Pronghorn Management Guide

2006

PRONGHORN MANAGEMENT: 2006

Biological and management principles and practices designed to sustain pronghorn populations from Canada to Mexico

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About the Biennial Pronghorn Workshop

The Pronghorn Workshop began in 1965 as the Antelope States Workshop and currently meets every even year. Attendees represent western state and provincial wildlife agencies, federal land and wildlife agencies, universities and colleges, wildlife consultants, and private conservationists from Canada, Mexico, and the United States. The Workshop's goals are to exchange information and encourage the perpetuation of sustainable wild herds of pronghorn on western rangelands.

Meetings are held in different locations to present technical and scientific data and conduct field trips. This information is assembled into proceedings, which provide "state of the art" knowledge on pronghorn and pronghorn habitat. In addition, the workshop periodically publishes “Pronghorn Management Guides”, providing a compendium of suggested practices and techniques for managing pronghorn and pronghorn habitat.

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PREFACE

Participants at the 1976 Pronghorn Antelope Workshop identified a number of problems affecting the welfare of pronghorn (*Antilocapra americana)*. As a response, several committees were formed to prepare guidelines to identify debilitating factors and suggest management procedures and techniques to rectify these problems and benefit pronghorn. These recommendations were compiled into the *Guidelines for the Management of Pronghorn Antelope* (Autenrieth 1978) and published as part of the Proceedings of the 8th Pronghorn Antelope Workshop. The objective of this publication was to provide resource managers with the best information available for managing and perpetuating pronghorn and their habitats. Although these initial guidelines incorporated many of the suggested management methods identified and developed by Griffith (1962) for the Interstate Antelope Conference, the intent was to make the Guidelines applicable to pronghorn rangelands from Canada to Mexico. The need to periodically revise and incorporate new information was recognized at the outset.

The first supplement to the Guidelines, *Trapping and Translocation* (McKenzie 1984), was printed and distributed by the Texas Parks and Wildlife Department, and published as part of the Proceedings of the 11th Pronghorn Antelope Workshop.

At the 13th Pronghorn Antelope Workshop in Oregon (1988), participants urged that the above section on trapping and translocation techniques be expanded with a special emphasis on how to evaluate suitable sites for translocations. O'Gara and Yoakum (1990) responded to this request with *Additional Capture Methods and Habitat Suitability Criteria for Pronghorn Translocations*, published in the Proceedings of the 14th Workshop. This publication contained information on some of the less-used capture methods as well as a survey of the literature on methodologies for evaluating translocations and relocation sites. Later, O'Gara and Yoakum (1992) produced the second edition of the Guides that consolidated various management supplements, along with updating and adding new biological and habitat findings.

At the 17th Workshop in California, it was again decided to update the Guides, particularly the sections on habitat evaluations and modifications. Portions of the second edition, along with other new information, were published in the third edition (Lee et al. 1998). This publication, the one previous to this in the series, contained still more information along with a number of revisions and modifications to make the Guidelines more comprehensive and easily understood. This field guide is similar in that it includes new techniques, removes redundancies, and addresses problems not heretofore considered.

Management guides for any species must be general in nature. Their values are found in the discussions of basic requirements and problems recognized in the management of the species involved. The purpose of the Pronghorn Management Guides is therefore to complement our collective knowledge of pronghorn, while any implementing methodologies compatible with a holistic approach to the ecosystems involved, and not the fragmented, single-species approach previously in vogue (Talbot 1976). And, because information from regional reports and past publications has been used to draw conclusions for management recommendations, care should be exercised in applying techniques successfully used in one area to another having different ecological conditions. It should also be remembered that these Guides reflect actual field management experiences as well as research investigations.

These Guides, when properly implemented, should assist land managers, biologists, and researchers in making decisions. The Guide should not be regarded as a "cookbook" of management practices to be used indiscriminately. Included are basic biological data plus recommended management procedures. Each technique needs to be evaluated for site suitability where the information will be used. When this is done, these Guides will continue to serve its intended purpose as previous guidelines have for more than 25 years

The following variations can be expected when managing pronghorn. 1) Pronghorn bucks may be territorial during breeding season, and 2), Bucks may have harems and/or territories. Given different years, even in the same general location, one cannot assume that buck pronghorn are naturally territorial at all times or for all habitats; this biological characteristic must be determined through field observations on site, and the resulting information corrected for different periods of time. Intensive studies in Oregon by Einarsen (1948), Hansen (1955), Yoakum (1957), and Trainer et al. (1983) showed most parturition occurred between 14 May and 2 June. This period is probably appropriate for other northern populations (Idaho, Wyoming, Colorado, etc.); however, for southern herds, Lehman and Davis (1942) and Buechner (1950) reported fawns born from February through April, and pronghorn in the Sonoran Desert typically give birth in February and early March (Murphey 1917).

Habitat suitability criteria have been established for some, but not all habitats. At times, a system for evaluating habitat suitability may be appropriate to use in different biotic communities, but care must be taken to use the appropriate regional ecological characteristics. An example would be that a ground cover of 5% grasses, 5% forbs, and 40% shrubs would be characteristic for vegetative composition in the Great Basin shrubsteppe; however, percentages for Plains grassland would more likely be 35% grasses, 30% forbs, and less than 5% shrubs. Pronghorn prefer certain forage species over others, but diets vary locally due to availability as well as preference; therefore, consumption should be determined through local food habit studies conducted on a year to year basis.

These Guides contain references throughout for the many management practices presently used to manage pronghorn and pronghorn habitat. Although attempts were made to summarize or review these practices, the reader is encouraged to consult the original reports for greater details regarding particular study results.

These Pronghorn Management Guides are the work product of dozens of biologists and resource managers. Most management practices are tried, tested, and proven; however, you may note items in need of correction.. Wanting to correct such errors, we strongly encourage suggested revisions be presented at the next Pronghorn Workshop meeting for consideration in the next edition. The Guide will continue to be valuable only if the publication is dynamic, and in keeping with current knowledge and experience gained.

The Compilers

FOREWORD

Pronghorn evolved in western North America during the last 20 million years (Frick 1937). During recent times, this North American endemic ranged from the south-central prairies of Canada through the Plains and Great Basin's grasslands and shrub-steppes of the United States, southwestward ward to the semidesert grasslands and deserts of northwestern Mexico. Although the total area of suitable habitat has now been greatly restricted by human settlement, pronghorn inhabit much of their historic range, possibly as much as 50%. Areas of highest density have always been open grasslands possessing short shrubs where the size of some pronghorn herds reached legendary proportions. Reports from the journals of the Lewis and Clark and Bartlett expeditions indicated pronghorn were most abundant on the Great Plains and in the Central Valley of California (Newberry 1855, Moulton 1983-2003, and Thwaites 1905).

Millions of pioneers, immigrants, and new settlers moved into the western rangelands between 1550 and 1920. Most showed little regard for pronghorn or their habitat. During this period, pronghorn numbers declined due to fencing, habitat loss, competition with livestock, and year-round hunting. By 1920 it was thought that only about 30,000 pronghorn remained (Nelson 1925). But then the future for pronghorn became brighter. Conservation-minded organizations supported state, provincial, and federal programs that curtailed hunting by settlers and market hunters and provided protection through refuges. A prolonged drought, extending from 1918 to 1934 (Pechanec et al. 1937), together with low prices and surpluses of farm products, made cultivated crops uneconomical on semiarid homesteads. Consequently, livestock numbers were greatly reduced, and many marginal agricultural enterprises were abandoned allowing sizable areas of cultivated land to revert to native vegetation. State, provincial, federal, and private organizations now begin regulating the harvests of pronghorn, which were now being reintroduced to unoccupied historic rangelands. Only in a relatively few areas was damage to vegetation by drought and livestock foraging so severe that pronghorn were unable to survive (Nielson 1962).

More favorable weather, regulated hunting, reversion of farmland to rangeland, and translocations resulted in a great increase in pronghorn numbers to more than a million in 1983 (Yoakum 1986). By 2000 legal harvests of more than 3.5 million pronghorn were being realized (O'Gara and Morrison 2004). Recently, pronghorn populations have fluctuated between 600,000 and 800,000 animals, depending primarily upon winter conditions in the northern states and drought in the southern states. Population expansions beyond these levels are currently limited by agricultural, urban, and mining expansions onto historic rangelands; restrictions of movement by fencing; the resistance of agricultural interests to population increases, the alteration of native vegetation by certain rangeland rehabilitation programs, and overuse. And, in certain locales, these and other debilitating factors are such that managers are hard pressed to even maintain existing populations.

Dave E. Brown and Jim Yoakum

I. INTRODUCTION: PRONGHORN HABITATS AND LIFE HISTORY

Habitat Requirements

Habitat requirements for pronghorns in intermountain, plains, shrubsteppe, valley, and semidesert grassland communities have been investigated and summarized by Sundstrom et al. (1973), Ockenfels et al. (1994), and Yoakum (2004)(Figures 1-). Similar criteria are just now being developed for desert-dwelling pronghorn (Figure 10).

Figure 1. In Idaho, certain pronghorn herds occupy intermountain grasslands at the foot of high mountain ranges. These areas are spring to autumn rangelands containing mixed communities of low-growing shrubs, grasses, and forbs. Aerial photo courtesy of the Edson Fichter collection.

Landscape Physiography: Although pronghorn typically use sites having slopes of less than 10%, these animals can and do occupy steeper terrain; slopes greater than 20% are generally avoided, however. Rugged landscapes also effect survival because mountain lions (*Puma concolor*) and other predators are often found in such sites (Ockenfels 1994b). Pronghorn typically use low rolling, expansive terrain. The area required depends on both habitat quality, quantity and, in some areas, the provision of seasonal movement and/or both habitat quality and quantity in migration corridors to avoid deep snow. Summer and winter rangelands are usually differentiated on the basis of snow accumulation, the availability of seasonal forage, and sources of drinking water.

Figure 2. Many pronghorn populations maintain small herds with a territorial male and harem of 6 to 12 females during the autumn breeding season. This scene depicts these conditions on the Palous intermountain grassland of the National Bison Range in Montana. Photo by Jim D. Yoakum.

Topography and Elevations: Pronghorn inhabit open, gentle landscapes, characterized by hills, ridges and draws. Substrates may be clay, gravel, or sand with dunes up to 6 feet (2m) in height. Elevations range from near sea level to an altitude of 11,000 feet (3,353 m). Animals in Mexico occur close to the seacoast while small herds in Oregon and Wyoming use alpine meadows. Greatest pronghorn densities, however, occur between altitudes of 4,000 and 6,000 feet (1,300 and 1,900 m); (Yoakum 2004).

Natural Barriers: Natural obstacles can curtail movements and exclude the occupancy of otherwise suitable habitats. Natural barriers include abrupt escarpments or mountain ranges, deep canyons, thick copses of shrubs or trees, and densely wooded areas. For example, steep-walled canyons effectively separate pronghorn populations into distinct herds in central and northern Arizona (Ockenfels et al. 1994, Ockenfels et al.1997). Einarsen (1948) cited two examples of such barriers in Oregon, the Columbia River and a forested region, where pronghorn did not move into suitable but isolated habitats nearby. A few trees, especially in open areas subject to high temperatures may be desirable for shade, however.

Figure 3. Prior to the early 1800s, millions of pronghorn and bison grazed the central grassland prairies of North America from Canada south through the western United States to northern Mexico. They still do but in much lass numbers as depicted in this recent scene taken in eastern Wyoming. Photo by Robb Hitchcock.

Figure 4. One of the largest ecosystems with the highest densities of historic and extant numbers of pronghorn, is the short grass prairie. Portrayed here, is a small herd of pronghorn that live year-long on the prairies of southern Alberta, Canada. Photo by Dave Simpson.

Figure 5. Pronghorn occupy portions of the tall grass prairie. When tall grasses are heavily grazed by bison or cattle, or burned by wild fires, then preferred grasses and forbs grow profusely and are readily consumed by pronghorn. A small herd pictured here lives on the Wind Cave National Park in South Dakota. Photo by Jim D. Yoakum.

Climatic Limitations*:* Highest pronghorn densities occur in ecosystems where mean annual precipitation ranges from 8 to 15 inches (20-38 cm). Populations in precipitation belts above or below these parameters have lower survival rates and densities (Yoakum 2004, Sundstrom et al. 1973).

Precipitation and Water: Winter precipitation appears to be more important to pronghorn recruitment and survival than summer precipitation. Studies in the Southwest have shown that pronghorn populations require a minimum of two inches (5 cm) of precipitation during the period October through March for herd maintenance (Brown et al. 2000). No mean maximum precipitation amount have been documented, but probably ranges between 20 and 30 inches (60-76 cm) (Büechner 1950).

Dew and the water content of cacti and forage plants may be sufficient to provide necessary water requirements for adult survival, but may not meet lactation needs (Fox 1997). Reports by Sundstrom et al. (1973) and Yoakum (2004) indicate that herds occupying rangelands with abundant drinking water every 1-3 miles had densities compared to areas with scant drinking water (Hervert et al. (1997) and Cancino et al. (1998)).

Figure 6. Thousands of pronghorn historically foraged the Central Valley of California when the Spanish arrived in the 1770s. Much of the native forage has been replaced with exotic annual plants. Small isolated pronghorn herds to day forage for grasses, forbs and shrubs on the Carrizo Plain National Monument and surrounding habitats in southern California. Photo by Peter Knapp.

In Texas, droughts were associated with decreased pronghorn vitality and fertility (Hailey1979). Baker (1953a) found that pronghorn in Wyoming sometimes died while trying to get through fences to reach water. Pronghorn will drink from most facilities designed to water livestock, but these facilities should remain functional and usable by pronghorn throughout the spring, summer and autumn on northern rangelands and year-round in southern habitats.

The quantity of water consumed by pronghorn varies with body size, sex, health, lactation demands, and physical activity, and the succulence of the forage, as well as humidity and ambient temperatures. Water use decreases with lower temperatures and the availability of snow, succulent forage, and the amount of dew or rain. Conversely, water use increases with drier atmospheric conditions, lack of snow, dry forage, and higher temperatures. In Wyoming, pronghorn were stressed when snow or free water was not available during winter (Cook et al.1984, Guenzel et al. 1982).

Based on studies of laboratory animals, summer water requirements for an adult pronghorn in Wyoming were 0.95 gal/day/100 lb animal (3.6 l/day/45 kg) (Whisler 1984). However, the water needs for free-roaming pronghorn accustomed to drinking water may be greater. Measurements of pronghorn water consumption were conducted in a Wyoming field study (Sundstrom 1968).

Daily consumption rates per adult pronghorn varied from 0.09 gal/day (0.34 l/day) in May to 1.19 gal/day (4.5 l/day) in August. Water in quantities of approximately 1/4 of summer consumption rates should be provided to pronghorn during winters when free water (including snow) is unavailable to herds accustomed to drinking in Wyoming (Sundstrom 1968).

A close relationship was observed between pronghorn distribution and water locations in Wyoming's Red Desert; 95% of 12,465 pronghorn surveyed from the air were within 4 miles (6.4 km) of a water source (Sundstrom 1968). Most pronghorn observations in Arizona and New Mexico are usually within two miles (3.2 km) of water (Ockenfels et al. 1994, Clemente et al. 1995). Occasionally, adult males are seen farther from water, and pronghorn in the Sonoran Desert have been seen 40 miles (24 km) from water (J. Hervert pers. com).

Benson (1956) considered the advent of water developments in Saskatchewan to be associated with the dispersion of pronghorn populations. In Oregon (Anonymous 1961), it was speculated that although suitable forage was available for pronghorn, the limiting factor was adequate drinking water in late summer. Beale and Smith (1970) suggested that water developments might encourage a greater distribution of pronghorn where natural water sources were limited, particularly during dry seasons or drought years. Water developments may also increase competition with livestock and elk into formerly unused habitats, however.

Minimum distance to water may be as important as maximum distance. Pronghorn in Arizona avoided the first 400 yards (400 m) from water sources, possibly to reduce the threat of predation (Ockenfels et al. 1992, Ockenfels et al. 1994). If an area is well watered, distance to water may vary little with the season (Ockenfels et al. 1994). In southern New Mexico, pronghorn ranged farthest from developed water in summer, when precipitation was the highest, thereby reducing reliance on stock tanks and other artificial water sources (Clemente et al. 1995).

Snow: When snow depths exceed 10-12 inches (25-30 cm), pronghorn frequently have difficulty obtaining forage. Prolonged periods of deep snow are especially detrimental when combined with such factors as inadequate forage, low temperatures, and snow crusting due to alternate freezing and thawing temperatures. Although wind increases chill factor, a complete absence of wind precludes bare patches of ground and interferes with foraging. Fences and other obstacles to movement may be especially detrimental as such times (Sundstrom 1969, Riddle and Oakley 1973, Hailey 1979). The severe winters of 1964-65 and 1968-69 resulted in high losses of pronghorn in Montana, the Dakotas, and even Arizona, often because the animals could not reach areas with adequate food (Compton 1970, McKenzie 1970, West 1970). Wishart (1970) reported that severe winter weather in Alberta caused prolonged emigration, starvation, and increased predation as well as depressed reproduction the following year. Even in southern regions, pronghorn are not immune to winter mortality. Many pronghorn trapped by drift fences froze to death during blizzards in the 1880s, and settlers killed 1,500 trapped by a drift fence in Texas in 1882 (Haley 1949).

Low temperatures seldom are a major limitation unless combined with deep, crusted snow. Freezing temperatures and precipitation during fawning may cause mortality to newborns. The effects of high temperatures, while poorly documented, nonetheless play a role in water loss, forage availability, and physiological functions. (Brown et al. 2006)

Figure 7. Semidesert grasslands in the state of Chihuahua sustained the highest number of pronghorn in Mexico; however, total numbers have greatly decreased during the last 100 years. They are classified as an endangered species by the federal government. Photo by Patrick Robles.

Vegetation: Ground cover in grasslands occupied by pronghorn averages 60-80% living vegetation (mostly grasses and forbs) with 20-40% being without vegetation. In shrubsteppe and semidesert grassland habitats, the percentages are 50% or more living vegetation and less than 50% bare ground, rock, litter, etc (Yoakum 2004). Habitats used by desert pronghorn possess less than 50% ground cover (Brown 1994).

Plant Composition and Structure: Generally, composition of vegetation is 5-15% grasses, 5-10% forbs, and 10-35% shrubs on shrub-steppes; in grasslands, the typical composition is 50-80% grasses, 10-20% forbs, and less than 5% shrubs (Yoakum 2004). In semi-desert grasslands in Arizona, grass cover averaged 15%, shrub cover averaged approximately 10%, and forbs cover fluctuated between two and 10% (Ockenfels et al. 1994). Desertlands used by pronghorn may have <10% shrub cover with annual grasses and forbs composing less than two percent of the ground cover. The use of semi-desert and desert habitats with tree cover is usually low, but increases during hot, dry periods when pronghorn use scattered trees or other structural cover for shade (Ockenfels 1994)

Figure 8. Semidesert grassland communities formerly hosted moderate to large numbers of pronghorn but because of fire prevention and the invasion of woody shrubs, reduced grass cover, and a loss of nutritious forbs, many of these areas now support few if any animals. The trees are *Juniperus monosprma*, a grassland invading juniper. Photo by Richard Ockenfels.

Low vegetative structure, averaging 10-18 inches (25-46 cm), is preferred. Vegetation over 25 inches (63 cm) is typically avoided, and that taller than 30 inches (76 cm) is infrequently used. Pronghorn may use areas having high shrubs while traveling to or from preferred habitats. However, reduced visibility or decreased mobility due to tall vegetation, are important factors in pronghorn survival (Goldsmith 1990).

Pronghorn in the Southwest often use savannas if canopy cover averages less than 20% and other vegetation is less than 24 inches (61 cm) (Ockenfels et al. 1994). Other special southwest habitats include dunes in the Vizcáino subdivision of the Sonoran Desert and “cholla forests” in northwest Sonora and southwest Arizona (Cancino et al. 1995, Hervert et al. 1998).

Figure 9. Great Basin shrubsteppes and desert scrub are biotic communities supporting limited numbers of pronghorn. These areas produce a wide variety and quantity of endemic and exotic forbs that consumed in large quantities. Shrubs are typically abundant and are browsed throughout the year, often becoming the key survival forage during critical winters. Photo by Tom Pojar

Figure 10. Sonoran Desertscrub community inhabited by pronghorn. Photo by David E. Brown.

Plant height and density are synergistic factors affecting pronghorn. Plants, including grasses, more than 2.5 feet (0.75m) tall are detrimental to pronghorn and dense stands of such plants preclude the animal's presence. Conversely, shrubs and other plants less than 18 in. (0.5m) tall are often advantageous to pronghorn, especially if the shrub cover is less than 40%. Trees and tall shrubs >2.5 feet tall should comprise less than 5% of the cover, and a density of such plants >15 % may exclude the permanent presence of pronghorn. As a consequence, pronghorn are usually lacking from dense big sagebrush (*Artemisia tridentata*), greasewood (*Sarcobatus vermiculatus*), one-seed juniper (*Juniperus monosperma*), and other tall shrub communities, just as this animal has always shunned tall-grass prairies (Yoakum 2004). Tree density in most pronghorn habitats in Arizona are typically less than 2/acre (5/ha) (Alexander and Ockenfels 1994).

Plant Diversity: Within shrubsteppes occupied by pronghorn, the number of plant species averages 5-10 grasses, 10-70 forbs, and 5-10 shrubs (Yoakum 2004). On grasslands the averages are 10-20 grasses, 20-60 forbs, and 5-10 shrubs. Although semi-desert grassland habitats exhibit similar diversity, most desert habitats possess less than five species of grass, five forbs, and one or two shrubs with some of the grasses and forbs being annuals. As a consequence, plant species richness may vary by month, with the greatest variety usually being in spring (Ockenfels et al. 1994).

Trees are often absent or scarce in grasslands and shrubsteppes. When present, species richness is usually two or less except in the Sonoran Desert where up to five species of trees may be present (Brown 1994).

Open landscapes supporting a patterning of vegetative types (meadows, forbs patches, riparian areas, dunes, etc.) are preferred in contrast to monotypic vegetative communities (Yoakum 1957, Sundstrom et al. 1973). Pronghorn also forage and often congregate in areas of recent wildfires as these "burns" typically produce new grass growth and a flush of succulent forbs (Deming 1963, Yoakum 1980, Courtney 1989).

Key vegetative components are those areas necessary to sustain a pronghorn population during critical periods (e.g., severe winters, droughts, etc.). The use of such areas may or may not be seasonal, and often depends on environmental conditions. Vegetative requirements for pronghorn vary widely in relation to land management practices, geographic location, climate, soils, and habitat types. Examples of key rangelands used by pronghorn include: spring feeding areas (Becker 1972), winter range (Compton 1970, McKenzie 1970, West 1970, Taylor 1975); seasonal movement routes, areas having water (Sundstrom 1968, Beale and Holmgren 1975), and fawning areas (Einarsen 1948, Pyrah 1974, Autenrieth 1976).

Life History

***Behavior**:* Due to the ease of observations, pronghorn behavior has been studied extensively. Northern pronghorn tend to winter in large herds, with animals of both sexes and all ages feeding and bedding in close association with minimal social conflicts. However, the sexes may remain segregated in areas experiencing mild winters (O'Gara 2004).

Behavioral adaptations during winter to conserve energy include: establishing hierarchies at feeding craters pawed in the snow; selection of microhabitats with lower wind velocities and less or softer snow, reducing daily travel, traveling single file, and lying down during days having hard snow and low temperatures. During periods of high winds, pronghorn may lay down in compact groups with their heads curled back along their bodies (Bruns 1969).

Does typically isolate themselves prior to giving birth. By mid-summer, does are typically found in doe-fawn groups, with non-territorial bucks interacting with others in bachelor herds (Prenzlow et al. 1968, Kitchen 1974, Autenrieth and Fichter 1975). Mature bucks are often territorial or strive to maintain a harem at this time.

The presence of mature, territorial bucks ensures that bachelor bucks do not compete with pregnant and lactating does for forage on the best rangelands (Gilbert 1973). The most rigorous bucks do most of the breeding in either a territorial or harem breeding strategy (Byers 1997). Unlike some other ungulates, younger bucks, < 5 years of age, possess the largest horns (Brown et al. 2002).

Movements: Pronghorn change locations due to drought, blizzards, disturbance, and forage and/or water availability. Pronghorn migration is defined as traditional movement from one seasonal-use area to another, following approximately the same route year after year. According to Einarsen (1948) and Yoakum (1978), most pronghorn exhibit seasonal movements and relatively few populations now participate in traditional migrations.

The timing and length of seasonal movements are generally in response to changes in climatic and vegetative conditions. In the northern parts of their range, pronghorn sometimes move up to 200 miles (320 km) in response to deep snow or to reach available winter forage (Riddle 1990). During dry seasons, southern pronghorn may move some distance in search of forage and water (Büechner 1950, Hailey 1979).

Reproduction: Although pronghorn fawns occasionally breed (Wright and Dow 1962, Mitchell 1967), does usually breed the first time when 16-17 months of age. The gestation period, averages 252 days, and is long compared to similar-sized ruminants (Hepworth and Blunt 1966). Most northern pronghorn breed during a short period from mid-September to early October (O'Gara 1968), but animals in more southern areas may breed from July through October (Lehman and Davis 1942, Büechner 1950, Hervert pers. com.). The mean number of fetuses per doe in 6 studies involving 209 does was 1.94 (O'Gara 2004b.). Mid-summer fawn to doe ratios (f:d) often are used as an index of recruitment. Fawn production rates in Montana were rated as follows (Trueblood 1971):

Fawns:100 Does	Rating
20-39	Very poor
40-59	Poor
60-79	Fair
80-99	Good
100+	Excellent

Care should be exercised in interpolating these ratios for other habitats, especially areas with lower carrying capacities such as semidesert grassland and desert ecosystems. Ellis (1970) gathered information on f:d ratios and reported means of 80-100:100 in the Great Plains and 30-50:100 in the Intermountain West. Fawn to doe ratios in the arid Southwest average less. In Arizona, hunt management guidelines indicate permit decreases when f:d ratios fall below 30:100 and indicate permit increases when fawn: doe ratios rise above 40:100.

Diet Selection*:* Pronghorn food habits vary greatly due to these ungulates occupying diverse vegetative communities in three biomes--grasslands, shrubsteppes, and deserts. Pronghorn are selective, opportunistic foragers, feeding on grasses, forbs, shrubs, and trees, depending on plant palatability and availability. More than 200 diet selection studies have been conducted during the past half- century (Yoakum 2004d); 21 of these provided data on forage classes available as well as the percent composition taken each season. Preference ratings, calculated from these data, were 4.7 for forbs, 1.5 for shrubs, and 0.2 for grasses (Fig. 5). Thus, management decisions favoring an abundance of palatable forbs throughout the year are desirable (Yoakum 2004d).

Grasses are grazed most intensively during first “Green-up” when shoots are 2-3 inches (5-8 cm) tall and highly nutritious. They will consume dry grass, but not in quantities. Shorter and fine-textures bunch grasses are preferred over large coarse bunch grasses. Annual and perennial forbs are grazed throughout the year when available. During the winter in the northern Great Basin shrubsteppes, Hansen et al. (2001) reported pronghorn consumed large quantities of perennial forbs during a mild winter with little snow covering small herbaceous plants.

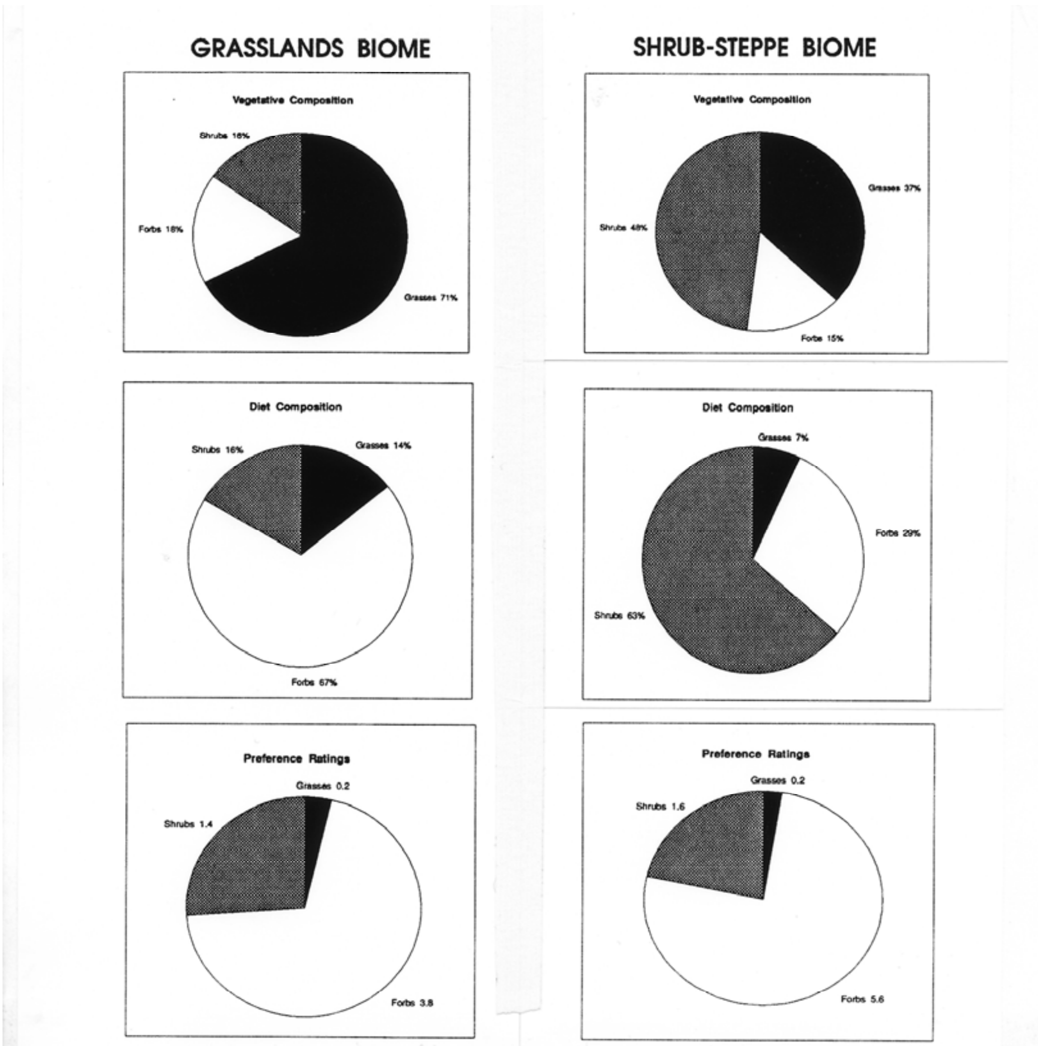


Figure 11. Comparison of vegetative composition, diet composition, and preference ratings for pronghorn year-long food habits in grassland and shrubsteppe (Yoakum 2004).

Forbes may well be the most important forage class to pronghorn densities, for they provide greater amounts of nutrients than grasses or shrubs during late winter and early spring (Ellis 1970, Smith and Beale 1980, Hervert et al. 2000). This is the time of year that most (southern herds may differ) parturient does are carrying two fetuses that grow rapidly during the third trimester. Hence, Pyrah (1987) referred to herbaceous plants as "production plants". Early summer is by far the most important season for consumption of forbs, as the doe must obtain sufficient quality forage for her to nurse two fawns and at the same time obtain enough nutrients to keep healthy.

Shrubs, like forbs, are often consumed each month of the year, however, they are browsed in greater quantities during autumn and winter. Shrubs are "survival food" because they often are available during deep snow depths and during years of droughts. Shrubs often have greater concentrations of nutrients during the autumn-winter than spring-summer. Some of the lesser preferred shrubs are consumed in greater quantities during severe winters and droughts because the total for nutritional forage is scarce.

While conducting studies of pronghorn for more than 20 years on the grasslands of the National Bison Ranch in Montana, Byers (2003) concluded that rangelands with an abundance of succulent, nutritious forbs in the autumn-winter sustained heavier, larger fawns and had high survival rates during summer following parturition.

Pronghorn mortality due to inadequate quality and quantity of nutritious forge is often not detected in the Field. Then too, malnutrition may be a secondary mortality factor that is credited as an agent for killing animals: (e.g., severe winters, froughts, entrapment in fenced pastures, predation, and others (Martinka 1967, Compton 1970, Ellis 1970, Riddles and Oakley 1973, Barrett 1974, Pyrah 1978, etc.)

Adult pronghorns require an average of 2.5-3.0 pounds (1.1-1.4 kg) of air-dry forage per day, and these animals consume less than 1% of the forage produced on western rangelands (Wagner 1978). The amount of forage required by young animals is unknown. Pronghorn seldom suffer ill effect from eating normally toxic plants and, at times, apparently relish them (Yoakum and O'Gara 1990).

Although pronghorn often visit salt and mineral blocks, their mineral requirements and use remains unstudied (O'Gara and Yoakum 2004).

