PROCEEDINGS OF THE 18th BIENNIAL PRONGHORN ANTELOPE WORKSHOP

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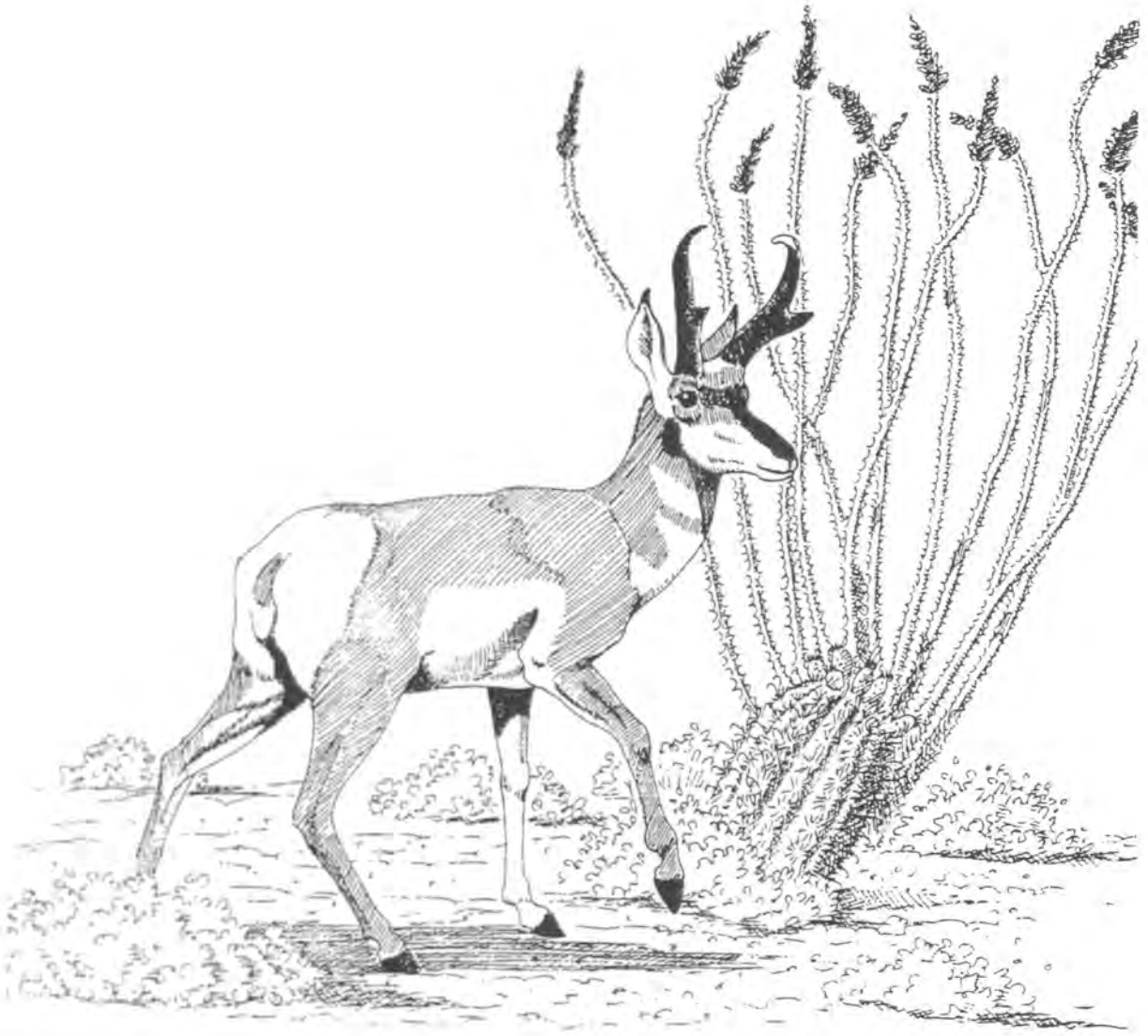

Editor

Richard A. Ockenfels

December 1999

Arizona Game and Fish Department Mission
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Meeting Site

Prescott Resort Conference Center and Casino
Prescott, Arizona, March 23-27, 1998

DEDICATION

The 18th Biennial Pronghorn Antelope Workshop, held March 23-27, 1998, is dedicated to the 50th anniversary of the 1948 publication of:

The Pronghorn Antelope - and its Management by Arthur S. Einarsen, Oregon Cooperative Wildlife Research Unit. Published by The Wildlife Management Institute, Washington, D.C.

Jim D. Yoakum, Western Wildlife, Verdi, Nevada, will present a brief review of A. S. Einarsen at the Wednesday night banquet. Jim was a graduate student of Art Einarsen, studying pronghorn.

The Pronghorn Antelope - and its Management was the first significant book on most aspects of pronghorn life history and ways to manage the species.

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SUMMARY OF PRONGHORN WORKSHOPS HELD TO DATE

Meeting Dates and Locations	Number Attending	Chairman	Host Agency
April 14-16, 1965 Santa Fe, NM	18	W. Huey	New Mexico Department of Fish and Game
February 16-17, 1966 Denver, CO	32	G.D. Bear	Colorado Game, Fish and Parks Department
February 5-6, 1968 Casper, WY	97	J.L. Newman	Wyoming Game & Fish Commission
January 27-28, 1970 Scottsbluff, NE	85	K.I. Menzel	Nebraska Game & Parks Commission
June 19-22, 1972 Billings, MT	85	H.O. Compton	Montana Fish & Game Department
February 19-21, 1974 Salt lake City, UT	52	D.M. Beale	Utah Division of Wildlife Resources
February 24-26, 1976 Twin Falls, ID	68	R. Autenreith	Idaho Department of Fish and Game
May 2-4, 1978 Jasper, Alberta	84	M.W. Barrett	Alberta Fish & Wildlife Division
April 8-10, 1980 Rio Rico, AZ	64	J.S. Phelps	Arizona Game & Fish Department
April 5-7, 1982 Dickinson, ND	69	J.V. McKenzie	North Dakota Game & Fish Department
April 10-12, 1984 Corpus Cristi, TX	45	C.K. Winkler	Texas Parks & Wildlife Department
March 11-13, 1986 Reno, NV	43	M. Hess	Nevada Department of Fish & Wildlife
May 31 – June 2, 1988 Hart Mt., OR	43	D. Eastman	Oregon Department of Fish & Wildlife
May 22-24, 1990 Silver Creek, CO	45	T.M. Pojar	Colorado Division of Wildlife
June 8-11, 1992 Rock Springs, WY	91	P. Riddle	Wyoming Game & Fish Commission
April 18-21, 1994 Emporia, KS	49	K. Sexson	Kansas Department of Wildlife and Parks
June 5-7, 1996 Lake Tahoe, CA	75	L. Colton	California Department of Fish and Game
March 23-27, 1998 Prescott, AZ	92	R.A. Ockenfels	Arizona Game & Fish Department

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GLOBAL PROCESSES, EMERGING PATTERNS OF SOCIETAL CHANGE, AND THE FUTURE CHALLENGES TO WILDLIFE MANAGEMENT

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INTRODUCTION

In the September 1998 issue of National Geographic magazine, the author of an article about the wonders of modern Vermont writes of the opportunity to "run some bear hounds through and sell the bear's gall bladder to Korean medicine men". Ah, nature; thus comes globalization to us all!

The wildlife management agencies of the Western states and Western provinces of Canada, whether targeting pronghorn *(Antilocapra americana)* management or that of another open range species, are accustomed to working in isolated, rural landscapes, among relatively traditional populations. They see themselves as domestic resource management agencies and are not accustomed to thinking that the goals, customs, values, and business plans of people half a world away have an immediate impact upon their local management plans.

Such parochialism is now dysfunctional. What happens in the most remote or populated corners of the world has the potential for immediate impact on local wildlife management plans wherever you are, yet I think that it is fair to say that most wildlife managers do not even know what the emerging global issues and trends are, much less how to respond to them. This essay looks at some emerging issues from a multi-disciplinary and transnational perspective. Since Jim deVos will be speaking to impacts on pronghorn habitat within Arizona, I will restrict my comments to global issues and trends, writ large, that are impacting society, and to the wildlife management agencies' likely responses.

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WILDLIFE AS A GLOBAL COMMODITY

Though managed locally, all wildlife is now essentially a global commodity if someone somewhere can find a commercial use for it. For example, during the communist era, Mongolian antelope herds were managed for local meat consumption. With the collapse of socialism, management shifted to the free market harvesting of antelope horns for the Chinese traditional medicine market. Why is this so?

A move towards globalizing national economies requires the broad loosening of border controls as a way of enhancing legitimate trade with other countries. Worldwide, we have seen a massive reorganization of national and international political, social, and economic structures to facilitate the freer movement of legal commodities. The goal is to increase national wealth, and it mostly works.

However, since opening borders for legitimate transnational trade also makes illegal transnational trade easier, what were once mostly domestic crime groups are:

- expanding in number within many countries (Russia alone now has an estimated 7,000 mafia organizations);
- increasing in sophistication and complexity;
- diversifying into new markets (including wildlife products); and
- increasingly moving into international trade at a record pace. Many are already major transnational economic actors.

In this instance, a locally used wildlife commodity, the Mongolian Saiga antelope (*Saiga tatarica mongolica*), now has enhanced value as an internationally traded commodity. Since antelope horn had little value to the local Mogolians, they once managed the herds for local meat production. But, the Chinese market for traditional medicine pays more for the horn than local Mongolians can get for meat. Hence, according to the laws of international supply and demand, an emerging transnational market in horn shifts local production from meat to horn. Since Chinese organized crime is already in the

United States and is engaged in various wildlife-related ventures, it will be sheer oversight if the pronghorn escapes the notice of such aggressive international businessmen. It may just be that the Mongolian herds are an easier source of supply for the present.

This brief case study of the development of an illegal wildlife trafficking market in the presence of expanding global influences was presented to introduce some larger points about the modern globalization process, and how it can affect domestic wildlife management issues in unanticipated ways. I hope that you will take from it the view that events in one country are increasingly impacted by events in another.

ILLEGAL WILDLIFE TRADE

Since the 1980s, we have already seen an expansion of illegal traffic in wild animal products worldwide. Current globalization processes will expand this trend immediately as to both quantity and diversity of the product. Whether for pets or parts, illegal wildlife trade now ranks second in value behind illegal drugs, but ahead of weapons, in the economies of Western Europe. In North America, we likewise have a healthy and expanding illegal wildlife trade. Expect more as expanding transnational organized crime groups, using the benefits of various globalization initiatives to their own ends, add an increasingly international dimension to the management of species that had previously escaped their notice for lack of profitable markets.

Because the structure of transnational organized crime is corporate, it is very logical. When risk, logistical costs, and procurement costs are relatively high, the focus is on high value and niche specialized trade; (whether drugs, weapons, or bear gall bladders), but as international transaction costs are reduced by legal globalization initiatives, the profit threshold for trade in many species is likewise reduced. Thus, the search for value should add new species to the list of potential internationally traded commodities.

Notice, however, that the real driving force behind this expansion to new markets and products is the customs, values, preferences, and needs of people within societies that most wildlife managers have barely heard of, much less considered in their management plans. This point is important. For most of the twentieth century, transnational values and laws have been Eurocentric. This changes as emerging societies increasingly push their values and perspectives onto the world's stage. Therefore, in order to understand what your wildlife management problems will be tomorrow, you need to study and understand the societal perspectives of many cultures that are just emerging as global players and also understand the board trends that are shaping international relations and trade.

RISE IN INTERNATIONAL INSTABILITY

This observation about shifting values as globalization expands leads to a discussion of an even larger international trend. Most of the countries in the world were created by European colonial powers during the late nineteenth and early twentieth century. As Western creations, they are typically completely artificial entities and often very unstable ones. With the rise in international instability in the past-cold war era – what I have elsewhere called the "New World Disorder" – , the role of both Western force and law generally has diminished as an effective tool for controlling regional, societal, and global changes. Today, there are countries that exist in name only, where there is neither effective public law no government. In these places, customary perspectives and values can freely couple with market forces so that very undesirable trade can grow and mature unchallenged. The impacts of such disarray are broadly transnational.

Add to this trend changes wrought on domestic society by the technological innovation supporting global change processes, by massive demographic change, by differential rates of wealth and poverty creation, and by various associated societal responses to uncertainty, one can see that wildlife managers, like managers in other domestic agencies, will be unable to ignore international trends and will have to confront the consequences of a very volatile and rapidly changing international environment. This is one important lesson of the growing breakdown of international order.

ADVANCED TECHNOLOGIES

But this brief discussion of mere international wildlife economics hides other important globalization trends. For example, modern "globalization" is based on the use of advanced telecommunications, computer, and transportation technologies coupled with politically enforced 'free' movements of goods and services. Because of very high education and skill requirements for this type of information-critical commerce, relatively few people globally are equipped to handle either these advanced technologies or to effectively manipulate the ideas and analytical techniques necessary for success within the emerging global marketplace. Consequently, incomes for globally competent workers are very high when compared to most workers. This is an outstanding situation for individuals who have globally saleable skills, but entails often severe short- to long-term costs for individuals who do not possess highly valued and globally saleable skills. Thus, worldwide not only are income disparities among individuals increasing, but the perceptions of people towards society and their places in it are diverging too; and in some very interesting ways.

Broadly speaking, people who are equipped with the necessary skills increasingly see the world as a global market, not as a local one. They are often not even interested in local economic, political, or social trends. For example, I live in Arizona but make absolutely no money here; my earning site is global. Arizona is merely where I hang my hat between trips. I have had several students who took overseas jobs with no hesitation when they were laid off from domestic ones. Forbes magazine recently reported that several hundred American millionaires surrendered their U.S. citizenship because other countries had offered them better tax deals; and of course, many countries now sell citizenship for just this purpose. These examples expose a critical point, which I will expand on later. For now, I want to make another point and discuss its relevance to domestic wildlife management.

GLOBAL ECONOMY

I think it is fair to say that no wildlife management professional is in this field for the money, but if you do not understand the role of money within the emerging global economy, then you cannot effectively respond to its various implications and impacts on local situations.

International business deals are denominated in the tens and hundreds of millions of dollars, or better. Consequently, consulting, management, and professional speaking fees range between about $1,000 and $75,000 per day, with higher performance-based pay possible if you are really somebody in the global game. Practically speaking, this means that there are many newly rich people with extra money on their hands. An immediate consequence for the profession of wildlife management is that they are using some of it to buy Western ranches, ranchettes, primary residences, and summer houses on land located within traditional wildlife ranges. This high-tech global money drives much of the current suburbanization of the West. In places like Aspen, Colorado, where the process is far advanced, the billionaires are driving out the millionaires, but you can see less extreme forms of the impact of global money throughout the West in the proliferation of yuppie hideaways, in the shift in political power from local to transnational industries, and in the new neighbors that are changing communities from places where people work on the land to places where people play on the land.

Simultaneously, we live increasingly in a world where the average Indonesian, Russian, Chinese, or African national earns between $300-500 per year, while at the same time select global players within their societies become millionaires and billionaires. In Indonesia, before the recent collapse, 98% of the wealth was held by 2% of the population. It is roughly the same story in China, Russia, most of Africa, and throughout much of Latin America. In the United States, average worker salaries have been stagnant for decades just as upper income individuals prospered.

The scissor effect of such economic and societal realities on wildlife management lies in the fact that while a small number of people around the globe are looking for new ways to play with and invest their significant disposable wealth, the rest of humanity is increasingly

stressed and looking for new ways to survive. Both patterns have long-term impacts on international and local wildlife management issues.

Naturally, political instability in many societies is also increasing under such conditions, and in many cases regional and ethnic national conflicts over resource control and autonomy are shattering societies. Indeed, such internal conflicts have largely replaced state-level conflicts within the international arena. Today, as I speak to you, we see Russia and Central Africa in turmoil. We also know that never since the 1950s has China been so unstable. Tomorrow, we will be concerned with yet other crises.

POWER SHIFTS

Summing then, under conditions of increasing global competition the shift in wealth and power is from the unskilled to the skilled, from the uneducated to the educated, from the already poor to the relatively rich, and hence also from the poorer countries to the richer countries. In effect, the power shift is from the globally uncompetitive to the globally competitive. In practical terms, this means that a lot of people in both developed and undeveloped countries are facing increasing stresses associated with earning a living. In this environment, governments worldwide are losing control of regions and populations, with a concomitant rise in intra-state conflict and crime.

The growing impact of this reality on wildlife populations is well documented internationally, as human-wildlife conflicts increase under conditions of rapid local economic development, associated mass human migrations, and the ever more common sub-state-level conflicts and wars. However, what is not commonly understood is that to the extent that globalization of economies expands and succeeds, these international trends will also increasingly impact developed countries.

We can already see some of these impacts on particular habitats and species. Beginning in the 1960s, increasing urbanization wrought dynamic changes in some parts of the West, but rural wildlife ranges remained relatively isolated from daily contact with urban Americans, because of their need to earn a living within the cities. Today, however, the increasing globalization of North America's economy, and associated technological, social-political, and transnational trends have changed this scenario.

Massive internal and international human migrations have occurred here too, most often as people seek economic gain or flee political turmoil within their homelands. The demography and values base of the United States and particularly the West, has changed dramatically, and in the future, wildlife managers will be working daily with an ever more diverse and often more sophisticated array of people. From a purely domestic migration perspective, this is so because information, communication, and transportation technologies have effectively separated earning location from living location for many people. In my opinion, this change is the most important one for our discussion of globalization impacts on domestic wildlife management problems. Globalization and technological innovation fostered each other, and both supported massive domestic demographic changes whose impacts are as yet unclear, but clearly growing.

It is now possible to run a global business from any place that has a telephone and an Internet service provider. Others, like myself, may want an airport within about a 2-hour drive from home for convenience sake. But, the point is that appropriately trained individuals are no longer bound to the business-centered metropolis of yore – they can now live right in the middle of your favorite pronghorn fawning or wintering ground. Give us a 5-acre (2-ha) ranchette, a computer, and a telephone, and its good-bye Los Angeles, New York, or Chicago – we are set. And why not? It's much nicer out here.

Prescott, the site of this conference, is a perfect example of this trend in professional lifestyle migration. What was in 1980 merely another sleepy, rural Arizona town surrounded by open range and national forest, is today not only an emerging adjunct of that Los Angeles clone called Phoenix, but it is also a home for people doing business worldwide. Add to this the impact on wildlife and wildlife habitat of a richer and longer-lived retired population, and you have a rural growth situation that is

rendering much of the West unrecognizable to those of us who have been here awhile. Globalization and its supporting high technology culture will expand this pattern of diffuse land use and global-rural lifestyle, as more people are able to live where they choose.

NEW SKILLS NEEDED

In your responses to such changes in wildlife habitat use, recognize another trend. The United States is now the third most populous country in the world behind China and India. By the early 21st Century, we will have around 320 million people, up from about 140 million when I was a child. The U.S. trend is counter to every other developed country, from Japan to Europe and Russia. These countries are declining in population, some to such an extent that Italy recently became the first country in the world with more people over age 65 than under age 20. Thus, whatever problems and challenges these emerging globalization trends will foster, you as a North American wildlife manager will be facing more of everything in the future. Your world and job just got exponentially more complex, and that of course means that some new skills are in order.

In the United States, we like to train our professionals to specialize early and narrowly within their chosen discipline. It takes practically an act of Congress to study broadly and across many fields in graduate school, and of course, being a "generalist" in academe is the surest road to scholastic ruin. Thus, our professionals are mostly highly focused experts who are often ignorant of anything outside their narrow expertise; particularly of the work of other fields and of important emerging issues of general interest.

This is precisely the wrong orientation for understanding and managing global change-associated problems. In a recent article in *Competitive Intelligence Magazine*, I discussed this point at some length. Therefore, let me merely say that in the future rather than sequentially seeking the input of many highly specialized experts, you will instead need a broad, multi-disciplinary, and systems-level approach to managing change processes if you want to succeed. Further, many necessary competencies will need to exist within the mind of each individual involved in the assessment and response task. In my view, the future belongs to people who can judge broad patterns and trends, and then put their insights to use.

SUMMARY

Future wildlife managers will need a good knowledge of history and of various cultures. And they will need to be as comfortable with the techniques and perspectives of the social sciences and economics, of various philosophies, and of relevant technical fields as they are today within the biological and management sciences. This is because societal problems exist in complexes, and therefore can only be understood and solves as parts of complexes.

As globalization processes enlarge the policy pie and thus make the complexes more complex, our current issue-focused approach to change management will increasingly fail. If you want to see the consequences of this globalization impact in action, look at the repetitive failures of today's hyper-specialized and highly compartmentalized intelligence agencies in judging emerging global events and trends. They have become so bad at prediction, that their endemic failure has become a matter of national public criticism. The world changed on them and they failed to effectively adapt.

Other management agencies will want to avoid such mistakes in responding to globalization impacts that affect their area of responsibility. But since we train almost nobody at university to look at the world from many angles, to be innovative and freethinking, and to have many competencies, I expect a rather steep learning curve as resource management agencies try to cope with increasingly volatile and complex realities using old management, assessment tools, and hyper-specialized experts. My guess is that only after they have failed often enough will significant innovation in assessment and management occur.

In a recent series of lectures and in an upcoming article, I have strongly suggested a move away from the modeling techniques currently in vogue and toward the softer techniques of change profiling as a better way to understanding how societies respond to complex change processes. In the world of global change, where good data are scarce, with

linkages being transnational and usually across cultures, managers will need to become much more comfortable at dealing with soft data, bad data, and variables that are not easily numerically valued, and thus with using judgment, experience, and insight to make the best decision. This emerging reality runs almost entirely counter to our current numbers-centered management styles and will cause huge bureaucratic problems in supporting decisions and following through on initiatives.

Finally, I suggest that in the resource management battles of the future the premium will be on insight, imagination, and with what I call a "surfing" style of change management; efficiently judging emerging forces and then responding so as to take advantage of the flow of events in order to achieve desired ends and useful forward momentum. Today, we like to battle the waves of change, to use force to oppose force, and to litigate every minor point. In the world of global change that exists today, forces that we do not know how to control confront us. In such a world, the wise person will use a flexible mind to make the best of any matter.

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STATUS AND MANAGEMENT NEEDS OF PRONGHORN HABITAT IN ARIZONA

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Abstract: Arizona's pronghorn (*Antilocapra americana*) populations are lower than historic highs. Further, pronghorn distribution has been reduced due to a variety of factors; some reduction is due to habitat loss and some the result of poor management practices. Habitat losses and fragmentation have resulted from urbanization, and construction of highways and utility corridors. Fire suppression and livestock grazing have resulted in grassland invasion by woodland and shrubland vegetative species. Today, less than 1% of Arizona's pronghorn habitat is classified as high quality and less than 1% of the area occupied by pronghorn is classified as high density. Human population growth and urban expansion is expected to continue, so impacts to habitat will continue, but strong land-use planning may reduce impacts of urban expansion. The real key to pronghorn management in Arizona, and likely other western states, is aggressive habitat improvement to restore grasslands to pre-European settlement conditions. Without habitat restoration and land-use planning efforts, Arizona's pronghorn populations will decline in the face of urban and woodland expansion.

Pronghorn Antelope Workshop Proceedings 18:7-15

Key words: Arizona, habitat restoration, land-use planning, pronghorn, urbanization.

INTRODUCTION AND HISTORICAL PERSPECTIVE

Prior to European settlement of the United States and Canada, pronghorn were abundant with an estimated population of 30-40 million (Nelson 1925). With settlement of much of the West, habitat fragmentation occurred with construction of roadways, powerlines, dams, and aqueducts, and pronghorn numbers declined. Yoakum (1968) estimated that pronghorn populations declined as much as 99% by the early 1900s due to human-related activities, such as habitat conversion to urban and agricultural lands, livestock fencing, competition with domestic livestock, disease, and unregulated hunting. As a result of these and other factors, it is estimated that the extent of suitable, occupied habitat in North America has been reduced by 75% (Lee et al. 1998).

In Arizona, similar population declines likely occurred. Davis (1982) summarized the writings of early Arizona explorers and indicated that these pioneers reported large numbers of pronghorn in areas such as along the Gila River in southern Arizona, an area largely devoid of pronghorn today.

Arizona is unique in that 3 of 5 recognized pronghorn subspecies occur in the state (Hoffmeister 1986). The Sonoran subspecies (*A. a. sonoriensis*) occurs in southwestern Arizona and northwestern Sonora, Mexico. This subspecies had undergone substantial declines in both distribution and abundance to the point that it was listed as an endangered species. The Chihuahuan subspecies (*A. a. mexicana*) at one time occupied most grasslands found in southeastern Arizona. Early explorers (Davis 1982) indicated that these grasslands had large pronghorn herds in the 1800s, however, most of these areas are lightly populated by pronghorn today. The third subspecies, (*A. a. americana*) is widely distributed, comprising approximately 95% of the statewide population (Alexander 1994).

On a continental basis, in the early 1900s, the pronghorn population was estimated to be as low as 30,500 (Yoakum 1986), however, conservation efforts have been successful in increasing pronghorn numbers to around 1.0 million (Lee et al. 1998). In Arizona, the recent population trend is similar, although the extent of population recovery may not be as great as the continental recovery. In much of the

southern portion of Arizona, translocations have aided in increasing pronghorn numbers.

The population objective identified for Arizona's pronghorn in the *Wildlife 2000* planning document is to "Maintain a statewide population of 7,500 to 9,000 post-hunt adult pronghorn" (AGFD 1995:43). With few exceptions, primarily during drought periods, this objective has been met for the past 20 years.

POPULATION AND HABITAT DATABASES

As part of management and research activities for pronghorn, Arizona Game and Fish Department maintains 2 Geographic Information System (GIS) databases. One of these is a database of pronghorn distribution and density estimates that is periodically updated as conditions change. This database is divided by density categories that range from very sparse (<0.39 pronghorn/km^2 [<0.1 pronghorn/mi^2]) to very high (1.5-2.3 pronghorn/km^2.[4.0-6.0 pronghorn/mi^2]). The map of this database (Fig. 1) indicates that pronghorn are generally located in 3 general areas: the Arizona Strip, grasslands in north-central Arizona, and in southeastern Arizona. Land status is available for analysis of this database. Thus, it is possible to summarize pronghorn density by land status (Table 1).

There are some interesting patterns within these data. Lands occupied by pronghorn are predominantly controlled by 4 different management authorities; private (31.9%), State Trust lands (20.8%), U. S. Forest Service (17.2%), and U. S. Bureau of Land Management (11.6%). There currently are approximately 53,816 km^2 (20,780 mi^2) of occupied pronghorn habitat in Arizona, of which only approximately 4,532 km^2 (1,750 mi^2) are rated as medium density or higher. This is less than 9% of the total land area occupied by pronghorn. Approximately 40% of medium or higher density and almost 90% of very high density lands are managed by the U. S. Forest Service. Private lands are also important to pronghorn management. Although pronghorn density on private lands tend to be in the lower end of the ranking scale, almost 1/3 of the lands occupied by pronghorn are in private holdings. Private lands are also important, as nearly 1/3 of the area used by reintroduced herds is in private holdings. State Trust lands have also been important locations for pronghorn translocations.

Lee et al. (1998) provides insight into what constitutes "typical" pronghorn habitat. Pronghorn typically occupy relatively level terrain (<20% slope), at elevations between 1,300 and 1,900 m, with rainfall patterns averaging 20-38 cm, in grass-dominated communities. In Arizona, slope and biome type were used to identify potential pronghorn habitat used in a habitat evaluation research project (Ockenfels et al. 1996*a*, *b*), wherein potential and occupied pronghorn habitat was evaluated and limiting factors identified. The exception to this statewide pronghorn habitat evaluation was the area occupied by Sonoran pronghorn, where numerous habitat studies were ongoing. Once identified, available habitats were evaluated, typically on the ground, although some aerial surveys were used in small, isolated areas. The outputs of this project are available in both digital and mapped (Fig. 2) formats. In all, 58 Game Management Units (GMUs) were evaluated.

Both high-density pronghorn populations and high-quality habitat were rare in Arizona. In all, 79,604 km^2 (30,738 mi^2) were evaluated in the field, with an additional 77,964 km^2 (30,104 m^2) being mapped from existing GIS data, for a total of 157,569 km^2 (60,842 mi^2). All habitats evaluated were placed in 1 of 4 quality categories including; high, medium, low, and poor/unsuitable. The breakdown for each category was: high = 1,311 km^2 (0.83%; 506 mi^2), medium = 18,061 km^2 (11.46%; 6,974 mi^2), low = 17,296 km^2 (10.97%; 6,679 mi^2), poor/unsuitable = 120,899 km^2 (76.7%; 46,683 mi^2).

Ockenfels et al. (1996*b*) identified several factors that led to reduced habitat quality during their evaluation. They concluded that on a statewide basis, habitat fragmentation was common, with highways, urbanization, and livestock fencing being key habitat intrusions. Another frequently encountered problem was extensive areas where tree and shrub invasion had adversely affected habitat quality through reduced visibility and reduced preferred forage availability. Year-round water availability was also a factor that limited habitat quality. Often,

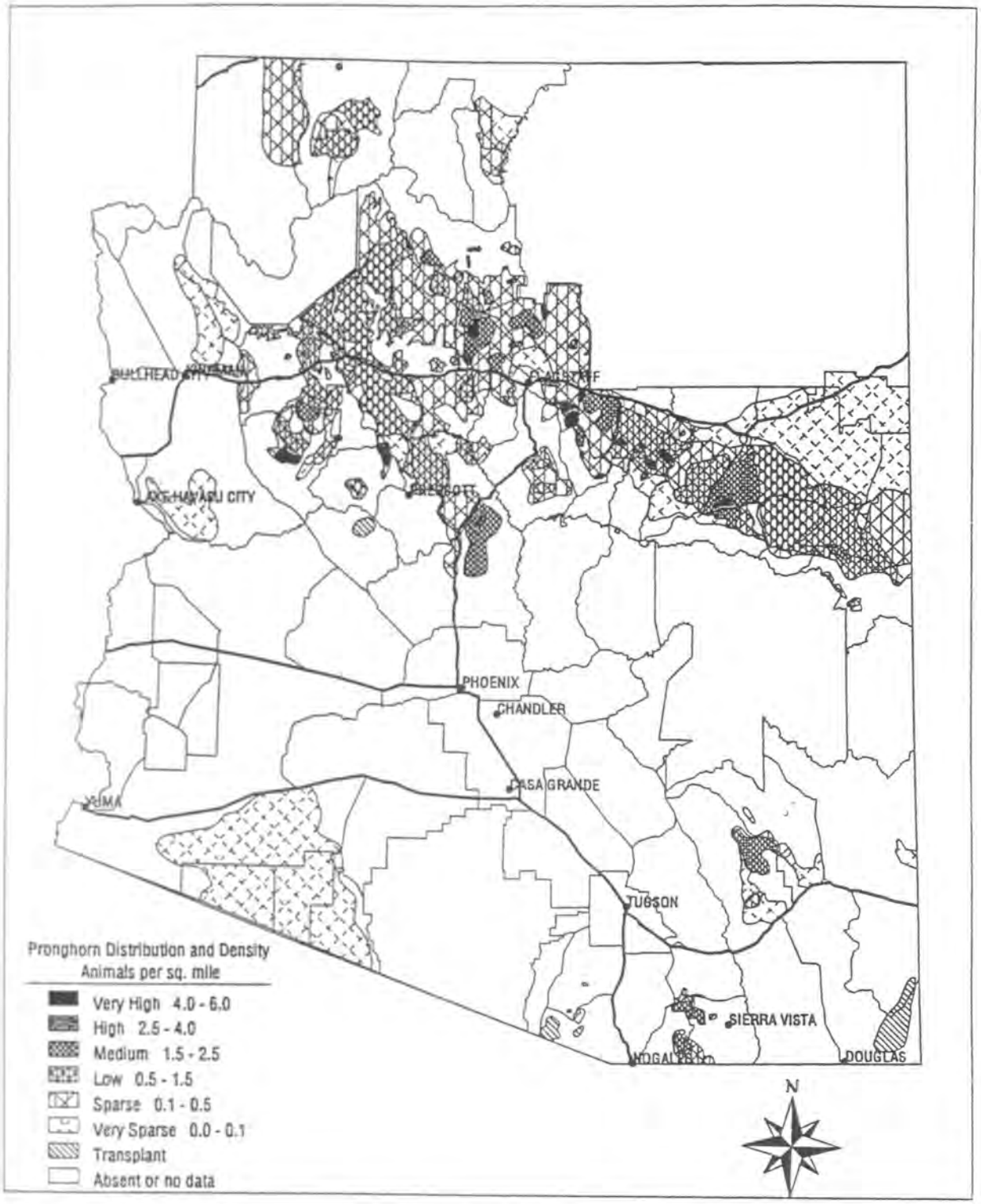

Figure 1. Pronghorn distribution and density from Arizona Game and Fish Department GIS database (last updated in 1988). Density estimates are in animals per square mile.

Table 1. Summary of the area (km^2) of estimated pronghorn density class[1] by management authority. Data are from Arizona Game and Fish Department pronghorn density database (last updated in 1988).

Management Authority	Very High	High	Medium	Low	Sparse	Very Sparse	Transplant	Total	Percent
Forest Service	78.94	85.43	505.68	607.42	1,716.04	552.49	21.98	3,567.98	17.17
National Parks-Monuments	0.03	0.63		0.02	85.39	580.55		666.62	3.20
Wildlife Refuge			6.61	3.44	9.04	1,173.87	39.78	1,232.74	5.93
Military				5.13	36.02	1,213.16		1,254.31	6.03
State Lands	4.74	46.45	337.80	1,515.97	1,284.70	958.97	172.61	4,321.24	20.79
Private	4.18	82.97	470.87	2,674.20	1,636.65	1,660.61	98.86	6,628.34	31.89
Tribal Nations			0.36	13.07	111.68	570.39		695.50	3.34
Bureau of Land Management		37.91	97.47	369.77	855.65	1,050.04	2.99	2,413.83	11.61
Total	87.89	253.39	1,418.79	5,189.02	5,735.17	7,760.08	336.22	20,780.56	
Percent	0.42	1.21	6.80	24.97	27.60	37.34	1.61		

[1]Density Class
- Very High = 4.0 – 6.0 pronghorn/mi^2
- High = 2.5 – 4.0 pronghorn/mi^2
- Medium = 1.5 – 2.5 pronghorn/mi^2
- Low = 0.5 – 1.5 pronghorn/mi^2
- Sparse = 0.1 – 0.5 pronghorn/mi^2
- Very Sparse = <0.1 pronghorn/mi^2
- Transplant = Introduced population.

