too early to make any definite conclusions about the effectivness of TMAD, the results appear promising. With continued research, it should be possible to develop odor attractants which are both safe and selective and which can be effectively used to resolve animal damage problems.

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# Cost and Other Effects of Predation on an Angora Goat Ranch

**Jerry H. Scrivner, Dale A. Wade, Guy E. Connolly, and L. Charles Howard, Jr.**

The Angora goat industry is an important part of the agricultural economy of Texas. In 1983, Texas had more than 90% of the Angora goats in the United States, with an estimated population of 1.1 million. In 1965, at the peak of the Texas goat industry, there were 4.6 million goats. Since that time goat numbers have steadily declined. A significant factor contributing to the decline of goat numbers has been predation, primarily by coyotes. Predation caused an estimated 73% of all goat and kid deaths during 1982 as compared to only 45% in 1967 (Texas Crop and Livestock Reporting Service 1983, 1979).

Little is known regarding the total economic impact of goat losses to predators. Most dollar estimates of predation impacts have considered only the cash value of livestock killed by predators. The purpose of this analysis was to identify and quantify costs and other effects of predation that generally have been overlooked.

## Study Area

The study was performed on a ranch operated by Mr. and Mrs. L. Charles Howard, Jr., near Meridian, Texas. The Howards operate a small, diversified farm and ranch enterprise in Bosque County in the Grand Prairie ecological area. They produce small grains, hay, and pecans and raise cattle, Angora goats, and a small flock of sheep. During the study, the Howards managed goats on 12 separate pastures, most of which were leased lands. The vegetation is dominantly mid and tall grasses as well as scattered ashe juniper and mottes of live oak trees. About 80% of the soils are very shallow to deep, well drained and are underlain by limestone. The terrain is gently sloping to steep with a gravely or cobbly clayey and loamy surface layer. Principal land uses in the area include livestock grazing of tame pasture, rangeland, and cropland.

The cost of predation on the Howard Ranch was determined for a 3-year period beginning October 1978. Pastures containing Angora goats were usually visited on alternate days unless coyotes were known to be killing livestock, in which case pastures were visited daily. Goats were examined for injuries caused by predators. Vulture activity often was used to identify location of dead goats, including predator kills. Periodically the goats were gathered and counted and the pastures systematically searched on foot and from horseback for suspected dead and/or missing animals.

Predation by coyotes and other species as a cause of death was established from tooth puncture wounds in skin and bones, hemorrahage around tooth marks, and tracks at kill sites. Costs of predation were calculated from livestock loss data and other ranch records. For cost factors identified but not specifically measured at the Howard Ranch, evaluation is based on the literature.

## Discussion

In comparison to 1979, predation losses on properties operated by the Howards were greatly reduced in 1980 and 1981 (Table 1). Confirmed livestock losses to predators reached a peak in 1979, when 106 animals valued at $10,690 were killed. Predators also killed or otherwise caused the death of an estimated 213 kids valued at $15,980. Thus, in 1979 total costs of predation exceeded total income from goats (Wade and Connolly 1980). By late 1979, intensive predator control by several methods, which included experimental use of 1080 toxic collars, reduced coyote numbers in the ranch vicinity and costs due to predation declined accordingly. In 1980, predation losses declined to 62 animals valued at $4,000, and in 1981, 92 animals valued at $5,280 were killed. In 1980 and 1981, total income from the goat operation exceeded costs of production and predation losses.

Authors are postdoctoral researcher, University of California, 4070 University Road, Hopland Field Station, Hopland 95449; Extension wildlife specialist, Texas Agricultural Extension Service, Route 2 Box 950, San Angelo 76901; wildlife research biologist, U.S. Fish and Wildlife Service, Denver Wildlife Research Center, P.O. Box 593, Twin Falls, Idaho 83301; and rancher, Route 2, Meridian, Texas 76665.

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**Table 1. Estimated economic value of Angora goat losses to predation on the Howard ranch for three production years (1 October - 30 September).**