Parasites and Diseases: Extensive epizootics controlling pronghorn populations are uncommon. However, 33 species of roundworms, 21 genera of bacteria, 14 viral diseases, 8 species of protozoa, 5 species of tapeworms, and 4 species of ticks, one fluke, and a louse fly have been reported in or on pronghorn (Lance and Pojar 1984, O'Gara and Yoakum 2004a). The impact of most of these agents on free-ranging populations is unknown. Bluetongue, is the most serious disease affecting pronghorn; at least 3,200 pronghorn died from this disease in eastern Wyoming during 1976, and another 300 known deaths occurred in northeastern Wyoming during 1984 (Thorne et al. 1988). How important bluetongue might have been in early pronghorn population declines is unknown. Bever (1950) reported the loss of 30-60% of pronghorn fawns in South Dakota, primarily due to parasitic worms. Bever (1957) stated that, with proper management of domestic livestock, no parasite-caused mortality was found, but that rangelands overgrazed by domestic sheep resulted in high parasite loads in pronghorn in South Dakota.

Figure 12. Territorial bucks' scent-mark vegetation to warn other bucks entering the area. Territoriality ensures that bachelors generally do not harass or compete for forage with pregnant or lactating does on rangelands in good ecological condition. Bucks may have territorial or harem breeding habits, or both, during different years in the same location. Photo by Jim D. Yoakum

Longevity: Pronghorn seldom live more than 9 years under natural conditions (Einarsen 1948, Hepworth 1965), but Trainer et al. (1983) reported collected does living as long as 16 years as determined by tooth sectioning. In their northern range, pronghorn are susceptible to frequent winter-kill (Einarsen 1948). Winter-kill is rare in more southern ranges, but can be catastrophic when it does occur (White 1969). Advancing age and disease also reduces survival. Hunting is generally strictly regulated and most of the harvest is males (O'Gara and Morrison 2004). As a result, male survival is often less than that of females. Predation is not considered a primary factor in adult survival. Four major fawn predators are common throughout most of the pronghorn range: coyotes, bobcats, golden eagles, and domestic dogs. Mountain lions are a concern in rugged terrain in the Southwest (Ockenfels 1994a, b). Other mortality factors include poaching, crippling, road kills, toxic poisoning (Hailey et al. 1966), fence entanglement, parturition complications (Canon and Byrant 1992), starvation, drought, and accidents (Einarsen 1948).

Adult survival rates vary by gender and by area. Hunting management strategies, weather, density of cover, and ruggedness of terrain are significant factors affecting survival rates. Annual survival rates may be as low as 0.55 (Mitchell 1980) or approach 1.00 (Canon and Bryant 1992, Ockenfels 1994a, and O'Gara 2004a, 2004c).

II. MANAGEMENT RECOMMENDATIONS

Populations

Survey methodology depends upon the survey objectives. Animal disturbance is an important consideration with ground surveys and high flying (> 300 ft (90m) 0 fixed wing aircraft causing the least disruption, and low flying helicopters causing a greater disturbance. The best methodology is usually aerial surveys using either fixed-wing aircraft or helicopters with a skilled pilot and observer(s).

Skill level and alertness are important to rapidly classify and count pronghorn, thus avoiding the need to remain close to the animals or having to make multiple passes. If multiple passes must be made, it is important to refrain from running the animals for long distances or for any length of time in order to reduce the amount of stress that accompanies any survey.

Figure 13. While conducting a winter survey, the photographer took this scene of the shadow of his fixed-wing aircraft and a herd of >270 running pronghorn on the shrubsteppes of southcentral Oregon. One technique to improve counting accuracy with large herds, is to photograph them and later detail count. Photo by Eastman Studio, Susanville, California.

Population and Composition Counts: Pronghorn inhabit open terrain making the animals relatively easy to observe. Observers can therefore get a false sense of security when making aerial survey designed to estimate population density and herd structure. Although easily visible under most conditions, pronghorn can also be very cryptic in some situations, which contributes to significant biases in making population estimates. However, obtaining useful and reliable population data is possible by following statistically sound sampling methods and by maximizing the search intensity of the area to be sampled.

Unfortunately, the ideal is not always possible and pronghorn managers have relied on trend counts, wherein those animals seen serve as indices of population size. Detection of changes in population size therefore depends on the precarious assumption that counting conditions have been standardized, and that the percentage of animals counted is similar from one survey to the next (Nichols 1992). In Wyoming, extensive line-transect samples indicate that traditional methods have consistently underestimated pronghorn numbers. Therefore, Wyoming is continuing to explore refinements in the line-transect method to further improve the reliability of their annual census. Lee (2000) and Polar (2004) discussed various wildlife survey techniques and factors that effect survey results.

Pronghorn group size and distribution vary throughout the year (Kitchen 1974, Mitchell 1980). The time of the survey has a profound effect on survey results and their reliability. Group size and distribution become important when choosing an effective sampling unit for a sample-based survey. Surveying dispersed subjects is an advantage in reducing the variance (i.e., increasing the precision) of sample-based statistics (Allen and Samuelson 1987, Johnson et al. 1991). Pronghorn are most dispersed during the May-June fawning period, and remain in relatively small groups through late summer (Mitchell 1980). Therefore, sample-based surveys generally have minimal variance if done during the May through August period. After mid-July, young of the year join adult groups, making it possible to include them in the survey results and thus obtain fawn to doe ratios.

Estimating Population Size: Sample-based aerial surveys are a statistically sound means of estimating total population size and, in addition, offer a significant savings in flight time over attempts at total coverage (Johnson et al. 1991). Some sampling techniques applicable to pronghorn surveys are: (1) strip transects, (2) line transects, and (3) quadrants. However, use of a sound sampling design does not ensure an unbiased total population estimate; search efficiency and the observability of the subjects influence the accuracy of the estimate. The assumption, common to all sample-based systems, is that all subjects in the sample unit (e.g., strip transects, quadrants) are counted in order to obtain an unbiased estimate. In line transect sampling there is also the assumption that no animals are missed on the center line or in the first distance interval from the center line (Burnham et al. 1980); animals can be missed in other distance intervals and not invalidate the method. Ideally, some means of estimating search efficiency should be employed on a portion of the sample units so that adjustments can be made for biases. For line transects, double sampling is always prudent, or results should be compared to known density areas (White et al. 1989). Unless strip transect data are corrected for bias by double sampling, distance interval data (line transects) should be collected to provide a correction for missed animals (Burnham and Anderson 1984, Graham and Bell 1989). Otherwise, only an unknown fraction of the population is counted and the nagging question, ubiquitous in wildlife inventories, persists -- "How good are the survey data"?

The demand for more precise management necessitates better population estimates, which allow managers to base decisions on better data rather than only indices or trends. Procedures are available to correct for biases in surveys and should always be employed at some level depending on management needs. Eberhardt (1987) demonstrated a double sampling technique to calibrate indices with estimates of population size. Observability models based on radio collared animals also provide reasonable corrections for survey bias where group size and vegetative cover are factors (Samuel et al. 1987). Capture-recapture models offer other correction possibilities (Nichols 1992). The intense search of quadrants using a helicopter resulted in an upward population correction of only 2.1% (Pojar et al.1995). This study suggests that intensive helicopter searches of relatively small sample units can be used in a double sampling scheme to correct survey information that, while less expensive to execute, produces less trustworthy population estimates.

The line transect method (Burnham et al. 1980) has been used successfully in Wyoming during mid-May, when pronghorn are widely dispersed and highly conspicuous against the green background (Johnson et al.1991, Guenzel 1997). Although it was not tested against known density or double sampling surveys, this survey method produced population estimates that were consistent with population modeling results..

The line transect method offers several attractive features: 1) it can be done with fixed- wing aircraft, which cost about 25% as much to rent as helicopters; 2) no on-the-ground markers are necessary if a navigation system such as GPS is employed; and, 3) confidence limits can be calculated for the population estimate. This method is far superior to total coverage by strip transects because it is more efficient and the "accuracy" of any estimates are subject to tests of variance. Line transect survey data analysis should follow the detailed descriptions provided by Guenzel (1997). The latest version of the line transect data analysis program (Version 4, release 2) can be downloaded from: http://www.ruwpa.stand.ac.uk/distance/distance40download.html

Figure 14. The line transect method can also be done with fixed-wing aircraft, which cost about 25% as much to rent as helicopters; no on-the-ground markers are needed if a navigation system such as GPS or Loran C is used; and confidence limits can be calculated by "double sampling" and then calculating a population estimate. Photo by Paul Wertz, courtesy of California Department of Fish and Game.

Fixed-wing line transects and helicopter quadrant surveys were compared for accuracy and by Pojar and Guenzel (1999) on northern pronghorn range (Colorado/Wyoming) where pronghorn densities are ca. one animal per 1-1.5/km^2. Helicopter survey results were used as the standard to compare with the more economical fixed-wing line transect method. Helicopter quadrant surveys are believed to provide the least biased estimate of pronghorn density of practical survey methods available (Pojar et al. 1995).

Line transect survey estimates averaged 0.735 of quadrant estimates. This gives managers an indication that line transect estimates should be adjusted by either dividing by 0.73 or multiplying by the inverse of 1.37 to get a more accurate estimate of total population size. Given the sampling intensity of this study, the precision was similar for both methods; 90% confidence intervals were $\pm$ 24 to 29%.

There is good evidence that the major assumption of the line transect method that all subjects in the innermost distance band are seen is not being met. Guenzel (1997) stresses the importance of training and close adherence to line transect protocol as a means of minimizing biases. "Double sampling," in which two observers independently record their observations is also highly recommended (Pojar and Guenzel 1998).

When money or expertise is unavailable for an aerial survey, and field conditions permit, a ground or spotlight census may be the best alternative to an aerial survey. Clemente (1992) experimented with walking and driving spotlight censuses of pronghorn and recommended driving road transects where roads are distributed in most of the survey area and vehicle traffic does not affect the presence of pronghorn. If such surveys are to be useful, however, the animals must be visible from a vehicle due to low vegetation and have eyes that reflect light, etc. As with most surveys, it is also highly desirable to be able to do a series of transects in a minimum amount of time.

Significant time and resources will be saved if a competent statistician is consulted during the design phase of a survey. A major reference on the methodologies of estimating animal populations is Seber (1982).

Fawn to Doe Ratio Surveys: the best time of year for conducting surveys in most of the pronghorn's range is during late summer. By this time, the initial surge of post-natal fawn mortality has subsided and fawns are still enough smaller than the does that they are easily distinguished.

There are three important factors for a reliable estimate of fawn to doe (f:d) ratios: an adequate sample of the population must be observed, an accurate classification must be made, and a random sample of the population must be obtained.

The first requirement of accurately classifying bucks, does, and fawns is relatively easy if the survey is done during late summer. Obtaining a random sample of the population to be surveyed is an important factor that is sometimes overlooked. If the sample is not representative of the population, the f:d ratio may be biased. Pronghorn distribution is determined by the location of food, water, and cover, and cannot be assumed to be a random distribution. Also, groups are not a random collection of individuals but a function of social structure in which different groups may be using different habitats. To circumvent potential bias in areas where the entire pronghorn habitat is not being surveyed, surveys should be conducted in randomly selected sample units, either strips or quadrants.

Another important factor for obtaining reliable f:d ratio estimates is determining the number of animals to classify. The Arizona Game and Fish Department (1993) analyzed historic survey records to determine adequate sample sizes to produce acceptable survey confidence intervals. These data showed it would be necessary to survey approximately 88% of the total population if the estimated number of animals is between 200-300, 57% if the number is 500-700, and 50% if the population is more than 1000 to get reasonable confidence limits for management purposes. Czaplewski et al. (1983) developed a chart of sample sizes required to obtain prescribed confidence intervals for ratio estimates. They assumed pronghorn are randomly distributed and that groups are formed of random individuals--seldom, if ever, is either assumption valid. However, their chart may be useful as a general guide for the number of animals to be classified and used in conjunction with a randomized sampling system. The randomized sampling system can be the same as, or a modification of, the system used to estimate population size. If possible, the surveys should be conducted from a helicopter as these maneuverable aircraft can fly low and slow, thereby minimizing classification errors.

If it is not possible to use an aircraft, either fixed-wing or helicopter, to do f:d ratio surveys, a ground survey can also obtain acceptable results. The sampling system described by Bowden et al. (1984) was modified to survey a 4,500 mile^2 (11,655 km^2) area of short-grass prairie in northeastern Colorado. Random ground routes, following established roads, were driven or walked by two person crews and all observed pronghorn were classified. The ground route ratios were comparable to those obtained on fixed-wing surveys taken a few days later in the same area.

Buck to Doe Ratio Surveys: Late summer is also an optimal time to conduct buck to doe (b:d) ratio surveys. Later surveys are less desirable as it is important that fawns can be distinguished from does to get accurate b:d ratios. After October 1, early fawns can be mistaken for does, which inflates the doe count and widens the b:d ratio.

Because bucks do not associate as consistently with does as do fawns, the estimated ratio of bucks to does is more variable than the f:d ratio. Bucks frequently are seen in all-buck groups or as singles; fawns are almost always seen with does. This behavior is responsible for a higher variance in b:d ratios than f:d ratios. Given the same sampling intensity, the b:d ratio will be less precise than the f:d ratio. For example, if the f:d confidence interval (90%) is ∀10 percent, the same sampling intensity might yield a b:d ratio confidence interval (90%) of ± 30 or more percent.

The potential for serious bias in estimates of b:d ratios is real. Buechner (1950) noted that isolated bucks did not flush from helicopter noise as readily as groups, and Firchow et al. (1990) observed that females moved sooner than bucks from quadrants that were repeatedly surveyed by helicopter. Therefore, an intensive search of a sample unit may be needed to detect all bucks present. Using a helicopter to search strip transects and mile square (2.59 km^2) quadrants, Pojar et al. (1995) obtained significantly lower ($P<0.10$) b:d ratios from strip transect estimates than from quadrant estimates. They attributed this difference to the more intense search of quadrants, which flushed single and small groups of bucks not flushed during the transect search. Since most herd structure estimates in western states are made from fixed-wing aircraft that are flown at 80-120 mph (130-190 kmph) and 300 feet (90 m) altitude, there is considerable potential for misclassifying animals and for missing animals that do not flush.

As with f:d ratio estimates, it is important to accurately identify observed animals, obtain a random sample of the population of interest, and classify an adequate number of animals to obtain reasonable precision. In addition, the search of sample areas must be intense enough to flush singles and small groups of bucks to get an unbiased estimate of the b:d ratio.

Harvest Management

After habitat management, harvest management is the most practical and effective method to ensure that pronghorn remain stable and viable components of the North American ecosystem. Population regulation is also necessary to keep the animals in balance with variable levels of human tolerance and to meet the demand for recreational use of pronghorn and their habitats. Information on harvest management is from O'Gara and Morrison (2004) unless otherwise cited.

Human dependence on wild game for food has given way to other motivations and objectives for hunting, although meat is still an important component of the hunt. Early settlers in the West did not concern themselves with regulating the harvest of pronghorn, but took what was needed to feed and clothe themselves and their families. Unregulated market hunting took a significant toll on wildlife populations, including pronghorn. By the beginning of the 20th century, government agencies and sportsmen's organizations sought to regulate harvest to prompt the recovery of many species that had been overexploited. From that fairly recent origin, the science of wildlife harvest management has made extraordinary advances in helping the recovery and sustainability of pronghorn and other wildlife. A boon to pronghorn management was the practice of maintaining harvest records. As the environment continues to be altered and as human demands for wildlife expand and shift, harvest management strategies must be continually refined and improved.

Pronghorn harvest regulations fall into two categories: those that manipulate the type and number of animals harvested, and those that "manage" the hunter. Regulating the type of harvest includes setting the bag limits, season lengths, legal weapons, number of permits, and other rules to ensure that a strategy-specific number and sex of pronghorn is harvested. In many states, politics dictate the "correct" system as much as biology. Regulating the hunter consists of various restrictions of hunter behavior to assure that hunts are conducted legally, safely, and ethically, and to maximize the opportunities for participation and harvest within the guiding principle of sustained yield.

Today's pronghorn managers need to establish long-term goals for pronghorn populations and their habitats relative to current and projected demands for the use of pronghorn and pronghorn habitat. Based on such goals, management is defined by objectives and refined by short-term strategies. At all levels of planning and action, the needs of the resource, consumptive and non-consumptive users, and the landowners (public and private) must be considered and meshed if the goal is to be achieved. When developing harvest recommendations, several factors must be addressed. These include, but are not limited to, habitat conditions, sex and age ratios, other uses of an area's resources (both animal and plant), and pronghorn behavior.

Nearly all pronghorn hunting in the U.S. and Canada is via limited-quota or limited-entry licenses. No legal hunting of pronghorn has been allowed in Mexico since the species was protected by decree in 1922.. In some states only residents are allowed to hunt pronghorn; in other states residents and non-residents are treated equally except that non-resident licenses and tags are priced measurably higher. These restrictions reflect the low numbers of animals in some states, and the need to distribute hunters into certain areas, even in states with abundant pronghorn. Because pronghorn are very visible, most hunters will be successful, and most will kill a buck unless they are forced to do otherwise by specified permits. If the number of licenses to take "any pronghorn" are too high, the b:d ratio will widen, and it becomes difficult to attract hunters because of proportionally fewer and smaller bucks. Some people want to hunt only on public land and want trophy animals. Ranchers generally want pronghorn numbers held in check, but also want to charge for hunting, which discourages some hunters and may make licenses in areas of private land difficult to sell. The manager must consider all of these facets while maintaining some control of pronghorn numbers.

Habitat Considerations: Habitat is a prime factor in the establishment of harvest objectives. Abundant, quality rangelands during one season of the year cannot make up for poor quality rangelands during another. All elements of the animal’s annual habitat requirements must be considered, including use of movement corridors between seasonal rangelands. These corridors may be critical because of fences, roads, developments, or other barriers to movements. Also, assessment of habitat needs must consider "worst scenario" conditions that result from occasional severe winters, droughts, or other natural or human-related catastrophes.

Too many or too few animals may occupy a particular rangeland, relative to habitat conditions and other management considerations. Harvest objectives must then be set to balance pronghorn numbers with habitat conditions in accordance with objectives developed to maintain animal numbers according to ecological, public, and bio-political factors. With proper harvest management, a pronghorn population can usually be balanced with its habitat within several years. In most cases where harvest strategies are used to increase or decrease a pronghorn herd relative to biological considerations, the strategy is implemented in concert with a program of habitat management. In Wyoming, where pronghorn are numerous, the numbers of licenses issued are based on the status of the herd (above or below population objective), potential for damage to stored or standing crops, and reproductive rates. Harvest rates range from 8 to 40% ($x \cong 20\%$) in herds above objective goals and 6 to 28% ($x \cong 15\%$) in herds below objective. The wide range in percentages taken from herds either above or below population objectives is related to depredation problems and recruitment rates. Naturally, a herd with 65 fawns:100 does cannot withstand as much hunting pressure as a herd with 120 fawns:100 does. Managers should consider harvesting does as many as 3 to 4 years before a herd reaches its population objective.

During periods of high pronghorn numbers, in states with large pronghorn populations, securing an adequate harvest can be a problem. The Wyoming experience indicates some of the techniques that have been used to address the problem. To control numbers of pronghorn, Wyoming began issuing licenses that required the hunter to take a doe or fawn. "Any" pronghorn licenses were issued through drawings to prevent the over harvest of bucks, and hunters who drew an “any” pronghorn permit could then purchase doe/fawn licenses over the counter. At first, only one or two doe/fawn licenses were allowed per hunter. To make them more appealing, these licenses were sold for full price until opening day, and then the price was halved. Later, hunters were allowed 3 doe/fawn licenses, then, unlimited numbers of such licenses could be purchased three days before the hunting season. These procedures were necessary to overcome the resistance of hunters to shooting females and fawns and to still obtain the needed harvest. In many cases, getting additional hunters into an area was difficult, so allowing hunters already there to kill more does was a logical solution.

Buck to Doe Ratios: Desired b:d ratios depend on the management goals set by wildlife agencies for particular pronghorn populations. A ratio of 1 buck to 4 does should be maintained for maximum recruitment into a population according to Salwasser (1980) and Hailey (1979). If the objective is to produce the maximum number of trophies, the b:d ratio should be 1:2 or greater (Hailey 1979). With this ratio, there will be a relatively large number of bucks in the population, and many of them will be 3-years old or older—the age of most trophy bucks (Brown et al. 2002). Hunting permits then can be regulated to leave enough three and four-year old bucks in the population to produce trophy horns. If the pronghorn management objective is to reduce the herd, prescribed b:d ratios can be maintained by issuing doe/fawn permits and issuing hunters multiple permits. Although narrower buck ratios may be desirable for trophy hunt objectives, a post-harvest ratio of one buck per 5 does is biologically safe and probably within the number of bucks needed for complete breeding according to Salwasser (1980). Buck to doe ratios; however, are sometimes set for political, not biological, reasons.

Timing of Seasons: Pronghorn have traditionally been hunted from mid-August through mid-October. Throughout most of their range, pronghorn shed their horn sheaths between late-October and mid-November, after which time the trophy quality of the bucks is decreased and differentiating bucks from does is more difficult. Hence, most states and provinces attempt to set hunting seasons before shedding occurs.

Game managers in a few states attempt, when possible, to hold concurrent deer and pronghorn seasons because non-resident hunters often come from a long distance and do not want to spend travel money to hunt only one big game species. Availability of multiple licenses for one species also attracts out-of-state hunters. Concurrent bird seasons may also be used to turn pronghorn hunts into combination hunts.

A concern in determining the dates of pronghorn hunting seasons is that traditional season dates frequently coincide with the breeding season. Copeland (1980) indicated that, in Idaho, hunting during the pronghorn breeding season caused dominant bucks to abandon their harems and territories. The harvest of dominant bucks resulted in chaotic breeding in groups that included bucks of all age classes and increased harassment of does. Deblinger and Alldredge (1989) found a similar situation in Wyoming. However, because rifle hunters usually only remained in the field for one or two days, bucks were again actively defending their territories by the third day of the season. Copeland's study involved a heavily hunted herd in a narrow valley. In Wyoming, pronghorn apparently have been hunted during the rut since open seasons were resumed in 1934. The state has more pronghorn than any other, a high pronghorn fawn survival rate, and many fine trophies are taken every year. Forrest (1985) used Wyoming Department of Game and Fish records to investigate the effect of hunting during the rut on reproductive rates. She found no statistical difference between areas, and killing dominant bucks did not appear to decrease f:d ratios. And, even though Copeland (1980) observed significant social disruption from hunting during the rut, he could not show any adverse effect on subsequent f:d ratios.

Criticisms of hunting pronghorn populations during the rut include a supposed premature depletion of the does' energy reserves, which is vital to winter survival, and breeding by immature or inferior bucks that may contribute to a lack of genetic vitality. These concerns have yet to be proven; nonetheless, legitimate harvest management objectives such as providing recreation to the sporting public and adjusting pronghorn numbers to a goal-oriented level need to be carefully considered and weighed against weather, hunter pressure, hunter success, etc., when recommending hunting season dates.

If a hunt is set at the optimum time for hunter convenience, breeding may be disrupted and bucks in prime breeding condition may not be prime table fare. This dichotomy of choices generally confronts managers and has significant bearing on other harvest recommendations, such as length of season and the definition of legal animals. For this reason, harvest management decisions must be made on the basis of reliable, recent data carefully analyzed by experienced managers.

Length of Seasons: Season length depends principally on numbers of pronghorn to be harvested in an area and the type of legal weapon allowed. Seasons in various states and provinces range from 2 days to 2 months. There are no pronghorn seasons in Mexico, and in states having only token populations. New Mexico restricts rifle and muzzleloader hunters to 2-3 days, while allowing archers up to 9 days (Morrison 1984). These are conservative seasons, especially for archers, and are dictated as much by administrative convenience or landowner pressures as by biological criteria. Montana, in contrast, had a 65-day archery season and 29-day general rifle season in 1991 with the last 29 days of the archery season concurrent with the rifle season.

Copeland's (1980) study in Idaho indicated that long, intense hunts were disruptive to pronghorn breeding, and he recommended that no hunting be allowed from 15 September through 10 October. In the states with the most pronghorn, Wyoming and Montana, archery seasons may last two months or more and continue through the rut. Rifle seasons may run concurrently with archery seasons for as long as a month. Although this sounds like excessive disturbance, the density of archery hunters is low, due to the vast geographic areas occupied by pronghorn.

During the first weekend of the rifle season most of the permitted hunters are in the field, and about 90% of the harvest is taken; therefore, little disturbance to pronghorn occurs for the rest of the season. Several states schedule their hunts after the breeding season that may be the best procedure for the long-term welfare of the species.

Legal Weapons: Harvest success and hunting opportunity objectives often dictate the type of weapons legal for hunting pronghorn in a particular area. Depending on the pronghorn population objective, most archery hunts have liberal bag limits and/or long seasons because of the low hunt success achieved by bow-hunters. Innovative archers, however, continue to increase their success by hiding in blinds near water sources, using decoys and calls during the rut, and utilizing more sophisticated equipment. During the 1981-1983 archery seasons in Arizona, the average harvest success was 7%; a decade later in 1994-1996, archery hunt success in that state had increased to 18%. In northwest Colorado, where archers often use pit blinds near water, success typically exceeds 60%. Managers can usually provide more opportunity to more people with archery hunts while minimizing the impact on pronghorn. An exception to this low impact may occur when hunters wait at water sources in arid areas and cause the animals to avoid drinking. Muzzleloader and other special weapons seasons, such as handgun hunts (Ochs 2000), usually have higher success rates than archery hunts, but their seasons still can be lengthier and with a more liberal bag than modern rifle hunting seasons. Because of the relatively high success achieved by modern rifle hunters, managers must make fairly precise calculations of the number of animals to be harvested and set permit numbers accordingly.

Legal Animals and Bag Limits: Legal animal definitions and bag limits vary according to pronghorn population levels and the state or provincial goals and objectives for that population. In Montana, Martinka (1966) reported that selection for adult males appeared to be based on hunter preference rather than herd structure. If the harvest management objective is herd reduction, a doe/fawn bag limit or multiple doe/fawn permits per hunter are ways to reduce the population during a short hunt. Doe/fawn harvests usually are accomplished by issuing permits only for pronghorn with horns shorter than their ears. The setting of a buck-only or either-sex (any pronghorn) bag limit with doe/fawn hunting allowed during the last few days of the season is confusing to the public and difficult to enforce. Archery hunters usually have an either-sex permit and their limited harvest normally has little effect on population levels.

Because adult male pronghorn establish and defend territories for breeding purposes (Bromley 1969, 1977, Kitchen 1974), or control and defend harems before and during the rut (Prenzlow et al. 1968, Deblinger and Ellis 1976), the larger males become easy prey for hunters during the rut. The hunting of large bucks to the exclusion of other herd members may cause a disruption in the dominance hierarchy, especially in small populations, and may have a direct influence on the fitness and "trophy quality" of the population (Copeland 1980, Deblinger and Alldredge 1989). Hunting can also induce non-territoriality behavior. If a hunt is to be held before or during the breeding season, consideration should be given to regulations that will either limit the number of bucks harvested or close selected areas to protect at least a portion of the dominant bucks.

Harvests on Public Versus Private Land: Proper management requires that, when setting pronghorn harvest regulations, managers consider the interests of landowners and land management agencies. Dood (1984) noted that "the basic social problem in pronghorn management is that pronghorn are a public commodity living on private land. About 62% of the pronghorn in Canada and the United States are found on private land (O'Gara and Morrison 2004). Private landowners also control access to considerable areas of public land. Obviously, cooperation between private landowners, such as the Desert Ranch in Utah/Wyoming, and provincial/state wildlife management agencies is necessary for coordinated harvest programs. As of 2000, 11 of 16 western states gave landowners some type of preference in obtaining pronghorn permits if they had substantial numbers of pronghorn on their land. Private landowners in Mexico could also issue pronghorn permits if they had a sizable population of pronghorn on their land and filed a pronghorn management plan with the proper authorities.

Each state and province has adapted to the problem of managing pronghorn on private land in different ways. In New Mexico, the success of hunts on private land often reaches 95%. If New Mexico restricted the season on public lands to accommodate the private landowner, it would penalize the public land hunter. Consequently, the state sets private and public land seasons to run concurrently and with uniform bag limits. Landowners sign hunt agreements to allow for the management of pronghorn on their private lands. If the landowner has public land leased for livestock privileges, the public must be allowed to hunt on these allotments. The numbers of permits assigned to such ranches are therefore split into private and public permits, according to the percentage of the pronghorn population in each land status. This strategy allows New Mexico to set permit numbers that match the needs of both the landowner and pronghorn population objectives.

Sportsmen hunting on private land in New Mexico do not necessarily have to draw for a permit. They may instead purchase "trespass rights" from a private landowner and then the landowner or his agent provides the hunter with one of his permits and an authorization to purchase a license from the state. This type of system is especially popular with wealthy non-resident hunters who do not need to go through the permit drawing process. On private lands containing "surplus" pronghorn, the state will set a doe-only hunt if the landowner will sign an agreement allowing some public hunting.

In California, landowners who develop a management plan approved by the Department of Fish and Game, and increase the number of pronghorn on their property, may obtain longer seasons or more liberal bag limits than on public lands (Pyshora 1986). In Texas, almost all pronghorn hunting is on private land. Permits are issued to the landowner who then charges hunters for the permits along with access rights (Dvorak 1986).

During the late 1970s, many ranchers in eastern Montana were closing their land to public hunting because of large hunter numbers, an increasingly stagnant agricultural economy, and hardening attitudes towards public use of private land. In 1985 the Montana Department of Fish, Wildlife and Parks instituted the use of a statewide block management system to enable wildlife managers to harvest enough animals to maintain healthy herds and reduce damage to agricultural crops (Korn 1990).

Two management procedures were especially designed to open private lands to hunting. One eliminated the need for the landowner to deal with hunters, and the other was designed to reimburse the landowner for time spent meeting and directing hunters. Thus, in eastern Montana, the Department often provides personnel to manage hunters or pays the landowner for time spent directing hunters, filling out permission slips, patrolling property, helping hunters retrieve downed game, and other activities. This resulted in more than 5,000,000 acres (2,000,000 ha) of private land being opened to hunting (Korn 1990). To date, block management has worked well for everyone concerned. Perhaps one reason that Montana ranchers have embraced block management is the Department's approach. Agreements are conducted in the manner to which Montana ranchers are accustomed--a handshake--not long, involved contracts (Korn, pers.com.). The Department, however, is reaching the limits of how much time and money can be expended on the program.

Wyoming has used a system for many years whereby a tag attached to each pronghorn permit can be detached and this "coupon" given to the landowner who is then reimbursed by the state. Currently, landowners get $9.00 for each coupon, a reimbursement generally considered to be inadequate. Wyoming's landowner coupon program came about in 1934 when the Game and Fish Commission was responding to what was considered to be an overpopulation of pronghorn in some areas of the state. The Commission passed a regulation to pay the landowners $2.00 for each pronghorn killed by residents and $5.00 for animals killed by non-residents to cover the "administration expense of feeding said pronghorn." The coupon program has undergone several changes since then, and the differential in the worth between resident and non-resident coupons has since been removed.

The intent of the program was, and still is, to reimburse landowners for forage consumed by wildlife residing on their property (Anonymous 1986). Nevertheless, a false notion evolved in the minds of some that the program was designed to encourage landowners to allow public hunting on their lands. The problems relating to private land access in Wyoming are significant and are worsening. Therefore, if there was any intent in the program to improve access to private land, it is failing. Landowners have expressed dissatisfaction with the program, citing two problems: the revenues are inadequate and not equitably distributed. The Wyoming Game and Fish Department researched the program and determined that the agricultural community was correct. The $9 amount does not compensate the landowner for the forage consumed by one animal, nor does it compensate for the animals not harvested by hunters. Also, pronghorn that reside on one landowner's property during the non-hunting season are often killed on another's land during the hunting season. Consequently, the landowner that gets to redeem the coupons may have sustained the least amount of forage loss (Anonymous 1986).

Most resident doe/fawn permits are sold at half price ($8.50) and license agents receive $0.50. Thus, the Wyoming Department of Game and Fish is subsidizing doe/fawn licenses to obtain an adequate harvest.

Establishing Permit Numbers: With rare exceptions, the number of animals to be taken from a given population must be regulated to prevent over harvest or an undesirable post-hunt sex ratio. Hence, managers restrict the number of permits issued to achieve particular harvest objectives. The number of permits in a game management unit or on a particular ranch usually is determined after annual surveys give an indication of population sizes and b:d ratios. The number of animals to be harvested is then calculated for individual herd units, and permit numbers are set using past hunter-success information as guidelines.

Drawings for permits by hunt units or districts are necessary to distribute harvest among pronghorn herds in a province or state. For instance, pronghorn herds in Montana are centered in the eastern part of the state, and human populations are centered in western Montana. Unless hunters are limited to particular areas, western pronghorn herds would be over-harvested, and some eastern areas would be largely un-hunted. The chances of drawing a permit in a western district are generally between 33 and 50%. Some eastern permits are usually available after the drawing and can be purchased over the counter.

In states where pronghorn numbers are more limited, but with a high percentage of trophy animals, hunting permits can attract considerable demand. In Arizona, for example, draw odds have been as high as 146 applicants per permit in some management units. Statewide the application rate is 22 applicants for each permit.

