TECHNICAL NOTE Technical Note 347

U.S. DEPARTMENT OF THE INTERIOR – BUREAU OF LAND MANAGEMENT

Habitat Management Guides for the American Pronghorn Antelope

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By

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1980

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ABSTRACT

The objective of this technical report is to provide a synopsis of knowledge regarding the life history, ecology, and management of the American pronghorn antelope in the sagebrush-grassland steppes of North America. Emphasis is given to the management of the habitat. Four basic principles of habitat management are described warranting the attention of wildlife biologists and habitat managers. The relationships of pronghorns to domestic livestock are discussed with suggestions for dual-use management. Under habitat improvements, techniques are provided that are beneficial to antelope regarding how to develop waters, manipulate vegetation, and construct fences. Several case histories are included substantiating that prescribed habitat management practices have resulted in changing low-quality habitat conditions to preferred habitat. The basis for such practices is proper design and implementation of techniques recognizing the pronghorn's habitat requirements. This has resulted in wider pronghorn distribution and increased populations. Conversely, improperly designed and implemented habitat manipulation practices have limited occupied rangelands.

Key words: Habitat management; habitat requirements, range improvements; livestock-antelope relationships; herd transplants; water developments; vegetation manipulation; livestock fences; multiple-use management.

ACKNOWLEDGEMENTS

The concept for "Technical Notes" containing a synopsis of information on how to manage habitats for wildlife was developed by John Crawford, Chief, Division of Wildlife and Endangered Species, USDI, Bureau of Land Management, Washington, D.C. The purpose was to have readily available for the desk of each field wildlife biologist a report containing known techniques and practices for managing the habitat for a featured species. This report on pronghorns is the third accomplished to date. The others are deer and sage grouse. Copies are available by writing to the U.S. Bureau of Land Management, Denver Service Center, Building 50, Denver, Colorado 80225.

The author recognizes and appreciates the assistance provided by many individuals in completing this report. Gratitude is especially expressed to the following for their endeavors: Don Spalinger, Mike Hansen and Larry White for collecting and analyzing field data, Peg Evers for research services and intensive manuscript review; Mayo Call for publication guidance; Don Seibert and Ed Roberts for clearing financial publication obstacles; Dennis Anderson and co-workers for professional cartography services; Pat Hansen for all drawings including the cover, first made available for publication in this report; and Linda DiMaggio for hours and hours of meticulous manuscript typing.

CONTENTS

INTRODUCTION

American pronghorn antelope are symbolic of the wide open western rangelands of the United States. They are endemic only to North America. Approximately 45 percent of all herds in the U.S. inhabit public lands administered by the USDI Bureau of Land Management (Colorado State University 1969). The USDI Bureau of Land Management (hereafter referred to as BLM) is, therefore, concerned with this unique American animal's welfare and future. One way to perpetuate healthy herds of pronghorns is through the dissemination of knowledge pertaining to basic ecological and managerial principles and practices -- the primary objective of this report. Since BLM's primary responsibilities are relative to land management, major emphasis in this report will be placed on habitat management.

Early records often referred to the pronghorn as "antelope", a term handed down through generations, resulting in its common use today. Therefore, use of "antelope" is acceptable; however, "pronghorn" is used more frequently in scientific writings. Since both terms are actually correct and commonly used, they are synonymous and both will be used throughout this report.

PRONGHORN BIOLOGY

HISTORICAL BACKGROUND

When Lewis and Clark crossed the North American prairies in 1804, there was an estimated 40 to 60 million buffalo and possibly the same number or more of pronghorns. The nineteenth century started with exploration ventures, but ended as a period of heavy exploitation of natural resources. Consequently, the vast herds of buffalo and pronghorns decreased from millions to remnant herds of hundreds. It was predicted by sincere naturalists at the turn of the century that the pronghorn was doomed to extirpation. Actually, the world's population of pronghorns had been decimated to approximately 10 thousand animals -- only a fraction of one percent compared to pristine herds.

The 20th century produced an era of conservation-minded Americans. During 1924 and 1925, the first extensive inventory of pronghorns was made and the total population was estimated at about 24,000. The next half century (1925-1975) witnessed the return of the American antelope to the western rangelands. During this fifty-year period, antelope numbers increased over 1,500 percent and at the same time, provided over a million recreation days for sportsmen (Yoakum 1978). The American pronghorn was again back on the scene providing aesthetic and recreational values that typify the wide-open rangelands of the west.

ECOLOGY

Taxonomy

The pronghorn is a member of the family *Antilocapridae*. During the Pleistocene epoch, there were many genera; however, only one genus existed when Lewis and Clark collected the first specimen for science in 1804 (Thwaites 1905). It was from animals in this collection that George Ord (1818) ascribed the scientific name *Antilocapra americana*. Thus, the pronghorn maintains a unique status in North American big game since it is the only native ungulate possessing scientific nomenclature for a single family, genus, and species.

The scientific classification for the pronghorn is primarily based on the prong of the horns and the annual shedding of the horn sheaths; however, this classification is currently being questioned by some scientists (O'Gara and Matson 1975).

Currently the five subspecies and their general areas of distribution are:

A. a. americana Ord (1918) - American pronghorn: ranges throughout the Great Plains of Canada and U.S.; most abundant sub-species; also inhabits western mountain and Great Basin states in U.S.

A. a. oregona Bailey (1932) - Oregon pronghorn: sagebrush steppes of southeastern Oregon; range extent not determined.

A. a. mexicana Merrian (1901) - Mexican pronghorn: limited ranges in southern Arizona, New Mexico, Texas and central Mexico.

A. a. peninsularis Nelson (1912) - Peninsula pronghorn: original range was southern California south into Baja California; now exists only in Mexico; listed as endangered in 1980 (Federal Register 1980).

A. a. sonoriensis Goldman (1945) - Sonoran pronghorn: central western plains of Mexico to southern Arizona; listed as endangered 1980 (Federal Register 1980).

DISTRIBUTION AND ABUNDANCE

The pristine range of pronghorn during the early nineteenth century was most of the western Great Plains, the high sagebrush steppes and valleys in the Great Basin states, parts of south central Canada and northern Mexico (Nelson 1925, Einarsen 1948). By the 1920's, the ancestral range had been drastically reduced. Actually, antelope did not inhabit all the area outlined by Nelson and Einarsen, as these early publications documented the antelope's general distribution pattern. There were areas within the range not inhabited by antelope such as the Rocky Mountain crest.

Rangelands occupied today by antelope are outlined in Figure 1. Most of their original rangeland is still inhabited today. Reintroductions since the 1920's have extended the range back into many historical areas. In addition, antelope have been translocated to three states not occupied during historical times -- Hawaii, Florida and Washington. The transplants to Hawaii and Florida were unsuccessful while that to Washington is experiencing problems.

During 1922-24, Edward Nelson conducted the first extensive census of antelope, recording 26,600 in the United States (Table 1). Within the next decade, the population skyrocketed to over 130,000, to 246,000 by 1944, and 360,000 by 1954. The population evidently began to reach a

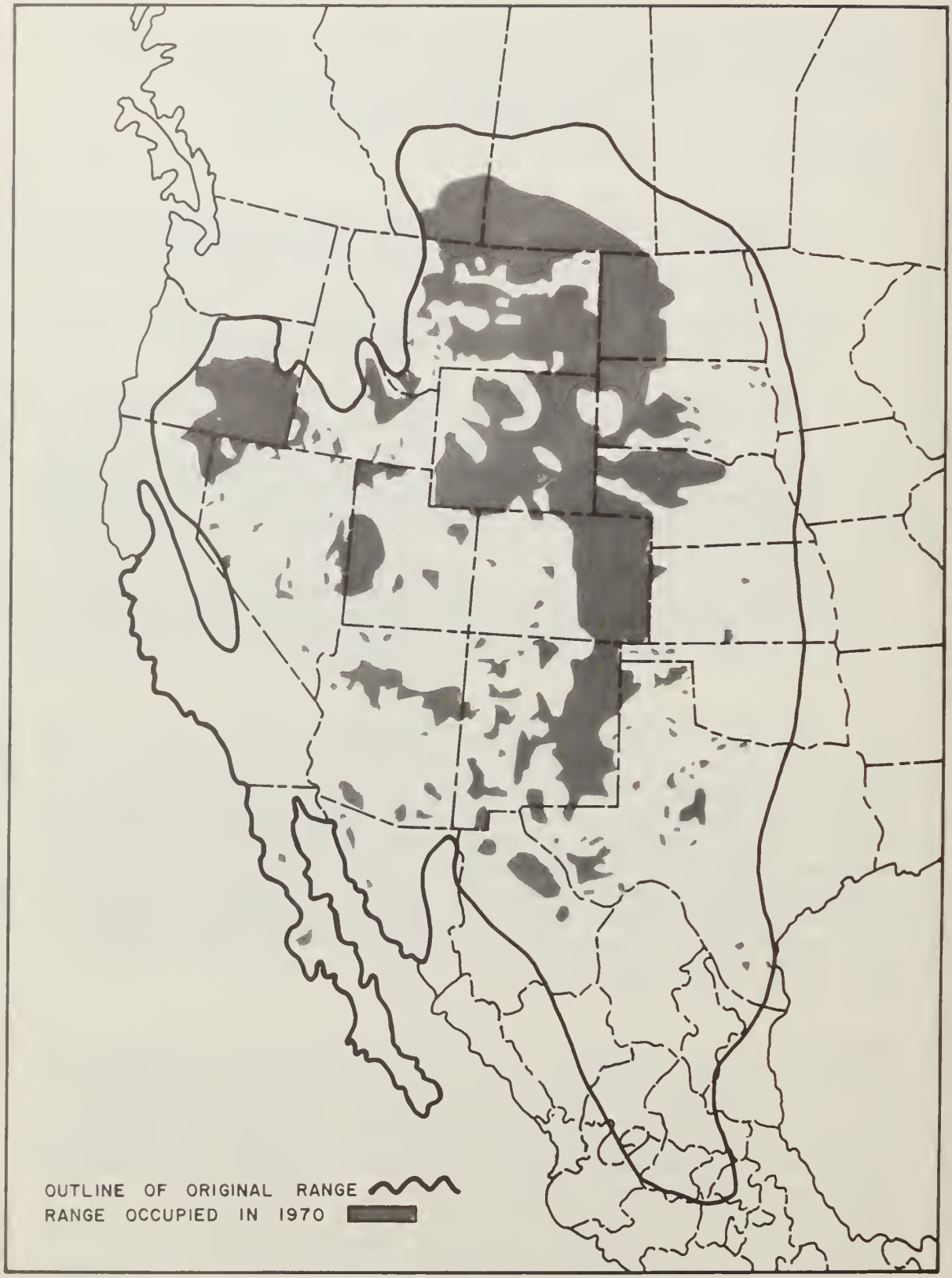

Fig. 1. Distribution range of American pronghorn. The area delineated for "original range" (modified from Nelson 1925) denotes only peripheral boundaries as not all areas within were inhabited. Range occupied in 1970 graphically modified from Sundstrom et al. (1973).

leveling-off point for it increased only another 5,000 by 1964. The estimated U.S. population total is now 406,400, which is approximately a 1,500 percent increase from the original census in 1924 (Tables 1 and 2).

Population estimates for Canada show a similar pattern of increased numbers during the 1900's. The counts jumped from 1,300 in 1924 to 22,300 in 1976, or a remarkable increase of around 1,600 percent (Table 1).

Data for Mexico is lacking in detail compared to the United States and Canada. In 1924, it was estimated that 2,400 antelope ranged throughout Mexico. Today it is assumed that there are around 1,000 animals. Within the past decade, the Mexican government has pursued efforts to increase numbers by translocating several herds from the United States to various sites in Mexico.

Life History

Mating occurs during late summer when bucks fight for harems of as many as 15 does. Often the mating season lasts only two to three weeks. The gestation period averages 252 days. The doe then seeks solitude during the parturition period of May-June. She usually has a single fawn at the first birth and then twins thereafter. At birth, fawns weigh from 5 to 7 pounds and are nourished by the doe's milk which is rich in solids. For the first week of life, the fawns remain inactive as they grow and gain strength. However, at the early age of about 5 days, they can outrun man. Within 3 weeks, the fawns begin to nibble vegetation and by 3 months they acquire adult-like pelage. Antelope can mate at 16 months and apparently breed throughout life, which generally runs 7 to 10 years (O'Gara 1978).

Population Dynamics

The fecundity of antelope averages 180 fawns per 100 breeding does. Survival by the end of summer on high-density ranges averages 100 fawns:100 does, whereas low-density ranges more frequently have ratios of 50 fawns (or less) per 100 does.

Antelope mortality rates were intensively studied for two herds in Oregon over a three-year period (Yoakum 1957). It was determined for 225 carcasses of known-age deaths that 38% died during the period of birth to two months, 12% during 3 to 6 months; 8% during 7 to 11 months; and the remaining 42% during 1 to 10 years.

Sex and age ratios over a 10-year period for an increasing antelope population in Colorado averaged 66 bucks:100 does:86 fawns (Hoover et al.1959). Buck numbers would no doubt have been higher in a non-hunted area. The figure for does included animals of all ages making the proportion for fawns seem small. A ratio averaged over a 7-year period for a relatively static population in Oregon indicated a

population ratio of 40 bucks:100 does:26 fawns (Yoakum 1978).

Mortality Factors

Factors affecting the survival of antelope have been studied extensively for the past 3 decades. Of these, predation has been researched the most. Coyotes and bobcats are recorded as the most consistent predator, especially on newborn fawns (Udy 1953, Yoakum 1957, Compton 1958, Beale and Smith 1973). Raptor predation was recorded as light (Hinman 1959). The importance of predation as a limiting factor appears relative to habitat conditions. Studies of predation on fawns in Alberta (Barrett 1978) and Nevada (McNay 1980) substantiated that as high as 50% of the annual fawn production succumbed to predation for both study sites. However, herds on grassland ranges in Alberta maintained high doe:fawn ratios, whereas the desert shrublands of Nevada experienced low doe: fawn survival ratios.

Intensive research regarding diseases has been well investigated (Einarsen 1948, Yoakum 1957). Pronghorns are noteworthy for their relative lack of epizootic diseases. Two fairly common non-epizootic diseases recorded were keratites (pinkeye) and actinomycosis (lumpy-jaw). Parasites, both external and internal, are likewise uncommon for antelope. Some reasons listed for the infrequency of diseases and parasites are the antelope's behavior of remaining in small groups, non-frequent use of moist areas, and constant daily movements resulting in infrequent use of the same feeding and bedding locations.

Natural accidents such as miring in muddy lakes, drownings, and locking horns take a minor toll each year. Severe winters with deep snows probably affect antelope populations the greatest through decreasing the animal's ability to obtain a sufficient quality of nutritional forage.

Man-influenced accidents such as road kills take a larger number of animals each year, especially on high-speed freeways. Barbed and woven-wire fences undoubtedly create one of the most serious problems today. Although resident antelope adapt to fencing, other herds forced to make seasonal movements because of deep snows on traditional wintering grounds experience major mortality problems. These herds, forced to move to forage grounds at lower elevations, become victims when fences limit their mobility to obtain adequate forage.

Since the highest recorded death loss for herds in the Great Basin is within weeks after birth, wildlife managers are investigating neonatal factors. It is postulated that does during the last three months of pregnancy lack quality nutritional forage to produce and maintain healthy wildlings at birth. This appears to correlate with the high doe:fawn ratios of the more succulent and diversified vegetative ranges in the plains states compared to the low doe:fawn ratios in the sagebrush steppes of the Great Basin ranges.

Table 1. Comparison of estimated pronghorn populations in North America, 1924-1976 (Yoakum 1978).

Region	1924[1]	1976	Change from 1924-1976 Number	Change from 1924-1976 Percent
Canada	1,300	22,300	+ 21,000	+ 1,615
Mexico	2,400	1,000	- 1,400	- 58
United States	26,700	406,400	+ 379,700	+ 1,422
Total	30,400	429,700	+ 399,300	+ 1,313

[1] Data from Nelson (1925). All population estimates rounded to closest 100.

Table 2. Estimated pronghorn populations, 1924-1976, and recorded harvests, 1934-1976, for the United States (Yoakum 1978).

Area	Population 1924[1]	Population 1976	Percent Increase	Recorded Total Harvest 1934-1976
Arizona	700	7,300	943	18,200
California	1,100	5,000	355	5,100
Colorado	1,200	31,000	2,483	102,100
Idaho	1,500	13,300	787	34,000
Kansas	10	1,100	10,900	200
Montana	3,000	71,200	2,273	485,700
Nebraska	200	9,800	4,800	22,300
Nevada	4,300	6,500	51	6,200
New Mexico	1,700	26,900	1,482	45,000
North Dakota	200	8,100	3,950	43,100
Oklahoma	20	200	900	100
Oregon	2,000	11,300	465	18,200
South Dakota	700	33,500	4,686	152,900
Texas	2,400	10,500	338	27,500
Utah	700	2,600	271	2,700
Washington		50		
Wyoming	7,000	168,000	2,300	999,200
Total	26,700	406,400	1,422	1,962,500

[1] Data from Nelson (1925). All pronghorn population numbers rounded to closest 100, except for Kansas, Oklahoma, and Washington.

Behavior

The timing and length of antelope movements varies with altitude, latitude, weather, and range conditions. These movements are invariably related to the animal seeking basic habitat requirements of forage and water. Some examples of these variances to obtain the year-round biological requirements of life can be realized by studying three separate herds living within sight of the Hart Mountain National Antelope Refuge in south-central Oregon:

1. Northern Warner Valley has an area with a diameter of 5 miles and is inhabited by a small herd of antelope. The site has sufficient forage and water year-round. Snow depth rarely, if ever, exceeds 6 inches. This site contains all of the pronghorn's biological requirements year-round; therefore, a small resident herd is maintained.

2. The adjacent Drakes Flat tableland is an area 15 miles in length occupied by a separate herd. Food and water is abundant all year. Antelope use the higher elevations 80% or more of the time depending on the snow depth which forces animals to move to lower elevations. As soon as snow depths recede, the herds move back to higher elevations where preferred plants are more readily available. This situation results in seasonal movements of the herd.

3. The Hart Mountain area supports summer and winter ranges of a decidedly different nature. The degree of traveling is related to the amount of snow, e.g., the deeper the snow, the further the herds travel seeking lower elevations with less snow. In a sense, these travels are not true migrations such as the caribou (*Rangifer arcticus*) undertake since the antelope movements differ each year and are related to annual snow depths.

It appears that the majority of pronghorns in the Great Basin exist in resident herds of 5 to 10 mile ranges. Possibly less than 10 percent of the total pronghorn population travels 50 to 100 miles; however, many of these herds have been traveling annually for hundreds of years and must continue to do so in order to survive. The placement of man-made barriers, e.g., fences, interstate highways, railroads, often seriously handicap movements and can limit or reduce the carrying capacity of certain ranges.

Pronghorn daily movements vary with the season of year primarily due to forage availability and behavior patterns. During the spring and summer, daily movements are generally 1/16 to 1/2 mile as forage and water are usually plentiful. However, during the fall and winter distances traveled daily are greater due to the mating season and a small quantity of desired forage available. Average distances traveled during this time of year are 2 to 6 miles per day.

Antelope appear to be the swiftest mammal in North America for they are able to run as fast as 50 miles per hour (Walker et al. 1968).

Pronghorns are gregarious animals. This is more noticeable during winter concentrations which may number 200 or more animals.

When spring approaches, dominant males establish territories with small bands of does, yearlings and fawns. Non-territorial areas contain bands of bachelors and non-dominant single males.

Bucks exhibit territorial dominance from March to October. Territories are placed in relation to resources -- small territories in areas with intervening ridges and larger ones in flatter terrain. In Montana, it was observed that territories possessed both sufficient forage and water during the rut period (Bromley and Kitchen 1974).

