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Management of carnivore predation as a means to reduce livestock losses: the study of coyotes (*Canis latrans*) in North America

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Many carnivore populations throughout the world are declining due to expansion of human populations, habitat loss, illegal poaching, legal hunting, disease, habitat fragmentation, declines in native prey, and increased competition with livestock and other human land uses. A major obstacle facing conservation efforts, reintroduction programs, and recovery plans for many carnivore species throughout the world is the continual issue of depredations by carnivores on agricultural interests (Mech 1996). In the United States, efforts to reintroduce and/or recover wolves (*Canis lupus*) and grizzly bears (*Ursus arctos*) in the northern Rocky Mountains has been met with much opposition by the livestock industry with depredations on livestock cited as the main reason for resistence. Gaining local support for carnivore conservation and swiftly dealing with depredation problems will always be an issue for biologists and managers as human populations continue to expand into and reduce carnivore habitat increasing conflicts between humans and carnivores (Mech 1996).

Predation on domestic livestock and poultry by carnivores is a historical and continuing problem faced by agricultural producers throughout the world (Harris and Saunders 1993). In the United States alone, producers lost 273,000 sheep and lambs valued at $16.5 million to predators in 1999 (U.S. Department of Agriculture 2000). These losses to predators represented 36.7% of total losses to all causes. In 1999, depredations on sheep and lambs were principally caused by coyotes, *Canis latrans* (61%), dogs (15%), mountain lions, *Puma concolor* (6%), and bobcats, *Lynx rufus* (5%). Rates of loss of sheep and lambs due to specific predators varies geographically (Table 1). Cattle and calf losses to predators in the U.S. totaled 147,000 head during 2000 with an estimated loss of $51.6 million (U.S. Department of Agriculture 2001). Coyotes caused 64.6% of predator losses on cattle and calves, followed by dogs (18%), and mountain lions and bobcats (7% combined). The loss of goats to all predators was estimated to be about $3-4 million annually. While losses of poultry to predators are not well documented, they are considered to be substantial.

The coyote is a generalist, opportunistic carnivore that adapts to landscape modifications and human environments, and is actually doing better today (in terms of population size and distribution) than when North America was first settled by Europeans (Moore and Parker 1992). As stated previously, the coyote is one of the leading causes of depredations on domestic livestock in North America. As such, no predator has probably received as much attention and persecution (current estimate: >100,000 coyotes removed annually) in an attempt to reduce depredation losses. Due to public pressure and increasingly fragmented sheep operations (decline in sheep industry means fewer flocks scattered over the landscape), large-scale population reduction programs are becoming less pronounced. In contrast, techniques that more benign and focus on solving the actual depredation problem are receiving more attention. Non-lethal techniques are becoming more popular and are readily accepted by the general public (Arthur 1981). However, after >30 years of research on methods to reduce predation by coyotes, it is quite clear that protecting livestock from coyotes is a complex endeavor. Each depredation event and management situation requires an assessment of the legal, social, economic, biological, ethical, and technical aspects (Knowlton et al. 1999). No one technique will solve the problem in all circumstances (i.e., there is no magic bullet to solve all depredation situations). Successful resolution of conflicts with predators involves an analysis of the efficacy, selectivity, and efficiency of all the various management scenarios available (Knowlton et al. 1999).

Control techniques may be considered either corrective (after a depredation event) or preventive (before the event). Techniques can also be classed as lethal or non-lethal. Selectivity of the technique is extremely important when attempting to actually solve the depredation problem. General population reduction through lethal means may not solve the depredation problem (e.g., Connor et al. 1998). Techniques that selectively remove the offending individual (Sacks et al. 1999*a,b*; Blejwas et al. 2002) are preferred over non-selective techniques that the killers may avoid once the Aproblem@ animal is identified (Linnell et al. 1999). Methods that are more selective for the target species are also preferred (Knowlton et al. 1999). The purpose of this paper is to present the various techniques that were developed to reduce or prevent depredations on livestock by coyotes. These techniques are the result of decades of research, evaluation, and funding. While the techniques were developed for coyotes, depredation problems for many carnivore species in Brazil may also be controlled in similar situations. Most of these techniques have direct application to carnivores in Brazil of similar body size (10-20 kg) and behavioral characteristics, and likely would be useful for depredation problems involving many of the different species of felids, canids, ursids, and mustelids in Brazil. Some of these techniques will not be useful for some of the larger carnivores (e.g., jaguars, *Panthera onca*) due to their innate predatory abilities (i.e., jaguars would probably kill guard animals).

