LINES OF DEFENSE:

Coping with Predators in the Rocky Mountain Region

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INTRODUCTION

Abundant wildlife makes the west a unique and desirable place to live. However, it also presents daily challenges for ranchers and even homeowners, who live near wilderness areas. The livelihoods of cattle, goat and sheep ranchers are especially at risk because predators such as coyotes, wolves, bears and cougars are responsible for nearly $60 million in livestock losses nationally. Utah State University Extension, with its state-wide reach, is uniquely qualified to address the needs of both wildlife and agriculture.

Extension has developed this publication to educate and assist livestock producers with a range of predator control options such as guard animals, traps, and/or repellants. The booklet also should help you understand the legal regulations and ramifications of predator control that vary from state to state. For further assistance from Utah State University Extension, please visit our website at www.extension.usu.edu.

Sincerely,
Jack Payne, PhD

Vice President for Utah State University Extension

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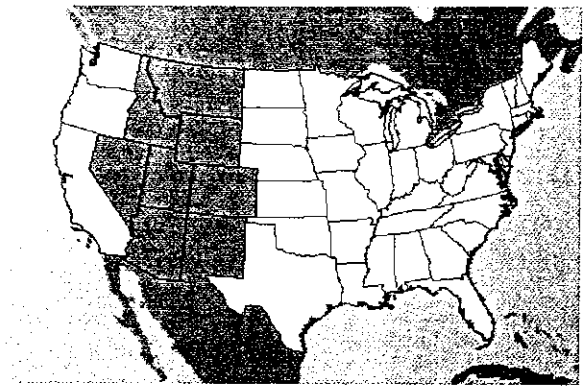


This sourcebook provides information useful to producers of all types of livestock in the Rocky Mountain States. The applicability of this information to specific livestock operations will depend upon the characteristics of the operation and the willingness and ability of producers to experiment with various techniques and procedures. Most producers will have experience with some methods of preventing losses to predators. Information in this booklet may provide new insights or sources of information for learning more about methods of depredation management. The booklet also includes information about techniques others are using, and provides opportunities for producers to contact people willing to share their ideas and whom may also want to learn from experiences of others. We also emphasize current research on predator control by including an up-to-date list of references and encourage producers to learn more about these methods in coming years.

CHARACTERISTICS OF RANCHES AND RANGELANDS OF THE ROCKY MOUNTAIN STATES

In 2004, the eight states of the Rocky Mountain region held about one-third (2.09 million head) of the sheep in the United States (6.1 million head; U.S. Department of Agriculture 2004a). Nationwide, sheep and lamb inventory has been declining over the past decade with declines of 3% from 2003 and 9% from 2002 levels (Figure 1). A relatively small number of producers (5%) operate the largest sheep enterprises in this region, with about 1.08 million head. As in other parts of the U.S., however, the majority of sheep producers in the Rocky Mountain States are small-scale producers with farm flocks. About three-fourths of operators in these states raise sheep in farm flocks encompassing some 422 thousand sheep in 1996, or about 15% of all sheep in the region (U.S. Department of Agriculture 1996).

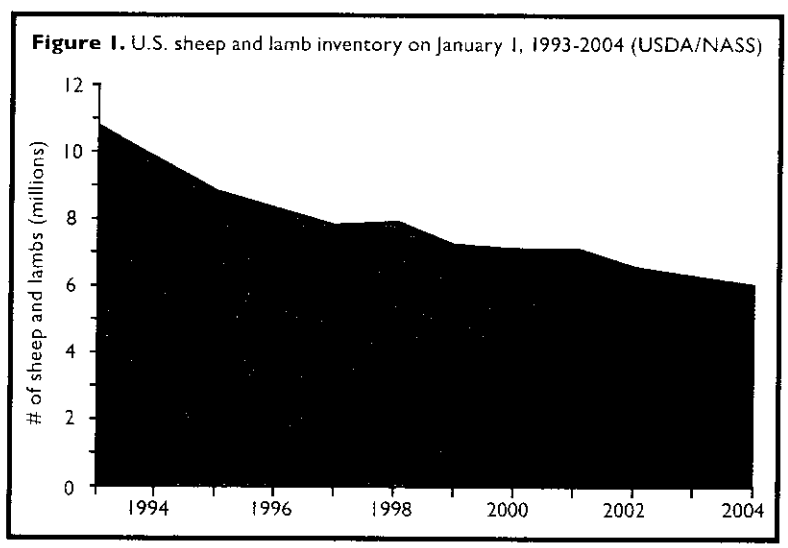


Figure 1. U.S. sheep and lamb inventory on January 1, 1993-2004 (USDA/NASS)

Cattle and calf inventory in the U.S. totaled 94.9 million head in 2004 (U.S. Department of Agriculture 2004b). Beef cattle production is dispersed throughout the U.S., but a significant amount of beef is produced on the rangelands of the western U.S. In 2004, the eight Rocky Mountain States had 11.94 million head (12.6% of national inventory). In the U.S., about 830,000 farms had beef cows in 2000 with almost 12 million cattle on feed annually. The size of the beef industry in the U.S. has declined gradually over the last 15 years from 1.0 million beef cow operations in 1986 to 0.83

million operations in 2000. The total number of beef cows, however, has remained stable at about 33 million head. The total value of the U.S. beef inventory is estimated at $70.6 billion. The beef industry provides more than one million jobs in the U.S., creating a ripple effect in the economy. For every dollar of cattle sales, there is approximately five dollars in additional business activity generated. During the 1990's, U.S. beef production generated more than $30 billion annually in direct economic output, plus about five times that amount per year in related economic output.

Goat meat production and consumption in the United States has historically been so low that statistics have not been routinely collected. However, interest in goat meat production has increased in the past 20 years with a number of marketing studies, conferences, pilot programs, and producer initiatives focused on the perceived potential for increased goat meat marketing in the U.S. In 1977, the first year the USDA began keeping statistics on goats slaughtered at federally inspected plants, some 35,000 goats were butchered nationwide (National Agricultural Statistical Service 1998). By 2000, this number had climbed 12-fold to 548,736 goats. While this number is still small compared to the slaughter data for sheep and cattle, only goat numbers showed a statistical increase during the 1980's and 1990's. Overall, the Food and Agriculture Organization of the United Nations reported 1.35 million head in the U.S. in 2001, although other estimates place the U.S. goat population as high as 5 million.

THE IMPACTS OF PREDATORS ON PRODUCER OPERATIONS

Predators can inflict severe economic damage to producers of domestic sheep, goats, and cattle. In 1999, for example, sheep and goat producers lost an estimated $19.9 million due to predation. In 1995, cattle producers reported losses to predators were worth $39.6 million. Coyotes alone caused $11.5 million in sheep losses, $1.6 million in goat losses, and $21.8 million in cattle losses nationwide.

SHEEP AND LAMBS

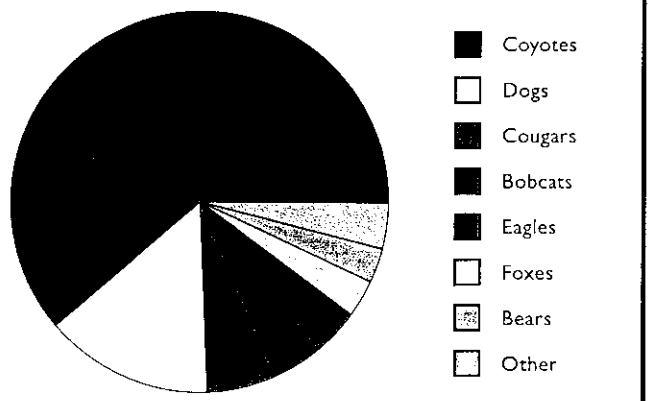
The National Agricultural Statistics Service of the USDA has tracked sheep and goat losses to predators in recent years. A 1999 survey of U.S. sheep producers by the National Agricultural Statistics Service showed total losses of sheep and lambs to predators throughout the U.S. at 273,000 head. This was about 4% of the total sheep and lamb inventory in that year (7.2 million head). The total value of these losses was estimated at $16.5 million dollars. Producers in the eight states of the Rocky Mountain region absorbed about $7 million of these losses, or approximately 42% of the nation's losses of sheep and lambs to predators. Other key states with losses of sheep and lambs were Oregon, California, South Dakota, and Texas, with the latter state leading in both the production of sheep and losses due to predators.

In estimating losses, researchers and producers alike recognize the importance of distinguishing:

- losses of lambs versus adult sheep (lambs are more vulnerable to predators)
- lamb losses before and after docking (lambs are more vulnerable before docking)
- procedures for identifying the predatory animal(s) involved (various wildlife may kill livestock or feed on livestock killed by another predator or dying from other causes. While there are some useful guidelines for identifying the predators involved, it is not practical to determine the cause of death in every case.)

In spite of various limitations, loss estimates usually follow general patterns in terms of relative losses to various predators. In 1999, the National Agricultural Statistics Service reported coyotes caused the majority of sheep and lamb losses to predators. Coyotes accounted for 61% of the losses due to predators (Figure 2). The next highest percentage was dogs at 15%. Mountain lions accounted for 6%, while all other predators each accounted for less than 5% of the losses of sheep and lambs to predators. These other predators included bears, foxes, eagles, and bobcats.

Figure 2. Losses of sheep and lambs to various predators in the U.S. during 1999 (USDA/NASS)



Within the Rocky Mountain region, coyotes have always been the primary predator of sheep and lambs, but there are important regional variations in the losses attributed to various other predators. Table 1 provides producer estimates of lamb losses to various predators in 1999.