Food Habits

According to Salwasser (1980), pronghorns are opportunistic herbivores selecting the most palatable and succulent forage available at all seasons of the year. The annual diet includes much forage switching from season to season (Fig. 2).

Year-long food habit studies were conducted in the Great Basin region by Mason (1952) for Oregon, Yoakum (1958) for California, Idaho, Nevada, and Oregon, and Beale and Smith (1970) for Utah. Yoakum's (1958) analysis lists over 10 species of grasses, 70 species of forbs, and 20 species of shrubs (Appendix I) as forage plants. Grass represented 7 percent, forbs 22 percent, and shrubs 71 percent of forage consumed (Table 3). Mason (1952) collected 26 pronghorns near Hart Mountain, Oregon, and noted that utilization was 1 percent grass, 30 percent forbs, and 69 percent shrubs.

Table 3. Percent volume of forage for 189 antelope collected in California, Idaho, Nevada, and Oregon (Yoakum 1958).

Forage Class	Percent Volume				
	Winter	Spring	Summer	Fall	Mean
Grass	6	10	1	13	7
Forbs	8	24	34	21	22
Browse	86	66	65	66	71

Table 4 lists species and seasons of use for plants utilized by pronghorns in the Great Basin (Yoakum 1958). Shrubs were heavily used yearlong, forbs were highly preferred, and grasses were used very little. The importance of shrubs is unquestionably important due to quantity of consumption. The importance of forbs is often less realized or understood. Bruce Browning (personal communication), who analyzed rumens for some 20 years, noted that during years of high forb production, pronghorns consumed a higher percentage of forbs. Ellis (1970) researched this subject for 3 years and hypothesized that pronghorn survival during spring and summer was correlated to forb production. His basis for this conclusion was a comparison of antelope production and survival to forb production on high and low density pronghorn habitats. Good (1977) studied the use of forb-covered playas by pronghorn in Oregon for 4 years and reported a significantly higher use of these mesic sites in comparison to adjacent xeric shrub-dominated rangelands. Additional information on this matter was recently provided by Stoezek et al. (1978) who documented the values of trace minerals. Their work concluded that low-quality vegetative sites have higher antelope losses than high-quality rangelands. The hypothesis is based on low amounts of trace minerals such as iron, zinc, cobalt, and selenium noted in antelope tissues from low-quality sites compared to rangelands producing a greater variety and abundance of forbs and succulent vegetation.

Food habit studies accomplished to date for the Great Basin region have been relatively limited. Few have compared animal consumption with seasonal forage availability. Also, little research has been accomplished on the nutritional value of plants consumed by pronghorns in this region. It is apparent that such research is needed to provide data for management to make proper decisions regarding forage allocations. This is especially important in light of the high demand for available forage for all ungulates on western rangelands. According to Wagner (1978) pronghorns use less than 1 percent of available forage today on public lands in the western U.S. Wagner's analysis is verified by Kindschy et al. (1978) for Oregon and Longhurst et al. (in press) for Nevada, who likewise document that pronghorns are using less than 1 percent of available forage on public lands.

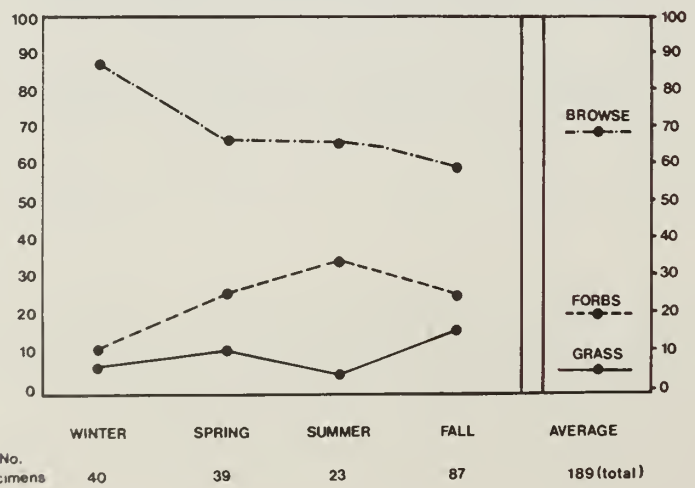

Fig. 2. Seasonal food habits for pronghorns in the Great Basin (Yoakum 1958).

Table 4. Seasonal food habits of 189 antelope expressed in volume percent (Yoakum 1958).

Common Name	Forage Class and Scientific Name	Winter	Spring	Summer	Fall
		No. of Samples			
		40	39	23	87
Grass					
Grass Family	*Gramineae* (green)	3.2	6.5	T	1.9
Grass Family	*Gramineae* (dry)	2.5	2.7		11.3
Total Grass		5.7	9.2	T	13.2
Forbs					
Knotweed	*Polygonum* sp.			10.6	
Wiregrass	*Polygonum aviculare*				1.2
Sowbane	*Chenopodium murale*				T
Russian thistle	*Salsola pestifer*				T
Tumbling mustard	*Sisymbrium altissimum*				1.3
Alfalfa	*Medicago sativa*			3.5	3.6
Clover	*Trifolium* sp.		T		
Hog fennel	*Lomatium* sp.		2.8		
	Carum sp.		1.4		
Phlox	*Phlox douglasii*	T	2.0	2.7	2.3
Phlox	*Phlox* sp.	T	6.2		T
Thistle	*Haplopappus racemosus*				T
Sunflower	*Helianthus* sp.		T		T
Balsam root	*Balsamorhiza* sp.		1.5		
	Lagophylla ramosissima				T
Poverty weed	*Iva axillaris*			4.5	4.3
Oregongold	*Eriophyllum lanatum*				T
Sunflower Family	*Compositae*				T
	Erigeron austinae				1.0
English Plantain	*Plantago lanceolata*			3.6	
Cactus	*Opuntia*				1.0
Unidentified Forbs		7.2	9.4	7.5	6.3
Total Forbs		7.2	23.3	32.4	21.0
Shrubs					
Douglas Fir	*Pseudotsuga menziesii*				T
Sheep fat	*Atriplex confertifolia*	1.8			2.2
Grey rabbitbrush	*Chrysothamnus nauseosus*		1.3		T
Green rabbitbrush	*C. viscidiflorus*		1.4	5.8	T
Bitterbrush	*Purshia tridentata*	T	4.6	24.3	2.9
Big sagebrush	*Artemisia tridentata*	57.4	55.9	34.8	41.1
Black sagebrush	*Artemisia cana*				3.0
Low sagebrush	*Artemisia arbuscula*	26.1	2.4		9.9
Unidentified Browse		T	T		T
Total Browse		85.3	65.6	64.9	59.1

T = less than 1% of total volume

Fig. 3. A scene in southern Oregon depicting a sagebrush-grassland community with abiotic and biotic factors favorable for pronghorn habitat requirements. (Photo by author)

HABITAT FACTORS AND REQUIREMENTS

The distribution and density of pronghorn populations has been related to vegetative communities (Yoakum 1972, Sundstrom et al. 1973). This was accomplished by overlaying state wildlife agency census data with a vegetative community map developed by Kuchler (1964). Results disclosed approximately 68% of the population inhabits grassland prairie states between the Mississippi River and the Rocky Mountains, 31% occupies the sagebrush-grassland steppes of the intermountain and Great Basin regions, and the remaining 1% exist in the hot and cold deserts of southwestern U.S. and Mexico (Table 5).

Since the majority of public rangelands (referring to lands administered by the USDI Bureau of Land Management) are in the sagebrush-grassland region, this report deals primarily with habitat management in this biotic region.

Table 5. Estimated pronghorn populations for the major vegetative communities of North America (Yoakum 1972).

Vegetative Community	Pronghorn Population	Percent of Total
Grasslands		
Short grasslands	190,210	49
Mixed grasslands	71,750	19
Total	261,960	68
Shrubland-grassland		
Sagebrush-grassland	103,810	27
Mesquite-grama	4,600	1
Woodland-galleta	10,950	3
Total	119,360	31
Desert	4,170	1

Habitat Requirements

Frequently the question is asked, "What are the factors of a range that allow it to produce and maintain more pronghorns than an adjacent range?" This question led to a 24-year study evaluating sagebrush-grassland communities in six western states (Yoakum 1974). Based on the findings in this study, habitat requirements for pronghorns in the sagebrush-grassland steppe were classified into two categories: abiotic (nonliving) and biotic (living). A description of these requirements includes:

ABIOTIC

1. Land Area

   A. Physiography: For centuries, pronghorns have occupied lands typified by undulating, wide open, expansive terrain. Slopes generally do not exceed 30% (Kindschy et al. 1978). Some small herds occupy ranges with sparse stands of ponderosa pine *(Pinus ponderosa)* or juniper *(Juniperus* sp.*)*, although these situations are few and such sites generally have low understory vegetation permitting visibility and rapid mobility.

   The amount of land area needed is dependent upon the site having all the habitat requirements in sufficient quality and quantity for all seasons of the year every year. The smallest known year-long occupied area is 25 square miles. It is believed that the majority of free-roaming pronghorns in the Great Basin inhabit ranges 100 square miles or larger in size. Examples of occupied rangeland size can be realized by comparing the three different ranges discussed on page 8.

   B. Natural Barriers: Natural barriers affect antelope movements and therefore the occupancy of habitat. Such barriers may be: large bodies of water; large rivers; an abrupt escarpment or mountain ridge; heavy, thick, high brush or trees; deep canyons; and others. Einarsen (1948) cited such examples when he referred to two cases (one being the Columbia River and the other a heavily-forested area) where pronghorns did not occupy or re-establish nearby favorable ranges.

   C. Elevation: Pronghorns occupy rangelands from sea level to 11,000 feet. Today only a few antelope occupy ranges at sea level and these are in Mexico; likewise, small herds use alpine meadows in Oregon and Wyoming. The highest densities of pronghorns occupy rangelands from 3,000 to 6,000 feet above sea level.

2. Climate

   A. Precipitation: Rangelands now producing high numbers of antelope receive precipitation averaging 10 to 15 inches per year.

Antelope that have been transferred to areas of higher precipitation have not become established. Pronghorns do live in areas of less precipitation, but densities appear to be proportionate to the decrease in the average precipitation.

B. Snow: Most pronghorn rangelands receive some snow. However, when snowfalls exceed 10" to 15" depths, pronghorns frequently experience difficulties in obtaining sufficient forage. Prolonged seasons of deep snows are especially deleterious when combined with factors such as: (1) low quantities or qualities of forage, (2) excessive winds resulting in an increased chill factor, and (3) obstacles to free movement (fences, roads, etc.).

C. Temperature: Temperature appears not to be a major problem. Pronghorns are biologically adapted to habitats from the hot deserts to alpine plateaus.

3. Soils

The habitat of pronghorns is extensive and covers various soil classifications, e.g., sandy, clay, basalt, etc. Soils are not a major criteria relative to antelope distribution or abundance. However, soils combined with 10" to 15" precipitation produce vegetation of a quality and quantity which becomes the major factor in antelope distribution.

4. Water

Rangelands maintaining high pronghorn numbers have water available every 1 to 4 miles. Animals can be found further than 5 miles from water; however, studies in Wyoming (Sundstrom 1968) disclosed 95% of over 12,000 pronghorns were within a 3 to 4 mile radius of water. Herrig (1974) reported distance to water for all pronghorn observations in Oregon during summer months was less than 1 mile.

Pronghorns use water from all sources, e.g., springs, streams, lakes, water catchments, metal troughs, and snow. When succulent forage is available, 1 quarter gallon of water per day appears sufficient. During dry summers, 1 gallon to a gallon and a half a day may be needed (Sundstrom 1968, Beale and Smith 1970).

BIOTIC

1. Vegetation

The quality and quantity of vegetation appears to be one of the most significant factors affecting pronghorn densities. The following characteristics of the sagebrush-grassland steppe for preferred pronghorn rangelands are:

A. Ground Cover: Ground cover averages 50% vegetation and 50% bare ground, rock or litter.

B. Composition: Generally, the composition is 30-40% grasses, 10-30% forbs, and 5-30% shrubs.

C. Variety: A large variety of plant species is preferred as forage. This often averages 5-10 grasses, 10-50 forbs, and 5-10 shrubs.

D. Succulence: Succulent plants are highly preferred. Frequently, these are forbs. Dietary studies conducted by the California Department of Fish and Game disclosed that during wet springs and summers on ranges producing an abundance of succulent forbs, pronghorns utilized more forbs (Bruce Browning, pers. communication). Good (1977) reported pronghorns move from dry rangelands to intermittent lake beds seeking abundant succulent forbs.

E. Rangeland Types: Rangelands having a variety of vegetative types (meadows, forb-covered playas, etc.) are preferred in contrast to extensive monotypic communities (Yoakum 1957). Antelope readily use wild fire areas for foraging. Such areas often provide grass sprouts and succulent forbs.

F. Height: Preferred pronghorn rangelands have vegetation with a mean height of 15". Areas with vegetation over 24" are less preferred and those over 30" are infrequently used. Antelope will seek taller vegetation occasionally for forage (e.g., saltbrushes) and may pass through tall brushy areas while travelling to and from preferred rangelands; however, their total year-long use of 30" or higher vegetal areas is minimal. There may be factors here of less visibility or decreased mobility which are relative to the antelope's survival.

G. Forage Requirement: Studies to date indicate pronghorns consume approximately two pounds of air-dry forage per day (Severson et al. 1968). Forage preferences are greatest for succulent, nutritious forbs in the spring and summer, followed by heavy use of shrubs during the fall and winter. Grasses are used lightly during all seasons. Food habit studies disclose pronghorns seek and utilize a mixed diet of forbs, shrubs, and grasses for all seasons of the year.

2. Wildlife

A. Other Ungulates: Historically, pronghorns grazed compatibly with bison, elk, deer, and bighorn sheep. There appears to have been few problems of tolerance or competition when forage was abundant. It is possible there was a commensal relationship with the vast herds of bison on the grassland prairies.

B. Predators: Coyotes, bobcats, and golden eagles are known predators of pronghorns. These predators have evolved with the pronghorn and other wildlife over eons. On some ranges, predation takes a heavy toll of the fawn crop (as high as 50%); however, recent studies indicate that such acts of predation are not as much a limiting agent as other environmental factors (Barrett 1978).

3. Man

A. Species Management: Today's scientific wildlife management practices have increased herds over 1,500 percent during the past 60 years. Effective control of hunting and large-scale trapping, transplanting, and herd re-establishment to historic ranges have been major benefiting practices.

B. Habitat Management: What man does to the rangelands affects the welfare of pronghorns more today than any other combination of factors. His land management practices including forage utilization and manipulation, fence and highway construction, human occupation, and the development of waters, all affect the pronghorn's ability to produce and survive. If these practices are accomplished with consideration for the pronghorn's habitat requirements, then pronghorns have the opportunity to fare well. However, if these requirements are not properly considered, then the range's characteristics can be altered to such a degree that habitats incapable of producing the right combination of forage, water and space to perpetuate thriving free-roaming pronghorn populations result.

In summary, it cannot be emphasized too strongly that optimum habitat for the American pronghorn antelope is directly related to the right amount and juxtaposition of all biological requirements in the ecosystem. Too little or too much of any biotic or abiotic habitat factor may become the primary component limiting antelope production and survival. The pronghorn's habitat requirements for the sagebrush-steppe region are summarized in Table 6. Knowledge of these habitat requirements becomes the ecological foundation for managers making decisions relative to the management of the pronghorn and its habitat.

Table 6. Checklist of pronghorn antelope requirements for habitat in a grassland-sagebrush community

Habitat Factors	Antelope Requirement[1]
ABIOTIC	
1. Physiography	Large expanse area (25 sq. miles minimum) - low rolling terrain - no major physical barriers (large rivers, mountain ranges, etc.) - less than 30% slope
2. Climate	
- Precipitation	10-15"
- Snow depth	Not over 10-15" for prolonged periods
- Temperature	Not a factor - populations in hot deserts to alpine meadows
3. Soils	Not a determining factor except to soil-site relationships in which some sites do not grow the right vegetation
4. Water	Desirable to have ¼ to 1 gallon per day for every day of year, particularly warm seasons. Water distribution every 1-4 miles
BIOTIC	
1. Vegetation	Ground cover - most ranges are 50% non-vegetative Composition: 30-40% grass 10-30% forbs 5-30% shrubs Variety of plant species: Grass - 5-10 Forbs - 10-50 Browse - 5-10 Succulence: The more available year-round the better in all plant species Communities: Variety and diversity important (meadows, intermittent lake beds, wild fire, burns etc.). Height: no higher than 24", preferably a mean of 15" Forage requirement: Approximately 2 lbs. air-dry forage per day
2. Animal	Big game: Tolerable of all species Predators: Affect antelope to some extent but not generally a limiting factor Man: Can or cannot be problem based on two major factors: - Effective enforcement of indiscriminate year-long killing - Methods and practices of habitat or range management

[1] These requirements must be available in the right combination. Too much or too little of any one may become the major limiting factor of antelope production or survival.

MANAGEMENT FOR SPECIES AND HABITAT

Wildlife management encompasses working with wildlife populations, the habitat, and human goals (Giles 1969). Emphasis will be given in this report to techniques, principles, and practices primarily relating to managing the habitat. However, no one component of the wildlife management triad can be effectively accomplished by itself; all have ties to each other.

Pronghorn Management

The management of pronghorns is primarily the responsibility of state wildlife agencies in the United States. These agencies census herds, set harvest seasons, and monitor mortality factors each year. Autenrieth (1978), Salwasser (1980), and Yoakum (1978) provide details of principles and practices for species management. Such biological data is needed and used by habitat managers to allocate forage and waters for wildlife in land use plans. Examples of information collected by state wildlife agencies and provided to habitat managers is discussed under "Inventories" on page 24.

Re-establishing herds is a management practice typifying data exchange and management endeavors accomplished cooperatively by state wildlife agencies and habitat management agencies. This practice can be accomplished when it has been determined pronghorns can occupy a habitat possessing sufficient forage, water, and space to support a herd. One of the best procedures for determining the potential of a habitat for pronghorn occupation was developed by the Colorado Department of Wildlife (Hoover et al. 1959). This survey form has been modified for the sagebrush-grassland steppes of the Great Basin (See Fig. 4).

Many trapping and transplanting endeavors have been successfully accomplished during the past 50 years (Yoakum 1978). Each of the western U.S. states have applied such practices. In addition, successful transplants have been completed in Canada and Mexico. Most transplants have become established on unoccupied historic rangelands; however, there have been some failures.

At times, sportsman organizations and conservation groups exert recommendations to transplant pronghorns into areas not capable of sustaining viable populations. Such unfortunate endeavors can be attested to by the loss of all animals to transplants in Florida and Hawaii (Yoakum 1978). An analysis of such cases often substantiates that the proposed habitat site did not meet the pronghorn's habitat requirements. Ignoring such basic biological requirements results in the eventual death of transplanted animals, high expenditure of public funds, and a negative confidence reaction by the public to the integrity of professional management.

FIGURE 4. Survey for selection of pronghorn transplant sites[1/].