In addition to regular permits, a number of states also issue special fund-raising hunting permits. These special permits, variously called conservation tags or Governors' permits, are raffled or auctioned to produce revenue to fund pronghorn management activities. The state Legislature in Arizona authorized the use of up to two big game tags for each species to be used for fund raising purposes each year, with all of the revenue from these tags ear-marked for specific projects. Since 1985, the 20 special pronghorn tags in Arizona have generated $163,121. The two tags auctioned in 1996 were sold for $19,500 and $16,000. These revenues support pronghorn transplant activities and habitat improvements.

Estimating the Harvest: Reliable estimates of harvest, hunter success, and hunter days (effort) are necessary for effective wildlife management, regardless of the method used to formulate such estimates (Cada 1985).

With this information, managers can assess the success or failure of harvest strategies and make adjustments to meet the pronghorn population objectives. If a manager can document a significant illegal take or crippling loss, then those losses should be considered when establishing harvest objectives.

Requiring hunters who harvested pronghorn to stop at a check station was the first method used to obtain harvest data. Biological information, such as body condition, horn size, and sex and age distribution in the kill, is gathered at such stations. With acceptable levels of precision now obtainable from mail and telephone surveys, the check station method has become less popular among wildlife management agencies, partly because of the high cost of operation. In areas where biological data are collected, check stations give managers an opportunity to obtain a variety of timely information about the harvest. Check stations allow managers to interact directly with hunters, which has public relations and educational values for both hunters and managers. Check stations also serve a law enforcement function. Information gathered at check stations also may be used to cross-check the accuracy of responses to mail and telephone questionnaire surveys. To do this, hunting license or permit number data must be recorded along with the biological information.

Check stations and hunter field checks are biased in several ways. Successful hunters, especially those with large bucks, are more likely to stop at check stations than are unsuccessful hunters or those with does or fawns. Some hunters even go out of their way to stop and show off their animals. Also, sample sizes at check stations often are low, unless access is restricted or regulations require hunters to check in and out of an area. Trophy hunters, non-residents, unsuccessful hunters, and those with multiple permits are also likely to stay in the field until after a check station is closed. Modern check stations are mainly for gathering biological data, with harvest statistics secondary. Good sex and age data can sometimes also be gathered economically at locker plants.

Research has shown that mail questionnaires can be used to estimate harvest levels and hunter days in the field, as well as provide information on type of weapon used, the age class and sex of the animal(s) killed, area hunted, and wounding rates. These data generally are accurate enough to provide trend information to wildlife agency personnel who then use the data for establishing season dates, bag limits, and weapon types.

A number of analyses have shown that biases exist within mail questionnaire data. Based on repeat mail-outs (to increase return rates) and on numerous comparisons with hunter checks, check station data, and telephone interviews, it appears that hunter numbers, success, and harvest tend to be overestimated. This bias results from successful hunters being more likely to return their questionnaire than unsuccessful hunters or those that did not go hunting. The biases generally result in overestimating the harvest by about 10%. If methods are consistent, however, the biases should also be consistent, and not compromise the comparability of data between years or areas. Reports regarding the sex of the animal taken and the number wounded generally result in errors of less than 5%.

Through various studies, statistical equations have been developed to account for bias in mail questionnaires. The critical factor in conducting reliable surveys is to get the questionnaire in the hunter's hands as soon as possible after the hunt. One procedure is to issue the survey with the license, so the hunter can be prepared to identify answers to the questions. If this is not possible, the survey should be mailed within days of the close of the hunt. Several states that used to conduct follow-up surveys to non-respondents found the expense to not be justified by the small statistical improvement in the results (Strickland 1979, Couling and Smith 1980, Cada 1985, Pyshora 1986).

An alternative to the mail survey is the telephone questionnaire survey. Telephone surveys provide direct contact with the respondent and allow for precise answers. Cada (1985) found that the telephone survey saved money, was more acceptable to the public, and reduced sources of error. Another benefit of telephone surveys is that the manager does not have to wait on the mail system to gather responses. However, this type of survey is not without its own problems--unlisted phone numbers, phone-blocking devices, people who refuse to talk to agency personnel, inaccurate responses, etc.

Figure 15. The most commonly used methods to obtain harvest information today are through mail and telephone questionnaire surveys. Check stations still are useful for this purpose at times, but most are now operated to collect biological data, such as the animal weights being taken here. Photo by G. Mitchell; courtesy of the Alberta Government Photograph Department.

Field checks also have been used to determine harvest. Where field checks are conducted, much time must be devoted to contacting enough hunters to give the data statistical validity. Conservation officers usually are the ones conducting field checks, and at times, the quality of the data may suffer due to the priority placed on the collection of law enforcement information. If field checks are used in compiling harvest statistics, managers must devote enough extra time and manpower to the effort to ensure that sufficient data are obtained. As a rule, field checks should only be used in small areas to gather data that can be compared with those gathered by mail or telephone surveys that obtain larger amounts of harvest data.

Population Models and Estimates

Efforts should be made to develop valid simulation models to better manage pronghorn populations (Salwasser 1980, Gasson and Wollrab 1986). A review of the various population models used to manage pronghorn is provided by Kohlman (2004). Simulation models also assist in collating available survey and hunt data and making reasonable population projections (Pojar 2004). As demand for pronghorn resources increase, it will become increasingly important to refine harvest strategies to maximize recreation, while ensuring that the resource is protected. Population simulations can provide better definition of herd units, help organize data collection, and stimulate better methods of data collection. Building a simulation model also serves as a learning experience because managers cannot replicate the structure of a population, manipulate that population, and judge the validity of their data without becoming increasingly aware of the complex interactions occurring. A better understanding of population dynamics and the ability to generate and explore management options before implementation can only lead to more enlightened management.

Several computer programs such as "Vortex" have been developed to model populations. "Vortex" has been used to model endangered pronghorn populations in Sonora and Baja California Sur (Cancino et al. 1995, DeVos and Thompson-Olais 2000, Hosack et al. 2002), This model works well with low population numbers and includes both stochastic events and deterministic forces (Miller and Lacy 1999).

In Wyoming, biologists use POP-II or POP-III computer programs developed by Fossil Creek Software, Fort Collins, Colorado. Wyoming conducts a pronghorn census about every 3 years with line transects or "total counts" used to align population models. The survey data, together with harvest and age composition information are then used to calculate population estimate models via POP-II or POP-III.

These models work partly off changes in ratios. To facilitate modeling, populations are defined as those animals having less than 10% interchange with adjacent populations. For modeling purposes it is essential to obtain adequate sample sizes of data on herd composition and unbiased harvest data. One advantage of the model is also that it identifies poor quality data. Pronghorn are perhaps the easiest species to model because they are the most observable. The principal value of models is to project pronghorn populations into the future, and calculate the numbers, sexes, and ages of animals that need to be harvested to meet management goals. Hunting as a management tool has been challenged in the past and will continue to be challenged by anti-hunting groups. Population modeling provides justification (not always accepted) for controlling and managing populations by hunters. Population models also allow wildlife managers, land managers, and public land users the ability to engage in productive discussions regarding the management of the pronghorn population in question and the range it inhabits.

Pronghorn Population Estimates: Pronghorn numbers have been estimated on an irregular basis for over 70 years. Using survey data, population estimates are calculated for particular herds, for game management units and other specified areas, for states and provinces, and even for nations. The first reliable large-scale population estimate based on survey data was a compilation by Nelson (1925) for North America. Later, during the 1930s and 1940s, the U. S. Forest Service and the U.S. Fish and Wildlife Service compiled estimates for the national forests and the U.S. Since then Yoakum (1968, 1978, 1986, 2004b.) prepared estimates of populations based on questionnaires sent to state and provincial wildlife agencies in Canada, Mexico, and the United States. Such documentation is necessary for tracking long-term population trends and determining reasons for changes. Pronghorn numbers should be compiled every two years in conjunction with the Pronghorn Workshop. Such documentation on a province-by-province and state-by-state basis can be compared with land-use changes, weather, management practices, and other phenomena, to better understand reasons for population increases and decreases. Such monitoring can best be accomplished by each provincial or state wildlife agency, but some organization should be in charge of compiling total population numbers for Canada, Mexico, and the United States, and ensuring that all data were obtained by similar procedures. The survey results of each state and province should, and have been, published in The Proceedings of the Pronghorn Antelope Workshops. But because there is no continuity of personnel attending the Workshop, some other organization, perhaps the North American Pronghorn Foundation, needs to take charge of contacting provincial and state agencies in time to present the findings for publication at future Pronghorn Workshops.

Pronghorn numbers are normally surveyed one or two times during the year—a July or August survey that estimates fawn recruitment (f:d) and b:d ratios, and a winter survey to estimate pronghorn numbers after the hunting season. State and provincial agencies traditionally have used the summer survey results for reporting annual herd sizes. Within the last decade or so, however, some state wildlife agencies have reported annual population figures based on post harvest (winter) surveys. When these are compared to other agency estimates, it is necessary to make sure that all numbers were obtained using comparable procedures for comparable areas during the same time of year. For example, some agencies allow legal harvests of from 10% to 40% of a given herd or herds. This harvest, coupled with crippling losses and illegal kills, can result in much smaller post-hunt population than was present the previous summer. Therefore it is imperative that state and province surveys estimating total herd size are based on data derived through similar methods obtained at similar times of the year.

Aesthetic Management: As stated by Smith and Beale (1980): "Besides hunters, many more people have enjoyed simply observing this unique, baffling and splendid animal." Some pronghorn populations, such as the animals on the National Bison Range near Moise, Montana and Antelope Island State Park in Utah, and in Yellowstone National Park are managed almost solely on the basis of aesthetics. Similar situations precluding the harvest of pronghorn are also present on some military bases and in numerous urban interface areas. Still other populations are present in zoos and animal parks, and the photography and life history of such populations has become an important component of pronghorn literature (Turbak et al. 1995; Byers 1997, 2003; Geist and Francis 2001).

It should nonetheless be considered that such populations often require overt management actions to prevent overcrowding and unbalanced sex ratios. In addition to the periodic capture and removal of animals, other actions may be needed to provide public visibility of the animals, prevent undue disturbance, provide inoculation against diseases, ensure the medical treatment of injured or debilitated individuals, and allow for the sacrifice of particular animals.

Capture and Translocation

Capture and translocation have and continue to be, integral to pronghorn management. Although restoration of this species through translocations has been phenomenally successful, such programs remain important components of pronghorn management in some areas.

Pronghorn Capture: Pronghorn can be captured using a wide variety of nets, traps, drugs, and under certain conditions, without the aid of either mechanical or chemical means. Each method is designed to either reduce a pronghorn (or a group of pronghorn) to a restrained condition as a requisite management goal or a research need.

Amstrup et al. (1980) suggested parameters to consider when selecting a capture method. Included were the number, age, and sex of animals needed; density of animals in the trapping area; the terrain and proximity to roads; whether pronghorn are accustomed to fences; how wary the animals are; the possibility and acceptability of mortalities; and the cost in terms of time and money per animal captured or marked.

Figure 16. A small herd of pronghorn from New Mexico were translocated to the state of Coahuila in northern Mexico. The new location is a private ranch where herds previously roamed historic rangelands. Such international management cooperation strive to reestablish natural wildlife diversity in North America. Photo by Patrick Robles.

Corral traps: Corral traps were used by Native Americans and have proved their worth many times over as a cost-effective means of capturing large numbers of pronghorn. Various agencies have modified the basic design to meet their specific needs. Detailed accounts of corral trap design and operation were provided by Fisher (1942), Couey (1949), McLucas (1956), Hoover et al. (1959), Russell (1964), Spillet and Zobell (1967), Moody et al. (1982), and McKenzie (1984). Many of these authors have suggested modifications resulting in improvements to the basic corral trap. Unless otherwise stated, the following trapping guidelines are adapted from McKenzie (1984) and O'Gara et al. (2004).

Placement of a pronghorn corral trap is of utmost importance (Fig. 17). The basic corral trap design consists of 2 linear wings, a containment pen with curtains, a gated corral divided by a moveable burlap curtain, and sometimes, a loading chute. The woven-wire wings of a corral trap usually form a "v" funneling animals into the mouth of the trap proper. Workers in Wyoming (Moody et al. 1982) gradually narrowed the distance between these wings from between 1000 and 1300 feet (300 to 400 m) at the outside edges approximately 0.3 mile (0.5 km) from the trap to the funnel and first curtain. This eased the problem of pronghorn attempting to go over (or through) the trap wings. They also used cargo netting (the same as used in the trap proper) as trap wings for the first 350-400 feet (100 m) from the trap mouth to ease the same problem and reduce injury to pronghorn.

The burlap or canvas containment curtain extending across the funnel facilitates moving animals the final distance of approximately 650 feet (200 m), into the corral trap. The distance between the wings at this point should be about 150 feet (50 m). The curtain is folded in place on the ground between the wings at or near blinds on each side of the funnel. As the target animals cross the folded curtain, workers emerge from the blinds and form a line across the funnel. When the line of workers is complete, the curtain is raised to establish a visual barrier to discourage escape attempts back through the funnel. Alternatively, a netted gate curtained with burlap can be laid across the funnel entrance and raised after the pronghorn have passed through, allowing for the storage of animals in the funnel while another group is worked into and through the trap.

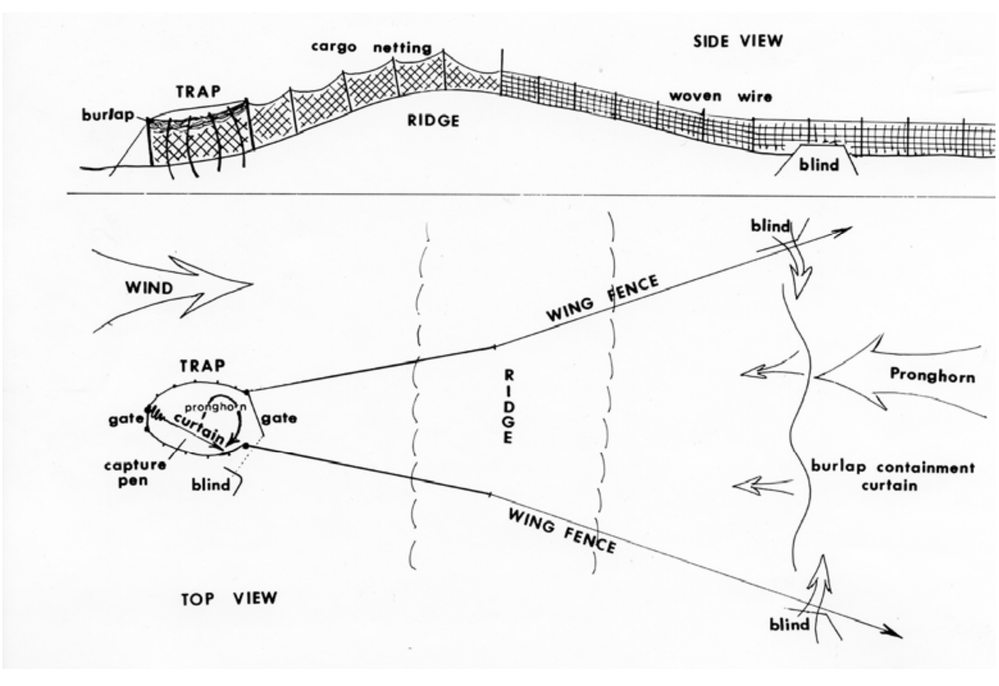


Figure 17. The basic corral trap design consists of 2 linear wings, a containment pen and curtain (gate), a gated corral divided by a moveable burlap curtain and, sometimes, a loading chute. Placement of a pronghorn corral trap, taking advantage of topographic features to hide the corral, is of utmost importance and prevailing winds should be considered. A reconnaissance flight to select a good location for the trap site and to obtain an idea of the number and distribution of pronghorn should be made before erecting corral traps. Traps or nets should be hidden by vegetation or topographic features along known or suspected pronghorn travel routes. Natural and manmade barriers, steep terrain, or tall vegetation should be avoided within the funnel of a corral trap, unless pronghorn are observed routinely using such areas as travel lanes. Existing fences near a trap site should be carefully evaluated. Sketch by Larry Saslaw; courtesy of the U.S. Bureau of Land Management, Rawlings, Wyoming.

The corral portion of the trap should be an oval 40-100 feet (13-30 m) in diameter with nylon-netting walls and posts on the outside. The tops of the posts should be offset 3-foot (1 m) offset to increase the "give" when pronghorn hit the net and to prevent collisions with posts. A visual barrier curtain (Fig. 10) is recommended for the top 2/3 of the trap proper. This burlap or canvas curtain reduces escape attempts (and injury to pronghorn) through the sides of the trap, and its suspension from the top of the trap walls discourages escape attempts over the top. Most importantly, the curtain is lowered simultaneously with the closing of the trap gate when the pronghorn enter the trap. Prior to being dropped, it is rolled up and secured at the top of the net with a quick-release string-washer-cotter pin assembly.

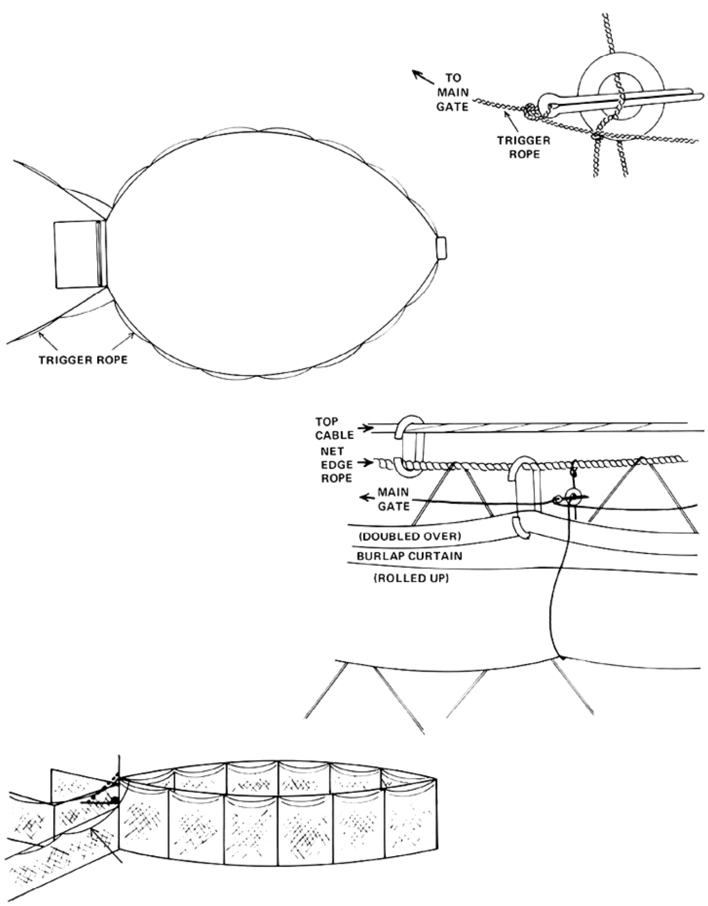


Figure 18. A visual barrier curtain reduces escape attempts and injuries to pronghorn. Trigger detail and placement of a trap drop curtain are shown here. Courtesy of the Texas Parks and Wildlife Department.

Correct trap placement, and the taking advantage of topographic features, is vital for the success of any attempt to trap pronghorn with fixed traps or nets. A reconnaissance flight to locate the animals to be trapped and to select the best trap location and is an essential first step in any trapping effort (McLucas 1956). To maximize the chances for success, it is also advisable to use vegetation or topographic features to conceal the traps or nets along known or suspected pronghorn travel routes. The funnel of a corral trap should not contain any natural or manmade barriers, steep terrain, or tall vegetation, unless pronghorn are observed routinely using such areas as travel lanes. Existing fences near a potential trap site should be carefully evaluated. Their presence may either aid or hinder a successful trapping operation depending on the reaction of the target pronghorn. Safety precautions for both workers and animals should be strictly followed. The mouth and wings of a corral trap should be positioned so that pronghorn run into the prevailing wind and are a safe distance from flight hazards (power lines, trees, etc.). Other flight precautions should depend on the pilot's judgment.

Herding pronghorn by aircraft during trapping operation stresses the animals. Thermal stress may occur during warm weather, and corral trapping is not recommended when the ambient air temperature is greater than 70ºF (21ºC) and, preferably, it should be 50ºF (10ºC) or cooler. Pronghorn are sometimes captured during the cool of the morning and placed in transport vehicles only to have the temperature rise to lethal levels later in the day during transport. During catch-and-release operations the temperature may not be as critical because of the short duration of captivity. Amstrup et al. (1980) and Reeves (1982) successfully trapped pronghorn during August, when ambient temperatures were high, but they usually trapped during early morning or late evening and avoided handling or herding animals during the heat of the day.

A helicopter is the best tool for herding pronghorn into the wings of a corral trap. Constant pressure applied by a helicopter appears to stress pronghorn, so the pilot should hold back and let the animals drift toward the net at a moderate pace until time for the rush into the wings and corral. Extended chases may result in increased mortality. Workers in Wyoming found mortality rates of animals chased for 40 minutes to be twice as high as for those chased for 20 minutes. The maximum chase time should not exceed 20 minutes.

The line of people with the containment curtain should advance toward the trap mouth when the pronghorn move in that direction, stop when the pronghorn stop, and move when they move. Gentle, but constant pressure is used until the animals enter the corral, the gate is closed, and the curtain barrier is released. Noise should be kept to a minimum.

It is recommended that captured pronghorn be allowed to settle down in the trap without human harassment for 10-40 minutes (or whatever appears to be a reasonable period of time). This is a judgment call depending on how far and how long the pronghorn have been moved and the ambient temperature. Once handling begins pronghorn should be processed as quickly as possible.

Trapping usually requires many volunteers and others who are not familiar with the trapping operation and handling of animals. A thorough briefing of all of the participants in the operation is therefore essential. The briefing should include: purpose of the operation, description of the trapping process, proper handling of animals, how injured animals are to be dispatched, and precautions for the safety of workers and animals. A detailed protocol of the capture operation is also required by the Federal Animal Care and Use Act.

Within the trap proper, there should be a canvas curtain that can be drawn across a portion of the corral, hiding the workers from the animals. This curtain is used for segregating small groups of 6-10 animals from the main body of trapped pronghorn during the hand-capture phase. Segregating animals into small groups reduces the chance of injury to workers and pronghorn while expediting the handling of the animals.

Handling and Loading - Handling and loading, as described here, applies primarily to capturing pronghorn in corral traps. Other methods of capture usually involve smaller numbers of animals and are considered as hand captures.

For each pronghorn segregated by the catch net, two persons should be available to hand capture the animal and restrain it as quickly and effectively as possible. The front handler should control the head of the animal with one arm and lift it with the other arm just behind the front legs. The rear handler should clasp his hands under the animal just forward of the hind legs. The animal should then be lifted just enough to get its feet off the ground. Each restrained or carried pronghorn should be positioned with its sternum down and its head well above the level of the rumen to prevent aspiration of rumen contents. At this point, the period of restraint is dependent upon the number of procedures (tagging, injecting, measuring, etc.) deemed necessary and whether tranquilizing drugs are used; nevertheless, during a translocation effort, all procedures should be kept to a minimum.

Tranquilizing drugs promote tameness and ease of handling. Two such drugs, Valium (5 mg/cc) and Acepromazine (50 mg/cc) are routinely used by some biologists during pronghorn translocations. Dosages are 1 cc for adults and 0.5 cc for fawns. Use of drugs should be avoided in most cases, however, because of the added hazards to the animal. An animal during transport could become physically incapacitated and be trampled by other animals and a released animal may be more susceptible to predation or accident before the affects of the drug wears off.

When groups of pronghorn are to be translocated, and individual handling for marking is not required, the use of a cattle-type loading chute (Fig. 19a & 19b) can reduce stress to the animals and expedite the loading process. The chute should be constructed specifically for pronghorn with solid wooden sides and runway, canvas top, and a width of approximately 22.5 inches (0.5 m) (McLucas 1956).

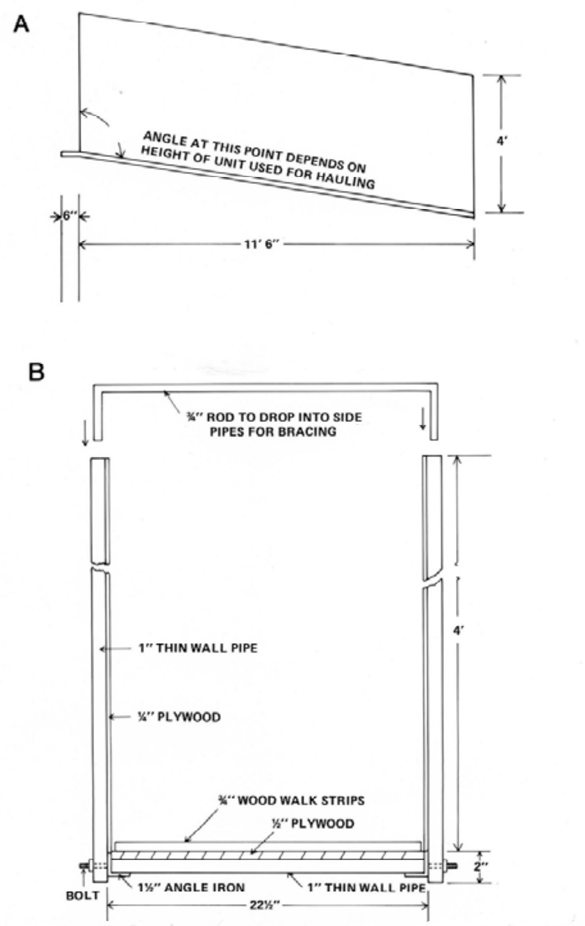


Figure 19a. Construction details of pronghorn loading chute, A = side view and B = end view (from McKenzie 1984).

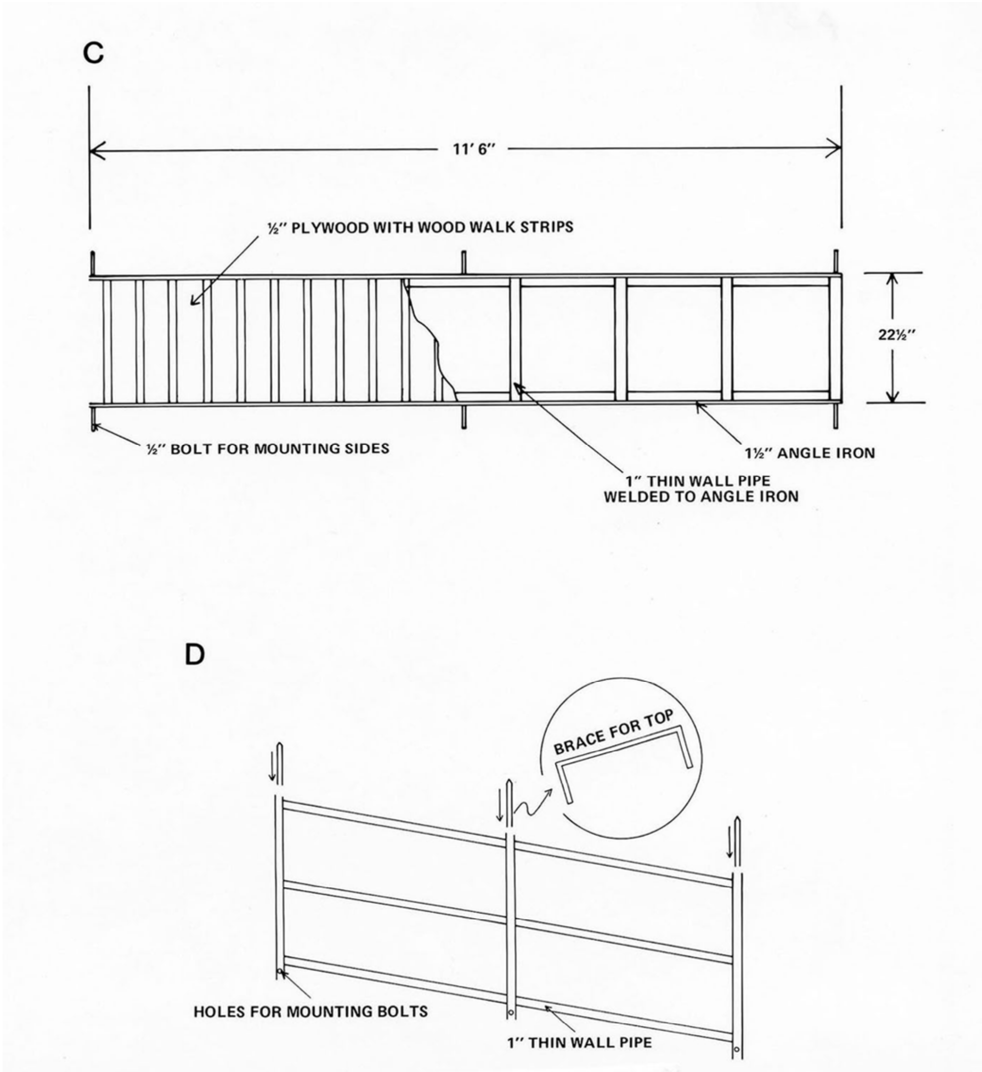


Figure 19b. Construction details of pronghorn loading chute. C = details of the bottom frame and D = details of the side frame (from McKenzie 1984).

Thomas and Allred (1943) described the conversion of 1/2 and 3/4 ton trucks with stake beds to transport deer. Such vehicles are practical for transporting pronghorn. Vehicles especially built for hauling pronghorn should be well ventilated, completely covered with a canvas top to make them as dark as possible, compartmentalized (to segregate horned males), and easy to load. Additionally, the space requirement for each pronghorn during transportation should be about 3.2 ft^2 (0.3 m^2).

Blindfolding horned males during transportation may be advisable, even when they are segregated from other pronghorn. Blindfolds are an alternative to removing the horn tips and likely serve the same purpose.

Each vehicle should start the trip to the release site immediately upon loading. The vehicular motion has a definite calming effect on pronghorn during transit. Pronghorn should not be transported when ambient temperatures are above 70°F (21°C), but if such a situation arises, the animals should be periodically sprayed with water.

Recommendations are for a gentle release (open the gates and walk away) as soon after arriving at the release site as possible or immediately after research needs are met. Should a transportation trailer be used, it is often beneficial to provide or build up a ramp to allow the pronghorn easy egress as newly released animals may fall down when jumping out of the trailer.

Linear Tangle Nets - Linear tangle nets have gained popularity in the capture of big game animals. Tangle nets are similar to corral traps in that animals must be herded into them. The axis of a tangle net should be positioned so pronghorn hit it while running into the wind. This helps to prevent animals from smelling the capture crew and facilitates control of the aircraft. These nets are best suited for the capture of a select number of target animals. A linear tangle net consists of a net 350-1,050 feet (100-300 m) long, approximately 8 feet (2.4 m) high, suspended vertically by notched wooden stakes or draped on vegetation. Sufficient nets to span at least 3,500 feet (1,000 m) are used in most operations. The best mesh size for pronghorn appears to be 7inch (18 cm) bar measure. Nets should be anchored about every 100 yards (100 m) so pronghorn cannot knock down whole nets or run into any backup nets. Nets should be hung loosely, with about 1 foot (30 cm) of net remaining on the ground, because animals can often back out of tight nets.

Amstrup et al. (1980) found that the linear tangle net could be successfully employed to capture small groups of pronghorn. They deployed the net as a cul-de-sac below a pass through rim rocks or at the end of woven wire wing fences along travel routes. A helicopter was needed to herd pronghorn successfully into the net. A major problem was collapse of the net with the impact of the first few animals, resulting in the rest of the herd jumping the net at that point. To prevent this, a second net was deployed a few yards beyond the first to form a double cul-de-sac to increase the catch. Amstrup et al. (1980) also thought a person hidden at the point in the net where lead animals tend to hit could stand up just before impact to scatter the herd and increase the number of contact points.

Clover Trap - Two adult pronghorn does were caught in clover traps in Oregon (M. Willis, pers. comm.). The traps were pre-baited with alfalfa hay and salt (salt appeared to be the most effective). Several other pronghorn were observed in the trap, but the drop panel froze open preventing their capture. If the panel had not been frozen trapping success would have been three trap-days per animal.

Cannon Nets - The cannon net can be used to capture select numbers of pronghorn. Animals must be enticed to feed or drink at a central point, and when they are at the target site, rockets are fired, propelling a 40 by 60-foot (12 by 18 m) net over the animals, the net being secured on the side of the cannons. The only baits that consistently attracted pronghorn were apple pomace (pulp remaining after the cider is squeezed out) and salt blocks (Amstrup et al. 1980). In arid regions water may serve as bait (Beale 1966).

Amstrup et al. (1980) found that one of 13 pronghorn captured in 4 netting attempts died in the trap. Another 4 were known to have died within two weeks from either capture myopathy or coyote predation. Because of the high mortality rate, this technique was not recommended for pronghorn. Pronghorn are not excessively stressed by a moderate amount of running, but they do not struggle as violently in a tangle net as they do under a cannon net. Violent activity is probably more conducive to capture myopathy, when the muscles have not been warmed by running. Also, pronghorn hitting tangle nets lose their footing almost immediately and can only struggle against the flexible net and soon cease struggling. Those under a cannon net often kept their feet on the ground and fought the net with all of their strength, not giving up until restrained by hand or exhausted. Pronghorn captured under cannot or drop nets lose much of their hair during the struggle under the net—a major consideration when trapping in cold weather.