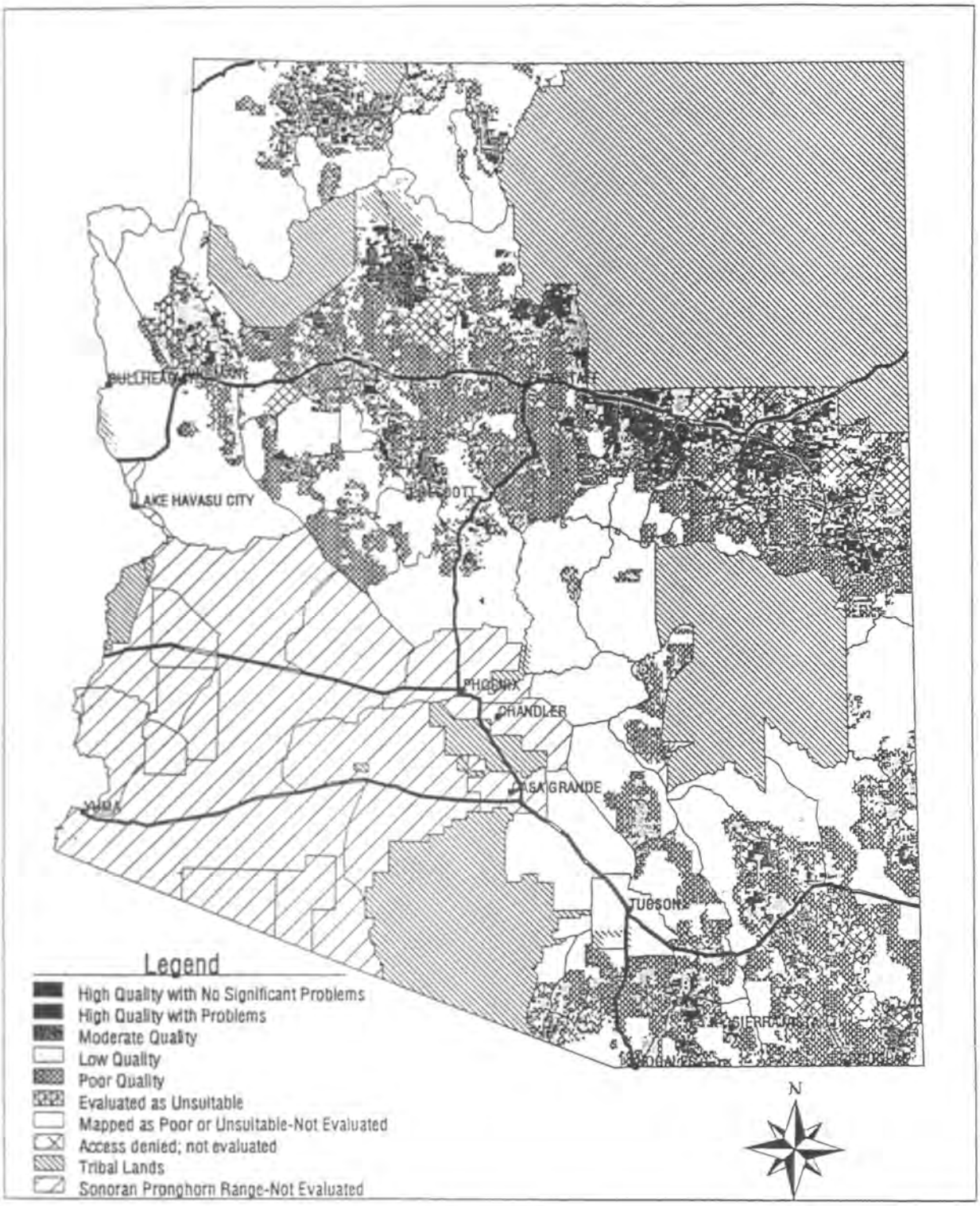

Figure 2. Habitat quality estimates for pronghorn habitat from Arizona Game and Fish Department GIS database (developed by Ockenfels et al. 1996*b*).

these factors acted in synergy to greatly reduce habitat capacity for pronghorn.

Both of the databases reviewed suggest that Knipe (1944) was correct in his assessment that pronghorn have not recovered to pre-European settlement levels, nor have they re-colonized all areas where they were once present in Arizona. Maintaining small pockets of high-density populations and high-quality habitat are important to meeting the management objective of maintaining 7,500 to 9,000 pronghorn (AGFD 1995). Land-use planning needs to recognize the importance of each of the high to very high-density herds identified in Figure 1.

PRIMARY PROBLEMS

Ockenfels et al. (1996*b*) found several common factors that reduced the quality of pronghorn habitat in Arizona. In general, habitat degradation occurs from 2 primary factors: reduced fire frequency and excessive livestock stocking rates. These impacts result in increased woody and shrubby invasion and loss of vegetative complexity, primarily in the forb component. Human-related negative factors include urban expansion, highway and utility corridor developments, and increased outdoor recreation. Arizona continues to be 1 of the fastest growing states in the U. S. and as a result, human impacts continue to affect pronghorn habitat; thus, a key to pronghorn management is strong land-use planning to minimize adverse impacts.

HABITAT MANAGEMENT

One of the important habitat-related factors identified in most GMUs evaluated by Ockenfels et al. (1996*b*) was encroachment by woody vegetation in the absence of historic fire regimes. This has resulted in extensive replacement of grasslands by pinyon (*Pinus edulis*), juniper (*Juniperus* spp.), mesquite (*Prosopis* spp.), and other woody species. As canopy cover increases, preferred forage items, which are largely comprised of forbs (Yoakum 1990) decrease. Also, as vegetative height increases to >61 cm (>24"), habitat suitability decreases for pronghorn (Ockenfels et al. 1994, Goldsmith 1990).

Another consequence of reduced fire frequency and overstocking of livestock is decreased species diversity in grasslands and an increase of unpalatable plant species. This type conversion was listed as a limiting factor in many of Arizona's pronghorn areas (Ockenfels et al. 1996*b*).

Maintaining or enhancing pronghorn populations depends on improving habitat quality in Arizona. Currently, less than 1% of this state's pronghorn habitat is rated as high quality, while over 75% is rated as poor or unsuitable. Lee et al. (1998) indicated that effective habitat management is the most important method to ensure pronghorn remain a component of the landscape. Pronghorn habitat restoration must include active measures to return as much of Arizona's grasslands to pre-settlement conditions as possible. It is important to work cooperatively with rangeland managers-owners to restore areas that have been invaded by woody plants to desired habitat conditions, including areas with high vegetative diversity and forb presence. Lee et al. (1998) provide guidance on what constitutes desirable rangeland conditions for pronghorn. These guidelines should be the basis for rangeland recovery efforts.

HUMAN-IMPACT MANAGEMENT

Human-related impacts to Arizona's pronghorn habitat are numerous, as identified by Ockenfels et al. (1996*b*). These factors do, however, fall within 2 general categories: those that result in habitat fragmentation and those that result in direct loss of habitat. Fencing, utility corridors, and roadways are the principle fragmentation factors identified. Urbanization and unregulated suburban developments are key components that result in direct habitat loss.

Fences have long been recognized as imposing barriers to pronghorn movements (Buechner 1950). Ockenfels et al. (1994, 1997) documented that highway fences impede movement and hence, fragment habitat and isolate pronghorn herds; this increases the risk that stochastic events will reduce the probability of herd survival. Fencing to control livestock movements have been documented to adversely affect pronghorn movements in numerous studies (Buechner 1950; Spillett et al. 1967; Barrett 1982; Ockenfels 1994, 1996*a*, 1997). Pronghorn are unable to negotiate many fence

configurations, and fence placement can eliminate critical habitat elements from pronghorn habitat. In the arid Southwest, access to water sources has been eliminated due to fence placement. Popowski (1959) summarized some of the problems associated with fences by showing that pronghorn denied access to key seasonal food sources have poorer body condition and can succumb to malnutrition.

Fences serve important land management functions, both along highways and on rangelands, and will never be eliminated from the landscape. The challenge is to reduce habitat fragmentation caused by fences. Several studies have resulted in recommendations for fence modifications that allow effective livestock and pronghorn management. This subject is discussed extensively in Lee et al. (1998), and Kindschy et al. (1982) provide recommendations that will greatly reduce fencing impacts. These recommendations include placing a bottom strand of smooth wire at least 41 cm (16") from the ground. This placement has become the standard in most federal agency guidelines.

Urbanization and overt habitat modifications have greatly reduced or eliminated many pronghorn populations (Ockenfels et al. 1996*b*). A case study is found in the Prescott, Arizona, vicinity. Until recently, very high quality pronghorn habitat occurred from Chino Valley to Lonesome Valley, a linear distance of approximately 100 km (60 mi). During the last 20 years, this region has experienced considerable urbanization, with substantial reduction in the amount of pronghorn habitat. Pronghorn are now nearly extirpated from much of this area. In other areas, urban growth has isolated pockets of pronghorn habitat that are no longer connected to other suitable habitat. In the Willow Lake area near Prescott, AGFD is currently planning on using the majority of the existing pronghorn herd in a translocation to help reduce pronghorn density and avoid increasing human-pronghorn interactions. As grasslands in this area continue to be developed, pronghorn will likely be eliminated from all but small patches of preserved lands.

Development of key grasslands will have detrimental impacts, such as increasing habitat fragmentation. Ockenfels et al. (1994) found that urban development in migration corridors can eliminate movements between portions of a pronghorn herd's seasonal use areas, which in turn reduces the ability of that herd to meet its biological needs.

CONCLUSIONS

Arizona's pronghorn habitat has undergone dramatic changes since European settlement. Current management strategies cannot maintain either existing pronghorn populations or distribution in Arizona. Fire suppression, coupled with excessive livestock stocking in some areas, has altered the ability of Arizona's grasslands to support high-density pronghorn populations. Importantly, conversion of grasslands to pinyon-juniper woodlands and other woody habitats, is expected to continue reducing suitable habitat for pronghorn. These type conversions also cause habitat fragmentation.

The Southwest will continue to be developed for people relocating from colder environments. While grasslands are not the only habitat type being affected by urban growth, limited amount of high-quality pronghorn habitat (<1% of Arizona's pronghorn habitat) makes land-use planning an essential part of any pronghorn management plan. Additionally, human-related impacts such as fencing, utility corridors, new or increased capacity roadways, and other fragmentation factors, continue to adversely affect pronghorn habitat and population persistence.

If these factors are not addressed, and increased management emphasis is not placed on restoring former grasslands to pre-settlement conditions, the future of pronghorn populations in Arizona is bleak. Future generations will not be able to enjoy the many benefits pronghorn provide us today. Fortunately, there are management prescriptions available to guide recovery efforts for grasslands (Lee et al. 1998). I believe some key actions needed to manage pronghorn habitat in Arizona are:

1. Set back pinyon-juniper (and other woody species) invasion in Arizona's pronghorn habitat.
2. Noxious shrubs that dominate much of Arizona's pronghorn habitat need to be

reduced and forage species, primarily forbs, increased.

3. Fencing that results in habitat fragmentation should be modified to facilitate pronghorn movements.
4. Urban growth needs to be planned to ensure high-quality pronghorn habitats are deferred from development.
5. Perennial, high-quality water sources need to be made available in areas where dependable water is not available.

To accomplish these recommendations will require considerable cooperation between land and wildlife management agencies, private landowners, and conservation organizations. The task of recovering Arizona's grasslands is daunting, however, if pronghorn are to continue to be an important component of Arizona's landscape, active habitat management and strong land-use planning are essential.

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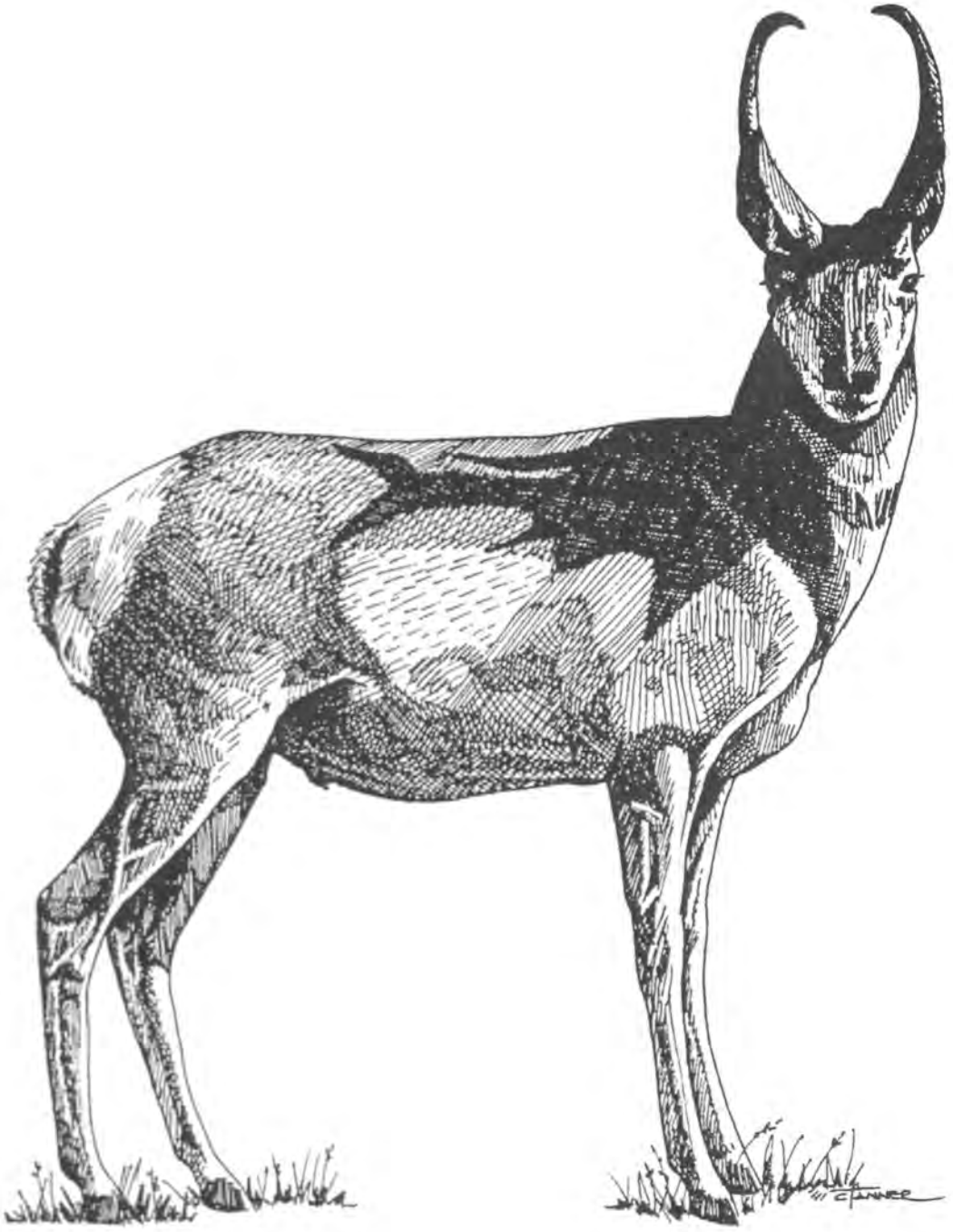

PRONGHORN ANTELOPE PROVINCE AND STATE STATUS REPORTS

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Abstract: We sent questionnaires to 16 western states in the United States, 2 provinces in Canada, and Mexico to collect 1997 pronghorn antelope (*Antilocapra americana*) population, survey, and hunt information and data. We received back responses from 12 of the 16 western U. S. states, and Mexico, but none from Canadian provinces. We summarized the information and data by topic and management strategies.

Pronghorn Antelope Workshop Proceedings 18:17-24

POPULATION ESTIMATES AND SURVEY METHODOLOGY

Population estimates for pronghorn ranged from 34 observed in Baja California Sur, Mexico, to an estimated 386,000 in Wyoming (Table 1). Surveys were conducted using fixed-wing aircraft, helicopter, and ground counts (Table 1). Fixed-wing aircraft were used in all states, except Nevada where helicopters were used. Nevada and South Dakota also used ground counts. Mexico only used ground counts. Line transects were the survey method implemented by most states; however, Colorado and Nebraska also used strip transects (Table 1). Most states derived population estimates from survey counts and/or population models (Table 1). Some states in Mexico reported numbers of pronghorn observed, but did not provide an estimate for total population size.

We categorized the time of year surveys were conducted into 4 seasons: spring (March-May), summer (June-August), fall (September-November), and winter (December-February). Generally, age and sex ratios were acquired during summer surveys and population sizes were obtained from winter surveys. Spring surveys were conducted in New Mexico, South Dakota, and Utah, where early vegetative green-up was used as an aid to increase ease of observations of animals (Table 1).

Observation rates varied by method and state (Table 1). Fixed-wing aircraft rates ranged from 33% in South Dakota to 100% in New Mexico. Nevada's helicopter observation rate was 26%, whereas ground surveys were 10% in South Dakota and 58% in Nevada.

HARVEST DATA

We used harvest data and population estimates to calculate percent of population harvested for each state (Table 2). The mean percent of pronghorn populations harvested in the western states was 9.8%, ranging from 5.5% in Nevada to 15.6% in Colorado. The states of Sonora, Baja California Sur, Chihuahua, and Coahuila in Mexico did not hunt pronghorn. All states except Arizona and Nevada harvested does/fawns (Table 2): Idaho did not report on this subject. Of the states that did hunt does and fawns, the harvest ratio of bucks:does/fawns varied from 52BB:48FF in North Dakota to 89BB:11FF in New Mexico (Table 2).

All states offered rifle and archery hunts, and 6 states had muzzleloader hunts (Table 3). Utah and North Dakota did not offer muzzleloader hunts. Kansas, Nevada, and South Dakota had firearm hunts in which muzzleloaders were included. Rifle hunt success in all states was greater than 62%. Rifle hunt success in Wyoming can be greater than 100% because more than one license may be issued to hunters. Percent muzzleloader success varied greatly, from 29-67%. Percent archery success was at or below 24%, with the exception of Wyoming (47.2%) and Utah (64%).

Table 1. 1997 pronghorn population estimates and survey methodology of western states and Mexico, 1998.

Country/ State	Pop. estimate	Survey vehicle	Survey method	Pop.estimate method	Survey season	Percent observed
United States						
AZ	9,700	fixed wing	l-transect[a]	model-POP DYN	summer & winter	~80%
CO	63,500	fixed wing	strip &l-transect	model	summer & winter	~80%
ID	10,500	fixed wing	l-transect	count	winter	~40%
KS	2,500	fixed wing	l-transect	count & reports	summer & winter	~80%
NE	7,000	fixed wing	strip & l-transect	count & good guess	summer & winter	15-25%
NM	37,500	fixed wing	l-transect	count	spring	90-95%
NV	15,000	helicopter	visual obs.	model-POP II	summer	~26%
		ground	visual obs.		fall	~58%
ND	5,200	Fixed wing		count	summer	>50%
OR	15,000	fixed wing	l-transect	count & unvalidated model		
SD	36,266	fixed wing	l-transect	count	spring	~33%
		ground	visual obs.		summer	~10%
UT	11,000	fixed wing	l-transect	model	spring & winter	50-90%
WY	386,000	fixed wing	l-transect	count & model	spring	~50%
Mexico						
Baja Calif.	34	auto	visual obs.	count		
Chihuahua	260					
Coahuila	180					
Sonora	88					

[a] line transect.

Table 2. 1997 pronghorn harvest data of western states, 1998.

State	Pop. estimate	Total harvest	Total % harvest	No. bucks harvest	% bucks harvest	No. does /fawns harvest	% does /fawns harvest
AZ	9,700	598	6.2	598	100	0	0
CO	63,500	9,884	15.6	5,416	55	4,468	45
ID*	10,500	1,411	13.4				
KS	2,500	191	7.6	160	84	31	16
NE	7,000	678	9.7	547	81	131	19
NM*	37,500	4,186	11.2	3,732	89	454	11
NV*	15,000	820	5.5	820	100	0	0
ND	5,200	419	9.4	217	52	202	48
OR*	15,000	1,316	8.8	1,087	83	229	17
SD*	36,266	5,599	15.4	3,514	63	2,085	37
UT	11,000	759	6.9	483	64	276	36
WY*	386,000	30,983	8.3	21,130	68	9,853	32

*1996 hunt data.

Table 3. 1997 pronghorn harvest and percent success by weapon type for 12 western states, 1998.

State	Rifle permits	Rifle % success	Muzzle-loader permits	Muzzle-loader % success	Archery permits	Archery % success
AZ	435	80	57	63	106	19
CO	9,460	75	56	39	368	17
ID[a]	1,163	68	93	42	155	18
KS[b]	169				22	18
NE	588	62	55	54	35	9
NM[a]	3,804	90	94	67	288	24
NV[abc]	784	75			36	22
ND[b]	489	83				
OR[a]	1,268	75	19	29	29	7
SD[ab]	5,501	71			98	12
UT[b]	718	88			41	64
WY[ab]	29,929	99			1,047	47

[a] = 1996 harvest data.
[b] = muzzleloader data combined with general firearms (rifle) data.
[c] = any legal weapon, but rifle generally used.

Ten-year trend data from 1987-1997 for harvest, hunter numbers, and hunter days showed that Colorado, Nebraska, Nevada, Oregon, and South Dakota had upward trends, whereas Idaho, New Mexico, North Dakota, and Wyoming showed downward trends (Fig. 1). Trends for Nebraska and South Dakota had the largest increase (100%, 200%, respectively), whereas Wyoming had the greatest decrease at 56%. Arizona had an upward trend for harvest and hunter numbers, but a downward trend for hunter days. Kansas had an upward trend for harvest, but a downward trend for hunter numbers and days. Utah had an upward trend for hunter days, but had a downward trend for harvest and hunter numbers.

SEASON STRUCTURE

Hunt season structure varied by state (Table 4). Most archery hunts opened prior to firearm hunts. Archery hunts in Colorado and Oregon opened at the same time as firearm hunts. Archery and muzzleloader hunts generally opened in mid- or late August, and firearm hunts typically opened a week or more later.

Colorado, New Mexico, Oregon, and Wyoming offered special status seasons with special provisions for youth hunts. Colorado and Wyoming provided price cuts for youth hunts. Arizona, Colorado, and New Mexico provided special opportunities for those physically impaired. Arizona and Colorado offered access mobility permits and New Mexico offered the first hunt of the season to challenged hunters.

MANAGEMENT STRATEGIES

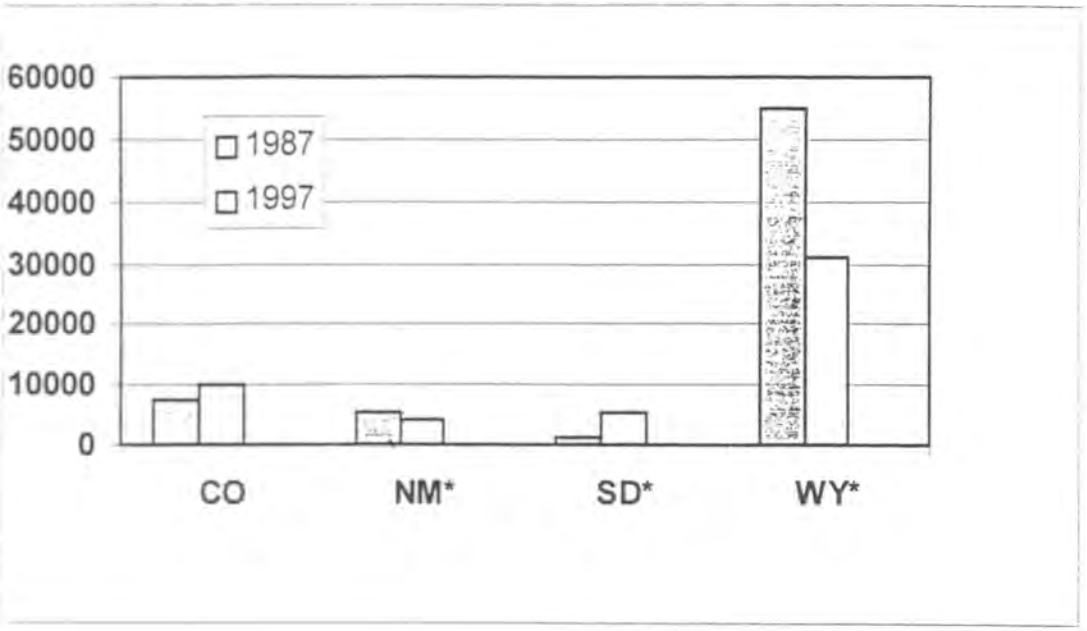
Non-resident hunters

All 12 states responding to the questionnaire, with the exception of Arizona and Colorado, had restrictions on non-resident hunters (Table 5). Non-resident hunters could not hunt in Kansas. Only North Dakota allocated archery permits to non-residents. Most states allocated up to 25% of hunt tags to non-residents. Idaho, Nebraska, North Dakota, and South Dakota did not have restrictions on non-resident numbers for archery hunts.

Partnership Programs

Most states had some type of a Partnership Program that addressed wildlife-landowner issues. For example, Arizona created local Habitat Partnership Committees that included local stakeholders to attempt more proactive solutions to wildlife-landowner issues. Such strategies included locally developed hunt programs and habitat enhancement projects. In 1996-97, these Habitat Partnership Committees approved the expenditure of $293,301 on 24 projects in northern Arizona. In addition, $166,750 was provided in matching funds from the U.S. Forest Service and various conservation organizations. Much of the funding for these projects came from the Arizona Game and Fish Department Heritage Fund, which was funded by revenue from the state lottery. Additional species specific funding for habitat improvement projects came from the auction of special tags. For example, in 1996-97 $46,000 was approved for 7 projects to enhance pronghorn habitat; this was matched with $117,000 from various cooperators.

Colorado and Utah offered Ranching for Wildlife Programs. Colorado had some ranches that participated especially for hunting pronghorn. It gave landowners more flexibility in season dates and provided some free-of-charge public hunting on private land that would otherwise cost a trespass fee or not be open to the public. However, the down side to this program was that some season dates were unreasonably long, such as having an opening date of July 11. This program was self-supporting with the exception of some administrative costs to the state wildlife agency, which were embedded in their operation costs. Utah offered their Ranching for Wildlife Program in 6 cooperative wildlife management units.



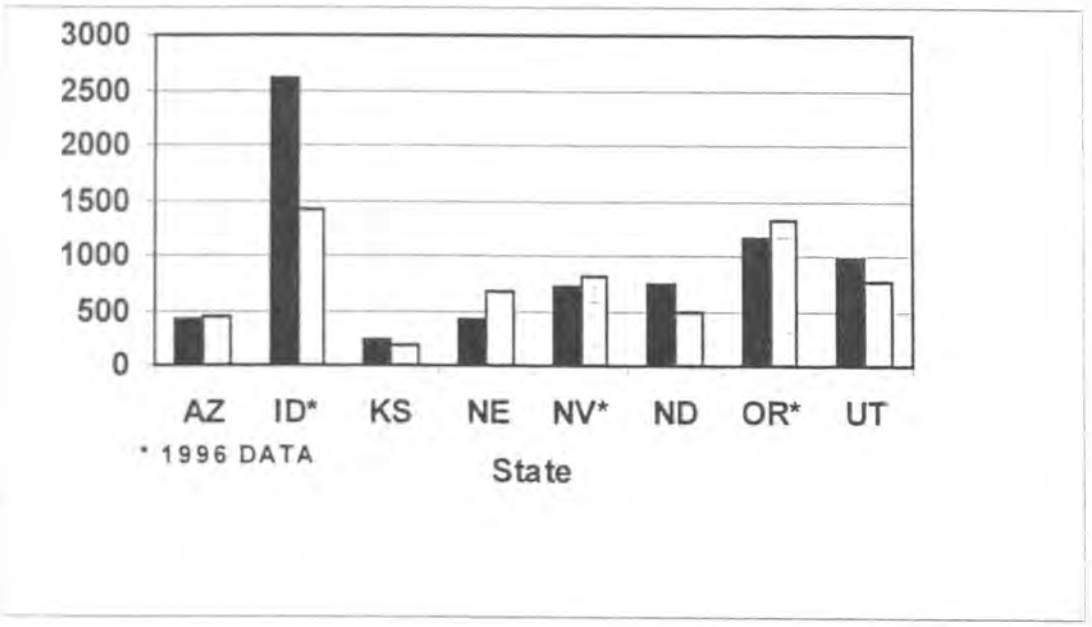


Figure 1. Total pronghorn harvest for 12 western states, 1998.

Table 4. 1997 pronghorn hunt season structures for 12 western states, 1998.

State	Opening day of firearms	Firearms season length (days)	Opening day of archery	Archery season length (days)	Opening day of Muzzle-loader season	Muzzle-loader season length (days)
AZ	Sept. 25	4-6	Aug. 28	14	Sept. 25	4-6
CO	Last weekend of Sept.	7	Last weekend of Sept.	30+		
ID	Sept. 25	30	Aug. 15	30		
KS	First Fri. of Oct.	4	Next to last Saturday in Sept.	9		
NE	Oct. 10	9	Aug. 20	116		
NM[a]	Aug. 30	2	Aug. 15	5	Aug. 15	2
NV	4th Saturday in Aug.[b]	9-10	1st Saturday of Aug.	16		
ND	1st Friday of Oct.	16.5	Last Friday of Aug.	19.5		
OR	Aug. 15	8	Aug. 15	8		
SD	First Saturday of Oct.	9	2nd Saturday of Aug.	70		
UT	Sept. 12	16	Aug. 22	21		
WY	Sept. 1	5	Aug15 /Sept. 1	30 /30		
	Sept. 10	10				
	Sept. 19	22				
	Sept. 20	8				
	Sept.25	7				
	Oct. 1	34				

[a] = New Mexico also has an August 8 handicap hunt.
[b] = Any weapon.

Table 5. 1997 restrictions for non-resident pronghorn hunters for 12 western states, 1998.

State	Restrictions Present (yes/no)	Restrictions
AZ	No	
CO	No	
ID	Yes	Up to 10%, no limits on archery.
KS	Yes	Not authorized to hunt.
NE	Yes, but	No limits on archery.
NM	Yes	Up to 22% (12% guided, 10% not guided).
NV	Yes	Up to 10%.
ND	Yes	Archery only.
OR	Yes	Up to 3%.
SD	Yes	Allocated 8% for firearms, no limit on archery.
UT	Yes	Allocated 10%.
WY	Yes	Up to 25%, depends on area of state. Resident licenses rolled over to private lands where residents will not pay to hunt (up to 90% non-resident).

Idaho had a Landowner/Sportsman Coordinator in each of their 7 management regions that addressed wildlife-livestock issues. The wildlife department paid for crop damage caused by wildlife on a case-by-case basis if damages for individual claims exceeded $1,000 (the owner paid the first $1,000). This program was funded by adding an additional $1.50 to each deer and elk tag.

In Kansas, half of all pronghorn permits were issued to landowners, but there were no procedures for landowners to sell or transfer their permits. Landowners may lease their land for hunting. The Kansas Department of Wildlife and Parks leased land under a program titled Walk In Hunter Access.

Nevada offered a depredation compensation tag to private landowners with more than 50 pronghorn on their lands. Ten tags were given to private landowners in 1996 to sell to the highest bidder. This program was well accepted and most complaining landowners were more tolerant of pronghorn on their lands.

North Dakota had a Private Lands Initiative Program that was primarily used for dealing with depredation problems, which were mostly deer caused. This program was funded by interest from a Game and Fish Reserve Fund ($300,000/biennium) and held some potential for habitat improvement projects.

Wyoming had a partnership-type program where habitat improvement grants were offered to landowners. Wyoming also provided damage payments, which included an $11 landowner coupon redeemable for pronghorn killed on private lands and 2 licenses per family or corporation. License sales funded the $700,000 annual cost of this program.

Special Tags

Arizona, Nevada, and Utah offered special hunter tag fund programs to generate revenue for pronghorn management. Arizona offered 2 tags each year that auctioned for approximately $36,000 each; Nevada offered 2 tags annually at approximately $12,000 each, whereas Utah

offered 1 state tag and up to 5% of tags from each hunt unit annually that generated approximately $7,000 each. Wyoming also offered special tags, but the monies generated went to non-profit organizations. Hunters with special tags were permitted to hunt in all open areas and had longer hunt seasons, usually starting before and ending after the general seasons. In 1998, Arizona generated $37,000 from the sale of a single tag and the second tag generated $28,000.

Harvest Pressure Management

Every state used harvest trend and buck:doe:fawn ratio data to manage harvest pressure. Arizona and North Dakota had strategic plans. North Dakota and South Dakota considered landowner tolerances, such as depredation complaints. North Dakota considered winter carrying capacity in determining harvest pressure.

Horns Versus Meat

Five states did not consider trade-offs between quality and quantity an issue. Colorado, Nebraska, and North Dakota attempted to maximize recreational opportunities, not trophy harvest. Idaho, Nevada, and Wyoming managed for trophy hunts. Idaho managed for a 12" (30.5 cm) average horn length and a 40-50 buck:100 doe ratio. Nevada managed for trophies only, except for depredation hunts, and Wyoming managed for a 40 buck:100 doe ratio. Arizona managed for trophy hunts and for recreational opportunities with a 30 buck:100 doe ratio.

Predator Control Programs

Arizona, Idaho, Kansas, and Utah conducted some form of predator control programs for pronghorn welfare. Arizona and Idaho contracted with USDA-APHIS for predator control. By state laws, Arizona Game and Fish Department must provide $23,000 annually and Idaho must provide $100,000 annually for predator control. Arizona aerially guns coyotes prior to fawning season. Kansas encouraged landowners to handle their own predator control problems and helped educate them to do so. Utah did not have a specific predator control program, but conduct predator control in certain units when deemed necessary.

Current Research

Arizona, North Dakota, and Mexico were currently conducting pronghorn research. In Arizona, pronghorn research was conducted statewide. In northern Arizona, there were 2 separate projects identifying habitat limitations of pronghorn. These projects were setting the groundwork to evaluate the effects of habitat modifications to pronghorn habitat use, home ranges, and movement patterns. Research on Sonoran pronghorn in southern Arizona continued relative to: monitoring production, recruitment, water use, and possible effects of U.S. Department of Defense disturbances (i.e., bombing). Genetics, bluetongue virus, and copper and selenium deficiencies of pronghorn were studied from pronghorn blood and tissue samples collected statewide. The U.S. Fish and Wildlife Service has been investigating the effects of U.S. Air Force aircraft noise on Sonoran pronghorn behavior and fawning on the Barry Goldwater Experimental Range in southwestern Arizona. In addition, they have been conducting some vegetative studies.

North Dakota evaluated pronghorn rangelands, distribution, and density using Geographical Information System technology, and Baja California Sur, Mexico, developed several projects as part of their Peninsular Pronghorn Recovery Plan, which included the formation of a semi-captive herd.

Other Management Programs

Nevada had an active pronghorn reintroduction program.

REGIONAL GENETIC DIFFERENTIATION IN ARIZONA PRONGHORN

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Abstract: Mitochondrial haplotype diversity was examined in pronghorn antelope (*Antilocapra americana*) to elucidate overall levels of genetic diversity and regional differentiation of the Arizona pronghorn population. A total of 389 Arizona pronghorn were analyzed for haplotype variation using polymerase chain reaction (PCR) protocols. The resulting amplified fragments were digested using 1 of each of the following restriction enzymes: Aci-I, *Bsp*-1286, *Hha*-I, *Hinf*-I, *Rsa*-I, and *Ssp*-I. Four composite haplotypes were observed in Arizona pronghorn, including 3 composite haplotypes (**C**, **A**, and **J**) previously observed in North American pronghorn and a single haplotype (**K**) that is potentially unique to Arizona. The **A** haplotype, once proposed as a potential genetic marker associated with Mexican pronghorn (*A. a. mexicana*), was found throughout the Arizona pronghorn range in high frequency. Haplotype **K** was found in highest frequency within the central portion of the historical pronghorn range in Arizona. In addition, there was differentiation in haplotype frequencies of Arizona pronghorn among regions (Arizona strip, northwestern, central, northeastern, and southeastern) of the state.

