred and seventeen vegetation species belonging to 32 different species were identified. Greatest diversity was obtained in the natural grass community (0.77), followed by halophyte grass community (0.74) and rosetophyll shrubs (0.53). Fifty-nine vegetation species were identified in the pronghorn diet and the poisonous plants: *Solanum rostratum* and *Solanum eleagnifolium* were determined in the pronghorn diet all-year round, though percentages consumed varied with season (0.96 % in wet season versus 11.2 % in dry season). Of the total diet consumed by the pronghorns, forbs ranked highest (75 %) while grasses and shrubs were eaten in almost similar quantities (12.5 % of each). Births averaged 0.17 ± 0.075 and 4 and 3 deaths were recorded in 1996 and 1998, respectively. Competition with cattle for grazing would occur under drought conditions. It is concluded that the pronghorn will continue to be endangered despite these translocation programmes. Further studies to evaluate supplementation strategies during critical times, to promote forb development and the dynamics of interaction with other ruminant animal species in the same rangeland, are necessary

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19:117

***Key words*:** Diet composition, habitat condition, pronghorn, translocation

NUTRITIONAL VALUES OF SOME PLANTS INGESTED BY PENINSULAR PRONGHORN.

JORGE CANCINO. Centro de Investigaciones Biológicas del Noroeste. Programa de Evaluación y Manejo de Recursos Naturales. La Paz, 23000, Baja California Sur, Mexico.

Abstract: Nutritional values from proximal analyses were obtainded for several items ingested by peninsular pronghorn. Direct and indirect observation was the base to select the samples collected. This observation was done with wild and captive (hand reared) animals. . Mourning dove (*Zenaida macroura*) feces sample was analyzed more detailed for some mineral content. Table 1). Vegetal samples include 13 species (or part). Vegetal samples were analyzed for: humidity, ash, protein, ether extract, crude fiber, and nitrogen-free extract (Table 2). The species key is Eule(g) *Euphorbia leucophyla* (green); Spam *Sphaeralcea ambigua*; Enfa *Encelia farinosa*; Eule(d) *Euphorbia leucophyla* (dry); Fodi(l) *Fouquieria diguetti* (leaves); Fodi(f) *Fouquieria diguetti* (flower); Lyca *Lycium californicum*; Erbe *Errazurizia benthamii*; Atca *Atriplex canescens*; Phfi *Phaseolus filiformis*; Enca(f) *Encelia californica* (flower); Padi(l) *Pachycormus discolor*; Eumi *Euphorbia misera*; Atju *Atriplex juneata*; Stli *Stillingia linearifolia*; Atba *Atriplex barclayana*

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19:118-119

Key words: Nutritional value, minerals, ingest, peninsular pronghorn.

Table 1. Chemical composition of feces of mourning dove (*Zenaida macroura*) consumed by peninsular pronghorn.

CONSTITUENT	CONTENT
Ca	4642.9 μg/g
P	5629.3 μg/g
Zn	24.43 μg/g
Fe	1833 μg/g
Cu	11.72 μg/g
Mn	77.54 μg/g

Table 2. Nutritional values for items consumed by peninsular pronghorn.

SPECIES	HUMIDITY	MINERALS	PROTEIN	ETHER EXTRACT	CRUDE FIBER	N.F.E. (*)
Eule(g)	69.34	2.89	12.70	5.58	2.92	75.92
Spam	69.24	4.01	19.66	4.36	4.41	67.56
Enfa	72.06	0.20	12.76	3.83	1.76	81.45
Eule(d)	6.20	0.12	10.20	4.77	8.52	76.39
Fodi(l)	72.63	2.07	17.32	3.62	0.87	76.13
Fodi(f)	71.79	1.33	9.87	3.34	3.89	81.57
Lyca	97.37	4.49	15.19	3.65	0.69	75.99
Erbe	60.95	2.86	16.06	6.00	6.54	68.54
Atca	43.71	12.71	14.04	2.59	2.95	67.71
Phfi	74.71	2.89	18.16	3.89	3.01	72.06
Enca(f)	74.47	2.31	12.91	9.22	1.97	73.58
Padi(l)	68.20	0.11	13.55	4.42	2.25	79.66
Eumi	77.87	2.34	17.03	6.74	1.23	72.65
Atju	60.21	0.23	5.78	3.24	7.43	83.32
Stli	80.46	2.01	23.41	6.41	1.67	66.50
Atba	70.89	10.48	8.61	3.53	2.19	75.19

PROGRAMA DE CONSERVACIÓN Y APROVECHAMIENTO DEL BERRENDO EN MÉXICO.