NON-LETHAL TECHNIQUES

Most non-lethal procedures fall within the operational purview of the agricultural producer. Most livestock producers (83%) utilize at least one non-lethal method to prevent or reduce predation (Table 2). During 1999, producers spent $8.8 million on non-lethal methods to protect sheep and lambs, and $184.9 million to protect cattle and calves (U.S. Department of Agriculture 2000). While there are reports of success with some non-lethal methods, failures are common, few have been subjected to critical evaluation or testing, and none have proven universally successful (Knowlton et al. 1999).

Livestock Husbandry Practices. One of the first lines of defense against depredations that a livestock producer can enact themselves is examining, and perhaps modifying, their animal husbandry practices (Robel et al. 1981, Wagner 1988, Acorn and Dorrance 1998). Several livestock management practices have been suggested as a means of reducing depredation losses. As a general rule, the more time you spend with your livestock, the less likely a predation event will occur. Several recommendations follow: (1) Using herders is a time-tested tradition that can alleviate predation. (2) Dead livestock can attract coyotes and other predators. Thus, removal or burial of carrion will not encourage predators to remain in the area and perhaps kill livestock. Taking carcasses to a rendering plant can also be useful, although rendering plants generally will not accept sheep carcasses because the wool fouls the rendering equipment. (3) Confining or concentrating flocks during periods of vulnerability (e.g., at night or during lambing) can decrease depredation problems. Calves and lambs are very vulnerable after birth, as well as ewes or cows following a difficult birth. Removing the afterbirth or stillborn lambs and calves can also reduce attractiveness of the area following a birth. Lambs that are weak or light-weight are especially vulnerable to predators and confining them for 1-2 weeks will reduce their potential to be killed. (4) Shed lambing, synchronizing birthing, and keeping young animals in areas with little cover and in close proximity to human activity will also reduce the risk of predation. The largest drawback of these procedures is that they generally require additional resources and effort, and may only delay the onset of predation

(Knowlton et al. 1999). For these methods to be effective, producers must develop strategies that will work for their own situations.

Guard Dogs. The use of guard dogs to deter coyotes and other predators from livestock has been a traditional use by many sheep producers, particularly in fenced pastures, and is gaining increased acceptance and use throughout the sheep industry (Acorn and Dorrance 1998). In Colorado, 11 sheep producers estimated that their guard dogs saved them an average of $3,216 of sheep annually and reduced their need for other predator control techniques (Andelt 1992). Several key points should be made with regards to guard dogs: (1) The dog breeds most commonly used as livestock guardians include the Great Pyrenees, the Komondor, the Akbash, the Anatolian shepherd, the Shar Planinetz, the Kuvasz, and the Maremma. While there does not appear to be one breed of dog that is most effective, livestock producers rated the Akbash as more effective at deterring predation because it is more aggressive, active, intelligent, and faster (Andelt 1999). The Great Pyrenees is the most common guard dog breed used to protect flocks of sheep in Alberta (Acorn and Dorrance 1998). (2) Studies investigating the effectiveness of guard dogs have shown the dogs to be effective in some situations and ineffective in others (Linhart et al. 1979, Coppinger et al. 1983, Green et al. 1984, Green and Woodruff 1987, Andelt and Hopper 2000). This disparity may be due to the inherent difficulty of guard dogs to effectively protect large flocks that are dispersed over rough terrain and in areas where thick cover conceals approaching predators. Thus, the effectiveness of guard dogs can be enhanced by confining flocks to more open pastures allowing a good view of the area. (3) Training and close supervision of the dogs seem important for this technique to be successful. Introducing the dogs to the flock at an early age (a pup at 7-8 weeks of age) seems to increase their effectiveness by bonding the dog to the sheep. (4) Check for reputable breeders when purchasing a pup. Some breeders will certify their dogs to be free from hip dysplasia and some will even guarantee replacement of a dog if it fails to perform properly.