Key Words: *Antilocapra americana*, genetic diversity, mitochondrial DNA, polymerase chain reaction, restriction enzyme.

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Antilocapra americana currently contains 4 recognized subspecies (American pronghorn, *A. a. americana*; Mexican pronghorn; Sonoran pronghorn, *A. a. sonoriensis*; and Peninsular pronghorn, *A. a. peninsularis*). Historically, 3 of these 4 subspecies of pronghorn (American, Mexican, and Sonoran) were believed to have occupied ranges in Arizona (Hoffmeister 1986; Fig. 1). However, because of sharp declines in numbers of pronghorn around the turn of the century, resulting in both isolated and extirpated populations, the Arizona Game and Fish Department (AGFD) initiated a series of pronghorn reintroductions beginning in the 1920s and continuing through the present. These reintroductions were designed to help bolster small populations and to repopulate historic pronghorn ranges. Although successful in reestablishing pronghorn populations to respectable numbers, these reintroductions compromised the historical intraspecific patterns of genetic variation in Arizona pronghorn and may have altered the spatial distribution of subspecies within the state.

Mitochondrial haplotype analyses have been used extensively to examine issues of intraspecific differentiation of organisms (Ellsworth et al. 1994*a*,*b* ; Theimer and Keim 1994; Cronin et al. 1996; Walpole et al. 1997). Restriction Fragment Length Polymorphism analysis of mitochondrial DNA (mtDNA) is a simple procedure whereby the mitochondrial genome, or portions thereof, are digested with restriction enzymes, electrophoresed, and scored for the presence or absence of restriction sites. Mitochondrial DNA has certain properties that make it ideal for use in phylogenetic analysis at the intraspecific level. Among these are maternal inheritance, a non-recombinant method of transmission, a high rate of evolution in

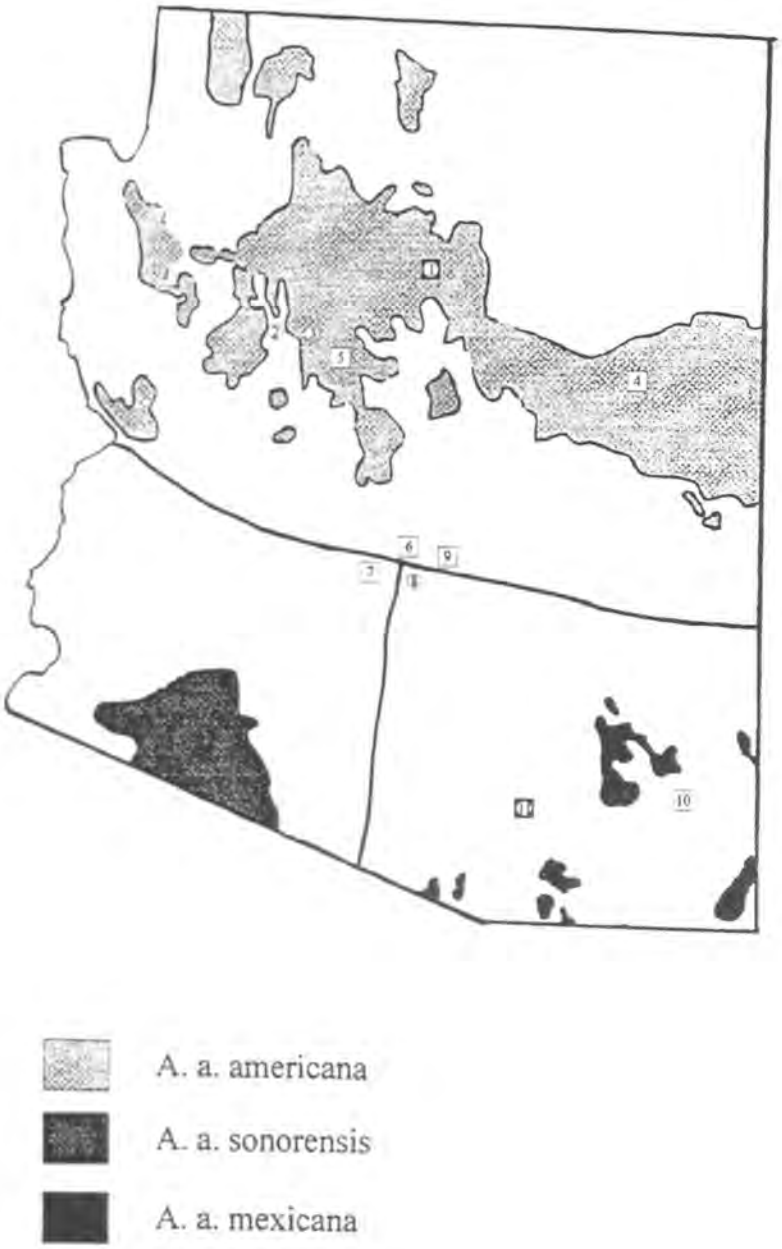

Figure 1. The distribution of pronghorn subspecies within the state of Arizona is indicated. Collection stations were run during pronghorn rifle hunts in 1996 (squares), 1997 (circles), or in both years (circle in square). Numbers within the symbols represent locations. 1) Flagstaff, 2) Wickieup, 3) Bagdad, 4) Showlow, 5) Prescott, 6) I-17 and Carefree Highway, 7) Wittmann, 8) Phoenix, 9) Beeline and Bush highways, 10) Willcox, 11) Tucson.

vertebrates (compared to the nuclear genome), and extensive intraspecific polymorphism (Avise et al. 1987).

Lee et al. (1994) reexamined subspecific differentiation of pronghorn across North America using a mitochondrial DNA haplotype analysis. Lee et al. (1994) discovered that their mitochondrial markers were useful in resolving intraspecific differentiation of pronghorn and observed unique regional haplotypes across North America, including 1, which appeared informative in resolving American pronghorn from Mexican pronghorn. Although Lee et al. (1994) were successful in surveying the majority of North American pronghorn range for haplotypic variation, Arizona, which has a mixture of recognized subspecies, was not included in their examination.

The objectives of our research were to survey pronghorn from 5 regions of Arizona using the same mitochondrial markers as Lee et al. (1994) and to describe patterns of regional haplotype variation.

METHODS

Collection

Collection kits, consisting of sample bags and instructions for tissue collection and handling, were mailed out to hunters that obtained permits to harvest pronghorn in Arizona during the 1996 and 1997 hunting seasons. In 1996, approximately 700 kits were mailed out to hunters throughout the state. In 1997, approximately 350 kits were mailed out to hunters that drew tags for areas under-represented in the 1996 sampling effort. Hunters were asked to collect liver and muscle tissue in the field and place samples on wet ice. Hunters were then asked to drop samples off at convenient collection stations located throughout Arizona at major highway intersections. In addition to roadside collection, AGFD wildlife managers in the field collected samples. 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. At Purdue University, samples were stored at -75 C until analysis.

PCR-RFLP Analysis

Following organic genomic DNA extraction, mitochondrial DNA (mtDNA) was analyzed for haplotype variation using a technique whereby a 2,290 base-pair (bp) portion of the NADH-2 gene region was amplified using standard Polymerase Chain Reaction (PCR) protocols (Lee et al. 1994). PCR is a technique where target DNA strands are copied by means of enzymatic amplification (Saiki et al. 1988). Following heat denaturation of the target DNA strands, primers anneal to their specific binding sites on the target DNA strands. Thermostable DNA polymerase (usually *Taq* DNA Polymerase) then recognizes the 5′ overhang from the primers and begins to extend the primers from the 5′ end to the 3′ end, incorporating deoxynucleotide triphosphates to their conjugate bases on the template strand. Repeated temperature fluctuations (denaturation, annealing, extension steps) produce millions of copies of target DNA sequence from only a few initial copies of template DNA.

The NADH-2 gene region was amplified using a slight variation of the protocol outlined by Lee et al. (1994). Cycling times and temperatures were as follows: 1) initial denaturation for 2 min at 95 C; 2) denaturation for 1 min at 95 C; 3) annealing for 1 min at 52 C; 4) extension for 2.5 min at 72 C; 5) final extension for 7 min at 72 C; and 6) soak at 4 C. Steps 2-4 were repeated 40 times (Reat 1998). Each fragment was amplified using the primers 5′ TAA GCT ATC GGG CCC ATA CC 3′ and 5′ ACT TCA GGG TGC CCA AAG AAT CA 3′ (Lee et al. 1994).

Resulting amplified DNA fragments were digested to completion according to manufacturer's recommendations using 1 of each of the following restriction enzymes: *Aci*-I, *Bsp*-1286, *Hha*-I, *Hinf*-I, *Rsa*-I, *Ssp*-I. Digested fragments were then electrophoresed on 1%-2% agarose gels (Sambrook et al. 1989), separating 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 record of these patterns was made using a

Stratagene Eagle-Eye II™ gel documentation system.

Composite haplotype frequencies were calculated for 5 geographic regions of Arizona (northeast, central, northwest, southeast, and the Arizona Strip; Fig. 2). Regions were selected based on their past history of reintroductions and degree of isolation. The Arizona strip and southeastern regions are isolated from the remainder of the pronghorn populations and were thought to have been entirely extirpated at some point in the past. The central region was considered the core of the pronghorn range in Arizona and had no reintroductions from other herds prior to our sampling. The northeastern region was selected based on its history of reintroductions from Wyoming, and the northwestern region was selected based on its somewhat isolated location relative to the other portions of Arizona pronghorn range.

RESULTS

During 1996 and 1997 collection efforts, 405 individual pronghorn were sampled throughout Arizona (1996, $n = 351$; 1997, $n = 54$). This represented approximate return rates of 50% in 1996 and 15% in [illegible], based on number of collection kits mailed to hunters. Of 405 samples collected, 389 were analyzed for composite haplotype variation of the ND-2 gene region of the mitochondrial genome.

All restriction enzymes, except Rsa-I, proved informative. *Aci*-I, *Bsp*-1286, *Hha*-I, and *Hinf*-I each resulted in 2 distinct fragment patterns, while *Ssp*-I resulted in 3 distinct fragment patterns (Reat 1998). From these individual restriction digests, 4 composite haplotypes were observed in Arizona's pronghorn, including 1 composite haplotype, **K**, not previously seen in North America. The remaining 3 composite haplotypes were observed previously by Lee et al. (1994) in North America.

Composite haplotype **A** consists of an A digestion with *Aci*-I, C with *Bsp*-1286, C with *Hha*-I, C with *Hinf*-I, C with *Rsa*-I, and C with *Ssp*-I. Composite haplotype **K** was viewed as an A digestion with *Aci*-I, C with *Bsp*-1286, C with *Hha*-I, C with *Hinf*-I, C with *Rsa*-I, and B with *Ssp*-I. Composite haplotype **C** was observed as C digestions with all restriction enzymes, whereas composite haplotype **J** was viewed as C with *Aci*-I, A with *Bsp*-1286, A with *Hha*-I, A with *Hinf*-I, C with *Rsa*-I, and E with *Ssp*-I.

Of 389 pronghorn analyzed statewide, 267 were characterized as having the **A** haplotype. Eighty-six pronghorn were observed as having the **C** haplotype, whereas 16 and 20 pronghorn were viewed as being haplotypes **J** and **K** respectively (Table 1). In northeastern Arizona, 103 pronghorn were analyzed. Of those, 81 pronghorn were characterized by the **A** haplotype, 6 pronghorn had the **C** haplotype, whereas 15 pronghorn and 1 pronghorn were characterized with the **J** and **K** haplotypes respectively (Table 1). In central Arizona, 136 of 188 sampled pronghorn were characterized with the **A** haplotype. Thirty-seven and 15 were observed as having the **C** and **K** haplotype respectively (Table 1). Twenty-six pronghorn were analyzed in northwestern Arizona, of which 20 were observed with the **A** haplotype and 6 had the **C** haplotype. Twenty-two pronghorn were analyzed in the Arizona Strip, of which 2 were characterized with the **A** haplotype, 19 were characterized with the **C** haplotype, and 1 had the **J** haplotype (Table 1). Finally, 50 pronghorn were analyzed from southeastern Arizona, of which 28 were observed with the **A** haplotype, 18 were characterized with the **C** haplotype, and 4 had the **K** haplotype (Table 1).

DISCUSSION

Three of the 9 composite haplotypes observed over the North American range of pronghorn (Lee et al. 1994) were detected in Arizona pronghorn populations. In addition, a previously unknown composite haplotype was detected in the Arizona population. Based on surveys of pronghorn performed by Lee et al. (1994), the **C** haplotype was found to be the most common haplotype detected across their North American range. The **A** haplotype was found to be fixed in pronghorn populations in the Marathon Basin, Texas, but occurred at low frequencies in other Texas populations as well as in 1 individual from both New Mexico and Colorado. Overall, the **A** haplotype is quite rare across most of the North American pronghorn range. The third previously detected haplotype observed in Arizona, haplotype **J**, has only been

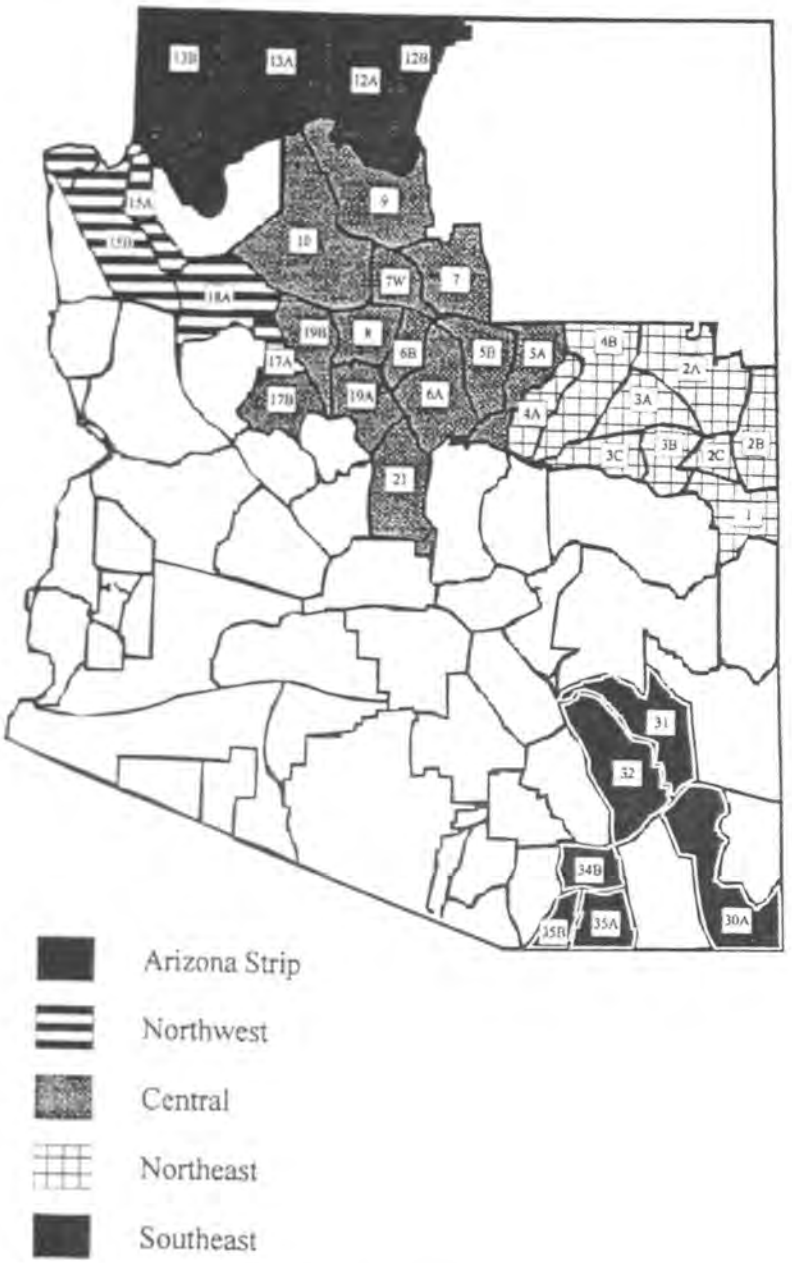

Figure 2. Samples from pronghorn were divided into 5 regional populations for analysis. Pronghorn were assigned to the Arizona strip, northwest, central, northeast, and southeast regions of Arizona. Game management unit numbers are provided within regions.

Table 1. Composite haplotype frequencies of the 2.3 kb ND-2 gene region of mtDNA are provided for pronghorn sampled in Arizona during 1996-97. Haplotype frequencies are provided for the overall herd and for 5 geographic regions of the state. Letters **A**, **C**, **J**, and **K** represent 4 composite haplotypes observed in Arizona pronghorn. Sample sizes are provided in parentheses.

	Haplotypes			
Region	A	C	J	K
Northeast	78.64 (81)	5.83 (6)	14.56(15)	0.96 (1)
Central	72.34 (136)	19.68 (37)	0.00 (0)	7.98 (15)
Northwest	76.92 (20)	23.08 (6)	0.00 (0)	0.00 (0)
Arizona Strip	9.09 (2)	86.36 (19)	4.55 (1)	0.00 (0)
Southeast	56.00 (28)	36.00 (18)	0.00 (0)	8.00 (4)
Arizona (total)	68.64 (267)	22.14 (86)	4.14 (16)	5.14 (20)

observed in 1 other population in North America, that being the Yellowstone, Wyoming, herd.

Perhaps the most striking result stemming from analysis of our data is the ubiquitous distribution of the **A** haplotype in Arizona. The **A** haplotype, proposed by Lee et al. (1994) as a potentially diagnostic marker for Mexican pronghorn, was actually the most common haplotype observed in Arizona pronghorn. This result alone does not provide the basis upon which to make a final determination on the actual utility of the **A** haplotype as a marker for Mexican pronghorn, but strongly suggests that the **A** haplotype may simply be a genetic marker that is common to pronghorn in the southern portion of this species range.

The discovery of the **K** haplotype in central and southeastern Arizona also is important. The central Arizona Game Management Units (GMU) in which the **K** haplotype was detected are generally considered to be the heart of pronghorn range in Arizona, and this region has been used extensively as a source for pronghorn transplants to the southeastern portion of the state. In addition, there have been no documented pronghorn reintroductions into the central Arizona GMUs in which the **K** haplotype was observed. Thus, it is likely that the **K** haplotype is an ancestral marker, potentially unique to Arizona, and central Arizona populations containing this haplotype should be protected from future translocations. Such protection should include limiting pronghorn reintroductions into the central region to sources within that same region. This would prevent dilution of the unique Arizona haplotype **K**. Occurrence of the **K** haplotype in southeastern Arizona, an area of the state that was considered to be entirely devoid of pronghorn at one time, is likely a consequence of extensive reintroductions to the southeast from the central portion of the state.

MANAGEMENT IMPLICATIONS

This study adds to work previously performed by Lee et al. (1994) on pronghorn of North America, by providing a clearer picture of mitochondrial DNA differentiation of the species nationwide. Our data indicate the presence of a regionally unique haplotype (**K**) within the central portion of pronghorn range in Arizona. Haplotype **A**, a marker proposed to be associated with Mexican pronghorn, was found to be distributed throughout Arizona in high frequency. In addition, there is evidence for a high degree of regional differentiation in haplotype frequencies across pronghorn range in Arizona. Using data collected in this study, Arizona biologists can make choices concerning selection of source populations for future pronghorn reintroductions based on haplotypic composition of recipient herds and can protect portions of the current Arizona pronghorn population that contain individuals with haplotypic diversity that is potentially unique in the North American pronghorn metapopulation.

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COPPER/SELENIUM LEVELS AND OCCURRENCE OF BLUETONGUE VIRUS IN ARIZONA PRONGHORN

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Abstract: A total of 288 serum and 330 liver samples were collected from hunter-harvested pronghorn (*Antilocapra americana*) during fall 1996 hunts throughout Arizona. Of 288 serum samples, 226 (78.5%) were positive for exposure to bluetongue as determined by the Agar Gel Immunodiffusion Test (AGID). Analysis by geographic area revealed no definite pattern of distribution. Serum neutralizing antibody titers ranged from 1:20 to >1:160 for all serotypes. Serotype 11 (BT11) was the most prevalent (77%), followed by BT17 (48.8%). Statewide, 97% (97/100) of liver samples had copper (Cu) levels below 25 ppm, the level reported as minimal for domestic livestock. Average liver Cu value for statewide samples was 8.3 ppm (range = 1.1-36.0 ppm, n = 100). Percent of samples below "adequate" liver Cu values for livestock revealed no apparent age-specific trends. Statewide, 73% (73/100) of liver samples were below 0.25 ppm selenium (Se), which is considered minimal for most domestic livestock. The average liver Se value for statewide samples was 0.19 ppm (range = 0.01-0.81 ppm, n = 100). When summarized by geographic area, samples from southeastern Arizona had the lowest mean liver Se level (0.101 ppm), and northcentral Arizona had the highest mean liver Se value (0.244 ppm).

Key words: Antilocapra americana, bluetongue virus, copper, pronghorn antelope, selenium, serological survey.

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Arizona pronghorn populations occupy a more variable environment, have lower recruitment rates, and are relatively small and isolated when compared to many other pronghorn populations in North America. As a result, these sensitive populations may require more intensive management to remain viable. Managers should strive to learn more about previously neglected sources of mortality, which affect populations spatially or temporally. Disease occurrence and mineral deficiencies in wild ungulates are 2 factors in need of future research. Understanding effects of these factors may result in the development of beneficial management actions and will allow managers to explain population trends to interested constituents.

Several studies have found bluetongue virus (BT) to be enzootic in pronghorn populations. Trainer and Jochim (1969) reported 11.6% (8/96) of pronghorn serum samples from western and central Wyoming and 35.1% (34/97) in Colorado samples were positive for BT in fall of 1969. None of 70 pronghorn killed in Carbon County, Wyoming, were seropositive for BT in late August of 1977 (Thorne et al. 1988).

In 1976, at least 3,200 pronghorn died during a bluetongue epizootic (BT17) in eastern Wyoming (Thorne et al. 1988). In 1984, another BT epizootic killed at least 300 more in the northeastern part of that state. During these disease episodes, fawn recruitment dropped to unusually low levels. Analysis of blood samples collected during the latter half of epizootics

revealed that 81% (1976) and 60% (1984) of animals harvested by hunters in fall were seropositive for BT (Thorne et al. 1988). The 1984 epizootic was estimated to have killed only 4-5% of the pronghorn in that area.

In 1983, a serologic survey in western Nebraska found 19% (16/84) of fawns and yearlings (1.5-years old) and 42.5% (37/87) of 2 to-7-year old animals were seropositive for BT (Johnson et al. 1986).

Selenium deficiencies have been shown to cause "white muscle disease" (nutritional muscular dystrophy) leading to cardiac arrest and may contribute to increased neonatal mortality (Reilly 1996). Sub-lethal effects are manifested by lowered immune response and reductions in feeding efficiency, growth rate, and reproductive rate (Reffett et al. 1988).

Very low levels of Se have been documented in pronghorn antelope (Heffelfinger and Olding 1996*a*, Stoszek et al. 1980), mountain goat (*Oreamnos americanus*; Hebert and Cowan 1971), mule deer (*Odocoileus hemionus*; Dierenfeld and Jessup 1990, Heffelfinger and Olding 1996*b*, Oliver et al. 1990), and African bovids (Murry 1967).

Copper deficiencies in domestic ruminants are manifested in reduced fertility, poor/faded pelage, reduced growth rate, diarrhea, cardiovascular disease, unthrifty young, neurologic disease of young animals, skeletal deformities, or even sudden death (Puls 1995). These conditions are readily observable in captive animals under close supervision, but most often go unnoticed in wild populations. Additionally, wild animals frequently seek seclusion when ill, further lowering chances of being observed.

Our objectives were to: 1) document the extent of seropositive response to bluetongue virus, and 2) collect baseline levels of serum/liver copper and selenium in Arizona pronghorn.

STUDY AREA AND METHODS

As part of another project concerning pronghorn genetic differentiation, collection kits were mailed to hunters who obtained permits to hunt pronghorn in Arizona in 1996. Hunters were asked to collect blood in a 50-ml tube and a small piece of liver in a plastic bag, place the samples on ice, and drop them off at 1 of 8 collection stations located throughout Arizona. Over 700 sample collection kits were mailed in August 1996. Volunteers from the Arizona Antelope Foundation and various universities located throughout Arizona were recruited to help operate collection stations. At collection points, samples were cataloged, and hunter information, harvest location, and estimated age were recorded (Dow and Wright 1962). Blood samples were centrifuged as soon as possible, and serum was collected to minimize negative effects of hemolysis on sample quality. Samples were transported to the Arizona Veterinary Diagnostic Laboratory for AGID screening and mineral analyses. Levels >1:10 are considered indicative of past exposure. Serum samples giving positive reactions with AGID were forwarded to the National Veterinary Services Laboratory (NVSL) for Serum Neutralization (SN) to define titer levels and for serotyping.

Liver samples were analyzed for Cu by atomic absorption spectrometry after digestion in nitric acid (Association of Official Analytic Chemists 1995). Total liver Se was determined as the 2-nitro piazselenol chelate by capillary gas chromatography using electron capture detection (Shimoishi 1976). Data are expressed in terms of wet tissue weight to be directly comparable to values reported by Puls (1995). In 77 of the 100 samples, liver and serum samples were from the same pronghorn, allowing correlation analyses of these 2 measurements.

RESULTS

Bluetongue Virus

A total of 288 serum samples was collected in late September 1996 hunts throughout the state. Of these, 226 (78.5%) were seropositive for exposure to BT as determined by AGID (Table 1).

Seropositive response rates in Game Management Units (GMUs) with ≥10 samples ranged from 61.9-100% for units. Summary by regions revealed no definite pattern of distribution throughout the state (Table 2). All 11 samples from southeastern Arizona were positive, while only 5 of 11 samples from northwestern Arizona were positive.

Table 1. Percent seropositive to bluetongue virus by age class of hunter harvested pronghorn in Arizona, September 1996.

Age	Percent (%) positive for exposure to bluetongue (AGID)	Sample size
1.5	66.7	9
2.5	85.2	27
3.5	74.6	63
4+	78.8	66
Mean	76.3[a]	165

[a] Differs from overall statewide average because samples with age data are a subset of the statewide data set.

Table 2. Percent seropositive to bluetongue virus by geographic area of hunter harvested pronghorn in Arizona, September 1996.

Geographic area	GMUs included	Percent (%) positive for exposure to bluetongue (AGID)	Sample size
N. of Grand Canyon	12AB, 13AB	76.5	17
Northwestern	15B, 18AB	45.5	11
Northcentral	6AB, 7, 8, 9, 10, 17A, 19AB, 21	75.2	149
Northeastern	1, 2ABC, 3ABC, 4AB, 5AB	75.0	100
Southeastern	30A, 31, 32, 34B, 35AB	100.0	11

A subsample of 186 AGID-positive samples were sent to the NVSL in Ames, Iowa, for serotyping by SN. Samples were tested for antibodies to bluetongue serotypes 2 (BT2), 10 (BT10), 11 (BT11), 13 (BT13), and 17 (BT17). Twenty-six (13.9%) of these samples were found to be negative for antibodies when analyzed with SN. Of the 160 remaining samples, 21-33 were determined unsuitable for testing among various serotypes. Titers for the remaining samples ranged from 1:20 to >1:160.

Of samples which were SN antibody-positive for at least 1 serotype, BT11 was the most prevalent (77%, 107/139) serotype, followed by BT17 (48.8%, 62/127), BT13 (22.2%, 30/135), BT10 (20.4%, 28/137), and BT2 (16.9%, 23/136). Some of these positives for individual serotypes may be the result of

cross-reaction with other BT serotypes; 71 of 151 (47%) usable samples reacted to more than 1 serotype. Of the 71 samples reacting to ≥2 serotypes, 16 (22.5%) had titers >1:40 for at least 2 serotypes.

Mineral Analysis

Over 330 liver samples were collected during late September 1996. Of these, 100, representing all geographic areas of the state, were selected for Cu and Se analysis. In addition, 288 serum samples were collected and 100 were selected to provide a uniformly distributed sample of serum Cu levels.

Liver Copper--Statewide, 97% (97/100) of the pronghorn samples were below 25 ppm (Table 3). The average liver Cu value statewide samples was 8.3 ppm (n = 100, SE = 5.5, range = 1.1-36.0 ppm).

When summarized by geographic area, samples from units north of the Grand Canyon (12A, 13AB) had the highest average liver Cu level (11.2 ppm), but still had less than half the minimum considered adequate for domestic animals (Table 3). The east-central portion of the state had the lowest average liver Cu value (6.10 ppm, n = 33). The percentage of samples below adequate ranges revealed no apparent geographic trends. Units north of the Grand Canyon had the lowest percentage of samples below the adequate range (8/9). Liver Cu values summarized by age class statewide show no age-specific differences for the 43 samples from known age animals (Table 4).

Liver Selenium--Statewide, 73% (73/100) of pronghorn samples were below 0.25 ppm ($\bar{x}$ = 0.19, SE = 0.11, range = 0.01-0.81 ppm) (Table 3). When summarized by geographic area, samples from southeastern Arizona had the lowest range of values (0.01-0.19 ppm) and lowest average liver Se level (0.101 ppm, n = 18) (Table 3). East-central Arizona had the highest average liver Se value (0.24 ppm, n = 31).

All 18 samples from southeastern Arizona and 81.8% (27/33) of east-central samples were below 0.25 ppm. The northwestern, north-central, and north of the Grand Canyon samples had 55.6-58.1% of the samples below 0.25 ppm (Table 3).

Analysis of liver Se by age class was hampered by small sample size in some age classes, however, a trend of decreasing liver Se levels with increasing age may be indicated (Table 4).

Serum Copper--Of 99 statewide pronghorn samples analyzed, 82 (82.8%) were below 0.70 ppm for serum Cu (Tables 3 and 5). Serum Cu averaged 0.59 ppm throughout the state (SE = 0.19, range = 0.22-1.8 ppm).

Serum copper vs. Liver copper--In 77 of 100 samples, liver and serum samples were from the same individuals allowing a comparison of these parameters. Serum Cu is generally less reliable because levels fluctuate with state of pregnancy, presence of viral/bacterial infections, and dietary intake of protein, molybdenum, Se, and sulphate (Puls 1995). There was no relationship between Cu levels in serum vs. liver (Fig. 1). Less than 1% of liver Cu variation was explained by liver Se values (r^2 = 0.0016).

DISCUSSION

Bluetongue

BT is a serious disease among pronghorn antelope. Presence of antibody titers (a seropositive reaction) may imply protection for those individuals, since none exhibited clinical signs of disease when harvested. Hoff and Trainer (1972) infected 4 pronghorn with BT8 subcutaneously. Prior to experimental infection, 2 of the pronghorn possessed antibodies (tested positive), 2 did not. Individuals with prior antibodies did not develop clinical signs, become viremic, or succumb. Pronghorn testing negative for exposure (no antibodies) prior to inoculation developed clinical signs and died 7 and 8 days after inoculation.

No trends were apparent when AGID exposure rates were summarized by age class, although yearlings may have lower rates of exposure than older animals (Table 1). Since antibody levels can persist for more than 1 year in black-tailed deer (*O. h. columbianus*) (Work et al. 1992), this lower exposure may reflect less opportunity to come into contact with disease vectors in younger animals.

Table 3. Serum copper, and Liver copper and selenium values by geographic area for hunter harvested pronghorn in Arizona, September 1996.

Geographic area	GMUs included	Serum Copper (ppm)			Liver Copper (ppm)			Liver Selenium (ppm)		
		$\bar{x}$ (*n*)	range	% <0.70ppm	$\bar{x}$ (*n*)	range	% <25ppm[a]	$\bar{x}$ (*n*)	range	% <0.25ppm[a]
Northwestern	15B, 18AB	0.512 (5)	0.39-0.63	100.0	8.47 (9)	5.0-18.0	100.0	0.194 (9)	.07-.35	55.6
North-central	6AB, 7, 8, 9, 10, 17A, 19AB, 21	0.614 (35)	0.38-1.80	88.6	9.50 (31)	1.1-36.0	93.5	0.244 (31)	.05-.81	58.1
N. of Grand Canyon	12AB, 13AB	0.630 (9)	0.33-1.20	77.8	11.24 (9)	5.4-28.0	88.9	0.220 (9)	.11-.36	55.6
Northeastern	1, 2ABC, 3ABC, 4AB, 5AB	0.553 (41)	0.22-0.93	85.4	6.10 (33)	2.2-13.5	100.0	0.168 (33)	.04-.36	81.8
Southeastern	30A, 31, 32, 34B, 35AB	0.677 (9)	0.48-0.84	44.4	8.52 (18)	5.5-14.0	100.0	0.101 (18)	.01-.19	100.0
Statewide	1-35B	0.590 (99)	0.22-1.80	82.8%	8.30 (100)	1.1-36.0	97%	0.190 (100)	.01-.81	73%

[a] Normal range reported for domestic goats:
liver copper: 25-150 ppm, liver selenium: 0.25-1.20 ppm, serum copper: 0.70-1.20 ppm.

Table 4. Liver copper and selenium levels by age class in hunter harvested Arizona pronghorn, September, 1996.

		Copper		Selenium	
Age Class	*n*	$\bar{x}$	% <25ppm[a]	$\bar{x}$	% <0.25ppm[a]
1.5	4	7.58	100.0	0.21	75.0
2.5	4	6.85	100.0	0.22	75.0
3.5	18	9.92	94.4	0.20	66.7
4+	17	7.53	100.0	0.15	88.2
Total[b]	43				

[a] Normal range reported for domestic goats:
liver copper: 25-150 ppm,
liver selenium: 0.25-1.20 ppm.
[b] Means reported in Table 3 because age data are a subset of all data.

Table 5. Serum copper levels (ppm) by age class in hunter harvested Arizona pronghorn, September 1996.

Age Class	*n*	$\bar{x}$	% <0.70ppm[a]
1.5	5	0.50	80.0
2.5	8	0.59	75.0
3.5	23	0.58	87.0
4+	21	0.64	71.4
Total[b]	57		

[a] Normal ranges:
0.70-1.20 ppm domestic goats
0.70-2.00 ppm domestic sheep
[b] Means reported in Table 3 because age data is a subset of all data.

Exposure to BT seems widespread throughout Arizona. However, actual effects of the disease on our populations remain obscure. BT can affect reproduction because of timing of infections (Thorne et al. 1988). BT, an insect-borne virus, affects animals in late summer (July-Sept), during the peak of vector activity. Because this period coincides with pronghorn breeding seasons, a viremic female may not be in good reproductive condition or her behavior may be altered enough to disrupt breeding. Bucks which become viremic in pre-rut and rut periods may be unsuccessful in defending breeding territories. In domestic animals, BT has been reported to cause still births, spontaneous abortions, decreased milk production, weight loss, and congenital abnormalities (Leudke et al. 1970).

