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.

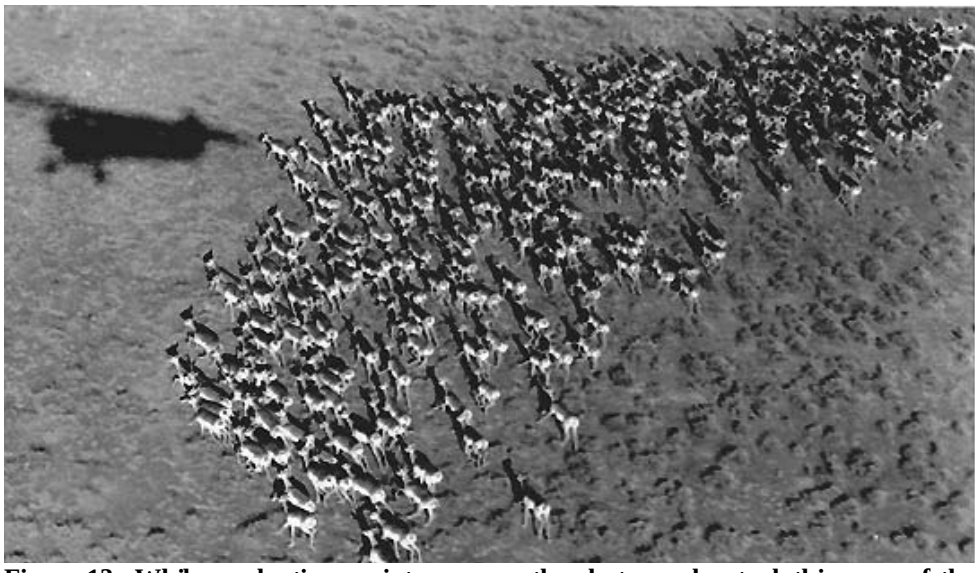

Figure 13. While conducting a winter survey, the photographer took this scene of the shadow of his fixed-wing aircraft and a herd of >270 running pronghorn on the shrubsteppes of southcentral Oregon. One technique to improve counting accuracy with large herds, is to photograph them and later detail count.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

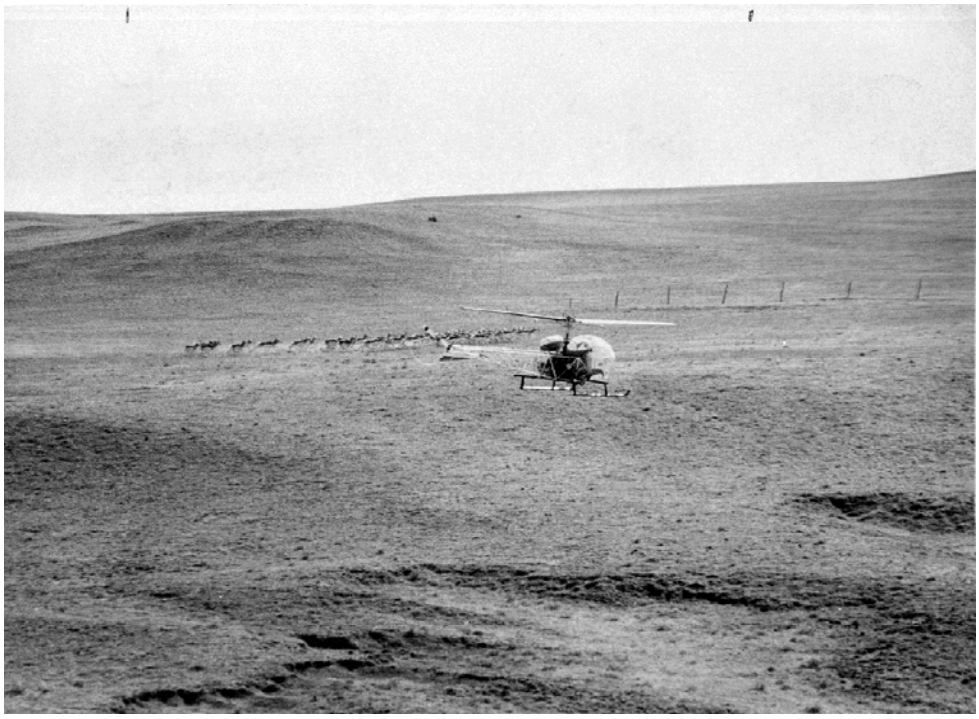

Figure 14. The line transect method can also be done with fixed-wing aircraft, which cost about 25% as much to rent as helicopters; no on-the-ground markers are needed if a navigation system such as GPS or Loran C is used; and confidence limits can be calculated by "double sampling" and then calculating 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 km²) 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.