Surround Net - Reeves (1982) devised a surround net for the capture of pronghorn. He constructed a 5-foot (1.5 m) woven-wire trap that arched around half of a pond or waterhole. The remainder of the pond was surrounded by nylon netting 9 feet (2.7 m) high and with a 5.6-inch (14 cm) mesh. A 350-foot (100 m) section of the netting was furled on the ground. This section was lifted by counterweights suspended from four 12-foot (3.7 m) poles when pronghorn entered the trap. The releasing mechanism for the counterweights was electrically activated from a distant blind. The trapping crew then rapidly approached the trap from the woven wire side. The startled pronghorn flushed into the netting, collapsed it, and became entangled.

Cancino et al. (2002) described how a combination corral trap and surround net were used to capture pronghorn in Baja California Sur. This technique employed fixed fences, an irrigation system, an observation tower with optical equipment, VHS radios and 2 person teams with vehicles.

Advantages of this trap include the ability to select the number, age, and sex of the animals to be captured, and minimal stress to the pronghorn. Reeves (1982) reported no post-release mortality among the 17 animals caught. Costs were considerably less than a corral trap or a drive net due to fewer materials and personnel and no aircraft being needed.

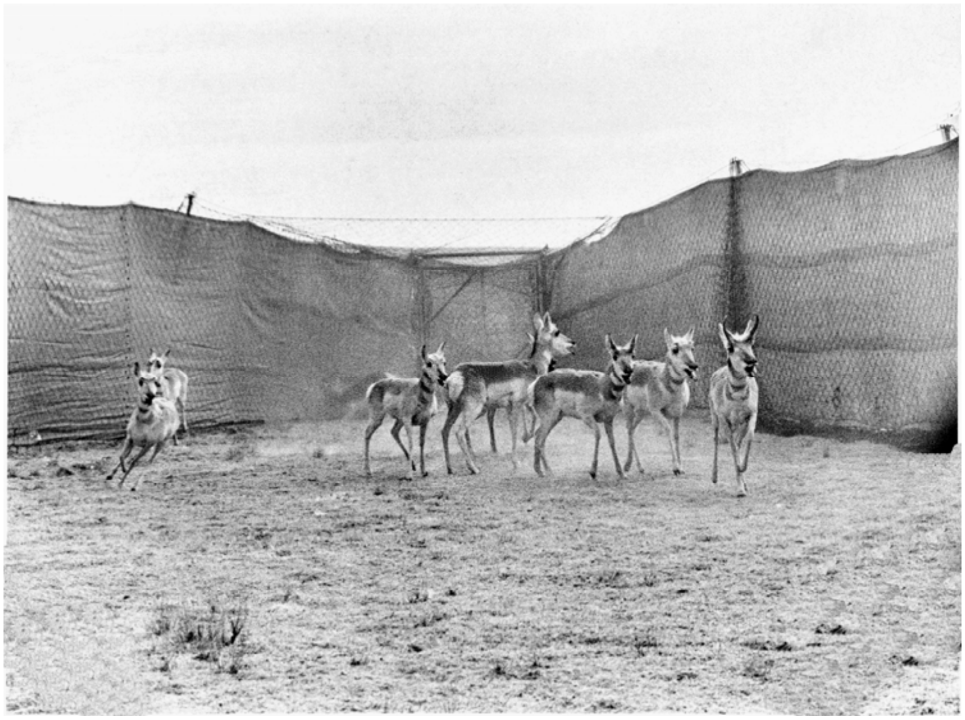


Figure 20. Within a corral trap, a canvas curtain should be rigged so that it can be drawn across a portion of the trap to facilitate hand-capture of pronghorn. The smaller area makes capture easier and reduces stress on the animals; it also can be used to separate 6-10 animals from a larger group. This reduces stress on the animals in the larger portion of the trap. Alfalfa hay scattered on the ground before capture reduces the amount of dust kicked up and inhaled by pronghorn during capture. Photo by Paul Wertz; courtesy of the California Department of Fish and Game.

Net Gun - Barrett et al. (1982) concluded pronghorn are captured easily with a net gun; however, considerable effort may be required to reduce capture myopathy and losses from trauma. Eighteen adult pronghorn were captured successfully using a 3-barreled net gun during 3 capture operations in Colorado (Firchow et al. 1986); two of the 20 pronghorn (10%) captured, or pursued for capture, died; 5 females captured during March and April were pregnant and carried fawns to full term. Initially the authors used 12 minutes as a cut-off point for hazing animals, but changed to a 7 minute maximum after signs of stress were noted in animals during the first capture operation. Fifty pronghorn (16%) died during 311 reported captures in Arizona, more than half from broken necks. Others were destroyed because of broken legs, and two died about two weeks after capture, apparently from capture myopathy.

The high cost of using helicopters encouraged Scott (1994) to net gun pronghorn from the ground in Yellowstone National Park. During net gunning of 21 pronghorn from a pickup, an average of one pronghorn was captured per 8-hour day at a cost of about $167 per animal; approximately 25% of the shots resulted in a capture (Scott 1994). Seventeen pronghorn were netted from a helicopter during the same study; in 3.5 hours of flying time (4.9 animals per hour), at a cost of about $403 per animal. Net gunning from the pickup truck resulted in 14% mortality compared to 47% for those netted from the helicopter. Scott (1994) concluded that ground net gunning was simpler, safer, and less expensive than aerial net gunning in Yellowstone. Additionally, ground capture caused fewer pronghorn mortalities and less public disturbance than did aerial captures. Captures in Yellowstone were only possible, however, because the animals were habituated to vehicles, a situation seldom encountered outside of parks or refuges.

The net gun is the tool of choice for capturing small numbers of pronghorn, particularly if few animals are present, if certain age or sex classes are needed for radio collaring, or if the capture area is difficult to reach by land-based vehicles. Pojar (2000) compared net gunning with the conventional corral trap method in terms of labor, equipment, and costs, and found net gunning using experienced commercial companies to be a practical and competitive capture method. Commercial companies that specialize in net gunning wild ungulates have recently become available. There are only a few of these companies in existence so choice and availability are presently limited. However, there are advantages to seeking out and using these companies, the most important being their net-gunning experience. The number of captures these companies have accomplished far exceeds those of individual agencies and this experience is of value in the efficiency, safety, and effectiveness of the technique.

A commercial company (Helicopter Wildlife Management, Salt Lake City, Utah) was used to capture 68 pronghorn in Colorado and 30 pronghorn in Utah (Pojar 2000). There was but a single mortality in the Utah operation and none in Colorado. This mortality rate is far lower than most agency operations and is attributed to operators' experience and familiarity with the technique.

Because the immediate control of the capture operation is often out of the hands of agency personnel, it is important to have a detailed protocol that addresses critical aspects of animal treatment. This protocol should be reviewed with the capture crew prior to the capture effort. The protocol should include standards for chase time and handling of captured animals as well as when animals should not be captured. A protocol for net gunning pronghorn from a helicopter is provided in Pojar (2000).

Figure 21. The net gun is the tool of choice for capturing small numbers of pronghorn, particularly if few animals are in an area, if certain age or sex classes are needed for radio collaring, or if the capture area is difficult to reach by vehicles. However, gunners should be thoroughly briefed before attempting captures as this technique can be dangerous for pilots and gunners. Photo by Richard Ockenfels.

Capture of Fawns - Fawns are captured for various management and research purposes including mortality studies. Most early captures were undertaken to raise fawns for eventual release in unoccupied, historical rangelands. In recent times, wildlife managers have conducted numerous studies to determine the causes of high fawn mortality by capturing newborn pronghorn and using radio telemetry to monitor their survival. Newborn fawns have also been marked to determine dispersal patterns upon maturing. Pronghorn fawns develop rapidly and can be easily captured only until about three days after birth. This short period necessitates specific procedures to minimize search time and ensure proper handling to avoid abandonment by does.

During fawning season observers should position themselves at strategic observation points. Binoculars and spotting scopes are useful for observing pre-parturient does or doe/fawn behavior. A doe signals impending parturition by leaving her band, frequent standing and lying, raising her tail, humping her back, and licking her belly and flanks. Surveillance should continue for about 4 hours after birth until fawns have nursed and mother/young imprinting is completed. This waiting period is critical to reduce incidences of abandonment and insure that fawns are several hours old at time of capture. The exact bedding location should be carefully noted and the fawns should be allowed to settle down for half an hour before being approached.

Lone does with large udders should be observed carefully, as they typically nurse their fawns about every 4 hours. Early morning and late evening are the most productive times to watch an animal, the doe sometimes glancing toward her fawns prior to nursing. After nursing and grooming, the fawns bed down and the doe leaves the immediate area.

Bedded fawns should be approached slowly and quietly from their rear, and a large long-handled net about 36-inch (1 m) in diameter should be gently placed over them to assure capture. Blindfolding fawns keep them calm while handling and wearing surgical gloves minimizes the transmission of human scent. Returning fawns to their original position and gently rubbing their tails reduces their tendency to run after release (Amstrup et al. 1980). The use of nets also allows the capture of some older fawns (up to 7 days old) without a chase.

Fawns too old or wary for daylight capture can be caught with spotlights at night (Brownlee and Hailey 1970). Observations of single females at dusk often indicate the presence of fawns, and it may be worthwhile to conduct a spotlight search in that locality after dark (Tucker 1979).

From 1953 to 1957, an intensive fawn-capture project was conducted in adjoining regions of California (Ackerly and Regier 1956), Nevada (Foree 1956), and Oregon (Hansen 1955, Yoakum 1957, Compton 1958). More than 600 captures were made, some taking place four weeks after the first capture. An adult, well-trained Labrador retriever, taught to heel behind a horse ridden by a biologist, assisted in recaptures of fawns more than a week old. When a fawn was flushed and began to run, the dog chased, caught, and held it until the biologists arrived. This technique did not result in any injuries to fawns during 156 captures in a 3-year period. Horses greatly assisted in the captures as mounted biologists were able to concentrate on looking for hidden fawns, and had the advantage of a high vantage point and ease and speed of travel. The average lone worker caught 25 fawns in a season, whereas the worker with the dog and horse caught 75 (Yoakum, pers. com).

Byers (1997) handled and marked fawns for 13 years on the National Bison Range and found no significant correlation between capture effort and survival. He concluded that proper handling of pronghorn fawns did not increase the risk of predation or cause an increase in mortality.

Chemical Immobilization -- Pronghorn seem to have a narrow tolerance to most immobilizing drugs. Occupying open country, pronghorn are especially difficult to drug with darts. Having thin skins, small muscle masses, and slender, fragile bones, pronghorn also are susceptible to injury from darts.

Kreeger(1996), in the *Handbook of Wildlife Chemical Immobilization*, recommended 0.04 mg/kg Carfentanil plus 1 mg/kg Xylazine and a repeated full dose if the animal did not go down in 20 minutes, and also recommended 100 mg Naltrexone, or Naloxone, per mg of Carfentanil given, plus 0.125 mg/kg Yohimbine to be used as an antagonist. Alternative drugs listed were either: (1) 0.1 mg/kg Etorphine plus 1 mg/kg Xylazine (antagonize with 2 mg Diprenorphine per mg Etorphine given, plus 0.125 mg/kg Yohimbine); (2) 5 mg/kg Ketamine plus 0.3 mg/kg Medetomidine (antagonize with 1.5 mg/kg Atipamezole). Keeger (1996) stated that to reduce renarcotization with Carfentanil, one should give a double dose of the antagonists, one IV and the other IM. Even after antagonism, expect the animal to undergo up to 30 minutes of excitement (rapid pacing, tongue hanging out, etc.). Do not give Xylazine to a pronghorn if you are not going to use an antagonist - prolonged hyperexcitability may ensue. Although Etorphine-Xylazine can be used on pronghorn, the Carfentanil-Xylazine combination has provided a safe and effective method for capturing large numbers of pronghorn with <5% mortality (Kreeger et al. 1998).

The Ketamine-Medetomidine combination has also been used with some success on unexcited captive pronghorn. In general, pronghorn are extraordinarily difficult to immobilize so one should be prepared for less than satisfactory results. Tiletamine hydrochloride with Zolazepam hydrochloride (Telazol) is now available in the United States on an experimental basis. Nothing has been published concerning its use on pronghorn, but Bill Lance (pers. comm.) reported satisfactory immobilization of pronghorn with 13 mg/kg Telazol. Such a dose would require a 2-ml dart, which is larger than desirable for pronghorn. O'Gara (pers. comm.) broke femurs of pronghorn bucks with 2-ml darts propelled by light (green) charges from a distance of 30 yards (30 m).

Little is known concerning the effect of immobilizing drugs on fetuses of does immobilized during late pregnancy, but attempts should not be made to immobilize pronghorn during the rut. As soon as a doe becomes unsteady on her feet, bucks in the area will attempt to breed her. This can result in an extended, fast chase and the death of the doe. When a buck becomes unsteady, other bucks attempt to kill him. If they do not succeed outright, the exertion can still result in death of the drugged buck. Bucks have been observed running as far as two miles (3.2 km) at top speed to mount or fight an unsteady animal.

Carfentanil and Rompun are probably the best drug combination available today for darting pronghorn. However, the net gun seems safer for the animals and more efficient than drugs.

Tranquilizing drugs - Tranquilizing drugs promote tameness and ease of handling. They act slowly, but last for a long time. Rompun used with Carfentanil for immobilization reduces the amount of Carfentanil needed. It also lessens convulsions and reduces excitement during handling.

Immobilizing or tranquilizing pronghorn with drugs administered orally in bait would eliminate many of the dangers associated with darting or drive-trapping. However, exact dosages cannot be administered, and the animals must be accustomed to feeding on the bait. Thus, the drug must have a wide safe-dosage range.

Valium has a wide safety margin, lacks toxicity, and has been administered orally to several species of deer in enclosures, resulting in successful captures. It has been administered orally to in livestock feed and functioned well in quieting and facilitating the handling of farm animals.

Pusateri et al. (1982) mixed oral tranquilizers with grain and fed it to pronghorn. Valium showed some possibilities, but dominance hierarchies established by gregarious pronghorn made the capture of large groups (10 or more) unfeasible. Dominant animals consistently ingested most of the bait. When severely tranquilized, the animals required constant attention. Poorly tranquilized pronghorn showed signs of hyperexcitability or had difficulty gaining their feet when bedded, and stumbled and lurched when approached. Interactions with non-tranquilized animals and continued capture attempts can cause such animals to injure themselves. Extended recovery periods of up to 30 hours also pose problems. Tranquilized animals require constant attention to prevent bloat, exposure, and predation.

A dose of 2-17 mg/kg of Promazine hydrochloride given orally to wild pronghorn fawns, and one adult, did not produce visible signs of tranquility (Pusateri et al. 1982). Doses of up to three times that recommended for a 1,200-pound (544-kg) horse were administered and still produced no signs of tranquilization. Pronghorn refused to eat bait containing doses of Promazine hydrochloride crystals that would result in dosages greater than 17 mg/kg.

Capture Myopathy--Pronghorn are delicate and excitable animals. Broken legs and necks are common occurrences when capturing pronghorn in corral traps or drive nets. Broken legs have also been reported when pronghorn were herded at high speed over rough country. A more subtle form of mortality, *capture myopathy*, sometimes results when pronghorn are captured and handled. Capture myopathy usually is associated with the animal's concerted and vigorous use of muscles during pursuit and capture, chemical immobilization, and transportation. Sub-lethal capture myopathy can predispose pronghorn to predation.

Using drive traps, Chalmers and Barrett (1977) captured 594 adult pronghorn in Alberta of which 29 succumbed to acute trauma. Some signs of capture myopathy appeared within an hour of capture, but most symptoms were delayed until handling or soon after release. A capture myopathy-like syndrome was associated with an estimated 20 additional deaths as the pronghorn were being processed.

Despite the normal appearance of 32 drive-trapped pronghorn that were radio-collared and released, 6 were found dead or recumbent within 2-8 days, and within 0.5-5 miles (0.8-8 km) of the trap (Chalmers and Barrett 1977). Coyotes had consumed some of the carcasses, and only one animal was found intact, so that determining the relative contributions of capture myopathy and predation was a problem. Some animals might not have been affected sufficiently to cause death, but were debilitated enough to become easy prey. Whatever the case, these data indicate an additional 19% of the processed and released pronghorn succumbed to capture myopathy and/or predation.

Seventy drive-trapped Alberta pronghorn were transported to rangeland enclosures and four to holding pens; three of the 70 animals were injured during transport and subsequently euthanized (Chalmers and Barrett 1977). However, the main cause of death (17 animals) appeared to be associated with capture myopathy. Most of these animals died 2-5 days after capture and transport; two died after 13 days. These investigators also examined two 2-week old fawns that died after being pursued by a vehicle. Both animals displayed clinical signs typical of capture myopathy. O'Gara et al. (2004) necropsied a fawn that was chased by a golden eagle and died of capture myopathy-like symptoms after its sibling had been killed by the same raptor.

Capture myopathy appeared more prevalent in pronghorn trapped during warm weather than cold weather and affected at least 4.2% of all pronghorn handled (Chalmers and Barrett 1977). During the later years of their study, these investigators found that the most effective practices in reducing acute cases of capture myopathy were less intensive aircraft pursuit, minimal handling, use of darkened trailers for transportation, and cold weather drive-trapping. Mortalities attributable to capture myopathy also were fewer when the transportation distance was short.

Although corral trap mortality of pronghorn generally is reported to be between two and 5%, overall mortality due to a trapping and translocating operation may be considerably higher. Mortality (probably acute trauma) at the trap site reported for 5,751 pronghorn (summation of reports) was 4.3%; mortality reported for 1,600 pronghorn transported to a release site was 7.5% (O'Gara et al. in prep.). Combining these percentages with Chalmers and Barrett's (1977) estimates of capture myopathy, overall pronghorn mortality from a trapping and translocating project ranges from 19 to 25%, and may, even under optimal conditions and reasonable precautions, approach 30%.

Chalmers and Barrett (1977) stated that chemical immobilization can also lead to capture myopathy. O'Gara (pers. comm.) noted that the only two pronghorn he immobilized with M-99 died within 2 days, even though they were immobilized for only a short time and appeared to recover without complications. One carcass was necropsied, and the cause of death was attributed to shock although clinical signs of capture myopathy were also present. Amstrup (pers. comm.) immobilized adult pronghorn with 8-10 mg of Succinylcholine chloride, but experienced a number of mortalities and observed symptoms of capture myopathy.

Pronghorn are highly susceptible to capture myopathy for a number of reasons: they have highly insulative coats that hold heat; their capture often involves long and occasionally arduous pursuit, which contributes to metabolic acidosis; and their highly excitable nature appears to predispose them to the psychological stresses of capture.

The first signs of capture myopathy include an increase in temperature, respiration, and heart rate. More advanced stages are recognized by stiffness, poor coordination, and variable paralysis. Terminal signs include a thready (faint, irregular) pulse, and a muffled heartbeat; the animal may then collapse and/or become prostrate. Severity of the disease ranges from minimal clinical signs to 100% mortality (Harthoorn 1975).

Treatment of capture myopathy in North American ungulates has been highly variable. Vitamin E and selenium preparations sometimes are administered, and although Chalmers and Barrett (1982) concluded that the injections did not necessarily reverse clinical signs, they did reduce mortality rates when used in conjunction with corticosteroids. In Oregon, Dexamethasone (5 ml) has been administered intramuscularly to moderately stressed animals, and Prednisolone Sodium Succinate (100 mg) has been used intravenously to treat advanced cases. In acute cases, Ringers Lactate Solution (500 ml) is administered intravenously with sodium bicarbonate (400 mEq/100 kg) intraperitoneally.

Marking**:** Colored collars, ear tags, or dyes have been used for years to identify individual pronghorn, but radio collars now are used most often to follow seasonal movements of pronghorn, identify causes of mortality, and delineate home ranges.

Figure 22. Pronghorn are often marked as an aid for later location or identification. Such techniques are of special value during mortality and seasonal movement studies, or locating herds translocated. Pictured here is an adult buck with a small marker in the left ear. It is purposely small, thereby assisting in marking the animal for life history activities, but still not easily seen by many public viewers. Photo by Jim D. Yoakum.

If visual recognition of individuals is desirable in addition to a radio collar frequency, fairly wide, ca. 3-in. (76 mm) colored collars are recommended. Narrow collars may be covered by mane and neck hair, making identification difficult. Wide collars can be observed from the air and individual markings easily discerned. R. Deblinger (pers. comm.) flew 50-100 feet (15-30 m) over pronghorn using a Piper Super Cub, and by slowing the plane down to pronghorn speed, could read the symbols or numbers on collars with little problem. Obviously, this technique can stress pronghorn, so care should be taken concerning the time of year and length of pursuit.

Collars should be tight enough that the animals cannot get a front foot or shrubbery caught in them. However, collars on sub-adults must allow for growth, and those on adult bucks must allow for neck swelling during the rut. Measurements of pronghorn from Colorado, Idaho, Montana, Nevada, Oregon, and Wyoming (Bear et al. 1973, McNay 1980, and Autenrieth 1984) indicate the following neck circumferences using as a maximum, the neck size immediately ahead of the shoulder, and the minimum as being just behind the ears. Adult bucks averaged 23.2 inches (590 mm) and 15.2 inches (386 mm), respectively. Adult females averaged 19.3 inches (491 mm) and 13 inches (330 mm). One-day-old fawns had neck measurements of 6.1-6.8 inches (155-172 mm).

Yearlings were so similar to adults that adult measurements can also apply for this age class.

Radio transmitters weighing no more than 0.26 lbs (120 g), including the collar, are less than 5% of the weight of a very small fawn. Generally, fawns are only one or two days old when collars are attached, requiring small, light batteries with a short life. The best radio collars for fawns have the transmitter and lithium battery hermetically sealed in a nickel-steel canister measuring about 1.5 by 1.4 by 1 inches (38 by 35 by 25 mm). The largest battery that should be put on a newborn fawn only has a life of 7-10 months and an expected range of 1.5-3 miles (2.4-4.8 km). Transmitters usually are riveted between strips of 1-inch (25 mm) nylon webbing that serves as the collar when the ends are joined. Most researchers do not want radio collars to remain on fawns for more than 3 months so that small, light batteries can be used. Several designs allow the radio collar to fall off before the batteries expire so that the collars can be retrieved. A simple design for short-term monitoring has the ends of the nylon webbing cut short and sewn to 1-inch (25 mm) wide elastic strips with strong nylon thread. These strips are sewn together with about 5 strands of light cotton thread to form an expandable neck collar. The cotton thread weakens with exposure and, as the fawn grows, and the tension on the collar increases, the threads break in 2-3 months. Tucks can be taken in the elastic with 2 or 3 strands of thread so the collar fits snugly. Successive tucks break away as the animal grows until the ends break and the collar falls off. Surgical tubing that is flexible and decomposes in 3-6 months has also been successfully used for fawn collars in Arizona.

When neck sizes increase greatly, nonadjustable collars may cause death. Keister et al. (1988) developed a durable, light-weight, self-adjusting radio collar for pronghorn fawns that allowed tracking animals up to one or more years of age. These collars were easy to attach and did not injure animals. Of 120 pronghorn fawns fitted with these collars, no deaths could be attributed to the collars, although five fawns were abandoned. The only problem was that some fawns lost their collars during the first few days—a problem remedied by adding a foam liner. Although collars lost resiliency with use, all retained enough tension to remain attached to necks of various sizes without becoming too tight. In about a year, however, some collars became slightly brittle and cracked. This weathering, along with the animals crossing through a number of barbed wire fences, contributed to some collar loss. But, because collar life was about equal to transmitter life, the potential for injury from collars was eliminated at about the same time as their usefulness was terminated.

Metal transmitters for fawns should be wrapped with dull-colored tape or painted, and the entire collar rubbed with sagebrush or other aromatic vegetation to mask unnatural odors. Carrying collars in a bag with vegetation from the study area also assists in this effort.

Solar-powered ear tag transmitters weigh about 0.06 lbs (25 g) compared to battery-powered adult collars, which weigh about 1 lb (454 g). Ear tag radios eliminate the risk of trying to fit a neck collar on a growing animal or a mature male whose neck circumference increases during the rut. The ear tag should be placed about mid-ear to prevent the long hairs of the lower ear area from covering the solar panels. T. Pojar (pers. comm.) used 25 solar ear tag radios on 5-month-old pronghorn fawns with variable results. Three of the female fawns' solar tags tore out of the ear within 6 months indicating that the cartilage of female fawns may not be strong enough to retain the ear tag. This problem was not encountered in male animals of the same age. Signal strength of these 25 radios was highly variable, possibly due to manufacture design or position of the tag in the ear. Some radios performed as well as battery-powered radios while others were weak or sporadic.

Properly designed ear tag radios may provide long term tracking ability. A solar-powered ear tag on a male continued to emit a signal after five years in the field, even though, the antenna had broken off limiting the range of the signal (T. Pojar, pers. comm.).

Even with their shortcomings, solar-powered ear tags are worth considering for specific investigations. Ear tags are less cumbersome than collars, and although they may tear out, they may be the better choice for marking fawns depending on the duration of the study period. Further design improvements will facilitate marking male pronghorn because these transmitters do need to consider changes in neck circumference.

Figure 23. Radio collars weighing no more than a ¼ of a pound (120 g) and having small, short life batteries, are used for marking one or two day old fawns. Fawn collars made of surgical tubing are flexible, allow for neck growth, and decompose in three to 6 months. Photo by Richard Ockenfels.

Pronghorn are flighty, nervous animals and marking them with streamers or other materials that move in the wind is not recommended. Many pronghorn have been marked with metal ear tags, and such tags have been retained for 10 years in some cases. However, O'Gara (pers. comm.) handled a pronghorn in Montana that was sloughing metal ear tags, apparently after her ears had frozen around the tags, the temperature having fallen to below -30EF (-34EC) about two weeks earlier. Plastic tags for earmarking livestock are available in stores supplying farm and ranch equipment. Such tags have less chance of freezing ear tissue and are easier to see at a distance than metal tags. Although plastic ear tags became brittle after one or two years when first available, those used in recent years have held up well.

Pronghorn do not always have to be marked for individual identification. An animal's horn shape, color, width of neck bands, the amount of white pelage, the configuration of the black areas on the face, etc, all serve to make an individual pronghorn recognizable by an observer who is familiar with the animals he or she is studying. From 1988 through 1994 Byers (1997) was able to identify all of the adult pronghorn on the National Bison Range (n = 84 to 136) by using sketches and photographs to help memorize their physical characteristics and coat patterns.

Translocations: Transplanting pronghorn should be considered only after it has been determined that the new or additional animals can survive in a habitat possessing sufficient quantity and quality of forage, water, and space in historic rangelands without being in conflict with other environmental issues (McCarthy and Yoakum 1984). Every translocation should be preceded by a feasibility study or management plan to document the objectives, translocation procedures, and post-release monitoring of the animals in their new habitat.

At times, sportsmen's organizations, conservation groups, agency personnel or local governments recommend translocating pronghorn into unsuitable areas. Such endeavors resulted in the loss of all pronghorn transported to Florida (Elliott 1966) and Hawaii (Nichols 1960). Analysis of these two cases disclosed the proposed sites did not meet pronghorn habitat requirements. Ignoring basic biological needs results in the eventual death of translocated animals, misuses of public funds, and elicits a negative reaction from the public as to the credibility of wildlife managers (Yoakum 1978). Similar unsuccessful translocations have been made into areas of unsuitable habitat in other U. S. states and in Mexico.

One of the first procedures for determining potential suitability of an area for the translocation of pronghorn to grassland habitats was developed by the Colorado Division of Wildlife (Hoover et al. 1959). Twenty-eight years later, the International Union for Conservation of Nature and Natural Resources (1987) proposed almost the same criteria, and summarized them as consisting of a feasibility study, a preparation phase, a release or introduction phase, and a follow-up phase. In many cases, the feasibility studies and preparation phases have been inadequate and the follow-up phase has neglected.

The trapping and translocating of pronghorn involve large amounts of manpower, time, and finances; therefore, it is recommended that feasibility studies and management plans be developed prior to authorizing any release. These plans should provide detailed procedures for capture, transportation, and release into new habitats. Management plans should specify the numbers of animals to be captured, and identify specific release sites. To ensure that the animals are captured and handled as safely as possible, the presence of a veterinarian at the capture site is highly recommended. The plan also should provide particulars regarding methods of release and follow-up monitoring.

Translocation goals should address the question of establishing a viable herd. Relocated herds that increase 20-30% within 5-10 years after release are indicative of herds that are responding to suitable habitat conditions. Franklin (1980) considered 50 breeding adults the minimum for a viable population. It therefore seems reasonable that translocations should contain at least 50 to 100 animals as recommended by Hoover et al. (1959). The only exception might be an emergency situation if some animals already were present in a release area judged to be below carrying capacity. Franklin also suggested 500 randomly mating individuals as the minimum population size for sustaining genetic variation at a level that would enable the species to adapt to changes in the environment. This appears appropriate for pronghorn, especially on rangelands experiencing frequent severe winters and/or numerous droughts.

Determining Suitable Release Sites - the initial factor to be evaluated for a release site is whether the area was historically occupied by pronghorn. Sites not historically inhabited apparently lacked some necessary habitat component. Any proposed release site should be evaluated as to why the site is not currently supporting the desired number of animals. To this effect, the following questions must be answered: what caused the animals to become extirpated and has the factor or factors responsible for their elimination been corrected? Has the habitat or other conditions now improved sufficiently to meet the pronghorn's habitat requirements? And, are current land uses and landowner attitudes favorable towards a re-introduction.

Translocations have assisted pronghorn populations in increasing from 30,500 in 1924 to more than 1,000,000 in 1984 (Yoakum 1986). Many of the translocations during the last 50 years were successful (Fisher 1942, Thompson 1947, Stokes 1952, Hoover et al. 1959, Russell 1964, Menzel and Suetsugu 1966, Yoakum 1978, and Britt 1980). Others, however, were unsuccessful (Aguirre and Sotomayor 1981, Tsukamoto 1983, McCarthy and Yoakum 1984, Del Monte and Kathman 1984). Improved techniques and knowledge from past experiences are therefore useful guides for future operations.

Feasibility Guide - Hoover et al. (1959) developed criteria for the selection of translocation sites for grasslands in Colorado. Eight of these criteria bear repeating with only slight modifications more than 40 years later:

> *1. Unless sufficient continuous rangeland is available to allow a translocated herd to be maintained or expanded, the site should be rejected. As a rule, each animal requires at least 1 square mile (2.6 km^2) of native grassland, and the number of animals should not be less than 100.*
>
> *2. Pronghorn feed primarily on forbs and shrubs, therefore, a good variety and production of these should be present. Rangelands in poor ecological condition or dense, high shrublands are not desirable.*
>
> *3. Concurrent use of rangelands by domestic livestock (cattle, horses, and sheep) should be evaluated. This involves competition for forage and water as well as compatibility, the presence of fences, predator control practices, and whether pronghorn or livestock might transmit diseases from one animal to the other.*
>
> *4. Depredation on agricultural crops is a potential conflict that needs evaluation. Isolated fields surrounded by rangelands usually are subject to more depredation than are numerous fields.*

5. A map illustrating the land ownership pattern should be prepared, especially if private lands are involved. Public lands are preferred, followed by large blocks of private lands with one owner. The least desirable sites are private lands in small units with many owners.

6. Reactions of people to an introduction should be considered, particularly those of local conservation organizations, personnel charged with administering public lands, livestock permittees, and private land-owners. It should also be ascertained whether the landowners would be agreeable to hunting on their property.

7. If all the above factors are satisfactory, written permission should be secured from all public land agencies and private land-owners in the area prior to the release.

8. It is also desirable to provide for alternate release sites to allow for last minute hitches, inclement weather, road conditions, etc.

Table 1. Form used for the selection of pronghorn transplant sites.

1. LOCATION:

   County ____________ Nearest town ____________

   Nearest ranch ____________ Accessibility by road ____________

   Township ____________ Range ____________

2. SIZE (Number of square miles of estimated habitat): ____________

3. TOPOGRAPHY: ____________ Physical Barriers: ____________

   Constructed Barriers:

   Fences (Location) (Construction Specifications)

   ____________ ____________

   ____________ ____________

   Major Highways, freeways ____________

   Other: ____________

4. CLIMATE: ____________ Elevation ____________

   Mean depth of snow ____________ Annual Precipitation ____________

5. WATER:

	Springs	Reservoirs	Lakes	Streams	Wells	Catchments
Number	____	____			____	____
Acres			____			
Miles				____		
Production:						
Surface Ac.		____				
Gal/Min	____			____		
Gal/Storage						____

   Mean distribution of water sources ____________

   Year-round water? ____________

6. VEGETATION:

Major Types	No. Acres	Mean Ht.	Estimated Percent Grass	Forbs	Shrubs
____	____	____	____	____	____
____	____	____	____	____	____
____	____	____	____	____	____

7. LAND OWNERSHIP (number of acres):

   Private ____________

   Public ____________

   Other ____________

8. LAND USE:

   Class of livestock ____________

   Stocking rate ____________

Table 1. Continued.

Grazing system ______________________

Cultivated crops ______________________

Other ______________________

9. PREDATION:

Natural: Coyotes ________ Eagles ________ Bobcat ________

Human ______________________

10. TRANSPLANT CONSIDERATIONS:

Is site historical pronghorn range? ______________________

Attitude of ranchers ______________________

Attitude of conservation organizations ______________________

Attitude of local sportsmen's clubs ______________________

____

Attitude of public land-management agencies ______________________

Is land manager(s) agreeable to management objectives of state or provincial wildlife agency? ______________________

Suggested number of pronghorn for transplant ______________________

Route of trucks carrying pronghorn and release point ______________________

____

____

Has a "habitat management plan" been developed? ______________________

____

____

Are cooperative agreements completed?