1. LOCATION:
   A. County _____ Nearest town _____
      Nearest ranch _____ Accessibility by road _____
      Township _____ Range _____
2. SIZE (Number of square miles of estimated habitat)
   _____
3. TOPOGRAPHY: _____
   A. Physical Barriers : _____
   B. Constructed Barriers:
      Fences (Location) (Construction Specifications)
      _____ _____
      _____ _____
      _____ _____
      Major highways, freeways
      _____
      Other
      _____
4. CLIMATE: _____
   A. Elevation _____ Annual Precipitation _____
   B. Mean depth of snow _____
5. WATER:

	Springs	Reservoirs	Lakes	Streams	Wells	Catchments
A. Number	_____	_____			_____	_____
Acres			_____			
Miles				_____		
B. Production:						
Surface Ac.		_____				
Gal/min.	_____			_____		
Gal/storage						_____

   C. Mean distribution of water sources _____
   D. Year-round water? _____
6. VEGETATION:

Major Types	No. Acres	Mean Ht.	Estimated Percent Grass	Forbs	Shrubs
A. _____	_____	_____	_____	_____	_____
B. _____	_____	_____	_____	_____	_____
C. _____	_____	_____	_____	_____	_____

7. LAND OWNERSHIP: (number of acres)

   A. Private _____

   B. Public _____

   C. Other _____

8. LAND USE:

   A. Class of livestock _____

   B. Stocking rate _____

   C. Grazing system _____

   D. Cultivated crops _____

   E. Other _____

9. PREDATION:

   A. Natural - coyotes _____ eagles _____ bobcat _____

   B. Human _____

10. TRANSPLANT CONSIDERATIONS:

   A. Is site historical pronghorn range?_____

   B. Attitude of ranchers _____

      Attitude of conservation officer _____

      Attitude of local sportsmen's clubs _____

      _____

      Attitude of Govt. agencies _____

   C. Is land manager(s) agreeable to management objectives of State wildlife agency?

      _____

   D. Suggested number of pronghorn for transplant _____

   E. Route of trucks carrying pronghorn and release point _____

      _____

   F. Has a "habitat management plan" been developed? _____

      _____

   G. Are cooperative agreements completed?

      Private land owners _____

      Public land agencies _____

   H. Other _____

      _____

      _____

1/ Adapted to sagebrush-grasslands from Hoover et al. 1959.

When the re-introduction of wildlife is made into unoccupied areas, the technique is referred to as habitat "expansion" (USDI, Bureau of Land Management 1975). A good example of this practice was the re-establishment of pronghorns to northwestern Arizona. Antelope were endemic to the region but were extirpated around the early 1900's. During the 1960's and 1970's, state and Federal agencies cooperatively re-introduced several herds and a viable population now exists.

One of the most interesting cases of natural "expansion" took place in Bear Valley of Central Oregon (Polenz 1976). Thirty years ago there were no antelope in the valley although herds occupied adjacent valleys. Bear Valley was predominantly private rangelands used for grazing domestic livestock. The area experienced a number of vegetative changes through manipulation practices. The objective was to decrease the abundant, tall, unpalatable (to cattle) sagebrush and plant nutritious grasses and forbs for livestock. This resulted in changing the vegetative structure from a dominant, high-shrub community to one of low-growing grasses and forbs (dryland alfalfa) with sparse stands of new sagebrush plants. In actuality, the ranchers through range improvement practices over a 30-year period changed the habitat from a low-quality vegetative community to one favorable to the pronghorn's habitat requirements as depicted in Table 6. During this time, pronghorns at first ventured into the valley for short periods and then moved back to their historic ranges. As additional acreages were manipulated and winters remained mild, the pronghorns became established in the valley year-long. The population expanded to over 600 animals within a 20-year period and supported one of the highest doe:fawn ratios in Oregon (Torland 1980).

Another case of habitat "expansion" occurred within the past decade in Long Valley of northeastern California. The valley was historic antelope range although no animals were seen there for at least 60 years. Sagebrush dominated the vegetation averaging a frequency of 60 percent and a height of 23 inches. Grasses and forbs were 37 and 3 percent, respectively, of ground cover. Then in July of 1973, a wild fire burned 38,000 acres. Immediately the site was seeded to grasses and forbs. Today the plant composition is 61% grass, 20% forbs, and 19% shrubs with a mean vegetation height of 17 inches. Within a few years following the wild fire, a herd of pronghorns moved into the valley and have been seen repeatedly since. Why the animals on their own suddenly began to inhabit the valley cannot be stated for sure; however, it is apparent that the structure of existing vegetation more favorably meets the pronghorn's habitat requirements than conditions existing prior to the wild fire (Fig. 5 and 6).

Habitat Management

There are four basic principles for managing habitats for pronghorns:

1. Inventory resources and follow periodically with monitoring studies: The foundation for habitat management is a base inventory of the habitat resource factors (food, water, physiographic features, etc.) as to quality and quantity. In order

Fig. 5. Dominant brushlands in Long Valley, California prior to the 1973 wild fire. Area (same as in Fig. 6) not occupied by pronghorns.

Fig. 6. Sagebrush-grasslands in Long Valley, California as a result of 1973 wild fire. Area (same as in Fig. 5) now occupied by pronghorns.

to keep track of the inventory, it is necessary to periodically conduct monitoring studies.

2. Obtain site-specific biological information and relate to pronghorn habitat requirements: It is axiomatic that wildlife have needs for habitat conditions in relation to their biological behavior and physical adaptations for production and survival. To not know or consider these habitat requirements is to flaunt mismanagement.

3. Where quality habitats exist, then by objective maintain such habitats: When base inventories disclose that an environment contains an ecological site condition meeting the habitat requirements of pronghorns, then it is a management objective to protect and maintain the quality of that ecological habitat. It cannot be emphasized too strongly that where good quality natural habitat exists, it is management's responsibility to maintain the habitat in a quality condition.

4. Enhance habitats in deteriorated condition or lacking a needed habitat factor: Deteriorated conditions denote areas where the environment has been changed through natural causes (repetitive lightning fires) or man's practices (changes in vegetation through intensive livestock grazing, diversion of waters for domestic or agricultural purposes, etc.). Lacking a needed factor can be defined as a case prevailing when one or more habitat factors do not exist (e.g., water at a critical season).

Each of these habitat management principles needs to be well understood for management implementation. The relationships of each to the other must be also well known; consequently, these principles will be now discussed in detail with examples of each provided.

RESOURCE INVENTORIES AND MONITORING STUDIES

Resource Inventories: Properly accomplished resource inventories become the base data from which management makes decisions. This is analogous to the grocer who takes inventories of his stock of groceries to run a business. Both managers need to know (a) what they have, (b) how much of each item, and (c) what is the condition of the stock. For wildlife management, there is a need to have an inventory of the wildlife species and its habitat factors.

Inventories of wildlife species are generally conducted by state wildlife agencies. These inventories are important to habitat managers as they provide data relative to the productivity of the habitat. For example, an inventory of 5 pronghorns per square mile is indicative of high-density rangelands compared to similar lands maintaining less than 1 antelope per square mile. Then too, when the state wildlife

agency collects field data on sex and age ratios, the information is relative to habitat conditions. For instance, rangelands maintaining a 20-year mean of 50 fawns per 100 does is a more productive range than an adjacent range maintaining 25 fawns per 100 does.

Information pertaining to population size and seasonal use areas is another example of inventory data gathered by state wildlife agencies and used by habitat managers. This data is essential to computing pounds of forage and gallons of water needed to support pronghorns in a land-use management plan. In this case, the habitat managers need to know specific information such as: (1) delineation of area of use for computing acreages; (2) number of animals; and (3) season of use. It is necessary to have this data in order to compute the amount of forage and waters to be reserved for a reasonable number of pronghorns.

Inventories of habitats include the following components:

1. Physiography

   - Delineate occupied habitats, list number of animals, and note seasons of use. Delineate "critical" or "crucial" habitats and note why so classified. Two such areas exist for pronghorns that annually migrate or conduct seasonal movements. These are (a) winter concentration areas and (b) fawning grounds.
   - References to known barriers (both natural and man-caused such as livestock fences, freeway fences).

2. Climate

   - Mean precipitation of rain and snow.
   - Mean depth of snow.

3. Waters

   - What kind and how many, for example:
     6 springs, 4 reservoirs, 1-5 acre lake, and 14 miles of streams.
   - Information as to whether these waters are available at certain seasons or year-long.
   - Notation of water quality (good for wildlife use, too salty or alkaline, etc.).

4. Vegetation

   - Vegetative types: how many acres of each type.
   - Production in pounds for each species of grasses, forbs, and shrubs for each vegetative type.
   - Height of each vegetative type. This is needed to record protective cover for other wildlife.

5. Other resource uses or practices of the land

   - Domestic livestock
   - Agricultural developments

- Range improvements, accomplished or planned, e.g., fences, roads, forage manipulation, water developments.
- Predatory animal control - how and when.
- Other factors that may affect the production or survival of pronghorns, e.g., mineral developement, planned development for expanded human occupation, etc.

A quick analysis of the above inventory list indicates that a comprehensive investigation is needed of the rangeland factors including both biotic and abiotic factors. How intensive the inventory should be conducted is directly related to how effective the habitat manager plans to fulfill responsibilities and objectives. Often times land managers (be they private or public) make decisions for an objective of one primary land use. If the manager has a good inventory of resource characteristics and is knowledgeable of the habitat requirements for pronghorns, the decision to maintain or improve the land can be made favorably for pronghorns in conjunction with another primary objective. An example of this situation is provided on page 22 for Bear Valley, Oregon. Here the private ranchers manipulated the vegetation with a primary objective to improve forage for livestock; however, the practices undertaken simultaneously changed the vegetative structure favoring pronghorn habitat requirements. The result was increased pronghorn numbers.

Monitoring Studies: As soon as a resource inventory has been completed, the data informs the habitat manager of the "condition" of the land. "Condition" has been referred to as the present "health" when related to the land's ecological site potential. Just as humans seek periodic medical "check-ups" to determine their "state of health", the habitat manager should periodically conduct examinations to determine the "state of health" for rangelands. Such periodic checks are referred to as "monitoring studies" and provide information pertaining to the rangeland's condition, that is, whether it is static or changing. There are a number of techniques to conduct "condition" and "trend" studies aptly described in range management textbooks (Stoddart and Smith 1943, Humphrey 1962, and Heady 1975).

How often trend studies should be accomplished will vary with the degree of changes the habitat is experiencing; however, it appears that a minimum of 5 years is desirable for relatively stable habitats. Rangelands experiencing rapid vegetal changes should be monitored more frequently. Both the quality and quantity of forage and waters should be monitored on a schedule determined by a management plan.

Rangelands occupied by pronghorns should be evaluated for "condition and trend" studies. This is especially true for sites undergoing major vegetative changes by man. The case cited on page 53 clearly illustrates how a site in Nevada changed within a 20-year period from status as unoccupied antelope habitat, to preferred habitat, to less desirable habitat. "Condition and trend" studies of vegetation substantiate plant succession which in turn is related to habitat suitability.

EVALUATE HABITAT SUITABILITY

After the base inventory of habitat factors has been completed, it is possible to evaluate the suitability of the area for pronghorns. This is accomplished by comparing the present habitat factors with the pronghorn's habitat requirements listed in Table 6. Table 7 provides a system for evaluating the suitability of sagebrush-grassland steppes for pronghorns. Field data from the inventory is placed in the categories and the summation of values provides the rating. The habitat can now be classified as having low, medium or high value. If a low rating is noted, the system will denote the factor(s) responsible for the low rating. This system helps document existing situations regarding whether the habitat is (1) presently in a quality condition to protect and maintain, or (2) in need of one or more factors to be manipulated or improved.

Managers may find this "habitat evaluation" method of assistance in making resource decisions. The author is familiar with the following cases where the system assisted management:

Case 1. Well-intentioned sportsmen repeatedly approached a state wildlife agency with recommendations to introduce pronghorns to a specific area of public lands. The basis for their suggestions were: no antelope presently existed; no major conflict with other uses of the land; and an abundance of vegetation. However, after the "habitat evaluation" was completed, the suitability of the habitat was rated "poor" based upon these facts: the area was not historic pronghorn habitat; water was scarce and inadequately distributed; and vegetation was inadequate for preferred forage species, succulence, variety and height. When the habitat evaluation was completed, it was agreed by the sportsmen, state wildlife agency personnel, and representatives of the land management agency, that it was neither economical or biologically feasible to release pronghorns in this site.

Case 2. The author was requested to help analyze why an extensive valley in northeastern Nevada was not occupied by pronghorns. The area was wide-open country with physiographic features favoring the antelope's biological requirements. Pronghorn herds were in adjacent rangelands with no physical or man-made barriers to limit expanded occupancy. However, antelope presently did not inhabit the valley in question, nor were there historical records indicating such occupancy.

After visiting the site and completing a "habitat evaluation" form, it was apparent: all factors favored pronghorn occupancy, except that the vegetation was dominantly desert shrub (80% of total vegetation cover), forbs were 15% and grass was 5%; water was scarce with a wide distribution (at times 10 to 20 miles between available sources and some of these were surrounded with thick, high, riparian vegetation). It was apparent the area was and always had been a cold-desert shrub environment with resource characteristics not totally favoring the pronghorn's requirements for a

Table 7. Pronghorn habitat suitability criteria and rating for sagebrush-grassland steppes.

HABITAT FACTOR	GOOD	FAIR	POOR
	CRITERIA & POTENTIAL RATING	CRITERIA & POTENTIAL RATING	CRITERIA & POTENTIAL RATING
WATER:	Availability pattern less than 2 miles (10-20)[1/]	Availability pattern 2-5 miles (5-10)[1/]	Availability pattern more than 5 miles (0-5)[1/]
VEGETATION:			
Quality			
Forbs	10-30% ground cover (10-20)	5-10% ground cover (5-10)	Less than 5% ground cover (0-5)
Grass	20-50% ground cover (10-20)	10-20% ground cover (5-10)	Less than 10% ground cover (0-5)
Shrubs	10-30% ground cover (10-20)	5-10% ground cover (5-10)	More than 30% ground cover (0-5)
Quantity	1,000#/ac or more (15)	500-1,000#/ac (10)	500#/ac or less (5)
Height	10-25" (10)	5-10" (5)	More than 25" or less than 5" (0)
POTENTIAL RATING	65-105	35-55	5-25

[1/] Denotes range of potential rating.

place to live. The fact that the animals were nearby and could have occupied the valley but had not was, in itself, information supporting the thesis that pronghorns do not occupy habitats lacking their needs for survival. An opposite example to this situation is the case discussed on page 22 for Bear Valley, Oregon, where pronghorns on their own moved from occupied rangelands to an adjacent valley which had been manipulated to provide habitat characteristics favoring the pronghorn's biological requirements.

MAINTAIN EXISTING QUALITY HABITATS

A cardinal principle for wildlife habitat management is when a natural environment exists in a good condition for its ecological site potential -- then maintain that site in that condition. The site will produce a variety of wildlife species (Shelford 1963, Thomas et al. 1979) that have adapted over centuries of time.

It is true that implementing this ecological principle will not always favor some objectives, such as producing maximum numbers of pronghorns. For example, some desert-shrub communities in the Great Basin have, as an ecological site condition, the composition of 60% or more shrubs. This is natural and not conducive to high pronghorn production. The low production is indicative the site has a low carrying capacity for pronghorn. Management should not expect the site to produce more pronghorns as this is to ignore the capabilities of carrying capacity.

When the condition of the ecosystem favors the biological requirements of pronghorns, then the maintenance of such sites is of utmost importance to the maintenance of pronghorn populations. The ecological conditions referred to here are the factors discussed in Tables 6 and 7. These factors are not the same for all ranges. In actuality, they exist in a variety of amounts and conditions. It is the combination of these amounts and conditions that establishes the sliding scale as to whether the site has the right characteristics to produce maximum numbers of pronghorns. Then too, sometimes these factors (such as vegetation undergoing plant succession as a result of a wild fire) are constantly changing. It is because of these changes that the habitat manager must undertake monitoring studies to keep current of the condition of the site.

It is axiomatic that pronghorns are products of their environment. If rangelands have the right combination of habitat factors, then the areas have the potential to produce optimum numbers of pronghorns. However, if the rangelands lack a factor or if a factor is present but in low quantities or quality, then the site is limited in its ability to produce maximum populations of pronghorns. This concept of carrying capacity is well documented for various species of big game (Caughley 1979, Dasmann 1971, Russo 1964), but appears to be not well understood for the American pronghorn antelope. Therefore, it is advocated that a basic principle of habitat management for pronghorns is to recognize habitats in good ecological condition and then maintain, by objective, these ecosystems. The retention of such sites would likewise provide natural environments for the security of other wildlife endemic to the

areas. Emphasis is given to this subject because the principle needs to be better understood in multiple-use management of rangelands. The author is familiar with the following cases where the land manager performed decisions favoring one use of the land at the expense of deteriorating rangeland productivity for pronghorns:

Case 1. An area with a good mixture of native grasses, forbs, and shrubs was allowed to be heavily grazed by domestic livestock. Within a 15-year period, the highly-preferred grasses and forbs were utilized to the extent they decreased 80%. Shrubs responded just the opposite: that is, they were of low palatability and increased in density 60%. The result was a diminishing frequency of use of the area by antelope.

Case 2. Another area had a natural mixture of native grasses, forbs and shrubs favoring pronghorn food habits. However, the natural vegetation was mechanically manipulated resulting in decreased shrubs and forbs and a monotypic grass seeding of exotic, coarse bunchgrasses. The site now lacked preferred, nutritious, succulent forbs and shrubs for antelope. Particularly lacking were shrubs for fall and winter use resulting in the pronghorns moving to adjacent rangelands where shrubs were available during years of heavy snowfalls. The result was less day's use of the site by pronghorns in comparison to use prior to the treatment practices.

ENHANCE HABITATS IN LOW QUALITY CONDITION OR LACKING A NEEDED HABITAT FACTOR

When rangelands are improved for a specific objective of increasing forage or waters for animal use, the practice is termed "range improvement" or "habitat improvement". In the United States, the majority of all range improvement projects are accomplished for other purposes than improving wildlife habitat. It is postulated that less than 1% of all range improvements are designed with the primary objective of improving wildlife habitat conditions. Most practices are accomplished to increase forage and waters for domestic livestock (Vallentine 1971).

Habitat improvements can be planned and implemented specifically for wildlife management (Yoakum et al. 1980). The science and art of such practices, however, are not as sophisticated as techniques for livestock management. A primary reason for this difference is the high monetary income received for agricultural products compared to wildlife values in North America today.

There are two primary objectives for range or habitat improvements:

1. When rangelands have a factor(s) that is in poor ecological site condition and the site is capable of producing the factor in better condition, then designed projects can improve habitat conditions. Example: A site has an existing vegetative composition of 5 percent grass, 10 percent forbs, and 85 percent shrubs. Prescribed treatment of the shrubs followed

with seeding of grasses and forbs can change the composition to 70% grasses, 20% forbs and 10% shrubs.

2. In some areas, a habitat factor may be limited in numbers or distribution and this can be improved through management practices. Example: Water is abundant through streams and springs for half an area but limited in distribution for the other half of the site. Management can develop waters in the latter portion, resulting in more even distribution and availability of waters throughout the entire area.

In North America today, the majority of rangeland improvements are accomplished for the following reasons:

Manipulate vegetation to decrease less palatable species and increase preferred species.

Develop waters for either quantity or distributional patterns.

Construct facilities that will help control or manage animals, e.g., fences, corrals, salt stations, and others.

These practices will be now discussed in detail as to why, when, and how they may be accomplished beneficially for pronghorns.

Vegetation Management

It is paramount to stress that if a habitat is in quality condition for the biological requirements of pronghorns, then the manipulation of the vegetation cannot be justified for improving conditions for antelope. Only sites in poor vegetative condition but having the right combination of other habitat factors can it be justified to initiate projects for improving forage for pronghorns. Pronghorn thrive well on rangelands in a subclimax vegetative condition (Kindschy et al. 1978). Such conditions can be the result of wild fires caused by lightning, grazing by herbivores, or vegetation improvement projects. Most vegetative communities in the Great Basin are a product of a variety of endemic grasses, forbs, and shrubs that have evolved over centuries. These mixed forage classes are natural and the best-adapted vegetal communities for pronghorns and other wildlife.