DIRECCIÓN GENERAL DE VIDA SILVESTRE. Av. Revolución 1425, Col Tlacopac, Del. Alvaro Obregón, México, D.F.

SUBCOMITE TECNICO CONSULTIVO PARA LA CONSERVACION, MANEJO Y APROVECHAMIENTO SUSTENTABLE DEL BERRENDO EN MEXICO. Av. Sauzales # 44. Col. Granjas Coapa. México, 14330, D.F.

This project contains goals, objectives and actions focused to resolve the pronghorn situation in Mexico, using protection, reproduction, recovery strategies, and reintroduction in potential areas. Each action or strategy will depend on the local and regional characterísts and problems, and should consider the social and economic development, the subspecies biological and ecological characteristics, and the factibility of national and international agreements which should involve the several social sectors (e.g. academic, private initiative, users and non guvernamental organitations), to search viable conservation alternatives, and in its opportunity, the sustainable use.

Este proyecto plantea una serie de metas, objetivos y acciones encaminadas a resolver la problemática del berrendo en México, a través de una estrategia de protección, reproducción, recuperación y reintroducción en áreas potenciales. Las acciones para el desarrollo de esta estrategia dependerán de las características y problemática local y regional, y deberán considerar el desarrollo socioeconómico, las características biológicas y ecológicas de cada subespecie, y la creación de convenios nacionales e internacionales con la participación de diferentes sectores de la sociedad (e.g. académico, particulares, usuarios e instituciones no gubernamentales), para la búsqueda de alternativas viables de conservación y, en su momento, aprovechamiento sustentable.

PROCEEDINGS PRONGHORN ANTELOPE WORKSHOP 19:120

Notes:

- Other participants are: Africam Safari, Bioparque Estrella, Environmental Flying Services, Espacios Naturales y Desarrollos Sustentables, Fish and Wildlife Services, Fondo Mexicano para la Conservación de la Naturaleza, Los Angeles Zoo, and Wyoming Fish and Game Department.
- Current web page is: www.berrendo.org.mx

19th Pronghorn Antelope Workshop Agenda
March 13-17, 2000
La Paz, Baja California Sur, México.

Monday March 13, Salon Conquistadores

18:00 - 20:00 h	Registration
19:00 - 21:00 h	Icebreaker, light refreshments provided.

Tuesday March 14, Salon Conquistadores

08:00 - 12:00 h	Registration
08:30 - 09:00 h	Welcome, general opening and messages
09:00 - 09:10 h	Break
09:10 - 09:30 h	States and Provinces Reporte. Jim DeVos
09:30 - 10:30 h	Lunch (on your own)
10:30 - 14:00 h	Technical Session I
14:00 - 14:20 h	Break
14:20 - 17:00 h	Technical Session II
17:00 - 20:00 h	Dinner

Wednesday March 15. Salon Conquistadores

09:00 - 14:20 h	Technical Session
14:00 - 16:00 h	Lunch
16:00 - 19:00 h	Business meeting and general discussion

Thursday March 16. Field trip.

Field trip to Magdalena Bay: Peninsluar pronghorn former range.

Friday March 17. Salon Conquistadores

09:00 - 12:00 h	Visit to CIBNor
12:00 - 13:00 h	Informal discussion.

WORKSHOP AGENDA

19th Biennial Pronghorn Antelope Workshop

March 13-17, 2000.
Los Arcos Hotel.
La Paz, B.C.S., México.