Private landowners ______________________

Public land agencies ______________________

Has a follow-up monitoring study been planned to document success of project or reasons for failure? ______________________

____

____

Other ______________________

____

____

[a]Modified from Hoover et al. (1959) for shrub steppes by Yoakum (1980).

Table 1. Form used for selecting pronghorn transplant sites.

As a guide for determining an appropriate release site, Hoover et al. (1959) developed a form recommended for completion prior to release on grasslands. Yoakum (1980) adapted the form for shrubsteppes, and this form warrants attention from managers planning translocations (Table 1). A similar form is also in use by the Game Management office of the Arizona Game and Fish Department to evaluate semidesert and other grassland sites.

Habitat Suitability Criteria – Determining suitable habitat for pronghorn is related to the right amount and juxtaposition of all habitat characteristics meeting the species' biological requirements. Knowledge of these habitat requirements is the ecological foundation for managers making translocation decisions (Yoakum 2004).

Suitable habitat for pronghorn can be determined through a system of rating habitat characteristics. Too little or too much of any biotic or abiotic factor may limit pronghorn production and survival. Knowledge of these relationships becomes the ecological foundation for making proper management decisions.

Quantitative rating systems have been developed to assess: winter rangelands (Allen and Armbruster 1982), translocation sites (McCarthy and Yoakum 1984, Arizona Game and Fish Department 1993), suitable year-round habitat (U.S. Bureau of Land Management 1980, U.S. Soil Conservation Service 1989), effects of wildfires on vegetation (U.S. Bureau of Land Management 1980), and the compatibility of domestic sheep to pronghorn (Howard et al. 1990). These rating systems have been used to evaluate pronghorn habitat in documented reports, thereby advancing pronghorn management from earlier "professional judgment" efforts to using written scientific criteria.

Habitat suitability was used as the main criterion for evaluating five potential shrub-steppe translocation sites in Mono County, California (McCarthy and Yoakum 1984). Similar strategies for evaluating sites can be used in assessing other potential release sites, to establish priorities, and to provide insight into the feasibility of a transplant. Procedures for choosing the best five sites included an evaluation of 9 criteria:

> 1. *Habitat suitability was evaluated for water, vegetation quality (percent forbs, shrubs, and grasses), vegetation height, and forage quantity using criteria established by Yoakum (1980).*
>
> 2. *Mean winter snow depths were interpolated using data from weather stations. Areas were considered suitable for winter use if mean snow depths were less than 10 inches (25 cm).*
>
> 3. *Natural physical barriers were evaluated to determine potential for restriction of pronghorn movements. Major physical barriers included large ravines, mountain ranges, and dense shrub or timbered areas.*
>
> 4. *The potential size of each release site was determined by using a polar planimeter and 7.5-min U.S. Geological Survey quad maps. Optimum area size was considered >100 square miles (259 km^2).*
>
> 5. *Livestock fences were evaluated in relation to pronghorn passability. A barbed-wire fence was considered passable if the bottom wire was at least 16 inches (41 cm) from the ground.*

6. Potential for predation on pronghorn was subjectively rated in terms of high, moderate, or low. Predator abundance information was obtained from various government agency personnel, ranchers, and individuals familiar with the sites.

7. Potential for crop depredations was estimated on the basis of location of agricultural crops in relation to each site. Distances were determined to the nearest cultivated field and a depredation potential rating of high, moderate, or low assigned to each area.

8. Seasonal suitability was evaluated on the basis of food availability and whether or not an area could support pronghorn on a year-round basis.

9. Potential for forage competition with livestock was estimated on the basis of class of livestock, animal unit months, and grazing systems. Each site was rated as having high, moderate, or low potential for livestock/pronghorn conflicts.

Following the evaluation of each site, limiting factors were addressed on the basis of the above criteria. The sites were compared with each other and prioritized in terms of the site(s) with the greatest potential for a successful pronghorn transplant. This system provided two components to help select the best potential release site: (1) it was based on ecological data collected in the field, and a numerical rating denoted the site with the highest potential; and (2) potential limiting factors were identified so that remedial measures could be taken prior to any releases, thus providing a better chance for a successful translocation.

In conclusion, the following guidelines are recommended for pronghorn translocations:

1. Translocation sites should be evaluated for habitat suitability prior to any animals being captured. Each state or province should establish a rating system that considers regional conditions and topography. Areas that do not meet such specifications should not be considered feasible until conditions meet all of the criteria required.

2. Multiple translocation sites should be prioritized to establish which areas have the highest potential for successful translocations. Ideally this should be done on a statewide, province-wide, or regional basis to assure that translocations are made only in the highest quality sites.

3. Habitat suitability criteria should be continually fine-tuned for site-specific release areas. Ratings for topography, vegetation and water availability should be modified to reflect ecological conditions within a state, province, or region.

4. Translocation projects should include monitoring the success of animals after release. This is important in developing and modifying translocation guidelines and ensuring accountability in translocation endeavors.

Care and Captive Management: Captive pronghorn have had an important management role since the early 20th Century (Brunner 1910, Floyd 1924, Nelson 1925, Nichol 1942, and Einarsen 1948), and continue to do so depending on the purpose involved. The main functions of captive pronghorn include public display, research, rehabilitation, and to assist in recovery efforts (Schwartz et al. 1976, Brinkley 1987, Wild and Miller 1991, Raisbeck et al. 1996, Blunt and Myles 1998, Lindstedt et al. 1991, Cancino et al. 2001). There are therefore captive pronghorn in zoos, on private ranches, at universities, and in public and private parks.

Depending on the objectives, a captive management program may employ a wide range of practices and facilities. For example, although the pronghorn on the National Bison Range are considered wild, all of the animals are fenced in, and essentially captives. The same holds true for the pronghorn on Antelope Island near Salt Lake City, Utah, and an enclosure on the El Vizcaíno Biosphere Reserve in Baja California Sur, even though the purpose of the former is primarily aesthetic, and the latter is part of a recovery effort for the endangered peninsular pronghorn (Tullous and Fairbanks 2002, Cancino et al. 2001). These and other facilities can be divided into three basic groups: 1) public display areas where animals are fed and receive medical care and other amenities on a regular basis; 2) research enclosures composed of corrals, pastures, and other facilities where the animals are more or less under constant observation (e.g., Sybille Wildlife Research Unit in Wyoming or the Foothills Wildlife Research Facility at Fort Collins, Colorado); and 3) large fenced areas within habitat that contain such basic facilities as water and food (Byers 1997, Blunt and Myles 1998, and Cancino et al. 2001).Depending on the objective the facilities may be used to hand rear and wean captured fawns, provide “soft care” for animals under observation, or intensively train research subjects.

Figure 24. At times management objectives may provide artificial or emergency feeding. For example, alfalfa hay was provided and readily used by pronghorn on the Carrizo Plain during a severe drought. Another case is pictured here where pronghorn were raised for future releases to historic rangelands on the Vizcaino Desert, Mexico. Photo by Ramon Castellanos.

Hand rearing captured fawns is the simplest way to start a captive herd. Once the fawns are removed from the wild, there are several protocols for bottle raising them (Schwartz et al. 1976, Brinkley 1987, Wild et al. 1994, and Martin and Parker 1997). The main differences are in the composition, mixing procedures, and volume of the formula. Although methods of alleviating gastrointestinal distress differ, all have the same goal--successfully raising fawns to the weaning stage. The hand raising process can be divided into five periods—adaptation, initiation, development, concluding, and weaning. The first or adaptation period is to accustom the fawns to feed from the bottle. Evaporated milk is used as a base, with or without boiled water. Eight days with an offer of a 5 to 8-ounce (.15 to .24 l) bottle should be sufficient. The initiation phase using a 10-ounce (.30 l) bottle for two weeks then begins.

The development period lasts about 50 days. During this phase, larger amounts of food are offered. According to the protocol selected, *i.e.*, the amount of milk mixed with the boiled water, milk consumption gradually increases until the consumption of vegetation begins. Depending upon the situation, the vegetation eaten can be native plants, alfalfa hay (*Medicago* sp.), or a mixture of the two. Salt blocks should also be accessible during this stage.

The length of the concluding period can be adjusted depending on the number of fawns involved and the weaning schedule desired. This adjustment should also consider the age when individual animals were captured, with the younger animals requiring more time than those caught later in the season. In pronghorn, permanent teeth replace the "baby teeth" at about 16 months of age (Jensen 1998).

Places like the National Bison Range require little overt care other than observation and other “soft care” techniques, and the periodic removal or restocking of individuals. Byers (1997) presents a detailed description of the monitoring and other procedures used at this and similar locations. Captive animals nonetheless always present the possibility for accidents, e.g., rattlesnake bites (Miller et al. 1989) or surgical emergencies. “Lumpy jaw” lesions associated with infected teeth roots are not uncommon in captive animals, and bacteria isolated from these jaw and mandibular abscesses include *Arcanobacter pyogenes* and *Fusbacterium necrophorum*. In addition to lancing and draining abscesses, treatment with antibiotics is often required to manage lesions (M. Wild, *pers. com*). As a consequence, it is usually advisable to have a veterinary staff on the premises, and under optimal conditions preventive medicine protocols would include annual treatment with vaccines as is done for domestic sheep. Euthanasia needs to also be considered in some cases.

Schwartz et al. (1976) described animals subjected to intensive training for ecological studies, Lindstedt et al. (1991) discussed the laboratory use of pronghorn in energetic studies, and Raisbeck et al. (1996) evaluated the susceptibility to selenosis. As stated the reader is urged to consult the original reports for greater detail.

Predator Control

Predators kill some pronghorn, especially fawns, and predation can be significant on marginal pronghorn rangelands or in areas where predator numbers are high in relation to pronghorn numbers (Smith et al. 1986). Most fawns killed are between 1-3 weeks of age, while separated from their dams. Trainer et al. (1983) reported that 87% of fawn mortality occurred during the first three weeks of life in their study area in Oregon.

Figure 25. Each species of predator has characteristic feeding patterns and often leaves evidence at a carcass in their attempts to bury or cover it. Here a bobcat has scratched out hair in an attempt to camouflage a carcass from carrion-eating birds. Cats often do this if ground litter is not available to cover a carcass. Feeding and covering patterns should not be considered conclusive evidence of a predator kill. Kills can only be determined by the typical wound patterns inflicted by a species of predator plus hemorrhages showing the prey was alive when the wounds were inflicted. Photo by Rod Canutt.

Pronghorn, although having made an impressive comeback, often are restricted in their movements due to fenced farms, highways, and right-of-ways as well as urban development. Thus, some herds are localized and relatively small. Under such artificial circumstances, predators may keep pronghorn populations from increasing, or even eliminate them (Udy 1953). Predator control to benefit a big game population often involves a reduction of predators over a large area, however, and even if desired, such control seldom is economically feasible. However, Smith et al. (1986) indicated that selective, time-specific application of aerial gunning in areas of high coyote density could be an economically beneficial means of increasing fawn survival on Anderson Mesa in north central Arizona.

As pointed out by Hornocker (1970), if suitable habitat is unavailable, no amount of predator control will bring about a flourishing population of a prey species. Also, controlling one species of predator may be compensated for by increased predation by other species, as happened on the National Bison Range when coyotes were reduced and predation by bobcats and golden eagles increased (Corneli et al. 1984). The overriding influences on pronghorn mortality are changes in carrying capacity and the quantity and quality of habitat available. As an example, Pyrah (1987) found that coyote density in the Yellow Triangle area of Montana was positively correlated with pronghorn numbers, presenting the possibility that coyote and pronghorn populations reacted concurrently to habitat factors.

Recognizing the many investigations relative to pronghorn neonate-predator relationships, a comprehensive report Yoakum et al. is being published in the 2004 Proceedings of the Pronghorn Workshop. The report assessed >35 publications from 1945 to 2006. A summary of these findings regarding pronghorn fawn relations to predators and predator control include:

1. *Native predators currently exist in all habitats occupied by pronghorn. Prey and predators have coevolved.*

2. *Pronghorn are prolific fawn producers—averaging 180 to 190 ff::100dd. Mortality of fawns are generally high—50 to 80 percent of annual production. Predation averaged 53 percent of overall fawn mortality for the 12 studies using radio telemetry.*

3. *Predation is highest during the first 30 days following parturition – hiding period for fawns before they grow large and swift enough to evade predators. Chronicle low fawn recruitment is not necessarily justification for a large-scale predator control program. Low fawn recruitment may be a symptom of low quality habitat or other predisposing factors.*

4. *For most habitats, coyotes are the main predator of pronghorn neonates. Bobcats and golden eagles take lower percentages.*

5. *Rates of neonatal mortality are generally higher in marginal pronghorn habitats or when a population is at or above ecological carrying capacity. Mortality rates are likewise high for areas suffering from high density dependency functions.*

6. *Even when predation has been identified as a major limiting factor for pronghorn and fawn recruitment below management objectives, other important mortality factors affecting carrying capacity should be considered before initiating predator control. Low fawn recruitment may be a symptom of low quality habitat or other predisposing factors: e.g., low abundance of alternate prey, large numbers of predators, poor health of prey, inclement*

weather, or unhealthy vegetation condition. Predation rates generally vary temporally and geographically, and recommendations for predator control should be supported by long-term studies (generally >5 years) that assess which environmental factors are truly responsible for limiting population size.

7. *Effects of predation are greatest when prey numbers are small and predators are many. Predation rates are generally higher for shrubsteppes and deserts than grasslands.*

8. *Numerous studies confirm that effective coyote control programs can increase initial fawn survival; however, it is rare that such practices result in increased pronghorn herd size. Generally, the condition and health of vegetation influences rates of predation.*

9. *A ratio of 15 to 20 ff::100dd in summer surveys is probably needed to sustain a population.*

10. *A predator control program to enhance pronghorn productivity may be justified if predation rates are high and the pronghorn population is well below carrying capacity.*

11. *A short-term predator control program may be justified to assist the growth of a newly translocated population, or to protect a captive herd.*

12. *To be effective, a coyote control program must remove >70 percent of the predators prior to the fawning season and be conducted for two consecutive years.*

The effects of predators and predator control on adult pronghorn mortality rates is less reported in the literature. This may be the result of fewer acts of predation on adult pronghorn compared to deer or elk that inhabit sites occupied by cougars and bears. O'Gara (2004d) provides examples of limited cases of predation on adults. Ockenfels (1994 and 1994b) reported increased cougar depredation when adult pronghorn moved to marginal habitats with abundant cougars.

Recommendations: In treating a problem situation in which pronghorn populations are reduced and predators are prevalent, the following guides should be used:

1. Determine what pronghorn herd parameters are desired. This may be in terms of total number, recruitment rate, age classes present, etc. Determine the year-round distribution of pronghorn and the habitat types involved. Consider other population influences including, but not limited to, predation.

2. If predation is determined to be a significant inhibitor of a particular population, the cost of actually controlling predators in the short-term must *be balanced against the long-term return. At present, the only method that appears to be economically feasible is aerial gunning of coyotes immediately prior to, and during the fawning season (Smith et al. 1986).*

3. If it is determined that an increase in pronghorn numbers justifies the cost, predator control should be done on those herd units where documentation indicates predator reduction can meet management objectives.

4. In some captive situations, predator may also take the form of preventive maintenance. In these situations double fence enclosures to control coyotes and overhead netting to discourage predations by golden eagles may even be desirable in small areas.

Protection from Harassment: Little information is available concerning the impact of harassment on pronghorn. Although generally considered unethical, chasing animals with vehicles during hunting seasons is a common practice. Such stress probably also increases crippling loss as necropsies done by Chalmers and Barrett (1974) showed that pronghorn dying during drive trap operations exhibited muscle hemorrhages in the hind limbs, and concluded that stress may be highly detrimental to the pronghorn's well-being. McNay (1980) reported that does in late pregnancy and does with young fawns reacted negatively to any form of harassment, and pregnant does moved out of a fawning area when cattle moved in.

Road closures, seasonal use restrictions, and closed areas have all recently been employed as means to reduce pronghorn stress during the fawning season and at other critical times, especially in winter. Although numerous studies have documented the negative effects of human disturbance (see e.g., Baker 1955, Scott 1976, Helms 1978, Crowe and Strickland 1979, Markham et al. 1980, Constan et al. 1981, Segerstrom 1981, Medcraft and Clark 1984, Andrews et al. 1986, Clark and Medcraft 1986, Dickens and Andrews 1986, Haag 1986, Hess 1988, Howard et al. 1990, Bastian et al. 1991, Chervick 1991, Tullous and Fairbanks 2002, Smith and Guenzel 2002, U.S. Fish and Wildlife Service 1994, and Yoakum 2002), few scientific studies on the efficacy of closing pronghorn habitats to humans have been conducted.. Such data are sorely needed.

Supplemental Feeding: The quality of game animals and the quality of human enjoyment of them result from good wildlife management (Murie 1951). Pressed by a public who want more animals to hunt or otherwise enjoy, and faced with limited or below par habitat, wildlife managers may turn to artificial feeding or other measures that affect the "gameness" of a species and thereby foster inferior animals. According to Leopold (1933), the recreational value of a herd of game is inverse to the artificiality of its origin, and a proper game policy seeks a happy medium between the intensity of management necessary to maintain a game supply and that which would deteriorate its quality or recreational value. The desirability of a
maintenance-free population should always be kept in mind when considering supplemental feeding.

Pronghorn populations are most stable on natural rangelands with unimpeded access to key seasonal habitats. Maintaining movement corridors to key habitats, some of which may be used no more than one year in 10, is becoming more and more difficult. Consequently, emergency feeding may be the only way to save large numbers of pronghorn during critical conditions. Supplemental feeding usually comes with considerable expense and logistical challenges, however.

When an emergency situation arises, pronghorn usually move toward key habitats unless stopped by fences or other human-made impediments. Generally, emergency feeding should begin within a couple of days of the onset of stress for best results. Pronghorn that are starved for 10 days or more usually will not survive no matter what measures are taken to save them (Pearson 1969). Thus, palatable rations that are immediately accepted are needed.

Ken Clay (pers. comm.) reported that the only pronghorn to survive a catastrophic die-off in Arizona during the winter of 1966-67 were fed clippings that had been mowed by highway department personnel. Animals fed alfalfa or other hay all succumbed. Torbit et al. (1984) developed and tested a winter pellet ration formula that was economical, nutritionally complete, digestively safe, and acceptable to pronghorn. These researchers also investigated the most practical ways to deliver these rations to wild populations. As a result, a pelleted commercial ration for emergency use is now available from RanchWay Feeds in Fort Collins, CO (Baker and Hobbs 1985). This ration was used successfully in two situations encountered in Colorado, and demonstrated that emergency supplemental feeding of wild pronghorn is possible.

While experiencing a severe summer drought on the Carrizo Plain National Monument in southern California, wildlife managers reported a shortage of succulent nutritious forage and drinking water for a herd of wild, fee-roaming pronghorn (Koch and Yoakum 2002). Consequently, emergency action was taken by providing alfalfa hay and fresh drinking water. Pronghorn readily located and consumed the forage and water. However, soon after the first autumn rains arrived and herbaceous forage sprouted, the pronghorn quickly reverted to foraging on native vegetation. Field investigations located no pronghorn mortalities during and after the drought emergency program.

Habitat Management

The foundation for habitat management is a base inventory of the quality and quantity of food, water, physiographic features, etc. Once the base inventory has been completed, periodic monitoring studies should determine whether habitat conditions are static, improving, or declining. How often monitoring studies should be conducted varies with the degree of change in the habitat; however, it appears that every 5 years is adequate for relatively stable habitats. Rangelands experiencing rapid environmental changes should be monitored more frequently. Both the quality and quantity of forage and waters should be monitored on a prearranged schedule. Techniques to monitor habitat are provided by Yoakum (1980, 2004) and Cooperrider et al. (1986). The habitat requirements discussed in Section II of this field guide should be included in every management program.

Evaluating Habitat Suitability and Habitat Models: After the base inventory has been completed, evaluating the suitability of an area for pronghorn is possible. This is accomplished by comparing the habitat characteristics with pronghorn habitat requirements. Suitable habitat for pronghorn can be determined through a system of rating the amount and juxtaposition of habitat characteristics. Too little or too much of any biotic or abiotic factor may become the primary component limiting pronghorn production and survival. Knowledge of these relationships becomes the ecological foundation for making management decisions.

Wildlife biologists today often use habitat models to evaluate pronghorn habitat suitability (quality), however, many of these models are based on professional judgment and lack quantified data. Models are used to synthesize knowledge of habitat components and apply information systematically towards management goals. Managers may find habitat suitability evaluations of assistance in making resource decisions. This is especially true when developing a plan to translocate herds, or when completing an Environmental Impact Study to determine the relationships between livestock and pronghorn using the same habitat or the impact of human involvement on pronghorn habitat. The utility of a model should be tested over a sufficiently long period of time, and on a large enough scale to sample a variety of conditions.

Models are generally of two types, either conceptual or quantitative. Conceptual models represent thoughts and ideas in a qualitative way rather than in terms of numbers. Quantitative models are based on ideas and relationships contained in conceptual models, but augmented by numeric data. Using measurable sets of environmental factors and relationships can often be used to predict the outcome of a future event

Habitat models may also be either extensive or intensive. Extensive models may be used to differentiate occupied from unoccupied environments on a broad geographic scale. One such endeavor was accomplished in Arizona by rating suitable pronghorn habitat in a statewide survey (Ockenfels et al. 1996).

Intensive quantitative models for pronghorn have been developed to assess: winter rangelands (Allen and Armbruster 1982), translocation sites (McCarthy and Yoakum 1984, Arizona Game and Fish Department 1993), suitable yearlong habitat (U.S. Bureau of Land Management 1980, U.S. Soil Conservation Service 1989), effects of wildfires on vegetation (U.S. Bureau of Land Management 1980), and the compatibility of domestic sheep with pronghorn (Howard et al. 1990). Each model has contributed to evaluating pronghorn habitat through documented reports, thereby advancing pronghorn management from earlier “professional judgment” efforts to written scientific rating systems (Yoakum 2004c.).

Examples of working systems for the Great Basin region are provided by Salwasser (1980), Yoakum (1980), and Kindschy et al. (1982). For the sagebrush-grasslands of Wyoming, a different system was used, which stressed the evaluation of winter habitats (Allen and Armbruster 1982, Cook et al. 1984, Cook and Irwin 1985).

At least 10 models are presently used to assess pronghorn habitat: Hoover et al. (1959), Yoakum (1974), U.S. Bureau of Land Management (1980), Allen and Armbruster (1982), Kindschy et al. (1982), McCarthy and Yoakum (1984), U.S. Soil Conservation Service (1989), Howard et al. (1990), Arizona Game and Fish Department (1993), and Ockenfels et al. (1996). Ockenfels et al. (1996) reviewed 9 habitat suitability methods developed since 1959, noting the strengths and weaknesses of each model, and presenting a landscape-level model for Arizona. In general, all models are based primarily on terrain physiognomy and vegetative structure and condition. Other factors are typically of secondary importance.

Figure 26. Rangelands with dominant, dense, tall shrubs are not productive pronghorn habitats. These shrublands decrease opportunities for pronghorn to see and flee from enemies. Extensive shrub communities also compete for moisture and soil nutrients and often lack nutritious forbs and grasses. Photo by David E. Brown.

Maintaining Quality Habitats: When a natural site is in good condition relative to its ecological potential, maintenance of that condition should be a major objective. Implementing this ecological principle, however, will not always favor some objectives, such as producing maximum numbers of pronghorn. For example, some shrub-steppe communities in the Intermountain West naturally have 60% or more shrubs; this is not conducive to high pronghorn densities, because such sites have low carrying capacities for pronghorn. Managers should not expect such sites to produce high numbers of pronghorn or try to manipulate the vegetation for that purpose, ignoring the site's ecological potential.

Habitats that provide optimal resources for pronghorn will produce optimum numbers of pronghorn. Therefore, recognizing habitats in good ecological condition and maintaining them, by objective, is important. This is especially true where the land is managed for multiple-use.

However, some land managers are not aware of optimum pronghorn habitat conditions and may suggest changing the vegetation composition favoring livestock production. Under such circumstances, it behooves the wildlife manager to know the habitat conditions required by pronghorn, and advocate the maintenance of those conditions for the welfare of pronghorn populations.

Figure 27. Today's dominant shrublands can be treated to improve forage for pronghorn. Managers can use control techniques to decrease shrubs, resulting in vegetative communities with a greater mixture of forbs, shrubs, and grasses, meeting the habitat requirements of pronghorn. Photo by David E. Brown.

Dunbar (2001) disclosed that playas (shallow intermittent lake beds) on the Hart Mountain National Antelope Refuge were key habitats for pronghorn. Although these playas represented 3% of pronghorn habitat, they were occupied by more than two-thirds (n=1933) of the pronghorn population because the sites contained drinking water and an abundance of succulent, nutritious, preferred forage. The importance of quality playas in providing water and forage during dry seasons helped managers recognize the importance of these key sites in quality conditions, and protecting them from severe competitive use by cattle and feral horses.

Enhancing Poor Quality Habitats: Improving rangelands for a specific objective of restoring or increasing forage, cover, or water, is termed "habitat improvement"

(Yoakum et al. 1980). When rangelands are in poor ecological condition, and the site is capable of better forage and/or cover, projects should be designed to improve habitat conditions. For example, a site having a vegetation composition of 5% grasses, 10% forbs, and 85% shrubs, can be improved for pronghorn. Prescribed treatment of shrubs followed by seeding with mixtures of grasses, forbs, and shrubs can change the site to a more favorable composition of 35% grasses, 25% forbs, and 40% shrubs. In some areas, a desirable habitat factor may be inadequately distributed, and this situation also can be improved through management practices. For example, streams and springs may be abundant in half of an area, but water may be lacking or limited in the other half. By developing waters in the latter portion, managers can provide a more equitable distribution and increase carrying capacity throughout the unit.

Water Developments: During a 5-year pronghorn study in the Red Desert (1966-1970), pronghorn were seen using every type of water source available (Sundstrom 1968). These water sources consisted of springs, creeks, rivers, lakes, reservoirs, stock water developments, galvanized troughs fed by windmills, and troughs filled by springs.

Water improvement projects to increase drinking water for livestock and pronghorn are varied (Yoakum 1980, Yoakum et al. 2004c, Vallentine 1989). Springs and seeps are used extensively because they are abundant in some habitats and pronghorn are accustomed to using them. Such sources can also often be improved with proper development techniques. Improper development techniques, however, can also impair or remove the water source. No two springs are alike; consequently, an experienced hydrologist should be consulted before any alterations are made.

Hundreds of small reservoirs have been constructed to trap and retain precipitation. Many of these have been built on public lands through cooperative funding by state and federal management agencies for the benefit of livestock, with some participation by private landowners. Such developments often are natural in appearance and serve a variety of wildlife, contributing to the well-being and range expansion of some pronghorn herds. In Malheur County, Oregon, 1,037 small reservoirs have been developed for livestock and wildlife needs on public lands (Heady and Bartolome 1977).

Another water development used by pronghorn, especially during late summer, is the dugout or trench reservoir. Dugouts commonly are placed in areas of comparatively flat, but well-drained terrain. A natural pothole or dry lake bed may be a good location for a dugout (Good and Crawford 1978). Heavy use by livestock and other wildlife species may negatively impact forage surrounding these areas, however.

Precipitation catchments (guzzlers) on ranges lacking natural waters have been successful in providing water for pronghorn (June 1965). Such water developments serve a variety of wildlife. A surrounding fence should be constructed to protect the facility from trampling damage and competition by livestock. Any water development, including catchments, must be properly maintained if pronghorn are to benefit. Catchments that go dry for whatever reason, or fail to provide water at critical times, may do more harm than good. If pronghorn access to water sources on rangelands occupied by cattle is a problem, see Figure 25 page 99.

Water Quality: Little information is available concerning water quality as it affects pronghorn. However, total dissolved solids and pH are probably important concerns. In the Red Desert, Sundstrom (1968) found little or no use by pronghorn of water sources that contained total dissolved solids in excess of 5,000 parts per million (ppm). Some use occurred on a water source with dissolved solids of 4,620 ppm. The maximum total dissolved solids recommended are about 4,500 ppm (McKee and Wolf 1963).

Figure 28. Water improvement project to increase drinking water for livestock may also aid wildlife. Dugouts or dirt stock tanks are commonly used by pronghorn if placed in flat, well-drained terrain. Photo by George Andrejko.

Livestock may be impaired by drinking water that contains excessive dissolved solids, and it is a good assumption that this may also apply to pronghorn. Continuous use of such water may cause general loss of condition, weakness, scouring, reduced milk production, bone degeneration, and death. However, animals can temporarily drink highly saline waters that would be harmful if used continuously. Animals also can adjust gradually to the use of waters with a higher solids concentration than that which they normally drink, although sudden change from slightly to highly mineralized water causes acute distress and diarrhea of varying severity. The limits of tolerance depend upon the particular salts present, the species of animal, its diet, age, physiological condition, season of year, climate, etc. (McKee and Wolf 1963).

The recommended pH range for most uses, such as domestic water supplies, irrigation, fish and other aquatic life, and recreational uses, appears to be from 6.5-8.5 (McKee and Wolf 1963). In Wyoming's Red Desert, when water sources exceeded a pH of 9.2, pronghorn appeared to seek other water sources (Sundstrom 1968).

Where water sources are available to pronghorn, but appear to be avoided, a complete water chemistry test should be made and measures taken to correct the problem. Where the water quality cannot be improved, and no other water source is in the vicinity, water catchments should be installed.

In addition to being designed to provide a continuous supply of water, water developments in pronghorn range should provide maximum safety for animals using them. Wilson and Hannan (1977) listed the rationale and criteria needed to assure wildlife friendly use of water developments designed to supply livestock with drinking water. To help prevent animals from being entrapped and drowned, they suggested a number of recommendations including the following considerations for pronghorn: Troughs or other water containers should not extend more than 20 inches (51 cm) above the ground so that both adult and fawn pronghorn have access to the water. Deeper troughs should be set into the ground to achieve the desired height. Barricades should be considered in some situations that would prevent the accidental entry of animals into unsafe areas and drowning. The distance from the rim of the trough to the barricade should not exceed 20 inches (51 cm). Where water depths exceed 20 in (51 cm), rocks or other material should assist animals that accidentally enter the water in obtaining a footing to find their way back to dry ground.

Food Habit Studies

For these Guides, we have defined the term "diet selection" (discussed on page 9) to denote what and how much of each plant species an ungulate consumes. The term "food habit studies" includes diet selection, plus other factors that influence diet selection (e.g. weather patterns, forage similarities and competition with other herbivores, nutritional values, etc.). Different techniques have evolved and the findings between the various methods are no always comparable (Sundstrom et al. 1973, Yoakum 1990, 2004d). To help provide consistency for comparing future food habit studies, the following recommendations by Yoakum (2004d) are:

Pronghorn food habits can be determined by direct or indirect observations using rumen contents, fecal analysis, or cafeteria trials. The various techniques are described in detail below:

Figure 29. One of the most intensive food habit studies of pronghorn was accomplished on the Pawnee Grasslands, Colorado. Diet selection was determined for pronghorn, bison, cattle and domestic sheep during all seasons of the year for pastures with different foraging intensities. Such investigations provide data on diet preference and overlap competition between ungulates. Photo by Chuck Schwartz.

Direct vs. Indirect Observations: Direct observations require observing feeding pronghorn at close range in the field and estimating the amount of each plant species consumed. Sometimes this procedure is referred to as "bite counts" or feeding-minute" studies, and has been used with varying success (Büechner 1950, Hoover 1971, Schwartz et al. 1976, Schwartz 1977). Tame, semi-tame, or constrained animals are generally used; often these animals are raised in captivity and accustomed to humans. The animals are taken to the field and allowed to forage while the biologist closely monitors the pronghorn and records what is eaten. The accuracy of direct observations of tame animals has been questioned, but Schwartz (1977) found food habit results similar for reared and wild pronghorn using the same plant community. Another good source for direct observation studies are animals in National Parks or other refuges where the animals have become accustomed to human presence and tolerate proximity for observation.

Indirect observations or "feeding site" examinations of foraging wild animals is one of the oldest methods used for pronghorn food studies. Rouse (1941) used the procedure of trailing pronghorn after a fresh snow and recording the species and/or numbers of plants consumed. Since then the method has been used by (Büechner 1950, Cole 1956, Severson 1966, Beale and Smith 1970, Campbell 1970). Basically, pronghorn are located in the field, the exact location where the animals were feeding is examined and any use of the plants is recorded. The system calls for little equipment other than a pair of binoculars (or a spotting scope) and a field notebook. This procedure can be extremely time consuming, however, and it is often difficult to determine use on certain vegetation, e.g., sagebrush.

Rumen Contents (or stomach analysis) is a method commonly used to determine food habits for pronghorn (Ferrel and Leach 1950, Mason 1952, Baker 1953b, Cole 1956, Hoover et al. 1959, Dirschl 1963, Russell 1964, Severson 1966, Bayless 1969, Tsukamoto 1969, Beale and Smith 1970, Campbell 1970, Mitchell and Smoliak 1971, Taylor 1972, Schwartz et al. 1976, Jacobs 1973).