Structure Manipulation: Extensive areas of dominant (more than 30%), high (exceeding 25") brushlands are often lower-density rangelands for pronghorns than similar sites with less shrubs and more grasses and forbs. These brushlands can be treated to change vegetal structure characteristics to conditions more favorable for pronghorns. Dominant shrub communities also create less desirable pronghorn habitat for two other reasons. They compete for moisture and nutrients with forbs and grasses. Then too, thick or high vegetation causes problems to pronghorn behavioral patterns which require low vegetal aspect for sighting and escape from enemies. Shrub control projects should, however, not attempt to eradicate or control all brush because shrubs are preferred

seasonal forage. The use of shrubs during winter seasons is of utmost importance for certain habitats, especially rangelands where snowfalls exceed 10 to 15 inches. Under these circumstances, shrubs can be the only available forage to carry pronghorn herds through critical winter seasons (Martinka 1967, Bayless 1969, and Burns 1977).

There is another factor of importance to consider prior to manipulating shrubs. That is, the vegetal control practice having the least deleterious affect to native grasses and forbs warrants consideration. Further discussions in this chapter will document that some shrub control techniques kill a higher percentage of grasses and forbs than other practices. This is highly undesirable for pronghorns and other endemic wildlife.

Brush control has been a major practice on western rangelands during the past 4 decades. Manipulating sagebrush with large brushland plows is one method used extensively. It can remove up to 90 to 95 percent of the sagebrush (Vallentine 1971). However, the practice often kills other native plants, especially forbs and perennial bunchgrasses used by wildlife. Chaining is accomplished by dragging heavy anchor chain in a U-shape behind two crawler tractors traveling in a parallel direction. The practice does not kill as many shrubs as plowing and is much less damaging to native grasses and forbs.

Herbicidal plant control has been practiced extensively to decrease shrubs on western rangelands. Chemical application can be targeted to specific plants, thereby controlling shrubs but not seriously harming other species (Vallentine 1971). However, there have been cases where applications of improper chemical formulas or treatments at inappropriate times resulted in high losses of broadleaf forbs. Herbicidal control can also result in leaving high shrub skeletal remains, which according to Kindschy et al. (1978), were less frequently used sites by pronghorns than areas mechanically treated.

Fire is a natural factor on rangelands and is considered one of nature's primary ways of developing and maintaining grasslands (Sauer 1950). Burning is the oldest known practice used by man to manipulate vegetation on grazing lands (Vallentine 1971). Accidental burns can be more deleterious than beneficial to rangeland resources; however, prescribed burning can be beneficial and economical as a habitat management technique. Prescribed burning denotes systematically planning the firing of lands when weather and vegetation favor a particular method of burning that can be expected to maximize benefits.

Recommended procedures and practices for prescribed burning are provided in detail by Vallentine (1971) and Yoakum et al. (1980). Vallentine provides a thorough discussion on objectives, techniques and results of burning sagebrush ranges. This chapter (pages 166 to 169) is recommended for review by persons planning prescribed burns in the sagebrush-grasslands. Pechanec et al. (1954) recommend sagebrush burning only when the following criteria are met:

1. Where big and 3-tip sagebrush is dense and forms more than half the plant cover.

2. Where fire-resistant perennial grasses and forbs form more than 20 percent of the plant cover or will be seeded following burning.

3. Where consideration has been justified for the economic and biological needs of all uses of the site; e.g. livestock forage, big game range, watershed values.

4. During late summer or early fall.

5. Not earlier than 10 days after perennial grass seed is ripe and scattered, and after leaves are nearly dry.

Deming (1963) reported on the relationships of pronghorns to wild-fire burns in Lake County, Oregon. He observed that only an occasional buck was seen on the predominantly sagebrush-covered Hart Mountain during the early 1950's. Then a wild fire burned 6,000 acres on top of the mountain in 1954, changing the plant community to native grasses and forbs with small stands of browse (Fig. 8). Pronghorn use of the area commenced the year following the fire, and 10 years later supported a herd of 55 bucks, does, and fawns during summers. Deming also reported on an extensive sagebrush area near Abert Rim which was burned by a wild fire in 1959 and seeded to grasses. He recorded that after the sagebrush had been burned, grasses and forbs remained greener and

Fig. 8. Inspecting the wild-fire burn on top of Hart Mountain, Oregon, that changed a sagebrush-grassland to a grassland. (Photo by author)

succulent three to four weeks later. Prior to the burn, no pronghorns occupied the site, but following the burn they moved into the area and have been using it ever since. Figures 5 and 6 depict an area near Reno, Nevada that was burned by a wild fire in 1973 and reseeded naturally. Prior to the fire, no pronghorns inhabited the site. After the fire, a herd from adjacent lands moved into the area and have been observed occupying the valley.

Prescribed burning has been used to a limited extent as a shrub control technique within the sagebrush-grassland region. This practice has many factors favorable to improving vegetative conditions for pronghorns. When properly accomplished, prescribed burning can decrease shrub height and create a mixed community of grasses, forbs, and shrubs (Beardahl and Sylvester 1974, Page 1975). Both authors found spring burning a successful method because sites remained small and burned in irregular natural patterns controlled by moisture.

Artificial Seedings: Antelope habitats having insufficient quality plants for reproduction can be artificially seeded. Low-quality vegetation can result from repeated wild fires destroying sagebrush-grassland types as occurred in Oregon (Robert Kindschy, personal communication). It can also result from mining operations stripping the natural vegetation for energy development. Under such circumstances on public lands, the Surface Mining Act of 1977 requires rehabilitation of the site to its original vegetative conditions, including the replanting of sagebrush. The major reason artificial seedings have been accomplished on western public lands in recent years has been to improve forage for domestic livestock. Such seedings (Fig. 10), when properly planned and implemented, can result in favorable conditions for pronghorns (Yoakum 1975). However, it cannot be emphasized too strongly that when artificial seedings are improperly accomplished, they can have little value to antelope. In other words, the practice to change a dominant shrubland to a dominant grassland seeding results in the same unfavorable rangeland factor to antelope, that is a monotypic forage class vegetative community.

Artificial seedings referred to as "mixture seedings" contain a number of different plant species (Plummer et al. 1968, Yoakum et al. 1980). Such seedings can produce a diverse habitat preferred by a variety of wildlife. What constitutes a mixture seeding depends on the variety of seeds used. However, for wildlife habitat restoration in general, Plummer et al. (1968) recommends seed mixtures to have a minimum seed variety of six species of each of grass, forbs, and shrubs. Plummer and his co-workers researched this subject for the past 30 years on over 24,000 acres of successfully treated rangelands. Their findings are the culmination of intensive research and field tried and tested results. Their publication, "Restoring Big Game Ranges in Utah" is a classic that should be a guide for range and habitat managers concerned with restoring western rangelands. It cannot be stressed too strongly that all vegetative improvement projects should be planned in conformance with the basic principles and practices for successful range restoration advocated by Plummer et al. (1968). These procedures have

wide application on similar sites throughout the West. They are referred to as "the Ten Commandments" for successful rangeland restoration and briefly are:

1. Changes in plant cover by the proposed measures must be determined to be desirable. Often a change in management to permit lighter grazing by livestock so that desirable species can develop may be all that is required.

2. Terrain and soil types must be suited to the changes selected. The soil and terrain should be carefully considered to determine where appropriate treatment would produce the most forage for wildlife.

3. Precipitation must be adequate to assure establishment and survival of seeded plants. The amount of precipitation, along with occurrence of indicator plants, is the most important guide to what species may be seeded successfully.

4. Competition must be low enough to assure that desired species can be established. Anchor chaining has been developed as a highly versatile, effective, economical and widely applicable method for eliminating competition of trees and shrubs. Other techniques such as plowing, herbicidal control, and prescribed burning may be used.

5. Only species and strains of plants adapted to the area should be planted. Seeded species must be able to establish and maintain themselves. There should be a balance of shrubs, forbs, and grasses.

6. Complex mixtures, rather than single species or simple mixtures, should be planted. It is advantageous to seed mixtures when the major purpose of restoration is for the improvement of game range. A general rule is to include a minimum of 6 species each of grass, forbs, and shrubs.

7. Sufficient seed of acceptable purity and viability should be planted to assure getting a stand. The amount per acre depends on seed purity, size and viability and whether seeds are drilled or broadcast.

8. Seed must be covered sufficiently. Deeper than 1¼ cm (½ in.) planting is seldom desirable; likewise, leaving seed exposed is unsatisfactory.

9. Planting should be done in the season of optimum conditions for establishment. Whenever climate permits, seeding in winter is best (December, January and February). Late fall is next best (late October and November). Transplanting of nursery stock, seedlings and wildlings is most successful when completed while the ground is still wet from snowmelt in the spring.

Fig. 9. A dominant sagebrush site in Malheur County, Oregon, not occupied by pronghorns. (Photo by author)

Fig. 10. An area formerly a dominant sagebrush site treated by plowing and planted with a mixture seeding, and now occupied by pronghorns. (Photo by author)

10. The planted area must be adequately protected. Young plants and seedlings should not be grazed or severely trampled by livestock, big game, rabbits, rodents or insects.

While there remains a great deal to be learned to reduce costs, successful shrub treatment followed with mixture seedings for large areas depends on following these time tested procedures. Their importance for planning and implementing vegetative restoration practices for wildlife cannot be over emphasized.

The values of planting dryland Nomad alfalfa *(Medicago sativa)* in rangeland projects to wild, free-roaming populations of pronghorns is worthy of special notation. The introduction of dryland alfalfa was one of the most successful techniques accomplished on antelope rangelands in southeastern Oregon (Kindschy 1974). In excess of 56,000 acres involving 36 separate seedings were planted. The alfalfa was aerially seeded over plowed sagebrush rangelands drilled with adapted grasses. Recent analysis of 20 seedings discloses that alfalfa maintained a 10.7% composition level over a 10-year period (Heady and Bartolome 1977). The seedings have increased the forb composition from 2 percent in untreated areas to 7 percent in seeded areas. During the August 1976 antelope census, more antelope does with fawns were observed in grass and forb seedings than on adjacent shrub dominant rangelands (Robert Kindschy, personal communication).

The value of crested wheatgrass *(Agropyron cristatum)* to pronghorn has not been well studied to date. Reeher (1969) conducted a two-year study on such seedings and other range restoration practices in southeastern Oregon. He noted antelope use plow and artificially seeded projects more than spray and seeded sites. He also recorded pronghorn seasonal use of forage development projects. Spalinger (1979) conducted an analysis of pronghorn fecal samples collected on a crested wheatgrass seeding from Malheur County, Oregon. The fecal samples were obtained during late winter of 1977. Using the technique described by Hanson et al. (1978), the feces were analyzed for plants consumed. Twenty fields were examined on each of five slides totaling 100 fields. In each field, the presence or absence of crested wheatgrass was noted, and the number of different identifiable fragments was recorded. No concerted effort was made to identify and quantify the complete diet of the pronghorn, but several of the most common species were identified and a subjective estimate made of their relative use. Crested wheatgrass represented approximately two percent of identifiable fragments. Other species comprising the majority of the diet included cheatgrass *(Bromus tectorum)*, scarlet globemallow *(Sphaeralcea* sp.*)* and sagebrush. Figure 10 depicts the seeding in which the fecal samples were collected. Crested wheatgrass was the dominant plant in the site; however, it was consumed in minor quantities for late winter. The other three species (cheatgrass, globemallow and sagebrush) represented less than 25% of vegetative production, but were more than 75% of volume consumption.

Cultivated Crops: Antelope are attracted to cultivated crops, especially alfalfa, a highly-preferred forage species. Winter wheat is another agricultural crop to which pronghorns have caused depredations,

mainly through mechanical means of trampling and bedding. Overall, pronghorn depredations regarding the use of cultivated crops is minimal in the Great Basin region.

Water Developments

During a five-year study of pronghorns on sagebrush-grasslands in Wyoming, Sundstrom (1968) observed antelope using every type of water source available; e.g., springs, reservoirs, water catchments, streams, lakes, and troughs filled by windmills. At times, pronghorns were seen using water developments with domestic livestock. Sundstrom noted that when water exceeded a pH of 9.25, antelope appeared to seek other sources. He also found little or no antelope use of water developments containing total dissolved solids in excess of 5,000 ppm. The maximum total dissolved solids recommended for big game is around 4,500 ppm (McKee and Wolf 1965). Studies in western Utah (Beale and Smith 1970) suggested that water developments may encourage distribution of antelope where natural water sources are limited, particularly during dry seasons or drought years.

Reservoirs: Hundreds of small reservoirs have been constructed to trap and retain precipitation for livestock and wildlife in the Great Basin (Fig. 3). Many of these have been constructed on public lands through cooperative funding by state wildlife organizations and federal land management agencies. Such developments are often natural in appearance and serve a variety of wild birds and mammals. In some cases, part of the reservoirs are fenced (Fig. 11). This protects vegetation growth

Fig. 11. A small reservoir, with a fence to protect vegetation on the dam, constructed for pronghorns and livestock on the Hart Mountain National Wildlife Refuge, Oregon. (Photo by author)

which in turn provides nesting and protective cover. In Malheur County, Oregon, 1,037 reservoirs have been completed (Heady and Bartolome 1977), and in Nevada, over 500 have been constructed on BLM administered lands (USDI Bureau of Land Management 1964).

The term "reservoir" refers to water impounded behind a dam. It may be formed by building a dam directly across a drainage or by enclosing a depression and constructing a diversion ditch into the resulting basin. Reservoirs should be designed to provide maximum storage with minimum surface area to reduce evaporation loss. Since there are a number of construction designs for reservoirs depending on locality, parent material, and use of site, persons desiring further information may obtain this data from published reports (Hamilton and Jepson 1940, USDI Bureau of Land Management 1964, Yoakum et al. 1980). Fig. 12 provides a schematic design that considers both livestock and wildlife use of a small reservoir.

Dugouts: Another water development of high value to antelope in the Great Basin is the "charco pit" or "dugout". These developments entrap and store precipitation for both livestock and wildlife. They are highly used by pronghorns, especially during late summer months when the weather is hot, vegetation becomes desiccant, and the animals physiological requirements for water increase.

Dugouts are most commonly used in areas of comparatively flat but well-drained terrain (Fig. 13). A natural pot hole or dry lake bed is often a good location for a dugout. Dugouts should not be located in wet or muddy areas because of the difficulty for large animals to get to the water without miring.

Fig. 14 depicts a small rectangular dugout with schematic design specifications. For larger dugouts, the length, width or depth may be increased but the side slopes should be about the same. All sides should be sloped sufficiently to prevent sloughing (usually 2:1 or flatter) and one or more relatively flat side slopes (4:1 or flatter) should be provided for livestock or big game entrances (Yoakum et al. 1980).

Water Catchments: The installation of precipitation catchments (guzzlers) on rangelands lacking proper water distribution has been successful for antelope (June 1965, Sundstrom 1968). Guzzlers have been constructed of various designs and materials (Yoakum et al. 1980); therefore, these sources should be consulted for design details.

Figure 15 illustrates a guzzler used by pronghorns in southcentral Wyoming. The developments were also used by many other species of wildlife including sage grouse, horned larks, vesper sparrows, rabbits, ground squirrels, deer, and elk.

Originally the guzzlers in Wyoming were fenced to exclude domestic sheep use and limit physical damage caused by trampling the apron. However after several years of observation, it was determined that these problems were minor and they generally could be alleviated through herding

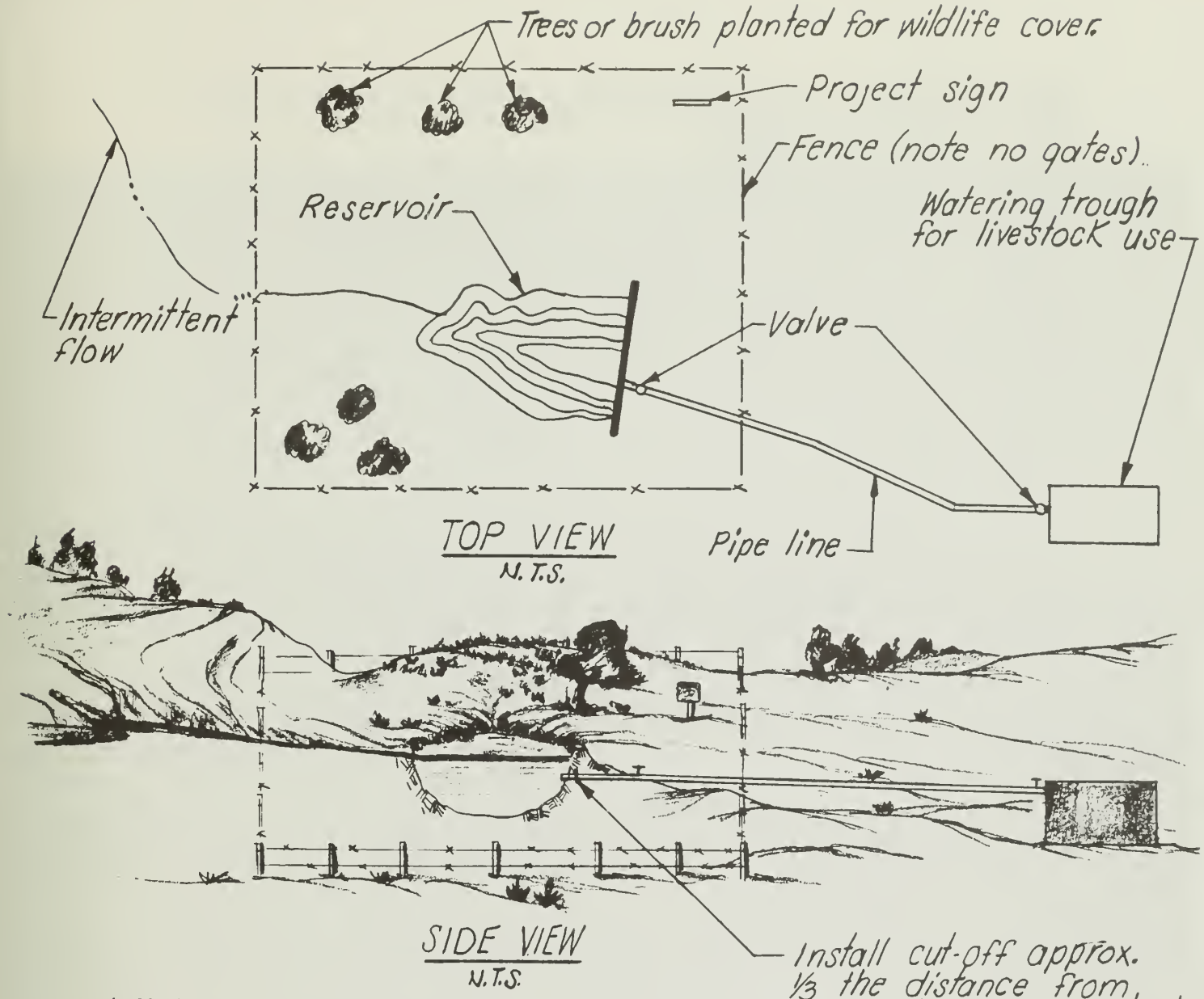

Fig. 12. Schematic plan for a reservoir with waters piped to a trough outside a fence.

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sheep in the area. The barbed wires were, therefore, removed from the fence. This in turn appeared to allow greater ease and use of the water catchment by pronghorns.