Monday March 13, Conquistadores Room.

18:00 - 20:00 h	Registration. Merchandise sales.
19:00 - 21:00 h	Icebreaker, light refreshments provided.

Tuesday March 14, Conquistadores Room.

08:00 - 12:00 h	Registration.
09:00 - 09:30 h	Welcome, general opening and messages. Dr. Mario Martínez García, Director General. CIBNor, S.C. Lic. Enrique Provencio. President. Instituto Nacional de Ecología.
09:30 - 09:40 h	Cofee break.
09:40 -	States and Provinces Report. Jim deVos.
- 12:40 h	Technical Session I: Nutrition and Genetic.
12:40 - 14:00 h	Lunch (on your own).
14:00 - 17:00 h	Technical Session II: Management. Poster presentation.
18:30 - 20:00 h	Dinner (included in your registration).

Wednesday March 15.

09:00 - 12:00 h	Technical Session III: Habitat and Miscellaneous.
12:00 - 13:00 h	Lunch (on your own).
13:00 - 16:00 h	Business meeting and general discussion.

Thursday March 16. Field trip.

Field trip to Magdalena Bay: Peninsluar pronghorn former range.

Friday March 17.

09:00	Visit to CIBNor

States and Provinces Report,
Technical Session I -- Nutrition and Genetic
Tuesday March 14, Conquistadores Room
10:00 - 12:40
(Bold Indicate presenter).

Moderator: *Jorge Cancino Hernández, CIBNOR, S.C.*

States and provinces report. ***Jim deVos.***

Nutrition:

Food habitat techniques for Pronghorn: a review. ***Jim D. Yoakum***

Relationships between nutrition and behavior in a captive group of pronghorn. ***Mary Robinson***, *Margaret Wild and John Byers*.

Genetic:

Analysis of reintroduced pronghorn populations in Arizona using mitochondrial DNA markers. *Olin E. Rhodes, Jr., Erin P. Reat,* ***James R. Heffelfinger****, and James C. deVos Jr.*

Genetic Variation among pronghorn populations using mitochondrial DNA control region as a molecular marker. ***Amor Dalia****, Oliver Ryder, Rob Ramey, and Rodrigo Medellin.*

Technical Session II -- Management. Poster Presentation
Tuesday March 14, Conquistadores Room
14:00 - 17:00

Moderator: *Ramón Castellanos, Reserva de la Biosfera "El Vizcaino".*

History and management of Yellowstone National Park pronghorn. ***Wendy E. Clark.***

Capture, hand rearing and captive management of Peninsular pronghorn. ***Jorge Cancino Hernández***, *Ramón Castellanos Giralda, and Victor Sánchez-Sotomayor.*

Alternative capture technique for the Peninsular pronghorn. ***Ramón Castellanos Giralda***, *Jorge Cancino Hernández, and Victor Sánchez- Sotomayor.*

Sensitivity analysis as a guide for population management of pronghorn. ***Patryce Avsharian*** *and John Byers*.

Pronghorn's reintroduction and monitoring in the state of Coahuila. *Guadarrama Enrique and* ***Manuel Valdez***.

States and Provinces Report,
Technical Session I -- Nutrition and Genetic
Tuesday March 14, Conquistadores Room
10:00 - 12:40
(Bold Indicate presenter).

Moderator: *Jorge Cancino Hernández, CIBNOR, S.C.*

*States and provinces report. ***Jim deVos.***

Nutrition:

*Food habitat techniques for Pronghorn: a review. ***Jim D. Yoakum***

*Relationships between nutrition and behavior in a captive group of pronghorn. ***Mary Robinson***, *Margaret Wild and John Byers.*

Genetic:

*Analysis of reintroduced pronghorn populations in Arizona using mitochondrial DNA markers. *Olin E. Rhodes, Jr., Erin P. Reat,* ***James R. Heffelfinger****, and James C. deVos Jr.*

*Genetic Variation among pronghorn populations using mitochondrial DNA control region as a molecular marker. ***Amor Dalia***, *Oliver Ryder, Rob Ramey, and Rodrigo Medellin.*