Korschgen (1980) described the technique in detail, including preservation of materials and identification of food items. Dirschl (1962) elaborated on sieve mesh size based upon working with pronghorn samples.
Food habits can be quantified by: (1) number and species, (2) frequency of occurrence, (3) volume, or (4) weight (Cooperrider et al. 1986).

Rumen analysis can be misleading in several ways. Certain plant species, such as graminoids, digest more quickly than forbs and shrubs; therefore, if the samples have not been timely or thoroughly preserved, these plants can be difficult to identify. Rumen sample collections usually also require dead animals, which can be costly, unacceptable to the public, or prohibited in the case of endangered species. For these reasons fecal analysis has become increasingly popular during the last three decades.

Fecal Analysis is now the most common technique used to determine pronghorn food habits (Jacobs 1973, Schwartz et al. 1976, Sneva and Vavra 1978, Meeker 1979, Body 1979, Sexson 1979, Bailey and Cooperrider 1982, Howard et al. 1983, Goldsmith 1988, Cancino 1994 and Hansen et al. 2001). Although samples are easy to collect, the accuracy of the technique has been questioned (Holechek et al. 1982). The procedure is similar to rumen analyses except that fecal samples are collected rather than a rumen sample. Since fecal analyses requires a great deal of laboratory preparation and expertise, it is usually more efficient for wildlife biologists to pay for such laboratory work rather than doing it themselves. Field procedures for this method were evaluated and considered relatively cost-effective by Cooperrider et al. (1982).

Following are six major advantages of the fecal analysis method (Holechek et al. 1982): (1) it does not interfere with the normal behavior of animals, (2) it permits practically unlimited sampling, (3) it is particularly valuable for sampling animals ranging over mixed vegetative communities, (4) it is the most feasible procedure to use when studying secretive or endangered species, (5) it can be used to compare the diets of two or more ruminants at the same time, and (6) its requires little equipment.

Holechek et al. (1982) and Gill et al. (1983) concluded that inaccuracy could be the greatest limitation to the method. Regardless, the method remains the most popular today for accomplishing food habit studies and has even been accepted as admissible evidence in judicial proceedings (Cooperrider et al. 1986).

Cafeteria trials are a method used to determine the food preferences of confined pronghorn. An observer records what plants are selected by animals from a number of equally accessible plants made available in approximately equal quantities. These plant species can then be analyzed for comparative nutritional values. The method was used by Smith et al. (1965) to study pronghorn preferences for different species of shrubs in Utah. Another study (Smith 1974) related artificial diets with different protein levels to pronghorn production and survival. Jacobs (1973) used cafeteria trials to test the validity of different food habit gathering techniques in Wyoming.

*Fawn Mortality***:** Pronghorn are the only artiodactyls known that conceive two or three times as many embryos as are born (Mitchell 1965, O'Gara 1969). Embryonic mortality and a long gestation period probably are recent adaptations to produce fewer and more precocious fawns. Under favorable conditions, pronghorn populations can increase rapidly, even when fawn mortality is relatively high (Pyrah 1987). Vriend and Barret (1978) reviewed literature and concluded that low pronghorn fawn survival was a primary management concern throughout most of North America. Fawn losses ranging from 25 to 65% of the annual production occur regularly, often in the first 2-3 months of life. Low fawn recruitment has been considered the most important factor limiting pronghorn population numbers in the Southwest (Brown et al. 2000).

Figure 30. A recent study in Oregon of predation on neonates documented an average loss of around 50% for 10 years. Although mortality appeared high, the herd increased more than 80% during the decade long study. The availability of abundant quality and quantity forage appeared to influence population trends more than predation. Photo by Jim D. Yoakum.

In areas where predator control is deemed beneficial for fawn survival, predator removal is most effective just prior to fawning, but the control method must be done repeatedly to be cost-efficient (Smith et al. 1986). Hailey (1979), in an area of Texas, and Willis (1988), in an area of Oregon, reported significant increases in fawn survival where coyotes were intensively controlled. Connolly (1978) lists numerous cases of predator control increasing fawn survival. Menzel (1994) reported that two years of coyote control increased fawn survival, but that subsequent surveys revealed no increases in populations.

A report, in the 2004 Proceedings of the Pronghorn Workshop, provided findings for 35 predator/fawn mortality studies during the last 60 years (Yoakum et al. in prep). A conclusion from these studies was that predator control practices often resulted in increased fawn recruitment, but predator control rarely resulted in increased herd numbers.

The availability of quality forage for pronghorn is a primary factor in fawn survival according to Ellis (1970). He compared population dynamics and habitat characteristics for herds in the Great Basin with those on the Great Plains for the last two months of gestation and the first two months of lactation. Ellis concluded that fawn survival was twice as high on the Great Plains because of the availability of more nutritious forbs during late gestation and early lactation. Thus, the lower availability of preferred, succulent, nutritious desert forage, exacerbated by its consumption by livestock, resulted in Great Basin rangelands having a lower carrying capacity for pronghorn (Hervert et al. 2000).

More than 200 food habit studies have been conducted during the past 50 years. However, different techniques were involved and the findings between the various methods often are not comparable (Sundstrom et al. 1973, Yoakum 1990). To provide consistency for comparisons in future studies, the following guides are suggested (Yoakum 2004d).

Determining Food Habits: Various methods can be used to determine pronghorn diets, including direct or indirect observations, collecting rumen samples, fecal analysis, cafeteria trials, and rumen fistulas. Of these, fecal analysis has been used almost exclusively as the method of choice during the past 20 years. When using fecal analysis, individual sample size should be at least 0.5 lbs (227g), air dried, in order to have sufficient material for forage identification, nutrient analysis, rechecks of earlier results, or samples for additional studies determined later in a project. Simple food habit studies, in which the only purpose is to identify the species of plants consumed can consist of as few as 25 pellets from five pellet groups (T. McKinney, pers. comm..)

If fecal samples are collected, the individual animal producing the pellets should be identified if possible. Random collections of fecal samples in the field without observing the animal responsible can result in misidentification and misjudgment of season (pellets dry quickly in arid ecosystems). Collection sites should be representative of major areas where animals forage, and include location data on crucial habitats such as wintering grounds, fawning areas, seasonal movement corridors, etc.

Depending on study design, pellet collections should be made monthly throughout the year. A good food habit study should include 3-5 years of data. Findings are of greatest value when taken over a period of years because, as precipitation patterns change, animal foraging habits respond to differences in forage availability.

It may also be desirable to collect samples from other ungulates using the same sites by season. This allows the computation of dietary overlap and species preferences for various forage classes.

Plant Collections and Forage Composition: Plant collections are needed for identifying forage in food habit studies and nutrition analysis. Plant collections should be from the same sites where pellet samples were obtained. Plant samples should include all forage classes (grasses, forbs, shrubs) by season. Although placing some plants in a particular forage class may be artificial, each sample should be assigned a category and an explanation as to what species each category contains. Lichens, mosses, cacti, and half-shrubs often have been placed in the forbs category. Plant samples need to be preserved and stored as herbarium collections. Forage preference by category can be determined by taking line transects (Gysel and Lyon 1980) or using the step-point method (Evans and Love 1957) of sampling vegetation composition in the sample areas. The step-point method is quick and allows for many transect readings in a relatively short period of time.

Ecological Factors: Recording ecological data at the time that pellet and plant collections are made is important. This information is needed when analyzing or relating findings. Examples of such information are: precipitation quantities by kinds (rain, snow) for all seasons of the year (relate to years of normal and above or below normal precipitation); the behaviors of pronghorn and other ungulates at the time of collections, especially foraging characteristics and note the phenology of the vegetation, especially those species producing seed. It is also especially important to record the implementation dates of any grazing systems involved; record other ungulate use or non-use of the site to evaluate dietary overlap; and note ungulate intensities and the effects on the vegetation. Those forage species which have been lightly, moderately, or heavily used should be noted.

Laboratory Analysis: Laboratory facilities and trained personnel are often lacking when food habit studies are attempted. Thus, sending fecal and plant samples to a specialty laboratory for analysis may be cost effective. Also, specialized laboratories often are more efficient in fecal analyses than a well- meaning technician or graduate student with a part-time commitment.

Some food habit studies (Meeker 1979, McInnes 1984) may not have portrayed a true picture because no correction factors were used to compensate for differences in digestibility of various forage plants. The problem of differential digestibility of various plants has plagued laboratory personnel conducting rumen and fecal analysis for years. However, recent studies have developed correction factors that are especially important for forbs and shrubs, the two most common forage classes in pronghorn diets (Yoakum 2004d).

Data Compilation and Evaluation: All diet collections should be compiled by plant species, and then totaled into species and forage classes by period of use. If analysis is by percent volume, list all plants, even those found in trace quantities (less than 1%), as this information may be needed for evaluating use of trace nutrient elements or noxious plants.

When field collections include quantitative data for diet selection and forage availability by season, computing dietary overlap for different ungulates is possible. Including ecological condition data is therefore important because the analysis may show species overlap. However, if other herbivores are not using the site during the particular season, it is important to note the lack of overlap competition.

Laboratory Locations: Currently, there are a number of laboratories and /or research institutions equipped and staffed with trained personnel to contract microscopic fecal analysis for western rangelands. These include the Department of Range Science, Colorado State University, Fort Collins, CO; Department of Range and Wildlife, Texas Tech University, Lubbock, TX; Animal and Range Sciences, New Mexico State University, Las Cruces, NM; and Department of Natural Resource Sciences, Washington State University, Pullman, WA. Other laboratories are available in Canada and Mexico. Local universities should be contacted to determine whether a local laboratory is operational.

Fire Management

Most grasslands have evolved under the influence of natural and human ignited fires, and indeed, fire is essential to their long-term welfare. Many grassland plant species are so fire- adapted, that they depend upon burning for maintenance. Fires stimulate plant succession; reduce the incidences of woody plants, provide ash and nutrients to the soil, and increase herbaceous vegetation. Fires can be beneficial or detrimental to pronghorn habitat, depending on how they influence vegetation in specific sites at specific times.

The California Department of Fish and Game (1997) assessed the pros and cons of the effects of fire on pronghorn habitats. Wildfires were recognized as the principal factor changing shrublands to grasslands favorable to pronghorn. Nonetheless, extensive and repetitive burns can, at times, decrease preferred shrubs for winter browsing and when grazed by livestock, increase the invasion of noxious and alien plants.

Wildfires: Lightning ignited fires are, or were, of frequent occurrence on western rangelands. Most such fires occur naturally during the spring dry season, and if sufficient fuel in the form of residual grasses is available, were historically common in the grassland and shrub-steppe biomes and rare in the deserts. Courtney (1989) observed pronghorn grazing new grass and forb growth soon after fires burned grasslands in Alberta. Stelfox and Vriend (1977) reported pronghorn moved into burns within a month after prairie fires. At such times, pronghorn readily consumed large quantities of burned prickly pear cactus (*Opuntia* spp.).

Deming (1963) observed that pronghorn readily foraged burned shrub-steppes in Oregon. He attributed this to the grazing of new succulent forage growth that remained greener into the autumn compared with unburned sites. Similar use was confirmed by Van Dyke (1990) and numerous other biologists who speculated that wildfires enhance pronghorn habitat.

A valley occupied historically by pronghorn in California, but devoid of herds for more than 75 years, experienced a pioneering herd moving into the valley and remaining permanently after a wildfire of more than 30,000 acres (12,000 ha). Apparently the lightning-caused fire, followed with rangeland seeding, changed habitat conditions from poor to good quality, allowing pronghorn to become successfully established (Yoakum 2004e.).

Prescribed Fires: Prescribed fires can, and should be, used to simulate the role of wild fires for changing and invigorating grassland vegetation. Fire management is especially appropriate for tall grasslands and grasslands dominated by shrubs and small trees.

The Hart Mountain National Antelope Refuge in Oregon suppressed fires prior to 1990. Now, prescribed fires are the primary vegetation management practice (Pyle and Yoakum 1994, Gruell 1995). Field studies revealed that more than 90% of the shrublands were in late succession, with little herbaceous undercover. The landscape objective was to sustain a mosaic of vegetation in different serial stages and to increase the abundance of forbs and grasses. Providing diversity is essential for ecosystem health and resiliency. Diverse vegetative communities generally support more vigorous wildlife populations, including pronghorn. Present objectives of the Refuge include maintaining 20-30% of shrubs in early and mid- succession; consequently, a prescribed fire program was implemented in 1994. Prescribed fires have been used since to produce a mixed pattern of burned and unburned patches in roughly equal proportion. There have been no major problems with the invasion of alien plants primarily due to their scarcity prior to burning, and perhaps to the lack of livestock grazing. Burning has been practiced only on spring/summer pronghorn habitats where there is a need to increase herbaceous forage. No treatments have been performed on winter rangelands where shrubs are key forage for pronghorn.

Tall grasslands are historic and extant landscapes for pronghorn (Eccles et al. 1994). These prairies grow grasses 9 feet (2.7 m) high; however, they can be changed to suitable habitat for pronghorn when the vegetation structure is lowered through burning and/or grazing by large herbivores (bison historically, now cattle). This vegetation manipulation changes tall, old growth herbaceous vegetation to low growing forage meeting pronghorn habitat requirements. When fires are started the vegetation is low to medium height, the weather cool: much of the burning is done at night when temperatures are lowest and humidity highest. Also, fires are timed to take advantage of slightly damp vegetation; therefore, fire intensity generally is not high or catastrophic. Simpson (1992) reported pronghorn did not flee from the fires, but wandered in and around, seeking unburned sites for forage.

Figure 31. Prescribed fires can be used to simulate the role of disturbance for changing vegetation, especially in tall grasslands and shrubsteppes. Prescribed fire is being used to reduce brush encroachment in a shrubsteppe in northeastern Utah. Photo courtesy of Desert Land and Livestock Ranch, Utah.

Fire is also essential to maintain semi-desert grasslands as pronghorn habitat. Without fire, or with fire suppression, these grasslands are converted to shrub-lands, brush-lands or dense savannas, thus reducing or eliminating pronghorn populations. As with fires in shrub-steppe, reduced grazing is often necessary to provide sufficient fuel for a burn, which should be done in May or June to emulate natural conditions (Brown 1994). Failure to instigate proper grazing and fire regimes is today the biggest threat to semidesert grassland populations of pronghorn.

Recommended practices for prescribed fires are provided by Yoakum et al. (1980), Vallentine (1989), Payne and Bryant (1994), Riggs et al. (1996), and Yoakum (2004) provide a thorough discussion of objectives, current techniques, and results of prescribed fires to enhance ecosystems for wildlife, including pronghorn.

Competition and Conflicts

Livestock Competition: Pronghorn and livestock have co-existed to various degrees on western rangelands for over 450 years (Wagner 1978, Leftwich and Simpson 1978, Yoakum and O'Gara 1990, Yoakum et al. 1996). Cattle, sheep, and horses, are the animals of principal concern, because they are the primary domestic animals on rangelands occupied by pronghorn today. Goats, however, were serious competitors with pronghorn in the past, and may remain so in parts of Texas and Mexico (Buechner 1950).

The chronology of livestock and pronghorn numbers was well documented by Wagner (1978). He graphically portrayed this relationship, illustrating the degree of forage consumed by both, emphasizing that pronghorn today consume less than 1% of the vegetation on western rangelands.

All livestock use probably has some effect on pronghorn, the degree depending upon ecological factors in different habitats. These will be discussed first, then those factors warranting management considerations will be covered for cattle, horses, and sheep.

Livestock in General: Rangelands can be rapidly or slowly altered by livestock (Wagner 1978, Kindschy et al. 1982, Wald and Alberswerth 1989, Yoakum et al. 1996). These changes can affect both the quality and abundance of preferred forage needed to sustain thrifty pronghorn herds (Ellis 1970, Howard et al. 1990). Decreasing vegetative cover brought about by livestock grazing was reported by Autenrieth (1982) to be a serious factor affecting fawn survival. Heavy use of forage by livestock during a severe drought forced pronghorn to turn to poisonous plants, resulting in direct mortality and poor reproductive performance (Hailey 1979). Grazing also inhibits fire, favors the proliferation of woody and shrubby vegetation, and otherwise alters pronghorn cover (Humphrey 1950).

McNay and O'Gara (1982) reported displacement of parturient does by livestock. Does used traditional fawning areas when livestock were not present, but moved to adjacent sites when livestock were allowed on fawning areas. Such competition for space resulted in does moving to sites with less desirable vegetative height. Management guides to alleviate this problem include excluding or delaying the turning-out of livestock in traditional fawning areas until after the pronghorn's parturition period.

At times, and in certain locations, livestock and pronghorn have a commensal relationship (Yoakum et al.1996). Although case histories are rare, livestock grazing on rangelands with an abundance of grasses can cause increased production of forbs and shrubs preferred by pronghorn. Then too, pronghorn consume many plants known to be noxious or poisonous to livestock such as larkspur (*Delphinium* sp.), death camas (*Zygadenus* spp.), locoweed (*Astragalus* spp.), and halogeton (*Halogeton* spp.) (Buechner 1950, Yoakum and O'Gara 1990). Predator control programs intended to benefit livestock may also benefit pronghorn, and Connolly (1978) lists numerous cases of predator control increasing pronghorn populations. Nonetheless, livestock can at times be reservoirs of diseases and parasites that deleteriously affect pronghorns (Yoakum 2004d).

Careful assessment needs to be used in identifying the assets and liabilities of livestock compatibility or competition on rangelands occupied by pronghorn. Here is a topic that warrants greater research conducted and reported for field conditions on sites in grasslands, shrubsteppes and deserts.

Cattle: Aggressive behavior between cattle and pronghorn appears to be minimal (Roebuck 1982, Pyrah 1987). However, forage competition can not be an issue depending on the vegetation composition and production. For rangelands with abundant native grasses, forbs and shrubs in an ecological healthy condition, interspecific competition can be minimal. This is because cattle are primarily grazer of grasses, whereas pronghorn predominantly forage on forbs and shrubs (Yoakum 2004c). It can not be stressed too strongly that these compatible relationships may occur on rangelands with abundant, healthy native vegetation. However, for monoculture grasslands or rangelands with low quantities or diversity of forbs and shrubs, there can be serious competition for preferred forage classes (Yoakum 2004c). Hoover et al. (1959) reported that the 10,000 pronghorn in Colorado at that time would not eat as much grass as would 200 head of cattle. Apparently, there is a low dietary overlap between cattle and pronghorn; a survey of 10 studies revealed ratings of less than 30% overlap in 9 cases (Yoakum and O'Gara 1990). One study found serious competition for grasses and forbs on Great Basin rangelands during spring and early summer, resulting in low fawn survival rates compared to Plains grassland (Ellis 1970). These are generalized tabulations over many different habitats, but are consistent in depicting the low rate of dietary overlap. Hence, on a year-round basis, competition is relatively low because of the consumption of different forage classes by the two species.

Figure 32. When rangelands are in healthy ecological conditions with an abundance of grasses, forbs, and shrubs, dual foraging by pronghorn and livestock can be compatible. Here, pronghorn and cattle can be seen foraging together in a short grass prairie community in central Arizona. Photo by George Andrejko.

Domestic Sheep: Investigators are not always in agreement concerning the social compatibility of pronghorn and domestic sheep. Authors finding problems of competition included: Einarsen (1948), Buechner (1950), Campbell (1970), Freeman (1971), and Pyrah (1987). However, Severson (1966) observed no apparent stress on either species as a result of the other's presence. Forage competition, due primarily to both animals consuming large quantities of forbs and shrubs was found in 6 food habit studies evaluated by Yoakum and O'Gara (1990). Sheep trailing through pronghorn fawning areas can also be a problem, and should be prohibited from 15 days before to 15 days after the peak of fawning activity.

Two other sheep foraging programs on rangelands can be deleterious to pronghorn: (1) sheep are carriers of parasites and diseases common to pronghorn, and (2) sheepmen encourage the construction of fences not favorable to pronghorn movements.

Horses (domestic and feral): Domestic and feral horses occupy a number of rangelands with pronghorn; however, only two studies have investigated interspecific competition between the two species (Meeker 1979, Berger 1986). Both noted little aggression between species, but horses were dominant at all times. Dietary overlap was minor on rangelands with an abundance of grass according to Yoakum and O'Gara (1990).

Other Ungulates: Bison and elk occur on pronghorn habitats in Arizona, on Yellowstone National Park, on the National Bison Range, and elsewhere. Excessive numbers of any ungulate can result in forage competition with pronghorn, and large numbers of elk may be responsible for some of the decline in pronghorn populations in Yellowstone N.P. (Boccadori and Garrot 2002) and on Anderson Mesa in northern Arizona (Brown et al. 2004).

Vegetation Manipulation: Pronghorn thrive on rangelands in a sub-climax vegetative condition. Such conditions were created historically by wildfires and, where precipitation was sufficient, seasonal grazing by herbivores such as bison and elk. On western rangelands today, most vegetation manipulation efforts are for livestock needs. These projects can be beneficial or detrimental to pronghorn. To benefit pronghorn, vegetation manipulation must increase the number of nutritious forbs and shrubs, and provide habitat diversity. Low diversity grasslands, and shrubsteppes of natural or artificial origin, can be improved by adding species that provide food or cover, whichever is most limiting (Yoakum 2000c).

Shrub control and artificial seedlings that develop monocultures have limited value for pronghorn (Yoakum 1980, Kindschy et al. 1982, Pyrah 1987), especially when accomplished in large blocks of 5,000-15,000 acres (2,000-6,000 ha). Large habitat projects require pronghorn to travel long distances for preferred shrubs during plant succession.

Shrub Control: Areas dominated by shrubs and shrubby trees are not desirable habitat because shrubs compete for moisture and nutrients with forbs, and thick or high vegetation prevents pronghorn from seeing and escaping enemies. Shrub and/or tree control may or may not enhance pronghorn habitat depending on local conditions and how the treatment is implemented. Controlling woody vegetation has not improved pronghorn habitat in Texas (C. Winkler, pers. comm.). However, numerous reports have documented that shrub control (mostly junipers and sagebrush) can increase the carrying capacity for pronghorn in the Great Basin region (Kindschy et al. 1982, Aoude and Danvir 2002, Yoakum 2000c). An ongoing study in Wyoming indicates that plants grow more vigorously on previously "controlled" areas than on "uncontrolled" areas (H. Harju, pers. comm.). This can be good or bad for pronghorn as areas of tall dominant shrubs (more than 50% canopy cover) make for marginal or low-density pronghorn habitat. This is especially true where shrubs are 30 inches (76 cm) or higher (Willis et al. 1988, Ockenfels et al.1994); such areas should be treated to decrease shrub quantity and height. Limiting the size of projects to less than 1,000 acre (400 ha) blocks is recommended, and each project should ideally maintain 5-20% shrub canopy cover. In general, shrub/tree control should attempt to mimic natural conditions, i.e., conditions maintained by periodic fires.

Wintering and spring fawning areas should be included in shrub control projects only when shrubs are decadent or so dense as to increase predation rates. Shrub control projects should not attempt to eradicate preferred shrubs that provide nutritious forage during fall and winter. Shrubs are of utmost importance where snowfall exceeds 12 inches (30 cm) because they often protrude out of the snow and are available for forage.

Shrub control frequently is accomplished by mechanical practices such as plowing and chaining. Plowing with large plows can remove 90-95% of the shrubs (Vallentine 1989), but often kills forbs that are highly preferred by pronghorn. Chaining is accomplished by pulling a heavy anchor chain between 2 large tractors. This practice does not kill as many shrubs and is less damaging to grasses and forbs. However in the south, it may promote rather than inhibit the production of mesquite, junipers, and other small trees and shrubs (R. Miller, pers.com.).

Chemical spraying is another shrub control technique. The spray (usually 2-4-D) controls shrubs without harming native grasses and can be targeted to specific species of plants (Vallentine 1989). However, this chemical has been shown to have deleterious effects on forbs when applied at inappropriate seasons. To avoid killing forbs, spraying should not be conducted during the late spring and summer.

Fires (wild and prescribed) are one of the surest disturbance agents for restoring and maintaining grasslands (Saver 1950), and burning grasslands is the oldest known practice used by man to manipulate vegetation (Vallentine 1989). Although accidental burns can be more deleterious than beneficial to rangeland resources, prescribed burning can be a beneficial and economical habitat improvement technique. Prescribed burning involves systematic planning so fires are set when weather and vegetation are in a condition to mimic natural conditions and maximize benefits. Timing is important as, when properly accomplished, prescribed burns can decrease shrubs and not seriously harm grasses and forbs (Beardahl and Sylvester 1974). Investigators have reported immediate stimulation of plant growth after burning, resulting in greater forbs production and forage yields (Deming 1963, Courtney 1989, Yoakum 2000c).

Valentine (1989) provided a thorough discussion on objectives, techniques, and results of burning shrublands. Pechanec et al. (1954) recommended burning sagebrush only where this species is dense and forms more than half the plant cover. Other recommendations included burning only when fire-resistant perennial grasses and forbs form more than 20% of the plant cover, or where the area will be seeded after burning, and where the economic and biological needs of all uses (livestock forage, big game habitat, watershed values, etc.) have been adequately considered. He also recommended burning sagebrush during late summer or early fall at least 10 days after the perennial grasses have ripened and dried, and the seeds have been scattered.

Artificial Seeding: When proper planning has shown vegetation plantings to be desirable for pronghorn, Plummer et al. (1968) recommended seeding a mixture of 10-30 species of grasses, forbs, and shrubs. Seeding with a monoculture frequently results in low densities and fewer varieties of forbs. Many manipulated rangelands have been planted to exotic perennial graminoids seldom consumed by pronghorn, such as crested wheatgrass (*Agropyron* sp.). When feeding on grasses, pronghorn prefer finer textured native species such as Sandberg's bluegrass (*Poa sanbergii*).

Although seeding with mixtures of native grasses and forbs is more costly, the result is a greater diversity of species, somewhat comparable to many rangelands in a natural condition. Also, native seed mixtures are in conformity with Federal laws (such as the National Environmental Protection Act of 1969, the Federal Land Policy and Management Act of 1976, and the Surface Mining Act of 1977) that mandate public lands be managed for their natural vegetation, including sagebrush (*Artemisia* spp.).

Ten principles for large-scale restorations of rangelands used by wildlife in Utah were developed by (Plummer et al. 1968). These procedures have wide application on similar sites throughout the West, although some modifications may be necessary to meet ecological conditions in the Southwest and in other local environments.

1. Changes in plant cover by the proposed measures must be desirable. Often lighter grazing by livestock, so that desirable species can grow, 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 ensure establishment and survival of seeded plants. The amount of precipitation, along with the occurrence of indicator plants, is the most important guide to what species may be seeded successfully.

4. Vegetative competition must be low enough to ensure that desired species can be established. Anchor chaining is a highly versatile, effective, economical, and a widely applicable method for eliminating unwanted competition from trees and shrubs.

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

6. Mixtures, rather than single species, should be planted. Seeding mixtures is advantageous when the major purpose of restoration is for the improvement of diversity needed by wildlife.

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

8. Seeds must be covered sufficiently. Planting deeper than 0.5 inch (13 mm) 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 (December-February) is best. Transplanting of nursery stock seedlings is most successful when completed while the ground is still wet from spring moisture.

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

When properly accomplished, artificial seeding has been proven to be beneficial to pronghorn. An evaluation of an 11-year, large-scale restoration project near Vale, Oregon showed herd increases of nearly 100% near areas seeded mainly with dryland alfalfa compared to adjacent untreated lands where populations increased 30% (Kindschy et al. 1982). Pioneering pronghorn herds in California, Oregon, and Nevada moved to manipulated rangelands having the pronghorn's habitat requirements of a variety of grasses, forbs, and shrubs (Yoakum 2004e).

Wildlife managers on the Desert Land and Livestock Ranch in northeast Utah and adjacent lands in Wyoming, reported on vegetation restoration program with an objective of increasing forbs for pronghorn and livestock (Aoude and Danvir 2002). Various methods of brush control were accomplished and some sites were seeded to herbaceous plant. The authors concluded that vegetation restoration projects increased pronghorn fawn production and carrying capacity compared to non-treated adjacent sites. Results of this study suggested that treating sites as small as 2 percent of the rangeland annually contributed to increased pronghorn herd numbers.

Grazing Systems: Livestock grazing systems are designed to maintain or improve forage conditions. There are a number of different systems, i.e., deferred grazing, year-round grazing, flash grazing, rest-rotation, holistic or short-duration grazing, etc. (Stoddart and Smith 1955, Heady and Child 1994, Holechek et al. 1997). Livestock managers frequently try or change grazing systems.

When forage is being allocated, plant species preferred by pronghorn should be reserved as forage for pronghorn. These include grasses, forbs, and shrubs identified by food habit studies in the same or a similar ecosystem. Consideration should be given to ensuring that key forbs and shrubs are not grazed beyond their sustainable tolerance. The forage reserved should also accommodate a reasonable number of pronghorn. Reasonable numbers should be based on management objectives of wildlife and land management agencies (Yoakum and O'Gara 1990).

When grazing systems are designed around "key plant species," forbs and shrubs should be included as key species. Grazing systems that simulate serial vegetation conditions closely resembling ecological potential are most favorable to pronghorn. Grazing systems that restrict, alter, limit, or deleteriously affect any of the habitat requirements of pronghorn should include mitigating and alternative procedures for enhancing pronghorn habitat. For example, any grazing system should require that livestock be restricted from fawning areas during the fawning season.

Animal Equivalents: The allocation of forage for livestock and pronghorn is a complex procedure. Various methods of calculating exchange ratios (animal equivalents) have been used, but none has been completely satisfactory (see e.g., Buechner 1950, Hoover et al. 1959, Severson et al. 1968, Taylor 1972, Kniesel 1988, Yoakum et al. 1996).

The most common system for calculating animal unit months (AUMs) of forage consumed by livestock and pronghorn is the ratio of metabolic weights (Heady and Child 1994). Based on this system, six pronghorn were considered equivalent to one AUM. In Idaho, Anderson and Denton (1980) used a system of comparing quantities of forage consumed per day, resulting in 14.8 pronghorn being the equivalent of one AUM. But when dietary overlap ratios were considered, Anderson and Denton (1980) recalculated their equivalents and determined that it took 59.2 pronghorn to equal one AUM.

Kniesel (1988) reviewed past procedures and practices for using equivalent ratios. He stressed the tremendous variation in ratios of pronghorn per cow used by management agencies (e.g., 105:1 in Colorado; 59:1 in Idaho; 39:1 in Texas; 7-14:1 in Oregon; and 5:1 in Montana). Kniesel attributed the wide variation to different methodologies and information used. Some investigators primarily used weight differentiations, while others included such considerations as dietary overlap and rangeland condition. He concluded that assessing AUM equivalents for pronghorn and livestock would remain a problem as long as there was little agreement between state and federal management agencies when it came to standardized animal equivalents for forage use on multiple-use ranges.

Fences

Pronghorn Biological Requirements and History: Within a decade of erecting barbed wire fences on western rangelands, Caton (1877:48) was reporting that 4-foot (1.2 m) high fences were restricting pronghorn movements: " *This inability to leap over high objects may no doubt be attributable to the fact that they live upon the plains, where they rarely meet with such obstructions, and so they and their ancestors for untold generations have had no occasion to overleap high obstructions, and thus from disuse they do not know how to do so, and never attempt it when they do meet them.*"

Caton was essentially correct. Pronghorn had adapted over the millennia to open landscapes without vertical barriers. In the relatively short time since the fencing of the West began, restricting the movement of nearly all pronghorn populations, these animals have shown themselves unable to go through fences as do bison, or to vault them as do deer and elk. Instead, pronghorn have learned to negotiate certain fences by crawling underneath them. But if the bottom wires are too low, by virtue of design or the buildup of sand, soil, vegetation or snow, pronghorn movement is seriously impeded.

Pronghorn welfare has suffered in proportion to the sale of barbed wire. In 1879, 5 tons (4.5 metric tons) of barbed wire was manufactured in the United States. Six years later, 40,000 tons (36,000 metric tons) were being strung across western rangelands. By 1945 this figure had reached 234,000 tons (210,600 mt) per annum (Leftwich and Simpson 1978). Initially most of the fences were "drift fences," which resulted in large numbers of pronghorn being trapped to freeze to death in blizzards (Hailey 1979). Later, the fencing of pastures became more and more commonplace, further restricting the movement of pronghorn populations until the species was excluded from much of its former range (Russell 1964, Martinka 1967, Spillett et al. 1967, Hailey 1979).

Today, fences are built on western rangelands to control access along roads, highways, and railroads; to protect agricultural crops; to limit access to mining operations, military installations, and private property; and for other purposes. However, the majority of fences are installed to control domestic livestock. How these fences are designed and constructed determines their effect on pronghorn welfare. Fences can be built to: (1) fully restrict and control pronghorn movement; (2) control cattle and horses, but allow pronghorn passage; or (3) control all ungulates including domestic sheep and goats, as well as pronghorn movements.

These fences present complete or partial barriers to movements of pronghorn and have obstructed seasonal movements and travel to water or feeding areas. As a result, pronghorn populations have continued to decline on some rangelands. Extensive mortality has also occurred when animals became entangled or trapped as they attempted to negotiate these barriers (Oakley 1973).