Springs and Seeps: Wildlife on western rangelands probably use waters from a myriad of springs and seeps more than any other source of water. Sometimes these sources can be developed to improve water productions; however, the practice can be tricky in that it is also possible to lose the water source during development. No two springs are alike as to development needs; consequently, there are several different planning techniques that can be applied (Yoakum et al. 1980). Figure 16 provides a schematic drawing of a spring developed for multiple-use purposes. Before a spring or seep is developed, the reliability and quality of its flow should be checked. Generally it is necessary to install a protective box to catch and store the water. Sometimes it is advisable to provide large capacity storage at sites where water flow is intermittent so that stored water will be available after the spring or seep quits flowing. These waters should be dug out of firm ground, hard pan, or rock to obtain maximum flow. The source, whether one or several, should be conducted to a collective basin and thence piped to a trough (Fig. 16). It is usually necessary and desirable to fence the water source and collection basin from human or cattle use.

Spring developments planned for wildlife should consider the following guidelines:

1. Provide as natural a drinking environment as possible.

2. Maintain or provide adequate vegetation around the watering area, either by saving the natural cover or by means such as plantings, brush piles, etc.

3. Provide, where applicable, an information sign to inform the public as to the purpose of the development.

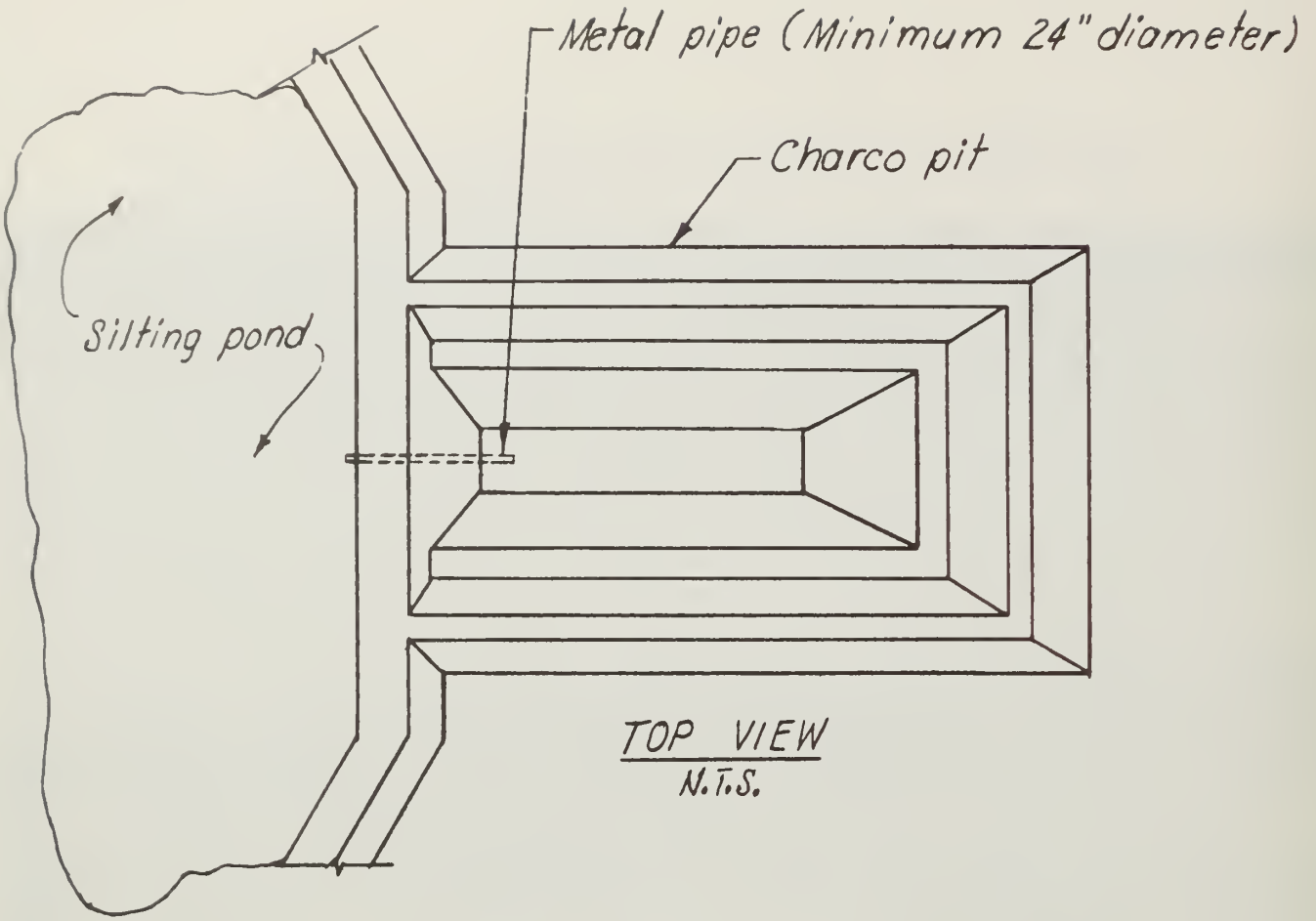
4. Provide water development of sufficient capacity to supply water at all seasons during which it is needed by wildlife.

5. Fence the development from cattle. Fences can serve the purpose of protecting the water source and food and cover. Protection should be negotiable by wildlife except where trampling or wallowing by big game will damage the spring source.

6. Provide safety from drowning for small or young wildlife by construction of gentle basin slopes or ramps in and out of tanks.

7. Provide public access to water by piping it outside of fenced water developments. Because many species of wildlife are shy, pipe water for human consumption some distance from wildlife waters. For example, it is recommended that sustained camping be discouraged within ½ mile radius of waters for pronghorns.

Fig. 13. A "dugout" used to provide water for livestock and pronghorns on Hart Mountain National Wildlife Refuge, Oregon. (Photo by author)



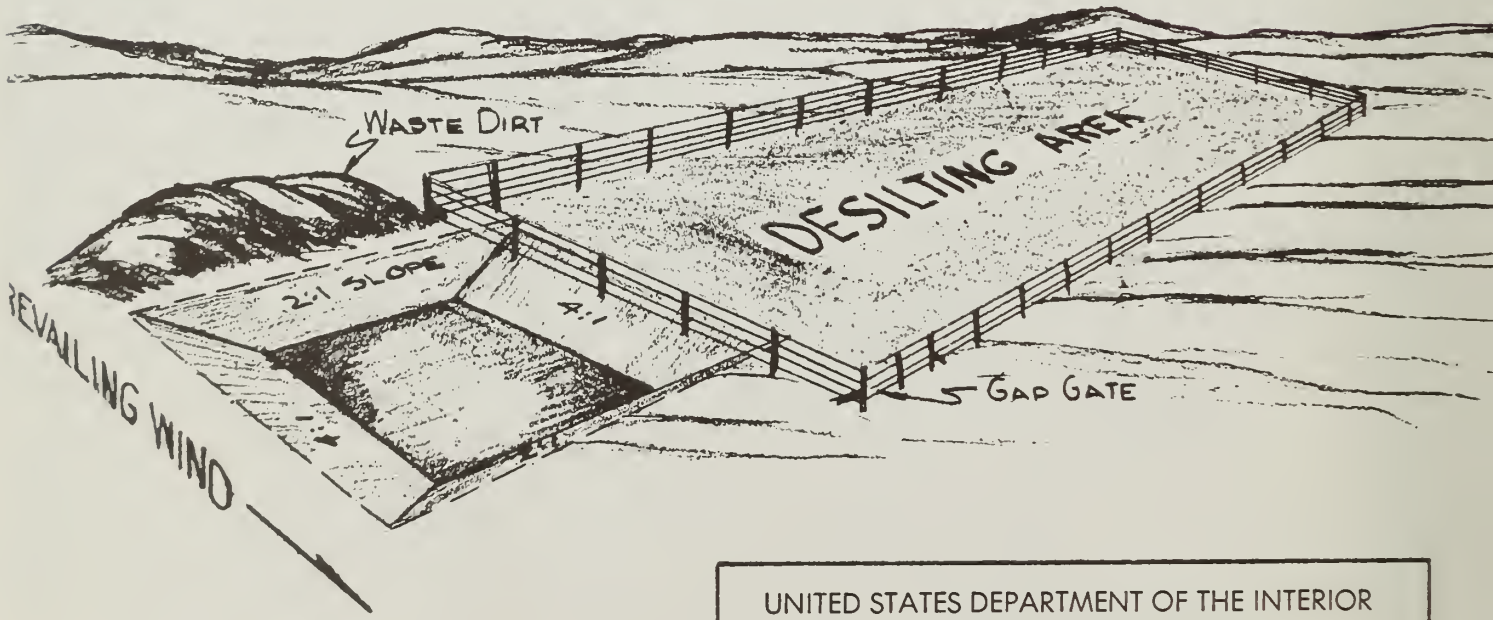


Fig. 14. Schematic sketch of a "charco pit" used to catch and retain waters for livestock and wildlife.

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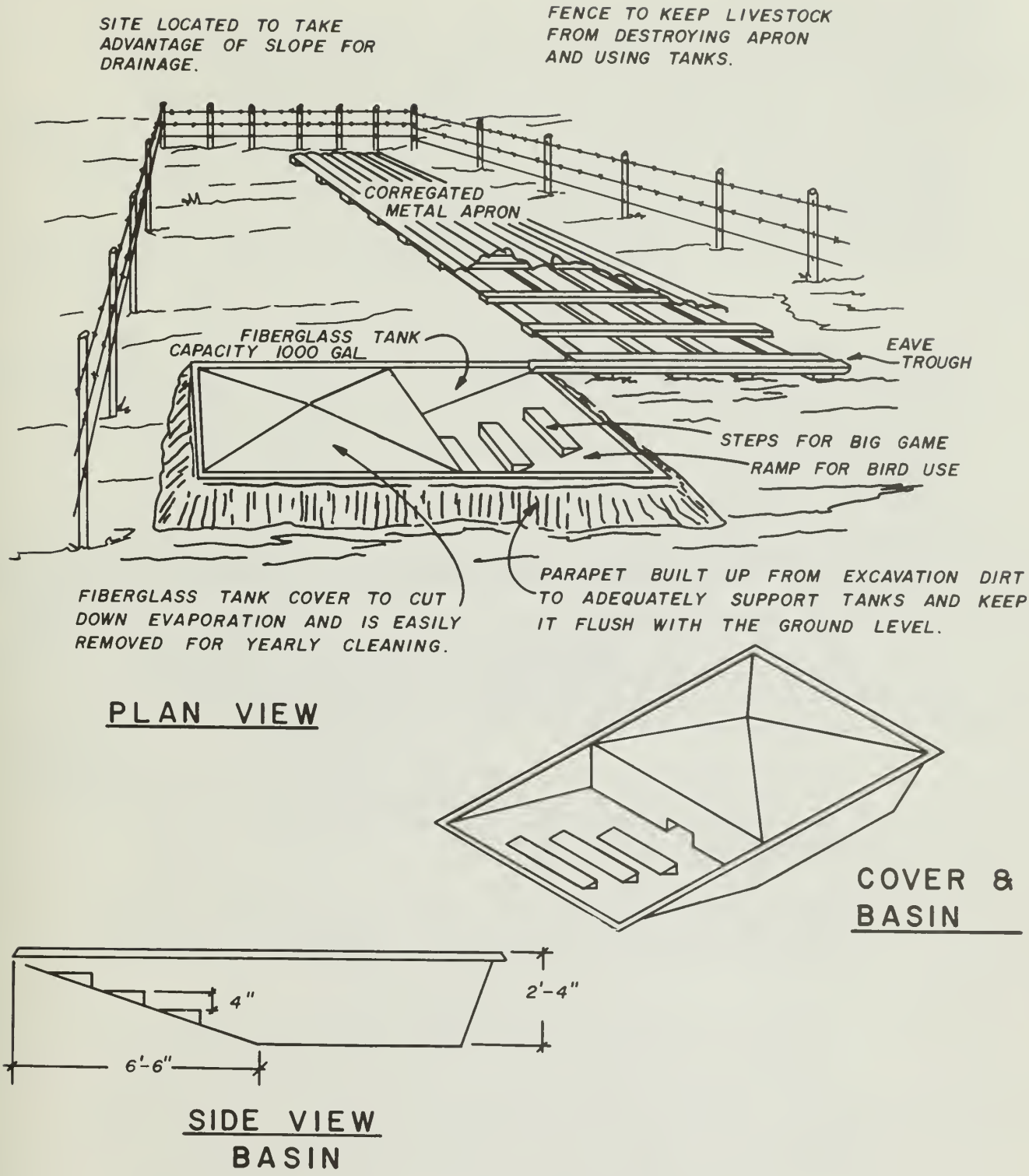


Fig. 15. A water catchment designed for antelope use on the Red Desert of Wyoming (adapted from June 1965).

Other Developments: Habitat managers may construct water developments such as tanks, troughs or wells strictly for the benefit of pronghorns. These water developments will more commonly be constructed for other purposes; e.g., for livestock drinking (Fig. 17), campground water storage, and fire suppression. Often a slight modification or addition to such developments can provide water for wildlife. Managers desiring additional information or specifications, plans and construction details for water improvements will find the following sources of value: "Range Improvement Standards Handbook" (USDA, Forest Service 1960), "Engineering Handbook and Construction Manual" (USDI, Bureau of Land Management 1967), and "Range Improvements" (Vallentine 1971).

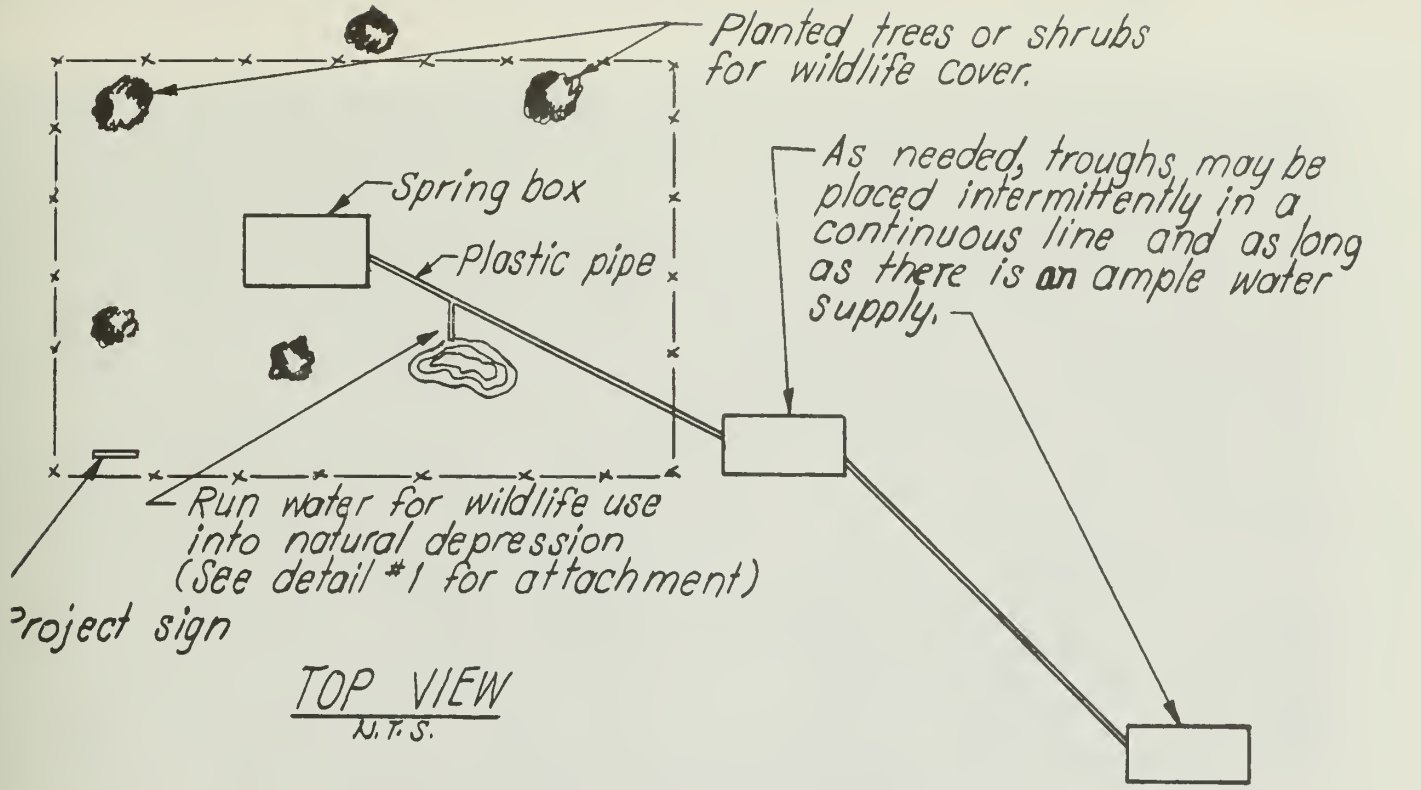
Safety Considerations in Water Developments: All water improvements, regardless of the purpose for development, should provide water both safely and continually for wildlife. Often this can be accomplished by recognizing wildlife as a resource user of all water and properly designing the facility. Wilson (1977) compiled a technical report listing the rationale and techniques for considering wildlife safety in water developments most frequently built to provide water for livestock. Specific design structures are provided to decrease entrapment or drowning of small mammals and birds. Regarding proper water facility designs for wild ungulates, Wilson suggested the following:

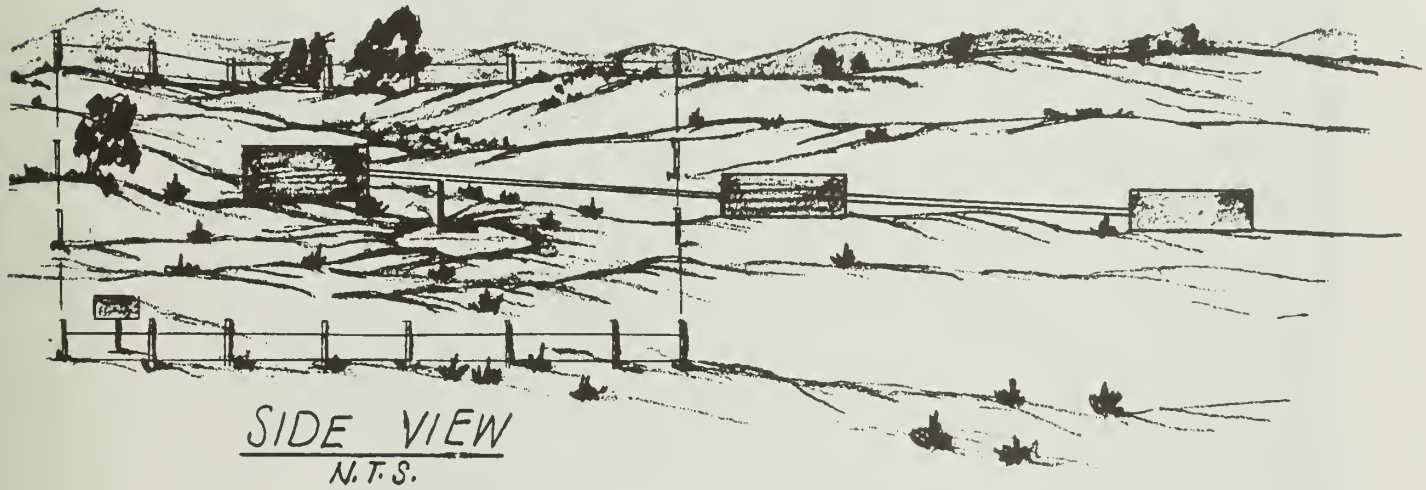
1. Whenever ground-level wildlife drinking facilities are not provided in association with other water developments, the height of troughs or other containers must not exceed 20 inches. Larger troughs may be set down in the ground to reach the desired height.

2. Consider installing safety barricades in developments to prevent the accidental entry and possible drowning of wildlife. The horizontal distance from the rim of the trough to the barricade must not exceed 20 inches.

3. Escape from a trough or water catchment by an ungulate may be more difficult than accidental entry. Consider installation of concrete blocks or rocks to form escape ramps in facilities where water depths exceed 20 inches.