Some poorly trained or supervised guard dogs have killed sheep and lambs, harassed or killed wildlife, and threatened people that intrude into their area. As compared to guard llamas, a main drawback of guard dogs is the need to feed and water the dog in the area containing the sheep and the possible bonding of the dog to humans if the flock is near human habitation. Another disadvantage is that the use of guard dogs precludes the use of other control devices (e.g., traps, snares, M-44's) and techniques (e.g., calling and shooting). Dogs can be killed or injured by poisons, snares, and traps used for predator control. In recent tests using 4 guard dogs together to protect calves from wolves in Montana, the wolves (about 50-60 kg body weight) eventually killed all 4 dogs in the pasture and continued to depredate calves

Guard Llamas. The use of llamas for protecting livestock from predators is growing in popularity. Studies have found llamas to be a practical and effective technique to deter predators from depredating livestock (Franklin and Powell 1994, Meadows and Knowlton 2000). The llamas behavioral trait of chasing predators out of pastures is likely a result of its evolution with native predators in South America. A major advantage of guard llamas is that they can be kept in fenced pastures with sheep or goats, do not require any special feeding program, are relatively easy to handle, and live longer than guard dogs (Knowlton et al. 1999). Several recommendations have been made when using llamas as livestock guardians: (1) Do not use an intact male as they may kill or injure ewes when attempting to breed with them. Female llamas also do not appear to work well and may be aggressive towards the stock they are supposed to be protecting. (2) Use of 2 or more llamas in a single or adjacent pastures is also discouraged as they will bond with one another and ignore the sheep. (3) Traits that may be useful in selecting a llama for use as a livestock guardian include leadership, alertness, and weight of the llama (Cavalcanti and Knowlton 1998). (4) Finding a reputable breeder is a good precaution when looking to purchase a guard llama. (5) Flocks in pastures with heavy cover may reduce their effectiveness similarly to guard dogs. Open pastures will good visibility are the best situations for guard animals to effectively operate. Attempts to use llamas to protect calves from wolves has been met with limited success with wolves reducing visitation in some pastures, while in other cases the wolves killed the guard llama.

Guard Donkeys. Similar to guard llamas, donkeys have also been used as livestock guardians (Green 1989, Acorn and Dorrance 1998). The protective behavior displayed by donkeys apparently stems from their apparent dislike of dogs. A donkey will bray, bare its teeth, chase and try to kick and bite any canid (including ranch dogs). Recommendations on the use of donkeys as livestock guardians include: (1) Use only a jenny or gelded jack (intact jacks are too aggressive towards livestock). (2) Use one donkey per flock or group and keep other donkeys or horses away or the animal will bond with them. (3) The donkey should be introduced to the livestock about 4 to 6 weeks prior to the onset of predation to properly bond with the group. (4) Donkeys are most effective in small, fenced pastures. (5) Check with a reputable breeder when shopping around for a donkey. Similar to guard llamas, donkeys do not require special feeding, can be kept penned with the sheep, and live longer than guard dogs.

Supplemental Feeding. Supplemental or diversionary feeding as a non-lethal technique to divert a predatory species away from a vulnerable commodity for a period of time has received some attention, but has not been tested on coyotes or to prevent predation on livestock. Many predators will readily consume food provisioned by humans. In the northwest U.S., black bear (*Ursus* *americanus*) damage to coniferous trees (they feed on the sapwood during the spring) could be reduced with supplemental feeding (Collins 1999, Partridge et al. 2001). Supplemental feeding should only be used for the duration of protection of the resource that is required, as continued feeding could actually increase the number of predators in an area by increased reproduction and emigration (i.e., a numerical response).

Fencing and Barriers. Livestock and poultry may sometimes be protected from predators with a properly constructed and placed barrier, such as a predator exclosure, electrical fencing, screening, or even a moat (de Calesta and Cropsey 1978, Gates et al. 1978, Linhart et al. 1982, Nass and Theade 1988, Acorn and Dorrance 1998). Some recommendations suggested for predator fencing include: (1) Ordinary fencing will not keep most predators from entering areas as they learn to jump over or dig under the fencing. (2) Many large predators may be deterred or excluded by adding an electrified single-wire strand charged by a commercial fence charger along a wire mesh fence. The electrified wire needs to be placed 20 cm out from the fence and 20 cm above the ground. A fence 1.5 m high with 9 to 12 alternating ground and charged wires spaced 10-15 cm apart is an effective barrier against coyotes (Gates et al. 1978, Acorn and Dorrance 1998). (3) A wire mesh fence can also be used and is more versatile, longer lasting, and can be stretched tighter than a conventional farm mesh wire. (4) Smaller carnivores may be deterred by use of a 0.9-m wire-netting fence placed 0.6-m above ground and 0.3 m below the surface; a 15-cm length of the fence below the ground is bent outward at a right angle and buried 15 cm deep. Fencing gives the additional advantage of increased efficiency during herd management, not often realized by producers. The costs of materials, installation, and maintenance usually precludes the use of fences for protecting livestock in large pastures or under range conditions.