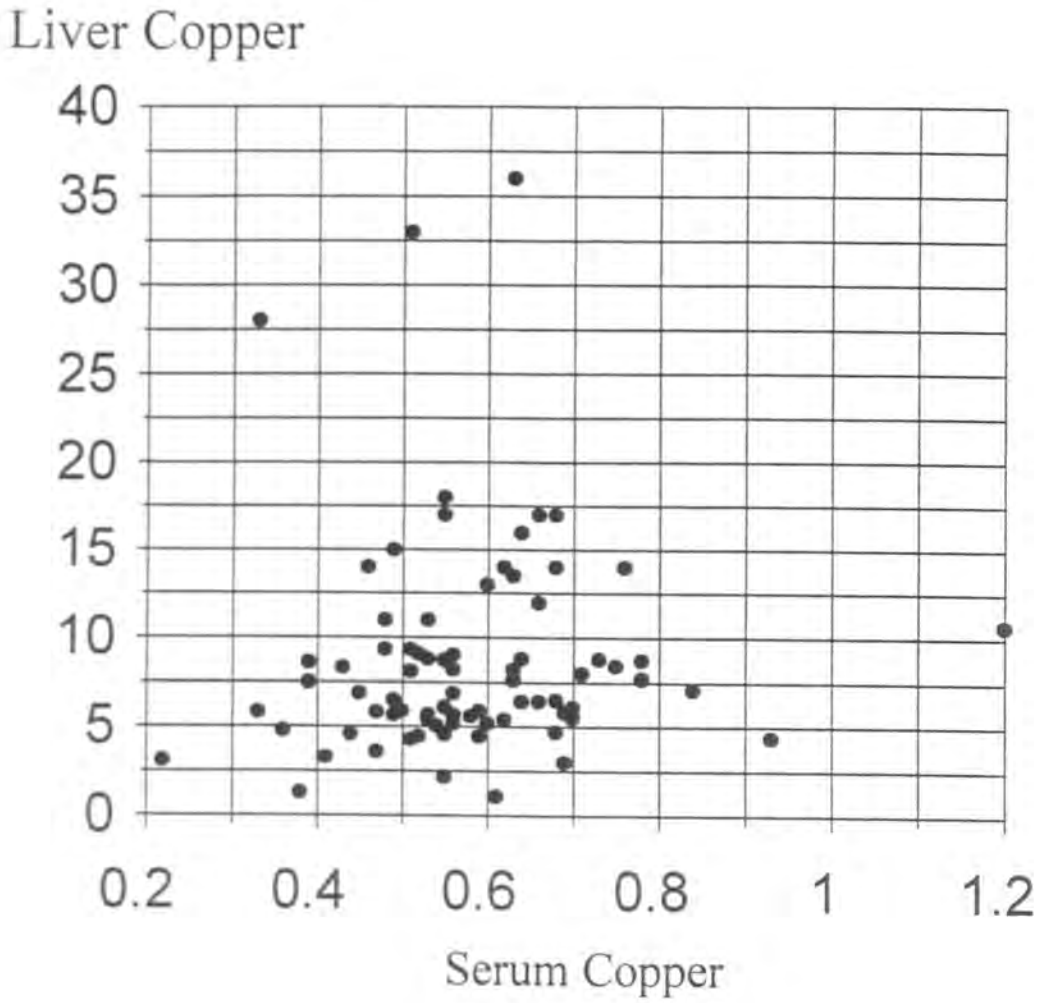

Figure. 1. Relationship between liver copper and serum copper values from individual hunter harvested pronghorn (n = 77) in Arizona, September 1996.

As in the present study, BT11 was the most prevalent serotype in 10 samples collected in a pilot study in southeastern Arizona in 1995. Positives for BT2 are undoubtedly the result of cross-reaction, as this serotype has not been found in the United States in over 16 years and never in the West (G. Gustafson, NVSL, pers. comm.). Some individuals may also have been infected by >1 serotype. Multiple infection are more likely when an animal has high titers (>1:40) for more than 1 serotype.

The percent of seropositive reactions we found seems near the highest level reported for this species, which is remarkable since no mortality has been detected from active disease. This high exposure was unexpected since the principal vector in other areas is reported to be *Culicoides variipennis*, which thrives in moist areas with standing water. These conditions are not typically found in Arizona pronghorn habitats. To what extent an alternative vector may be involved is unknown. No known epizootics have been reported in recent times in Arizona to account for high exposure rates. If mortality of exposed individuals is high, evidence of exposure should be low because most exposed animals die. If, however, the virus kills only a small percent of those exposed, a higher percent of the population will carry neutralizing antibodies. BT is undoubtedly enzootic in the state's pronghorn populations, constantly cycling but apparently causing little outright mortality of adults, but perhaps affecting them in ways that are less apparent and more significant to the population (i.e., lowered reproduction).

Mineral Analysis

Arizona pronghorn have liver and serum Cu and Se levels far below what is considered normal in domestic ruminants (Puls 1995). Because of variability in Cu and Se values from different geographic areas and diverse taxa, it is unclear if these values pose a substantial problem for Arizona pronghorn. Controlled experiments with captive animals are needed to assess physiological consequences of levels observed in wild animals. It is unknown to what extent wild ungulates use mineral supplementation for domestic livestock. However, this practice has potential to affect geographic pattern of mineral levels in pronghorn. We currently do not know where supplementation occurs in the state, at what level, or if pronghorn use mineral supplement when available.

Liver Copper--Adequate liver Cu level is 25-150 ppm in domestic goats and 25-100 ppm in domestic sheep and cattle (Puls 1995). Liver Cu levels for pronghorn collected in southeastern Arizona in September 1995 averaged 11.7 ppm (n = 12, range = 4.4-30.8 ppm). Eleven of 12 samples (91.7%) were under 25 ppm (Heffelfinger and Olding 1996*a*). Of 66 southeastern Arizona mule deer liver samples collected in November 1995, 20 (30.3%) were below adequate Cu values in domestic animals (25 ppm; Heffelfinger and Olding 1996*b*). The average liver Cu value for these samples was 34.7 ppm (range = 8.3-91.5 ppm). Monitoring trace minerals is very difficult because of complex interrelations and interactions among minerals. For example, absorption of Cu in ruminants is affected by dietary levels of molybdenum, iron, and sulfate. Low levels of Cu found in Arizona pronghorn are cause for concern with respect to historically low recruitment rates. Only through manipulative experiments or evaluation of captive animals will it be possible to determine true effects, if any, of these low levels.

Liver Selenium--Adequate values for liver Se are reported to be 0.25-1.20 ppm in domestic goats, 0.25-1.50 ppm in domestic sheep, and 0.25-0.50 ppm in cattle (Puls 1995). Precise nutritional requirements and tissue concentrations of Se have not been established in wild ruminants (Oliver et al. 1990). Liver Se values for domestic livestock have been reported to vary widely between 0.04 - 14.7 ppm (Ihnat 1989:147). Large temporal and spatial variation in liver Se levels makes it difficult to determine whether a particular species or population is deficient.

Studies have shown a relationship between Se concentrations in the soil and those in forage available to ruminants (Kubota et al. 1967). Se levels in ruminant tissues is, in turn, related to dietary intake of the element (Brady et al. 1978, Ihnat 1989). Annual variation in climatic conditions also influences Se levels in forage

(Underwood 1977).

Native Arizona grasses from some areas are very low or deficient in Se levels. Several cases of stillborns, white muscle disease, unthriftiness, retained placentas, and diarrhea in domestic animals have been reported in Arizona and may be associated with lack of dietary Se (Frederick 1997).

Analysis of liver Se by age class was hampered by small sample size in some age classes, however, a trend of decreasing liver Se levels with increasing age may be indicated (Table 4). This may also be an artifact of sample size as it conflicts with what is known about pronghorn breeding biology. Dominant pronghorn bucks establish territories where forage quality and quantity are superior during the pre-rut and rut periods, and therefore should have access to a higher nutritional plane. The age class "4+" also contains aged bucks that may not be able to defend optimal habitats.

All samples in this study were from male pronghorn because only bucks are legally harvested by hunters in Arizona. A study involving 151 mule deer in California found no sex-specific differences in whole blood Se (Dierenfeld and Jessup 1990). Sex-specific differences in Se levels are generally not reported (Ihnat 1989:123), however, Oliver et al. (1990) found significant sex-specific differences in Se levels of 1,695 California mule deer.

Stoszek et al. (1980) reported a Se deficiency in Idaho pronghorn populations reported to have pronghorn fawns suffering from "weak fawn syndrome." Se levels in tissue samples collected from these Idaho pronghorn populations which suffered from overall poor fawn recruitment were lower ($P < 0.001$) than similar samples of Montana pronghorn with no apparent fawn recruitment problems. Se found in the Idaho animals averaged 0.52 ± 0.16 ppm with individual levels as low as 0.35 ppm, whereas Montana pronghorn averaged 1.21 ± 0.20 ppm.

For Arizona pronghorn, Se deficiency may be a real effect because of widely reported deficiencies in cattle and horses in Arizona (Frederick 1997). Mineral supplementation of domestic livestock should be considered as a possible factor effecting trace mineral values in wild ruminants.

Liver Se levels of 12 pronghorn samples collected in southeastern Arizona in September 1995 averaged 0.306 ppm; only 2 (16.7%) were under the 0.25 ppm minimum considered adequate (Heffelfinger and Olding 1996*a*). Pronghorn in east-central Arizona had the highest average liver Se value (0.24 ppm, $n = 31$). This runs contrary to the observation by Kubota et al. (1967) that Tertiary volcanic rocks of the east-central area are low in Se.

In October/November 1995, 66 southeastern Arizona mule deer liver samples were analyzed for Se levels (Heffelfinger and Olding 1996*b*). The average liver Se value was 0.30 ppm, with 19 (28.8%) below 0.25 ppm, however, *Odocoileus* may have a much lower dietary requirement for Se (Brady et al. 1978). Also, Dierenfeld and Jessup (1990) reported fluctuation over 300% in whole blood Se levels among years during their 8-year study.

Our 1996 sampling effort occurred during an extremely dry year and may have resulted in values lower than during most years. This is supported by higher average values for Cu and Se the previous year (Heffelfinger and Olding 1996*a*).

Serum Copper--According to reference data, "adequate" ranges for serum Cu are 0.70-1.20 ppm for domestic goats and 0.70-2.0 ppm for domestic sheep (Puls 1995). Nutritional requirements and baseline blood concentrations of Cu have not been established in wild ruminants and are variable temporally, however, available information indicates that adequate levels for domestic livestock are above 0.70 ppm. Summary by age class failed to reveal obvious age-specific differences. Serum Cu levels are not a reliable indicator of Cu status because not all Cu in blood is available to the animal (Puls 1995). In addition, infections or trauma seems to increase serum Cu levels, causing serum levels to be labile. Values are reported here to establish a reference for future sampling limited to blood only (i.e., endangered Sonoran pronghorn [*A. a. sonoriensis*]).

Cu levels of 7 samples from southeastern Arizona in September 1995 averaged 0.64 ppm. Four (57.1%) were under 0.70 ppm (Heffelfinger and Olding 1996*a*).

MANAGEMENT IMPLICATIONS

Attempts to correlate precipitation patterns with pronghorn fawn recruitment have been largely unsuccessful (D. E. Brown, Arizona State University, pers. comm.). It seems there are confounding factors that complicate this relationship. Determining effects of enzootic BT infections on fawn survival will be more difficult, but represent an additional factor that may affect fawn recruitment. Research under controlled conditions will be necessary to determine these effects. There may be little that pronghorn managers can do to ameliorate negative effects of BT infection. However, a more thorough understanding of the impacts will allow managers to better explain pronghorn population dynamics to hunters and other interested publics.

Unfortunately, all suppressive factors intensify simultaneously. During drought years, fawns are born with lower birth weights, forage for lactating does is poor, forage for fawns after weaning is poor, hiding cover for fawns is lacking, predators lack abundant alternative foods, and stressed animals are more susceptible to diseases and predation. Separating these factors from effects of viremia during the breeding season would be a daunting task.

Management options for confirmed mineral deficiencies include dietary supplementation with mineral blocks throughout pronghorn habitat. This would provide an opportunity to work with the ranching community to the mutual benefit of both parties. Flueck (1989) reported that supplementation with intraruminal Se pellets in pronghorn increased survival of fawns born to treated does by an overall factor of 2.6.

Investigations are needed to determine if mineral supplementation will enhance immune function and result in better reproduction or survival. Managers should establish a "management experiment" in Se and Cu supplementation. Mineral could be supplied economically, but the livestock operator would have to agree to not supplement in the control area.

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BLOOD CHEMISTRY AND TRACE MINERAL VALUES FOR PRONGHORN ANTELOPE IN OREGON

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Abstract: Blood samples from 105 pronghorn (*Antilopcapra americana*) were analyzed to determine baseline values for trace mineral and blood chemistry parameters, and to determine if blood parameters in Oregon reflect general nutritional status of habitats. Samples were collected from 3 distinct Oregon populations between 1988-1997. Most parameters differed between populations and generally reflected differing nutritional planes. Although fawn:adult doe ratios seemed different between populations, data were not sufficient to test for nutritional influence on population productivity. Where sample size was sufficient for comparison, values did not differ between males and females for all parameters except blood urea nitrogen (BUN), chlorides, and zinc. We recommend controlled experimentation to determine nutritional impacts on blood profiles and whether blood profiles may be used as indices of population performance in pronghorn. Interspecific comparison of reported baseline blood parameters are discussed.

Key words: Antilopcapra americana, blood chemistry, Great Basin, nutrition, Oregon, pronghorn, serum trace mineral.

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Pronghorn antelope are an important big game species throughout the western United States, including Oregon. As a result of conservative harvest management, numbers of pronghorn counted in Oregon have recovered from less than 2,000 animals in 1945 to over 18,000 in 1991. However, recent data indicate Oregon's pronghorn population may be declining. Decreases are most dramatic at regional scales. Late summer fawn:doe ratios <5:100 in 1995 suggest complete recruitment failures in some populations (ODFW 1997).

In response to declining populations and historic low fawn:doe ratios, a study was conducted describing factors influencing neonatal pronghorn fawn survival, including blood indices of nutrition and disease (Dunbar and Velarde 1998, Gregg et al. 1998). However, this study compared pronghorn blood parameters to those of domestic livestock rather than free-ranging pronghorn. There is a need to establish baseline values for Oregon pronghorn. The objectives of this study were: 1) determine baseline values for trace mineral and blood chemistry parameters in Oregon pronghorn, and 2) determine if blood parameters in Oregon reflect general nutritional status of habitats.

STUDY AREAS

Pronghorn were sampled from 3 separate populations utilizing 3 distinct habitat types. The first population was an agricultural area in Baker Valley (BV) of northeastern Oregon. The area was privately owned and managed primarily for livestock production. This pronghorn population became established in agricultural portions of the valley after an introduction on nearby native rangelands. This population lives yearlong within a large alfalfa (*Medicago* spp.) hay field and increased from <10 animals in the late 1980s to 59 in 1997 (ODFW 1997), with a relatively high buck:doe ratio and low fawn:doe ratio (Table 1).

Conservative, buck–only hunting was allowed in adjacent areas. Coyotes (*Canis*

Table 1. Population characteristics for 3 Oregon pronghorn populations at time of blood sampling, 1988-1997.

Sampling		##:100 Does		
Location	Year	Bucks	Fawns	Nutritional plane[1]
Hart Mountain Refuge (NAR)	1996	29	17	Low
	1997	24	31	Medium
Umatilla Army Depot (UAD)	1988	92	63	Medium
Baker Valley (BV)	1996	140	29	High

[1] Relative nutritional plane based on habitat type: Medium = Late successional fallow field and shrubland; High = Alfalfa; Low = Desert shrubland.

latrans) were controlled opportunistically by landowners.

The second population occurred on the Umatilla Army Depot (UAD) near Pendleton, also in northeastern Oregon. The Depot was owned by the U.S. Army and was used primarily for weapons storage. Habitats were typical of late–succession fallow fields, with a strong annual forb component interspersed with shrub dominated vegetation. Pronghorn were originally introduced into the area in 1969. Pronghorn long–term carrying capacity for the area was arbitrarily determined to be 100 animals by Army personnel, and the population was controlled primarily with periodic trap and transplant operations (Oregon Department of Fish and Wildlife 1989, unpubl. data). Coyote control was occasionally used to improve fawn recruitment. Buck to doe and fawn to doe ratios were the highest reported in Oregon at time of sampling (ODFW 1989, Table 1).

The third population occurred on the Hart Mountain National Antelope Refuge (NAR). Samples were collected during 2 time periods (December 1996, March 1997). Habitats on NAR were characteristic of northern Great Basin grasslands and included a strong shrub component consisting primarily of sage (*Artemisia* spp.), rabbitbrush (*Chrysothamnus viscidiflorus*), and spiny hopsage (*Atriplex spinosa*). A detailed description of refuge habitats can be found in U.S. Fish and Wildlife Service (1994). Pronghorn populations were naturally occurring in the area and were declining from record high numbers of animals in the early 1990s (ODFW 1997). Although somewhat variable, buck:doe and fawn:doe ratios were considered low for Oregon at time of sampling (Table 1). Conservative buck only hunting and active prescribed burning were primary management activities for pronghorn. Coyote control, hunting, or trapping had not occurred since the late 1970s.

METHODS

We assumed relative nutritional plane (high, medium, low) for each population sampled reflected relative abundance of herbaceous vegetation in respective habitats. Because the BV population lived year round in irrigated alfalfa fields, we assumed their nutritional plane to be high. We assumed a medium nutritional plane was present for UAD animals as a result of the strong annual forb component in UAD habitats, and for NAR animals during the March sample period as a result of spring greenup. We assumed animals sampled during winter (December) on NAR existed on a low nutritional plane as a result of poor availability of herbaceous vegetation.

In February 1988, animals on UAD were driven on foot into a modified corral trap (Lee et al. 1998) for release in other areas. Blood samples were collected opportunistically from captured animals and serum was stored at –20°C until analysis in 1997. Blood samples were collected from BV pronghorn when they were captured in December 1996 using a modified corral trap and a helicopter. A net gun (Coda

Enterprizes, Inc., Mesa Arizona, USA) fired from a helicopter (Barrett et al. 1982) was used to capture NAR animals in December 1996 and March 1997 specifically to collect blood samples.

Blood samples were collected from all animals via jugular venipuncture using EDTA and serum separator tubes. Centrifugation occurred within 30 min of capture for serum extraction. Samples from UAD animals were stored frozen (-20°C) until anlyses in 1997. All samples were shipped frozen to local laboratories where blood chemistry and trace mineral analyses were conducted.

Analysis of variance for unbalanced designs was conducted using PROC GLM (SAS Institute, Inc. 1989). Means were separated using Duncan's New Multiple Range test (SAS Institute, Inc. 1989). Although blood screens may also be indicative of disease in individual animals (Chin 1997), we report means here in an effort to describe norms for populations existing at certain nutritional levels. Statistical differences were considered significant when $P < 0.05$.

RESULTS

A total of 105 blood samples were collected from 3 Oregon pronghorn populations between 1988 and 1997. Thirty of 62 (48%) animals captured on UAD were sampled in 1988, and 34 of 59 (58%) animals were sampled in the BV population during 1996. On NAR, 20 and 21 animals were sampled during December 1996 and March 1997, respectively.

Except for alanine aminotransferase ($P = 0.817$), diagnostic blood parameters (bilirubin, gamma glutamyl transferase, asparate aminotransferase, creatinine, chloride, globulin) differed ($P = 0.0001$) between study areas and times (Table 2). Blood chemistry parameters also differed ($P = 0.0001$) between study areas and time periods, with few exceptions (Table 2). Only Cholesterol did not differ ($P = 0.156$). Most parameters commonly used as an index to diet quality (BUN, total protein [TP], albumin, and albumin/globulin ratio) were generally highest in BV animals (high nutrition) and lowest in NAR animals (low – medium nutrition). Globulin was highest in UAD animals and lowest in BV animals. Except for total protein, nutritional indices were higher during the medium nutrition period (March 1997) than during the low nutrition period (December 1996) in NAR animals. Although mean concentration differed ($P = 0.0001$) between sample area and period for all minerals except sodium ($P = 0.204$) and iron ($P = 0.293$), no consistent trend was apparent relating mineral concentration with relative nutritional plane (Table 3).

Because sample size was biased to females, no comparisons were made between males and females in the BC and both NAR study areas. Nearly equal but small sample size (15 male, 15 female) allowed limited comparison between sexes on UAD. All diagnostic criteria were similar between males and females ($P > 0.05$, Table 4). Of the common nutritional indices examined, only BUN and chlorides differed between the sexes, with males having higher BUN and lower chloride levels than females (Table 4). Zinc was the only trace mineral differing between the sexes and was higher ($P = 0.05$) in males.

DISCUSSION

Few reports are available that document blood chemistry profiles for pronghorn. Seal and Hoskinson (1978) sampled from a range of similar habitat types in Idaho. When we classified relative nutritional planes as high, medium, and low based on protein content of reported dominant vegetation for their sample populations (Seal and Hoskinson 1978), values for BUN, TP, and albumin levels were similar to those reported here (Table 5). However, globulin levels were higher in Oregon animals than in Idaho (Seal and Hoskinson 1978). Although nutritional level was not specified, pronghorn from Wyoming (Dhindsa et al. 1975) and Alberta, Canada (Barrett and Chalmers 1976)

Table 2. Average blood serum chemistry values for pronghorn captured in Oregon, 1988-1997. Means with the same letter in a row are not different (Analysis of variance for unbalanced designs, Duncan's New Multiple Range Test, $P = 0.05$).

	Baker Valley[1]		Hart Mountain[1]				Umatilla[1]		ANOVA	
	(12/96) $n = 34$		(12/96) $n = 20$		(3/97) $n = 21$		(2/88) $n = 30$		F	$P>F$
Parameter[2]	Mean	s^2	Mean	s^2	Mean	s^2	Mean	s^2	Mean	s^2
BUN *(mg/dl)*	43.7^{a}	18.8	15.1^{d}	7.3	31.0^{b}	29.2	23.6^{c}	27.4	78.61	0.0001
Total Protein *(g/dl)*	6.5^{b}	0.2	6.1^{bc}	0.3	5.8^{c}	0.3	7.3^{a}	1.8	13.95	0.0001
Albumin *(g/dl)*	5.0^{a}	0.1	4.3^{b}	0.2	3.9^{c}	0.1	4.1^{b}	0.1	59.40	0.0001
Globulin *(g/dl)*	1.5^{c}	0.1	1.9^{cb}	0.1	1.8^{b}	0.5	3.1^{a}	1.8	24.98	0.0001
Alb./Glob. Ratio	3.6^{a}	0.8	2.3^{b}	0.1	2.1^{b}	0.2	1.2^{c}	0.2	83.93	0.0001
Cholesterol *(mg/dl)*	40.5	50.2	42.0	37.8	38.0	43.0	---	---	1.91	0.1556
Glucose *(mg/dl)*	262.3^{a}	1302	203.0^{b}	1577	189.0^{b}	863	110.4^{c}	1992	80.07	0.0001
Total Bilirubin *(mg/dl)*	1.0^{a}	0.1	0.3^{b}	0.1	0.2^{c}	0.01	0.3^{b}	0.01	86.30	0.0001
Creatinine *(mg/dl)*	2.1^{a}	0.5	1.8^{ab}	0.1	1.3^{c}	0.01	1.7^{b}	0.1	12.53	0.0001
Chlorides *(meq/l)*	107.7^{b}	4.6	113.2^{a}	4.5	111.8^{a}	6.6	103.5^{c}	10.6	63.99	0.0001
GGT *(U/L)*	7.6^{c}	15.0	20.1^{a}	126	15.6^{b}	49.7	16.6^{ab}	45.3	14.97	0.0001
Calcium *(mg/dl)*	9.5^{b}	0.2	9.1^{bc}	1.6	8.9^{c}	0.4	10.0^{a}	0.2	12.53	0.0001
Phosphorus *(mg/dl)*	3.1^{c}	1.2	6.6^{b}	2.3	7.7^{a}	0.8	6.4^{b}	1.6	75.72	0.0001
ALP *(U/L)*	44.6^{b}	1139	49.3^{b}	596	97.4^{a}	6249	32.8^{b}	179	10.28	0.0001
AST *(U/L)*	139.8^{b}	2558	226.6^{a}	12809	237.0^{a}	16260	59.1^{c}	216	25.81	0.0001
ALT *(U/L)*	23.9	61.1	25.2	88.3	24.0	24.8	---	---	0.20	0.8170

[1] Baker Valley = High Nutrition; Hart Mountain = low (12/96) and Medium (3/97) Nutrition; Umatilla = Medium Nutrition.

[2] BUN = Blood Urea Nitrogen; GGT = Gamma glutamyl transferase; ALP = Alkaline phosphatase; AST = Asparate aminotransferase; ALT = Alanine aminotransferase.

Table 3. Average blood serum trace mineral concentration for pronghorn captured in Oregon, 1988-1997. Means with the same letter in a row are not different (Analysis of variance for unbalanced designs, Duncan's New Multiple Range Test, $P = 0.05$).

	Baker Valley[1]		Hart Mountain[1]				Umatilla[1]		ANOVA	
	(12/96) $n = 34$		(12/96) $n = 20$		(3/97) $n = 21$		(2/88) $n = 30$		F	$P>F$
Parameter[2]	Mean	s^2	Mean	s^2	Mean	s^2	Mean	s^2	Mean	s^2
Sodium[2] *(meq/l)*	153.3^c	8.0	159.1^a	12.4	155.8^b	9.8	158.4^a	15.6	13.53	0.0001
Potassium[2] *(meq/l)*	4.6^b	0.4	4.6^b	0.3	4.5^b	0.2	7.8^a	0.9	151.72	0.0001
Na (ppm)	---	---	3703	5501	3714	13653	3756	12658	1.63	0.2037
K (ppm)	---	---	189.2^b	492.1	191.0^b	340.3	332.5^a	1470	186.28	0.0001
Na/K	33.8^a	14.9	19.8^b	5.3	19.6^b	2.4	11.5^c	2.1	3458.12	0.0001
Se *(ng/ml)*	69.1^b	1039	98.6^a	1231	49.1^c	83.5	46.1^c	33.3	20.83	0.0001
Zn (ppm)	0.8^b	0.01	1.4^a	0.1	1.5^a	0.2	0.9^b	0.03	38.54	0.0001
P (ppm)	37.9^c	132.5	70.1^b	242.6	85.0^a	108.8	74.7^b	130.8	72.02	0.0001
Fe (ppm)	2.6	0.2	2.5	0.2	2.7	0.4	2.4	0.3	1.26	0.2933
Mg (ppm)	23.1^b	8.9	28.9^a	4.9	27.2^a	11.3	28.5^a	8.5	23.75	0.0001
Cu (ppm)	0.8^a	0.02	0.6^b	0.01	0.6^b	0.01	0.6^b	0.04	16.43	0.0001
Ca (ppm)	104.8^a	60.6	97.7^b	36.3	93.0^c	38.5	103.4^a	29.3	15.68	0.0001

[1] Baker Valley = High Nutrition; Hart Mountain = low (12/96) and Medium (3/97) Nutrition; Umatilla = Medium Nutrition.
[2] Measured from blood serum chemistry.

Table 4. Average blood serum chemistry values for male and female pronghorn captured on Umatilla Army Depot, Oregon, 1988. Sample size = 15 male and 15 female unless otherwise noted. Means in a row with an * differed ($P = 0.05$, Duncan's New Multiple Range Test).

	Male		Female	
Parameter	Mean	s^2	Mean	s^2
Blood Urea Nitrogen (*mg/dl*)	26.0	5.4	21.3	4.9 *
Total Protein (*g/dl*)	7.3	0.5	7.3	1.9
Globulin (*g/dl*)	3.3	0.5	3.0	1.9
Albumin (*g/dl*)	4.3	0.4	4.0	0.3
Albumin/Globulin Ration	1.2	0.2	1.1	0.6
Glucose (*mg/dl*)	114.0	43.3	106.9	52.2
Total Biliruben (*mg/dl*)	0.4	0.1	0.3	0.1
Creatinine (*mg/dl*)	1.6	0.3	1.8	0.2
Chlorides (*meq/l*)	102.0	3.0	105.1	3.5 *
Gamma Glutamyl Transferase (*U/L*)	17.0	6.5	16.3	7.8
Calcium (*mg/dl*)	10.1	0.4	10.0	0.6
Alkaline Phosphatase (*U/L*)	36.0	13.8	29.5	14.1
Asparate Aminotransferase (*U/L*)	56.5	8.0	61.7	20.0
Sodium (*meq/l*)[1]	157.5	4.5	159.4	4.6
Potassium (*meq/l*)[1]	7.9	0.9	7.7	1.1
Na (ppm)	3768.3	94.0	3744.6	130.1
Se (ppm)	47.2	6.8	44.9	5.2
Zn (ppm)[2]	1.0	0.1	0.8	0.2 *
P (ppm)[3]	71.9	12.2	76.7	11.3
Fe (ppm)[2]	2.3	0.4	2.6	0.7
Mg (ppm)[2]	27.9	2.7	29.0	3.1
Cu (ppm)[2]	0.6	0.2	0.6	0.2
Ca (ppm)[2]	104.6	6.1	102.2	4.6
K (ppm)[2]	336.1	29.0	329.2	46.3

[1] Measured in blood serum chemistry analyses.
[2] Sample size = 12 male, 13 female.
[3] Sample size = 5 male, 7 female.

Table 5. Comparison of selected blood parameters between pronghorn antelope populations and other big game species.

Species/Study	Nutrition level[1]	BUN	Total protein	Albumin	Globulin	Cholesteral	Glucose
Pronghorn							
This study	High	43.7	6.5	5.0	1.5	40.5	262.3
	Medium	31.0, 23.6	5.8, 7.3	3.9, 4.1	1.8, 3.1	38.0	189.0, 110.0
	Low	15.1	6.1	4.3	1.9	42.0	203.0
Seal and Hoskinson 1978	High	44.0	6.8	4.5	0.4	---	---
	Medium	18.6	6.5	4.8	0.5	---	---
	Low	11.3	6.7	4.4	0.5	---	---
Barrett and Chalmers 1976		37.6	6.5	4.1	---	57.8	212.6
Dhindsa et al. 1975		35.0	7.4	---	---	37.0	97.0
Elk							
Bubenik 1982	High	26.3	7.2	1.1	---	85.7	136.0
	Low	---	5.6	2.3	3.4	---	---
White-tailed deer							
DelGiudice et al. 1987	High	27.3	5.8	3.6	---	37.8	256.0
	Low	36.5	6.1	3.8	---	63.0	110.0
Mule deer							
Anderson 1981		7.4 – 29.8	4.6 – 8.5	1.6 – 4.4	1.8 – 5.1	70.2 – 111.9	37.2 – 161.1

[1] Nutrition level is relative based on our interpretation of author study descriptions.

had similar values for BUN, TP, albumin, globulin, cholesterol, and glucose (Table 5).

Blood chemistry values have been indexed to habitat quality in other species as well (Table 5, Chin 1997). Bubenik (1982) observed lower BUN (26.3) and higher TP (7.2) levels for elk (*Cervus elaphus*) on high nutrition than we found in Oregon pronghorn. Values for BUN were lower in white-tailed deer (*Odocoileus virginianus*) on high nutrition than we found in pronghorn on high nutrition range in Oregon (DelGiudice et al. 1987). However, white-tailed deer on low nutrition diets had higher BUN than Oregon pronghorn on a low relative nutritional plane (DelGiudice et al. 1987, Table 5). This is likely a result of protein catabolism by white-tailed deer on a starvation diet and may indicate that the low relative nutritional plane in our study was not sufficient to induce protein catabolisim.

Trace mineral concentrations also are likely related to diet. Although the general physiologic role of most specific minerals has been identified (Robbins 1983), little information describing baseline values for most wildlife species is available (Puls 1995). No consistent trends were evident from our data, suggesting that availability of specific nutrients is highly variable between sample locations and periods (Table 3). Additionally, whole blood may not be the best sample for measuring some minerals. For example, liver selenium values may be more appropriate than blood selenium values.

Data from this and other studies support the conclusion that selected blood chemistry parameters can be used to index general diet quality of habitats for pronghorn (Seal and Hoskinson 1978), as well as for other ruminants (Trout 1976, Seal et al. 1978, Bahnak et al. 1979, DelGiudice et al. 1987, Chin 1997,). For example, animals on high nutrition diets should present higher BUN and TP values than animals on medium and low nutrition diets. However, caution should be used when interpreting such data because of the numerous factors, including starvation, which may impact values for blood chemistry parameters (Warren et al. 1982). Additionally, lack of differences between sexes for most blood chemistry and trace mineral analyses in UAD suggest that data from hunter harvested pronghorn, which tend to primarily be male, may be useful in monitoring population health.

The data we report here identify a critical problem in need of further study. Controversies over applicability of livestock baseline values in interpretation of wildlife blood parameter data and inability to quantify long term habitat carrying capacities for pronghorn provided much of the impetus for the current report. Although many authors have reported relationships with blood parameters and diet quality in pronghorn and other wild ungulates (Trout 1976, Seal and Hoskinson 1978, Seal et al. 1978, Bahnak et al. 1979, Stoszek 1980, DelGiudice et al. 1987, Chin 1997, Heffelfinger et al. 1999), we were unable to locate studies where average blood chemistry values have been related to long-term performance of a population. Differences in types and timing of collection did not provide sufficient data to evaluate relationships between blood indices of habitat quality and pronghorn population performance in Oregon (Table 1). However, we did provide some baseline blood values for pronghorn in Oregon that should be useful to other researchers. Further research should focus on long-term, manipulative studies to identify existence and magnitude of such relationships, and to clearly define management alternatives should relationships exist.

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GENETIC VARIATION IN PRONGHORN FROM ARIZONA

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Abstract: Three hundred twenty-two pronghorn antelope (*Antilocapra americana*) were surveyed for genetic variation at 22 allozyme loci by means of starch gel electrophoresis of allozymes. Genetic diversity measures, including heterozygosity, number of alleles per locus, and percent loci polymorphic, were estimated for the overall Arizona pronghorn sample and for selected regional populations. Pronghorn from Arizona exhibited levels of genetic diversity that were greater than average values for other North American pronghorn populations. Analyses of pronghorn populations in the Arizona Strip, northwestern, central, northeastern, and southeastern portions of Arizona indicated that there was significant differentiation in allele frequencies among herds inhabiting these regions. The significant genetic structuring observed among pronghorn populations in Arizona should be taken into account when sources are selected for future translocations of pronghorn into the state.

Key words: allozyme, *Antilocapra americana*, heterozygosity, nuclear DNA.

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Both mitochondrial and nuclear genetic markers have been surveyed in pronghorn antelope throughout much of the central and northern portions of this species range in North America (Lee et al. 1989, Lee et al. 1994). However, few genetic data exist for pronghorn populations inhabiting the southern portion of the North American pronghorn range, including areas in Arizona and Mexico. Arizona in particular is an area of considerable interest to pronghorn biologists, given that 3 of the 4 currently recognized subspecies of pronghorn in North America historically occurred in this state (Hall 1981, O'Gara 1978). Despite the unique opportunity for analysis of genetic structure and taxonomy represented by study of pronghorn in Arizona, only recently have genetic investigations been initiated in this area (Reat 1998).