Coyotes were the leading cause of depredations of lambs in all eight Rocky Mountain States, accounting for at least 60% of lamb losses to predators in all states except New Mexico. The reduced

Table 1. Percentage of total lamb losses due to specific predators for eight Rocky Mountain States in 1999 (USDA-NASS)

	ROCKY MOUNTAIN STATES							
Predators	Arizona	Colorado	Idaho	Montana	Nevada	New Mexico	Utah	Wyoming
Coyotes	60.0	71.1	82.4	79.4	80.0	50.7	64.2	77.3
Bobcats	(a)	(a)	(a)	(a)	(a)	28.0	2.7	(a)
Eagles	(a)	(a)	(a)	7.1	(a)	9.3	1.6	10.0
Dogs	26.7	12.2	5.4	1.6	(a)	4.0	6.4	1.8
Foxes	(a)	2.2	(a)	4.8	(a)	(a)	1.1	4.5
Cougars	(a)	3.3	5.4	1.6	13.0	5.3	15.5	4.1
Bears	(a)	7.8	4.1	1.6	4.0	(a)	8.0	2.3
Others (b)	(a)	(a)	(a)	3.2	(a)	(a)	0.5	(a)

(a) Unpublished figures.
(b) Other predators included ravens, vultures, wolves, wild pigs, and other animals.

number for New Mexico (50.7%) resulted from a relatively large amount of lamb losses attributed to bobcats (28%). New Mexico producers also reported relatively large numbers of lambs lost to eagles (9.3%). Other states with sizable losses to eagles were Montana (7.1%) and Wyoming (10%).

These numbers are consistent with earlier research findings. Surveys of USDA-Wildlife Services field personnel regarding predator problems with eagles found Wyoming having the largest number of personnel reporting problems with eagles (83%). Other states with over 50% of field personnel reporting eagle problems were Colorado, New Mexico, Utah, and Montana. Problems were concentrated in eastern Montana, eastern and southern Wyoming, as well as northwestern Colorado, west central Utah, and southeastern and central New Mexico.

The 1999 survey of agricultural producers indicated dogs and foxes were also important factors in the loss of sheep and lambs. Dogs were particularly problematic for Arizona producers, accounting for 26.7% of lamb losses to predators. Colorado producers also reported a relatively large number of lamb losses to dogs (12.2%). Montana and Wyoming producers attributed 4.8% and 4.5% of lamb losses to foxes, respectively. With wolf recovery in the Rocky Mountain region and the southwest (Mexican wolves in Arizona and New Mexico), depredations on livestock by wolves may increase for some producers near the main recovery areas. Management of wolves and handling of wolf-livestock interactions will likely continue to be the responsibility of the U.S. Fish and Wildlife Service and USDA-Wildlife Services. If wolves are delisted as Threatened or Endangered species, state agencies will take over management of wolves, but delisting likely may not occur for several years.

Cougars were an especially important problem for producers in Utah, accounting for 15.5% of lamb loss, and for producers in Nevada (13%). Utah producers also saw significant losses to bears (8%), as did Colorado producers (7.8%).

CATTLE AND CALVES

Cattle and calf predation loss throughout the U.S. (excluding Alaska) totaled 147,000 head in 2000. This equates with a loss of $51.6 million to farmers and ranchers due to predation. Coyotes were the primary cause of losses at 64.6% of total head loss. Dogs were the second leading cause (17.7%), followed by cougars and bobcats (7.5%), bears (1.9%), and wolves (1.1%).

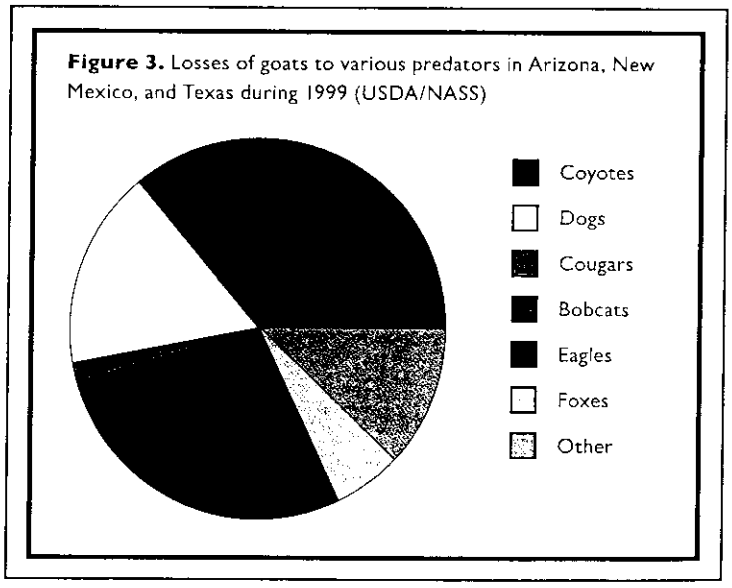


Figure 3. Losses of goats to various predators in Arizona, New Mexico, and Texas during 1999 (USDA/NASS)

GOATS

In 1999, the National Agricultural Statistics Service assessed goat losses to predators in three leading goat production states: Texas, Arizona, and New Mexico. As with sheep and lambs, coyotes were the leading predator of goats, accounting for 35.6% of predator death losses, or an estimated 21,700 head (Figure 3). Bobcats accounted for the next highest loss of goats (19.2%) followed by dogs (17.5%). Other significant predators of goats were cougars, foxes, eagles, bears, wolves, ravens, and vultures. In all, producers in Texas, Arizona, and New Mexico reported losses of 61,000 head of goats in 1999 to all predators at a value of $3.4 million.

PREDATORS

COYOTES

On a national basis, coyotes are clearly the number one predator of sheep, lambs, goats, and cattle. However, research has found the majority of the coyotes diet is comprised of rodents and other small animals. While most coyotes may be potential livestock killers, studies have found that many coyotes do not prey on livestock. Killing livestock appears to be a learned behavior not shared by all coyotes. In some cases, they may be an asset to landowners by defending a territory against other coyotes and keeping other predator numbers low. If a producer is not experiencing loss of livestock to coyotes, removal of a territorial pair may result in the establishment of other coyotes that do prey on livestock. If a problem with livestock loss is identified, control efforts should attempt to target the problem coyotes. This may be both a less expensive and more effective strategy than indiscriminate control efforts which may create other problems.

Coyote predation on livestock may increase during pup rearing, and research has shown that sterilized coyotes kill fewer sheep than coyotes with young. Research has also shown increased losses of lambs may result from reduced buffering by natural prey when natural prey populations are severely reduced.

Several methods have been tested to prevent or reduce depredations by coyotes, including non-lethal procedures such as fencing, herding, shed-lambing, frightening devices, and various removal techniques like leg-hold traps, snares, calling and shooting, and livestock protection collars. These options are described in more detail beginning on page 12. Some options can be used directly by producers; others require a level of training, and some are regulated by state or federal agencies. All require an investment that may not be readily redeemed in the early stages of implementation. For example, fencing to exclude predators requires an investment of materials and labor to install. But, once implemented and successfully reducing predation, the costs can be amortized over several years after the initial investment.

BOBCATS

Depredation on livestock by bobcats generally is not a large problem, but they can cause problems for individual producers in some states. In New Mexico, producers reported a much higher incident of bobcat predation than all other Rocky Mountain States. Lambs and young goats are most vulnerable to bobcats. Several recommended

methods of controlling livestock losses from bobcats include exclusion, fencing poultry and other small livestock near human residences, and clearing brush around farmsteads. Frightening devices such as flashing lights and loud music also appear to provide some relief. Usually, bobcats can be trapped using leg-hold traps, cage traps, or snares, or called in and shot, hunted with hounds, and occasionally aerial gunned (if permitted).

FOXES

Problems associated with foxes include depredation on domestic animals and their potential as vectors of disease organisms (e.g., rabies). Most problems are associated with red foxes, with the smaller foxes (swift and kit) generally not creating problems. Red foxes will prey on small livestock such as ducks, chickens, rabbits, and very young lambs, but they generally do not bother larger livestock. Foxes often carry their prey to a secluded area or their den where it is eaten by the adults and young.

Livestock can be protected from foxes with secure pens, coops, or fencing. Since most predation occurs at night, it is particularly important to provide protection at that time. Foxes will dig or squeeze under poorly maintained fences and may climb over small fences. Some electric fence designs provide reasonably good protection. Outdoor dogs may also keep foxes away. Potential food sources, such as pet food, meat scraps on compost piles, and dropped fruit below fruit trees should be eliminated. Other methods to reduce fox problems include hunting dogs, guard dogs, snares, frightening devices, M-44's, shooting from aircraft, leg-hold traps, denning, and calling and shooting.

COUGARS

Many wildlife professionals believe cougar populations are rebounding. Habitat loss and persecution reduced the lion's North American range to 12 western states, Mexico, British Columbia, Alberta, and a small remnant population in southern Florida. A survey conducted by the Colorado Division of Wildlife in 1991 found that sheep on open range were considered the most significant problem with regard to cougar predation. Arizona Game and Fish investigated the effects of cougar predation on commercial cattle operations in 1995 and found cougar density and predation on calves remained high despite removal of substantial numbers of mountain lions as a result of depredation control efforts. Research is currently using DNA identification methods to identify cougars involved in livestock predation (Ernest and Boyce 2000).

Cougars may prey on domestic stock, including sheep, goats, cattle, and horses. Control techniques for cougars include hunting with hounds, use of guard dogs, or capture with snares and leg-hold traps. Tracking with hounds from depredation sites can be effective in removing the offending individual.

BEARS

Depredation issues involving black and grizzly bears occur in some areas. Because of its status as an Endangered Species, grizzly bear depredation on livestock is handled by federal and state agency personnel. Conflicts with black bears can usually be handled by various non-lethal means. Research into reducing livestock loss to bears indicates fencing, shed lambing, and frightening devices can be beneficial. Livestock losses vary, typically with higher losses in years of low natural food abundance. Techniques for removing bears include hunting dogs, live traps, leg-hold traps, foot snares, and shooting, where legal.

Electric fences can be effective for keeping bears away from cattle and other livestock, and bee yards. Research suggests two to three strands of electrified wire work better than one, electric fence ribbon seems to work better than smooth wire, and inclusion of ground aprons will make it more effective. Where practical, lambs, piglets, calves, or poultry should be brought into barns, sheds or enclosures at night to minimize losses.

The use of frightening devices such as exploder cannons, barking dogs, fireworks, radios, and human effigies with recorders may provide temporary relief in reducing problems, but over time, bears can become very tolerant of such methods. These procedures should be used at the first signs of bear problems. Before using audio repellents, consideration should be given as to the proximity of neighbors and the impacts of the audio repellents on neighbors.