Pronghorn should be given high priority when considering fencing and a greater effort should be made to harmonize rangeland use by livestock and pronghorn. U. S.

Bureau of Land Management (1985) manual H-1741-1 states that all means of livestock control (herding, use of natural land forms, exclusion of certain kinds and types of livestock, distribution of salt and water sources, etc.) should be considered before deciding to use a specific fencing configuration. The manual also directs that the potential effects of fencing, including costs, on other resources be considered carefully before deciding what fencing to use. Provincial and state wildlife managers should ensure that federal land managers comply with these important directives. Wyoming Game and Fish Department fencing guidelines maintain that no fencing should occur perpendicular to major migration routes or on transitional and winter rangelands used by pronghorn (Lee et al. 1998).

Often, past efforts were concerned primarily with ways to modify pronghorn behavior to minimize the effect of fences. It cannot be assumed that pronghorn will adapt to changes resulting from livestock use, or that they will learn behavior patterns allowing these animals to adjust to habitats altered by fences. Observations in Wyoming indicate no marked increase in the number of pronghorn learning to jump fences; however, older individuals have a greater tendency to jump fences than fawns, which have never been observed jumping fences (H. Harju, pers. com.).

Net-wire fences to control domestic sheep are particularly disastrous for pronghorn seeking preferred forage in the arid southwest (Buechner 1950, Hailey 1979). In northern habitats, fences often severely impede pronghorn movements during winter (Spillet et al. 1967, Oakley and Riddle 1974, Mitchell 1980, Barrett 1982, Pyrah 1987). Woven wire and sheep-tight fences prevent pronghorn from drifting ahead of severe storms to rangelands with preferred forage or less snow. By restricting free movements, fences cause pronghorn to remain in areas offering little protection or food during storms, resulting in malnutrition and death from “winter-kill.” Popowski (1959) aptly summarized the seriousness of this issue by stating "When pronghorn are denied freedom in seeking seasonal food requirements, they sicken and die of malnutrition; and when they can't drift to avoid severe winter storms they often collect in fence-corners and freeze to death." Deep snow fills depressions where pronghorn normally crawl under fences can make fences pronghorn-proof. Crusted or wind-packed snow covering the fence’s lower wires prohibited pronghorn from crawling underneath, and snow does not provide a solid enough surface for launching an effort to jump the fence. In such situations, fences on pronghorn movement corridors and wintering areas need to be "laid down."

After more than 100 years experience with fences, pronghorn primarily still go under rather than through or over fences. Büechner (1950) observed that most pronghorn seem unaware of their ability to jump, and often die of starvation rather than jump sheep-tight fences. Yet, during pronghorn trapping operations in Wyoming, adult pronghorn jumped over an 8-foot (2.4 m) fence (Spillet et al. 1967), and have jumped 7-foot (2.1 m) horizontal structures (Mapston 1968). Spillett et al. (1967) reported that a pronghorn's ability to see over a fence was an important factor in their willingness to jump fences; they also observed pronghorn using snowdrifts to cross fences.

Research and Litigation: One of the first extensive evaluations into pronghorn/fence interrelationships was accomplished in Montana and Wyoming by Rouse (1954). He noted fences were obstacles unless the bottom wire was at least 15 inches (38 cm) above the ground, and that fences with lower bottom wires were totally impassable.

The first intensive field study of the effects of fencing on pronghorn was conducted in Wyoming by Spillett et al. (1967). These investigators tested 22 types of fences to evaluate pronghorn movements under controlled conditions. Results indicated a fence 32 inches (81 cm) high was the maximum most pronghorn would readily jump. When pronghorn could not pass under a sheep-tight fence, a cattle guard-like structure called an "antelope pass" was developed, which proved only partially satisfactory due to fawns sometimes breaking their legs when negotiating the “pass.”

More recently, another intensive pronghorn/fence study was completed near Roswell, New Mexico (Howard et al. 1990). Rangeland pastures were stocked with pronghorn to evaluate the influences of cattle and domestic sheep, especially the effects of stocking rates and competition for forage. Pronghorn viability was greater in cattle pastures than in sheep pastures due in part to fewer restrictions posed by cattle fencing. Cattle fences allowed more movement even though sheep-tight fences were modified with short sections that allowed pronghorn to move between pastures as forage conditions changed.

Figure 33. The Vizcaino pronghorn facility, located in Baja California Sur, Mexico, contains all interior fences with 6 strands of smooth wire for 7 separate small pens. The smooth wire fences have been effective for more than a decade (Cancino et al. 2002). Photo by Ramon Castellanos.

Two major lawsuits have involved livestock fences and pronghorn welfare on public lands. On the Roswell Grazing District in New Mexico, fences were modified "wolf type" by the federal government to permit the passage of pronghorn. The decision to modify fencing on public land was contested by livestock permittees. But the appeal was dismissed in administrative hearings, resulting in a major victory for pronghorn and multiple-use. Hence, modifying fences for pronghorn on public lands dedicated to multiple use are on solid grounds and should continue (Yoakum 1980).

The second legal case also established an important precedent. A rancher near Rawlins, Wyoming constructed a fence around approximately 9,600 acres (3,885 ha) of private and public lands, thereby excluding pronghorn from critical winter rangelands. Many pronghorn died due to being denied access to favored winter foraging areas. The case went to the U. S. District Court for the District of Wyoming and the judge decreed that the rancher's woven-and-barbed wire fence was in violation of the federal Unlawful Enclosures Act of 1885. The rancher immediately appealed the federal judge's ruling and the case went to the Tenth Circuit Court of Appeals, where three judges unanimously upheld the lower court's decision. The case then went to the U. S. Supreme Court, which upheld the decisions of the District and Circuit courts.

Figure 34. Woven-wire fences topped with 2 to 3 strands of barbed wire, often present complete barriers to the movement of pronghorn. This is especially true for fawns that are less capable of jumping over wire fences. Photo taken on the Sybille Wyoming Wildlife Research Unit by J. Ward.

Highway Fences: Büechner (1950) recognized early on that fenced highways impacted pronghorn movements. Fenced highways and railroad rights-of-way effectively fragment habitat and isolate pronghorn herds (Ockenfels et al. 1994, Ockenfels et al. 1997). The combination of multiple fences and nearly constant traffic seriously restricts, but does not necessarily prevent, movement across highways. The ability of pronghorn to negotiate highways is often critical to their survival. Devastating winter-kills have occurred when snow cover prevented pronghorn from going under highway fences

(White 1969). Ockenfels et al. (1994) present a list of possible mitigation features to use at highway rights-of-way. Removing or taking down fences during severe winter weather should also be considered, even though such action may require much coordination and planning.

Fences for Pronghorn: Fences constructed with objectives to allow or completely restrict pronghorn movement generally fall into 2 categories. The first consideration is to allow pronghorn unobstructed passage and is covered elsewhere. The second category is to control pronghorn movement to keep the animals out of agricultural fields, landing strips, highways, etc. Such exclusions can be permanent or temporary. Past research and field testing of the many different fencing configurations has determined the fence designs most appropriate for various control needs. Spillett et al. (1967) emphasized that pronghorn in captivity react differently to fences under different motivational levels, with the level of motivation being the key factor in determining the extent of the barrier required. If not stressed by harassment or lack of forage or water, pronghorn can be controlled with a low fence with the bottom wires close to the ground. Some situations, however, are inadequate to control highly motivated animals, which require a higher barrier to restrict movement.

The following discussion pertains to a fence design that has been proven to contain "highly motivated" pronghorn. Of two successful applications of this fence design, one involved keeping pronghorn from an irrigated alfalfa field surrounded by sagebrush steppe during the late summer and fall when native vegetation became mature and dry. Another "highly motivated" situation was the enclosure of pronghorn that had been trapped and transported 60 mi (100 km) from their native range (Pojar et al. 2002). In both cases, there was direct visual and track evidence that the animals "paced" the fence indicating a desire to cross. This fence design precluded any breech of the fence by pronghorn while allowing "jumpers" such as mule deer and elk passage over the fence.

The fence (Fig. 35) is 61 in. (155 cm) high and was a combination of smooth wire and net wire with 6 in. (15.25 cm) squares (Pojar et al, 2002). The first smooth wire was 1 in (2.54 cm) above the ground and 1 in (2.54 cm) below the bottom of the net wire. The net wire was 32 in (81.3 cm) high. Above the net wire there were an additional 4 strands of smooth wire. The first was spaced 3 in (7.6 cm) above the net wire with 3 more strands spaced equally at 8 in (20.3 cm) above the preceding wire. For additional strength, it would be desirable to have the top wire replaced with 1 in (2.54 cm) wide metal impregnated nylon tape (as is used for electric fences). This should be some color other than white so the jumpers can see it against a snow background. Of course it is important to make sure the bottom of the fence adequately seals all geographic depressions and drainages to prevent pronghorn crawling under the fence.

With increased speed and volume of motor vehicle traffic on Interstate and alternate highways, crossing structures are needed in pronghorn habitat to protect the animals and vehicle passengers. The above fence design would assist guiding pronghorn to less hazardous areas.

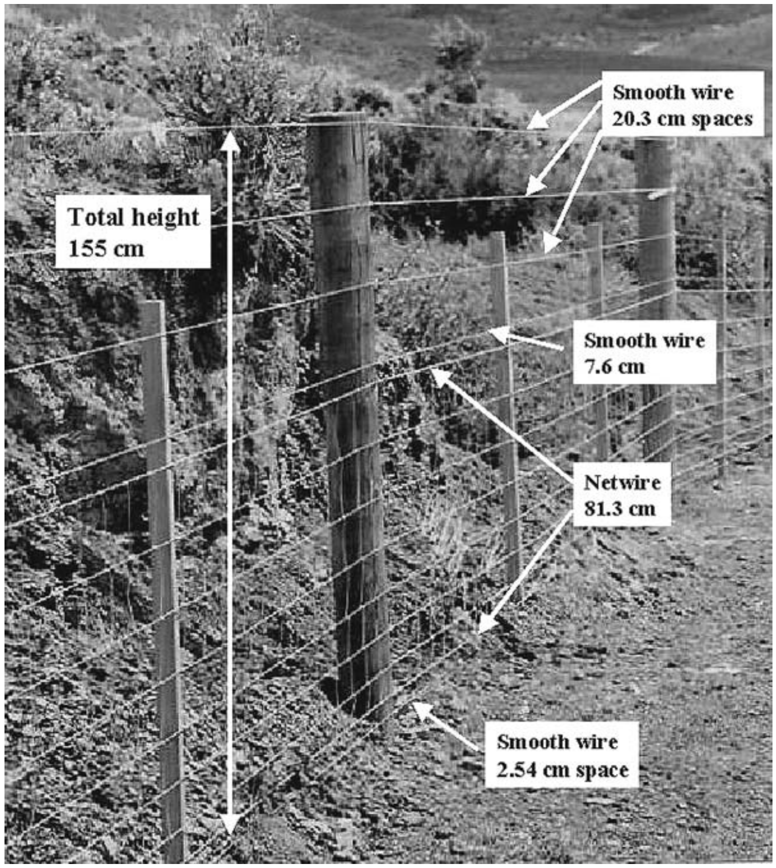


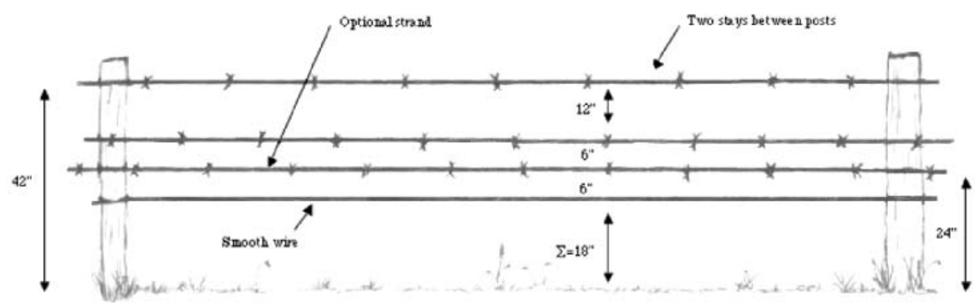
Figure 35. Effective fence design for controlling pronghorn movement under moderate to strong motivation. This type of fence has been successfully used as both an enclosure for newly translocated pronghorn and as an exclosure to prevent pronghorn from using an irrigated alfalfa field. Photo by Tom Pojar.

To hold pronghorn in a large rangeland enclosure containing adequate food, water, and space throughout the year, the fence specifications in Fig. 23 can also be used. Gates should be constructed of wire rather than wood, thereby allowing the pronghorn to see through the fence. Many miles of these "sheep-tight" fences (including the "wolf-type" variation to control coyote movements) are virtual barriers to pronghorn. Should the fenced area be small, and the possibility for harassment from domestic dogs and other sources exist, the fence should be at least 8 feet (2.4 m) high to keep pronghorn from jumping over.

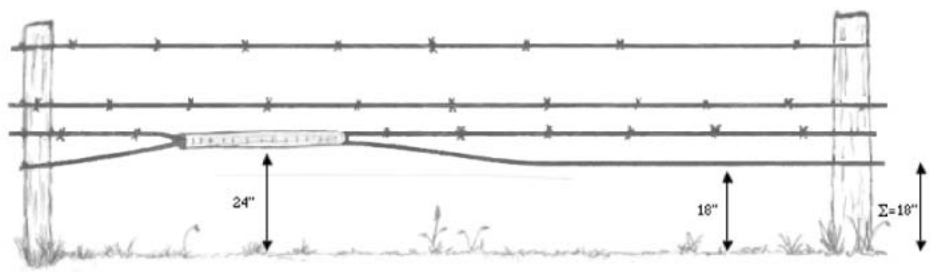
Smaller fences, designed to hold captive animals, present certain unique problems and are often best constructed of wood to prevent panicky or adventurous animals from getting caught between wires or in net-wire openings (Tim Hill, pers. com.). For larger enclosures, an electric fence outside of a net or woven wire fence is used (Fig. 33). To reduce cost, one of the fences can consist of 7 smooth wires provided that a visual barrier is also present to reduce the chances of pronghorn colliding with the wire (R. Castellanos, pers. com). This barrier may consist of cloth, plastic, or be a “snow fence.” In these larger enclosures, such as the pens built on the Cabeza Prieta National Wildlife Refuge and near

Guerrero Negro in Baja California Sur, it may also be advantageous to have 10 m shunts of woven wire fence to facilitate the segregation and movement of animals.

Fences to Control Livestock: Fig. 36a and 36b illustrate suggestions for barbed-wire fence specifications that allow pronghorn of all ages to go under the bottom wire, yet control movements of cattle and horses (Kindschy et al. 1982). Fences constructed according to these specifications have been built for hundreds of miles on pronghorn habitat, and have proven effective for rangelands experiencing dual use (livestock and wildlife) since the fence design was originally published during the 1950s (Griffith 1962). Although arguable by some livestock personnel that the fences allow calves to go under the fence, the return reply has been that such calves can likewise return back to the cows. More than a half century of hundreds of miles of rangeland fences built—appear to confirm that this is a reality. This case record stands as one of the most successful fence designs on western rangelands used by pronghorn and cattle.



Proposed "Pronghorn friendly" fence design for livestock (Fig 36a).



Same fence with "Goat-Bar" in strategic location (Fig 36b).

Figure 36a and 36b. Suggested wire fence specifications using barbed and smooth wires for rangelands used by cattle and pronghorn. Such fences have been most effective on extensive rangelands. They are less effective surrounding agriculture fields and drinking water facilities (Kindschy et al. 1982).

Ranchers in the Southwest often encircle water sources with fences to trap or redistribute livestock. These enclosures often are built of woven-wire, and contain 10 or more strands of barbed wire, or snow fencing. Such structures are highly detrimental to pronghorn, especially young animals inexperienced in negotiating such obstacles. The fencing of water holes in such a manner appears to violate the same basic mandate prohibiting sheep-tight fences on public lands dedicated to multiple use (Yoakum 1980, Yoakum and O'Gara 1990).

Special facilities allowing pronghorn movement through livestock fences were developed in Wyoming by Spillett et al. (1967) and later modified by Maptson (1972) and Howard et al. (1990). These so-called "antelope passes" allowed adult animals to jump through sheep-tight fences, but some fawns broke their legs in passing. “Antelope passes,” therefore, have limited application and are not recommended for mitigating pronghorn movements through woven-wire fences (Yoakum et al.1996).

Wildlife biologists working in Idaho adjusted barbed-wire fences to allow seasonal access by pronghorn when rangelands were not in use by livestock (Anderson and Denton 1980). The height of the lower wire was increased from 18 to 38 inches (46 to 97 cm). Raising fences has special merit for areas experiencing snow depths of 12 inches (31 cm) or more. However, such a system requires that habitat managers have adequate personnel available to manipulate the wires lest the fence be a detriment rather than a benefit to pronghorn and other wildlife.

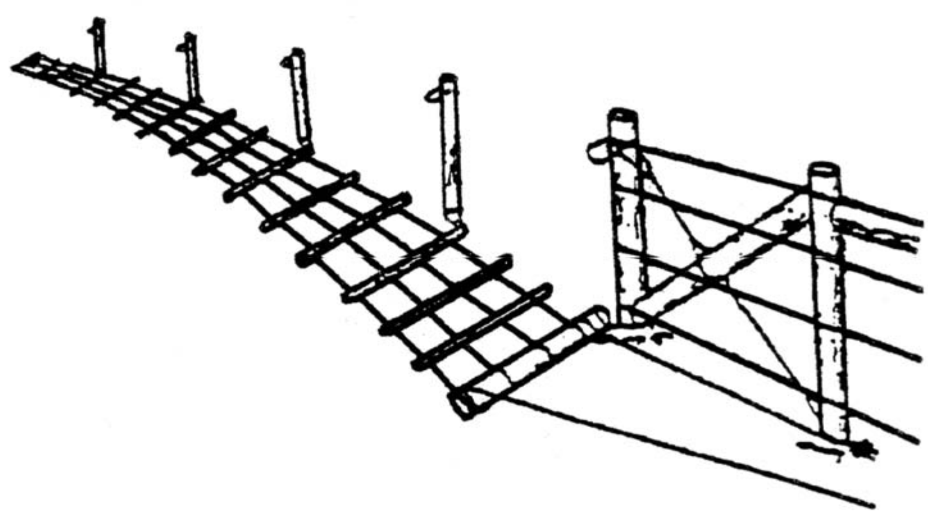


Figure 37. Let-down fence to permit pronghorn and other wild ungulates to cross (Karsky 1988). Letting down the wires from at least four posts should suffice, and distances between gaps would depend on the local conditions. (from Yoakum 2004e)

Let-down panels may serve well under some conditions but are rarely used (Fig. 37). Inherent problems concerning who puts them up and takes them down are common, however. When a bad storm hits, ranchers take care of their livestock first, and wildlife agencies generally do not have enough personnel to let down the panels when needed. Pronghorn tend to become conditioned to fence lines, and in some instances when let-down panels have been installed, migrating pronghorn have walked past the downed area, seemingly unaware of the opening. Leaving gates open in such areas when livestock are not present might help alleviate this problem.

A better solution, although one still not as ideal as no fence at all, is the provision of “goat bars” in strategic passageways. These “goat bars” consist of pieces of a longitudinally slit PCB pipe from 6 to 12 feet in length, into which the bottom two strands of fence are inserted into the slit, thus lifting the "bar" and facilitating the passage of pronghorn under the fence (Figure 36b).

Disassembling Fences: Designing, installing, and maintaining fences includes the responsibility to modify or dismantle these structures when they are detrimental to other resources or no longer serve the objective for which they were originally intended

An area in central Colorado in which a barbed-wire fence had been constructed many years previously to control livestock had been unoccupied by pronghorn until relatively recently (Pojar and Gill 1990). The fence was known to contribute to physical injuries and restrict pronghorn movements. Unfortunately, funds were not available to modify the fence for the benefit of pronghorn. Through the cooperation of conservation and education organizations that volunteered their labor, the bottom wire of the fence was raised to 16 in (40.6 cm) above the ground, thus benefiting pronghorn. There are hundreds of miles of similar fences on private and public rangelands that can be improved as pronghorn habitat. In Arizona, the Arizona Antelope Foundation and other wildlife conservation organizations volunteer their labor to modify many miles of fence each year to make them more passable to pronghorn.

The need to disassemble barbed and woven-wire fences on pronghorn habitats was first recognized as a responsibility of habitat managers during compilation of the Environmental Impact Statement and Comprehensive management Plan for the Hart Mountain National Antelope Refuge in Oregon (U.S. Fish and Wildlife Services 1994). Case histories identified that fences built to manage livestock had maligned and killed pronghorn, deer, bighorn sheep, and other wildlife. More than 212 miles (341 km) of refuge interior fences were constructed on the refuge during the last 100 years. Since these fences no longer served a management purpose, annual removal projects have been conducted. As of 2005, around 198 miles (318 km) of fences have been disassembled—primarily through volunteer labor of conservation organizations (Chappel 2005). Similar fence removal and/or modification projects have been accomplished on the Charles Russell National Refuge in Oregon, Buenos Aires and Cabeza Prieta National Wildlife Refuges in Arizona, and the National Monuments of Aqua Fria in Arizona and Carrizo Plain in California.

A review of range improvement guides and manuals discloses detailed specifications on how to construct and maintain fences. Recognizing that fences can contribute to physical injury and at times restrict mobility of pronghorn and other wildlife, it is recommended that guides, handbooks, manuals and management plans to construct fences contain specifications to modify or remove fences that adversely effect wildlife and no longer serve their original objective. Few were found that provided recommended techniques for modifying fences to meet wildlife needs and none could be located that identified the responsibility for disassembling fences that no longer served a purpose (U.S. Bureau of Land Management 1980, 1985, Karsky 1988, Brunner 2000).

Specifications for three and 4-strand barbed wire fences designed to control cattle but facilitate pronghorn movement are shown in Figures 38a and 38b. These heights and measurements allow pronghorn to negotiate such fences under most circumstances (Spillett 1965, Kie et al. 1994, Lee et al. 1998, Yoakum 2004d).

The fence illustrated in Figure 38 is intended to control domestic sheep, yet allow the passage of pronghorn (U. S. Bureau of Land Management 1985, Salwasser 1980, Yoakum 1980, Karsky 1988, Kindschy 1996, Payne and Bryant 1998). However, the bottom wire is 10 inches (25 cm) above the ground—a height restrictive to pronghorn. This design is not recommended for pronghorn habitats. According to Rouse (1954:11): "any fence that effectively controls domestic sheep will likewise control pronghorns."

"Wolf" and 'Anti-Coyote' Fences: A "wolf-type" fence was designed in Texas and New Mexico during the 1940s to exclude coyotes from rangelands containing domestic sheep. Their design was essentially a 36-inch (91 cm) roll of net wire fence with the bottom 12 inches (30 cm) buried below the ground. Three to four strands of barbed wire were then strung above the woven wire to a height of 50 to 60 inches (127 to152 cm). Other "anti-coyote" fences have been designed using combinations of barbed, et, and electric wires (Karsky 1988, Kie et al. 1994)—all having the objective of preventing coyotes from digging under, passing through, or jumping over the fence. Although successful in their intended purpose, these fences also prohibit pronghorn movement and are illegal on public lands where "multiple-use" is a land –use objective (Yoakum 1980).

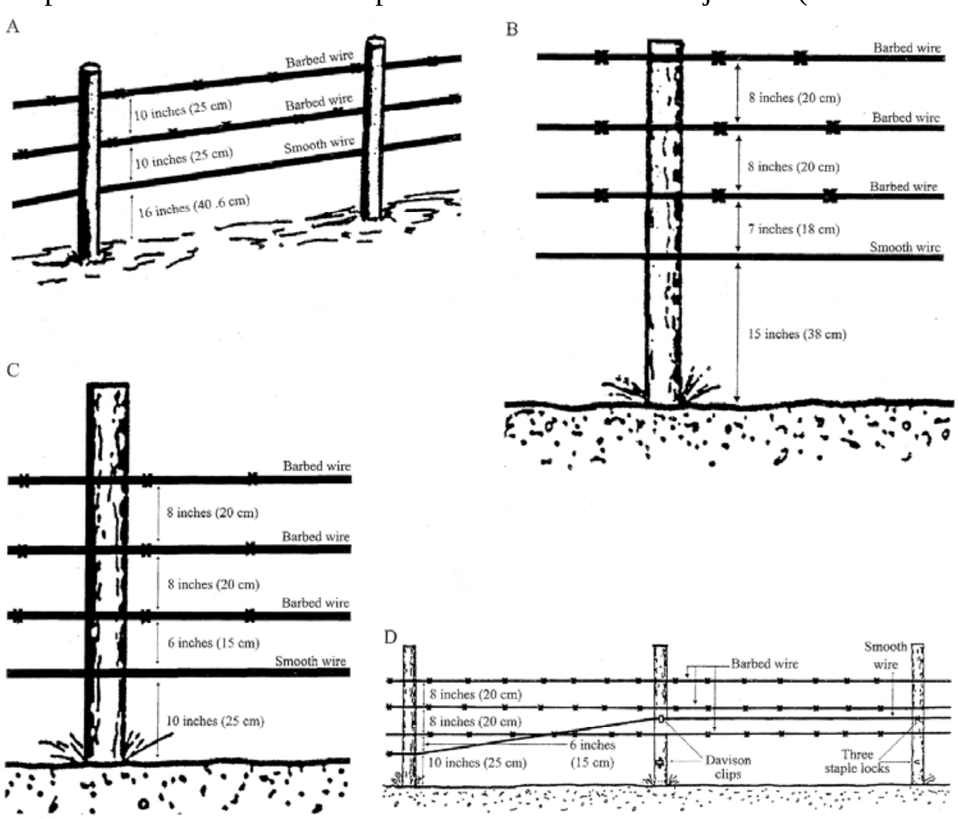


Figure 38. Specifications for (A) three-strand (Karsky 1998) and (B) suggested four-strand wire fences on rangelands used by cattle and pronghorn and (C) barbed and smooth wire fencing

recommended for fences on rangelands grazed by domestic sheep, cattle and pronghorn (Karsky 1998). The latter fence will restrict pronghorn movements because the lower wire is too close to the ground, so it will not allow pronghorn to crawl underneath. However, it can be modified to allow pronghorn access through the fence when the bottom wire is raised as illustrated in (D).
(from Yoakum 2004e)

Let-down Fences: A "let-down" fence is designed to allow sections of wire to be laid on the ground, thus allowing pronghorn the opportunity of passing over the barrier during times of seasonal movement or after deep snows (Karsky 1988). One design uses a wire loop at the top of the fence post and a pivot bolt at the bottom to hold a "stay" in place (Figure 37). Such a design allows sections of the fence to be easily let down and be re-erected. Another design allows the "let-down" section to be pulled back against a section of standing fence. Such fences must be designed to provide for an adjustment of the wire's tension as the wire cannot be so taut as to not allow the fence to lay flat nor so loose that loops of wire create a hazard to pronghorn. Experience over the last 3 decades indicates that labor is often unavailable to "let-down" these fences prior to severe snow storms, however.

Adjustable Fences: The "adjustable fence illustrated in Figure 39 was designed in Idaho (Anderson and Denton 1980) to allow the lower strand of wire to be raised from 16 inches (41 cm) to 38 inches (97 cm) to 38 inches (97 cm) above the ground. This design is especially beneficial to pronghorn in areas where the snow depth can exceed 12 inches (30 cm). One person can adjust a mile (1.6 km) of wire in approximately 30 minutes.(L. Anderson , pers. comm.) reported that pronghorn repeatedly selected the sites having the bottom wire higher than those sections of fence where these wires had not been raised.

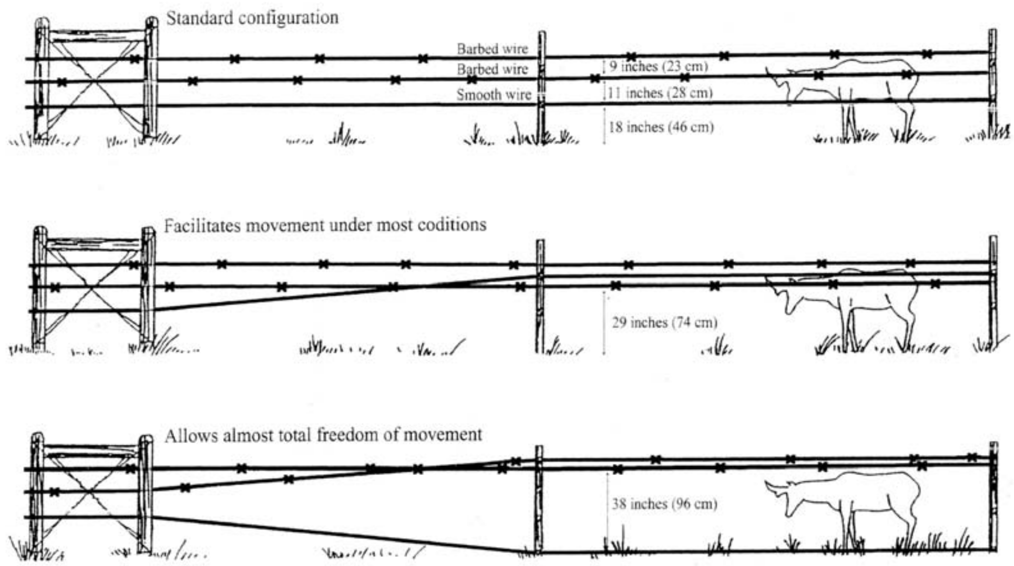


Figure 39. Three-strand barbed wire fence with modifications for pronghorn access (Anderson and Denton 1980). This design especially is beneficial when snow makes it difficult for pronghorn to crawl under the fence. The configuration depicted in the center would suffice during most winters. The 38-inch (97cm) clearance would be needed where snow depth exceeded 20 inches (51cm). If the fence blocked a movement corridor from summer to winter rangelands, long areas of modification might be required to accommodate pronghorn moving with a snowstorm. (from Yoakum 2004e).

Buck and Pole Fences: Wood fences constructed of aspen or pine logs are no longer widely used on rangelands due to their labor–intensive construction, the local scarcity of materials, and difficulty of transportation. Nonetheless, such fences, are still found due to heir aesthetic values and durability in areas of heavy snow.

Scott (1992) reported on the ability of pronghorn and other wild ungulates to negotiate through a buck and pole fence on the northern boundary of Yellowstone National Park in which the bottom rail was 18 inches (46 cm) above the ground. Of the pronghorn that attempted to reach the other side, 72 % either passed around the fence or crawled under the fence even though they sometimes experienced some difficulty in the process. Pronghorn encountered more problems on the park side of the fence, which had four wood rails as opposed to only one brace rail on the other side. Pronghorn too inhibited to pass through the fence walked along the barrier until finding an open gate or other opening. A suggested design that allows pronghorn to pass through a buck and pole fence is provided by Karsky (1988) in Figure 40.

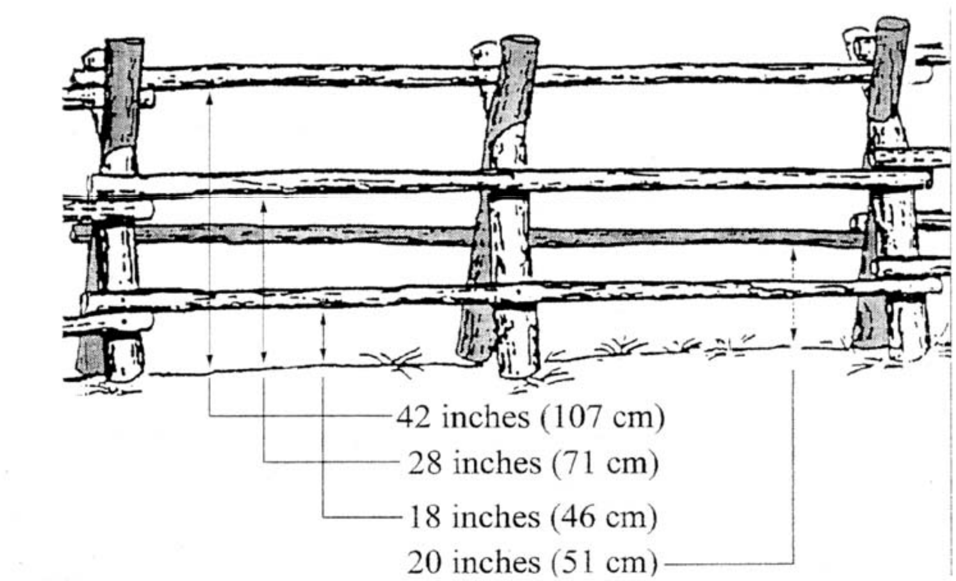


Figure 40. Typical section of a three-rail buck and pole fence that will allow pronghorn to pass through (Karsky 1988). An attribute of this type of fence is that it enables snow to be scoured out by turbulent winds, making the fence negotiable during times of deep snow without the requirement of seasonal removal. However, wooden fences generally are not used on western rangelands because materials are costly, and the fences are labor intensive to build and maintain. (from Yoakum 2004e)

Electric and Other Anti-pronghorn Fences: Management objectives may at times seek to prevent pronghorn from entering a certain area or to restrict their movements to within an area (Yoakum 1980, Yoakum et al. 1996). Such restrictions can be accomplished with an electric fence that carries intermittent electrical charges that shock animals coming into contact with the fence. Once pronghorn are exposed and conditioned to an electric fence, such fences can pose a psychological barrier as well as being a physical obstacle. Such fences are relatively easy to install, have a reasonable service life, and may result in a 25 to 30% savings in the cost of labor and materials (Karsky 1988).