Frightening Devices. Devices such as lights, distress calls, loud noises, scarecrows, plastic streamers, propane exploders, aluminum pie pans, and lanterns have been used to frighten away predators (Acorn and Dorrance 1998). Most testing has been with devices that periodically emit bursts of light or sound to try to deter coyotes from sheep in fenced pastures and open-range situations (Linhart 1984, Linhart et al. 1992), but the benefits are often short-lived (Bomford and O=Brien 1990, Koehler et al. 1990). While all of these devices can provide some level of temporary relief in reducing damage or deterring predators, habituation by the predator to the device is common. The usefulness of the device can be prolonged by frequently changing the location of the devices, changing the pattern of the stimuli, or combining several techniques (Linhart et al. 1992). Using a combination of warbling-type sirens and strobe lights reduced coyote predation on lambs by 44% (Linhart 1984). These battery-operated devices were activated in the evening by a photocell set on a schedule of 10-second bursts at 7- to 13-minute intervals. The use of propane exploders delayed or prevented lamb losses to coyotes for a period of time (Pfeifer and Goos 1982). A recent development used to deter wolf predation is the Radio Activated Guard (RAG) box. This device is activated only when a radiocollared wolf is in the vicinity and its radiocollar activates the collar, preventing habituation of the animal to the lights and siren. This has application only in areas with radioed animals, but can deter endangered predators from causing problems to livestock producers. The use of frightening devices is not widespread, mainly because the use of sirens and strobe lights at night near people is generally not acceptable (Knowlton et al. 1999).

Repellents and Learned Aversions. Presently, there are no commercially available repellents that effectively deters the act of predation. Several noxious compounds have been tested (e.g., thiabendazole, pulegone, cinnamaldehyde, allyl sulfide) with a few of these reducing food consumption among predators. There are some areas where chemicals apparently have repelled animals from certain objects. Quinine hydrochloride and capsaicin appeared to discourage coyotes from chewing on irrigation hoses (Werner et al. 1997), but these repellents do not deter predation. Thiabendazole has been used to condition black bears to avoid beehives (Polson 1983).

Probably one technique that received much heated debate and attention in the past couple of decades was the use of conditioned taste aversion using lithium chloride to reduce coyote predation on sheep. The main problem was that results of these studies were mixed. Some researchers reported success (Gustavson et al. 1974, 1982; Forthman-Quick et al. 1985*a,b*), while others were either unable to replicate those findings or found it to be ineffective in field situations (Burns 1980, Bourne and Dorrance 1982, Burns 1983, Burns and Connolly 1985). While lithium chloride indeed does reduce prey consumption, it apparently does not deter the act of predation. Ten years after extensive field trials using lithium chloride, a survey of the same sheep producers revealed that only one producer still used it (Conover and Kessler 1994). Current available evidence suggests that conditioned taste aversions are either ineffective or unreliable for deterring predation, but may limit food consumption (Knowlton et al. 1999).

Electronic Training Collar. A new device receiving some attention as a non-lethal method to deter predation on livestock is the use of an electronic training (shock) collar usually used for training dogs (Andelt et al. 1999). Using captive coyotes, researchers reported that the training sequence with the electronic collar stopped all attempted attacks on lambs, decreased the probability of an attempted attack, eliminated successive chases, and even caused avoidance of lambs (Andelt et al. 1999). Application may be limited under field conditions because the predator must be captured and the training collar attached (batteries would need to be occasionally changed), but does suggest avenues of future research on response-contingent aversive stimuli that changes the behavior of the predator during the attack phase of a predatory sequence.