WOLVES

Problems associated with wolves involve predation primarily on cattle, particularly calves, but depredations on sheep also occur. With an estimated 760 wolves in the Rocky Mountain region in 2004, conflicts between wolves and livestock have increased since the initial reintroductions into Yellowstone National Park and central Idaho in 1995 and 1996. Many techniques useful for deterring coyote depredations are also effective on wolves. However, some techniques (guard dogs and llamas) may place the guardian animal at risk. Guard dogs and llamas have been killed by wolves, while coyotes appear to leave guardian animals alone. Use of frightening devices (see page 17) and fencing can be helpful. Aversive conditioning with cracker shells and rubber bullets also appears effective in causing wolves to leave areas with vulnerable stock. Materials and training for this are available from the U.S. Fish and Wildlife Service. The training allows producers to deter wolves from using their pastures. Removal of problem animals currently falls under the jurisdiction of the U.S. Fish and Wildlife Service in cooperation with the Wildlife Services program of USDA. Currently, compensation for verified wolf depredations is available from the Wolf Fund operated by the Defender's of Wildlife.

BADGERS

Badgers generally are not a problem for livestock producers, but on occasion may kill small lambs or prey upon poultry. More of a nuisance is their burrowing and digging in fields which can damage farm machinery or impede harvests. They sometimes burrow into earthen dams or dikes posing risks of flooding or damaging irrigation systems. Badgers primarily feed on small mammals, rabbits, and ground-nesting birds. Frightening devices, leg-hold traps, snares, and shooting are generally used to limit problems associated with badgers.

EAGLES

Golden eagles occasionally kill livestock, particularly very young lambs and kids on open range. Losses can be severe on a very local level. Control techniques for eagles include frightening devices, trapping and relocation, shooting, and husbandry practices. The protected status of eagles requires that permits be obtained from the U.S. Fish and Wildlife Service before dealing with depredations by eagles. Intervention by government depredation control specialists may be required.

IDENTIFYING PREDATORS RESPONSIBLE FOR LIVESTOCK LOSS

Actually witnessing a depredation event is rare. Thus, accurately assessing the event requires a careful examination of the animal and the site. Upon arrival, one should approach the site carefully. Do not trample tracks, feces, blood, vegetation, or other evidence that may help determine the cause of death and the predator involved (if it is predation). Check for signs of predation and the predator involved on the prey item and around the kill site. Extensive hemorrhaging is usually characteristic of predation. If predation is suspected, skinning the carcass (particularly the neck, throat, and head) may provide clues as to the predator involved by examining for subcutaneous (below the skin) hemorrhage, tissue damage, and the size, spacing, and location of tooth marks. Hemorrhaging occurs only if the skin and tissue damage occurred while the animal was still alive. Animals that died from causes other than predation normally do not show external or subcutaneous bleeding. The cause of death is best evaluated if the carcass is examined when fresh. Tracks and scats alone are not proof of depredation or of the species responsible, only that a particular predator visited the site. Other signs associated with a depredation event include injured, nervous, or alert livestock, or females calling or searching for young. All evidence must be considered to determine if the death is due to predation and the species responsible. Many predators will scavenge carcasses and should not be confused with predation.

COYOTES

- Bite marks and subcutaneous bruising and hemorrhaging on the neck and throat
- Bites across the top of the skull may occur with small lambs and kids
- Attacks to sides and hindquarters; often bite nose, especially in young animals
- Spacing of punctures by canine teeth: upper canines = $1^1/_8$ - $1^3/_8$ inches apart
  lower canines = 1 - $1^1/_4$ inches apart
- Feeding usually begins on flank just behind the ribs, consuming organs and entrails
- Tracks are generally 3" (7.5 cm) in length, more rectangular and the toes are closer together than domestic dog tracks

DOMESTIC DOGS

- Bite marks may be on any part of body; "sloppy" killers

- Rarely coyotes also attack in an indiscriminate fashion similar to a dog; conversely, dog attacks can appear similar to those expected from a coyote
- Often dogs consume very little or none of the prey; sometimes "surplus" killing
- Tracks of large dogs can be confused with coyotes and wolves, but dog tracks are generally more round with the toes spread apart as compared to coyotes and wolves

WOLVES

- Generally attack the hindquarters and the flanks; slash marks from the canine teeth may be found on the rear legs and flanks
- Usually eat the viscera and hindquarters first; most of the carcass is typically consumed and large bones may be chewed or cracked open
- If the victim is badly wounded and collapses, wolves may disembowel the animal
- Spacing of teeth punctures are wider than those of a coyote
- Tracks larger than coyote and domestic dog, usually about 5" (12.5 cm) in length

FOXES

- Usually attack the throat of lambs, but may kill by multiple bites to the neck and back
- Often carry poultry away from depredation site leaving only a few drops of blood and feathers
- Eggs are typically crushed and contents licked out
- Spacing of teeth punctures are much narrower than either coyotes and dogs
- Tracks are similar to other canids, but much smaller than either coyote or domestic dog

BOBCATS

- Bite marks typically on the head or back of neck (especially for lambs)
- Subcutaneous hemorrhaging from claw punctures on the neck, back, sides, and shoulders
- Upper and lower canines spaced approximately $^{3}/_{4}$ - 1 inch
- Often feed first on the viscera
- Remains of prey are often dragged away and covered

BLACK BEARS

- Bite marks on spine, skull, and dorsal side of neck; may kill calves by biting them through the forehead
- Claw marks on the neck, back, and shoulders of larger prey
- May kill multiple animals at one time
- Feed on udder and flanks, usually remove but not eat the intestines
- Often "skins out" the carcass leaving the hide intact but consuming most of the body
- Prey remains are often dragged and covered

COUGARS

- Bite marks on back of the neck and skull with massive hemorrhaging
- Canine puncture spacing: upper canines = $1^{3}/_{4}$ - 2 inches
  lower canines = 1 - $1^{3}/_{4}$ inches
- Large claw marks on head, neck, shoulder, flank
- Usually eviscerate the carcass, and eat the organs and leg muscles
- Prey remains are frequently dragged from the site and covered

BADGERS

- Usually destroy the nest of ground-nesting birds
- Often carry parts of lambs and poultry away from the site and buries in holes

- May leave signs of digging near prey remains
- Tracks appear to be coyote-like, but are distinctly pigeon-toed and may leave impressions of their long toenails in certain substrates

EAGLES

- Talon punctures in head and body; hallux (opposing talon) punctures are 4-6 inches from the middle toe wound
- Internal hemorrhaging
- Carcass often "skinned out"
- Consume entrails, organs, sometimes open skull and eat brain tissue
- Ribs frequently "clipped" near the spine on young animals and removed
- Presence of white-streaked fecal deposits

Some leading references of predation research & predator ecology:

- Ministry of Natural Resources (Ontario), Wild Furbearer Management and Conservation in North America (1987), edited by Milan Novak, James A. Baker, Martyn E. Obbard and Bruce Malloch.
- Society of Range Management, Rangeland Wildlife (1996), edited by Paul R. Krausman.
- The Wildlife Society, Identification and Control of Wildlife Damage (1994) by Dolbeer et al., pages 474-506 in Research and Management Techniques for Wildlife and Habitats, edited by Theodore A. Bookhout.

PRODUCER PERSPECTIVES ON PREDATOR LOSSES

As with most things presented in this manual, like the loss statistics reported in the previous section, thoughts of "good news" or "bad news" is a matter of perspective. On the one hand, losses would be much higher were it not for preventative and corrective actions to stop carnivore depredations and the efforts of producers to reduce risks of predator attacks. For example, estimates provided by 125 producers in Colorado indicate their 392 guard dogs prevented losses of $891,440 worth of sheep from predation during 1993. On the other hand, many livestock producers operate on narrow profit margins, and the losses that farmers and ranchers incur can jeopardize the economic viability of their enterprises. It is also true losses to predators have increased since about 1950.

Many producers emphasize the importance of preventative coyote hunting, as well as corrective lethal control measures to reduce losses to coyotes and other predators. Other issues producers specify as important when considering predator management options are:

- Indirect losses involved: management of predators results in loss of time that could be devoted to other activities, including family.
- Efforts to improve lamb survival (e.g., lamb shed) make each lamb lost more costly, in terms of producers' effort/perceptions regarding work invested.
- Producers have to work within individual cultural views of the land. Some view western rangelands as a productive landscape. However, as one rancher observed, many wildlife researchers and/or environmentalists view the western rangelands in terms of "habitats" that are part of functioning ecosystems involving natural (and some introduced) species, but do not consider livestock within that construct. In the former view, the coyote and other carnivores have limited relevance but they are an integral part in the latter.
- The general public falls somewhere in-between. Markets demand cheap food and fiber. At the same time there is political pressure to reduce lethal control of predators, especially where there

is a perception the process is inhumane (e.g., trap bans in various states). There often is popular support for the survival and/or reintroduction of large carnivores.

- Ranchers also value the landscapes and wildlife of the western rangelands and repeatedly support many efforts to enhance wildlife and protect western rangelands (e.g., PARM, Red Canyon Ranch).

Some resources for perspectives on coyotes, predator control, and wildlife damage research:

- Understanding the Coyote, Kansas State University Cooperative Extension, Manhattan, Kansas.
- Coyotes in Kansas by H. Gier, Kansas State University Agricutural Experiment Station, Lawrence, Kansas.
- A Matter of Perspective video from Texas A&M University, College Station, Texas.
- Matter of Understanding—Coyotes video from Kansas State University, Manhattan, Kansas.
- Predator Control and the Sheep Industry, by F. Wagner, Regina Books, Claremont, California.

EFFORTS BY PRODUCERS TO PREVENT LOSSES

In selecting control techniques for specific damage situations, a number of factors must be taken into consideration. These include: the species responsible for the predation, the magnitude, extent, and frequency of the loss, and the likelihood of the loss reoccurring. In choosing a control technique, the biological and legal status of the target species and potential non-target species must be considered, as well as local environmental conditions and possible environmental impacts, and the practicality of available control options.

NON-LETHAL METHODS

Producers spend substantial money, time, and effort on non-lethal methods to prevent livestock losses to predators. For example, farmers and ranchers spent $184.9 million on non-lethal methods to prevent loss of cattle and calves to predators. The preferred methods vary substantially from state to state (Table 2).