Technical Session II -- Management. Poster Presentation
Tuesday March 14, Conquistadores Room
14:00 - 17:00

Moderator: *Ramón Castellanos, Reserva de la Biosfera "El Vizcaino".*

*History and management of Yellowstone National Park pronghorn. ***Wendy E. Clark.***

*Capture, hand rearing and captive management of Peninsular pronghorn. ***Jorge Cancino Hernández***, *Ramón Castellanos Giralda, and Victor Sánchez-Sotomayor.*

*Alternative capture technique for the Peninsular pronghorn. ***Ramón Castellanos Giralda***, *Jorge Cancino Hernández, and Victor Sánchez- Sotomayor.*

*Sensitivity analysis as a guide for population management of pronghorn. ***Patryce Avsharian*** *and John Byers.*

*Pronghorn's reintroduction and monitoring in the state of Coahuila. *Guadarrama Enrique and* ***Manuel Valdez***.

Pronghorn rescue program in the states of Chihuahua and Coahuila. ***Carlos Manterola***.

Poster presentation

Monitoring a translocated pronghorn population in the northwestern Coahuila, México. ***E. Paola Miranda Almazán*** *and Alfonso Martínez Muñoz*.

Nutritional values of some plants ingested by Peninsular pronghorn. ***Sonia Rocha Meza***, *Jorge Cancino Hernández, and Paloma Carton de Grammont Lara.*

20 Años de observación en la partida de berrendos de la Gregoria, Chihuahua. ***José Treviño*****.**

Programa de Conservación y Aprovechamiento del Berrendo en México. Dirección General de Vida Silvestre. Instituto Nacional de Ecología.

Technical Session III -- Habitat and Miscellaneous
Wednesday March 15, Conquistadores Room
09:00 - 12:00

Moderator: *Rodrigo Medellín, Instituto de Ecología U.N.A.M.*

Habitat:

Sonoran pronghorn recovery: habitat enhancements to increase fawn survival. ***John J. Hervert****, Jill L. Bright, Linden A. Piest, Mark T. Brown and Robert S. Henry*.

A validation of Arizona's landscape-level pronghorn habitat model. ***Cindy L. Ticer*** *and Richard A. Ockenfels*.

Sonoran pronghorn home ranges and habitat use. *Jill L. Bright, John J. Hervert, Linden A. Piest, Mark t. Brown and Robert S. Henry.*

Biotic and abiotic factors affecting quality and quantity of habitat of the Peninsular Pronghorn (Antilocapra americana peninsularis) in the Biosphere Reserve "El Vizcaino", Baja Calidfornia Sur, México. ***Fernando González Saldívar*** *and Jorge Cancino Hernández*.

Miscellaneous:

Effect of birth date on survival of neonatal pronghorn in the northern Great Basin. ***Michael A. Gregg****, Martin Bray, Kevin M. Kilbride, and Michael R. Dunbar*.

Pronghorn populations in Chihuahua, determined by aerial censuses. ***Azuara Danae****, Rodrigo Medellín and Carlos Manterola.*

Evaluation of aerial line transect for estimating pronghorn populations in Oregon. **Donald G. Whittaker**, Walter A Van Dyke, and Stuart L. Love.

BUSINESS MEETING AGENDA
19th BIENNIAL PRONGHORN ANTELOPE WORKSHOP

Old business

1. IUCN update.
2. National Pronghorn Antelope Interpretative Center.
3. Bylaw Changes.
4. Management Guidelines on Internet and BLM Intranet.
5. Spanish Version Management Guidelines.
6. Proceedings from previous PAW's (17th and 18th).

New business

7. Biennial Pronghorn Workshop Award(s).
8. Biennial Antelope States Workshop page.
9. Peninsular pronghorn workshop.
10. New issues.
11. Date and place for next PAW
12. 19th Biennial Pronghorn Workshop Reconnaissances.
13. General topics.