Reproductive Interference. In the 1960's there was interest in the use of chemical sterilants to influence the reproductive rate of coyotes (Balser 1964). This interest was based upon the assumption that reduced reproduction would reduce population levels and that fewer coyotes would result in fewer depredations on livestock. Trials with diethylstilbesterol indicated that reproduction among coyotes could be curtailed (Balser 1964, Linhart et al. 1968), but depredation rates were not measured, timing was critical, the approach was impractical without effective delivery systems, and research on this substance eventually ceased (Knowlton et al. 1999). Currently there is renewed interest in reproductive inhibition using either chemical or immunocontraceptive agents (DeLiberto et al. 1998), mainly as a means of changing the predatory behavior of coyotes. Surgical sterilization (tubal ligation and vasectomy) of coyotes was effective in reducing predation rates on domestic lambs without affecting social behavior and territory maintenance (Bromley and Gese 2001*a,b*). Coyote packs with pups killed on average six times more lambs than sterile packs without pups. Among wolves, vasectomies of males has been proposed as a method of population control (Haight and Mech 1997). However, at the present time there are no substances available for fertility control among predators that is species specific. Species specificity may have to be achieved through appropriately designed delivery systems.

LETHAL TECHNIQUES

Many lethal techniques require special training, certification, or licensing in order to use. Several methods are best left to professional specialists trained in wildlife damage management. Some techniques are available for use by livestock producers, but local regulations need to be checked before implementing any of these lethal techniques. Lethal techniques are viewed less favorably by the general public to control predators than non-lethal methods (Arthur 1981).

Livestock Protection Collar. Livestock protection collars (LPC=s) consist of rubber pouches or bladders filled with Compound 1080 attached around the throat of lambs and kid goats (Acorn and Dorrance 1998). The LPC is designed to kill predators when they puncture the bladders during an attack on a lamb or kid. The main advantage of LPC=s is that they kill the problem animal and frequently kill individual predators that have evaded other control techniques (Connolly and Burns 1990, Burns et al. 1996, Blejwas et al. 2002). The LPC comes in two sizes, large and small, with the larger LPC working effectively on larger lambs. The major disadvantages of LPC=s are the initial purchase costs and labor required to place the collars of the lambs or kids, the collar being punctured by thorns, wire, or snags, anticipating which lambs or kids are most likely to be attacked (use of a sacrificial herd has been tried with limited success), and the required training and accountability of the collars (Acorn and Dorrance 1998, Knowlton et al. 1999). Because of the use of compound 1080 in these collars, generally their application is limited and may require assistance from agency personnel.

M-44. The M-44 is a mechanical device that ejects sodium cyanide into an animal's mouth after they pull on the device (Connolly 1988, Acorn and Dorrance 1998). Because of the use of cyanide as the poisoning agent, application of this technique in the U.S. generally requires certified agency personnel. The M-44 consists of a holder wrapped with cloth, fur, wool, or steel wool; a plastic capsule or case that holds the cyanide; and an ejector unit. A spring-loaded plunger ejects the cyanide. When assembled, the components are encased in a tube driven into the ground and baited with fetid meat, a lure, or tallow. When an animal is attracted to the bait and tries to pick up the baited holder with its teeth, the cyanide is ejected into its mouth. Non-target species are sometimes attracted to the bait used on M-44s; however, species specificity can be enhanced by proper site and lure selection. A study on coyotes in California found that the M-44 was not a selective technique in targeting or removing the breeding animals involved in sheep depredations (Sacks et al. 1999*b*). The M-44 is registered and authorized by different agencies for control of coyotes, foxes, and feral dogs, and has numerous restrictions in North America.

Aerial Hunting. Aerial hunting is a commonly used method for reducing predator numbers. Different types of fixed- and rotary-wing aircraft have been used to control wolves, coyotes, bobcats, and foxes in North America. A 12-gauge semiautomatic shotgun is most commonly used with number 4 buck-shot, BB, or number 2 shot. Aerial hunting can be more efficient if a ground crew works with the aircraft. The ground crew induces coyotes to howl by using a horn, siren, voice, or recorded howl. When animals respond, the aircraft is directed to the area by two-way radios. Early morning and late afternoon appear to be the most productive times for aerial hunting. While aerial hunting is species specific, selectively removing the problem animal is questionable without snow cover for tracking the individual from the depredation site. In the U.S., federal law requires each state where aerial hunting is allowed to issue aerial hunting permits; some states also require low-level flying waivers. Regulations should be checked before using this technique and is usually performed by trained agency personnel and pilots.