| | 1979 | | 1980 | | 1981 | |
|---|---|---|---|---|---|---|
| | No. of goats | Cost ($) | No. of goats | Cost ($) | No. of goats | Cost ($) |
| Losses due to predation[1] | | | | | | |
| Adults goats killed | 91 | 9,560 | 45 | 3,150 | 50 | 3,050 |
| Large kid goats killed | 15 | 1,130 | 17 | 850 | 27 | 1,430 |
| Small kid goats killed (estimated for 1979) | 213 | 15,980 | 0 | 0 | 15 | 800 |
| Deaths of adult goats to ketosis | 7 | 740 | 0 | 0 | 8 | 490 |
| Deaths of adult goats to parasites and complications | 90 | 9,450 | 0 | 0 | 0 | 0 |
| Lost value of goats sold because of parasites and complications ($40 loss/head) | 90 | 3,600 | 0 | 0 | 0 | 0 |
| Subtotal cost | | 40,460 | | 4,000 | | 5,770 |
| Costs of management to protect goats | | | | | | |
| Labor and travel[2] | | | | | | |
| for predator control | — | 1,680 | — | 1,020 | — | 360 |
| for penning goats at night | — | 1,470 | — | 130 | — | 140 |
| for shed-kidding | — | 3,430 | — | 0 | — | 3,810 |
| Support of a Wildlife Damage Control Specialist | — | 840 | — | 480 | — | 480 |
| Veterinary fees and drugs | — | 820 | — | 0 | — | 530 |
| Extra feed for goats in sheds | — | 640 | — | 0 | — | 800 |
| Cost of purchasing and maintaining 2 guard dogs | — | 0 | — | 1,040 | — | 140 |
| Subtotal cost | | 8,880 | | 2,670 | | 6,260 |
| Total cost | | 49,340 | | 6,670 | | 12,030 |

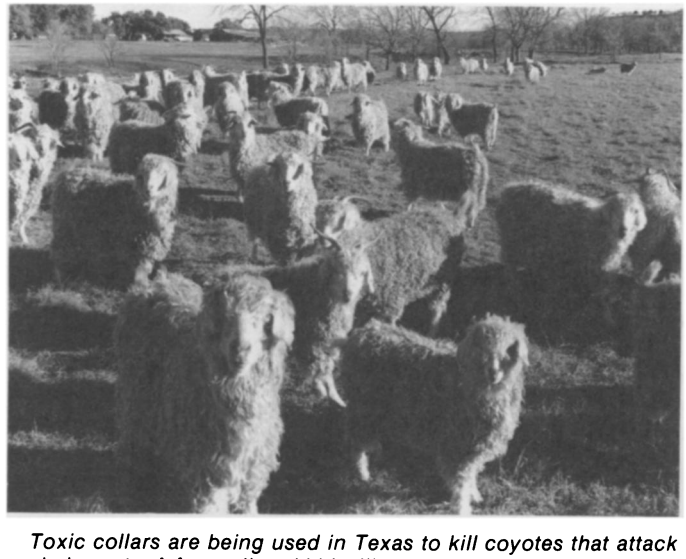
[1]Goat values were for unshorn goats and were valued as follows: 1979 adults @ $105, kids @ $75; 1980 adults @ $70, kids @ $50; 1981 adults @ $61, kids @ $53. The 1979 prices estimated by Wade and Connolly (1980) were revised according to published market reports (The Ranch Magazine 1979-1982, summer issues).
[2]Labor and travel costs of predator control and night penning of goats for 1979 were estimated by Wade and Connolly (1980). Other labor and travel costs were valued, respectively, as follows: 1979, $4.50/h and $0.12/km; 1980, $4.75/h and $0.12/km/ 1981, $5.00/h and $0.14/km.

In addition to cash value at the time of death, predation deaths resulted in future income loses. For example, additional income could have been generated beginning in 1979 had 91 adult goats not been killed and had predators not killed or otherwise caused the death of 213 small kids and 15 large kids and had 90 adult goats not died due to parasites and complications due to penning to reduce predation. Furthermore, repayment of loans on these goats was delayed due to loss of income, causing increased interest costs.

The expense of predator removal to ranchers has several components. First, is the cost of fuel and equipment (i.e. traps, snares, M-44s[1], etc). for predator control. Ranchers also may need to give support to government and/or private animal damage control agents. The direct costs of predator control (not including use of 1080 toxic collars) for labor and transportation, and support of a Wildlife Damage Control Specialist employed by the Texas Rodent and Predatory Animal Damage Control Service on the Howard Ranch from 1979 through 1981 averaged approximately $1,600/year (Table 1).

Aside from removal of predators, management techniques used to protect goats from predation included shed-kidding, penning goats at night, moving goats from problem areas to safer pastures, and the use of guard dogs and scare devices. Costs of such husbandry techniques include fuel, feed, labor, and supplies such as fencing materials and lights.

Shed-kidding was practiced in 1979 and 1981 because of predation in pastures that were normally used for kidding. Although confinement kidding may increase kid crops by protecting them from predation and adverse weather, the Howards prefer to kid on pasture, because the kids generally grow faster, are less subject to illness and also because of a shortage of qualified labor and kidding facilities (shed space, kidding stalls, etc.). Costs associated with shed-kidding include labor, travel, feed, veterinary fees and drugs, loss of



*Toxic collars are being used in Texas to kill coyotes that attack mohair goats. A few collared kids, like 15 at bottom center, were placed in large flocks. Collared kids comprised only 6% of goats exposed to coyotes, but they received 42% of the attacks. USFWS photo by Guy Connolly at Meridian, Texas, March 1981.*

[1]The M-44 consists of baited capsule staked at ground level. When a coyote pulls the baited capsule, sodium cyanide is spring-ejected into the coyote's mouth.