The first substantial population level analysis of genetic structure in pronghorn was performed by Lee et al. (1989). Lee et al. (1989) used allozyme markers at 24 presumptive gene loci to assess genetic relationships and patterns of genetic variation in western Texas pronghorn populations ($n = 65$). This study indicated that western Texas pronghorn populations were characterized by relatively low levels of genetic diversity (mean multilocus heterozygosity of 0.027) and moderately high levels of genetic differentiation among populations ($F_{ST} = 0.103$).

Lee et al. (1994) followed up this initial work in Texas with a more comprehensive examination of genetic diversity and structure in pronghorn from 29 locations across northern and central portions of the North American pronghorn range. In this second study of pronghorn genetics, Lee et al. (1994) used both

mitochondrial DNA and allozyme markers to examine effects of past population declines, isolation, and translocation on current genetic structure of North American pronghorn populations. Analysis of allozyme data generated from their research indicated low levels of genetic diversity (mean multilocus heterozygosity of 0.024), Roger's distance values ranging from 0.01 to 0.07, and significant differentiation of allele frequencies among North American pronghorn populations at only 2 loci (Lee et al. 1994).

Arizona pronghorn, because of the historical presence of 3 subspecies in the state, are an excellent choice for initial analysis of the southern portion of the North American pronghorn population. Although extensive pronghorn reintroductions have occurred in portions of Arizona (Lee 1988), segments of the statewide population have remained undisturbed by translocation events (Hoffmeister 1986). A preliminary examination of genetic diversity in Arizona pronghorn is needed to assess genetic parameters of these animals within the context of the larger North American perspective. Furthermore, elucidation of regional variation in genetic diversity of Arizona pronghorn should provide insights into consequences of pronghorn reintroductions to allelic differentiation of pronghorn across the state. Thus, objectives of this research were to assess basic genetic parameters of pronghorn populations in Arizona relative to values reported by Lee et al. (1994) for other North American pronghorn herds and, to evaluate levels of genetic differentiation among regional pronghorn populations within the state.

METHODS

Sample Collection and Location

Collection kits, consisting of sample bags and instructions for tissue collection and handling, were mailed to hunters that obtained permits to harvest pronghorn in Arizona during the 1996 hunting season. Seven hundred kits were mailed out to hunters throughout the state. We asked hunters to collect liver and muscle tissue in the field and place the samples on wet ice. Hunters were then asked to drop samples off at collection stations located throughout Arizona at major highway intersections (Reat 1998). In addition to roadside collection, samples were collected by Arizona Game and Fish Department wildlife managers in the field. On day of collection, samples were cataloged and placed in liquid nitrogen for storage until they could be transported to Purdue University on dry ice. At Purdue University, samples were stored at -75°C until analysis.

We classified pronghorn samples as to 5 geographic regions of Arizona (northeast, central, northwest, southeast, and the Arizona Strip) for analysis (Fig. 1). Regions were selected based on their past history of reintroductions and degree of isolation. The Arizona Strip and southeastern regions were isolated from the remainder of the pronghorn populations and were thought have been entirely extirpated at some point in the past. The central region was considered the core of pronghorn range in Arizona and had no reintroductions from other herds prior to our sampling. The northeastern region was selected based on its history of reintroductions from Wyoming, and the northwestern region was selected based on its somewhat isolated location relative to the other portions of Arizona pronghorn range.

Starch Gel Electrophoresis

We used starch gel electrophoresis of allozymes as described in Lee et al. (1989), Rhodes et al. (1991), and Lee et al. (1994). Thirty-seven biochemical loci were surveyed using liver and/or muscle tissue. Twenty-two loci were selected for further analysis, based on reliability of scoring, and surveyed for genetic variation in pronghorn (Table 1). Less than 2 percent of individuals scored over all loci surveyed could not be assigned genotypes. We calculated allele frequencies, percent polymorphic loci, and single locus heterozygosities. The overall measure of multilocus heterozygosity (H) was calculated from direct counts of observed heterozygotes at all loci divided by the product of the number of pronghorn analyzed and the total number of loci analyzed.

Contingency table chi-square statistics (Workman and Niswander 1970) were calculated for each variable locus (and for all loci combined) and used to analyze differences in genetic characteristics among pronghorn sampled from different regions within the state.

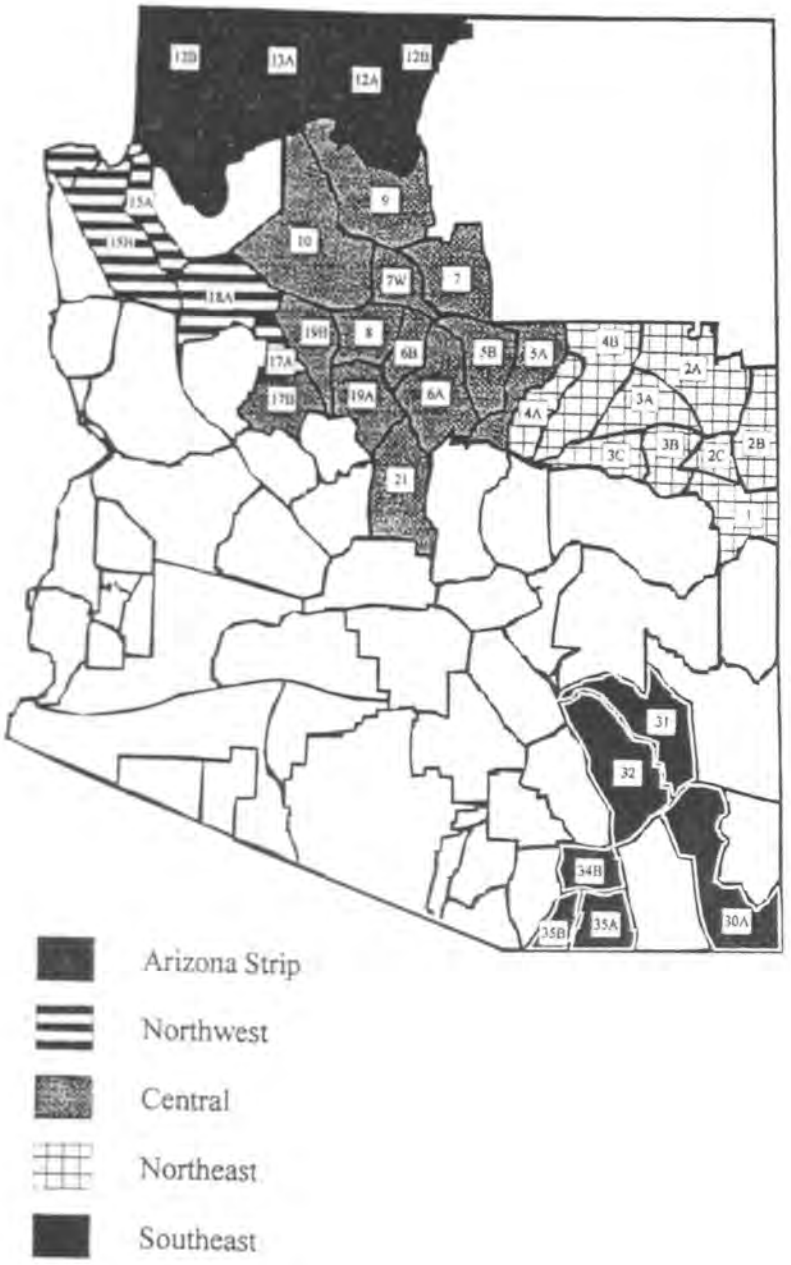

Figure 1. Samples from pronghorn were divided into 5 regional populations for analysis. Pronghorn were assigned to the Arizona Strip, northwest, central, northeast, and southeast regions of Arizona. Game Management Unit numbers are provided within regions.

Statistical genetic analyses were performed using BIOSYS (Swofford and Selander 1981).

In order to compare levels of genetic variation between Arizona pronghorn and data published for other North American populations, we reanalyzed allele frequency data reported in Lee (1992) using only those loci common to his study and our own. Sixteen loci were common to both studies (Table 1). Based on allele frequencies reported in Lee (1992), we calculated average numbers of alleles per locus, percent polymorphic loci, and expected single locus heterozygosities for 29 North American pronghorn populations. Overall average values for numbers of alleles per locus, percent polymorphic loci and expected heterozygosities across the 29 North American pronghorn populations were calculated as weighted (by sample size) means.

Table 1. A list of electrophoretic conditions used for the 22 loci studied in pronghorn antelope. Locus acronyms, enzyme commission numbers (E.C.), tissue types, and gel buffers with respective pH's are presented.

Loci		E. C.	Tissue[a]	Buffer[b]
AAT-1[c]	Aspartate aminotransferase-1	2.6.1.1	L	TC 8.0
AAT-2[c]	Aspartate aminotransferase-2	2.6.1.1	L	TC 8.0
ACP[c]	Acid phosphatase	3.1.3.2	L	AC 6.1
ACON[c]	Aconitase	4.2.1.3	L	AC 6.1
EST-2	Esterase-2	3.1.1.1	L	RW 8.5
IDDH[c]	L-iditol dehydrogenase	1.1.1.14	L	AC 6.1
IDHP-1[c]	Isocitrate dehydrogenase-1	1.1.1.41	M	TM 7.4
IDHP-2	Isocitrate dehydrogenase-2	1.1.1.41	M	TM 7.4
LDH-1[c]	Lactate dehydrogenase-1	1.1.1.27	M	TC 8.0
LDH-2	Lactate dehydrogenase-2	1.1.1.27	M	TC 8.0
MDH-1[c]	Malate dehydrogenase-1	1.1.1.37	L	TC 8.0
MDH-2[c]	Malate dehydrogenase-2	1.1.1.37	L	TC 8.0
ME-1[c]	Malic enzyme-1	1.1.1.38	M	TM 7.4
ME-2	Malic enzyme-2	1.1.1.38	M	TM 7.4
MPI[c]	Mannose-6-phosphate isomerase	5.3.1.8	M	TC 8.0
NP[c]	Nucleoside phosphorylase	2.4.2.1	M	TM 7.4
PEP-1[c]	Peptidase-1	3.4.11.-	M	TM 7.4
PEP-2[c]	Peptidase-2	3.4.11.-	M	TM 7.4
PGDH	6-Phosphogluconate dehydrogenase	1.1.1.44	M	TM 7.4
PGM-1[c]	Phosphoglucomutase-1	5.4.2.2	L	PK 8.2
PGM-2	Phosphoglucomutase-2	5.4.2.2	L	PK 8.2
PGI[c]	Phosphoglucose isomerase	5.3.1.9	L	PK 8.2

[a]L = liver, M = muscle
[b]AC 6.1 = Amine-Citrate 6.1, TC 8.0 = Tris-Citrate 8.0, TM 7.4 = Tris- Maleate 7.4, PK 8.2 = Poulik discontinuous Tris-Citrate 8.2, RW 8.5 = Ridgeway 8.5
[c]Loci common to both Lee (1992) and our study.

RESULTS

During the 1996 collection efforts, 351 individual pronghorn were sampled throughout Arizona. This represented approximate return rates of 50%, based on the number of collection kits mailed to hunters. Of 351 samples collected, 322 were analyzed for genetic variation using starch gel electrophoresis of allozymes. Sample sizes from the 5 regions of Arizona were as follows: Arizona Strip (n = 19), northwest (n = 19), central (n = 166), northeast (n = 97), and southeast (n = 19).

Mean multilocus heterozygosity, average number of alleles per locus, and proportion of polymorphic loci (0.95% criterion) were 0.064, 2.14, and 0.23, respectively, in the pooled Arizona pronghorn population. Single locus heterozygosities in the pooled population ranged from 0.006 to 0.36 over the polymorphic loci surveyed. Of 22 loci surveyed, only 6 were monomorphic (malate dehydrogenase-2, isocitric dehydrogenase-1&-2, peptidase-1&-2, and lactate dehydrogenase-1).

Allele frequencies and mean single locus heterozygosities for 5 regional pronghorn populations sampled are provided for polymorphic loci (Appendix 1). Among 5 regional pronghorn populations surveyed, mean multilocus heterozygosities ranged from 0.05 to 0.09, mean number of alleles per locus ranged from 1.5 to 1.9, and proportion of polymorphic loci (0.95 criterion) ranged from 0.18 to 0.36 (Table 2). Regional populations containing unique alleles (i.e., alleles not observed in other populations) ranged from zero unique alleles observed in the Arizona Strip and southeastern regions to 4 unique alleles in the northeastern region (Table 2).

Over all loci, differences in allele frequencies were detected between the 5 regions of Arizona surveyed ($\chi^2 = 360.97$, df = 100, $P <$ 0.00001). Differences in specific allele frequencies among the 5 regions were detected at the acid phosphatase, aconitase, glucose phosphate isomerase, phosphoglucomutase-1&-2, aspartate aminotransferase-2, esterase-3, malic enzyme-2, nucleoside phosphorylase, and mannose phosphate isomerase loci ($P < 0.05$ for all significant loci).

When only the 16 loci common to both Lee (1992) and our study were analyzed, Arizona pronghorn population had an average of 2.2 alleles per locus, 25.0 percent polymorphic loci (0.95 criterion), and an overall expected heterozygosity of 0.101. Data from these same 16 loci in the 29 North American herds surveyed by Lee (1992) indicated an average of 1.38 alleles per locus, 13.7 percent polymorphic loci (0.95 criterion), and an overall expected heterozygosity of 0.043.

Table 2. Genetic variability measures for the 5 pronghorn populations surveyed in Arizona based on analysis of 22 loci. Standard errors are given in parentheses.

Population	Mean sample size per locus	Mean number of alleles per locus	Percentage of loci polymorphic (0.95 criterion)	Mean multilocus heterozygosity (direct count)	Number of unique alleles
Northeast	94.7 (0.4)	1.9 (0.2)	18.2	0.063 (0.026)	4.0
Central	163.9 (0.6)	1.8 (0.1)	27.3	0.064 (0.020)	1.0
Northwest	18.6 (0.2)	1.6 (0.1)	22.7	0.050 (0.016)	1.0
Arizona Strip	18.0 (0.2)	1.6 (0.2)	22.7	0.062 (0.021)	0.0
Southeast	17.9 (0.3)	1.5 (0.2)	36.4	0.090 (0.033)	0.0

DISCUSSION

The suite of loci examined in this research differs from those used by Lee et al. (1994) in only a few ways. Both studies encompass the majority of the most variable loci observed in pronghorn populations across North America. However, our analysis involved several loci that were unresolved by Lee and his colleagues (i.e., isocitric dehydrogenase-2, lactate dehydrogenase-2, malic enzyme-2, 6-phosphogluconate dehydrogenase, and phosphoglucomutase-2). In addition, our analyses revealed extensive polymorphism at the mannose phosphate dehydrogenase locus in pronghorn from Arizona. This was not the case for North American pronghorn populations surveyed by Lee et al. (1994). Alternatively, we did not survey Arizona pronghorn populations at several loci that exhibited low levels of variation in North American pronghorn examined by Lee et al. (1994; i.e., peptidase-3, esterase-1, esterase-4, superoxide dismutase, hemoglobin, and glucose phosphate isomerase).

Using data from loci common to both studies, the statewide Arizona pronghorn herd exhibited relatively high levels of genetic variation relative to estimates for other North American herds (Lee et al. 1992, Lee 1994). For instance, the expected multilocus heterozygosity value of 0.10 is substantially higher than average for other North American herds (0.04), and falls outside the range of values observed (0.00 to 0.094; based on our reanalysis of the data from Lee 1992). Values for average number of alleles per locus (2.2) and percentage of loci polymorphic (25.0; 0.95 criterion) for pronghorn in Arizona were high relative to mean values for these parameters in other North American populations (1.38, range 1.00-1.80; and 13.7 range 0.00-31.3, respectively).

Analysis of genetic diversity measures from the 5 regional pronghorn populations indicated that levels of heterozygosity and gene polymorphism vary across the state. Pronghorn from the southeastern habitat exhibited the highest level of heterozygosity and polymorphic loci observed in any of the regional populations, but had the lowest number of alleles per locus of any region. These pronghorn are believed to be entirely composed of reintroduced pronghorn from multiple sources (Lee 1988).

A potential explanation for the pattern of high heterozygosity, high percentage of polymorphic loci, and low number of alleles per locus in the southeastern portion of the state stems from its reintroduction history. Several sources of pronghorn were used to repopulate the southeastern pronghorn range in Arizona, including animals from various locations in central Arizona and 2 locations in Texas. Pronghorn introduced from these sources probably contributed to the high percentage of polymorphic loci, through their individual contributions of new polymorphic loci into the reintroduced population. Thus, the higher level of heterozygosity stems from the inflated proportion of polymorphic loci in the southeastern population.

A second noteworthy result is the high number of unique alleles observed in the northeastern population. The northeastern population had 4 low-frequency, unique alleles (i.e., undetected in any of the other regional populations) distributed over 3 loci (AAT-1, AAT-2, and PGI). Although this region received reintroductions from Wyoming (A. Munig and R. M. Lee, Arizona Game and Fish Department, Unpub. data), data from Lee et al. (1994) did not indicate presence of these rare alleles in the Wyoming populations sampled (n = 12 individuals). While it is possible that these rare alleles may have been introduced into the northeastern herd from Wyoming, it is also possible that they may actually be representative of the historical genetic stock of this region. Further analysis of the actual gene frequency data indicated that 1 individual, sampled from Arizona Game Management Unit (GMU) 4A, which received pronghorn from Wyoming, was responsible for the occurrence of rare alleles in 2 of the 4 cases. However, the remaining 2 rare alleles were found in northeastern GMUs with no recorded pronghorn transplants. Presence of these rare alleles is probably indicative of the reintroduction history of this region, as well as the historical genetic structure of pronghorn in this population.

Our analysis of allele frequency differences among the 5 regions sampled in Arizona revealed highly significant differences in allele frequencies across all loci, with ≥ 10 different loci contributing to this differentiation. This is not surprising considering the large geographic

area over which samples were collected and the wide variety of interstate reintroduction sources that have been used to supplement Arizona's pronghorn population (i.e., Colorado, Montana, Texas, Utah, and Wyoming). The high degree of differentiation observed in allele frequencies indicates that there are allele frequency shifts over the broad geographic scale at which we sampled. Potential impacts to the genetic structure revealed by our analyses should be considered prior to further pronghorn reintroductions in Arizona. Further analyses at a finer scale of geographic resolution (e.g., Arizona GMUs) would provide an even clearer picture of gene dynamics in Arizona pronghorn.

MANAGEMENT IMPLICATIONS

Genetic diversity data collected in this study indicate that there are higher than average levels of genetic heterozygosity, numbers of alleles per locus, and percentages of polymorphic loci in Arizona than would be expected for pronghorn in North America. There are significant shifts in allele frequencies among regional pronghorn populations in Arizona, and within regional populations, local gene dynamics may partially reflect recent reintroduction events. Significant genetic variation exists in the Arizona pronghorn population distributed in a nonrandom fashion throughout the state. Future transplant efforts into existing Arizona pronghorn populations should take into consideration potential genetic impacts. Further genetic analysis of the Arizona pronghorn population that specifically takes into account reintroduction history and that focuses on a finer scale of geographic resolution (e.g., GMUs or local herds) is needed to elucidate current patterns of genetic diversity in Arizona pronghorn.

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Appendix 1. Allele frequencies and single locus heterozygosities (direct count) for the variable loci examined in pronghorn antelope sampled in Arizona during 1996.

Locus	Northeast	Central	Northwest	Arizona Strip	Southeast
AAT-1					
(*n*)	97	164	19	19	19
A	0.990	0.951	0.974	0.974	0.895
B	0.005	0.000	0.000	0.000	0.000
C	0.005	0.049	0.026	0.026	0.105
(*h*)	0.021	0.085	0.053	0.053	0.105
AAT-2					
(*n*)	97	164	19	19	19
A	0.979	0.936	0.868	0.974	1.000
B	0.005	0.000	0.000	0.000	0.000
C	0.015	0.064	0.132	0.026	0.000
(*h*)	0.041	0.055	0.158	0.053	0.000
ACP					
(*n*)	97	166	19	19	19
A	0.974	0.970	0.974	0.974	0.947
B	0.000	0.000	0.026	0.000	0.000
C	0.026	0.030	0.000	0.026	0.053
(*h*)	0.052	0.060	0.053	0.053	0.105
ACON					
(*n*)	95	165	19	19	19
A	1.000	0.994	0.947	1.000	1.000
B	0.000	0.006	0.000	0.000	0.000
C	0.000	0.000	0.053	0.000	0.000
(*h*)	0.000	0.000	0.053	0.000	0.000
EST-2					
(n)	92	158	19	19	19
A	0.717	0.915	0.868	0.789	0.816
B	0.283	0.085	0.132	0.211	0.184
(*h*)	0.152	0.120	0.158	0.316	0.053
IDDH					
(*n*)	96	164	19	19	19
A	0.995	1.000	0.974	1.000	1.000
B	0.005	0.000	0.026	0.000	0.000
(*h*)	0.010	0.000	0.053	0.000	0.000

Appendix 1. Continued.

Locus	Northeast	Central	Northwest	Arizona Strip	Southeast
LDH-2					
(*n*)	92	161	17	17	15
A	0.995	0.991	1.000	1.000	1.000
B	0.005	0.009	0.000	0.000	0.000
(*h*)	0.011	0.019	0.000	0.000	0.000
MDH-1					
(*n*)	97	165	19	19	19
A	0.995	0.988	1.000	1.000	1.000
B	0.005	0.012	0.000	0.000	0.000
(*h*)	0.010	0.024	0.000	0.000	0.000
ME-1					
(*n*)	94	166	19	17	17
A	1.000	0.982	1.000	0.971	1.000
B	0.000	0.018	0.000	0.029	0.000
(*h*)	0.000	0.036	0.000	0.059	0.000
ME-2					
(*n*)	93	160	18	17	17
A	0.984	0.984	1.000	0.912	0.765
B	0.016	0.016	0.000	0.059	0.206
C	0.000	0.000	0.000	0.029	0.029
(*h*)	0.032	0.031	0.000	0.059	0.353
MPI					
(*n*)	94	159	16	17	16
A	0.447	0.651	0.625	0.265	0.719
B	0.005	0.013	0.031	0.029	0.031
C	0.548	0.336	0.344	0.706	0.250
(*h*)	0.468	0.321	0.250	0.294	0.313
NP					
(*n*)	94	166	19	17	17
A	0.830	0.843	0.974	0.971	0.706
C	0.170	0.157	0.026	0.029	0.294
(*h*)	0.255	0.253	0.053	0.059	0.471
PGDH					
(*n*)	94	166	19	17	17
A	1.000	0.994	1.000	1.000	1.000
B	0.000	0.006	0.000	0.000	0.000
(*h*)	0.000	0.012	0.000	0.000	0.000

Appendix 1. Continued.

Locus	Northeast	Central	Northwest	Arizona Strip	Southeast
PGM-1					
(*n*)	96	165	19	19	19
A	0.615	0.779	0.789	0.579	0.500
B	0.245	0.124	0.053	0.053	0.316
C	0.141	0.097	0.158	0.368	0.184
(*h*)	0.281	0.206	0.211	0.211	0.421
PGM-2					
(*n*)	96	165	19	19	19
A	0.953	0.997	0.974	0.842	1.000
B	0.047	0.003	0.026	0.158	0.000
(*h*)	0.031	0.006	0.053	0.211	0.000
PGI					
(*n*)	97	166	18	19	19
A	0.985	0.916	0.972	1.000	0.921
B	0.005	0.000	0.000	0.000	0.000
C	0.005	0.084	0.028	0.000	0.079
D	0.005	0.000	0.000	0.000	0.000
(*h*)	0.031	0.169	0.056	0.000	0.158

COMPARISON OF FIXED-WING LINE TRANSECT AND HELICOPTER QUADRAT PRONGHORN SURVEYS

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Abstract: Fixed-wing line transect and helicopter quadrat survey methods were compared for accuracy, precision, and cost. We conducted a cooperative survey (Wyoming and Colorado) to estimate size of an interstate pronghorn (*Antilocapra americana*) population. We compared both survey methods during late spring in 1997 and 1998 on 2,144 km^2 in northern Colorado and southern Wyoming. The density and 90% confidence interval were $1.22/km^2 \pm 26.2\%$ and $1.01/km^2 \pm 29.1\%$ using the quadrat survey for 1997 and 1998, respectively. Line transect survey estimates were $0.90/km^2 \pm 26.1\%$ and $0.71/km^2 \pm 24.1\%$ for 1997 and 1998, respectively. Sampling 10% of the area with quadrats and placing a line every 1.609 km resulted in comparable precision of estimated density. Costs for fixed-wing line transect surveys averaged about $2,000 (10 hours flight time) and costs of helicopter quadrat surveys averaged $7,200 (12.5 hours flight time) for the 2 years of surveys. In this study, line transect population estimates averaged 0.73 of quadrat estimates. Therefore, to adjust fixed-wing line transect survey results to generally match the less biased helicopter quadrat survey results, an approximation can be made by dividing the line transect estimate by 0.73 or by multiplying it by the inverse, 1.37.

Key words: aerial survey, *Antilocapra americana*, Colorado, density, fixed-wing, helicopter, line transect, pronghorn, quadrat, Wyoming.

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Free-ranging wildlife populations have little respect for man-made political boundaries. Where there is contiguous habitat for a species, it is given that a species will move at will within that habitat. Management of any particular herd is usually based on the premise that it is a discrete herd and that management practices apply to the entire herd. When habitat, and therefore the herd, is divided by a state boundary, it is common for different segments of the same herd to be managed differently. Cooperative management efforts are often attempted, but may not be successful because managers may be viewing the population from different databases and may be dealing with different management policies and objectives. Population size may be estimated following different procedures or at different times, resulting in the possibility of either failure to count or duplicate counting of individuals (Springer 1950).

Wyoming and Colorado share a pronghorn herd in the North Park (Colorado) and Big Creek (Wyoming) areas. This herd (NP/BC) has long been considered a contiguous herd, but has been managed separately by the 2 states. This paper reports on a test of 2 survey methods for estimating pronghorn density for the NP/BC herd. We compare results of fixed-wing line transect and helicopter quadrat surveys to provide managers with an evaluation of the more economical fixed-wing line transect method and a "correction" factor to get more accurate estimates of herd size. The ultimate goal of this cooperative effort is a coordinated management plan based on a single data set.

Strip transect surveys, also called conventional trend counts, are the simplest form of transect surveys and have been extensively used for counting pronghorn. This method has serious shortcomings; the most serious are 1) total area coverage is assumed and, 2) counts are not adjusted for the unknown proportion of

animals not observed. This unobserved proportion can vary with counting conditions. Finally, there is no measure of reliability for these surveys (Guenzel 1994). Johnson et al. (1991) demonstrated that by using a sample-based line transect survey technique, it was possible to survey pronghorn herds in Wyoming and obtain reliable population estimates in ≤50% of the flight time required for conventional trend counts.

Line transect methodology is attractive because it does not require that all subjects within the bounds of the transect are seen. Detection functions used during analyses provide a correction for missed animals (Burnham et al. 1980). Other attractive operational features of line transects include: 1) minimal effort is required to establish the survey design (White et al. 1989), 2) they can be done from fixed-wing aircraft that are more economical than helicopters, and 3) they make efficient use of flight time because the survey is continuous except during ferry time between lines. Probably the greatest advantages of line transects are that they are time and cost efficient for large areas and they offer an estimate of reliability (Guenzel 1994). The most stringent assumption of the line transect method, however, is that all subjects in the first distance interval are counted (Guenzel 1997). Accurate delineation of all other distance interval boundaries is important to ensure proper fit of the detection function to the distribution of subjects. Absolute enumeration of subjects in distance bands other than the first is not critical to the successful application of this technique.

We used a helicopter quadrat survey as the standard to compare with the fixed-wing line transect results, because helicopter quadrat surveys are believed to provide the least biased estimate of pronghorn density of practical survey methods available (Pojar et al. 1995). Bias was examined for helicopter quadrat surveys by Pojar et al. (1995) using a secondary search helicopter and observation crew. The secondary helicopter flew behind and about 150 m above the primary search helicopter; the secondary crew recorded location, movement, and number of pronghorn for each group observed on each sample quadrat (2.59 km^2). Mean number of pronghorn seen per quadrat did not differ ($P = 0.346$) between crews, and after adjustments between crews, the population size estimate differed by only 2.1% (Pojar et al. 1995). Thus, over-count bias was not detected and under-count bias would have been proportional to the number of animals that did not flush and were not detected during a search of the quadrat by 2 helicopter search crews. Quadrat searches by the primary helicopter were made at 15-30 m above ground level; Luz and Smith (1976) demonstrated that pronghorn react and flush when subjected to the noise and sight of a helicopter flown at 45 m altitude. Because of this, we believe a near total count of pronghorn is possible on quadrats searched by helicopter.

STUDY AREA

Our study area straddled the Colorado/ Wyoming boarder. Herd units are known as the North Park (Colorado) and Big Creek (Wyoming) units and, combined, are considered a naturally discrete herd unit. There is contiguous pronghorn habitat, and pronghorn movement across the state line is uninhibited by geographical features. In general, the area is located between 106^0 00' - 107^0 50' longitude and 40^0 28' - 41^0 13' latitude. The area is considered an "intermontane park" surrounded by mountains rising 610 - 1,525 m above the valley floor (Steinert and Snyder 1996). The valley floor ranges from 2,550 m elevation in the southern areas of North Park to 2,266 m elevation near Riverside and Encampment, Wyoming, which are contiguous towns on the northern boundary. Walden is the only town in North Park.

Topography of pronghorn habitat on the valley floor is undulating sagebrush steppe (*Artemisia* spp.), with many small drainages from the surrounding high mountain ranges that drain into the North Platte River. The North Platte runs north into Wyoming, with Big Creek and Beaver Creek converging with it from the Wyoming portion of the area. Throughout the entire area, meandering streams are associated with irrigated lowland hay meadows.

METHODS

Fixed-wing line transect surveys were conducted as outlined by Johnson et al. (1991) and included procedures described by Guenzel (1997). Data were analyzed according to guidelines provided by Buckland et al. (1993) using program DISTANCE v2.2 (Laake et al. 1996). A 2-hr training session was held for new observers by an experienced observer (Guenzel). Navigation for both lines and quadrats was with a Global Positioning System (GPS). Quadrats were surveyed as described by Pojar et al. (1995). Universal Transverse Mercator (UTM) coordinates were estimated for each quadrat corner from USGS topographic maps and loaded into the GPS receiver memory. An external GPS antenna was mounted on the tail boom of the Bell-Soloy helicopter for unobstructed reception of satellite signals. A 3-person crew (pilot, secondary observer/navigator, and primary observer) conducted quadrat surveys.

Helicopter quadrat surveys were completed during May 30-31, 1997, and May 29-30, 1998. Fixed-wing line transect surveys were done during May 31-June 2, 1997, and June 7-9, 1998. Colorado personnel conducted line transect surveys in Colorado, and Wyoming personnel conducted the Wyoming portion.

RESULTS

The same 10% random sample of quadrats (83 quadrats) were searched each year with 263 and 221 pronghorn seen in 1997 and 1998, respectively. Total linear flight distance for line transects was 1,537 km (955 miles) in 1997 and 1,477 km (918 miles) in 1998; 175 clusters (groups of pronghorn) were seen in 1997 and 186 in 1998. A reasonable fit to the line transect data was obtained using a half-normal function with 1 cosine adjustment term. The area was stratified by the Wyoming and Colorado portions of the area. It was assumed that estimated group size from the first 2 distance bands was the most accurate, so this mean was used in the population size estimate. Comparisons of accuracy, precision, and cost of the 2 survey methods are in Table 1.

Table 1. Comparison of accuracy, precision, and cost between fixed-wing line transect and helicopter quadrat surveys to estimate pronghorn abundance of the North Park, Colorado/ Big Creek, Wyoming herd, 1997 and 1998.

	1997		1998	
Accuracy	Pop. Est.	Correction[a]	Pop. Est.	Correction[a]
Quadrat	2,607		2,170	
Line Transect	1,932	0.74	1,530	0.71
Precision	Standard Error	90% C.I.	Standard Error	90% C.I.
Quadrat	407	±26%	374	±29%
Line Transect	304	±26%	222	±24%
Cost[b]	Dollars	Time	Dollars	Time
Quadrat	$8,625	15 hours	$5,712	9.6 hours
Line Transect	$2,000	10 hours	$1,974	9.4 hours

[a] The correction for the line transect estimate is expressed as a proportion of the quadrat estimate.

[b] Cost is based on a 10% sample of quadrats and 1,537 km (955 miles) and 1,477 km (918 miles) linear distance of line transect in 1997 and 1998, respectively.

DISCUSSION

Accuracy

Line transect survey estimates averaged 0.735 of quadrat estimates. This gives managers an indication that line transect estimates should be considered approximately 0.73 of the more accurate quadrat estimates. This adjustment can be made by dividing the line transect population estimate by 0.73 or by multiplying by the inverse, 1.37. Using this correction factor adds an unknown amount of variation to the population estimate because this variate will have its own distribution about a mean. This distribution was not discernable with only 2 years of data.

Precision

Precision is affected by sampling intensity. Under the sampling intensity of this study, the precision was essentially equal for each survey method. Given pronghorn density encountered on this area, reducing sampling intensity would reduce number of groups observed and, therefore, increase the variance of the line transect estimate. For example, reducing sampling intensity by one-half would result in fewer than 100 groups on which to base the detection function, and precision would deteriorate to a level of ±50%, which may be unacceptable for most applications. Therefore, under conditions encountered in this study, enough linear flight distance should be designed into the survey to encounter about 200 groups (see Guenzel 1997 for survey design details).

Cost

Cost of both survey techniques is dependent on sampling intensity and desired level of precision. All other factors being equal (cluster density, size, and distribution), the cost differential would increase (helicopter quadrat surveys costing relatively more) as size of the area being surveyed increases. The reason for this is ferry time between quadrats would increase proportionately with area. In contrast, line transect efficiency would increase under conditions where subjects are evenly distributed over a large area and cluster size is not highly variable. Guenzel (1997:35-47) provides extensive discussion of sampling procedures for various area sizes, cluster densities, and cluster sizes. Software to assist in calculating sample size is available (Guenzel 1997). As a general rule, however, the survey should be designed so a minimum of 200 clusters are encountered during the survey. The efficiency of line transect sampling of large areas is demonstrated by Guenzel (1997:37), when he states "...total line length needed to encounter a sample of 200 clusters is the same for a herd occupying 500 mi^2 as for one occupying 2,000 mi^2 if the cluster density is the same." Thus, required line length to be surveyed is dependent on desired precision level and the encounter rate of clusters (i.e., density of clusters) (Buckland et al. 1993).

MANAGEMENT IMPLICATIONS

We provide evidence that fixed-wing line transect survey population estimates may be biased downward. Reasons for this may be violation of the key assumption that all clusters in the innermost distance band are seen. Speed and altitude of the observational platform (i.e., the aircraft) may preclude 100% detection of subjects in the innermost distance band. Another possibility is experience of observers. Guenzel (1997) stresses the importance of training and close adherence to the prescribed line transect protocol to minimize bias. Although relatively expensive, periodic comparison with helicopter quadrat survey estimates should be considered for each herd unit surveyed with fixed-wing line transects. First, to determine if correction is needed. Second, if correction is needed, then to estimate the amount of correction.