Table 2. Non-lethal methods used to prevent losses of sheep and lambs to predators in 1999 (USDA-NASS)

	ROCKY MOUNTAIN STATES							
Methods	Arizona	Colorado	Idaho	Montana	Nevada	New Mexico	Utah	Wyoming
Fencing	21.7	31.3	46.4	36.0	47.3	83.9	53.6	27.0
Guard dogs	23.2	23.0	55.2	27.5	50.7	8.4	28.5	36.0
Llamas	60.9	9.1	9.9	22.7	8.3	70.4	7.4	20.0
Donkeys	6.0	3.4	2.5	15.1	2.8	1.9	2.3	7.9
Lamb shed	23.8	66.6	45.5	65.6	57.0	78.6	46.5	55.7
Herding	8.7	7.1	11.3	12.9	7.5	5.0	11.9	13.4
Night penning	20.4	79.4	50.2	44.4	52.1	86.0	34.4	53.5
Fright tactics	6.3	5.6	7.3	3.3	1.4	3.6	5.8	9.2

What the table does not show is how the methods used vary with the sizes of operations, although this may be reflected in the types of operations that dominate in particular states. Llamas appear to be more popular in the southwestern states of Arizona and New Mexico, possibly due to the many pasture-type operations in the region. Meanwhile, herding is a more significant aspect of preventing losses to predators in states like Idaho, Montana, and Utah, which may be attributable to more open range sheep operations in these states.

A survey of New Mexico producers by J. Allen May in 1994 found that 83% of producers used at least one non-lethal method to reduce losses to predators. Other findings included:

- Calving pens were particularly effective in protection of cattle. Eighteen out of twenty cattle producers in the survey said that this reduced loss to an acceptable level.
- Husbandry techniques, fencing, and guard dogs were effective for cattle, sheep, and goats according to producers who used these techniques. A number of producers found these methods to be effective in reducing predation to an acceptable level. For example, 28% of those who used guard dogs said that the dogs helped reduce losses to an acceptable level.
- However, many other producers did not report the same level of success with these methods, and 90% of producers used lethal control in addition to non-lethal methods.

SELECTING AND USING *LINES OF DEFENSE* METHODS FOR YOUR OPERATION

Successful resolution of conflicts with predators involves a careful consideration of each livestock operation situation (size, terrain, budget, manpower) and types of predators likely to be encountered (Knowlton et al. 1999). The preferred solution in any given situation will be determined by the knowledge and skills of the individuals involved as well as their ability to adapt solutions to the situation at hand.

Control techniques may be considered either preventive (actions taken before any losses occur) or corrective (actions taken after one or more predatory events). Wildlife damage experts emphasize that control methods should not be used haphazardly or in isolation of broader efforts to manage wildlife and wildlife conflicts.

The entire field of wildlife damage management involves state and federal agencies, private organizations, pest control firms, and individual producers. A great deal of coordination is necessary to cope with wildlife conflicts in the most effective and economical manner possible. It includes the responsibility of preserving healthy wildlife populations for future generations.

This coordination is not involved in every situation, but is an important aspect whenever wildlife damage management decisions are made, whether those decisions are about state or federal-level policies or personal decisions regarding the operation of a specific farm or ranch. In general, techniques that require the most coordination are those which potentially have the most impact on wildlife populations (both target species and non-target species) or those which require large-scale implementation to be effective. Most lethal control methods fall in this category and, therefore, frequently require special permits or licensing to be legal.

The selectivity of the techniques and procedures is extremely important when attempting to solve depredation problems. General reduction of local predator populations seldom solves depredation problems, while techniques that selectively remove offending individuals (e.g., livestock protection collars or calling and shooting) are preferred. The degree of selectivity associated with individual techniques (e.g., traps or snares) hinges on the skill of the operator. Identifying the "problem" animal, however, can be very difficult. Methods that are more benign in their effects on other species, mainly non-target species, are preferred.

OPTIONS FOR YOUR *LINE OF DEFENSE* AGAINST PREDATORS

There are four categories of options for your lines of defense in protecting livestock from rangeland predators:

1. Use husbandry practices that deter predators:

- Use good herders and herding practices
- Remove dead livestock and carrion from pastures or ranges
- Confine or concentrate livestock when they are most vulnerable
- Synchronize birthing
- Practice shed lambing
- Your best management practices not only improve your bottom line, they also help reduce time and stress in dealing with predators

2. Use Guard Animals appropriate to your situation:
   - Guard dogs
   - Llamas
   - Donkeys
   - Learn about guard animals. They can be extremely effective, but every animal and every situation presents special considerations and challenges
3. Deter predators with Anti-predator Fencing or Frightening Devices:
   - Good quality fences on your farm are effective at keeping predators, including domestic dogs, out of your pastures
   - Frightening devices have provided temporary relief
   - Reduce the chance of predators reaching your livestock. Let them know that your animals are off-limits!
4. Developing technologies for depredation management:
   - Repellents and aversive agents
   - Electronic training collars
   - Reproductive interference
   - Keep aware of developments as new techniques and procedures are tested

LIVESTOCK HUSBANDRY PRACTICES

Your first line of defense against predators involves using good animal husbandry practices (Robel et al. 1981, Wagner 1988, Acorn and Dorrance 1998). As a general rule, the more effort expended with livestock, particularly during vulnerable periods, the less opportunity predators will have to take animals.

Some recommendations:

- Using herders is a time-tested tradition that can reduce predation in many range situations.
- Dead livestock can attract coyotes and other predators. Removal or burial of carrion will not encourage predators to remain in the area and perhaps learn to kill livestock. Taking carcasses to rendering plants can also be useful, although most rendering plants do not accept sheep carcasses because the wool fouls the rendering equipment.
- 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 just after they are born. Similarly, ewes and cows can be vulnerable following a difficult birth. Removing the afterbirth and stillborn lambs and calves can also reduce attractiveness of the area to predators. Lambs that are weak or light-weight are especially vulnerable to predators and confining them for 1-2 weeks can reduce their vulnerability.

- Shed lambing, synchronizing birthing, and keeping young animals in areas with little cover and in close proximity to human activity can also reduce the risk of predation.

A disadvantage of these procedures is the additional resources and effort they require. Their use 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 ANIMALS

GUARD DOGS

The use of guard dogs to deter coyotes and other predators from livestock traditionally has been used in many European and Asian countries for centuries (Fytche 1998). Many sheep producers in the U.S. are now using this technique, especially those with fenced pastures. It is gaining acceptance throughout the sheep industry (Acorn and Dorrance 1998). In Colorado, 11 sheep producers estimated their guard dogs saved an average $3,216 in sheep losses annually and reduced their need for other predator control techniques (Andelt 1992). Breeds most commonly used as livestock guardians include large dogs such as Great Pyrenees, Komondor, Akbash, Anatolian shepherd, Shar Planinetz, Kuvasz, Karabash, and Maremma. While there is no one breed of dog that is most effective, livestock producers rate the Akbash as more effective at deterring predation because it is more aggressive, active, intelligent, and faster (Andelt 1999). The Great Pyrenees is also a common guard dog breed used to protect flocks of sheep in the western U.S. (Dolbeer et al. 1994).

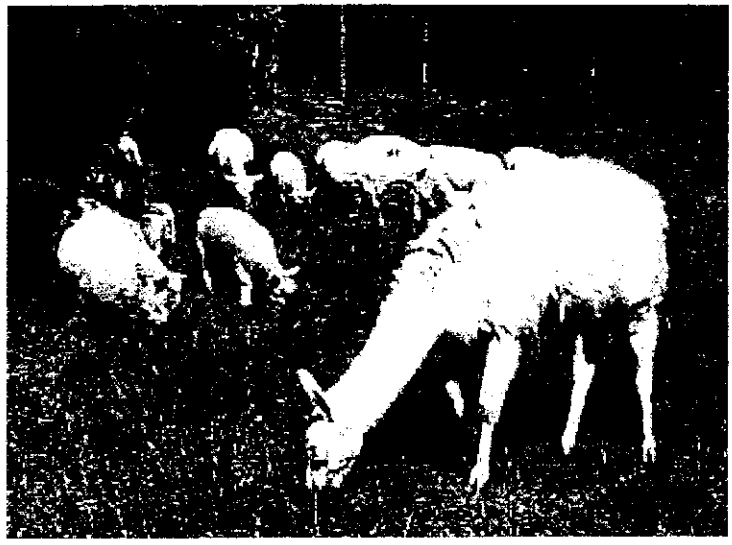
Studies have found the effectiveness of guard dogs to be good in some situations and ineffective in others (Linhart et al. 1979, Coppinger et al. 1983, Green et al. 1984, Green and Woodruff 1987, Andelt and Hopper 2000). The disparity in findings among various studies may be due to the inherent difficulty of guard dogs to effectively protect large flocks of sheep dispersed over rough terrain. In addition, areas with thick cover can conceal approaching predators from the dogs. The effectiveness of guard dogs can be enhanced by confining flocks to more open, fenced pastures allowing a good view of the area. Absence of cover will also deter some predators from approaching the flock.

Training and close supervision of the dogs are important factors for the success of this technique. Introducing the dogs to flocks at an early age (pups 7-8 weeks of age) increases the effectiveness of bonding the dog to the sheep. Seek reputable breeders when purchasing a pup. Some breeders certify their dogs to be free from hip dysplasia and some even guarantee replacements if a dog fails to perform properly. In some cases, poorly trained or supervised guard dogs have killed sheep and lambs, harassed or killed wildlife, and threatened people that intrude into their area. Teaming a guard dog with a herder is a time-tested technique to effectively reduce livestock depredations.

Compared to guard llamas, the main drawback of guard dogs is they need to be fed and watered in the area containing the sheep with the potential of increasing the bond of the dog to humans if the flock is near human habitation. Another disadvantage is their use frequently precludes the use of other control devices (e.g., snares, M-44's) and techniques (e.g., calling and shooting). Dogs can be killed or injured by

M-44's, snares and traps used for predator control and presence of a guard dog can disrupt attempts to call and shoot predators. Guard dogs have been killed by wolves, so caution should be exercised in areas where wolves are present or if wolves are suspected of causing the livestock depredations.