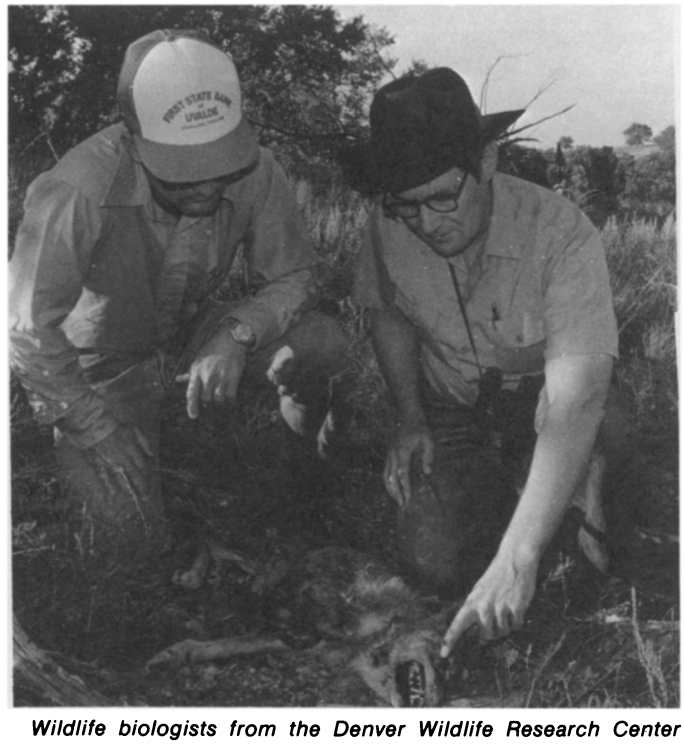
*Remains of a toxic-collared kid mohair goat killed by coyote(s) in Texas are examined by Dr. Dale A. Wade, Texas A&M Wildlife Extension specialist. The collar that contained Compound 1080 appeared to have been broken by the attacking coyotes, but was missing from the dead goat. USFWS photo by Guy Connolly, September 1979.*

adult goats due to ketosis (resulting from rapid changes in feed), and deaths of newborn kids from diseases such as scours and tetanus (Table 1). Disruption of mother-young bonds due to intensive human activity also may have occurred but no attempt was made to quantify this factor.

Night-penning of goats was used to reduce predation losses during all three years of the study. Severe predation during spring and early summer of 1979 caused confinement of 800 goats in a single 9.7-ha pasture of Sudan grass by day and a small corral at night. This unusually close confinement resulted in severe parasite infestations which caused the deaths of approximately 90 adult goats and an unknown number of kids. Many other adult goats were sold at a loss due to poor health caused by this close confinement (Table 1). Only by repeated drenching and moving the goats back to large pastures as coyote predation decreased was the parasite problem alleviated. The greatest single cost, however, was the loss of nearly all kids born in 1979. Weather during the 1979 kidding season was favorable and few kids were lost prior to the onset of predation. With these weather and shed-kidding conditions, the Howards normally could have expected at least 240 kids from approximately 300 breeding nannies. Only 27 kids actually survived, so it was estimated that predators killed or otherwise caused a loss of 213 kids (Table 1).

In addition, night-penning increased labor and transportation costs, as two trips were required each day to pastures where goats were penned, one to pen at evening and another to let the goats out each morning. Costs of labor and travel resulting from night-penning were estimated to be $1,470, $130, and $140 for 1979, 1980, and 1981, respectively. Penning also concentrates goats around the corrals, causing overgrazing at these sites and promoting soil erosion. It often results in decreased productivity due to shortened grazing periods and the increased energy costs due to penning.

In 1980, the Howards bought two Komondor dogs at $450 each in the hope that they would help protect goats from predators. Other costs were not recorded but Green et al. (1980) estimated the annual cost of maintaining a Komondor dog to be $275. One of the dogs refused to work and later died, apparently from heat exposure. The second dog was placed on pasture with a herd after several months of training. This dog appeared to be effective for approximately two months, but killing by coyotes then resumed. The dog also began killing goats. After killing three goats and injuring three others, the dog was removed from use. No further efforts were made to this this technique.



*Wildlife biologists from the Denver Wildlife Research Center examine the carcass of a coyote that died after killing a toxic-collared goat in Texas. The coyote's teeth were stained by dye from the collar. USFWS photo by Guy Connolly, September 1979.*

Other protective procedures used for which no costs were recorded included moving goats from problem areas to safer pastures and operating a radio and lights continuously at the shed during kidding.