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ANESTHESIA OF PRONGHORN IN AN URBAN ENVIRONMENT USING CARFENTANIL AND XYLAZINE

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Abstract: Pronghorn (*Antilocapra americana*) were anesthetized at F. E. Warren Air Force Base in southeastern Wyoming in 1996 and 1997 with pre-measured dosages, based on estimated body weights (BW), of 1.5 mg carfentanil plus 35 mg xylazine (fawns), 2.0 mg carfentanil plus 50 mg xylazine (does), or 2.5 mg carfentanil plus 60 mg xylazine (bucks). Mean induction times were 7.1 ± 1.5 min in 1996 (n = 40) and 6.7 ± 2 min in 1997 (n = 17; P = 0.85). Two adult females died after capture (mortality rate = 4.6%) in 1996 and 1 was released without shipment. No pronghorn died as a result of capture in 1997. Forty pronghorn were translocated to Oklahoma in 1996 and 17 in 1997. Five animals (12.5%) died enroute and 1 moribund pronghorn was euthanized within a week of release in 1996, and 2 died enroute in 1997 (12%). The use of carfentanil and xylazine was a safe, efficacious, and economical method for capturing a large number of pronghorn in an urban area. Also, this operation provided evidence that translocation of pronghorn accustomed to a restricted environment may not move long distances from a release site.

Key words: anesthesia, *Antilocapra americana*, carfentanil, ketamine, pronghorn, Wyoming, xylazine.

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Pronghorn have been captured by a variety of chemical and physical means. Drugs used for chemical immobilization have included succinylcholine (Beale and Smith 1967, Amstrup and Segerstrom 1981), etorphine (Copeland et al. 1978, Autenrieth et al. 1981), or carfentanil (O'Gara 1987). Physical capture has been accomplished by corral traps (O'Gara and Yoakum 1992), linear tangle nets, cannon nets (Amstrup et al. 1980), surround nets (Reeves 1982), and net guns (Barrett et al. 1982, Firchow et al. 1986). For catching large numbers of pronghorn, corral traps are the most efficient; for targeting specific animals, chemical immobilization or net gunning is probably more suitable (Copeland et al. 1978, O'Gara and Yoakum 1992).

Under a cooperative agreement, the Wyoming Game and Fish Department (WGFD) committed to capture and translocate pronghorn to the Oklahoma Department of Wildlife Conservation (ODWC) in exchange for Rio Grande turkeys (*Melagris gallopavo intermedia*). F. E. Warren Air Force Base (WAFB), Cheyenne, Wyoming, was chosen as the pronghorn capture site because: 1) the animals were sedentary and it was felt that they might remain close to the release site; 2) grassland habitat on WAFB was similar to release site habitat; 3) hunting was not allowed and the increasing population was creating safety and depredation problems on the base; and 4) a cooperative agreement between WAFB and the WGFD already was in place to allow capture operations.

Approximately 250 pronghorn live on the 2,315-ha base inhabited by 4,100 people. In December 1995, attempts were made to capture

pronghorn by driving them into a corral trap with ground personnel, but these attempts were unsuccessful. Ground personnel were used instead of helicopters because buildings, powerlines, and roads presented unsafe conditions.

In November 1996, another corral trap operation was scheduled, but based on the 1995 experience, we investigated other capture means. Because pronghorn were acclimated to humans and vehicles, they could be approached closely, and we attempted to chemically immobilize a small number of pronghorn as an adjunct to the main capture operation. Due to the initial success of this chemical immobilization, we continued capturing pronghorn in this manner. Herein, we report on the use of carfentanil and xylazine to chemically immobilize a large number of pronghorn within an urban environment.

METHODS

This operation took place at WAFB on November 18-20, 1996, and again on December 8, 1997. Adults and fawns of both sexes were to be captured. A mixture of the opioid anesthetic carfentanil, plus the alpha-adrenergic tranquilizer xylazine, was used for immobilization because of their demonstrated efficacy on pronghorn (O'Gara 1987, Kreeger 1996). Three pre-measured dosages were employed, based on an initial dosage of 0.04 mg/kg of carfentanil and 1.0 mg/kg xylazine (Kreeger 1996) and on estimated body weights: fawns, 1.5 mg carfentanil plus 35 mg xylazine; does, 2.0 mg carfentanil plus 50 mg xylazine; and bucks, 2.5 mg carfentanil plus 60 mg xylazine. In 1997, 50-100 mg of ketamine was added to each dart to assess if this drug would improve induction times. Prior to the start of operations, several darts were loaded with each of the 3 dosages. The 2-ml, 13-mm (0.50 cal.), single-use darts (Pneu-dart, Inc., Williamsport, Pa.) were equipped with 25-mm, barbed needles.

Most pronghorn were approached and darted from a pickup truck containing 2 shooters and a wildlife veterinarian in back, and a driver and spotter in front. Shooters were equipped with either a CO_2- or .22-cal.-powered dart rifle. Both rifles were capable of adjusting distance that the dart was delivered. As animals were approached, their distance from the vehicle was measured using a range finder and dart guns adjusted accordingly. Usually 1 animal was shot at a time, but sometimes 2 were darted. Animals were then observed until anesthetized.

Once recumbent, animals were blindfolded, hobbled, and examined. One of 2 transport trucks containing a driver and 2 handlers was then contacted by radio to deliver animals to a base camp staffed by a veterinarian and a veterinary technician. At base camp, pronghorn were weighed, examined for injury, given antibiotics and antihelmintics, radio-collared as required, blood sampled for disease screening, given antagonists for carfentanil (100 mg naltrexone per mg carfentanil) and xylazine (0.15 mg yohimbine/kg BW) and placed into a darkened stock trailer. Three stock trailers were used: one that was divided and well padded; another that was divided; and a third that was neither padded nor divided. At the end of each day, captured animals were transported directly to Antelope Hills, Oklahoma, where they were released upon arrival. Pronghorn transported in 1997 were given 10 mg of the tranquilizer diazepam administered intramuscularly to assess if this would calm animals during transport.

Attempts were made to recover all darts that missed animals because carfentanil can be extremely toxic to humans should accidental exposure occur (Kreeger 1996). Many darts were fired in areas frequently occupied by humans. When a dart missed, its approximate location was marked with flags and a team was deployed to search the area visually and with a metal detector.

Recorded data included induction time (time from drug injection to recumbency), BW, and actual drug dosages on a BW basis. Comparison of induction times between years was by one-way analysis of variance, and comparison of transport mortality rates between years was by Fisher's Exact Test at a significance level of $P = 0.05$. Means are reported with standard errors.

RESULTS

In 1996, 43 pronghorn were immobilized: 4 adult bucks, 24 adult does, 7 fawn males, and 8

fawn females. In 1997, 18 pronghorn were captured: 3 adult bucks, 13 adult does, and 2 fawn females. Three of the 1996 pronghorn were darted twice; 2 because the initial dose did not result in complete immobilization, and 1 was accidentally struck twice. Three pronghorn were struck with the dart, did not go down, and were not recovered. Two adult females died after capture in 1996 (mortality rate = 4.6%), and 1 was released because she was questionable for transport. All 3 of these animals ran for extended periods of time before capture. One of the females that died was necropsied by a board-certified wildlife pathologist and diagnosed as succumbing to physiological complications due to stress. There was 1 dart injury that required extensive cleaning and antibiotic treatment. No pronghorn died in 1997 as a result of capture, but 1 female was released because of prolonged induction time.

For 1996 pronghorn, mean induction time ($n = 40$) was 7.1 ± 1.5 min. For 1997 pronghorn, mean induction time ($n = 17$) was 6.7 ± 2 min. There was no difference ($P = 0.85$) in induction times between years. Body weights for adult bucks were 47.6 ± 2.6 kg; adult does, 44.8 ± 2.4 kg; fawn bucks, 36.4 ± 3.4 kg; and fawn does, 35.7 ± 5.9 kg. Actual dosages based on BW were 0.047 mg/kg carfentanil and 1.15 mg/kg xylazine.

Twelve darts either missed animals or hit and bounced out; 9 of these were recovered. The 3 lost darts were in an open field infrequently used by humans. Also, 2 of 3 darts that struck pronghorn (which did not go down) were later recovered.

In 1996, 40 pronghorn were translocated to Oklahoma in 3 successive shipments. The distance traveled was 1,024 km miles and took 15 hrs to complete. Thirteen of these were radiocollared. Five animals (12.5%) died en route, presumably due to trauma caused by other pronghorn. One moribund pronghorn was euthanized within a week of release. Within 2 weeks of release, 4 more animals were found dead, 2 of which were suitable for necropsy. There was a definitive diagnosis of pneumonia for 1 of these 2. Almost 3 months after the release, another pronghorn was found dead and scavenged. Four other animals were never seen again after release, were not radiocollared, and were presumed dead. Two others were last seen alive and well in December and February 1997, have not been recently sighted, and their fate is unknown. As of March 1997, 23 animals in 3 groups were known to be alive; 2 males, 1 herd of 8, and 1 of 13. All animals are within 4.8 km of the release site.

In 1997, 17 pronghorn were transported to Oklahoma. None of these animals were radiocollared. Two pronghorn (12%) died during transport. There was no difference ($P = 0.94$) in mortality rates due to transport between the 2 years. The status of the released animals is currently unknown.

DISCUSSION

Successful capture and transport of pronghorn is difficult at best. Both physical and chemical capture methods have resulted in animal mortality. Six percent of 475 pronghorn died in drive trap operations in Alberta, with an additional 4.2% dying after release. When Alberta pronghorn were drive trapped then transported and released, total mortality increased to 27% (Chalmers et al. 1977). Two percent of 772 pronghorn died in corral trap operations in Wyoming, mostly due to broken necks and legs (Moody et al. 1982). Other trap and transport operations in Wyoming resulted in mortality rates of 1.1 - 17.6%. Although corral trap mortality generally is reported to be 2-5%, overall mortality for trapping and translocation may be higher. O'Gara (B. W. O'Gara, University of Montana, unpublished data) summarized several drive trapping operations and determined trap-site mortality for 5,751 pronghorn to be 4.3%, with an additional 7.5% loss for 1,600 pronghorn transported to a release site.

One of 13 (8%) pronghorn died in 4 capture attempts with cannon nets. Four additional animals died within 2 weeks of capture myopathy or coyote predation (Amstrup et al., 1980). Netgun capture operations have caused mortality rates of 10-13% (Firchow et al. 1986, O'Gara and Yoakum 1992).

Chemical immobilization of pronghorn can result in mortality due to drug overdose, dart injuries, or capture myopathy or other post-capture complications. One of the earliest drugs used to immobilize pronghorns was succinylcholine. Initially, it seemed that this drug was efficacious, when Beale and Smith (1967) successfully immobilized 11 pronghorn from a blind with no mortality. Subsequently, however, Amstrup and Segerstrom (1981) could not recommend use of succinylcholine, when 31 of 46 (67%) attempts to immobilize pronghorn failed and 5 of the 15 (33%) successful immobilizations resulted in mortality.

In helicopter darting operations using etorphine and a tranquilizer, 3 of 9 (33%) pronghorn died from penetrating dart wounds and 2 (22%) others died within 36 hrs of capture (Copeland et al. 1978). In a similar operation, 5 of 26 (19%) pronghorn immobilized with etorphine died directly and 1 died within 24 hours and another within 10 days of capture (Autenrieth et al. 1981).

The use of carfentanil and xylazine on pronghorn was first reported by O'Gara (1987), who darted 5 bucks from the ground with no mortality. However, 5 of 5 (100%) other pronghorn died after antagonism of the carfentanil with naltrexone, 3 of which were due to injury of recovering animals caused by undrugged, rutting bucks (O'Gara and Yoakum 1992). Direct mortality in this study using carfentanil and xylazine was < 5%, which was less than many other capture techniques and considered within acceptable limits (Clark and Jessup 1991). The addition of ketamine to the drug mixture in the 1997 operation did not improve induction times and may have actually caused an adverse reaction. Ketamine hydrochloride is slightly acidic and it seems to cause stinging or burning when administered to domestic animals. In 1997, darted pronghorn ran much further distances before becoming recumbent than they did during the 1996 operation. This increased running may have been due to irritation caused by ketamine. Based on no demonstrable advantage to its use and a suspected disadvantage, we do not recommend addition of ketamine to the carfentanil/xylazine mixture.

Animal losses during transport were most likely due to trauma caused by pronghorn that did not calm down during the trip. Differences among trailers also could have contributed to trauma. Three of 5 mortalities in 1996 occurred in the trailer with no divider or padding. A divided trailer may prevent excessive animal movement and thus injury. Susceptibility to such trauma also could have been exacerbated by a residual drug effect or "renarcotization" of carfentanil (Jessup et al. 1984), resulting in an impaired ability of an animal to protect itself, but this theory could not be confirmed. Mortality occurring several days after capture could have been due to capture myopathy or disease resulting from stress-suppression of the immune system (Chalmers and Barrett 1977). Mortality due to either cause often results from prolonged exertion associated with physical capture or extended transport (Chalmers and Barrett 1977).

Physical exertion, and associated morbidity and mortality, during transport might have been reduced by either tranquilizing the animals (O'Gara and Yoakum 1992) or by physically reducing opportunity for animals to move around within trailers. However, tranquilizing pronghorn with diazepam during the 1997 operation did not seem to have any effect on behavior of animals during transport or on mortality rates. Long-acting tranquilizers (Ebedes 1992) have been used successfully to reduce stress and injury when transporting African antelope, but they have not been tested on pronghorn, and their use on elk (*Cervus elaphus*) resulted in trampled animals. Based on empirical observations, we feel that most mortality that incurred during this operation was a result of prolonged transport.

Comparative costs to other types of capture techniques are difficult. In 1996, we used 13 people in 3 vehicles for 3 days to transport 40 pronghorn. Drug and associated dart equipment costs, including missed darts, amounted to $2,830 ($71/pronghorn).

Given the unique circumstances surrounding this capture operation, we felt that use of carfentanil and xylazine was a safe, efficacious, and economical method for capturing a large number of pronghorn in an

urban area. In addition, it seemed that translocation of pronghorn accustomed to a restricted environment may not move long distances from the release site.

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COLLABORATIVE PROGRAMS FOR MEXICO AND THE UNITED STATES TO ENHANCE PRONGHORN: A REVIEW

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Abstract: During the last 25 years, there have been numerous cooperative endeavors by Mexico and United States (U.S.) sources to enhance pronghorn (*Antilocarpo americana*) in Mexico. Most notable has been the capture of herds in the U.S. and releases in Mexico. Other joint efforts include population surveys, food habit studies, predator control training, endangered species modeling, and financial contributions. Historical and current herd distribution, estimated population numbers, and translocations sites are reported for 4 pronghorn subspecies in Mexico. In addition, a listing of literature references is provided for cooperative investigations and research projects for all subspecies.

Key words: academic theses, *Antilocapra americana americana, A. a. mexicana, A. a. peninsularis, A. a. sonoriensis*, cooperative relation, Mexico, translocations, U.S.

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There are many references and projects substantiating the history of cooperative relationship for enhancing pronghorn between Mexico and the U.S. (see Literature Citation and Appendix 1). Alcerreca and Sánchez-Sotomayor (1979) and the U.S. Fish and Wildlife Service (1998) report that early 1970s was the period many endeavors commenced: e.g., herd translocations, personal training sessions, financial contributions, and exchanges of biological and technical information. Such cooperation continues to modern times, such as that reported for endangered species (Cancino et al. 1996, Castillo et al. 1996, Hervert et al. 1996, Ramírez et al. 1996), predator control training (Linhart 1984*a*), laboratory investigations (Cancino 1988), survey monitoring (Castillo et al. 1996), and population modeling (Cancino et al. 1995, deVos and Thompson-Olais 1996, Hosack 1996).

Objectives of this paper are to report and discuss various collaborative programs between Mexico and the U.S. for enhancing the welfare of pronghorn in Mexico.

TRANSLOCATION OF HERDS

There have been 4 projects to capture pronghorn in the U.S. and translocate them to historic unocupied habitats in Mexico (Fig. 1). Apparently, the first relocation effort was done during 1967 to Tiburon Island in the Gulf of California; however, we have been unable to locate any report providing information regarding plans and procedures of this attempt, finding just a brief reference in a general description of the island (Quiñones 1979). The project was unsuccessful in establishing a herd.

The second attempt was made in 1979, when 52 American pronghorn (*A. .a. americana*), comprising 33 does and 19 bucks from New Mexico, were relocated to San Luis Potosi in exchange for 5 wild sheep (*Ovis canadensis*). The objective was to establish a viable population and to consider the possibility

Figure 1. Translocations (year and state) of pronghorn in Mexico.

of hunting in the future. A management plan was developed and implemented (Alcérreca and Sánchez-Sotomayor 1979). Part of the program included rearing of fawns for release and this was accomplished for 10 (Ramírez 1986). Two males and 2 females survived until 1987 (Palacio 1991).

A herd of 22 American pronghorn from Colorado was relocated to the state of Sonora, Mexico, in 1988 (Thompson-Olais 1994). We have been unsuccessful in finding reports of this project.

Two relocations were made from New Mexico to Coahuila: 1 in 1996 and a second in 1998 (Pallares 1999). Herds were release in the Colombia Valley in northwestern Coahuila. According to feasibility studies completed prior to the release, the site seemed to meet habitat requirements of the species (New Mexico Department of Game and Fish 1993).

OTHER COLLABORATIVE PROJECTS

Other cooperative programs included field and laboratory training (Cancino 1988, Jaramillo 1989), telemetry monitoring (Castillo 1990, U.S. Fish and Wildlife Service 1998), population surveys (Castillo 1990, Cancino et al. 1994, U.S. Fish and Wildlife Service 1998), endangered species workshops (Cancino et al. 1995, Hosack 1996), and financial grants (U.S. Fish and Wildlife Service and Dirección General para la Conservación y el Aprovechamiento Ecologico de los Recursos Naturales 1996). Short descriptions of these projects follow under subspecies categories.

Antilocapra americana mexicana

Fortunately, Villa (1955) was mistaken when he asserted "la última manada" (the last herd) was doomed for Mexican pronghorn. Fortunately for us today, there are several free-roaming herds on Mexico's alto-plano. Treviño (1978), Hinsaw (1990), and González-Romero and Lafón-Terrazas (1993) conducted population inventories in the state of Chihuahua.

Aerial surveys of pronghorn in Chihuahua were also completed during winter 1995-96. The National Ecology Institute, Chihuahua State University, and Mexican Air Force cooperatively conducted the survey. They reported observing 172 pronghorn.

Results from a project working with

Mexican pronghorn are indicative of population viability. During the 1996 fawning season, a herd of 40 pronghorn were observed with 21 fawns (J. M. Reyes, personal communications).

A Pronghorn Management Plan for the State of Chihuahua has been developed. It includes management projects to modify fences for allowing greater pronghorn mobility, capture and translocation of isolated animals, hand rearing for semicaptive management, and predator control during fawning season (J. M. Reyes, personal communications).

Antilocapra americana peninsularis.

Huey (1964) reported on the status of the peninsular pronghorn and stated "...a few reputedly living... north and south of Bahia de Los Angeles", thus not reporting animals in the Vizcaino Desert.

Since the 1970s, human development activities have accelerated in the northwestern region of the State of Baja California Sur. Brown and Webb (1979) reported on a preliminary reconnaissance of the habitat. During 1984, the U.S. government sent a team of wildlife specialists (including Drs. Bart O'Gara, Samuel Linhart, and Julius G. Nagy) to provide recommendations for management of endangered peninsular pronghorn. Linhart (1984*a,b*) prepared reports and made a second trip to help train representatives of Mexico in techniques of predator control. Another benefit from this U.S. team was a suggestion to conduct diet selection studies--later accomplished by Cancino (1988). Two other recommended proposals (nutrient analysis and embryo transfer) are being investigated (O'Gara 1984).

Various other representatives from the U.S. have contributed assistance to the survival of the endangered pronghorn in Mexico. During 1993, Robb Hitchcock (president of the North American Pronghorn Foundation headquartered in Casper, Wyoming) traveled to La Paz to coordinate Mexico-U.S. cooperative relations for pronghorn. Hitchcock noted and recommended implementing several interagency cooperative ventures (The Prairie Press 1994). Hitchcock also encourages James D. Yoakum to conduct a habitat reconnaisance survey of peninsular pronghorn. Yoakum visited the Vizcaino Desert in 1993 and counseled wildlife biologists and administrators of Mexico regarding the need to complete more intensive diet selection studies. He also advocated that success of restoring endangered species can at times be directly related to restoring habitat conditions to meet pronghorn requirements, especially preferred vegetation for nutrient intake.

The first aerial survey, in 1985, of peninsular pronghorn was a cooperative effort with Wyoming Department of Game and Fish. Since 1993, aerial surveys have been made, being assisted by Sandy Lanham of Environmental Flying Services (Cancino et al. 1994).

During November 1994, a weeklong Mexico/U.S. meeting entitled "Population and Habitat Viability Assessment Workshop" was held in La Paz. Delegates exchanged technical knowledge on pronghorn living in desert habitats and developed models using the VORTEX system to determine potential trends of endangered pronghorn (Cancino et al. 1995).

Antilocapra americana sonoriensis.

The U.S. Fish and Wildlife Service (1998) noted that efforts to develop the Sonoran Pronghorn Recovery Plan in the U.S. commenced in 1975. The original Recovery Plan was completed in December 1982 (U.S. Fish and Wildlife Service 1982). Since 1989, cooperative efforts for the subspecies in Mexico have been coordinated with Centro Ecologico de Sonora, Sonora, Mexico. These efforts include telemetry studies, habitat evaluations, herd surveys, population modeling, and public education programs (Castillo et al. 1996, U.S. Fish and Wildlife Service 1998).

In 1998, the Sonoran Pronghorn Recovery Plan for Arizona was revised and updated (U.S. Fish and Wildlife Service 1998). Pertinent information is included regarding data for the Sonora pronghorn in the State of Sonora, Mexico.

Shared Strategies of Peninsular and Sonoran pronghorn Management.

Monson (1968) suggested that these 2 subspecies could be called "desert pronghorn" and considered them 1 subspecies. Population

Viability Assessment workshops have been held for both subspecies (Cancino et al. 1995, Hosak 1996), where it was stressed that genetic studies to verify taxonomic status were needed. Some additional Sonoran and peninsular pronghorn samples have recently been collected. Ryder (1995), and Conde and Medellín (1997) are conducting a comprehensive genetic study.

An embryo transfer project for peninsular pronghorns was suggested by O'Gara (1984). The project could be investigated for both subspecies. Superovulation and interspecies embryo transfer, applied to wild Spanish ibex (*Capra pyrenaica*), have been described by Fernández-Arias (1996). We believe that superovulation is not needed and that the application could be intraspecific. This could require a small herd of *A. a. americana*.

Antilocapra americana americana.

Although the original goal of establishing a viable herd of American pronghorn was not accomplished for the herd relocation to San Luis Potosí in 1972, the project was benefical in generating a Recovery Plan and gaining experience in management activities. Three academic theses were produced as a result of this program (Alcerreca and Sanchez 1979, Ramirez 1985, and Palacio 1991). Future translocations of this subspecies are expected.

ACADEMIC THESES

We would like to mention various theses that have been completed while accomplishing pronghorn management activities beneficial to Mexico.

A professional thesis can be submitted in Mexico as partial fulfillment of an undergraduate degree, and 5 pertaining to pronghorn have been completed to date: Alcérreca and Sanchez (1979), Ramírez (1985), Cancino (1988), Jaramillo (1989), and Palacio (1991).

Treviño (1978) investigated pronghorn in the state of Chihuahua and with findings from this research completed a master of science degree at the University of New Mexico, Las Cruces, New Mexico.

Clemente (1992) studied pronghorn in New Mexico and was successful in submitting his research toward a doctor of philosophy degree at the University of New Mexico, Las Cruces, New Mexico.

CONCLUSION

Between 1972 and 1999, a total of 4 herd translocations, 7 academic theses, at least 6 field workshop and training sessions, and 3 financial grants have been accomplished to enhance pronghorn welfare in Mexico. Governmental agencies, academic institutions, conservation organizations, and individuals have all contributed time and finances to make these endeavors possible. The success of past collaborative efforts is an inspiration that Mexico's new National Pronghorn Recovery Plan (Cancino et al. 1996) may be successful through international cooperation to restore viable population for all pronghorn subspecies in the next millennium.

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HISTORICAL NOTATIONS REGARDING PRONGHORN *(Antilocapra americana)* IN MEXICO

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Abstract: Some evidence exists and assumptions are made regarding humans and pronghorn (*Antilocapra americana*) in northern Mexico; starting with petroglyphs with an age of approximately 2,000 years and other records, like antique documents, oral tradition, and ethnographic descriptions of the first naturalist voyagers.

Key words: Pre-colombian Mexico, pronghorn indigenous names, uses.

Proceedings Pronghorn Antelope Workshop 18:81-83

In a broad sense, the missionary Sahagun first indicated documentation on the man-nature relationship in America. However, with a very particular focus, this note will present evidence concerning the relationship between some pre-Colombian indigenous groups from Mexico and pronghorn. The particular interest in pronghorn is a response to the fact that in spite of its former abundance (no less than 30-40 million, Nelson 1925), Mexican references to this relationship are scarce and widely spread. Similar information for native Americans can be found in Van Wormer (1969) and Turbak (1995).

Evidence includes, in a first category, graphic representations dated to be at least 2,000 years old (Massey 1949), and in a second category, names and uses which were recorded 1,500 years later, during the colonization of Mexico. The criteria for this division, therefore, are chronological. Special consideration is given to stone spearheads, which can be placed in both groups, assuming their use in hunting during both periods.

Of the few records and testimonies describing the relationship between man and pronghorns in pre-colombian Mexico, cave paintings and petroglyphs (Fig. 1) are evidence from the first category. The Baja California peninsula proofs were made approximately 2,000 years ago (Massey 1949). Also, in the states of Tamaulipas (F. Ramirez, personal communication) and Nuevo Leon (Manterola 1994), pronghorn appear in these kinds of paintings.

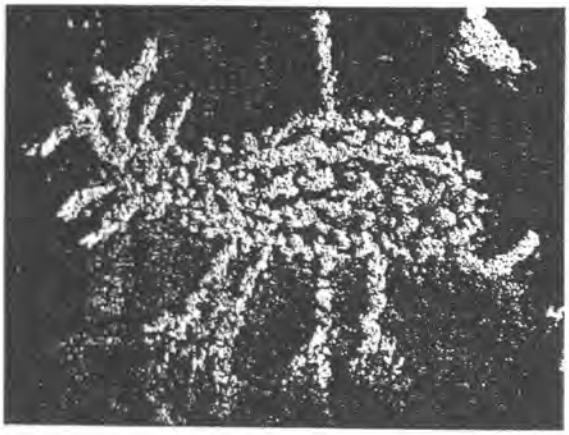

Figure 1. Petroglyph showing a pronghorn hunted with a spear.

In terms of language, there exist several further testimonies. Miguel del Barco (1973), a Jesuit missionary, wrote that the Cochimies, natives from the Baja California peninsula, named the pronghorn "**Ammo-gokio**," which possibly refers to the white color of its rump. In mainland Mexico, other indigenous names for pronghorn include "**Tenthlalmacame**" (Yoakum 1967), which may mean "hart or deer with blunted horns." Valadez (1992) stated that the pronghorn was called "**Tlamacazcamazatl**" in the Nahuatl language, meaning "deer with lengthened face". Hernández (1985, cited by Sánchez 1985) mentions "**Teotlalmazatl**" which meaning is "deer of the sacred land". "**Shejt-cojp**" is the pronghorn's name from the Seri, another native group (R. Medellín, personal

communication). Furthermore, the Papago name for pronghorn is "**Cubida**", meaning "deer that runs in open places" (Fonseca 1995).

In reference to uses of the species, Valadez (1992) stated that the Teotihuacan people utilized pronghorn as food and raw material. He found 1 pronghorn to 5 deer bones in archeological excavations. In the "José Longinos expeditions journal" (which was in 1803), it is stated that the horn of the pronghorn was used to make fishhooks (Bernabéu 1994). Regarding the animal skin used for the ancient Mistec Codex, "Codice Colombino", Alvarez (1966) concluded, after a process of deduction that included 11 possible species, that the hair features of the hide were most probably of pronghorn. In addition, some stone spearheads found in the Vizcaino Desert were in a place where no animal but pronghorn could likely be hunted.

It has been stated that the Spaniards were the first Europeans to encounter pronghorns (Nelson 1925), and Torquemada (1723) was the first to record pronghorns in a written form (Yoakum 1967). Torquemada's report describes a hunt carried out in 1540 in the state of Hidalgo, Mexico. Lumholtz (1904) also described pronghorn hunting in northern Mexico and stated that Apaches used the skin to cover and disguise decoys (Fig. 2).

Figure 2. Pronghorn hunter disguised (photo taken from Lumholtz 1904).

Since the conquest and colonization of Mexico, the history of the pronghorn has changed. Nowadays, its Spanish name is "**Berrendo**", and although we can still find places whose names indicate their earlier presence, we no longer find the presence of the pronghorn name today.

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FACTORS AFFECTING HOME RANGES AND MOVEMENTS OF PRONGHORN ON A SHORTGRASS PRAIRIE OF NORTHERN ARIZONA

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Abstract: Results of a statewide pronghorn antelope (*Antilocapra americana*) habitat analysis (Ockenfels et al. 1996) indicated that pronghorn habitat on Babbitt Ranches in northern Arizona needed enhancement; grasslands possessed low plant diversity, water sources were few in number and frequently inaccessible, and fence structure likely restricted pronghorn movement. We coordinated with Babbitt Ranches to determine specific factors affecting pronghorn populations in that area. We captured, radiocollared, and eartagged 17 pronghorn to monitor home ranges and movements. We used a Geographical Information System (GIS) to estimate distance (km) pronghorn locations were from water sources, fences, and roads. We used concentric series of isometric buffers (0.40-km wide) to measure areas (km^2) for expected distributions. We compared distributions of pronghorn locations to expected distributions with Chi-square contingency tables, Bonferroni simultaneous confidence intervals, and Jacobs' *D*. Pronghorn home ranges and movements were individualistic; no discernable movement patterns were observed. However, fences often dictated home range boundaries. Future project modifications on Babbitt Ranches should include: water quality enhancement, improvement of existing water sources or installation of additional water sources, and fence modifications to improve access to water sources and facilitate pronghorn movements.

Key words: *Antilocapra americana*, fences, habitat modification, habitat use, home range, movement patterns, pronghorn antelope, roads, shortgrass prairie, water sources.

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Pronghorn continue to be a species whose population levels are often below goals established within the Arizona Game and Fish Department's long-range planning document, *Wildlife 2000* (Arizona Game and Fish Department 1996). Because of reduced population levels and restricted distribution within the state, pronghorn have been the focus of considerable research in Arizona during the last 10 years (Ockenfels et al. 1992; Ockenfels 1994*a,b*; Ockenfels et al. 1994; Ticer and Miller 1994; Ockenfels et al. 1996; Ticer 1998). Research efforts have focused on data that best described pronghorn use of habitats and their home ranges and movement patterns. From this information, a landscape habitat model (Ockenfels et al. 1994) was designed and implemented statewide to evaluate potential pronghorn habitats (Ockenfels et al. 1996). These field evaluations included recommendations for manipulating specific habitat factors to enhance pronghorn habitat.

One of the many areas evaluated included 2 back-to-back ranches owned and operated by Babbitt Ranches, Inc. Evaluation of this area in northern Arizona concluded unhealthy vegetative conditions, restrictive fence structure, and low water availability likely inhibited pronghorn use. Consequentially, Babbitt Ranches and resource managers expressed interest in improving this rangeland for pronghorn.

This project was designed to monitor pronghorn herds by evaluating pronghorn home ranges and movements prior to and following planned habitat enhancement projects on Babbitt Ranches. Specific objectives were:

1. Determine home-range sizes and shapes for male and female adult pronghorn.
2. Document pronghorn movement patterns.
3. Determine effects of water placement and numbers on pronghorn home ranges and movements.
4. Determine effects of fence location and design on pronghorn home ranges and movements.
5. Determine effects of roads on pronghorn home ranges and movements.
6. Determine further research needs and develop specific pronghorn habitat enhancement techniques.

STUDY AREA

The study area was located in north-central Arizona along the Colorado Plateau at an elevation of 1,676-1,829 m. Two ranches, situated side-by-side, comprised approximately 182,115 ha of mostly deeded land. The southern end of the study area was mostly checkerboard state and private lands.

This area was arid, with an average of 24.1 cm precipitation annually, most of which occurs in the form of summer monsoons and winter rainstorms (Sellers and Hill 1974). Terrain consisted of flats and gentle, rolling hills bisected longitudinally by steep-walled Cataract Canyon.

Habitat was Shortgrass Plains Grassland integrating with Great Basin Grassland (Brown 1994). Blue grama (*Bouteloua gracilis*) and ring muhly (*Muhlenbergia torreyi*) were predominant grasses. Forbs most often observed included globe-mallow (*Sphaeralcea* spp.), various composites, filaree (*Erodium* spp.), phlox (*Phlox* spp.), and plantago (*Plantago* spp.). Salt-bush (*Atriplex* spp.), buckwheat (*Eriogonum* spp.), winter-fat (*Eurotia lanata*), rabbitbrush (*Chrysothamnus* spp.), and snakeweed (*Gutierrezia sarothrae*) were common shrubs. Extensive stands of rabbitbrush or snakeweed dominated sites in unhealthy ecological status. Big sagebrush (*Artemisia tridentata*) dominated much of the area along 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 of juniper woodlands.

Two well-maintained dirt roads ran east-west through the study area; 1 at the northern end and 1 at the southern end. Dirt 2-track roads occurred throughout. Within the study area, the main ranch headquarters was located centrally, 1 small housing development at the northern and another at the southern, and 1 south-centrally located bunkhouse with corrals was used by ranch workers and research personnel. Human disturbance appeared seasonal. Ranch workers supplementally fed cattle in several pastures 3 times weekly during winter months. Week-long cattle drives involving dozens of ranch workers and approximately 12 semi-trucks were held twice a year during the early spring and again in the fall. Livestock grazing and sport hunting were predominant land uses.

METHODS

We captured, radiocollared, and eartagged adult pronghorn in March 1997 using a net-gun fired from a helicopter (Firchow et al. 1986). We aerially located pronghorn weekly during fawning season (March-July) and twice monthly the remainder of the year. We also ground-located each collared pronghorn twice monthly. Locations were plotted on U.S. Geological Survey (USGS) 7.5-min topographic maps. Universal Transverse Mercador (UTM) coordinates were recorded for each location. Aerial and ground locations were combined and coordinates transferred into a GIS.

Statistical significance was set at $\alpha = 0.05$. Home-range sizes were determined using minimum convex polygons (Hayne 1949). A Mann-Whitney U-test was used to test for gender-related differences in home-range size.

We used GIS technology to evaluate pronghorn use patterns relative to water sources, fences, and roads (Ockenfels and Wennerlund 1994). We did this by measuring area (km^2) within concentric series of isometric buffers (0.4-km wide) around water sources, along fences, and along roads as expected

distributions, then we compared pronghorn distributions among buffers to expected distributions with Chi-square contingency tables, Bonferroni simultaneous confidence intervals (Neu et al. 1974, Byers et al. 1984), and Jacobs' *D* (Jacobs 1974).

