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# A REVIEW OF COYOTE CONTROL RESEARCH

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ABSTRACT: Research on coyote control has lagged behind operational control for several decades. With the current controversy over toxicants and control of coyotes, attention has suddenly been given to the research needs of the problem. In the past research on annual damage problems, particularly predators, was concentrated on coming up with new lethal methods. The picture has changed with a definite need to study the entire problem, including the measurement of losses, the ecology of predators and prey, their behavior, and means of solving loss problems by non-lethal methods or mechanical protection. In any lethal control research, selectivity must be emphasized. The ultimate solutions lie in a greater understanding of all phases of the problem, particularly on ecological and economic considerations, and do not depend solely on the development of one or two more control methods.

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The purpose of this paper is to review the previous and current status of research on coyote control methods in the United States.

During the 1930's, 1940's, and 1950's, research on coyote control methods was largely conducted by one or two individuals in the Bureau with the primary work on food habits of the coyote by Sperry (1941), on control methods in the application of the coyote-getter by Robinson (1943), and 1080 stations by Robinson (1948; 1953). During the late 1950's and 1960's, there was a complete reliance on the existing methods which consisted primarily of steel traps, the coyote-getter, 1080 stations, aerial hunting, snares, denning, and shooting. By 1960, there was not a single research study on the problem of livestock damage and its alleviation or control in the United States. A few short-term university studies were occasionally run on the coyote in the field of ecology -- usually isolated natural history studies such as food habits. Attempts to initiate longer range ecological studies were generally unsuccessful. We are paying for this lack of research today and attempting to make up for it all at once.

There are a number of other reasons why the predator-livestock problem has reached its present proportions. The research on coyote control in the past was largely limited to the search for improved coyote control methods aimed primarily at general population reduction. The predator problem is much broader in its ecological, economic, and sociological implications than the control aspects of coyotes or livestock predators alone. Due to this lack of understanding of all phases of the problem, the livestock industry and agencies involved in predator control are having a difficult time maintaining the necessary level of livestock protection, and gaining public acceptance and understanding of control programs.

Another shortcoming was the absence of research on the evaluation of control methods. A good evaluation of each method of control would have first provided the information to quell many of the current dogmas and second, would have resulted in rapid adjustments in administration and management of control programs when they were off target.

In 1961 the Bureau attempted to broaden its role in coyote control research. Studies were initiated on antifertility agents at the Denver Wildlife Research Center. The concept of antifertility agents to suppress reproduction on and around intensive sheep-production areas was chosen because it was felt to be an improvement over methods requiring removal by lethal means. By the mid-1960's, the program was expanded to a four-five man team concentrating mainly on non-lethal methods, primarily the antifertility agents and tranquilizers to improve the humaneness of steel traps.

Until recently, few state agencies were involved in predator control programs; consequently, there were no research projects involved in control methods and only occasional studies on coyotes were initiated at either universities or by other research groups. There are two basic reasons for this -- lack of funding and a general aversion by the wildlife profession to the area of animal damage control.

The Leopold report (1964) strongly supported predator research but this did not materialize in an increased research effort. With the advent of the Cain report (1972)

and the Executive Order banning the use of toxicants on public lands in 1972, additional funds were programmed into predator damage research in FY 1973 and again in FY 1974.

Following this, the Bureau of Sport Fisheries and Wildlife of the U.S. Department of the Interior, Agriculture Research Service of the U.S. Department of Agriculture (USDA), Economic Research Service of the USDA, the Agriculture Extension Service, through a western regional project, and many universities and other groups have shown an awakened interest in predator research. The area of research has now broadened, perhaps well beyond the ability to proceed in an orderly fashion. Many inexperienced investigators are involved in studies without having a knowledge of the coyote problem or the literature. In the area of coyote literature, we now have some 2,700 references on a computer retrieval system by 93 descriptors and plan to make this available shortly to other researchers. The type of studies now needed generally requires an interdisciplinary effort or a sizable field team to obtain sufficient amounts of data. Finally, the coyote and predator-prey interactions are most difficult and time-consuming to work with in the field.

We are now in the rapid expansion phase of research when proliferation and diversification occur, and it should be recognized that it will take considerable time to realize the results of this research.

In an attempt to help individual investigators become familiar with current research and to provide an exchange of information, the Predator Section of the Denver Wildlife Research Center put out approximately 500 copies of a "Coyote Newsletter" in June 1973. A second issue is being prepared. There is no intention of making this a periodical, but as sufficient material is gathered that will be of interest to everyone, it will be compiled and sent out. It is no substitute for publications so it will not be used for research results or data.