BUSINESS MEETING
19th BIENNIAL PRONGHORN ANTELOPE WORKSHOP

LA PAZ, BAJA CALIFORNIA SUR, MEXICO
MARCH 15, 2000

The business meeting was called to order by Chair Jorge Cancino at 13:00hrs. Meeting minutes were taken by Lorie Mc Cracken and Ramón Castellanos. Delegates were present from Arizona, Baja California Sur, Colorado, Chihuahua, Idaho, Nebraska, North Dakota, Oregon, Utah, and Wyoming. Also present were representatives from U.S.A. and Mexican federal agencies, from non-governmental organizations, and Mexican and U.S.A. universities. A complete list of participants and their affiliation is in the Attendance register on pages iv-vi of this Proceedings.

Old business

1. **IUCN update.**

Kim Brinkley from the Los Angeles Zoo indicated that a studbook for pronghorn is proposed. She also mentioned that the TAG (Taxonomic Advisory Group) recommended that a pronghorn SSP (Survival Species Plan) be developed. The discussion pointed out that SSPs are management and breeding cooperative programs including all the captive animals as a population. These programs are coordinated by AAZA (American Association of Zoos and Aquariums) to enhance management (genetics and demographics) of small captive populations.

Jim deVos from Arizona asked for more information about the recommendation and asked about the benefits of this approach.

Kim Brinkley and Jeff Holland (L.A.Zoo) explained that it is specific to captive herd conservation and helps focus funds, scientific support, and collaborative work with local or federal agencies on these animals. **No action taken.**

2. National Pronghorn Antelope Interpretative Center.

Tom Pojar (Colorado) and Robb Hitchcock (North American Pronghorn Foundation) explained the proposal to establish a National Pronghorn Antelope Interpretative Center. The general objetive is to increase awareness of pronghorn. There was mention about the funds search for this year and about the support the Foundation offers for different pronghorn projects. **No action taken.**

3. Bylaw Changes.

Richard Ockenfels (Arizona) commented about the previous Business Meeting review of the Bylaws and the changes that were made. He pointed out that the new Bylaws start on the page 111 of the 18^{th} P.A.W. Proceedings and asked for comments.

Rodrigo Medellín (from U.N.A.M.) remarked that México is listed as another state and would have only one vote in this manner. Richard clarified that México has 4 votes; one for each of the states with pronghorn. There was general discussion about voting rights and it was pointed out that representatives for other categories (universities or federal agencies) lacked voting ability. Richard suggested to put off the voting, but Jim deVos (from Arizona) pointed out that the Pronghorn Workshop is sanctioned by the Western Association of Fish and Wildlife Agencies (WAFWA) and that only member states-provinces are afforded voting rights. **No action taken.**

4. Management Guidelines on Internet and BLM Intranet.

Richard Ockenfels presented the 1998 Pronghorn Management Guidelines and ask if it could be included in the NAPF website. The objective is to be available for more people. The attendees supported the proposal and added that this document should be readily available to the public. Richard will make sure that the document is provided to any appropriate website (for example, federal or state pages) when requested to do so.

5. Spanish Version of the Management Guidelines.

Jorge Cancino commented about the utility of this document to managers in Mexico. He reports that translation to Spanish is progressing (about 60 % complete) and that the Subcomité Técnico Consultivo Nacional para el Manejo, Conservación y Aprovechamiento Sustentable del Berrendo (the National Subcommittee for the Conservation of Pronghorn) will print the translation. Jorge also pointed out the necessity of some modifications to the guidelines to adapt them to the conditioins in Mexico. **No action taken.**

6. Proceedings from previous PAW's (17th and 18th).

Jorge Cancino and Richard Ockenfels presented the 18^{th} Pronghorn Antelope Workshop Proceedings. They commented that John Fisher (from California) is in charge of the 17^{th} Pronghorn Antelope Workshop Proceedings and that they were expected soon. Bylaws states that chairperson has to prepare and distribute the proceedings of the Workshop for which they are responsible. Extra copies of the 18^{th} Pronghorn Antelope Workshop Proceedings are available from Richard Ockenfels.