The inability to use available range because of the high risk may be the greatest single cost of predation in Texas. We estimated this cost on the Howard Ranch by considering the difference between the number of goats actually owned and the number that would have been owned in the absence of predation. In 1979, when predation was at its worst, an average of 1,100 were present. The rancher had planned to buy 700 additional goats but coyote predation prevented the use of available pastures that would have supported them and labor that would have been divested to management of these additional goats was diverted to predator control. In 1979, gross revenue for mohair clipped from 700 goats would have been approximately $42,000 (7,000 lbs mohair @ $6.00/lb). The difference between the number of goats managed in 1981 and 1980 was 300. Thus, an additional 300 head could have been accommodated in 1980 if predation had been less severe. This represents an additional $11,000 (3,000 lbs mohair @ $3.67/lb) for 1980.

Predation on goats also results in other, less tangible effects. Goats use many browse plants that are relatively unacceptable to cattle and sheep and can be used to control low-growing brush and sprouts after brush has been reduced by chemical or mechanical means. Control of brush can increase soil moisture and activate springs or increase their flow rate. Grazing a mixture of livestock species often allows greater total stocking rates than does grazing by a single species and also can be beneficial to wildlife. In general, diversification of enterprises with cattle, sheep, and goats allows producers to reduce economic risk and permits the flexibility to shift to alternate livestock or crops in response to changing prices, costs, labor availability, and predation. Potential economic returns resulting from proper grazing management and brush control can be significant.

In addition, predation disrupts the social life of ranch families. Family outings may be planned and anticipated only to be cancelled because coyotes have been killing livestock and efforts must be made to reduce predation. Similarly, if predation becomes serious when ranchers are preoccupied with other, time-critical production activities, such as pecan spraying or oat planting, they must decide which has the highest priority and neglect the others. For example, if they continue to spray pecans or plant oats, they risk a serious loss of livestock. If they stop farming activities in order to protect livestock, they may lose part of their crop. Thus, ranchers sometimes operate under excessive stress at times when a decision either way can be extremely costly. While it is difficult to quantify economic and social costs of such factors, they are real and can be severe.

In summary, most studies have underestimated the impact of predation on farm and ranch enterprises since only economic costs associated with deaths were recorded. However, this study of data from one Texas goat ranch and pertinent literature has identified other significant effects which are generally overlooked. These include the costs of animal injuries and/or deaths, management and other procedures used to reduce predation, the inefficient use or loss of forage resources, and other less tangible effects such as the inability to use goats for brush control and added personal stress from constant concern about predation. Consideration of these costs is essential to determine the potential benefits of Angora goat production and the potential costs of predation.

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# Evolutionary Implications for Grazing Management Systems

**Karen A. Platou and Paul T. Tueller**

This paper is meant to deal with grazing systems, an old and complicated topic lying at the heart of range management. In taking readers through a thought process, using simplified and sometimes theoretical concepts, it is hoped that they will be left with new insight on the connection between natural and managed grazing systems, and ecosystem-herbivore interactions in general.

Over time, plants and animals coexisting within a given set of environmental conditions become ecologically dependent through the process of evolutionary selection. In designing grazing systems for livestock production, it may be helpful to look first at how native ungulates and plants have coevolved, thereby generating natural grazing systems. Comparison and evaluation of salient plant and animal features resulting from evolution can suggest characteristics which should be retained in a livestock system to maintain the efficiency inherent in natural grazing systems. This comparison is illustrated with two important North American grazing regions, the Great Basin shrub-steppe, and the Great Plains mid and short grass prairies (Table 1).

The authors are graduate research fellow and professor of range ecology, Department of Range, Wildlife, and Forestry, University of Nevada, Reno, 1000 Valley Rd. Reno 89512.

The authors welcome comments from others on statements which to some may not clearly support applied and theoretical viewpoints, or which may seem overly speculative.

### Great Basin:

The sagebrush-steppe covers over 138 million acres of intermountain cold desert rangeland, from eastern California, across Nevada to western Utah, and from south-eastern Oregon to northwestern Arizona. The range type is classed as Great Basin sagebrush and sagebrush-steppe. Soils underlying the sagebrush vegetation are mostly Aridisols. The arid climate is characterized by an average annual precipitation of 8 to 12 inches but annual variation is on the order of 20%. One-half or more of this precipitation comes as snow during the winter (West 1983). During late spring and summer, essentially no surface-penetrating rains occur. The ground becomes increasingly drier as evapotranspiration is intensified by warm southwesterly winds. Growing conditions are even more limited than the average 100-day frost free period because of inadequate moisture.

As the name implies, the Great Basin shrub steppe is dominated by a mix of brush and grass species adapted to the prevailing climatic and soil conditions. The grasses, which tend to be of the cool-season type, grow rapidly during a