4. Make sure the design of the facility considers the needs and safety of other wildlife also. This can be accomplished by constructing "wildlife savers" or ladders which lead into and out of water facilities. These ladders should have a minimum slope of 30 degrees and not exceeding 45 degrees. One escape ladder per 30 linear feet of trough perimeter should be installed. A floating wildlife platform should be installed in all large open water storage tanks. Such a platform will allow birds to drink and escape.





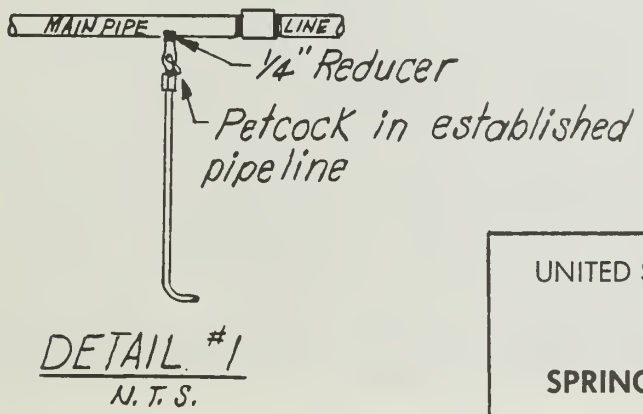


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Fig. 16. Drawing of a spring development with specifications beneficial to livestock and wildlife.

Fig. 17. A trough receiving water from a pipeline for the use of livestock and wildlife. (Photo by author)

PROTECTIVE COVER

The use of protective or thermal cover by pronghorns has received little study to date in the Great Basin region. Pyrah (1974) working in Montana and Autenrieth and Fichter (1975) in Idaho described fawning cover needs stressing the use of sagebrush as protective cover. Bodie (1978) studied antelope mortality in Idaho and noted that fawns bedding in tall sagebrush had significantly higher predator related mortality than fawns using short sagebrush-grasslands. Pronghorn neonates were studied over a five-year period in Alberta, Canada regarding bedding sites (Barrett 1978) where it was determined bedding sites were mainly located on native grass prairies; however, they were found in all major habitat types and preferred sites could not be determined.

Pronghorns use microhabitats to minimize energy drain caused by heat loss and travel through deep snows (Bruns 1977). They were observed using wind velocity barriers such as creek and river banks, road fills and dikes, and the lee sides of sagebrush. Bruns believed that wind velocity, but not air temperature or relative humidity, was the major reason pronghorns made microhabitat selections during winters. Observations by Chuck Sundstrom (personal communication) substantiate Bruns hypothesis regarding wind barriers. Sundstrom noted during the harsh 1979 winter near Laramie, Wyoming, that antelope were bedding on the lee side of highway snow fences for thermal protection from winds during below zero (Fahrenheit) air temperatures. The author has observed pronghorns using vegetation as thermal cover during summers in the Great Basin. One sighting was a herd of 30 antelope shaded under a lone, large pine tree *(Pinus ponderosa)* in the middle of an open valley west of Susanville, California. Three observations were made of antelope shaded under mountain-mahogany trees *(Cercocarpus ledifolius)* on Hart Mountain and Drakes Flat in Lake County, Oregon. Two sightings were noted of antelope under juniper trees *(Juniperus occidentalis)* in Nevada. A review of the literature (Yoakum 1967 and 1980) indicates there is a lack of records documenting the need for protective vegetative cover for pronghorns. Apparently these native animals have evolved over eons on the wide open country, free of high vegetative communities such as used by deer and elk for thermal cover.

PRONGHORN-LIVESTOCK RELATIONSHIPS

Pronghorns lived with bison *(Bison bison)* in a commensal relationship for centuries on the prairies of North America. Grinnel (1929) stated pronghorn numbers probably exceeded the legendary herds of bison. The two co-existed without major competition problems for eons. It is postulated this relationship has merely changed; that is, cattle now replace bison on the western rangelands. A cursory review of western rangelands discloses that approximately 98 percent of all lands occupied by pronghorn are in dual use with domestic livestock, primarily cattle.

Competition: The general effects of livestock on antelope centers on two general aspects of herbivore-food relationships: (1) direct competition for forage resources, and (2) alterations in plant composition caused by livestock grazing.

Range forage preferences for domestic livestock and antelope have been assessed by Wagner (1978) and Longhurst et al. (in press). It is evident that cattle, horses, and sheep are more dependent on grasses than pronghorns. Domestic sheep consume more browse and forbs than cattle, but not as much as antelope. Consequently, significant competition between livestock and pronghorns would not be anticipated as long as all classes of forage are in adequate supply. However, availability of preferred forage species is not adequately abundant for many public western rangelands (USDI, Bureau of Land Management 1975b). Competition for forage resources can be related to populations. Figure 18 illustrates how forage demands for wildlife and domestic livestock have reversed during the last 100 years. Pronghorns now consume a fraction of one percent of forage today. It is, therefore, apparent that pronghorns are not a serious competitor with livestock. This relatively minor use of forage is further supported by Longhurst et al. (in press) for Nevada and Kindschy et al. (1978) for Oregon, who report that pronghorns consume less than one percent of forage on rangelands dually used with domestic livestock.

Vegetational changes caused by livestock grazing have probably had a greater impact on antelope than direct competition for forage. Under pristine conditions, bunchgrass interspersed with sagebrush predominated over much of the Great Basin region. Overuse of bunchgrasses and succulent forbs by domestic livestock initiated successional changes in vegetation composition, and has resulted in conversion of substantial portions of Great Basin sagebrush-grassland steppes to dominant shrublands. Native bunchgrasses and forbs have been gradually replaced by less palatable and less nutritious shrubs. This change reduced rangeland carrying capacities for livestock and pronghorns. Antelope, which originally had been reduced partly through over-hunting, have failed to recover in substantial numbers largely because of unfavorable changes in vegetation or reduction of habitat because of land use changes. By reducing the plant species on which they feed, livestock not only initiate successional changes in forage supplies, but also increase competition for remaining sources of preferred vegetation on a long-term basis.

Under pristine conditions, native perennial grasses apparently maintained considerable density in the sagebrush-grassland steppes. Grasses are capable of competing successfully with shrub seedlings through their ability to extract most of the available moisture from the upper-soil layer. Brush seedlings are especially vulnerable to moisture stress during periods of establishment and before roots extend to a depth below the root zone of grasses (Nord 1965). When livestock removed grasses and forbs through grazing activities, which they did to a greater extent than native ungulates, many species of shrubs increased in density because seedlings had a better opportunity for successful establishment.

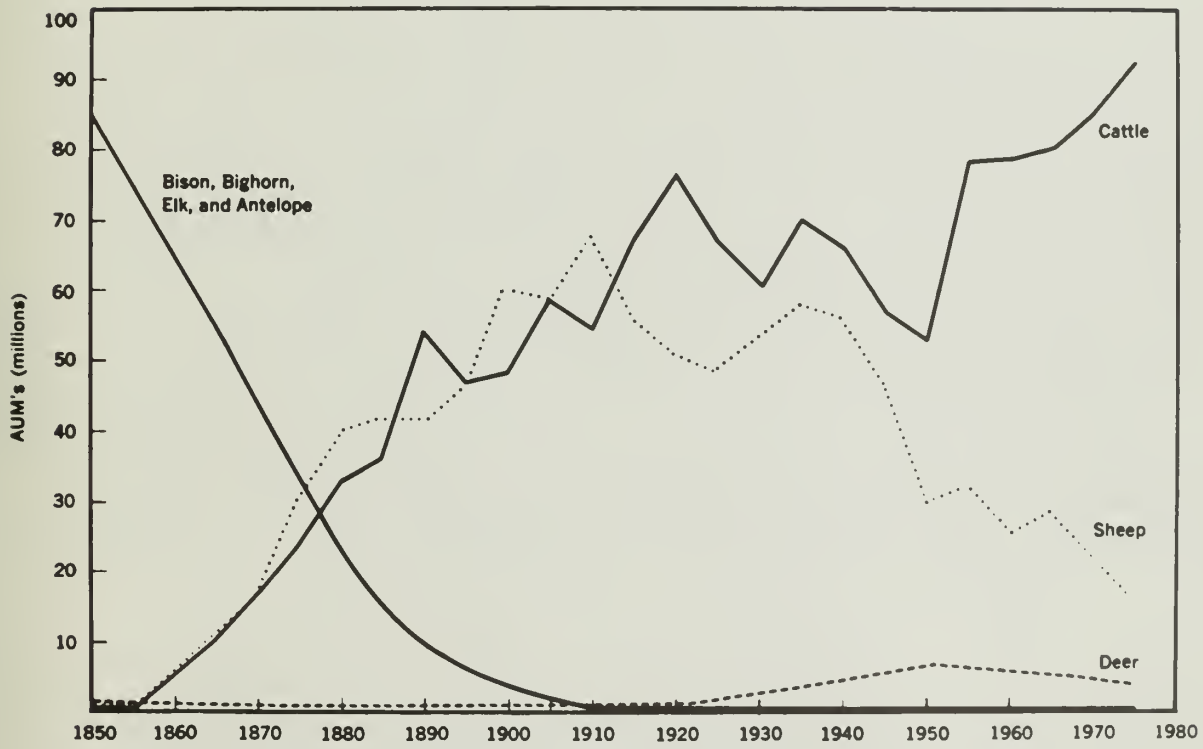


Fig. 18. Conjectured animal unit months of wild and domestic grazing pressures on rangelands of the 11 western states (Wagner 1978).

The role of livestock-induced changes in forb densities and species composition is another important aspect of vegetation changes that developed slowly and has not been well defined. All classes of domestic livestock consume forbs, many succulent species being highly preferred. Some rangelands are depleted of forbs because of heavy livestock use over the past century. When available, these forbs are often highly nutritious and preferred forage at all seasons by pronghorns. The loss or decrease of nutritious forbs to antelope during the last century may well have resulted in deficiencies of trace elements or other nutritional and physiological requirements, which in turn, contributed to the frequency of postnatal mortalities.

Rangeland Improvements: Management practices aimed at improving range conditions for livestock can be beneficial or detrimental to pronghorns. The evaluation of such practices should not be a debacle of the practice, but an objective analysis of how the practice was planned, implemented, and its effect on resources. The following reports will substantiate that there are a number of cases now on record regarding the relationships of pronghorns to projects accomplished primarily for improving rangelands for livestock.

Vegetative manipulation projects are a good example of controversial range improvement techniques relative to the welfare of antelope. Artificial seedings and brush control practices used to develop monoculture grasslands have limited values to pronghorns (Reeher 1969). This is especially true when accomplished in large blocks (5,000 to 15,000 acres), since the larger the project the further pronghorns have to travel to obtain preferred browse. Then too, seeded grassland monocultures frequently have low densities of a variety of succulent forbs so vital to pronghorns during all seasons of the year. Many thousands of acres of sagebrushlands have been converted to monoculture grasslands with introduced perennials such as exotic crested wheatgrasses. Although pronghorns consume some coarse wheatgrasses, they appear to prefer the softer endemic bunchgrasses such as Sandberg bluegrass *(Poa secunda)*.

Over 30 years of studies by Plummer et al. (1968) report that dominant shrublands or pinyon-juniper communities can be successfully rehabilitated for both livestock and wildlife. The key is proper planning and implementation. This requires control of the dominant species and then planting to a complex mixture of grasses, forbs, and shrubs. The mixture must be a complex mixture, that is, at least 6 species each of grass, forbs, and shrubs. If more seed species can be planted, then this produces a more favorable seeding for wildlife. Herein lies a major differentiating objective between livestock and wildlife habitat management. Rangelands, primarily grasslands, serve well the needs of livestock. Rangelands having a variety of vegetative species of all forage classes (grass, forbs, and browse) best serve wildlife. The concept of well-mixed vegetative communities likewise most effectively meets the biological requirements of the American pronghorn.

Unfortunately, no quantitative data is readily available regarding how many monoculture and mixture rangeland seedings have been accomplished

to date. However, it is believed an overwhelming number (possibly greater than 80 percent) have been single-species seedings or simple mixture (1 or 2 species of grass and 1 species of forb) seedings on western public lands.

One justification often quoted for planting single-species seedings as opposed to complex-mixture seedings, is the cost of seed. It is true that a single-species seeding may cost one-quarter or less than a complex seeding; however, this differential cost cannot be supported for rehabilitating public lands since passage of the National Environmental Protection Act of 1969, the Federal Land Policy and Management Act of 1976, and the Surface Mining Act of 1977. These public laws make it clear that the public's lands are to be managed for their natural resources. They are national laws to be upheld and to ignore them is resource management irresponsibility bordering on professional malpractice.

The value of improving rangelands for both livestock and wildlife can be realized through continued evaluations of animal responses to treatment projects. Three such cases have been monitored for pronghorns. In each case, the primary objective of the vegetative manipulation practices was to increase forage production for livestock; however, each case provided major benefits to pronghorns.

Case 1. Pony Springs area, 20 miles north of Pioche, Nevada.

This site is historic pronghorn habitat. The area has been heavily grazed by domestic cattle and sheep resulting in a gradual vegetation change from a mixed shrub-forb-grass type to a dominant shrub community. Range transect data indicated a composition of the dominant shrub type during the early 1960's to average 16% grass, 2% forb, and 82% shrubs, with an aspect height of 32 inches. No use was made of the site by pronghorns although they occupied adjacent rangelands. During the 1960's some 6 to 8 thousand acres were treated in a number of different project years by controlling the shrubs through plowing and chaining and subsequently planting grasses. Five years following treatment, the vegetation composition on one chaining and seeding job was 60% grass, 10% forbs, and 10% shrubs, with a mean vegetal height of 18 inches. Pronghorns readily moved into the treated area and were seen frequently. The site was heavily grazed by cattle during the 1970's. Now the plant composition is 36% grasses, 14% forbs, and 50% shrubs and height is 22 inches. Pronghorns now rarely occupy the site.

Case 2. Bear Valley, Oregon.

This situation was referred to earlier on page 22 and is a good example of pronghorn numbers beneficially affected by changes in habitat conditions. In this case, the habitat was changed on predominantly private lands to decrease sagebrush and artificially seeded to a simple mixture of palatable grasses and legumes for increased livestock forage. The value to pronghorns was the reoccupation of historical habitat unoccupied for decades.

Case 3. The Vale Project, southeastern Oregon

One of the most intensive evaluations of rangeland rehabilitation programs was Heady and Bartolome's (1977) review of "The Vale Project" in southeastern Oregon. Although multiple-use in concept, the 11-year large-scale program emphasized improving forage and waters for livestock on public lands. The 60 by 175 mile area is 90 percent sagebrush-grasslands. Much of the project area was producing less than 50% potential forage due to destruction from past uses of the land.

After Congress appropriated approximately $10 million beginning in 1963, the monies were spent on the following improvement jobs: 506,000 acres of brush control; 267,000 acres of artificial seedings (both single species and simple mixtures), 2,000 miles of livestock fences, 600 water developments, and 463 miles of pipelines installed for better water distribution. Approximately 9 percent of the area was treated for brush control and artificial seedings.

Fifteen years following vegetation manipulation practices, transects were run to determine vegetative composition and height on treated and non-treated sites (Figs. 9 and 10). The non-treated sites averaged 52 percent grass, 3 percent forbs and 45 percent shrubs, with an aspect height mean of 28 inches. Plowed and seeded sites maintained 76%, 11%, and 13%, respectively, of grasses, forbs, and shrubs, with an average height of 18 inches. These vegetative manipulation practices should not be classified as type conversions as no vegetative types were changed but only controlled. Crested wheatgrass was the major species planted in all seedings. Dryland alfalfa was planted in 26 seedings as reported on page 38 of this report. Heady and Bartolome (1977) extensively sampled the treated areas and reported that most attempts at land rehabilitation succeeded. Control projects reduced brush but rarely were all brush plants killed. Sagebrush regrew shortly following treatment on all sites; however, where perennial grass stands were dense, sagebrush reinvaded to only about 25 percent of ground cover.

An analysis of pronghorn numbers for the large-scale Vale restoration project was made and compared with similar evaluations for adjacent lands receiving minor rangeland improvements. All antelope population data were obtained from state wildlife agency aerial censuses (Oregon State Game Commission 1962, 1963, 1964, 1972, 1973, and 1974). During early years of the Vale project (1962-64) the herds averaged 1,420 per year in the project area. Following implementation of the rangeland improvement practices (1972-74), the herds about doubled in numbers (mean of 2,600). During this same time period, herds on adjacent rangelands increased less than 30 percent.

Fences: Range fences in the west are primarily constructed to manage domestic livestock. Rarely are fences built to control wildlife. How livestock fences are constructed can have an impact on pronghorns and other wildlife. As early as the 1870's, records document the fact that livestock fences affect the welfare of pronghorns (Caton 1877). Caton noted pronghorns habitually go under barbed wire fences rather than through or over.

Fences can be major obstacles when antelope mobility is restricted to procure food, water or escape from deep snows. This is most paramount for traditional antelope migrating herds moving from summer to winter ranges (Martinka 1967, Sundstrom 1970, and Oakley 1973). Similar seasonal movement problems for herds in southern U.S. were noted by Buechner (1950) and Hailey (1979) in Texas. Here antelope tried to move from sparsely vegetated dry rangelands to adjacent higher areas with succulent forage, but were restricted by barbed wire fences.

Recommendations for livestock fences that best allow pronghorns to negotiate are provided in a number of research projects and agency guidelines: Spillett 1965, Spillett et al. 1967, Zobell 1968, Mapston and Zobell 1972, Interstate Antelope Conference 1962, and USDI Bureau of Land Management 1974 and 1975).

One of the most comprehensive reports substantiating the antelope-livestock fence problem was the result of a public meeting held in Cheyenne, Wyoming, March 22-23, 1974. Some 150 participants from conservation organizations, sportsmen clubs, environmental groups, government land management agencies, state wildlife agencies, professional resource societies, and general public attended. They listened to presentations and recommendations of the problems. Then the participants formed subject work groups where they analyzed the presentations and submitted suggestions for constructing fences on western rangelands. The results are provided in a 74-page report entitled, "Proceedings Regional Fencing Workshop" (USDI, Bureau of Land Management, 1974). The Bureau of Land Management took this report and synthesized the data into a manual for distribution to all BLM field offices (USDI, Bureau of Land Management 1975a). The manual is now policy and provides the following specifications (see Fig. 20) for the construction of all fences on BLM administered public lands occupied by pronghorns:

1. Net-wire fences are generally barriers; therefore, their construction on antelope ranges is discouraged.

2. Barbed wire fences should be constructed to the following specifications:

    a. Bottom wire at least 16 inches (41 cm) from the ground.

    b. Next wire up 10 inches (25 cm).

    c. Next wire up 10 inches (25 cm), comprising a total of 36 inches (91 cm) height from ground.

    d. Bottom wire should be smooth wire, for antelope generally

Fig. 19. Checking a barb wire fence to make sure the bottom wire meets requirements of 16" from the ground for pronghorns. (Photo by author)

go under fences. Barbless wires minimize physical injuries.

e. No stays between posts, as this provides for a less tight fence allowing easier antelope passage

f. Important antelope travelled pathways, migration routes, etc., should allow for low-height or lay down panels, or pass structures.

g. Keep fenced areas as large as possible, thereby providing an opportunity for antelope to obtain all the basic habitat requirements listed in Table 6.

These fencing guidelines were adopted in principle by the Pronghorn Antelope Workshop at their biennial meeting in Alberta, Canada in 1978. However, one additional item was added. The so-called "wolf-type" fence constructed with woven and barbed wire was declared totally non-negotiable for antelope passage (Autenreith 1978). The biological effects and legal implications of the "wolf-type" fence are well documented in the legal hearing held during April, 1978 (Gist Ranch, New Mexico 6-78-1, August 21, 1978). The final conclusion was that "wolf-type" fences were legally constructed on public lands prior to passage of the Federal Land Use and Management Act of 1976; however, this new federal law mandated multiple-use on BLM administered lands and such fences now violate this mandate.