At this point in time, it is difficult to maintain close contact with so many predator research projects because researchers are busy and may be reticent to discuss progress and results. Also, press releases on the entire predator question are not necessarily noted for their accuracy or award-winning potential. For this reason, one cannot blame researchers for avoiding publicity.

Because we do not know the details of all the research going on, and because of the ethical right of researchers to report on their own studies, I will describe the general areas of predator research in terms of the Bureau of Sport Fisheries and Wildlife research program. The Bureau's research program on predator damage research and the breakdown in the Coyote Newsletter follow essentially the same pattern involving three major areas: (1) Damage Assessment, (2) Depredations Control, and (3) Predator Ecology. For the sake of simplicity, we often include another area -- Behavior -- as a subheading under Ecology, but it is a vast area involved with crossties into every aspect of the predator problem.

There are two further areas of research that need to be undertaken, but we have not been able to do so although one or two studies have been initiated by universities. These are in the area of socio-economic studies and disease.

Socio-economic studies involve questions on how value judgments are reached by society and what these value judgments are on predators, predator control, and livestock losses. Such studies should include the tradeoffs society is willing to make between coyotes and food or game animals and not be merely an opinion poll. At present, the methodology appears to be a handicap and other disciplines will have to be called on for assistance.

Wildlife disease research with respect to predators and prey is important. In the absence of control, epizootics often rear their heads as natural controls on both predators and prey, whether direct or indirect. It will be extremely important to understand the role of disease as natural controls if our urban population sentiment forces predator management to back up to natural population regulation. This will result in trading today's problems for a new set of problems tomorrow.

Before we go into detail on livestock losses, some basic statistics of the sheep industry should be reviewed. There are slightly over one billion sheep in the world or one for every three people. Sheep numbers have increased in most of the world in the past several decades except in Western Europe and the United States. One questions whether this is related to labor costs or the standard of living and technological development. The decline in sheep numbers both in eastern and western United States appears to be similar, suggesting there are economic reasons for the decline. Although some of the decline is

reportedly due to predators in the West, dogs and heavy parasitism in the damp climate of the East could cause a decline of equal magnitude. The decline, however, appears to be primarily economic. We do not know all the factors involved, but agricultural research should certainly look into it.

Concerning the problem of losses to predators, approximately 90 percent of the livestock losses in western United States are sheep, primarily lambs. Calf losses amount to about five percent of the total losses west wide but the dollar value, of course, is much higher proportionately. The remaining five percent of losses consists of other domestic species such as goats, turkeys, pigs, etc.

Not counted or measured is a considerable loss of man's companion animals, dogs and cats, etc., to coyotes. Nearly every major city of the West has such problems but the reports of such losses go to a dozen or more local agencies, and it would be very difficult to gather accurate statistics on these losses.

The primary predator involved in livestock predation in the West is the coyote. While larger predators and the domestic dog are involved locally, the numbers and distribution of coyotes across the major sheep ranges of the western United States greatly overshadow any other predator in these environs. In fact, domestic dogs do not survive well in primary coyote range and learn quickly not to venture out from the ranch yard alone when coyotes are abundant.

We can then say that the predator—livestock damage problem is primarily one of coyote predation on sheep. Because of its magnitude, it is the most difficult to solve and is, therefore, receiving priority attention from research.

## DAMAGE ASSESSMENT

The damage assessment research is primarily directed at measuring total losses, then breaking it down by time, and finally cause. Ultimately, we should be able to characterize losses to predators so a more refined management program can be designed to alleviate damage. The following is an outline of the areas of research in damage assessment that have been reviewed. Undoubtedly, there are others but resources prevent us working on more than a portion of the research outline at one time.

I. Predator Damage Assessment

- A. Description and trends of sheep industry
- B. Documentation of sheep losses
- C. Losses in absence of coyote control
- D. Characterization of heavy-loss situations

Most damage estimates to date have been reported through questionnaire type surveys. The primary survey of this type is that run by the Statistical Reporting Service of the USDA, which reports total losses. As stated by Wagner (1972), this sets a ceiling on the maximum losses that might be incurred by predation, but I might point out that first of all, predator control has been applied over the entire range of sheep and continuously through the period of this survey. Therefore, these total loss figures do not indicate what losses would be without control.