GUARD LLAMAS



Use of llamas for protecting livestock from predators is growing in popularity in the western U.S. Studies have found llamas to be a practical and effective technique to deter predators, mainly coyotes and dogs, from preying on livestock (Markham et al. 1993, Franklin and Powell 1994, Meadows and Knowlton 2000). Much of the llamas defensive abilities comes from their evolution with predators in South America. Llamas can be kept in fenced pastures with sheep or goats, do not require a special feeding program, are relatively easy to handle, and live longer than guard dogs. However, problems with llamas can occur (Fytche 1998). Sometimes the guard llama is over-protective creating difficulties for the shepherd to work. Because of their dislike of canids, guard llamas may attack herding dogs, so precautions should be taken so the llama realizes the dog is part of the operation, or remove the llama when moving the herd. Sometimes the sheep crowd the llama from feeders, so a separate feeder may be needed for the llama that is too high for the sheep to be able to feed. Similar to guard dogs, wolves have killed guard llamas, so caution should be exercised if wolves are the species involved with livestock losses.

Several recommendations have been made when using llamas as livestock guardians:

- Do not use intact male llamas because they can kill or injure ewes when trying 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.
- Use of two or more llamas in single or adjacent pastures is discouraged to avoid having them associate with one another rather than the sheep.
- Some traits that may be useful in selecting a llama for use as a livestock guardian include leadership, alertness, and weight (size) of the llama (Cavalcanti and Knowlton 1998).
- Finding a reputable breeder is a good precaution when looking to purchase a guard llama.
- Flocks in pastures with heavy cover may reduce their effectiveness similar to guard dogs. Open pastures with good visibility are the best for guard animals to work effectively.
- While guard animals may not always deter predators from being near livestock, they may change the behavior of predators when they are in those areas (Knowlton et al. 1999).

GUARD DONKEYS

Similar to guard llamas, donkeys have also been used as livestock guardians (Green 1989, Acorn and Dorrance 1998, Fytche 1998). The protective behavior of donkeys stems from their apparent dislike of dogs. A donkey will bray, bare its teeth, chase, kick, and try to bite coyotes and dogs. Like llamas, donkeys do not require a special feeding program. Sometimes individual donkeys are not

suitable as guardians and require replacement. Bad habits which donkeys may display include pulling wool, picking up lambs, biting off ears, dominating a feeder, separating calves from their mothers, and even killing lambs.

Recommendations on the use of donkeys as livestock guardians include:

- Use only a jenny or gelded jack (intact jacks are too aggressive towards stock).
- Use one donkey per flock and keep other donkeys or horses away since the animal may bond with them.
- 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.
- Donkeys are most effective in small, fenced pastures.
- Check with a reputable breeder when shopping around for a donkey; insure the breeder knows the donkey will be used as a livestock guardian. If possible, get the option to return the animal if it is unsuitable for guard duty.
- Most successful bonding occurs when the donkey grows up with the sheep or cattle.

FENCING AND BARRIERS

Livestock, poultry, and crops may sometimes be protected from predators with a properly constructed and placed barrier (de Calesta and Cropsey 1978, Gates et al. 1978, Linhart et al. 1982, Shelton 1984, Nass and Theade 1988, Acorn and Dorrance 1998, Fytche 1998). This may be the most effective deterrent where high value resources are concentrated in relatively small areas. Barriers may be in the form of a predator exclosure, electrical fencing, nest screening, or even a moat.

Recommendations for use of fencing to deter predators include (Dolbeer et al. 1994, Acorn and Dorrance 1998, Fytche 1998):

- Although few fences are "predator proof" because most predators learn to jump over or dig under such devices, they do offer some deterrence and help define the travel ways the predators are using when coming and going from pastures.
- Larger predators (coyotes, foxes) may be deterred or excluded from areas by adding an electrified single-strand wire charged by a commercial fence charger along a wire mesh fence. The mesh wire must not have spaces larger than 15 cm by 15 cm (coyotes may crawl through spaces larger than 15 cm). The electrified wire needs to be placed 20 cm out from the fence and 20 cm above the ground.
- A high-tensile 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.
- Skunks may be deterred from entering poultry areas with 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 part below the surface is bent outwardly at right angles and buried 15 cm deep.
- Mink and weasels may be excluded from barns or coups by covering all openings larger than 2.5 cm with metal or hardware cloth.
- Wolves have been temporarily deterred from entering or approaching areas with the use of flagging

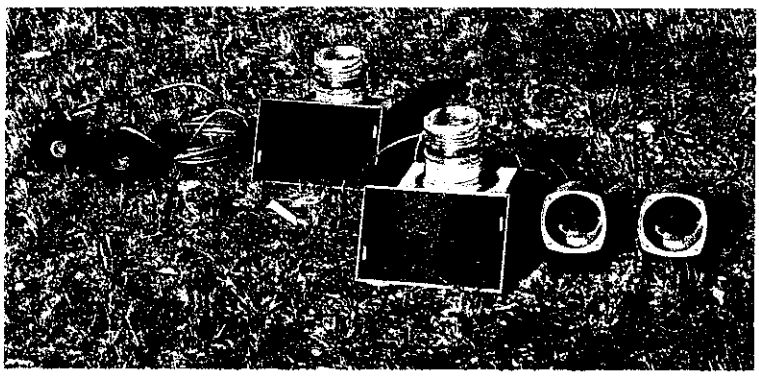
or fladry. Eventually the animals may become accustomed to the flagging and disregard it, but deterrence may last 1-2 months. Some producers suggest they have had success discouraging predators by hanging Christmas ornaments, aluminum plates, or any shiny object on a fence.

- 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.

Fencing also provides another benefit in increased efficiency during herd management, not often realized by producers (Knowlton et al. 1999). Installation and maintenance costs usually preclude the use of fences for protecting livestock in large pastures or under range conditions. Fencing is best suited when protecting high-value commodities in small areas. Black bears in Japan were successfully deterred from entering crops and apiaries using an electric fence (Huygens and Hayashi 1999).

FRIGHTENING DEVICES

Devices with intermittent signals such as lights, distress calls, loud noises, scarecrows, plastic streamers, propane exploders, aluminum pie pans, and lanterns have been tried to frighten away predators (Dolbeer et al. 1994, Acorn and Dorrance 1998). Most testing has been with devices that periodically emit bursts of light or sound to frighten coyotes from sheep in fenced pastures and open-range situations (Linhart 1984, Bomford and O'Brien 1990, Koehler et al. 1990, Linhart et al. 1992), but the benefits are often short-lived. Such devices can provide temporary relief in reducing damage or deterring predators, but the predators commonly habituate to the device in a relatively short time (Knowlton et al. 1999). Changing the location of devices and the pattern of the stimuli, or combining several techniques can prolong the frightening effect (Dolbeer et al. 1994). Using a combination of warbling-type sirens and strobe lights reduced coyote predation on lambs by 44%. 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 also delayed or prevented lamb losses to coyotes for a period of time.



A recent development used to deter wolf predation in the Rocky Mountain region is the Radio Activated Guard (RAG) box and the Movement Activated Guard (MAG) device (Shivik and Martin 2001, Breck et al. 2002, Shivik et al. 2003). The RAG box is a frightening device triggered (activated) by the radio signal of a radio-collared animal. When the radio-collar is in the vicinity it activates the device. This reduces the likelihood of the animal habituating to the lights and siren. This has application only in areas with radio-collared animals, but can deter endangered predators from causing problems to livestock producers (e.g., wolves and grizzly bears). The MAG device is similar but is activated by a passive infrared detector which sets off lights and sounds to scare predators from the area or pasture. The use of frightening devices is not widespread, mainly because sirens and strobe lights going off at night near people is generally not well tolerated (Knowlton et al. 1999). These devices also have the additional advantage of alerting the producer that a radio-collared predator is nearby, thus allowing vulnerable stock to be brought in for the night or brought closer to dwellings until the predator has moved on.

OTHER DEVICES

Some producers reported attaching a bell, flagging, or various objects to some of the animals in their flock discouraged predators from approaching. The novelty of the item seemed to cause the predator to avoid contact with the sheep. Others report adding different livestock (e.g., horses, Highland cattle, goats) to their flock of sheep also acted as a deterrent to predators with some livestock aggressively chasing coyotes from the area.

DEVELOPING AND INNOVATIVE DEPREDATION CONTROL TECHNIQUES

REPELLENTS AND LEARNED AVERSIONS

Presently, there are no commercially available repellents proven effective in deterring predation by carnivores. Various noxious compounds have been tested with a few of these (e.g., thiabendazole, pulegone, cinnamaldehyde, allyl sulfide) causing reduced food consumption among predators. Breaking predatory tendencies is a separate issue.

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, but these repellents do not deter predation.
- Thiabendazole has been used to condition black bears to avoid beehives.
- Researchers in Minnesota reported that black bears could also be discouraged from consuming meals-ready-to-eat (MRE's) on a military reservation by treating the MRE's with thiabendazole.
- Skunks may be repelled from areas with ammonia-soaked cloths or moth balls.
- Coyotes and dogs are repelled by the smell of pulegone (the odor commonly associated with mint), but this has not yet been demonstrated to stop acts of predation.
- Regulatory requirements for chemicals should always be renewed before using them.

One technique that received much attention and heated debate in the past is the use of conditioned taste aversion using lithium chloride to reduce coyote predation on sheep (Burns and Connolly 1985, Forthman-Quick et al. 1985a,b). Results of studies have been mixed. Some researchers reported success (Gustavson et al. 1974, 1982), while others were either unable to replicate those findings or found it to be ineffective under field situations (Burns 1980, 1983; Bourne and Dorrance 1982). While lithium chloride does reduce consumption, coyotes learn to avoid tainted baits and the effects are transitory. Treatment with lithium chloride apparently does not deter the act of predation. Ten years after extensive field trials in Canada 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 with currently known materials are either ineffective or unreliable for deterring predation.