Richard mentioned that he and some people from the U. S. Fish and Wildlife Service have the complete set of the Proceedings and propose a data base to be available for those people who would benefit from access to these documents.

It is recommendable that the Proceedings of the 19th Pronghorn Workshop should be published in a year. **No action taken.**

New business

7. Biennial Pronghorn Workshop Award(s).

Item proposed by Jim deVos. He suggets the creation of a Pronghorn Workshop Awards Committee. The idea is to create a mechanism to recognize people who have made significant contributions to pronghorn or pronghorn habitat conservation, management, and research. It was decided that the current chair of the Workshop would appoint such a committee. This will be enacted at the next Pronghorn Workshop

8. Biennial Antelope States Workshop page.

There was some discussion on the need to develop a website for the Biennial Pronghorn Antelope Workshop. After considerable discussion, it was decided that this was not practical at this time, and that notice of the workshop would be included in the North American Pronghorn Foundation's website. The Chair has the responsibility to pass the information on to NAPF. Richard Ockenfels asked if the Foundation had the resourses to improve their webpage, and Robb Hitchcock (President) answered that they did and were working on it.

9. Peninsular pronghorn workshop.

Jorge Cancino led a discussion about the need for a special workshop to assist in developing a Recovery Plan for the peninsular subspecies. Jorge said he will continue to work to develop this workshop at some time in the future.

10. New issues.

Ramón Castellanos (from El Vizcaino Biosphere Reserve, Baja California Sur) asked about the possibilities of obtaining an airplane, like a Cessna 182, in order to conduct surveys and to monitor the different pronghorn populations that inhabit northern Mexico. Jim deVos indicated that on occaison that narcotics agencies from the States seize aircraft that are transporting narcotics. It may be possible that one of these aircraft could be made available for this purpose and suggested that someone from a Mexican federal agency (possibly PROFEPA) could explore the opportunity to have one of these aircraft made available. Robb Hitchcock recommended that someone should contact the different airplane manufacturers to see if it was possible to make a plane available through a donation. He suggested that a joint request (U.S. and Mexico) be prepared as this would show international cooperation for work with endangered species.

11. Date and place for next PAW

Jim deVos helped Jorge Cancino with this matter. Jim commented that the last 3 meetings were in south, and that if a northern state would host the meeting, it would facilitate participation from biologists in the northern states and provinces. Jim asked if there was a volunteer to host the 20th Biennial Pronghorn Workshop. He asked if Don Whittaker from Oregon and Jeff Abegglen from Nebraska were interested in being the host.

Don Whittaker explained that his agency is in charge of another workshop (Deer-Elk Workshop) but he would ask his Director. Jeff Abegglen will also see if his agency would be willing to host this workshop.

Jim deVos suggested that the decision should be postponed until we hear from both of these states.

12. 19th Biennial Pronghorn Workshop Acknowledgements.

José Maria Reyes (from Mexico City, Dirección General de Vida Silvestre) passed out acknowledgement to attendees.

13. General topics.

Don Whittaker ask about the deadline for the complete manuscripts for the proceedings. Jorge Cancino answered that an announcement will be sent, but about 5 months from the date of the meeting was the timeframe the reviewers suggested.

Note: After the meeting, Chair Jorge Cancino informally passed the English version of the Pronghorn National Program poster to Robb Hitchcock for use at the National Pronghorn Antelope Interpretative Center.

Submitted by Lorie Mc Cracken, Pronatura, March, 2000
Edited by Jorge Cancino, June 2001

We really appreciate the suppor from

CENTRO DE INVESTIGACIONES
BIOLÓGICAS DEL NOROESTE, S.C.

INSTITUTO NACIONAL DE ECOLOGÍA
SEMARNAP

SIERRA
MADRE

U.S.
FISH & WILDLIFE
SERVICE
DEPARTMENT OF THE INTERIOR

NORTH AMERICAN WILDERNESS FOUNDATION
1991

ARIZONA
GAME
& FISH

THIRD WORLD ACADEMY OF SCIENCES