We selected 2 pastures to investigate pronghorn distribution around water sources. These pastures were selected because numerous pronghorn home ranges were contained within them. We determined which water sources within these pastures were available to pronghorn using an evaluation that considered factors that may affect pronghorn accessibility to the water sources. Factors included type of water, terrain, adjacent vegetation, burm height (cm), fencing, and distance to human disturbance.

RESULTS

We captured, radiocollared, and eartagged 17 (6M, 11F) adult pronghorn. We acquired 374 locations (271 aerial, 103 ground) between March and December of 1997.

Mean home-range size was 77.2 km^2 (SD = 43.0), and we found no gender-related differences (M-W $Z = -0.201$, $P = 0.841$). Upon visually examining home-range polygons, we could see that numerous home ranges were contained within single fenced pastures (Fig. 1).

We could not detect a difference ($X^2 = 2.16$, 3 df, $0.50 < P < 0.75$, $n = 73$) in pronghorn distribution relative to waters (Table 1), likely because of small sample size or unknown influences. However, pronghorn distribution was substantially affected by fences ($X^2 = 20.00$, 3 df, $P < 0.001$, $n = 165$)(Table 1) and roads ($X^2 = 29.12$, 3df, $P < 0.001$, $n = 326$)(Table 1). Pronghorn selected for the 800-1,200 m class from fences and avoided the 0-400 m class. Similarly, pronghorn selected for the >1,200 m class from roads and avoided the 0-400 m class.

DISCUSSION

Lack of gender-related home-range sizes was consistent with other home range studies conducted in Arizona (Ockenfels et al. 1994, 1997). Pronghorn use of home range generally reflects response to changes in their environment, such as food and water preference and availability, irritating disturbances, and weather conditions (O'Gara and Yoakum 1992; Ockenfels et al. 1994). Although pronghorn home-range sizes did not differ by gender, it is possible that there are gender-related differences of habitat use within home ranges. For example, there are likely gender differences in nutritional requirements during rut and during parturition, which may cause differing use of food items. Knowledge of how pronghorn use areas within their home ranges will assist in determining what habitat modifications or enhancements would best aid pronghorn populations in the area.

Water may be a limiting factor affecting pronghorn densities in the arid Southwest. O'Gara and Yoakum (1992) and Clemente et al. (1995) reported for studies on western rangelands that distribution of pronghorn apparently was related to availability of drinking water. We suspect that water is a limiting factor on this study area. Several livestock water sources within the study pastures were eliminated from analysis because they were not accessible (i.e., fenced) to pronghorn. It is possible that pronghorn used some of these water sources when a gate was left open or when they found a small area of passable fence. Some water sources dried during critical times, such as fawning season.

Pronghorn movements were mostly affected by fences and only somewhat by roads. Some fences acted as movement barriers to pronghorn, as was demonstrated by the number of home ranges constrained within fenced pastures. Statewide habitat evaluations (Ockenfels et al. 1996) found that fences within this study area did not meet game standards as described by O'Gara and Yoakum (1992). Barbed-wire strands close to the ground were typically much less than 41 cm. Additionally, there were many tall (>91 cm) woven-wire fences that were positioned to ground level, which likely preclude pronghorn crossings.

We were surprised that roads affected pronghorn movements in the area because there seemed to be little traffic. We suspect there may be seasonally heavy road traffic during hunting seasons and that increases in seasonal ranch use of roads may affect pronghorn movements more than we originally had thought it would. However, Ockenfels et al. (1994) concluded that

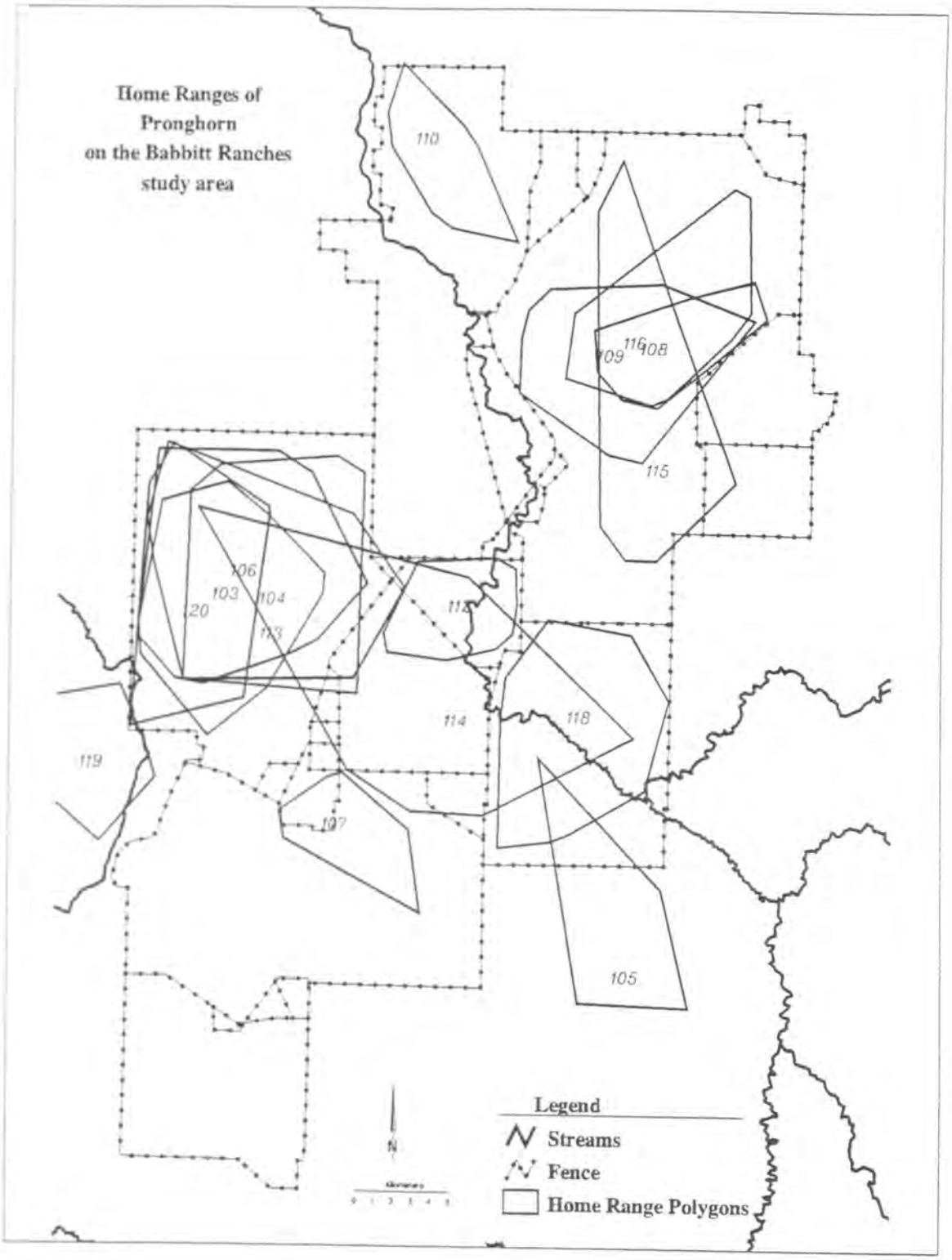

Figure 1. Pronghorn home ranges relative to fences in northern Arizona, 1997.

Table 1. Distances of pronghorn locations in northern Arizona from water sources, fences, and roads compared with percent area in isometric distance buffers, 1997.

Distance class (km)	No. of locations	% of locations	Bonferroni 90% CI	% of area[a]	No. of locations expected	Jacobs' D[b]
Waters						
0-400	7	6.1		7.2	8.3	NS[c]
401-800	21	18.3		18.6	21.4	NS
801-1200	30	26.1		24.4	28.0	NS
>1299	57	49.6		49.8	57.3	NS
Fences						
0-400	32	19.4	12.5 – 26.3	35.5	58.5	-0.39
401-800	51	30.9	22.8 – 39.0	29.1	48.0	NS
801-1200	57	34.5	26.2 – 42.8	25.3	41.8	0.22
>1299	25	15.2	8.9 – 21.5	11.2	18.5	NS
Roads						
0-400	51	15.6	11.1 – 20.1	25.4	82.8	-0.30
401-800	62	19.0	14.1 – 23.9	22.5	73.5	NS
801-1200	69	21.2	16.1 – 26.3	20.0	65.3	NS
>1299	144	44.2	38.0 – 50.4	32.0	104.5	0.25

[a] Based on GIS derived percent area within isometric distance class buffers.
[b] Jacobs' D indicates direction-magnitude of avoidance-selection.
[c] NS = no selection detected. Used as expected.

the combination of roads along fences might inhibit pronghorn use more than unfenced roadways. Such conditions occurred on the ranches. Furthermore, we plan to examine effects of proximity of roads to water sources on pronghorn home-ranges and movements.

MANAGEMENT IMPLICATIONS

Investigations of home range monitoring should further aid in determining seasonal use areas, which would assist in targeting habitat improvements of fawning or key winter areas. Additionally, a large enough sample of locations should be taken to analyze home ranges seasonally, according to gender.

Water quality evaluation, including monitoring presence or absence of water at water sources, needs to be conducted. Water quality may also affect drinking water availability to pronghorn. Livestock may suffer a general loss of condition, weakness, scouring, unthriftiness, reduced milk production, bone degeneration, and death from continuous use of water that contains excessive TDS (total dissolved solids) (O'Gara and Yoakum 1992). It is recommended that TDS levels not exceed 4,500 ppm for livestock (McKee and Wolf 1963). McKee and Wolf (1963) recommended a pH range of 6.5-8.5 for most uses. Sundstrom (1967) found that when the pH of water sources in the Red Desert of Wyoming exceeded 9.2, pronghorn seemed to seek other drinking water sources.

Water levels need to be monitored to determine which water sources are available to pronghorn at critical times. If water is found to influence pronghorn home ranges and movements in the area, then appropriate modifications can be made. Accessibility of water sources could be improved through fence modifications, poor water quality might be improved, or additional water sources could be provided.

Based upon our findings, fence specifications should be designed or modified to meet or exceed game standards, permitting pronghorn movements, as identified in O'Gara and Yoakum (1992). Fence structures within

and surrounding the study area should then be evaluated to determine if fences designed to meet pronghorn access specifications were used by pronghorn.

Although roads influenced pronghorn movements, there is little modification that could be done to improve the situation. Roads are necessary for daily ranch operations, however, fences along the roads could be modified to meet game standards or moved back further from the road to ensure pronghorn ease of travel. During hunts, use of 2-track roads could be restricted. For example, resource and ranch managers of the Fain Ranch in central Arizona found that restricting 2-track road use by hunters greatly reduced habitat damage and eliminated vehicles harassing (chasing) pronghorn and livestock (S. Andrews, Arizona Game and Fish Department, personal communication).

Lastly, pronghorn movements and home ranges need to be evaluated following habitat modifications to determine effectiveness of such alterations on pronghorn.

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EVIDENCE OF INBREEDING EFFECTS ON AN ISOLATED PRONGHORN POPULATION

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Abstract: During a collection of pronghorn (*Antilocapra americana*) on the National Bison Range, Moiese, Montana, during 1965 and 1966, 3 of 32 embryos and fetuses were grossly deformed. No abnormalities were observed in twice as many of a sample collected in Yellowstone National Park during the same period. The only fawn taken into captivity from the Range in 1968 died of a congenital deformity at 4 days of age. Considering the small founder numbers, small population sizes, and that a few territorial bucks did most of the breeding, the possibility of inbreeding depression existed. However, the fact that the herd increased rapidly when coyotes (*Canis latrans*) were controlled, and the small sample size, precludes firm conclusions. Two abnormal fawns were born on the Range during spring 1984, possibly because the feeding area used by their dams was sprayed with 2-4-D and Torodon herbicides during late summer 1983.

Key words: abnormalities, deformity, embryos, fawns, fetuses, herbicides, inbreeding depression, Montana, National Bison Range, population genetics, pronghorn, Yellowstone National Park.

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The purpose of presenting this paper is to document abnormalities of pronghorn embryos in a small, isolated population. Samples presented are small, but may be important if combined with similar information from future studies. With fragmentation of pronghorn populations increasing throughout their range, recording potential inbreeding effects wherever they occur seems important.

Pronghorn were not indigenous to the National Bison Range, Moiese, Montana, but were successfully introduced in 1951 and 1952 for a study to estimate age from tooth eruption and wear (Dow and Wright 1962). After release, the animals were free to roam the 7,500-ha Range. The original herd of 15 animals increased to 120 by 1962 (Refuge Narrative Reports 1956-1977), despite the collection of more than 44 animals while the population was small (P. Wright, personal communication). Although numerous animals were cropped for studies, high recruitment necessitated transplanting about half the population in alternate years (O'Gara and Malcolm 1988). The herd never exceeded 142 animals (Byers 1997*a*). After sodium monoflouroacetate (1080) was banned in 1972, coyotes held the herd at less than 100 animals. When the herd would drop below 80 and most animals were old because of high fawn mortality, limited coyote control would result in good fawn survival and increased population size.

The loss of genetic variation (homozygosity), caused by limited population size, is an important concern for conservation and health of small populations. It has harmful effects on development, survival, and growth rates. The antithesis of such depression is heterosis, an increase in vigor. Increased heterozygosity often is associated with crossing of different (possibly inbred) lines or races (Allendorf and Leary 1986). Also, the possible effects of herbicides on mammals are poorly understood.

Location, physiography, climate, fauna, and flora of the National Bison Range are treated by Morris and Schwartz (1957), Anonymous (1967), and Kitchen 1974).

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METHODS

Between August 1965 and May 1966, 26 pronghorn does were collected by shooting on the National Bison Range, and 83 were similarly collected in Yellowstone National Park, 6 of them during autumn 1967 (O'Gara 1968). Blastocysts were immediately flushed with 5% formalin from the uteri of pregnant does, or embryos and fetuses were weighed, measured, and preserved in alcohol, formalin, and acidic acid (AFA).

RESULTS

Of the 26 does collected on the Range, 16 (including 1 fawn) were carrying 32 embryos or fetuses large enough for abnormalities to be recognizable. Twenty-eight of the 83 does collected in Yellowstone Park had 55 embryos or fetuses *in utero* large enough to be checked for aberrancy. Female fawns collected in the Park were not pregnant.

One of a pair of twin embryos collected on 15 November 1965 was obviously dead. It was 2 mm shorter than its sibling and was light-brown caudally and ventrally after fixing; viable embryos are white when fixed in AFA. The dead embryo had a normal eye and face on one side, but the other side was malformed, resembling somewhat the surface of a cauliflower floret. The sibling appeared normal in color and size, but had an open neuropore exposing the brain. The lower jaw and legs of a fetus from a doe collected on 30 December 1965 were approximately half-normal length.

During spring 1968, I took a fawn into captivity from the Range, and it died at 4 days of age. Necropsy showed that its small and large intestines were not properly joined and it died of peritonitis from intestinal contents spilled into the abdominal cavity.

Two grossly abnormal fawns were born on the Range during 1984. One, found dead, was almost without a nose; the lower jaw wrapped up around its face so the incisors were between its eyes. The other was born alive but only lived about an hour. Its legs were approximately 20% of normal length, its head was huge, and its heart was spherical and about twice normal size. During 1986, I captured 9 does in central Montana and released them on the Range.

DISCUSSION

Two anomalous embryos and an abnormal fetus out of 32 seems high, and none were found in twice as large a sample from Yellowstone Park. That 2 abnormalities from 1 doe are dissimilar is surprising. The "cauliflower head" appeared to represent developmental control gone awry. The open neuropore seemed simply arrested development and represents a condition that is rarely seen in humans and domestic animals.

The fetus with the short jaw and legs resembled fawns occasionally born to sika deer (*Cervus nippon*) in England. There, they are common enough to have been named "Andy Gumps" by gamekeepers. Sika were brought to Great Britain at least as early as 1244 by Norman barons (Harrington 1973). They were kept in small numbers to run with hounds. The staghounds readily caught roe deer (*Capreolus capreolus*) and were large enough to kill them. Red deer (*Cervus elaphus*) would give the hounds and horsemen a good run, but they sometimes killed hounds. Sika provided a good compromise. Because of the small breeding groups, it was assumed "Andy Gumps" resulted from inbreeding. These abnormal fawns usually lived a short time and died (K. Whitehead, personal communication).

Pregnant does were not collected and necropsied on the Bison Range before or since 1965 and 1966. Thus, how common or uncommon *in utero* abnormalities might be is unknown.

The improper joining of small intestine and colon, as seen on the only fawn taken into captivity from the Range, apparently happens in about 1 out of 10,000 human babies (P. McCarthy, M.D., personal communication). Two of 10 fawns taken into captivity during studies in Oregon appeared to have died from congenital problems (Yoakum 1957 and personal communication).

The 2 abnormal fawns from the Range during 1984 may represent only 2 out of hundreds born there. Such grossly deformed animals seldom are seen, either because they are rare or are soon consumed by predators or scavengers and practically never found. Range personnel conducted aerial spraying with 2-4-D

and Torodon for weed control during late summer 1983 (B. West, personal communication). Spraying covered Antelope Ridge, and pronghorn remained and fed there after the spraying.

Whether the seemingly high rate of abnormalities seen on the Range resulted from inbreeding can only be speculated upon. One or 2 bucks did most of the breeding each year (Kitchen 1974), and harems are primarily sister groups (Pyrah 1987). Thus, homozygosity undoubtedly was high in the small population. However, Byers (1997*a*) indicated there was no evidence of inbreeding depression on the Range, and my 35 years of observations of breeding potential there support that contention.

Since the introduction of new blood in 1986, no deformed fawns are known to have been born. Byers (1997*b*) captured fawns nearly every spring from 1981 to 1996 and has not seen any deformities except the 2 reported above (J. A. Byers, University of Idaho, personal communication). Also, my students captured fawns on the Range from 1974 through 1979 without finding abnormalities.

The observations reported here raise the possibility that inbreeding caused the embryonic and fetal abnormalities (and congenital death) in pronghorn on the Range. However, with small sample sizes, and the fact that the population rapidly increased when coyotes were controlled, this report can only serve to alert managers and researchers to the possibility of inbreeding depression in small pronghorn populations. This problem may increase as populations become more fragmented by human-induced barriers to pronghorn movements. Weed spraying seems the most likely explanation for the 2 abnormal fawns that died shortly after birth. Introduction of new breeding stock to the Bison Range pronghorn herd in 1986 may have temporarily eliminated the inbreeding problem, if it indeed existed.

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1996-97 SURVEY OF PRONGHORN

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Abstract: A survey of pronghorn (*Antilocapra americana*) during 1996-97 was accomplished by mailing questionnaires to provincial and state wildlife agencies in Canada, Mexico, and the United States. Survey results were compared with similar surveys conducted during the previous 4 decades. After years of steady increases (1915-1980), this trend began to reverse in 1983; a 34% population decrease occurred from 1983 to 1997, with the most dramatic decline (25-30%) occurring during 1995-1997. Several possible reasons contributing to this downward trend are discussed, with severe winter conditions in 1992-93 and 1996-97 paramount, especially in Canadian provinces and northern states. A recommendation is provided for the Pronghorn Antelope Workshop, at a future meeting, to consider appointing a committee to investigate and periodically report on the decrease/loss of pronghorn habitat throughout North America.

Key words: Antilocapra americana, Canada, Mexico, pronghorn, population survey, United States.

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Extensive surveys of pronghorn have been conducted at various intervals during the past 75 years (Nelson 1925; Yoakum 1968, 1978, 1986; Sundstrom et al. 1973; O'Gara 1996). These surveys indicate that numbers may have exceeded 30 million during the early 1800s, declined to some 15,000 by 1915, and then steadily increased to about 1 million by 1983 (Yoakum 1986). Pronghorn have been cited as hunted big game animals that have benefitted from modern wildlife management practices in North America (Turbak et al. 1995, Yoakum et al. 1996).

The continual population increase from 1915 to 1984 was concurrent with increased human activities on western rangelands. During that time span, thousands of hectares of pronghorn habitat were modified or lost because of conversion of rangelands to agricultural crops and various other human uses. But, even though large tracks of the western landscape were lost to pronghorn, their numbers continued to increase. Human populations in rural areas of pronghorn states also increased 17% between 1910 and 1990, from 10,362,000 to 12,117,000 (compiled from U.S. Statistical Abstracts). The largest increase, 225%, was in Arizona, and the largest decrease, 42%, was in North Dakota. By virtue of closed seasons or closely regulated harvests, and/or other management initiatives in the different provinces and states, pronghorn proved remarkably adaptive to human intrusions. The increase in numbers from 1915 to 1984 probably reflected pronghorn coming back from near extirpation to fill available niches, which were greatly reduced in comparison to pristine times.

The objectives of this paper are to report estimated pronghorn numbers during 1996-97 and compute the current population trend.

METHODS

The Wildlife Management Institute has planned publication of a detailed monograph on the ecology and management of pronghorn. To obtain current pronghorn numbers, a questionnaire was mailed in January 1998 to provincial and state wildlife agencies in Canada, Mexico, and the United States. Pre-hunt numbers of pronghorn during 1996 and 1997

were requested--data comparable to that gathered during earlier surveys. Survey data were obtained by July 1998 and compiled by September 1998. The 1996-97 estimated numbers were then compared with those of similar surveys conducted during the past 4 decades. It was readily apparent that the total pronghorn population had decreased substantially. Accordingly, telephone calls were made to representatives of provincial and state wildlife agencies in an attempt to determine causes.

RESULTS

Estimated numbers for 1996 and 1997 were received from all contacted provincial and state wildlife agencies in Canada and the United States and are reported in Table 1. Figure 1 contains comparable data for similar surveys during the past 4 decades. No response to the 1998 questionnaire was received from Mexico. That country has conducted only 1 nationwide pronghorn survey in the last 4 decades (Gonzales and Terrazas 1993), so no information was available to show pronghorn trends.

When population numbers for 1997 were compared with data for 1995, major changes were evident. Colorado, Kansas, Nebraska, and New Mexico indicated increases, whereas Alberta, Saskatchewan, Montana, North Dakota, and South Dakota reported major decreases (Table 2). Total numbers indicated a 25-30% decrease from 1995 to 1997 and a 34% decrease from the record high in 1983.

Telephone calls to various wildlife agencies to try to determine if reasons were known or postulated for the high losses produced varied responses. No agency contacted reported scientific findings to explain major declines, but each expressed intuitive explanations. For northern herds, the severe 1992-93 and 1996-97 winters, coupled with droughty summers and high coyote (*Canis latrans*) numbers, were reported as factors (G. Erickson [Montana], W. Jensen [North Dakota], D. Dobson [Saskatchewan], C. Shluter [South Dakota], and R. Lanka [Wyoming], personal communications 1999). R. Lee (Arizona Game and Fish Department, personal communication 1998) reaffirmed concern about an insidious loss of habitat to incompatible human developments. In the Great Basin, vegetation remains in poor condition for pronghorn due, at least in part, to intensive livestock grazing and aggressive fire suppression (Yoakum et al. 1996).

DISCUSSION

It should be emphasized that population surveys are merely estimates. However, they generally are accomplished by experienced wildlife biologists familiar with survey procedures and results (Pojar et al. 1995). Recent surveys are more sophisticated than those conducted 30-40 years ago. Survey data provide trend data when computed over a period of years, indicating whether populations are increasing, static, or decreasing.

Twentieth century reports indicate that pronghorn experienced a gradual increase from about 1915 to 1983, remained relatively static until 1995, then plunged some 30% in 2 years (Figure 1). Severe winters, droughty summers, and coyote predation on the northern plains, where pronghorn populations suffered the most dramatic declines, were given as major decimating factors.

Almost certainly, piecemeal attrition of pronghorn habitat, particularly in critical wintering and fawning areas, as well as travel corridors, is accelerating. During the 1980s and 1990s, intensified agriculture, subdivisions, accelerated energy development, upgraded roads, and other activities financed by a continent-wide, growing, affluent society prevailed. Such habitat modification and loss may negatively influence recovery of pronghorn from inevitable weather-induced die-offs. Clearly, loss of pronghorn habitat translates to loss of pronghorn. Unfortunately, habitat losses tend to be insidious, go unreported, and are not analyzed before the loss of pronghorn is substantial.

Based on this assessment, it is recommended that the Pronghorn Antelope Workshop, at a future meeting, appoint a standing committee to investigate and periodically report habitat losses in each of the pronghorn provinces and states.

Table 1. Population surveys for pronghorn in Canada and United States during the 1980s and 1990s. (Note: All figures rounded to 100.)

Political Unit	1983[a]	1989[b]	1995[b]	1996[c]	1997[c]
Canada					
Alberta	21,500	22,300	17,300	10,900	13,200
Saskatchewan	10,000	27,300	22,000	18,500	10,000
Subtotal	31,500	49,600	39,300	29,400	23,200
United States					
Arizona	9,000	9,000	11,000	12,000	10,200
California	6,800	7,000	6,500	5,300	5,600
Colorado	57,500	58,000	68,000	73,200	72,600
Idaho	23,500	21,000	12,500	12,000	12,000
Kansas	1,200	2,000	1,800	2,500	2,500
Montana	161,000	300,000	225,000	77,500	77,500
Nebraska	9,000	2,500	4,100	6,000	6,500
Nevada	9,800	15,000	15,600	14,800	14,500
New Mexico	30,000	30,000	36,000	35,000	35,000
North Dakota	5,700	7,800	10,000	8,200	5,200
Oklahoma	400	600	1,500	1,500	1,500
Oregon	14,000	22,600	17,100	14,300	15,000
South Dakota	67,000	35,000	47,900	36,300	20,500
Texas	12,000	14,500	12,000	10,800	9,600
Utah	6,000	7,000	11,000	9,500	10,500
Wyoming	608,000	450,800	441,500	386,300	370,300
Subtotal	1,020,900	982,800	921,500	685,200	649,000
Total	1,052,400	1,032,400	960,800	734,600	692,200

[a]Yoakum et al. 1996.
[b]O'Gara 1996.
[c]Wildlife Management Institute 1998 questionnaire.

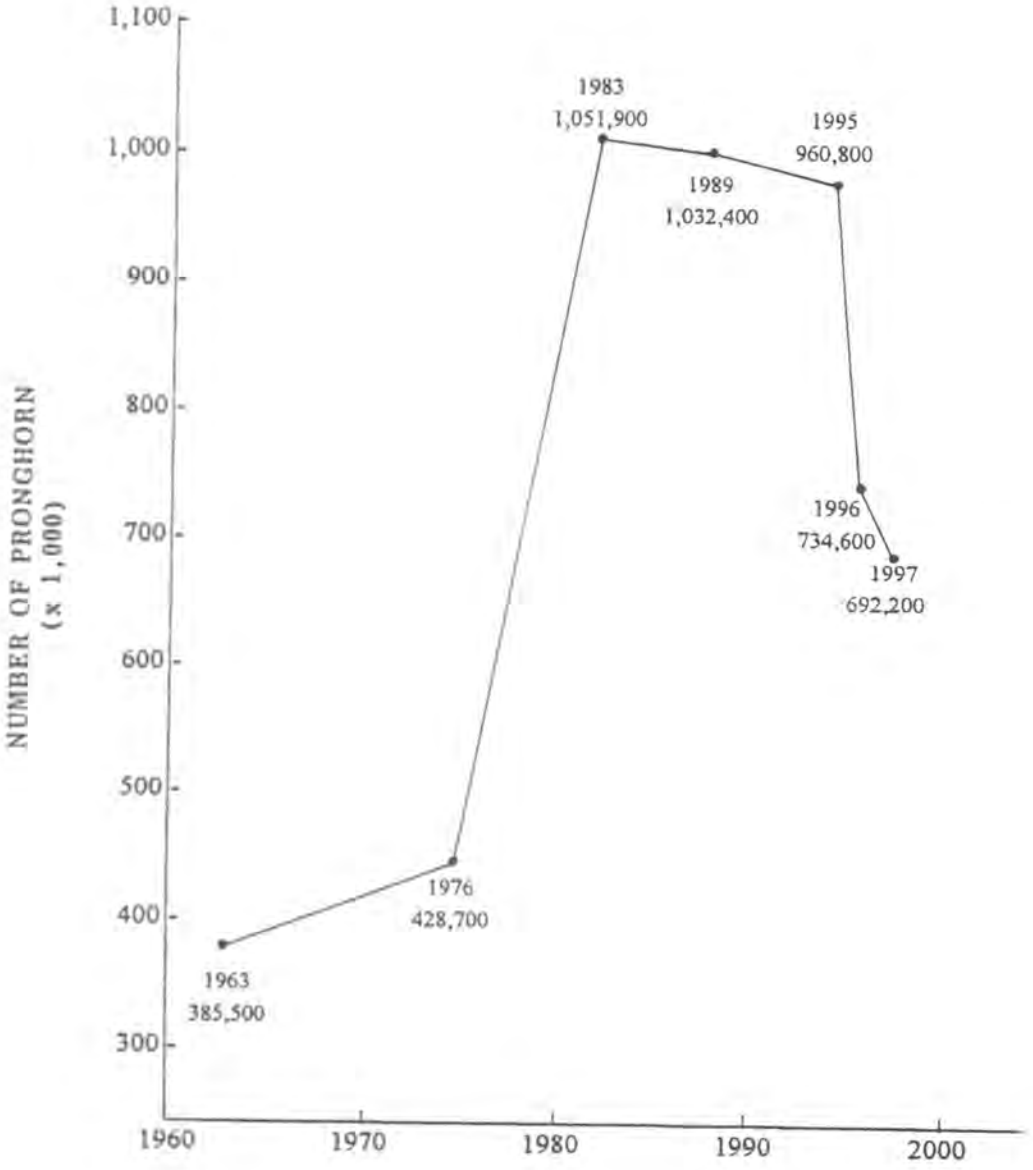

Figure 1. Trend in pronghorn numbers for Canada and the United States from 1963 to 1997, inclusive. References: 1963 (Yoakum 1968), 1976 (Yoakum 1978), 1983 (Yoakum 1986), 1989 and 1995 (O'Gara 1996), 1996 and 1997 (Wildlife Management Institute questionnaire).

Table 2. Trend in pronghorn numbers in Canada and the United States from 1995 to 1997. Percent change in parenthesis.

	Decreased percentage	
Increased percentage	<25	≥25
Nebraska (37)	Texas (20)	Montana (66)
Kansas (28)	Wyoming (16)	South Dakota (56)
New Mexico (14)	California (14)	Saskatchewan (55)
Colorado (6)	Oregon (12)	North Dakota (48)
	Arizona (7)	Alberta (25)
	Nevada (7)	
	Utah (5)	
	Idaho (4)	

Note: Oklahoma population was stable.

ACKNOWLEDGEMENTS

Appreciation is extended to provincial and state wildlife biologists who compiled statistical data for the questionnaire. We thank D.E. Brown, T.M. Pojar, and an anonymous reviewer for helpful comments and suggestions.

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HEALTH EVALUATION OF PRONGHORN ON HART MOUNTAIN NATIONAL ANTELOPE REFUGE, OREGON

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Abstract: One hundred four neonatal and 40 adult female pronghorns (*Antilocapra americana*) were captured on the Hart Mountain National Antelope Refuge (HMNAR) in Lake County, Oregon, during 1996 and 1997 to determine the cause(s) of low fawn survival. As part of that study, a health evaluation was conducted to assess physiological parameters of nutrition and disease to determine if these were involved in fawn mortality. Septicemic pasteurellosis was the only disease found and accounted for 11% of the fawn mortality in 1997, but for none in 1996. This is the first report of this disease in pronghorn in Oregon. Some adults were tested for neutralizing antibodies to *Brucella* spp. (n = 20, neg), *Leptospira* spp. (n = 20, neg), bluetongue virus (n = 20, 35% pos), epizootic hemorrhagic disease virus (n = 20, 30% pos), respiratory syncytial virus (n = 18, neg), parainfluenza virus type I (n = 18, 67% pos), infectious bovine rhinotracheitis (n = 18, neg), and bovine viral diarrhea (n = 18, neg). No abnormalities were found in hematological parameters of adults (n = 40) or fawns (n = 44 to 67). Abnormalities found in biochemical parameters from adults and fawns included low serum total protein and blood urea nitrogen. Selenium levels were considered marginal to low and copper levels were marginal when compared with domestics and other wild ungulates. Copper levels in fawns were correlated with survivability; fawns that perished had significantly (P = 0.02) less than those that survived. Nutritional parameters would suggest that pronghorn on HMNAR exist on a diet low in protein and selenium and marginal in copper which may be reducing range carrying capacity.

Key words: disease, nutrition, pronghorn antelope, serology, serum chemistry, trace minerals.

Proceedings Pronghorn Antelope Workshop 18:99

SEARCHING FOR AND HERDING THE PENINSULAR PRONGHORN

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Abstract: Five aerial searches for the peninsular pronghorn (*Antilocapra americana peninsularis*) were made between November 1995 and June 1997 in the Vizcaino Desert, Baja California Sur, Mexico. There was an apparent population decrease and population spread from previous years, with 149 found in November 1995 and only 3 pronghorns in June 1997. Two different aircraft were used, a Cessna 182 and 2 ultralights. These aerial searches were done with a ground team as support. Herding is the frequent ground search and close observation for individual identification. Records from this activity confirm the Biosphere Reserve's "Nucleus Zone", population is widely dispersed and intensive management is needed.

Key words: Baja California Sur, intensive management, Peninsular pronghorn, Vizcaino Desert.

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INFRARED SURVEY OF SONORAN PRONGHORN ON THE BARRY M. GOLDWATER RANGE

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Abstract: The purpose of this study is to conduct aerial surveys from fixed-wing aircraft using infrared (IR) technology to determine population levels, sex ratios, and group size of endangered Sonoran pronghorn (SPH) (*Antilocapra americana sonoriensis*). Approximately 90% of the known range of the SPH in the U.S. lies under restricted airspace or military operations areas (MOAs) utilized by the U.S. Air Force (USAF). As a federal agency, the USAF is mandated by the Endangered Species Act of 1973 (87 Stat. 884) to manage and protect endangered species inhabiting lands under their jurisdiction. A prerequisite to effectively manage a population is knowledge of the size or density of that population. Information on size or density of a population allows for an understanding of mortality, natality, rate of increase or decrease, dispersal, and competition (Caughley 1977). A reliable method to determine these population characteristics is vital to the study of population dynamics, assessing management activities, impact assessment, developing management programs, and resource protection (Caughley and Sinclair 1994). The knowledge of these population characteristics is especially important in managing an endangered species such as SPH. Previous IR technologies have lacked the ability to determine to sex and age of animals, let alone confirm the species of the animal picked up on the sensor. The most current civilian IR technologies have the ability to determine the species, as well as the sex and age class of the animal. The survey altitude is high enough to avoid disturbance to the animals reducing startling effects and double counting. This study describes a new censusing technique using light, fixed-wing aircraft and forward looking IR (FLIR) with natural-color zoom camera lens to detect and verify SPH.

Key words: aerial surveys, Arizona, Barry M. Goldwater Range, census, infrared surveys, management techniques, Sonoran pronghorn.