SUPPLEMENTAL FEEDING

Diverting predatory species away from vulnerable commodities for short periods of time has received some attention, but has not been tested for protecting livestock. Many predators readily consume food provisioned by humans. In a recent study, researchers found that while skunks and other predators responded to supplemental feeding, depredations on waterfowl nests remained unchanged. They

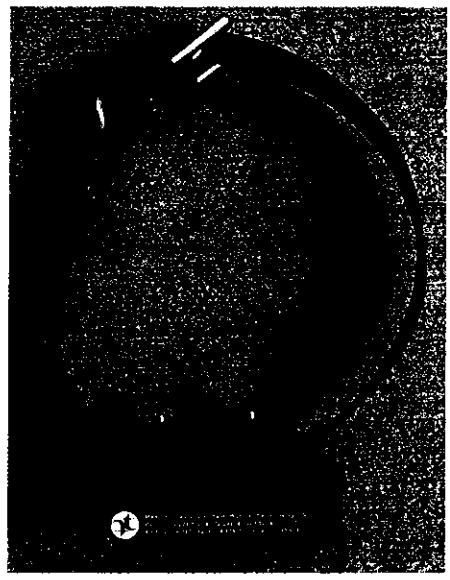
concluded that food provisioning had limited value for managing depredations on waterfowl nests in the Prairie Pothole region because the predator community is large and complex.

In the northwest U.S., black bears damage coniferous trees by feeding on sapwood during the spring. Researchers reported that damage to trees by black bears was highest in areas where bears did not receive supplemental feeding (i.e., pellet feeders). Supplemental feeding reduced bear damage to the trees, but appeared to have no long-lasting effect on bear condition or productivity (Partridge et al. 2001).

While supplemental feeding has only been tested to protect natural resources, it has been theorized that supplemental feeding of black bears could reduce depredations on sheep if the food is placed far from pastures containing flocks, but this remains untested. Supplemental feeding should only be used for the duration required to protect the resource. Continued feeding could actually increase the number of predators in an area by increased emigration or reproduction.

ELECTRONIC TRAINING COLLAR

A new device receiving 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, Shivik and Martin 2001). Using captive coyotes, researchers reported a training sequence with the electronic collar stopped all attacks on lambs, decreased the probability of an attempted attack, eliminated repeated chases, and even caused avoidance of lambs (Andelt et al. 1999). Application under field conditions may be limited because the predator must be captured and the training collar attached plus the battery needs frequent recharging. However the results suggest that response-contingent aversive stimuli can change the behavior of the predator during the attack phase of a predatory sequence (Shivik and Martin 2001). More research is needed to assess the potential for applying this technique.



REPRODUCTIVE INTERFERENCE

In the 1960's there was an interest in influencing the reproductive rate of coyotes with chemical sterilants (Balser 1964). This interest was based upon assumptions 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 (Linhart et al. 1968), but in those studies depredation rates were not measured. Timing of application was critical and the technique was impractical without effective delivery systems. Research on this substance eventually ceased.

Currently there is renewed interest in reproductive inhibition using either chemical or immunocontraceptive agents, mainly as a means of changing the predatory behavior of coyotes. Surgical sterilization (tubal ligation and vasectomy) of coyotes has been shown effective in reducing predation rates on domestic lambs without affecting social behavior and territory maintenance (Bromley and Gese 2001a,b). Male vasectomy has been proposed as a method of population control among wolves (Haight and Mech 1997). However, at present there are no substances available for fertility control among predators that is species specific (i.e., most compounds will affect all mammals). Species specificity may have to be achieved through appropriately designed delivery systems. Research on techniques and procedures for

procedures for reproductive interference continues. This concept appears more widely acceptable to the general public as a means of depredation management.

LETHAL METHODS

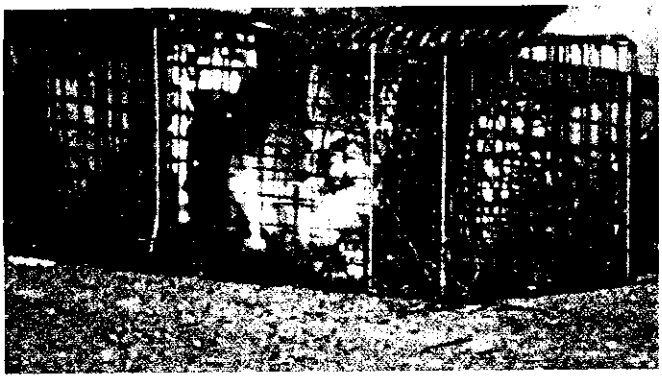
There are a variety of lethal methods for removing predators to reduce livestock losses. Some have been used for hundreds of years, such as cage and leg-hold traps. Leg-hold traps can be modified with padded or offset closures to make them more humane for target animals and to reduce injuries to non-target animals so they can be released back into the wild. Other techniques involve sodium cyanide ejectors, denning, shooting, snaring, and calling.

Often, the most effective strategy to resolve predator losses is to integrate the use of several methods. This is known as integrated pest management (IPM). Using an IPM allows you to reduce losses while minimizing any harmful effects of the control measures on humans, non-target wildlife, and the environment. For example, IPM may incorporate husbandry techniques like shed lambing, use of guard animals, and use of trapping, snaring, or shooting methods.

Many lethal techniques require special training, certification, or licensing. Several methods are best left to professional state or federal agency specialists trained in wildlife damage management. Some techniques are available for use by livestock producers, but state and federal regulations need to be checked before implementing any of these lethal techniques.

BOX TRAPS

Trapping problem animals is a technique producers can often employ themselves. State regulations should be consulted since there may be restrictions of the types of traps that can be used. Live traps are available from several companies in various sizes, materials, and configurations to capture small, medium, and even large predators such as bears. Problem bears can be caught in a live trap made from steel culverts equipped with a trapdoor and triggering device. They are commonly mounted on trailers to permit personnel to easily relocate bears. Generally, coyotes, foxes, and bobcats are difficult to capture in box traps because of their caution and reluctance to enter the confined area of a trap.

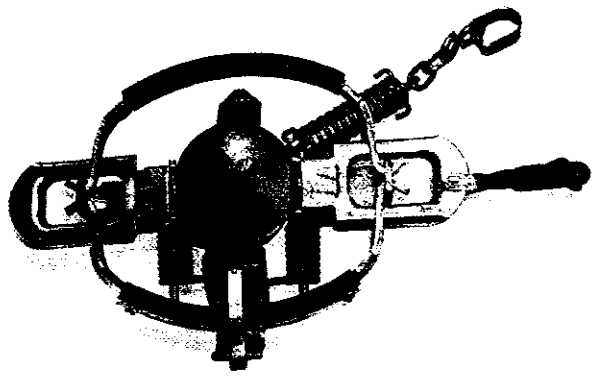


Canned dog or cat foods are effective baits for raccoons, opossums, skunks, and cats (Dolbeer et al. 1994). Traps for skunks can be covered with a canvas or heavy cloth along with a flap for the door. When a skunk is captured, the trapper can walk up to the trap on the covered side and drop the flap over the door allowing the skunk to be transported to a release site. To release, the trapper should stand beside the trap and ease the flap and door open; the trap may need to be propped open to allow the animal to leave when its ready (Dolbeer et al. 1994). In many instances, professional personnel humanely euthanize captured predators under the assumption releasing animals into already occupied habitats places them at undue and unjustified risk.

LEG-HOLD TRAPS

The use of leg-hold traps requires more experience than setting box traps, but is a technique producers can do themselves. Local trappers often offer instructions in the proper use and setting of traps. State and local regulations on use of leg-hold traps vary from state to state. Local authorities should be consulted

before traps are used. Most states have regulations on the types of traps, baits, sets, and trap visitation schedules. Some states no longer allow the use of leg-hold traps. Leg-hold or steel traps are manufactured in various sizes. Modification of traps (e.g., padded jaws) and attachment of a trap tranquilizer device can greatly diminish injuries to the animal (Sahr and Knowlton 2000). Pan tension devices should be considered as a means to exclude non-target species (Phillips and Gruver 1996).



The following trap sizes are recommended for the animals listed (Dolbeer et al. 1994):

#0 and 1: weasels, ground squirrels

#1 and 1½: skunks, opossums, mink, feral cats, muskrats, eagles

#2 and 3: foxes, raccoons, small feral dogs, nutria, marmots, mountain beavers

#3 and 4: bobcats, coyotes, large feral dogs, badgers, beavers

#4 and 4½: wolves

#4½ and 114: cougars

Selectively removing offending animals responsible for depredations with the use of traps can be difficult (Sacks et al. 1999). Success in trapping 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 (a "blind" or trail set) or set off the trail and baited with a lure, bait or natural substance (scat or urine). A dirt-hole set is effective for raccoons, foxes, and mink. Lure selectivity is very important for the target species. The location of a trap set also influences its selectivity (Dolbeer et al. 1994). When placed beside a carcass, a trap can catch non-target animals such as vultures, eagles, badgers, and other non-target predators. Many states no longer allow trapping in the vicinity of carcasses. Weather also affects the efficacy of traps. Frozen or wet ground can prevent traps from springing or slow their rate of closure. Problem eagles can be captured with a foam rubber padded leg-hold (No. 1½), but requires state and federal permits.

SNARES

Similar to trapping, snaring is a technique producers can implement, but generally requires a level of expertise to be successful. Improperly set snares by inexperienced personnel can alert problem animals and reduce the likelihood of success. Snares are made of varying lengths and sizes of wire or cable looped through a locking device that allows the snare to tighten but not relax (Dolbeer et al. 1994, Acorn and Dorrance 1998). There are two types of snares: body and foot snares (Dolbeer et al. 1994). The body snare is used primarily on coyotes and foxes. This snare is set where animals crawl under fences, at den entrances, or in narrow passageways. The loop of the device is placed so the animal puts 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 generally is spring-activated (Logan et al. 1999). When the animal steps on the trigger a spring is released which then lifts and tightens the noose around the leg or foot. The foot snare is commonly used in a pen, trail, 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, or a pan tension device,

under the trigger that requires some minimum weight before the snare is triggered (Dolbeer et al. 1994). Closed or open-cell foam pads can be placed under the trigger pan to prevent unintentional triggering of the snare by small mammals as well as preventing dirt from infiltrating under the pan and inhibiting trigger function. Foot snares have advantages over large traps in that they are lighter, easier to carry, and less dangerous to humans and non-target animals (Dolbeer et al. 1994). Development and testing of new and improved power snares is continuing.