In some areas of the southwest, ranchers have practiced the management technique of placing fences around water holes to facilitate cattle trapping or distribution. The fences encircle the water source and when cattle come into the enclosure, the gates can be closed and the cattle entrapped for movement to other areas. The fence can also be closed entirely by closure of gates, thereby restricting animals from using the water and forcing movement on to other rangelands. The enclosures are often constructed of woven wire, 6 or more barbed wires, or snow-control fencing. These fenced water sources have a detrimental effect on wild ungulates desiring to use the waters. The effects are most noticable for young animals of the year as they are less experienced in negotiating such facilities. The fencing of water holes resulting in restricted access for waters is the same basic mandate violation of rangelands multiple-use as "wolf-type" fences are to restricting pronghorns accessibility for forage.

A study in Wyoming investigated the feasibility of constructing special facilities that would allow pronghorn movement through livestock fences (Mapston and Zobell 1972). The result was a newly designed structure called an "antelope pass". Figure 21 gives construction design details. Although this structure proved effective in allowing some movement by pronghorns, the authors were explicit in identifying limited mitigating values of these facilities. Some antelope would not pass through at any time. Then too, the structures were not negotiable for fawns. The conclusions of the investigators were that the facilities had limited value for allowing pronghorn access through livestock fences.

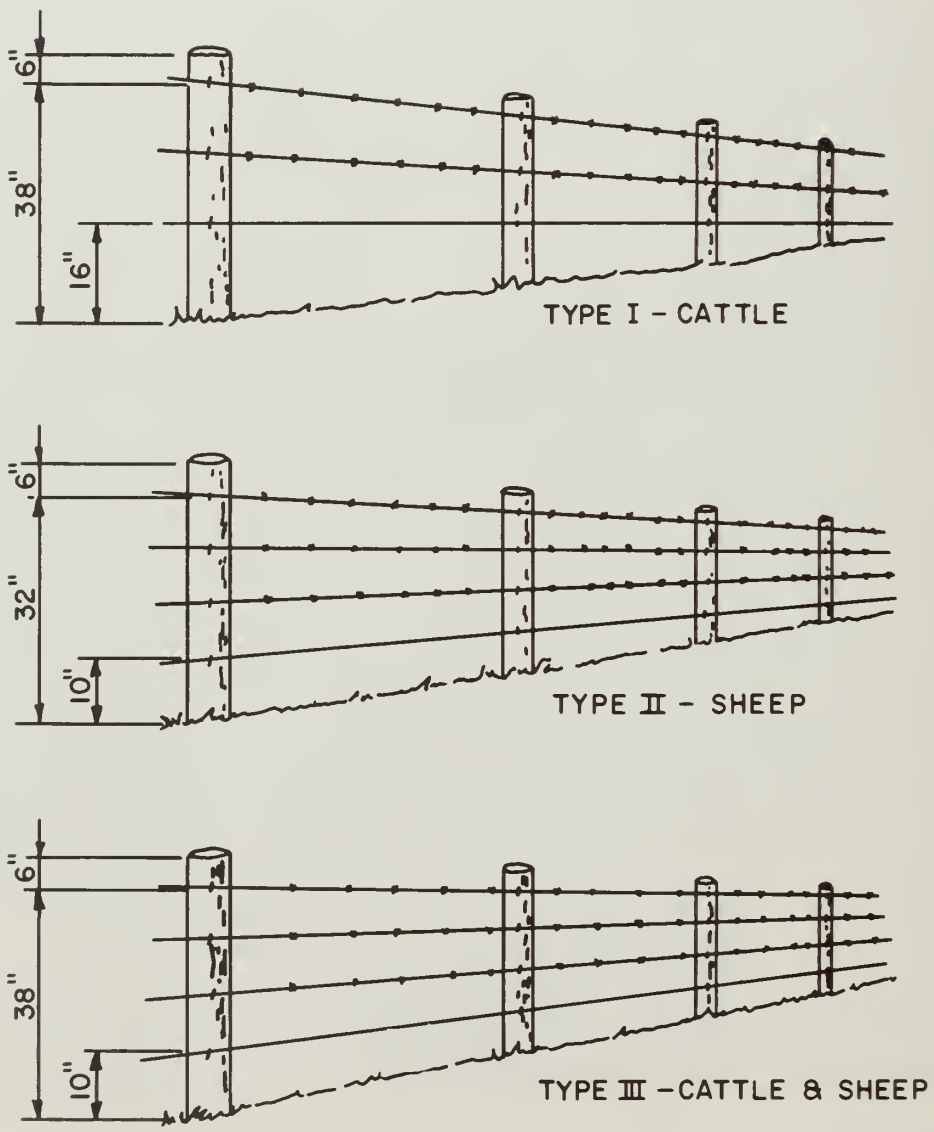


Fig. 20. Barbed wire fence specifications for livestock ranges occupied by pronghorn antelope (USDI, Bureau of Land Management 1975a).

Wildlife biologists working in Idaho have developed a new technique of adjusting wires for seasonal movement of antelope through fences when rangelands are not used by domestic livestock (Anderson and Denton 1980). The system has been field tested and works for both antelope and deer. It is of particular value to pronghorns since it can increase the traditional height of the lower wire from 18" to 38". This has special merit for areas experiencing snow depts of 12" or more, thereby restricting movement under the fence and resulting in entrapment. Figure 22 provides illustrations for 3 fastening mechanisms for adjusting wire fences. Figure 23 illustrates how the wires can be adjusted to allow unimpaired movement for pronghorns. One person can adjust one wire for a mile in approximately 30 minutes. Use of the Davison Fence Clip can be used on wood or metal posts, but it requires special pliers. The staple lock fastener can be used only on wood posts and requires slightly more time to adjust wires. Anderson (personal communication) reported from observations in the field that pronghorns repeatedly selected sites of the highest lower wire to pass under fences; consequently, when the lower wires were adjusted, pronghorns readily adapted to the modifications.

Grazing Systems: Livestock grazing systems are planned procedures for grazing livestock in accordance with basic principles of rangeland management. They provide objectives including the control of livestock on and off areas, range improvements, determining how many livestock will utilize a certain range and what season of use, rangeland condition and trend monitoring studies, suitability of ranges for grazing, physiology of plants, and the effects of other uses on the rangelands. There are a number of different grazing systems, i.e., deferred grazing, year-long grazing, flash grazing, rest-rotation grazing, prescribed grazing and others (Stoddart and Smith 1943, Heady 1975).

Livestock management is turning more each year to establishing grazing systems. For rangelands dually used with pronghorns, the following guidelines are recommended for each livestock grazing system:

1. When alloting vegetation for antelope, the following forage needs will be provided:

    a. The right species and quantity of vegetation will be recognized as forage for antelope. This includes grasses, forbs, and shrubs as determined from on site food habit studies. Special consideration will be given to key forb and shrub species.

    b. Forage will be reserved for a reasonable number of pronghorns. Reasonable numbers will be based upon: (1) the average herd population for the past 30 years, (2) the average forage production for the past 15 years, and (3) management objectives for herd size determined by state wildlife agencies.

    c. When alloting forage, proper amounts will be proportioned for a reasonable number of animals for the area and season

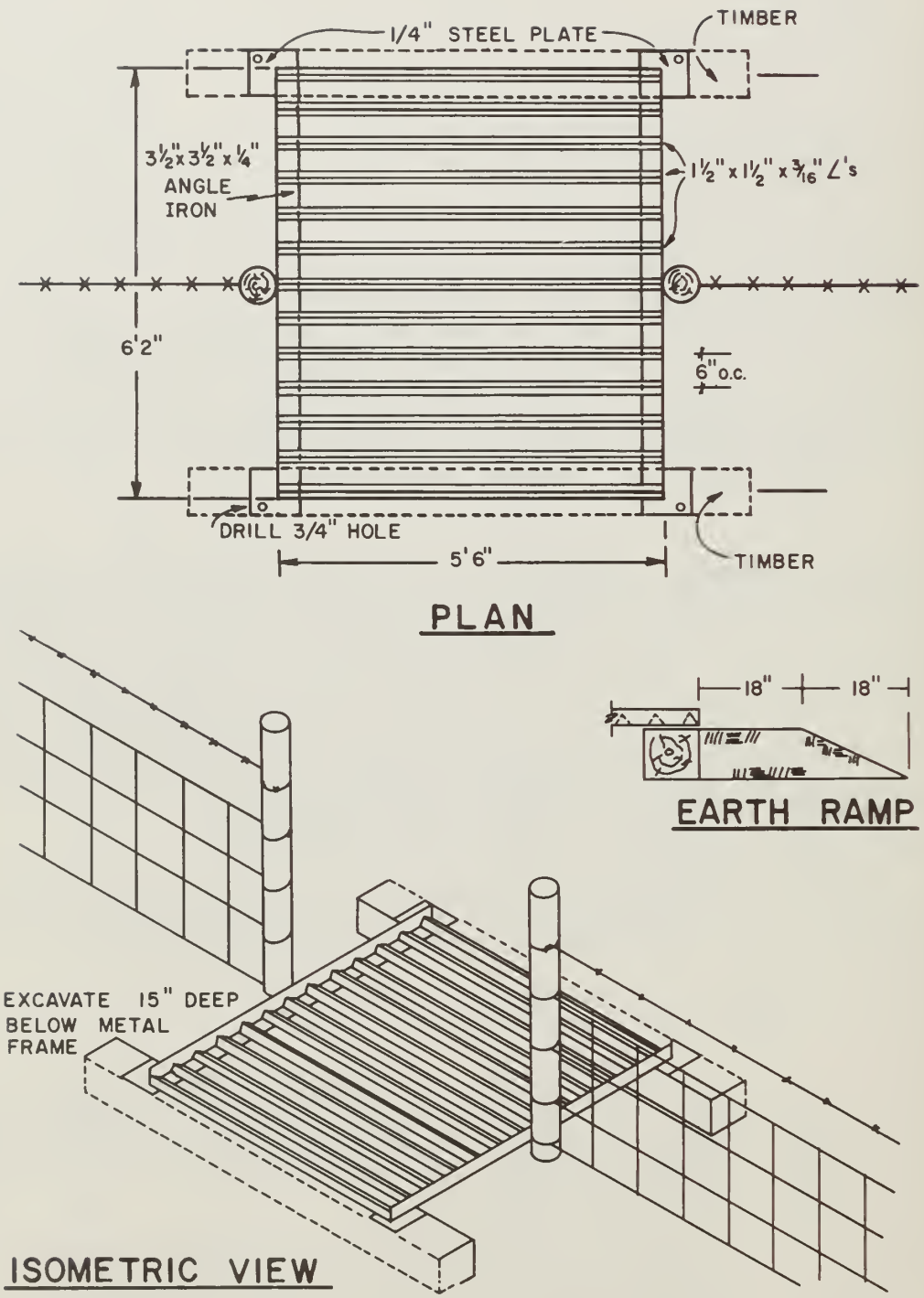
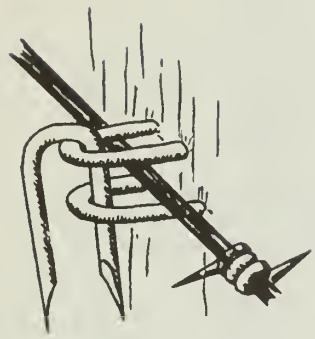
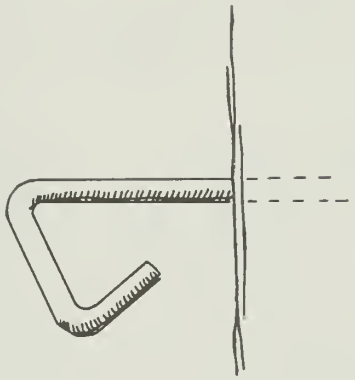


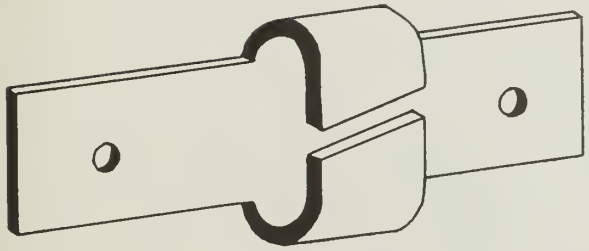
Fig. 21. Antelope pass specifications and recommended method of installation (Hapston and Zobell 1972).



Staple lock - Simple and effective on wood posts. Holds wire tight if standard fence staples are used. Lock staple (or nail) easy to lose.

Hook - Made from large square-end staple. Quite adequate for bottom hook but difficult to drive into untreated portion of post. Use in conjunction with staple lock or metal clip.





Metal clip - Excellent on either wood or steel posts. Easy to install, no maintenance and allows fastest wire adjustment. Existing fences easy to modify with this clip.

Fig. 22. Fastening mechanisms for adjustable wire fences (Anderson and Denton 1980).

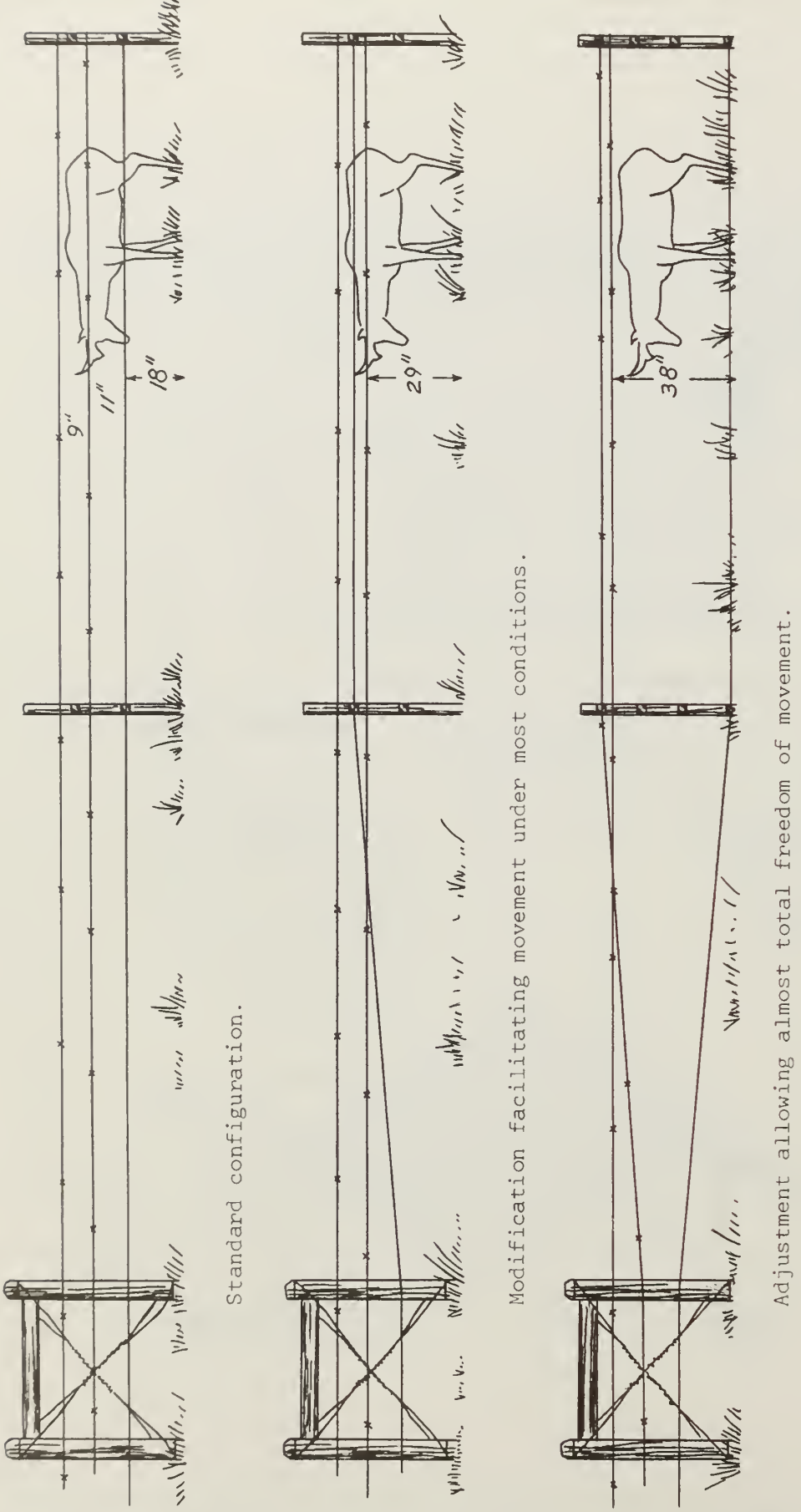


Fig. 23. Three-strand, 38" high barbed wire fence with modifications for antelope (Anderson and Denton 1980).

of use. Special attention to be given to reserving sufficient quality forage for crucial or critical areas (i.e., fawning grounds, winter use areas, etc.).

2. All waters will be maintained for antelope for the seasons the animals are on the ranges.

3. Fence construction will meet appropriate specifications for antelope movement specified in the Regional Fencing Workshop Proceedings (USDI, Bureau of Land Management 1975), and the Pronghorn Antelope Workshop Guidelines (Autenreith 1978).

4. When grazing systems are designed with the concept of key plant species, preferred pronghorn forage species for forbs and shrubs will be included as key species. This is especially important for rest-rotation grazing systems.

5. Livestock grazing systems which restrict, alter, limit or deleteriously affect the habitat requirements of antelope should include mitigating measures and alternate procedures for enhancing antelope habitat.