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PAYING FOR PRONGHORN ON PRIVATE LAND

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Abstract: Many of Arizona's pronghorn (*Antilocapra americana*) occur on either private or private-State Trust checkerboard lands. Currently, no incentives exist in Arizona for landowners to manage for pronghorn. A phone questionnaire was done to states with pronghorn to determine whether incentive programs existed to compensate landowners if hunting occurred on their property. Many states used a variety of methods to compensate landowners; only Arizona and North Dakota did not have compensation programs. Based on this questionnaire, a mail questionnaire describing 5 incentives was developed. Members of the Arizona Antelope Foundation were then queried as to which incentives would be the most acceptable method of compensating private landowners who allowed pronghorn hunting by the public. Most respondents favored paying ranchers a surcharge or tresspass fee. Compensating ranchers by providing them with special tags or other special antelope hunting opportunities was strongly opposed by most respondents.

Key words: Arizona, human dimensions, hunting, incentives, landowners, private property, questionnaire, trespass fee.

Proceedings Pronghorn Antelope Workshop 18:102

DENSITY DEPENDENCE IN GREAT BASIN PRONGHORN: IMPLICATIONS FOR ADAPTIVE HARVEST MANAGEMENT

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Abstract: Oregon's Great Basin Desert region is on the periphery of pronghorn antelope (*Antilocapra americana*) distribution. Pronghorn habitats are often marginal in this area and populations are characterized by pronounced fluctuations in population size and herd composition. Stochastic factors, such as winter severity, predation, or disease are often suspected of causing these dynamics. However, much of this variability in population growth may be attributable to a predictable pattern resulting from density dependent population regulation. To be successful, harvest management of pronghorn must consider: (1) the strength and predictability of the population's response to management action, and (2) the ability of the management strategy to deal with stochastic events. In this study, we demonstrated how to evaluate the hypothesis of density-dependent population regulation by analyzing time series of standard population survey data. We describe how adaptive population management strategies can be designed from this information. We used a stochastic, logistic simulation model to evaluate effects of harvest strategies and discuss implications for population inventory and adaptive management in pronghorn.

Key words: adaptive management, *Antilocapra americana*, density dependence, harvest, modeling, population dynamics, pronghorn antelope.

Proceedings Pronghorn Antelope Workshop 18:103

SONORAN PRONGHORN USE OF DISTURBED PLANT COMMUNITIES: MANAGEMENT IMPLICATIONS

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Abstract: Habitat use patterns of Sonoran pronghorn *(Antilocapra americana sonoriensis)* were investigated using 6 to 16 radiomarked animals from December 1994 through December 1997. Mean (+/- SE) annual home-range size was 107,789 ha (SE = 18,322 ha) for 1995; 126,328 ha (SE = 46,561 ha) for 1996, and 114,433 ha (SE = 28,135 ha) for 1997. Habitats disturbed by military training activities were used by pronghorn in greater proportion than expected ($P < 0.001$). The disturbed plant communities resulted in opening up habitats and seemed to be an attractant to pronghorn. Annuals (forbs, grasses) persisted longer in the disturbed habitats, thereby resulting in prolonged availability of preferred forage. Predation of adult pronghorn by coyotes (*Canis latrans*) and bobcats (*Lynx rufus*) seemed to be related to habitat type (=vegetative type) and to drought conditions.

Key words: Arizona, disturbances, drought, forage, forbs, habitat use, home range, military training, predation.

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DISTRIBUTION, HABITAT USE, AND COMPETITION BETWEEN PRONGHORN AND FERAL HORSES AT DUGWAY PROVING GROUNDS, UTAH

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Abstract: Pronghorn (*Antilocapra americana*) and feral horse distribution, habitat use, and competition were investigated during 1996-1997 in a Great Basin shrub-steppe environment at U.S. Army Dugway Proving Ground (DPG), Utah. Aerial surveys counted 184-245 pronghorn and 49-87 horses, and in winter and summer pronghorn concentrated in playa and foothill areas, while horses occurred mostly in foothills and mountains. Most of 22 radio-marked pronghorn made subtle range shifts between summer and winter rather than distinct migrations. Most of 18 radio-marked horses used higher elevations near water sources in summer and lower elevations in winter. Overall, pronghorn distribution enveloped horse distribution. Pronghorn and horse 50% core ranges barely overlapped in summer, but closely coincided in winter, in foothill upland shrub habitats. Fecal analysis showed that pronghorn consumed primarily shrubs in winter, forbs in summer, and both in spring. Horses ate mostly grass in summer and spring, but over 60% shrubs in winter. Summed seasonal overlaps of forage peaked at 6% in winter. In summer, divergent diet preferences tend to segregate pronghorn and horses, but in winter both species seek browse and greater spatial overlap occurs, although forage competition remains low due to differing browse species selection.

Key words: diet, feral horses, forage competition, Great Basin, habitat utilization, pronghorn, spatial overlap, U.S. Army Dugway Proving Ground, Utah.

Proceedings Pronghorn Antelope Workshop 18:105

FACTORS AFFECTING SURVIVAL OF NEONATAL PRONGHORN IN THE NORTHERN GREAT BASIN

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Abstract: We investigated factors (predation, health, weather, range condition) affecting pronghorn (*Antilocapra americana*) fawn survival at Hart Mountain National Antelope Refuge in southeastern Oregon during 1996 and 1997. Fifty-two fawns (<1 to 4 days old at capture) were radiomarked and monitored from mid-May to mid-July during each year of the study. Eighty-three percent (86/104) of the marked fawns died during the study. Predation was the major cause of mortality, which accounted for 72% of the fawn deaths. Coyotes (*Canis latrans*) were responsible for 81% of the predator-based mortality where most fawns were killed within the first 3 weeks of life. The least number of deaths (n=5) were associated with disease (weak fawn syndrome and *Pasteurella multicida*) and starvation. No apparent relationship existed between mortality rates and health and weather variables that suggested fawns were predisposed to predation. Forage availability during both years was acceptable for pronghorn. Reduction in fawns lost to coyote predation would likely result in an increase in summer fawn survival.

Key words: coyote, fawn, Great Basin, health, mortality, predation, pronghorn, radiotelemetry, recruitment, survival.

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DENSITY DEPENDENT SUMMER PRONGHORN SURVIVAL RATES IN THE NORTHWESTERN GREAT BASIN--REVISITED

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Abstract: Density dependent (DD) pronghorn (*Antilocapra americana*) fawn survival was strongly evident in the northwestern Great Basin population 11 years after originally reported despite a catastrophic 6-year drought ending in a record setting winter in 1993. California and Oregon continued to collect comparable data, but Nevada dropped its winter survey in 1994. With 38 years of winter census data and 43 years of summer composition data, the correlations among all state samples were as robust ($P < 0.001$) as they were with 32 years of data. A linear regression comparing winter totals and the following summer doe samples showed a very strong relationship ($r^2 = 0.9481$, $y = -1409.5 + 0.3863x$, $n = 38$, $P < 0.001$). A linear regression comparing the natural logarithms of the winter census totals and the succeeding summer fawn/doe ratios resulted in a substantial negative relationship ($r^2 = 0.5071$, $y = 2.377 - 0.201x$, $n = 38$, $P < 0.001$), strongly reaffirming DD in this pronghorn antelope population. Fawn predation, starvation, abandonment, and weak fawn syndrome are symptoms of DD in the northwestern Great [illegible] causes of low fawn survival. With the pronghorn population >4X that of the 1950s, it is questionable if low [illegible] is a real biological problem. Either a relocation program or a liberal hunting strategy reducing pronghorn antelope population density would produce more fawns much cheaper than predator control.

Key words: antelope, *Antilocapra americana*, California, census, density dependent, fawn ratio, Great Basin, Nevada, Oregon, predation, population.

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NAVAJO NATION PRONGHORN STATUS

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Abstract: The Navajo Nation's pronghorn (*Antilocapra americana americana*) population is estimated at 250 animals. The majority occur near Sanders, Arizona, in the southcentral part of the Navajo Indian Reservation. This is the only hunted population. An annual fixed-wing aerial survey and mandatory harvest check is used to monitor the Sanders population and determine harvest. Three buck permits were issued in 1997, with a 100% success rate. Navajo Fish and Wildlife Department is currently working with Petrified Forest National Park to transplant pronghorn into adjoining Navajo Nation/Park lands to augment an existing herd.

Key words: aerial survey, Arizona, harvest, Navajo Nation, Petrified Forest National Park, transplant.

Proceedings Pronghorn Antelope Workshop 18:108

STATUS OF THE NORTHERN YELLOWSTONE PRONGHORN HERD

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Abstract: The northern Yellowstone pronghorn (*Antilocapra americana americana*) herd occupies part of the extreme northern portion of Yellowstone National Park (YNP) and adjacent lands in Montana, and seems to be isolated from other pronghorn populations in Montana and Wyoming. The YNP population has experienced an apparent precipitous decline in population numbers over the last 6 years, falling from a high of 594 animals in 1991 to approximately 250 animals in the fall of 1997. Active management of this herd within the YNP boundary ceased in 1968. The state of Montana currently issues 5 either-sex rifle season permits for this population, which is also part of a multi-region archery hunting area. The annual harvest since the hunt began in 1991 has been estimated at 2-36 animals. Current monitoring efforts consist of annual spring and fall aerial counts, winter ground counts, periodic ground composition counts, and surveys of coyote (*Canis latrans*) density on winter range. Anticipated research consists of a proposal to conduct modelling of the effectiveness of various management strategies in enhancing the pronghorn population. Because of the biological and historical significance of this population, concern is mounting over the current decline in numbers. A recent population viability analysis has shown that the probability of extinction of the YNP pronghorn herd is approximately 18% in 100 years, a risk well above the threshold usually considered acceptable. Findings from a pilot study of fawn mortality indicated that coyote predation on fawns may be causing extremely low recruitment rates. In addition to predation and hunting, factors contributing to the decrease in pronghorn numbers may include increasing human use of portions of limited winter range, invasion of exotic vegetation into winter range, and competition for limited range with elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), and bison (*Bison bison*).

Key words: aerial counts, coyote, decline, extinction, harvest, Montana, mortality, predation, viability, Wyoming, Yellowstone National Park.

Proceedings Pronghorn Antelope Workshop 18:109

18th BIENNIAL PRONGHORN ANTELOPE WORKSHOP

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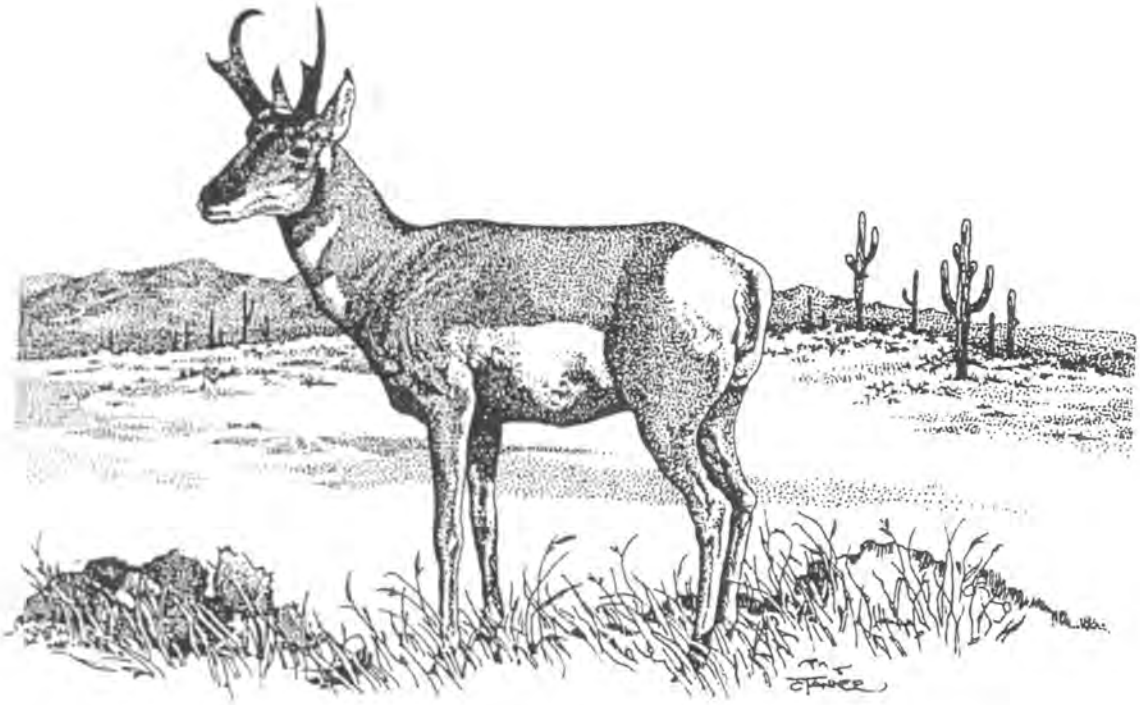


ORGANIZATION and FUNCTION of the PRONGHORN ANTELOPE WORKSHOP

BYLAWS

I. Designation

This organization shall be known as the "Pronghorn Antelope Workshop." The official publication of the Workshop shall be known as the Pronghorn Antelope Workshop Proceedings.

II. Goal

The goal of the Workshop is to provide information relative to and encourage the perpetuation of sustainable wild stocks of pronghorn antelope as an ecological, aesthetic, and recreational natural resource on western rangelands, both public and private, at their most productive levels consistent with other proper land uses.

III. Objectives

A. To provide an opportunity for all persons interested in pronghorn antelope to meet and discuss current research and management of the species and its habitat.

B. To provide a vehicle for disseminating research and management findings to the various agencies and organizations concerned with pronghorn antelope management.

C. To promote species-oriented research for development of new information on all aspects of pronghorn antelope ecology, life history, and management on western rangelands.

D. To identify particular problems associated with pronghorn antelope management and to formulate recommendations and resolutions directed to the appropriate agency or organization, including the Western Association of Fish and Wildlife Agencies.

E. To promote cooperation among all agencies and organizations concerned with pronghorn antelope management and research, particularly among the various provincial, state, and federal agencies with the primary responsibilities of managing this species and its habitat.

IV. Organization

A. The Workshop shall be open to any person interested in pronghorn antelope and its management.

B. Voting

Voting members shall consist of one representative of each of the following:

1. States, provinces, and countries.

Alberta, Arizona, Baja California Sur, California, Chihuahua, Coahuila, Colorado, Idaho, Kansas, Montana, Mexico, Nebraska, Nevada, New Mexico,

North Dakota, Oklahoma, Oregon, Saskatchewan, Sonora, South Dakota, Texas, Utah, Washington, Wyoming.

2. Federal Agencies.

   Bureau of Land Management, Canadian Wildlife Service, Forest Service, Fish and Wildlife Service, National Park Service, Natural Resources Conservation Service, Parks Canada, and the Direccion General de Fauna Silvestre.

3. Universities and Colleges.

   The chair may appoint up to three people to represent colleges and universities. This appointee shall come from any college or university actively engaged in pronghorn antelope research.

Voting representatives for the states, provinces, and countries shall be appointed by the agency directly responsible for wildlife management within the above named states, provinces, and countries.

The chair shall request that each of the above named federal agencies appoint one voting member. This request shall be directed to one of the regional offices or service centers in the western United States, Canada, and Mexico.

Voting shall be accomplished only by those authorized representatives in attendance at the business meeting of the Workshop.

C. The Workshop will be scheduled biennially on even number years. The host state, province, or country shall select the time and place of the meeting. The host shall appoint one of its representatives who will act as chair. The duties of the chair shall be:

1. To serve as chair for the two-year period following his/her appointment.
2. To call for papers and prepare an agenda for the Workshop and assemble and distribute any recommendations or resolutions made or passed at the Workshop.
3. To prepare and distribute the proceedings of the Workshop for which he/she has been responsible.
4. To organize and conduct the meeting and business of the Workshop.
5. To appoint committees as necessary.
6. To maintain the goals and objectives of the Workshop.
7. To prepare and make a formal report to the Western Association of Fish and Wildlife Agencies.

D. The new host state, province, or country shall be selected and announced at the business meeting of the Workshop. It is the intent of the Workshop that host state, province, or country will be volunteered on a rotating basis among the actively participating member states, provinces, and countries.

E. The mailing list of the Workshop shall be:

1. The Western Association of Fish and Wildlife Agencies.
2. The Director and Game Chief of every member state, province, and country.
3. All biologists known to be conducting pronghorn antelope research.
4. All Bureau of Land Management State Offices and Regional Service Centers in the western United States.
5. All Regional Forest Service Offices in the western United States.
6. All Fish and Wildlife Service Regional Offices in the western United States.
7. All Natural Resources Conservation Service Regional Offices in the western United States.
8. All Cooperative Wildlife Research Units in the western United States.
9. All persons attending the Workshop.
10. Any person or organization requesting a copy of the Proceedings.

F. The chair shall forward the mailing list and other pertinent material to the new Workshop chair upon completion of his/her responsiblities as chair of the current Workshop.

As amended on March 27, 1998, at Prescott, Arizona.
18th Biennial Pronghorn Antelope Workshop
Richard A. Ockenfels, Chair

Ratified by Western Association of Fish and Wildlife Agencies
Jackson, Wyoming
July 2, 1998

WORKSHOP AGENDA

18th Biennial Pronghorn Antelope Workshop
March 23-27, 1998
Prescott, Arizona

MONDAY, MARCH 23 GRANITE MOUNTAIN ROOM

3:00 - 9:00 p.m.	Check-in, Registration, Merchandise sales
6:00 - 9:00 p.m.	Informal Reception *Hosted by Arizona Bowhunters Association*

TUESDAY, MARCH 24 COTTONWOOD ROOM

6:00 - 8:30 a.m.	Field Trip to Native American Archaeology Site
9:00 - 9:15 a.m.	Welcome, General Opening, Messages
9:15 - 9:45 a.m.	Keynote Address by *Dr. Guntram F. A. Werther,* **Globalization processes, emerging patterns of societal change, and the future challenges of wildlife management**
9:45 - 10:15 a.m.	General Address *by James C. deVos, Jr., Arizona Game and Fish Department,* **Challenges to pronghorn managers into the next millenium: a case study**
10:15 - 10:40 a.m.	Break
10:40 - 12:00 noon	State Status Reports by *Cindy L. Ticer and Amber Alexander, Arizona Game and Fish Department*
12:00 - 1:20 p.m.	Lunch (on your own)
1:20 - 3:00 p.m.	Technical Session I - Health and Genetics
3:00 - 3:30 p.m.	Break
3:30 - 5:00 p.m.	Workshop (ArcView GIS - statewide pronghorn habitat)
5:00 p.m.	Evening on your own - Enjoy!

WEDNESDAY, MARCH 25 COTTONWOOD ROOM

9:00 - 10:20 a.m.	Technical Session II - Management Techniques
10:20 - 10:40 a.m.	Break
10:40 - 12:00 noon	Technical Session III - Management Issues
12:00 - 1:20 p.m.	Lunch (on your own)
1:20 - 2:40 p.m.	Technical Session IV - Life History and Research
2:40 - 3:10 p.m.	Break
3:10 - 4:30 p.m.	Workshop (Limiting Factors on Pronghorn Populations)
6:00 p.m.	**GRANITE MOUNTAIN ROOM** - Semi-formal Banquet (entertainment included, awards) *Hosted by Arizona Game Rangers Association*

THURSDAY, MARCH 26 FIELD TRIP

7:00 a.m.- 5:00 p.m.	All day field trip (Prescott Valley, Cherry, Dugas) that includes hosted dinner & refreshments by *Arizona Antelope Foundation, International Association of Fish and Wildlife Agencies*, and *Valley of the Sun YMCA (Chauncey Ranch Camps)*

FRIDAY, MARCH 27 PRESCOTT-CHINO ROOM

6:00 - 8:30 a.m.	Local field trip to historical Sharlot Hall Museum
9:30 - 12:00 noon	Business Meeting (representatives of states & provinces of Western Association of Fish and Wildlife Agencies)
1:30 - 5:00 p.m.	Informal discussion in the central lounge area

Technical Session I - Health and Genetics
Tuesday, March 24, Cottonwood Room 1:20 - 3:00 p.m.
Moderator: Jim deVos, Arizona Game and Fish Department

1:20 - 1:40 p.m. Analysis of genetic differentiation in Arizona Pronghorn. *E.R. Reat, O.E. Rhodes, Jr., J.R. Heffelfinger, and J.C. deVos, Jr.*

1:40 - 2:00 p.m. Health evaluation of pronghorns on Hart Mountain National Antelope Refuge, Oregon. *M.R. Dunbar, R. Velarde, M.A. Gregg, and M. Bray*

2:00 - 2:20 p.m. Occurrence and distribution of bluetongue virus and copper/selenium levels in Arizona's pronghorn. *J.R. Heffelfinger and R.J. Olding*

2:20 - 2:40 p.m. Blood chemistry and trace mineral values for pronghorn antelope in Oregon. *D.G. Whittaker, M. Bray, and L.D. Conn*

2:40 - 3:00 p.m. Genetic variation in pronghorn antelope from Arizona. *O.E. Rhodes, Jr., R.N. Williams, J.R. Heffelfinger, L.K. Page, E.R. Reat, and J.C. deVos, Jr.*

Workshop I - ArcView GIS
Tuesday, March 24 Cottonwood Room 3:30 - 5:00 p.m.
Instructors: Susan R. Boe and Susan M. Schuetze, Arizona Game and Fish Department

Informal, interactive training session to introduce participants to the use of ArcView v3.0, a Geographic Information System mapping and query software for personal computers. The demonstration and training will use the 1996 statewide pronghorn habitat evaluation database for Arizona. Participants can query the habitat evaluation results of many of the Game Management Units in Arizona.

Technical Session II - Management Techniques
Wednesday, March 25, Cottonwood Room 9:00 - 10:20 a.m.
Moderator: Raymond M. Lee, Arizona Game and Fish Department

9:00 - 9:20 a.m. Searching for and herding the Peninsular pronghorn. *V. Sanchez-Sotomayor, J. Cancino, C. Olivera, and A. Galas*

9:20 - 9:40 a.m. Interstate pronghorn survey: comparison of fixed wing lines and helicopter quadrats. *T.M. Pojar and R.J. Guenzel*

9:40 - 10:00 a.m. Infrared survey of Sonoran pronghorn on the Barry M. Goldwater Range. *S. Bernatas, R. Spaulding, P.J. Mock, and D. King*

10:00 - 10:20 am. Chemical immobilization of large numbers of pronghorn in an urban environment using carfenyanil and xylazine. *T.J. Kreeger, B. Lanka, T. Smith, and T.G. Smeltzer*

Technical Session III - Management Issues
Wednesday, March 25, Cottonwood Room 10:40 a.m.-12:00 p.m.
Moderator: James R. Heffelfinger, Arizona Game and Fish Department

10:40-11:00 a.m. Paying for pronghorn on private land. *D.E. Brown, N.L. Lewis, D.R. Johnson, and R.A. Ockenfels*

11:00-11:20 a.m. Density dependence in Great Basin pronghorn: implications for adaptive harvest management. *S.G. Kohlmann, D.G. Whittaker, and M. Hedrick*

11:20-11:40 a.m. Past and present Mexico-United States relationship concerning the pronghorns. *F. Ramirez, J. Cancino, j. Maria Reyes, and V. Sanchez-Sotomayor*

11:40-12:00 Sonoran pronghorn use of disturbed plant communities:management implications. *J.J. Hervert, L.A. Piest, W.B. Ballard, R.S. Henry, and M.T. Brown*

Technical Session IV - Life History
Wednesday, March 25, Cottonwood Room 1:20 - 2:40 p.m.
Moderator: Amber Alexander, Arizona Game and Fish Department

1:20-1:40 p.m.	Evidences of the relationship between man and pronghorns (*Antilocapra americana*) in pre-Columbian Mexico. *J. Cancino and F. Reygadas*
1:40-2:00 p.m.	Home range and movement patterns of pronghorn on a shortgrass prairie of northern Arizona. *C.L. Ticer, S.R. Boe, R.A. Ockenfels, and J.C. deVos, Jr.*
2:00-2:20 p.m.	Distribution, habitat use, and competition between pronghorn and feral horses at Dugway Proving Grounds, Utah. *S.A. Boyle, L.L. Mead, and S. Bates*
2:20-2:40 p.m.	Factors affecting survival of neonatal pronghorn in the northern Great Basin. *M.A. Gregg, M. Bray, K.M. Kilbride, and M.R. Dunbar*

Workshop II - Limiting Factors on Pronghorn Populations
Wednesday, March 25 Cottonwood Room 3:10 - 4:30 p.m.
Moderator: Richard A. Ockenfels, Arizona Game and Fish Department

This session will be an open forum (i.e., discussion) of the various factors that limit pronghorn populations. Factors such as habitat quality, density dependence, genetics, nutrition, predation, rut hunting, doe/fawn hunting, poaching, climatic conditions, and habitat loss impact the survival of adult and young pronghorn, or adversely impact reproduction. The concepts of limiting factors will be discussed. Researchers and managers will present their views and perceptions about population dynamics. The workshop will illustrate that no single factor is totally responsible for limiting pronghorn populations over the entire range, or even in a herd over time.

Poster Session
Tuesday, March 24 - Wednesday, March 25
Cottonwood Room All Day

A variety of posters and displays from organizations will be available for viewing before, during breaks, and after sessions. Poster presenters will be available to discuss their findings or organizations. Set up will be on Monday afternoon-evening or Tuesday morning (prior to 8:30 a.m.). Take down will be prior to Wednesday, 5:00 p.m.

Banquet
Wednesday, March 25, Granite Mountain Room
6:00 p.m. - 10:00 p.m.

6:00 p.m.	A buffet serving starts. Silent auction begins. Keg of beer provided, cash bar for mixed drinks.
6:45 p.m.	Jim Yoakum will give a brief note on Art Einarsen and the 1948 publication of ***The Pronghorn Antelope - and its Management.***
7:00 p.m.	Representatives of North American Pronghorn Foundation and Arizona Antelope Foundation will present brief introductions of their organizations.
7:30 p.m.	Musical entertainment.
8:30 p.m.	Raffles, silent auction ends.
9:00 p.m.	Music until 10:00 p.m. for relaxation and dancing.

BUSINESS MEETING AGENDA

18th Biennial Pronghorn Antelope Workshop
March 23-27, 1998
Prescott, Arizona

A. 9:00 a.m. Call to Order: *Chair Richard A. Ockenfels, Arizona Game and Fish Department*

B. Identify Voting Members

According to current bylaws, only one representative from each of 20 state, province, and country (Mexico), each of 7 federal agency, and up to 3 colleges and universities (appointed by chair) may vote.

C. Amendments to Bylaws

Minor editorial changes: 1) agency or organization name changes, 2) gender changes.

D. 1998 Pronghorn Management Guides: *Ray Lee, Arizona Game and Fish Department*

Discussion and vote on how to pay for the cost of printing 1998 Guides.

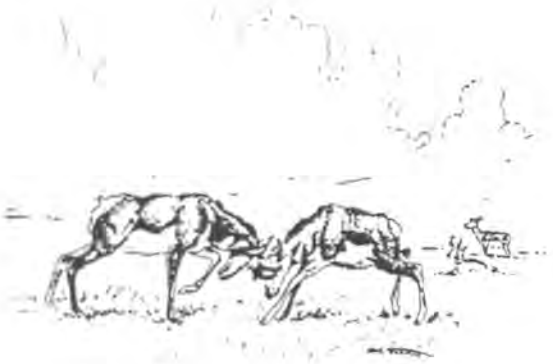
E. Selection of site of 19th Biennial Pronghorn Antelope Workshop for year 2000.

F. Certificates of Appreciation for co-sponsors and contributing hosts.

Co-sponsors, Arizona Antelope Foundation and North American Pronghorn Foundation. Contributing hosts, Arizona Bowhunters Association, Arizona Game Rangers Association, International Association of Fish and Wildlife Agencies, and Valley of the Sun YMCA.

G. Other New Business

H. Close of Business by Chair.



BUSINESS MEETING
18th BIENNIAL PRONGHORN ANTELOPE WORKSHOP

PRESCOTT, ARIZONA
MARCH 27, 1998

The business meeting was called to order by Chair Richard Ockenfels at 9:30 a.m.

Delegates were present from Arizona (Ray Lee), Colorado (Tom Pojar), Nevada (Mike Hess), North Dakota (Bill Jensen), and Baja California Sur (Jorge Cancino). Bart O'Gara (Univ. of Montana) represented the universities and colleges, whereas Paul Podborny (Nevada, Ely District) represented Bureau of Land Management. Seven voting members were noted.

Also present were non-voting Cindy Ticer, Amber Alexander, Carol Evans, and Jim deVos of Arizona Game and Fish Department; Wilma O'Gara (Montana, retired); Jim Yoakum (Nevada, retired); Dan Friese of Luke Air Force Base, Arizona; Melissa Smith (California, Merced Zoo); and Kim Brinkley (California, Los Angeles Zoo).

19th Biennial Pronghorn Antelope Workshop

The first order of business was selection of the next site for the 19th Workshop. Jorge Cancino (Centro de Investigicones Biologicas, La Paz) represented Mexico in requesting that the 19th Workshop be held in La Paz, Baja California Sur, in 2000. Jim deVos and Ray Lee provided support by noting that this would help provide credibility for the research and management programs in Mexico. deVos and Lee will provide assistance to Jorge and the rest of Mexican biologists in the preparation of the meeting through the Arizona Game and Fish Department international program. Richard Ockenfels and Cindy Ticer will provide Jorge with the necessary information to organize the meeting. deVos discussed the facilities in La Paz and noted that tickets would cost approximately $200-300 more, depending on flight origination. **Moved (Ray Lee) and seconded (Bart O'Gara) that 19th Workshop be held in La Paz, Baja California Sur. Passed 7-0.**

1998 Pronghorn Management Guides

Ray Lee (Arizona Game and Fish Department) presented information on the newly revised and printed management guidelines. Lee noted that printing funds were provided by Arizona Antelope Foundation, a non-profit organization from Phoenix, Arizona. Chair Richard Ockenfels noted that approximately 40 copies were sold at the Workshop and recommended that excess Workshop funds, if available, reimburse the Foundation for some of the printing. Following discussion on how and to whom these guides should be disseminated, a motion was formulated to use excess monies to send guides to member organizations and encourage them to purchase additional copies from the Foundation. **Moved (Ray Lee) and seconded (Bill Jensen) that the 18th Workshop purchase copies and distribute to the Western Association. Passed 7-0.**

Jim Yoakum and Mike Hess expressed concerns that these guides may not be readily available to those who really need them, which includes all field biologists. Bill Jensen suggested that a copy be sent to all states that did not attend the Workshop. Tom Pojar recommended making use of the Internet to advertise the guides. Paul Podborny suggested a guide be sent to each BLM state office. **No action taken.**

Jorge Cancino requested that a Spanish version of the guides be produced. He would investigate the possibility. **No action taken.**

Jim Yoakum recommended that a committee be formed to produce revisions of future management guides. This committee would begin working on the revisions immediately and also seek funding for printing and distributing costs to ensure that a sufficient number of copies be produced and available to all biologists working with pronghorn antelope. **Chair Richard Ockenfels assigned Cindy Ticer, Tom Pojar, and Jim Yoakum as volunteer committee members.**

Bylaw Revisions

Richard Ockenfels requested that the bylaws be updated to gender neutral, to correct organization names, and to correct miscellaneous punctuation, gammar, etc. Richard presented a strikeout-Redline version with recommended changes.

Jim Yoakum further recommended changing IV.B.1 so that Mexico be treated as other countries by acknowledging 4 states as voting members; Baja California Sur, Chihuahua, Coahuila, and Sonora. He further recommended that IV.B include a section for other organizations (e.g., North American Pronghorn Foundation, Arizona Antelope Foundation) and a section to include private consultants.

Mike Hess cautioned against adding sections IV.B.4 and IV.B.5 at this meeting and moved that Chair Richard Ockenfels be authorized to complete the requested changes to gender neutral, organization names, gammar, and adding states of Mexico. Bart O'Gara seconded motion. **Moved (Mike Hess) and seconded (Bart O'Gara) to have Chair make necessary changes and modify IV.B.1 to include 4 states from Mexico. Passed 7-0.**

Dan Friese (Luke AFB) requested that the Department of Defense also be included in the organization as a voting member. Bill Jensen motioned to include IV.B.4 and IV.B.5 sections. Discussion by Mike Hess and Ray Lee that the Workshop is sanctioned by the Western Association of Fish and Wildlife Agencies (WAFWA) and must represent members interests. **Motioned died for lack of second. No action taken. It was decided that such proposed changes be a point of discussion at the 19th Workshop.**

Jim Yoakum continued to argue his case to amend IV.B.4 and IV.B.5, to maintain life in the organization. Discussion agreed to his points, but Amber Alexander and Chair Richard Ockenfels reminded everyone that any changes in the bylaws must be approved by WAFWA. It was decided that Chair Richard Ockenfels would write a letter to WAFWA regarding these future considerations, likely through Arizona Game and Fish Department.

Workshop Recognition

Chair Richard Ockenfels noted that he was preparing acknowledgements for the organizations that contributed or sponsored the symposium. These organizations included North American Pronghorn Foundation and Arizona Antelope Foundation as co-sponsors, and Arizona Game Rangers Association and Arizona Bowhunters Association as contributors. **No action taken.**

17th Biennial Pronghorn Antelope Proceedings

Amber Alexander suggested incorporating the 17th Workshop proceedings into these proceedings since the 17th was not finished yet. Chair Richard Ockenfels strongly argued against such a move, as it would also jeopardize the 18th Proceedings. Instead, a motion was formed to have Chair Richard Ockenfels send a strong letter of request to California Department of Fish and Game reiterating that the 17th Workshop proceedings were the obligation and responsibility of the host agency to complete and distribute. **Moved (Bart O'Gara) and seconded (Tom Pojar) that the chair send letter to California Department of Fish and Game. Passed 7-0.**

National Pronghorn Antelope Interpretative Center

Jim Yoakum suggested that somebody obtain information regarding the construction of the NPAIC in Wyoming, so that we could provide technical support. Jim mentioned that it would be a great educational opportunity. A motion was formed that Chair Richard Ockenfels appoint a committee or someone to investigate the matter. **Moved (Tom Pojar) and seconded (Mike Hess) to have a committee look into the NPAIC. Passed 6-1. Carol Evans, Tom Pojar, and Jim Yoakum agreed to be the committee, with Carol as chair. Chair Richard Ockenfels so appointed the volunteers to a NPAIC Committee to report at La Paz in 2000.**

IUCN

Jim Yoakum brought up the idea that we should become involved with the antelope sub-group (specialty group) of the IUCN. Kim Brinkley (Los Angeles Zoo) agreed to act as a conduit between us and IUCN, and will discuss her findings at the 19th Workshop in La Paz.

18th Workshop Recognition

Mike Hess led a notable pat on the back to Arizona Game and Fish Department for pulling off a great symposium.

Adjournment

Chair Richard Ockenfels adjourned the meeting, as all necessary business was completed. The meeting adjourned at 11:30 a.m.

Submitted by Cindy Ticer, Arizona Game and Fish Department
Co-Chair
March 27, 1998

Edited by Richard Ockenfels, Arizona Game and Fish Department
Chair
April 21, 1998

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