Denning. A common practice in the intermountain west of the U.S. is the removal of pups from the den to reduce depredations by coyotes. Increased depredations of livestock (mainly lambs) during the spring and summer by coyotes may indicate that a pair of adults is provisioning a litter of pups nearby (Till and Knowlton 1983). Removal of only the pups and leaving the adults in place was equally effective in reducing depredations as removing both the pups and adults (Till and Knowlton 1983). Den hunting is difficult and time-consuming, particularly on hard ground and in heavy cover. Some people use a dog to aid in locating the den. Caution should be taken while digging out dens because of the possibility of cave-ins. Use of a chemical smoke cartridge is often employed to remove the pups. An alternative to denning is the use of surgical sterilization (see Reproductive Interference) on coyotes which worked as effectively without the requirement of finding the den every year and the effect lasted several years (Bromley and Gese 2001*a,b*).

Box Traps. Trapping the problem animal is a technique that producers can often do themselves. Local regulations should be consulted as there may be restrictions of the type of trap that can be used. Box traps are available from several companies in various sizes, materials, and configurations to capture various sizes of predators. Generally, most large predators are difficult to capture in box traps because of their caution and reluctance to enter the confined area of a trap, but can work effectively with smaller carnivore species. Capture of non-target species can occur and selectively removing the offending individual can be problematic when using box traps.

Leg-Hold Traps. Steel leg-hold traps have been used for centuries to remove problem carnivores. Setting of leg-hold traps does require a bit more experience than setting box traps, but is still a technique that producers can do themselves. Local trappers will often offer instruction in the proper use and setting of traps. Local regulations on leg-hold trap use should be consulted before trapping begins; there may be regulations on the types of traps, baits, sets, and trap visitation schedule. In the U.S., some states no longer allow the use of leg-hold traps. Leg-hold traps are manufactured in various sizes for capture of different carnivore species. Modification of traps (e.g., padded jaws) and attachment of a trap tranquilizer device can diminish injuries to the animal (Sahr and Knowlton 2000). Selectively removing the offending animal causing the depredations with a trap can be difficult (Sacks et al. 1999*b*) and capture of non-target species is common. Tension devices should be considered to exclude non-target species (Phillips and Gruver 1996). Success in trapping really depends on the placement of the trap (along travel routes such as dirt roads and trails). The trap can be set unbaited in a trail ("blind" or trail set) or set off the trail and baited with a lure, bait or natural substance (scat or urine). The type of lure and trap location are very important in selectively targeting the intended species. When placed beside a carcass, a trap can catch non-target animals (e.g., vultures, eagles, badgers). In the U.S., many states no longer allow trapping in the vicinity of a carcass. Weather also can affect traps with frozen or wet ground preventing a trap from springing.

Calling and Shooting. Calling and shooting can be used as a means to control certain predators (Coolahan 1990). This technique can be employed by producers, but local regulations should be consulted. Calling and shooting, with or without the help of lure dogs, can be a selective means of removing the offending animals that kill livestock, particularly during the denning and pup-rearing seasons (Sacks et al. 1999*b*). Commercial calls and recorded calls are available from various manufacturers. Open-reed predator or duck calls can be blown to imitate the sound of a rabbit in distress and works well, but requires some practice. Some individual predators can become wise to the call. Conversely, the call may be an effective method to remove a trap-wise animal. Some recommendations to keep in mind when trying to call in a predator: (1) Ensure that the area being called is upwind to prevent the predator from detecting the caller's scent. (2) Have a full view of the area so that the predator will be unable to approach unseen. (3) Avoid being seen by wearing camouflage clothing and hiding in vegetation. (4) Most effective times to call predators are early morning and late afternoon. (5) Calling at night while using a spotlight can be effective, but regulations should be checked.

Hunting Dogs. The expense of hunting dogs often precludes the use of this technique for most producers, but a local houndsman may be employed to remedy a predation problem. Two types of dogs can be used. Dogs that hunt by sight, such as greyhounds, which are kept in a box or cage until the predator is seen, then released to catch and kill the animal (effective only in open terrain). The other type of dog is the trail hound, which follows an animal by its scent. Trail hounds hunt on bare ground; however, heavy dew can make trailing easier. Hot, dry weather makes trailing difficult; therefore, early morning is the most effective time. Several breeds such as bluetick, black and tan, Walker, and redbone, in packs of 2-5 dogs are used as trail hounds. Trained trail hounds are used to catch and "tree" predators, such as raccoons, opossums, bobcats, bears, and cougars. Often these dogs are able to track the offending animal from a kill, thus making this control method highly selective. Local regulations must be consulted prior to initiating this activity.