CALLING AND SHOOTING

Calling and shooting, oftentimes called critter or predator calling, can be used as a means to remove coyotes, bobcats, and foxes (Coolahan 1990, Acorn and Dorrance 1998). Producers can use this technique, but local and state regulations should be consulted. Calling and shooting, with or without the help of lure dogs, can be a selective means of removing the offending coyotes that kill livestock, particularly during the denning and pup-rearing seasons (Sacks et al. 1999). Commercial calls and recorded calls are available from various manufacturers or outlets. Open-reed predator or duck calls can be blown to imitate the sound of a rabbit in distress. They can be effective, but require practice. Some predators become "wise" to the call but, conversely, calling may be an effective method to remove a trap-wise animal. Calls imitating a pup in distress can also attract the adults.

Generally, four factors should be kept in mind to successfully call predators (Dolbeer et al. 1994):

- Ensure the area being called is upwind from the caller to prevent the predator from detecting the caller's scent before the animal comes within shooting range.
- Have a broad view of the calling area so a predator is unable to approach unseen.
- Avoid being seen when approaching and establishing your calling position.
- Minimize detection by wearing camouflage clothing and hiding in vegetation.

The most effective times to call predators are early morning and late afternoon (Dolbeer et al. 1994). Hunters can gain another advantage by locating an animal beforehand by inducing howls. Calling at night and using a spotlight can also be effective; however, state game laws should be consulted (Dolbeer et al. 1994).

DENNING

Increased depredations of livestock (mainly sheep) and poultry during the spring and summer by coyotes and foxes may indicate a pair of adults is feeding a litter of pups nearby (Till and Knowlton 1983, Dolbeer et al. 1994). During the spring and summer, adults will increase their food requirements for provisioning of pups. A study in Wyoming showed sheep losses to coyotes were dramatically reduced following removal of the pups even when the adults responsible for the depredations were not removed (Till and Knowlton 1983). Digging out dens or use of chemical smoke cartridges are often employed to remove the pups (Dolbeer et al. 1994). An alternative to denning is the use of surgical sterilization on coyotes which worked as effectively as denning, without the requirement of finding the den every year and with the benefits persisting for several years (Bromley and Gese 2001a,b).

Dens are usually located by tracking or observing the adult coyotes, or the use of simulated howling to get the pups to respond (Dolbeer et al. 1994). An active den is evident by hair around the entrance, fresh tracks, and, if the pups are large enough to come out of the den, matted and worn vegetation around the entrance and small pup scats. Dens may also have prey remains scattered about the den area. Den hunting is difficult and time-consuming, particularly on hard ground and in heavy cover (Dolbeer et al. 1994). Sometimes dogs are used to aid in locating dens. A call imitating a frightened

or injured pup sometimes brings adult coyotes within gun-shot range near a den site. Dens can also be located from aircraft. Caution should be taken while digging out dens to avoid the risks of possible cave-ins. These hazards can be eliminated by using gas cartridges to kill the pups in the den. When using gas cartridges, it is important to follow the instructions and insure that all of the den entrances are blocked (sealed).

HUNTING DOGS

The expense of maintaining hunting dogs often precludes the use of this technique for most producers, but a local houndsman can be employed to remedy some predation problems. Two types of dogs can be used for predator removal (Dolbeer et al. 1994). Dogs that hunt by sight, such as greyhounds, which are restrained until a predator is sighted, are then released to catch and kill the animal (typically 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, snow or heavy dew can make trailing easier. Hot, dry weather makes trailing difficult; therefore, early morning provides the most effective hunting time. Packs of two to five dogs are generally used. Several breeds such as bluetick, black and tan, Walker, and redbone are used as trail hounds. Trained trail hounds are used to catch and "tree" raccoons, opossums, bobcats, bears, and cougars (Dolbeer et al. 1994). Often these dogs can track offending animals directly from a kill site, thus making this control method highly selective. State regulations must be consulted prior to initiating this activity.

LIVESTOCK PROTECTION COLLAR

Livestock protection collars (LPC's) consist of rubber pouches or bladders filled with Compound 1080, sodium monofluoroacetate, attached around the throat of lambs and kid goats (Connolly 1980, Burns and Mason 1997, Acorn and Dorrance 1998). The LPC is designed to kill predators (mainly coyotes) when they puncture the bladders during an attack on a lamb or kid. The major advantage of LPC's is that they selectively remove the problem animal directly involved in the act of depredation (Connolly and Burns 1990, Burns et al. 1996). In addition, LPC's frequently kill individual predators that have evaded other control techniques (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 using LPC's are the initial purchase costs, labor required for their application, collars being punctured by thorns, wire, or snags, anticipating which lambs or kids are most likely to be attacked, as well as the training and accountability of the collars required due to the presence of a toxic substance. Because of the use of Compound 1080 in these collars, generally their application is regulated and limited, and requires assistance from state or federal agency personnel (Wade 1985). Use of LPC's is legal only in certain states.

M-44

The M-44 is a mechanical device that dispenses sodium cyanide directly into an animal's mouth when it triggers the device by pulling on it with its mouth (Connolly 1988, Dolbeer et al. 1994, Acorn

and Dorrance 1998). Because cyanide is a toxicant, use of this tool is generally limited to certified agency personnel, but some states permit producers to be trained in its use. 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 a 7-cm spring-loaded ejector unit to eject the cyanide (Dolbeer et al. 1994). 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. Canids, skunks, raccoons, bears, and opossums are sometimes attracted to the bait used on M-44s; however, species specificity can be enhanced by proper site and lure selection (Dolbeer et al. 1994). One study on coyotes in California suggested the M-44 did not selectively target or remove breeding animals involved in sheep depredations (Sacks et al. 1999). The M-44 is registered and authorized by various agencies for control of coyotes, foxes, and feral dogs. Numerous restrictions apply to its use.

AERIAL HUNTING

Aerial hunting is commonly used by USDA/Wildlife Services in open rangeland areas as both preventative and corrective depredation control methods, particularly for coyotes (Wade 1976, Wagner and Conover 1999). Aerial hunting is most effective when there is snow on the ground and deciduous foliage is off of trees to enhance tracking and spotting the animals. Aerial hunters typically use a 12-gauge semiautomatic shotgun with #4 buck-shot, BB, or #2 shot (Dolbeer et al. 1994). A ground crew can enhance results by using calling equipment to induce coyotes to howl and then directing the aircraft toward the responding animals. Early morning and late afternoon hours are usually the most productive times for aerial hunting (Dolbeer et al. 1994).

Because aerial hunting is dangerous and requires specialized skills, it is also carefully regulated and is usually performed by federal agency personnel and pilots, although private contractors can be licensed. Federal agents also work closely with state wildlife management agencies in performing aerial hunting of state managed wildlife species to enhance big game populations. Federal law requires private citizens who perform aerial hunting to obtain state permits. Some states also require low-level flying waivers. State USDA/Wildlife Services offices can provide additional information for specific states (see listings below).

LEGAL INFORMATION REGARDING PREDATOR CONTROL IN THE ROCKY MOUNTAIN STATES

Most predators may be killed by agricultural producers to prevent them from killing or injuring livestock. It is essential to check state regulations before proceeding, since regulations are state specific, and some methods and techniques are unlawful (e.g., certain poisons) or have specific limitations attached to their use. Because state regulations are frequently changing, it is impractical to provide reliable up-to-date information for each state in this manual. Directly contacting the respective state or federal agency for the most current regulations is encouraged and necessary to remain legal.

STATE-BY-STATE INFORMATION

ARIZONA

Information from the Arizona Department of Game and Fish can be found at http://www.gf.state.az.us. On March 13, 2000, the Arizona Game and Fish Department formed a Predator Management

Team to develop a plan involving the public addressing a proposed Draft Arizona Game and Fish Commission Predator Management Policy. A copy of the final draft can be found at http://www.gf.state.az.us/w_c/predator_management.html. The Arizona state office of USDA-Wildlife Services can be reached at (602) 870-2081.

COLORADO

A permit or permission from a district wildlife manager with the Colorado Division of Wildlife is required to possess or relocate wildlife. Relevant revised statutes are as follows:

Colorado Revised Statutes 33-3-106-3 Excessive damage - permit to take wildlife - harassment by dogs states: "Nothing in this section shall make it unlawful to trap, kill, or otherwise dispose of bears, mountain lions, or dogs in situations when it is necessary to prevent them from inflicting death or injury to livestock or human life and additionally, in the case of dogs, when it is necessary to prevent them from inflicting death or injury to big game other than bear or mountain lion and to small game, birds, and mammals."

Colorado Revised Statues 33-6-130 Explosives, toxicants, and poisons not to be used states: "Unless permitted by law or by the division, it is unlawful for any person to use toxicants, poisons, drugs, dynamite, explosives, or any stupefying substances for the purpose of hunting, taking, or harassing any wildlife."

Up-to-date information is available at http://www.coopext.colostate.edu/wildlife/cdow_permits.htm. The Colorado state office of USDA-Wildlife Services can be reached at (303) 236-5810.

IDAHO

Information on regulations in Idaho can be obtained on the web page of Idaho Fish and Game at http://www2.state.id.us/fishgame. The Idaho state office of USDA-Wildlife Services can be reached at (208) 378-5077.

MONTANA

Many producers in Montana are currently concerned about possible losses of livestock to wolves and the options available to them to prevent or recoup the cost of these losses. Livestock producers can obtain assistance to reduce depredation risks from Montana Fish, Wildlife, and Parks, and producers are allowed to harass wolves, or to kill wolves caught attacking, killing or threatening their stock. In addition, to remove a wolf causing chronic conflicts, a livestock producer can receive a special permit to kill wolves. All such incidents must be reported to FWP and an investigation will follow. This is consistent with current state laws that address the protection of human life and private property when they are in imminent danger.

General information on regulations regarding predator control to reduce livestock losses can be found at: http://www.fwp.state.mt.us. The Montana state office of USDA-Wildlife Services can be reached at (406) 657-6464.