Standard, two wire electric fences, have effectively managed livestock on Western rangelands, and kept pronghorn our of newly planted rangeland seedlings in Malheur County, Oregon (R. Kindschy, pers. com.).

With recent innovations, electric fences, formerly considered temporary structures, can now be virtually permanent. Standard energizers can electrify up to 6 miles (9.7 km) of wire with a useful life of up to 4 years. Recently developed New Zealand energizers can effectively electrify more than 75 miles (121 km) for a period of 10 to 15 years (Karsky 1988).

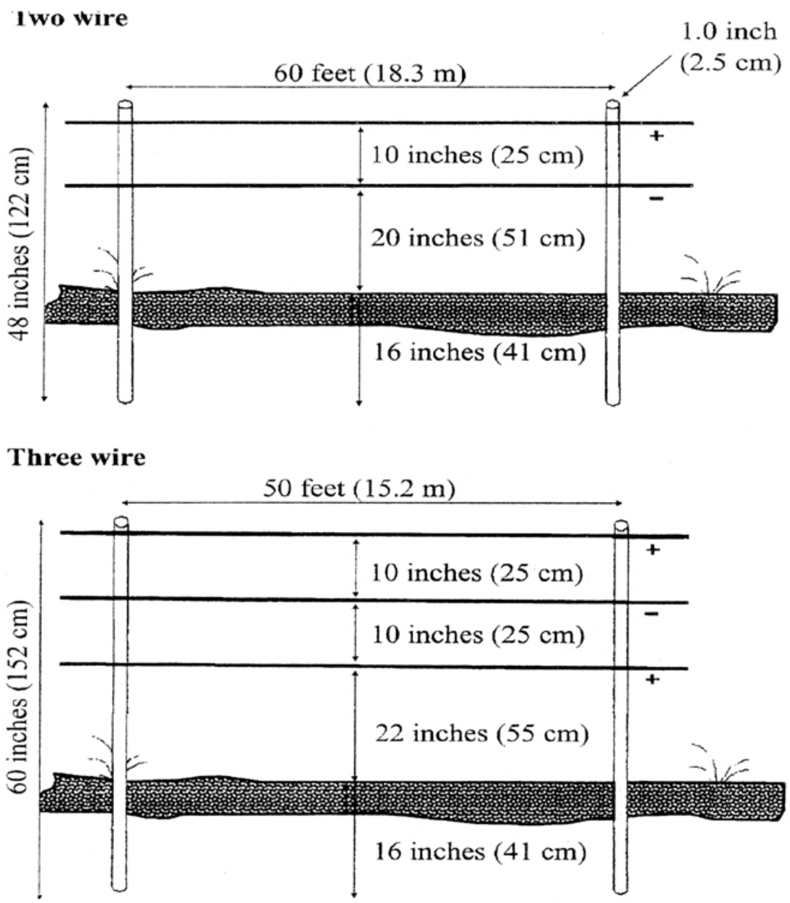


Figure 41. Two-(top) and three-wire (bottom) electric fence designs featuring 0.75 1.0 inch (1.9-2.54cm) diameter, solid, fiberglass line posts. The wire is 21.5 gauge, class III galvanized, with a maximum tensile strength of 170,000 pounds per square inch (11,953 kg/cm2) and a maximum breaking strength of 1,308 pounds (626 kg). The wires are connected to the line posts and stays by metal clips. (from Patritch 2005).

In central Colorado, a three-strand electroplastic-twine fence was installed around an alfalfa field visited by pronghorn (Pojar et al. 2002). In addition, the field was fenced with sections of four-strand barbed and net wire to control livestock. Before the electric fence was installed, the daily mean daily number of pronghorn on the field over a 6 day period was 38.7. After the electric fence was erected, the mean daily number was 2.16 (n=70). This study indicated that electric fences can be a substantial barrier to pronghorn movement, especially where the animals come into contact with "live wire." Hence, to facilitate pronghorn passage, electric wires should not be strung so that the bottom wire is "live" (Fig. 41). Even so, future research on the use and non-use of pastures bordered by electric fences is much needed.

When erecting a permanent electric fence to exclude pronghorn, Pojar et al. (1994), suggested building a 60-inch (150 cm) tall five-strand (or more) high-tensile wirer fence, as described by Palmer et al.(1985). Such a fence (Fig. 42) would result in a fence with a long life, low maintenance costs, less expensive than conventional net-wire fencing, and be an effective barrier for both pronghorn and deer.

Recently, preliminary results of a long-term study relative to the effects of electric fences on bison, elk, deer, pronghorn and cattle for fences constructed on rangelands were reported by Patrich (2005). Specifics of the fence designs tested are in Figure 29. When a pronghorn or other ungulates came in range, a camera recorded the animal's reaction to the electric fence resulting in 191 recordings for pronghorn. Findings indicated pronghorn were not often severely shocked. Apparently electric shock appears not to be an important factor influencing reactions. The insulating quality of pronghorn guard hairs, combined with generally dry soils, allow animals to contact the hot wires and feel little or no pain. They may be more susceptible to shock when the soils are wet. The authors contended that a 3-wire fence is as effective structure to meet the goals of controlling bison and livestock, and allowing pronghorn, deer, and elk access on western rangelands.

*Antelope Passe*s The 1963-64 Wamsutter, Wyoming, pronghorn-fence research project, saw the development of several devices purported to facilitate the movement of pronghorn through fences (Spillet 1965, Spillet and Zobell 1967). One of these, the "the antelope pass" (Mapston 1968, Mapston and Zobell 1972) was essentially a miniature cattle guard that capitalized on the tendency for pronghorn to "broad jump" rather than "high jump." These "antelope passes" were placed in strategic locales, usually near a fence corner, and monitored for use by pronghorn (Figure 42).

Unfortunately, later field tests showed that although some adult animals jumped over the guards, others refused to negotiate them. Fawns could not easily leap over the structures and some suffered leg injuries in the attempt. Investigators therefore concluded that, even with a doubling of the "passes' width, the "antelope pass" was of limited value and should only be used if no other means of passage could be provided (Newman 1966, Kerr 1968, Mapston 1968, Bear 1969).

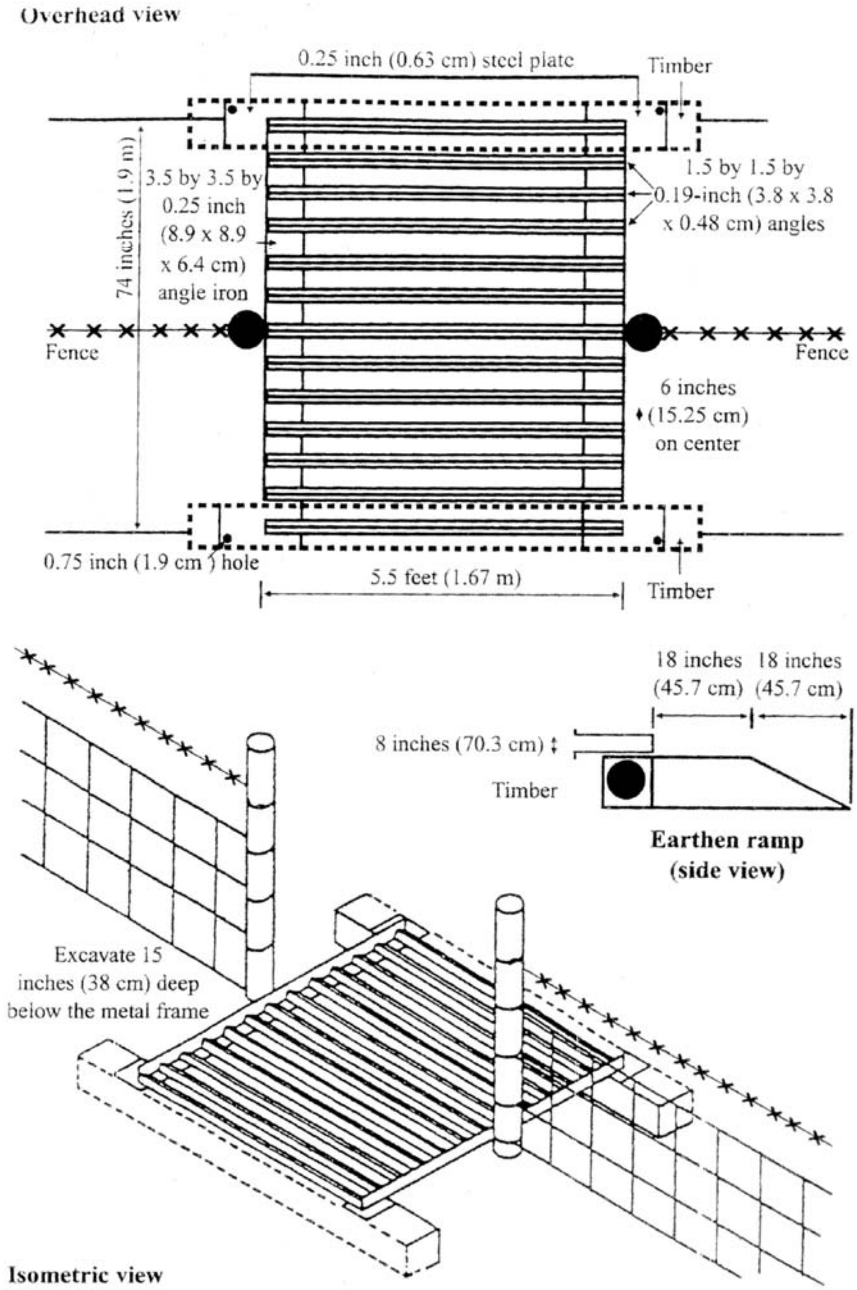


Figure 42. Antelope passes were designed and tested to allow pronghorn passage through woven-wire fences on public lands in Wyoming (Mapston 1968). These structures were about half the size of standard cattle guards and designed to prevent vehicle access. Because they are narrow, the cost of materials to build an antelope pass is about half that of cattle guards (Mapston and Zobell 1972)

Recommendations for Fencing Pronghorn Habitats: The issue of pronghorn/fence interrelationships involves biological, managerial, and legal decisions; therefore, the following checklist should be reviewed prior to installing fences on pronghorn habitats (Yoakum 2004).

1. No fencing should be constructed until a comprehensive evaluation has been made for each proposed project site. The probable effect the proposed fencing would have on pronghorn and the benefit to livestock management should be evaluated and determined to the extent possible.

2. Where fencing is deemed necessary, only the minimum amount for livestock management should be permitted. Where fencing is required, provisions should be made for unrestricted passage for all pronghorn age classes, during all seasons, and under all climatic conditions.

3. Fencing a waterhole may be as detrimental as fencing a seasonal movement route. Critical pronghorn habitats (winter concentration areas, seasonal movement corridors, fawning areas, water sources, etc.) should be designated as "special" biological areas requiring specific justification to be fenced.

4. Barbed-wire fences for cattle that allow pronghorn movements should consist of three strands of wire with the bottom wire smooth and 16-18 inches (41-46 cm) or more above the ground, with maximum heights of 36 inches (91 cm).

5. For rangelands having domestic sheep the problem is more complex. Any fence that effectively controls sheep will most likely restrict pronghorn movements. Net wire fences should not be built in pronghorn habitats. Where net wire must be used, mitigating provisions such as let-down panels or adjustable fences should be incorporated into the fence line at strategic pronghorn movement sites.

6. Specially designed fences (buck and pole, rail, suspension, etc.) should be no higher than 34 inches (86 cm) from ground level, with a bottom gap at least 16 inches (41 cm) above the ground.

7. All new fences should have white rag flagging tied to the top wire between each post to improve visibility of the new hazard. Pronghorn may become accustomed to the new fence by the time the flagging deteriorates. Grey "camouflage" steel posts should be avoided.

8. "Wolf-type" fences to exclude coyotes from pastures completely restrict pronghorn movements. The construction of this fence design should not be allowed on public rangelands occupied by pronghorn.
9. "Antelope passes" have been shown to be of limited value because fawns have been observed to break legs trying to jump over the guards. This is particularly true where such devices are only infrequently used, as in areas with low pronghorn densities, or seasonal movement corridors.

10. *No more than two "stays" should be permitted between fence posts to allow sufficient slack in the bottom wire. If three or more stays are used, no more than*

two stays should be attached to the bottom wire. Many highway and pasture fences are too "tight" for easy pronghorn egress and ingress.

11. Let-down fences serve well under some circumstances. A major concern is the managerial guarantee that the fence will be let-down prior to severe snowstorms.

12. Where rangeland operations switch from domestic sheep to cattle, net wire fences should be removed or extensively modified to allow pronghorn movement.

13. Emphasis should be placed on reduced fencing, and other livestock control methods such as herding should be considered as alternative management practices. Livestock operations, especially for domestic sheep, should be implemented with minimum fencing.

Existing fences that restrict pronghorn movements should be modified to allow free passage for these animals. Modifications should include the total removal of unnecessary fences, removal of excess wire strands, restringing bottom wires to >16-18 inches (41-46 cm) above ground level, replacing barbed bottom wires with smooth wire, and installation of passage devices (goat bars, let-down panels, adjustable fences, etc.).

Dysfunctional fences in pronghorn habitat that no longer serve their intended purpose should be removed. Abandoned fences, together with cattle guards, corrals, and other structures, have the potential to cause injury and impede the movement of wildlife, especially pronghorn.

Although funds are often requested to construct new fences, funding to remove dysfunctional fences are often difficult to come by due to the lack of an immediate objective. And, because the disassembly of fences, is rarely part of a government agency's budget, it is important that periodic evaluations and management plans address this need. Similar procedures should also be employed on private and other lands as a responsibility of land stewardship.

Fortunately, problems associated with abandoned or unnecessary livestock fences are increasingly being recognized. This is especially so on wildlife refuges, and to a lesser extent on lands administrated by the U. S. Forest Service and Bureau of Land Management. As a result, such agencies are encouraging public organizations to remove and salvage unwanted fences—especially those in pronghorn habitat. Sportsmen's groups and conservation volunteers are increasingly taking up this challenge and are themselves requesting land management agencies to conduct fence inventories and participate in cooperative fence removal projects. Since the 1990s, the Oregon Natural Desert Association, the Order of the Antelope, and numerous other conservation organizations, have assisted in dismantling hundreds of miles of fence in pronghorn habitat throughout the West, not only on federal land, but also on state and private lands. Indeed, such cooperative projects, along with similar efforts at fence modification, have been a *cause celeb* providing both a purpose and field experience for such disparate organizations as the Arizona Antelope Foundation, the Sierra Club, various chapters of the Audubon Society, and a variety of land trusts—all working in cooperation with state and federal agency personnel.

Industrial Developments

Human developments remove hundreds of thousands of acres of pronghorn habitat each year. Examples vary from new housing developments, through highway right-of-ways, to such hideous examples of needless excess as the International Airport outside of Denver. Recently, however, the most pervasive and large-scale threat to pronghorn habitat appears to be oil and gas development.

The greatest potential impacts from oil and gas development and production to pronghorn are through loss of habitat and displacement. Winter rangelands, seasonal movement corridors, and fawning areas require special management attention to reduce stress from oil and gas activities. To reduce stress on pronghorn in such crucial areas, land managers have used seasonal use restrictions to prohibit fluid mineral exploration and development activities. Such restrictions may be imposed by the public land manager under the terms of a federal oil and gas lease for the protection of wildlife. Although seasonal use varies with geographic area, definable fawning areas usually are occupied between 1 May and 31 July, and winter ranges are occupied between 15 November and 30 April. Depending upon severity of climatic conditions (i.e., snow depth, snow crusting, daily mean temperatures), the last 60 days of the winter range time limitation may be suspended by the authorizing officer.

New oil and gas wells often intrude into previously undisturbed, road-less areas, causing increased human activity as well as direct loss of habitat (Fig. 43). Most well locations require 2-5 acres (0.8-2.0 ha) of surface disturbance in addition to roads and other facilities. Areas where activity should be avoided include south-facing slopes and wind-blown ridges on pronghorn winter ranges. Another recommendation that would minimize impacts is to only allow oil and gas drilling activities during non-crucial seasons, allowing pronghorn to gradually become accustomed to these disturbances. Oil and gas drilling activities probably would be less disruptive if they were already in progress when pronghorn moved into an area, as opposed to initiating operations during the wintering period and displacing animals. The effects of disturbance may often extend beyond the drill pad boundary and cause pronghorn to move into adjacent areas, thereby increasing the use of sub-optimal habitats, conflicts with agriculture, and human confrontations.

Pronghorn reactions to roads usually vary in response to traffic volume. Primary effects of well-site access roads may come with associated fences and the resulting hindrance of pronghorn movements (Riddle and Oakley 1973).

Most geophysical exploration activities result in minimal surface disturbance over a short period, and it is concentrated human activity that causes increased stress or displaces animals from preferred habitats. Hence, the need for seasonal avoidance may vary on a site-specific basis, depending on local conditions.

Mineral conveyors transporting coal or oil more than 0.5 mile (0.8 km) across pronghorn rangelands should be mitigated by constructing earthen (hill-like) overpasses at 0.5 mile (0.8 km) intervals on high ground. Or, the conveyor may be raised 20-30 feet (6-9 m) above the ground level at strategic locations (Tessman 1985). During railroad construction, fence designs that impede big game migration/drift should be avoided. Fences in areas of significant pronghorn movements should be designed so that they can be temporarily let down to free entrapped animals when necessary.

Coal, oil, and gas field developments have impacted pronghorn habitat in several western provinces and states, and energy and mineral resource development and post-development land-use practices will continue to significantly alter western rangelands. Impacts of these developments will be compounding and cumulative. Therefore, in regions where the potential for extensive development exists, actions to protect and preserve pronghorn habitat should be planned, coordinated, and applied to the entire area of expected impact. The suggestions listed below are offered as guides to industry and to regulatory agencies for protecting pronghorn populations, for mitigating habitat destruction, and for reclaiming, rehabilitating, or enhancing pronghorn habitat on disturbed lands.

Figure 43. Gas well pipeline on Otero Mesa in southeast New Mexico. Increased travel and disturbance may be more detrimental to pronghorn than the presence of wells and pipelines themselves. Sierra Club photo by Jim Steitz.

Overview - When and where applicable, local, state, provincial, and federal regulatory and management agencies should jointly develop regional priorities for areas that should and should not be developed to minimize the loss of ecologically important systems.

Lead Time - Specific industrial developments and related informational needs on pronghorn populations should be identified early enough to allow sufficient lead time for seasonal field work, budgeting, personnel assignments, and review by state or provincial wildlife management agencies and other interested parties.

Steering Committees - Steering committees, directed by the state or provincial wildlife management agency and composed of involved members of industry, federal, university, and interested citizen organizations or agencies, should be established as needed. Committees should be formed on a regional basis to provide guidance and advice for providing post-development land-use goals and to develop basic strategies for accomplishing them on each lease site.

Goals - Post-development land-use goals should include a commitment to maintain pronghorn, as an integral part of the development plan for each lease, on both public and private lands that supported pronghorn prior to development.

Pre-development Surveys: Before initiating and completing an energy development plan, industry personnel should quantitatively identify, describe, and map the quality and extent of pronghorn distribution, movement patterns, and population characteristics; associated recreation and economic values; and baseline habitat/vegetative data for pronghorn. These parameters should be monitored throughout the life of the development. Study plans and progress should be directed and approved by the responsible state or provincial management agency.

Information on previous classifications of pronghorn herds in the general area of the project site should be complied. Surveys need to be conducted to determine pronghorn production and population trends on and adjacent to the project site during both the pre-development and development phases.

Each population or herd's home range and movement patterns should be described and documented.

If available, obtain previous seasonal population estimates and index trends from reliable sources. Identify factors that affect populations such as habitat, weather, private landowner tolerance, hunting pressure, and harvest levels. Calculate the recreational value of pronghorn populations to be impacted, considering both non-consumptive and consumptive uses, land status adjacent to the project site, hunter and observer access, hunting quality, etc. Determine the economic value of the herd or an individual pronghorn

Identify unusual or excessive mortality, if any, from such causes as vehicles, severe weather, diseases, poaching, and predation.

Prepare qualitative and quantitative vegetative type maps of the affected areas prior to development. Prepare maps at 1:24,000, or at a similar scale, as a basis for reclamation goals and plans. Vegetation data should include a list of plant species, plant communities, height, and production. Quantitative data should include percent canopy cover, plant composition (grasses, forbs, shrubs), frequency, and expected annual production by major species.

Identify key species of plants important as pronghorn forage in relation to the seasons of the year that pronghorn are present. Based upon vegetative typing, delineate actual and potential pronghorn habitat within the development area.

All existing natural and man-made waters available to pronghorn should be depicted on maps. Quantitative data should be recorded for each water source, including gallons (liters) available during each season of the year and test results of water quality.

Monitoring: Specific areas identified as key to the maintenance and perpetuation of a pronghorn population, and which are difficult areas to duplicate, should receive top priority and, where possible, remain unaltered and available for use by pronghorn.

County land use planning for any ancillary or subsequent developments (housing, shopping centers, recreational facilities) should locate such developments away from critical pronghorn areas, particularly movement corridors.

An effort should be made to maintain existing public access and, where desirable, provide additional access to public lands while minimizing energy development access, operations roads, and associated fences. Those roads and railroads that are required should be located on the periphery of pronghorn use areas. Where this is not feasible, mitigation should be pursued.

Minimize the area for exploration and drilling and use techniques that create the least amount of activity and disturbance, and employ a unified, consolidated storage area for all energy development equipment and materials.

Restrict human activities to essential energy development-related efforts to prevent unnecessary disturbance to pronghorn. Prohibit or minimize disturbance of key areas and maintain a “no-entry” buffer zone of 0.25 mile (0.4 km) around all developments.

Enhancement: Restrict all impacting actions (post-development land use, emissions, discharges, effluents, etc.) to provide a subsequent level of pronghorn habitat that approximates or surpasses pre-development conditions. Strategies for achieving this (i.e., increased carrying capacity through range fertilization and/or enhancement, water development, purchase of private lands by public agencies) should be detailed in formal plans (i.e., energy development plans, species and habitat management plans, state comprehensive and operational plans).

Key areas lost during development should be mitigated by providing sites of equal value in adjacent or other areas and where displaced pronghorn can persist in similar or higher numbers than were present prior to development.

Reclamation plans should consider priorities for re-vegetation on the basis of nutritional and cover needs, and disturbed areas should be shaped into terrain that enhances pronghorn habitat and simulates natural conditions.

Water discharges and effluents resulting from any development should be made available for pronghorn and should meet or exceed suggested standards. Additional water sources should be developed as needed, e.g., drinking water ponds, springs, streams, guzzlers, etc., in all areas actually or potentially occupied by pronghorn.

Reclamation: Federal laws require restoration of public lands to natural conditions. Damaged and disturbed habitats should be restored and regenerated so that they approximate natural conditions. Reseeding mixtures should include native forbs and shrub species important to pronghorn (see Habitat Management). Domestic livestock and wildlife use on reclaimed areas should be postponed or regulated to promote an ecological succession that will enhance pronghorn populations. State or provincial wildlife management agencies should cooperate in regulating wildlife populations on reclaimed areas to ensure successful reclamation

Reducing competition between pronghorn and domestic livestock on adjacent, non-developed lands can sometimes be used to mitigate habitat loss to development. When doing so, all environmental hazards and contaminants should also be removed from pronghorn rangelands, immediately after the cessation of development operations. These include all unused mining equipment, hardware, wire, pipe, barrels, toxic substances, etc., that might constitute a hazard to pronghorn. Oil field slush pits should be fenced with net-wire to prevent waste ingestion by pronghorn.

Post-development Objectives: Whenever possible, pronghorn losses due to development should be mitigated. Mitigation measures would include transplanting and restocking pronghorn when deemed necessary, desirable, and feasible by the state or provincial wildlife management agency. An even better mitigation solutions is to purchase pronghorn habitats elsewhere or to purchase easements to "land-locked" public lands occupied by pronghorn (i.e., by use of mineral severance taxes or through lease stipulations, etc.).

Crop Depredations

Although pronghorn can generate considerable income to some landowners, they can also damage agricultural crops (Fig. 44). Such losses appear modest when viewed on a statewide or provincial basis, but can be important to the individual landowners affected. In nearly all cases, crop depredations are brought about by human-caused landscape changes. Examples include fences and sub-divisions that block movements, plowing summer or winter rangelands to grow crops, converting shrub-steppes to grass, prohibiting hunting, or charging too much for hunter access. Crop depredation complaints appear to be increasing, apparently because pronghorn numbers generally are increasing while traditional pronghorn habitat is being lost to "improved" pastures, grain fields, and human development. Results of a survey sent to conservation agencies in 18 western states and provinces in 1991 indicated that depredations were stable in 9 states and increasing in 8. Only in Nebraska were depredation complaints decreasing, apparently because pronghorn numbers in that state were depressed. Almost every agency reported some damage to alfalfa and wheat; a few others added soy beans, field peas, and fall rye to the list. Most state agencies did not pay compensation for crop damage; those that did paid a total of about $85,000 in U. S. dollars in 1990 (O'Gara and Yoakum 2004).

Because of resistance to expanding pronghorn hunting seasons in California, translocations were used to reduce depredations to irrigated alfalfa fields. Translocations are only practical, however, if suitable habitat is available for the released animals. Apparently because of political pressure, the pronghorn were translocated into marginal habitat (McCarthy and Yoakum 1984), resulting in the eventual death or movement of remaining animals to adjacent, more favorable habitats in Nevada. Thus, translocations designed to save pronghorn from hunters' bullets resulted in a loss of both pronghorn and of funds that could have been better used to benefit animals elsewhere.

Other states, such as the Nevada Division of Wildlife, also have the option of holding depredation hunts (Tsukamoto 2003). Where depredation problems are expected, the Division plans a special depredation hunt in conjunction with the season setting process. Hunt applicants apply for these special hunts during the spring, and when a depredation complaint is received, a depredation hunt can be initiated within 2 weeks. Unsuccessful applicants in the regular hunt process for that hunt unit are also contacted and awarded tags if necessary. Such hunting seasons, staggered during the depredation period, alleviate much of the problem by removing and harassing the pronghorn involved.

Figure 44. Alfalfa crop depredation is one of the most prevalent agricultural damage cases attributed to pronghorn. However, it can at times serve management as was the case for this area in northern California where excess pronghorn were captured and translocated to other sites. Photo by Bob Schaffer.

The Nevada Legislature recently authorized the Division to develop procedures and regulations whereby big game tags can be allocated to landowners having depredation problems. Under this system, the landowner cannot use the tags, but can sell them. The number of tags a landowner is qualified for is based on the number of animals found on his/her property, and the ratio of tags to numbers of animals is to be negotiated.

The most practical method for solving crop depredation complaints appears to maintain a pronghorn population capable of living mostly on uncultivated rangelands through the issuance of sufficient numbers of doe/fawn permits during the regular hunting season. If problems persist, special permits issued for hunts in the affected fields, and at the time of depredation, may solve the problem. Early season depredation hunts should only be authorized for bucks, because fawns would be orphaned by shooting does. The same is true for translocation captures. Orphaning fawns would only result in their deaths during about two months of the year, however, usually June and July (Bromley and O'Gara 1967). Shooting bucks may do little to reduce pronghorn numbers in an area, but accompanying animals often stay away from fields after a few bucks are shot. In some cases, simply fencing a haystack will solve a problem.

Pronghorn Management Plans

With the growth of human populations and society's expanded use of the land, the need to document pronghorn' requirements for forage, water, and space has increased. Pronghorn have thrived during the past half- century, but the need exists to manage for healthy populations and compatible human use. One way to meet these needs is by Management Plans that list the objectives, goals, and procedures to best manage the species by maintaining and/or improving forage, water, and space; and by coordinating pronghorn management into holistic land-use plans.

Wildlife Management Plans usually are initiated by state and provincial wildlife agencies. They emphasize practices to protect, reduce, maintain, or enhance populations. They typically spell out methods to inventory populations, alleviate limiting factors, and how to harvest or translocate surplus animals.

Habitat Management Plans are generally prepared by government or by private land agency personnel. Such plans emphasize the maintenance or improvement of forage, water, and space for pronghorn, and attempt to identify to what degree pronghorn are compatible or competitive with other land uses.

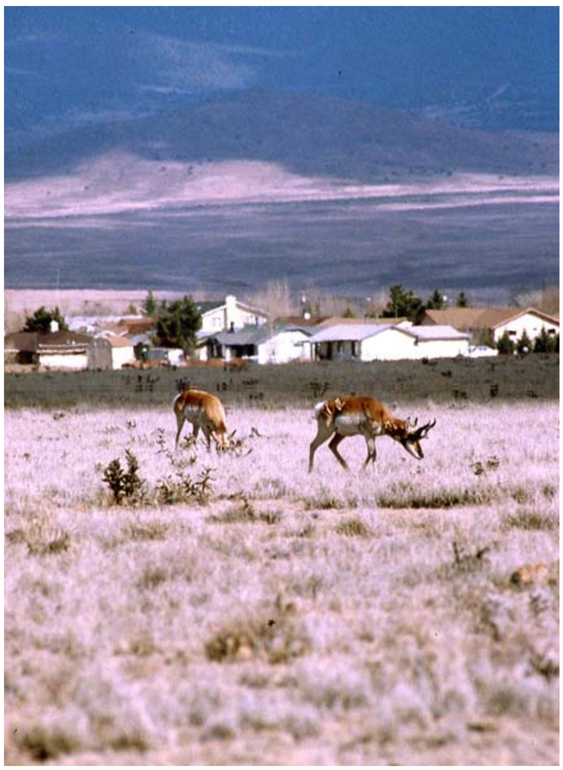


Figure 45. Crop depredation and loss of habitat are brought about by changes made by humans. Photo by Bart O'Gara.

Management Plans (Recovery Plans) for endangered species are mandatory in accordance with the Endangered Species Act (1973). Such plans identify possible procedures to increase a species or sub-species to a level sufficient for de-listing.

The various guides suggesting techniques and practices to manage pronghorn and their habitat are aids to biologists developing Management Plans. To date, these include: *Wildlife Management Techniques Manual* (Ripley 1980); *Habitat Management Guides for the American Pronghorn Antelope* (Yoakum 1980); *Range/Wildlife Habitats in Managed Rangelands-The Great Basin of Southeastern Oregon: Pronghorn* (Kindschy et al. 1982); *Pronghorn Antelope Populations and Habitat Management in Northeastern*

Great Basin Environments (Salwasser 1980), *Programa para la conservación, manejo y aprovechamiento sustentable del berrendo* (Antilocapra americana) *en Méxíco* (Direccíon General de Vida Silvestre 2000, Cancino et al. 2000), *The Peninsular Pronghorn Recovery Plan* (Cancino et al. 2004), and Final Pronghorn Management Plan F.E. Warren Air Force Base, Wyoming (Anonymous 2004). In addition, Yoakum (2004c.) provides a discussion and listing of Management Plans specific for pronghorn, their habitat, and enhancements for the recovery of imperiled populations.

Figure 46. When pronghorn are retained in enclosures for long periods of time (e.g., field research, holding for transplants, etc.), it is advisable to provide shade. Pronghorn readily use such facilities, especially in desert environments as pictured here for penned animals in Baja California Sur, Mexico. Photo by Jorge Cancino.

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PRONGHORN ORGANIZATIONS

The North American Pronghorn Foundation is a not-for-profit corporation whose principal mission is to "preserve, conserve and enhance both pronghorn antelope and their ecosystems." The Foundation intends to accomplish this mission by ensuring the future of free-roaming, wild pronghorn by providing financial and other assistance to continue research, public education, inter-agency cooperation, habitat development, sound management practices, and issue advocacy through protective legislative policy.

This Foundation is organized with a Board of Directors and selected Executive Officers, who are supported by various committees and a compliment of Advisory Councils that includes Research and Education, Inter-Agency Coordination, Management and Habitat, and Issue Advocacy. The Foundation established a base of operations headquartered in Wyoming (1905 CY Ave., Casper, WY, 82604). Ultimately, the Foundation expects to expand to every state and province that harbors a resident pronghorn population, as well as establish chapters in any locality where sufficient interest and local support are evident. May joint efforts of many parties guarantee the realization of the motto: "May Pronghorn ever grace the North American plains."

The Arizona Antelope Foundation, founded in 1992, is a single purpose organization dedicated to the welfare of pronghorn antelope. The Foundation actively seeks to increase pronghorn populations in Arizona through habitat improvements and acquisition, the translocation of animals to historic ranges, and public comment on activities affecting pronghorn and their habitat. The AAF’s motto is *Libertas ad Vagor* meaning “Freedom to Roam.”

It is hoped these guidelines will provide wildlife managers with biological data and management practices to support optimum pronghorn production and quality habitat from Canada to Mexico. Individuals interested in promoting the welfare of pronghorn and desire to affiliate with an organization dedicated to this purpose may do so by joining either the North American Pronghorn Foundation or the Arizona Antelope Foundation, Inc. For membership information, write to the Arizona Antelope Foundation, Inc., P. O. Box 15501, Phoenix, AZ 85060-5501 or contact their website at www.azantelope.org.