Snares. Similar to trapping, snaring is a technique that can be implemented by producers themselves, but also requires some level of expertise to be successful and not educate the problem animal by being inexperienced with setting a proper snare. Similar to trapping, snares will capture non-target species, and selectively removing the problem species or individual can be difficult. Snares are made of varying lengths and sizes of wire or cable looped through a locking device that allows the snare to tighten. There are generally two types of snares: body and foot. The body snare is used primarily on coyotes and foxes. This snare is set where the animals crawl under a fence, at a den entrance, or in some other narrow passageway. The device is looped so that the animal must put its head through the snare as it passes through the restricted area. When the snare is felt around the neck, the animal normally will thrust forward and tighten the noose.

The foot snare has been used to capture large predators and is spring-activated (Logan et al. 1999). When the animal steps on the trigger the spring is released, lifting the noose and tightening it around the foot. The foot snare can be used in a bear pen or cubby set. Deer and livestock can be prevented from interfering with the snare with a pole or branch placed across the trail, directly over the set about 0.9 m above the ground. The selectivity of the foot snare may be improved by placing sticks under the trigger that break only under the weight of the heavier animals. Open-cell foam pads can be placed under the trigger pan to prevent unintentional triggering of the snare by small mammals (Logan et al. 1999). Foot snares have advantages over large traps because they are lighter, easier to carry, and less dangerous to humans and non-target animals.

In closing, many different techniques exist to reduce or deter depredations by carnivores. Selectivity, efficiency, and compatibility of the technique should be carefully evaluated prior to implementation. Surveys indicate that non-lethal techniques are readily accepted by the general public (Stuby et al. 1979, Arthur 1981). Surprisingly, compensation programs to ranchers are less acceptable to the public than other non-lethal techniques (Arthur 1981). Among lethal techniques, those methods that are considered cruel and inhumane, or are not selective to the target species, are generally unacceptable to the public (Stuby et al. 1979, Arthur 1981). It can not be stressed enough that no one technique will solve all depredation problems in all situations. Using various techniques in combination will allow one to be able to adjust to the behavior of the target animal and environmental conditions. In areas where carnivore conservation is an issue or endangered/threatened species occur, non-lethal techniques should be considered first, with lethal control only if non-lethal methods fail or are impractical in that current situation. There is the perception that as long as you respond, listen, and are Adoing something@ to solve their depredation problem, livestock producers will appreciate your attempts to help and can lead to acceptance of carnivores in their area. Doing nothing or not responding to their requests for assistance generally leads to the 3 S=s: Ashoot, shovel, and shut-up.@ Being out in the field, responding quickly (usually within 24 hours), and showing that you care about their problem will lead to increased tolerance of carnivores among livestock producers and local communities.

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Table 1. Percent of depredated lambs lost to specific predators for six states in the Rocky Mountain region during 1999 (U.S. Department of Agriculture 2000).

Predator	Arizona	Colorado	Idaho	Montana	Utah	Wyoming
Coyote	60.0	71.1	82.4	79.4	64.2	77.3
Bobcat	B	B	B	B	2.7	B
Eagles	B	B	B	7.1	1.6	10.0
Dogs	26.7	12.2	5.4	1.6	6.4	1.8
Foxes	B	2.2	B	4.8	1 [illegible]	4.5
Cougar	B	3.3	5.4	1.6	15.5	4.1
Bears	B	7.8	4.1	1.6	8.0	2.3
Other[a]	B	B	B	3.2	0.5	B

[a] Other predators include wolves, ravens, vultures, and other animals.

Table 2. Percent of non-lethal methods used by livestock producers to reduce predator losses of sheep and lambs for six states in the Rocky Mountain region during 1999 (U.S. Department of Agriculture 2000).

Method	Arizona	Colorado	Idaho	Montana	Utah	Wyoming
Fencing	21.7	31.3	46.4	36.0	53.6	27.0
Guard dogs	23.2	23.0	55.2	27.5	28.5	36.0
Llamas	60.9	9.1	9.9	22.7	7.4	20.0
Donkeys	6.0	3.4	2.5	15.1	2.3	7.9
Shed lambing	23.8	66.6	45.5	65.6	46.5	55.7
Herding	8.7	7.1	11.3	12.9	11.9	13.4
Night penning	20.4	79.4	50.2	44.4	34.4	53.5
Fright devices	6.3	5.6	7.3	3.3	5.8	9.2