NEVADA

Information from the Nevada Department of Wildlife can be found at: http://www.ndow.org. Permit applications for aerial depredation, wildlife depredation, and trap registration can be accessed from this site. The Nevada state office of USDA-Wildlife Services can be reached at (775) 784-5081.

NEW MEXICO

New Mexico Department of Game and Fish at http://www.gmfsh.state.nm.us provides information about living with predators and regulations on removing problem animals. The New Mexico state office of USDA-Wildlife Services can be reached at (505) 346-2640.

UTAH

The Utah Department of Agriculture has a web page containing information regarding pesticide use and animal control: http://www.rules.utah.gov/publicat/code/r068/r068-007.htm. It also contains a link to study and training guides for vertebrate animal pest control. This guide contains information about the legal status of various predators in the state of Utah and methods of controlling each of them. General information from the Utah Division of Wildlife Resources can be found at http://www.wildlife.utah.gov. The Utah state office of USDA-Wildlife Services can be reached at (801) 975-3315.

WYOMING

Information on regulations can be obtained at http://gf.state.wy.us for the state of Wyoming. Producers experiencing losses due to predation can apply for permission to remove problem animals under the Wyoming Fish and Game Commission Regulations, Chapter 34 - Depredation Prevention Hunting Seasons. Producers can also request that agency personnel remove problem animals as per Chapter 56 - Regulation Governing Lethal Taking of Wildlife. The Wyoming state office of USDA-Wildlife Services can be reached at (307)261-5336.

OTHER MANUALS AND EXTENSION PUBLICATIONS

A leading source of information for all types of wildlife damage is a manual, "Prevention and Control of Wildlife Damage" (1994), edited by Robert M. Timm and published by the Nebraska Cooperative Extension Service. This is a two-volume set of fact sheets on all kinds of wildlife, from large carnivores to rodents. The manual also includes fact sheets on how to obtain assistance and sources for materials. The 3rd edition is currently out of print, but may be ordered as a computer CD-Rom for $10.00. For ordering information, call (413)796-9916 or write to the following address: Wildlife Damage Handbook, 202 Natural Resources Hall, University of Nebraska, Lincoln, NE 68583-0819. Fact sheets may be viewed individually and downloaded free of charge from the Internet Center for Wildlife Damage Management, http://wildlifedamage.unl.edu.

Sheep Production Handbook, American Sheep Industry Association, $49.95. This publication is a spiral bound notebook covering all aspects of sheep production. The chapter on predator control incorporates information from numerous other publications. There is also a reference section to the handbook that provides contact information for State wildlife agencies, extension agents, and Wildlife Services. The handbook is updated regularly; purchasers of the handbook receive the updates by mail.

A Producers Guide to Preventing Predation of Livestock (1992), USDA APHIS Information Bulletin No. 650.

Managing Predator Problems: Practices and Procedures for Preventing and Reducing Livestock Losses (1980). Kansas State University Cooperative Extension Service, Publication C-620.

Understanding the Coyote (1987). Publication C-578. Kansas State University Cooperative Extension

Coping with Coyotes: Management Alternatives for Minimizing Livestock Losses (1997). Texas Agricultural Extension Service, Publication B-1664.

Procedures for Evaluating Predation on Livestock and Wildlife (1985). Texas Agricultural Extension Service, Publication B-1429.

Coyote Predation of Livestock (1998), Alberta Agriculture, Food and Rural Development, Publication #684-19, 31 pages, $8.00. This is a high quality, color publication dealing with methods of preventing losses from coyotes and other predators. Several useful features of this publication include:

characteristics of attack and feeding behavior of predators (including domestic dogs, coyotes, wolves, bears, and cougars), a simplified table for identifying attack characteristics of various predators on sheep, calves, cows, pigs, horses, and poultry, and an excellent discussion of electric anti-predator fences, including color illustrations. The publication also provides some general information on guard dogs, guard donkeys, and electronic frightening devices, and discusses various types of lethal control of coyotes. Please note that some lethal means of control may not be legal in certain states (contact your local agency).

Fencing with Electricity, Publication #724-6, 47 pages, $10.00. This publication contains greater detail regarding fence construction with detailed illustrations and photos. It also contains helpful information on fence safety, maintenance, and troubleshooting tips.

Much of the information on electric fences is available on the web at:

- Protecting Livestock from Predation with Electric Fences. Revised 1997.
  http://www.agric.gov.ab.ca/agdex/600/684-7.html
- Using Electric Fences to Protect Stored Hay from Elk and Deer. 1993.
  http://www.agric.gov.ab.ca/agdex/600/8400017.html

Methods of Investigating Predation of Livestock, Publication #684-14, 36 pages, $8.00. This publication contains greater detail regarding the identification of a predator species based on evidence at a kill site. Some useful sources regarding smaller predators can be found at:

- Prevention of Predator Damage in Poultry Flocks, Alberta Agriculture, Food and Rural Development, Agdex 450/684-1
  http://www.agric.gov.ab.ca/agdex/400/450_684-1.html
- Predator Damage Control in Cultured Fish. 1999, Alberta Agriculture, Food and Rural Development. http://www.agric.gov.ab.ca/agdex/400/485_685-1.html
- Prevention and Control of Raccoon Damage. 1992.
  http://www.agric.gov.ab.ca/agdex/600/84000016.html

The Berryman Institute at Utah State University (see address below) produces several publications for dealing with wildlife damage issues. For example:

- Raccoons: C. M. Huxoll, T. A. Messmer, and M. R. Conover
  http://extension.usu.edu/files/natrpubs/raccoon.pdf
- Skunks: K. Dunstin, T. A. Messmer, M. R. Conover, L. D. Dotson
  http://extension.usu.edu/files/natrpubs/skunks.pdf
- Overview of Techniques for Reducing Bird Predation at Aquaculture Facilities:
  This bulletin provides guidance regarding the management of avian predators to public and private aquaculture facilities operators and owners throughout North America.
  http://extension.usu.edu/files/natrpubs/birdpre.pdf
- Landowner's Guide to Common North American Predators of Upland Nesting Birds:
  This publication provides information to increase basic understanding of predator/prey interactions and the biology and ecology of common North American predators of upland-nesting birds, their nests, and young.
  http://extension.usu.edu/files/natrpubs/landown.pdf

SOURCES (HOW TO CONTACT)

Alberta Agriculture, Food and Rural Development

Alberta Agriculture, Food and Rural Development has numerous publications of interest to farmers and ranchers. To request a catalog of publications, videos, and CD-ROMS available for purchase, call them at the number listed below. There are free publications on their website: http://www.agric.gov.ab.ca/index.html. Copies of publications may be purchased by calling 1-800-292-5697 or by filling out an online order form: http://www.agric.gov.ab.ca/agdex/000/orderin.html

American Sheep Industry Association

6911 South Yosemite, Suite 200
Englewood, CO 80112-1414
Telephone: (303)771-3500
Fax: (303)771-8200
Email: info@sheepusa.org
http://www.sheepusa.org/

Jack H. Berryman Institute for Wildlife Damage Management

http://www.berrymaninstitute.org/services.htm
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5210 Old Main Hill, NR 206
Logan, UT 84322-5210
Requests can also be sent to Dr. Conover at: conover@cc.usu.edu

Cooperative Extension Service (Leading universities in predation research and information)

Texas A&M University Cooperative Extension
Williams Administration Building
College Station, TX 77843-7101
(979)845-7800; Fax: (979)845-9542
E-Mail: agextension@tamu.edu
http://agextension.tamu.edu/admunits.htm
Publications include:
Procedures for Evaluating Predation of Livestock and Wildlife, by Wade and Bowns. This bulletin explains how to distinguish predation from other causes of wildlife and livestock deaths by examining internal and external carcass features and surrounding evidence.
Predator Management by Rollins. This combination slide set/audiotape program explains how to diagnose predator kills of wildlife and livestock–primarily sheep and goats. There is specific information about various predator species, including their modes of attack.

Kansas State University Agricultural Experiment Station and Cooperative Extension Service.
121 Umberger Hall
Manhattan, KS 66506-3414
(785) 532-5790
http://www.oznet.ksu.edu/
Publications include:
Managing Predator Problems: Practices and Procedures for Preventing and Reducing Livestock Losses. The primary emphasis in this publication is on reducing sheep losses to coyotes and dogs. http://www.oznet.ksu.edu/library/wldlf2/samplers/C620.asp

University of Nebraska Cooperative Extension
Cooperative Extension Division,
211 Agricultural Hall,
University of Nebraska-Lincoln,
Lincoln, NE 68583-0703
(402) 472 2966.
http://www.extension.unl.edu/

Colorado State University Cooperative Extension
1 Administration Building,
Colorado State University,
Fort Collins, CO 80523-4040
(970) 491-6281; Fax (970) 491-6208
http://www.ext.colostate.edu/index.html
Wildlife conflicts information and publications
http://www.coopext.colostate.edu/wildlife/
Has several useful fact sheets at: http://www.coopext.colostate.edu/wildlife/bulletins.html
Livestock Guard Dogs, Llamas, and Donkeys: http://www.ext.colostate.edu/PUBS/LIVESTK/publive.html
Bears: http://www.coopext.colostate.edu/wildlife/bears.html

USDA, National Wildlife Research Center
United States Department of Agriculture
Animal and Plant Health Inspection Service/Wildlife Services
National Wildlife Research Center
4101 LaPorte Ave.
Fort Collins, CO 80521
970-266-6000/970-266-6032 (Fax)
http://www.aphis.usda.gov/ws/nwrc/
The U.S. Department of Agriculture's National Wildlife Research Center is the federal institution devoted to resolving problems caused by the interaction of wild animals and society. The Center applies scientific expertise to the development of practical methods to resolve such problems and to maintain the quality of the environments shared with wildlife.

The Mammal Research Program: http://www.aphis.usda.gov/ws/nwrc/MammalHomePage.htm. This site contains information about current research programs at various field stations. Projects related to coyote predation include work on coyote biology, behavior, and ecology, capture systems and aversive stimuli, reproductive intervention, and selective removal strategies.

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