Grazing systems on public lands should be based upon policy decisions not only for livestock but for all natural resources. Each resource is valued differently by various segments of society; consequently, decisions should reflect the will of the public. The responsibility of the resource manager is to provide objective analysis of decision alternatives and consequences. It is now evident there is some degree of competition between livestock and wildlife. Wagner (1978) recognized this plight and provided three alternatives for managing livestock and wildlife on western rangelands (Fig. 24). The first option is to maintain management at present status quo which is little to no intensive management. This would continue rangeland deterioration at a relatively slow rate over a long period of time with results of low livestock and wildlife production. Option number two calls for intensive rangeland improvement and management accentuating domestic livestock production. Rangelands would be fenced into a mosiac of pastures; many monoculture grass seedings would be planted and waters would be intensively developed. This would result in higher livestock and lower wildlife production. Option number three strives for management on a natural or ecological basis, stressing the return of the rangeland's potential. Right now, three-fourths of these lands are producing less than one-half their vegetative potential (Box et al. 1976). The return of these rangelands to ecologically potential natural production would provide increased numbers of livestock and wildlife and retain a more natural environment. Needless to say the third management option most favors the future of the pronghorn. Recognizing present knowledge and experiences with good rangeland maintenance and enhancement practices, it is postulated that present day pronghorn numbers could be increased 100 percent. In actuality, this would amount to two antelope where one now exists. With this increase in the pronghorn population, it would still be less than 1 percent use of all the forage on the public lands. The increase would be substantial but in comparison to 200 years ago, there

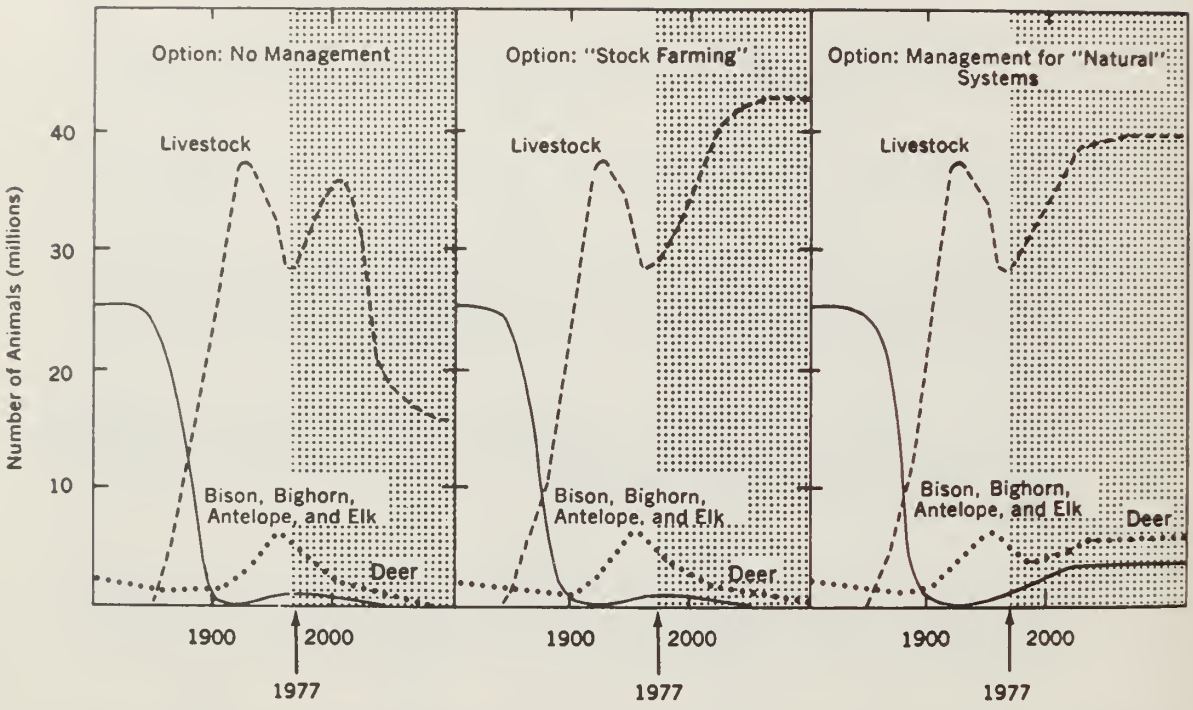


Fig. 24. Three intensities of management options relative to production of livestock numbers and wild ungulate populations (Wagner 1978).

would be merely one antelope where 40 used to roam.

Properly implemented livestock grazing systems require an ecological equilibrium that can produce goodly numbers of livestock and wildlife. Two systems, prescribed and rest-rotation, are frequently advocated today; therefore, these will be discussed relative to the welfare of pronghorns.

Rest-rotation: Hormay (1970) identified the principles and practices for applying rest-rotation grazing. He stressed "production and maintenance of vegetation are of first consideration in management". He advocated management procedures that recognized and supported the physiology of plants. Hormay's published work and training sessions concentrated on establishing formulas using grasses as key species for livestock forage. For pronghorn ranges, the grazing formula should include key forb species which generally have a month or so later seed-ripe time. Then too, Hormay's training identified that on certain shrublands, e.g., antelope bitterbrush *(Purshia tridentata)*, the physiology of these shrubs requires two seasons of rest to set and produce seed. Figure 25 provides a recommended grazing formula that should be established on rangelands where bitterbrush is recognized as a key species. In the Great Basin region, bitterbrush was the next important browse to sagebrush for pronghorns (see Table 4 and Appendix I). Results from Utah (Smith and Doell 1968) support Hormay's recommended

procedures for managing bitterbrush ranges. Smith and Doell state "long term changes in vegetation may necessitate rotation grazing and use of different dates in order to equalize the effects of grazing among the several species in the stand".

Prescribed Grazing: When livestock are used as a tool to maintain and improve range quality for subclimax-adapted species of wildlife, the procedure can be termed "prescribed grazing". This practice requires an understanding of seasonal preferences of both wild and domestic animals, the plant species present, the reaction of plants to grazing, and the phenology of the plant species present. When properly planned and implemented, prescribed grazing can be advantageous to pronghorn habitat. Following are examples:

1. Objective: Control high densities of grasses to increase forbs. Salwasser (1980) reported that since cattle are primarily grazers, they can be used through spring flash grazing of grasses to increase forb growth for summer and fall for pronghorns.

2. Objective: Increase production of preferred browse. Hubbard and Sanderson (1961) found grasses competitive with bitterbrush. Reduced vigor of bitterbrush and increased vigor of grasses appeared to be associated with reduced cattle grazing. When the grass competition was removed, bitterbrush previously in poor vigor increased significantly in forage production and plant reproduction. In this case, prescribed numbers and seasons of use by cattle was used to

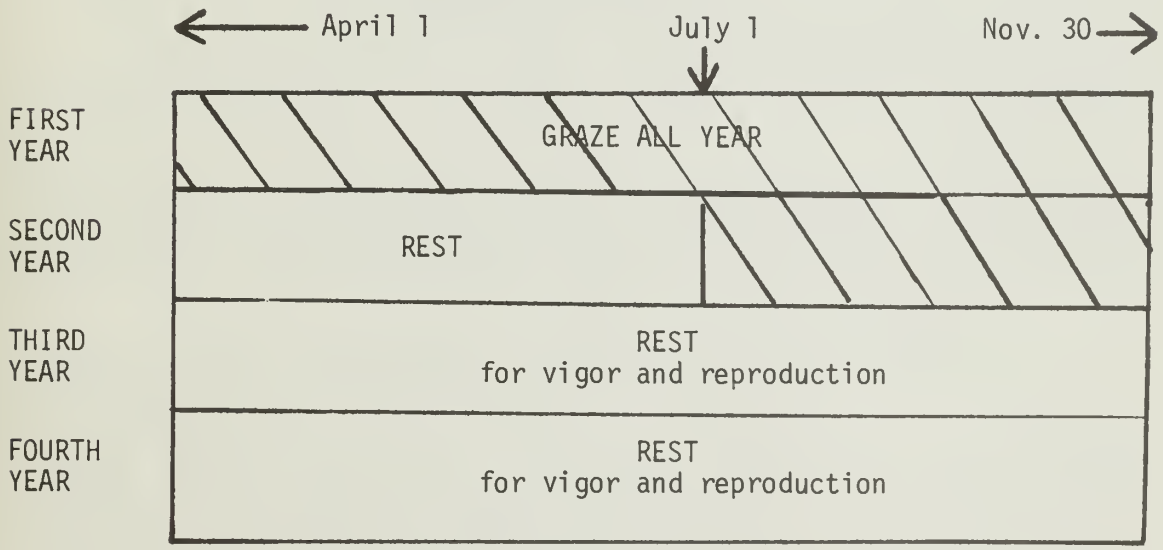


Fig. 25. A four-pasture formula for grazing livestock on a bitterbrush range.

maximize foraging of grasses which in turn favored production of bitterbrush. Similar livestock grazing reactions to shrub-grass relationships were noted by Nord (1965) and Longhurst et al. (in press).

It cannot be emphasized too strongly that in order for livestock grazing to benefit antelope, the specific practices of livestock management must be designed with knowledge of the ecological requirements of pronghorns, and in concurrence with the objectives of wildlife habitat management. To not follow these principles could be analogous to a medical doctor prescribing an incorrect treatment for an ailing patient. In both cases, the prescription of the wrong treatment could end with the loss of, rather than the improvement of the intended source.

Animal Equivalents: The allocation of forage for domestic livestock and wild ungulates is a complex procedure. It is accomplished to determine how much forage is needed for various species of animals using rangelands. A common standard term used in these procedures is the "animal unit month" or "AUM". The National Research Council recommends a value of 2.1 pounds of air-dry forage be granted for each 100 pounds of a 1,000 pound cow for one month which equals one AUM. Recognizing the above criteria for establishing an AUM, animal equivalent figures can be established for how much forage a pronghorn needs in relation to one AUM. However, the procedures are not entirely simple for ready conversions. There appears to be two major methods: (1) comparing body weights, and (2) comparing vegetation consumption of forage classes utilized.

One of the first intensive studies on this subject was conducted by Buechner (1950) in Texas. His weight equivalent findings resulted in 9.39 antelope equal one AUM based on an average weight of 90.5 pounds per antelope and 850 pounds per cow. However, Buechner further elaborated on the differences in forage species consumed resulting in a more realistic equivalent figure of 47 antelope consuming the same forage as one cow.

Working in Colorado, Hoover et al. (1959) used the weight of 100 pounds for antelope and 1,000 pounds for a cow to determine that it took 105 pronghorns to consume an equal amount of forage as one cow. The authors stated, "all the antelope in the state (9,000) would not eat enough grass to feed 100 head of mature cattle".

One of the most studied livestock-antelope forage relationship projects was accomplished on the Red Desert of Wyoming during the 1960's (Severson, May, and Hepworth 1968). They studied the food preferences, carrying capacities, and forage competition between antelope and domestic sheep. It was determined that the carrying capacity for this site was 8 antelope per year for 120 acres. For equivalent ratios, they gave two figures: (1) when grass, forbs, and browse food habits were considered, it took 5.67 sheep to equal one antelope or an AUM equivalent of 29 antelope, and (2) when only grass consumption was computed, it took 43.5 sheep to equal one antelope, or an AUM equivalent of 220 antelope.

Working with sagebrush-grasslands in Idaho, Anderson and Denton (1978) determined that 54 pounds of forage were needed per antelope per month. With this information they computed an equivalent AUM ratio as follows:

$$\frac{800 \text{ lbs/AUM}}{54 \text{ lbs/antelope AU}} = \begin{array}{l}14.8 \text{ antelope consume 800 pounds} \\ \text{of forage per month}\end{array}$$

However, these figures did not consider the degree of competition for different forage class vegetation used between cattle and antelope. When this calculation was determined (based on an estimated dietary overlap of .25), the authors calculated that it took 59.2 antelope to consume the same forage as one AUM. Conversely, one AUM of cattle forage will provide 25% of the diet for 59.2 antelope for one month.

Each of the above procedures for alloting forage has been based upon relationships of body weight or direct forage species competition. These procedures have their values, but there is a possibility that the most important factor that should be determined in forage allocations is the quantification of nutrient supplies and availability. Wallmo et al. (1977) accomplished nutrition analyses for deer habitats in Colorado and advocated these procedures for determining carrying capacity. Additional similar studies for deer rangelands in California support the contention that ungulate diets leading to a decline in energy reserves of doe deer during the last trimester of gestation resulted in high neonatal mortality (Hall, Salwasser, and Browning 1978). This mortality problem is a paramount problem throughout most pronghorn habitats (Vriend and Barrett 1978) in the sagebrush-grasslands.

DISCUSSION

Over twenty years ago, Starker Leopold (1959) investigated the values, problems and objectives of big game management in Nevada. He reported pronghorns existing in greater numbers prior to the settlement of whiteman, and that in recent times "the species is no more than holding its own". Mortality factors such as predation and poaching were not major limiting factors. He believed changes in rangelands were largely responsible for the decrease and retention of low antelope numbers. Leopold summarized his report by stating, "Antelope restoration in the future will depend largely on the program of range management". He recommended range improvements to restore ecological potential site conditions of original sagebrush-grasslands for the benefit of all native wildlife.

Leopold's above recommendations proved wise counsel for wildlife habitat management. The major objectives of this report were to gather and analyze field data regarding pronghorn populations to range conditions. Sufficient number of cases are now on record to state pronghorn numbers and distribution are related to habitat conditions. There is more

reason now than ever before to stress how we should maintain and enhance sagebrush-grasslands.

Data and findings for the sagebrush-grassland steppes of the Intermountain, Great Basin, and Pacific regions were emphasized throughout this report. Sagebrush species are many in variety, however, big sagebrush *(Artemisia tridentata)* is the most prevalent species. Other subspecies of sagebrush should be recognized for their structural characteristics and forage preferences. This is especially true for species maintaining a low density (less than 30 percent of plant cover) and low height (less than 25 inches).

There is an ever-increasing need in wildlife management to relate wildlife populations to society's concepts, policies, and practices to environmental stewardship. Each day brings forth more humans and each human requires more land for life. It is unrealistic to advocate we should strive for the return of the historic legendary millions of pronghorns with an increasing human population. However, there are still thousands of acres of western rangelands under public land administration mandating multiple-use objectives. This means the society of the U.S. wants both livestock products and wildlife values, in addition to other natural resources from public lands. It is this challenge to manage public rangelands for many resources that this technical report emphasizes known data regarding how to maintain and enhance rangelands for the optimum production of pronghorns in conjunction with livestock. These rangelands can best be managed for their ecological site potential of sagebrush-grasslands which are historic pronghorn habitat. Consequently, the American pronghorn antelope is an excellent symbol of a native wildlife species that live compatibly with livestock. In this case, the public lands can produce goodly numbers of both livestock and pronghorns, providing proper consideration is given to the biological habitat requirements of the pronghorn. This can be done.

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Appendix I. Seasonal food habits of 189 antelope expressed in frequency of occurrence in percent for the northwestern Great Basin (Yoakum 1958).

Common Name	Forage Class and Scientific Name	Winter	Spring	Summer	Fall
		No. of Samples			
		40	39	23	87
GRASS (includes grass-like plants)					
Rattlesnake Brome	*Bromus brizaeformis*		2		
Downy Chess	*Bromus tectorum*	38	35	22	7
Brome Grass	*Bromus* sp.		7		3
Wild Barley	*Hordeum* sp.	5		4	
Cultivated Barley	*Hordeum vulgare*	2			
Squirrel Tail	*Sitanion* sp.			4	
Bluegrass	*Poa* sp.		7	4	
Spikerush	*Eleocharis* sp.				1
Rush	*Juncus* sp.			4	
Sedge	*Carex* sp.	2			2
Sedge Family	*Cyperaceae*		3		1
Grass Family	*Gramineae* (green)	39	66	39	19
Grass Family	*Gramineae* (dry)		62	22	55
Grass Family	*Gramineae*	4			4
FORBS (includes moss, lichens, & cactus)					
Lily Family	*Liliaceae*		6		
Knotweed	*Polygonum* sp.		4	35	1
Wiregrass	*Polygonum aviculare*				5
Willow dock	*Rumex sallicifolius*				7
Dock	*Rumex* sp.	2	8	22	1
Buckwheat	*Eriogonum* sp.	13	23		7
Goosefoot	*Chenopodium* sp.				4
Sowbane	*C. murale*				2
Saltbrush Family	*Chenopodiaceae*	1	2	26	2
Russian Thistle	*Salsola kali*	19			2
	Salsola pestifer				6
Prostrate pigweed	*Amaranthus blitoides*			4	3
Buttercup	*Ranunculus* sp.		5		
Rockcress	*Arabis* sp.	4		4	3
Peppergrass	*Lepidium montanum*				2
Peppergrass	*Lepidium* sp.		5		4
Pennycress	*Thlaspi arvense*				2
Tumbling mustard	*Sisymbrium altissimum*				2
Mustard Family	*Cruciferae*		7		2
Burnet	*Sanguisorba annua*		2		
Lupine	*Lupinus* sp.			22	2
Medick	*Medicago* sp.		5		
Alfalfa	*Medicago sativa*			4	5
Alfalfa & other forbs					4
Rattle weed	*Astragulus* sp.		16	35	
Clover	*Trifolium* sp.		8	13	

Appendix I. (Continued).

Common Name	Forage Class and Scientific Name	Winter	Spring	Summer	Fall
		No. of Samples			
		40	39	23	87
Owls Clover	*Orthocarpus* sp.			8	
Vetch	*Vicia* sp.				2
Red-stem Filaree	*Erodium cicutorium*		8		2
Filaree	*Erodium* sp.		3		3
Violet	*Viola* sp.			8	1
Willow herb	*Epilobium* sp.				4
	Boisduvalia glabella				2
Primrose	*Oenothera tanacetifolia*		2	4	
Primrose	*Oenothera* sp.		2	8	
Button snakeroot	*Eryngium* sp.		3		1
Hog fennel	*Lomatium* sp.		22	8	
	Carum sp.		2		
Parsley Family	*Umbelliferae*		3		
Bindweed	*Convolvulus arvensis*				1
Gilia	*Gilia* sp.		4	4	
Gilia Family	*Polemoniaceae*				1
Fiddleneck	*Amsinchia* sp.		2	4	1
Phlox	*Phlox douglasii*	4		4	13
Phlox	*Phlox dolichantha*		6		
Phlox	*Phlox* sp.	11	23	17	8
Phlox	*Phacelia* sp.		2		2
Nievitas	*Cryptantha* sp.				2
Bozage Family	*Boraginaceae*				1
	Collinsia sp.		15	4	
Pentstemon	*Pentstemon* sp.				1
	Pentstemon deustus		7		2
Valerian Family	*Valerianaceae*		3		
Wild Lettuce	*Lactuca* sp.				4
Dandelion	*Taraxacum vulgare*		2		
Thistle	*Crepis* sp.				1
	Haplopappus racemosus				1
Sunflower	*Helianthus* sp.	9	2		2
Balsam root	*Balsamorhiza* sp.	15	3	4	
Balsam root	*Balsamorhiza sagitta*		2		
Arrowleaf	*Wyethia* sp.				1
	Blepharipappus scaber				4
Tarweed	*Madia* sp.				2
	Lagophylla ramosissima				4
Poverty weed	*Iva axillaris*	1	6	22	14
	Eriophyllum lanatum		5	13	4
	Eriophyllum sp.	6			1
Sunflower Family	*Compositae*	4	15	17	9
	Arnica sp.		2		
	Verbene sp.			4	

Appendix I. (Continued).

Common Name	Forage Class and Scientific Name	Winter	Spring	Summer	Fall
		No. of Samples			
		40	39	23	87
Yarrow	*Achillia* sp.			4	
	Senecio sp.		2	4	
	Monolepis sp.			8	
	Erigeron austinae		4	17	5
	Erigeron sp.		4		
Caraway	*Perideridia* sp.			4	
Bird's beak	*Corylanthus* sp.			4	
Bedstraw	*Galium* sp.			4	
English Plantain	*Plantago lanceolata*		4	4	
	Collomia sp.			4	
	Mertensia longifolia			4	
Cactus	*Opuntia*				13
Lichen	*Lichen*		2		
Moss	*Bryophyta*		2		1
Unidentified Forbs		17	12	31	40
Mustard	*Rigiopappus leptocladus*		2		
	Lesquerella sp.				1
BROWSE (includes trees)					
Western yellow pine	*Pinus ponderosa*		2		
Sierra juniper	*Juniperus occidentalis*	4	7	4	6
Juniper	*Juniperus* sp.		4	13	4
Douglas fir	*Pseudotsuga menziesii*	2			4
Hop sage	*Grayia spinosa*	7	3	4	
Sheep fat	*Atriplex confertifolia*	38			19
Wild rose	*Rosa* sp.		2	4	
Rabbitbrush	*Chrysothamnus* sp.				9
Grey rabbitbrush	*C. nauseosus*	6	14	17	5
Green rabbitbrush	*C. viscidiflorus*	7	10	17	8
Manzanita	*Arctostaphylos* sp.		5		
Western serviceberry	*Amelanchier alnifolia*		3		
Bitterbrush	*Purshia tridentata*	2	22	57	15
Big sagebrush	*Artemisia tridentata*	33	33	87	81
Black sagebrusn	*A. nova*		2		
Black sagebrush	*A. cana*			4	4
Low sagebrush	*A. arbuscula*				14
Small sagebrush	*A. spinescens*	15	4		
Greasewood	*Sarcobatus vermiculatus*	7			
Horsebrush	*Tetradymia* sp.			8	
	T. glabrata			8	
Snowberry	*Symphoricarpus* sp.				3
Unidentified Browse				4	11
Willow	*Salix*		2		

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BLM-YA-PT-81-027-6611