Further, we have learned that losses from birth to docking (tail docking, when the first lamb counts are made) are not reported and cannot be determined by simple observations or counts. Without recorded birth rates, there is no base level from which to measure actual losses. Some types of predator losses are indirect. We have witnessed losses due to trampling caused by predator harassment. Other potential losses that can be directly or indirectly caused by predators in addition to outright kills are pile-ups causing multiple deaths, abandonment, abortion, loss of weight, and finally, close herding to protect against predators can cause localized overgrazing, uneven utilization of foliage, and slow growth rates and lighter lambs at marketing.

It would be most difficult to establish values for all these losses, and in many instances, while loss estimates are questioned, it may be just as easy for a rancher to underestimate losses due to predation as to overestimate them.

The problem lies in determining just what these losses are. Review of the literature and studies to date indicate an extremely wide range from none to over 50 percent.

If ten percent of the ranchers suffered 20 percent loss, it would only be a two percent industry loss but we would surely have ten percent of the ranchers going out of business or seriously in debt each year.

A two percent industry loss may not seem serious, but it is about one-half of the reported profit margin of four percent. This is another area that needs study to determine what profit margins are and how predator losses and total losses relate to various livestock operations. Again, this is beyond the scope of our biological studies but should be done by agricultural research.

In general, biological field studies based on search and necropsy techniques indicate predation losses amount to about one percent on ewes and about three to four percent known losses on lambs. In a sense, to attempt to get an average figure for a state or the West is very misleading because it does not give the range of losses.

Measurement of losses is proving to be more difficult than anyone realized. Not only is there little meaning in generalizations or broad averages, most detailed field studies are coming up with a 60 percent to 70 percent rate of unknown losses. The high unknown loss practically destroys any attempts to obtain statistically reliable data. We are attempting to crack this problem with sheep mortality transmitters, but it will take several more years to do so.

I should again point out that all the loss studies to date, whether by questionnaire, personal interview, or field search and necropsy, are with predator control in effect. In addition, the other pressures of man on the coyote and fur harvests, bounties, and sport hunting throw other unknown variables into the equation. What losses would be without control are unknown. We are attempting to measure this by selecting areas where no control will be applied and paying for each loss to predators.

It is only by measuring losses with and without control with a number of replications will we ever be able to measure the value of predator control in reducing losses. This will be expensive and time-consuming.

There are factors in both predator damage research and in the control of damage that do not lend themselves to stock answers or solutions and we might as well indicate now to everyone concerned that man is going to have conflicts with coyotes as long as they both exist.

PREDATION ECOLOGY

The second major area of research involves ecology of predators, prey, and their environment. The following is our working outline for predator damage research in the area of ecology. Again, we are able to undertake only a small portion of it and the problem often boils down to asking a few of the most pertinent questions and setting priorities. These are census, coyote mortality, and food base studies correlated with mortality studies to determine what regulates coyote populations naturally.

II. Predation Ecology

A. Coyote density vs food base
B. Coyote population studies
C. Western states coyote census
D. Coyote census evaluations
E. Impact on natural prey population
F. Modeling predator-prey systems

I might say here that too much attention is given to species such as the coyote, and not enough to the entire predator complex, which is in constant interaction and, most emphatically, not enough attention is given to the environment that supports predators -- hence, the importance of studying not just coyotes but all the interrelationships with their prey, other predator species, and their habitats.

Everyone wants to know something about the status of the coyote. So our first task has been to develop some form of measurements of coyote densities. A coyote index of

abundance was developed (Linhart and Knowlton, manuscript in process of publication) consisting of 50 scent posts at three-to ten-mile intervals on 15-mile transects. A three-foot circle of sifted soil an inch or more deep allows one to read tracks. The frequency of scent stations visited each night for a five-night period is then recorded and provides the relative index of abundance.

One line was established for each 5,000 square miles in 17 western states. Wildlife Services ran the bulk of these lines in 1972 and again in 1973. Changes are shown in the accompanying slides and will be released for publication by the time this is in press. The index of abundance should provide a base for not only measuring population changes but relative carnivore densities and a base against which to compare damage and results of control.

It should be pointed out the coyote is our most dominant and abundant predator of consequence in the western United States. It is in no danger from control or man's activities in the foreseeable future, contrary to what many people believe. Estimates of coyote population densities were reviewed by Knowlton (1972). Densities often vary from one to every one to three square miles to as high as four or five per square mile in south Texas.

In certain poor habitats or in intensively-controlled livestock production areas coyote numbers may be as low as three-five per township.

To refine these estimates for given localities or areas in successive years would cost many times more dollars than the data would be worth. Numbers also vary widely with the seasonal changes due to births and deaths and would be almost instantly outdated. However, one might theorize that with 1,800,000 square miles in 17 western United States at one coyote for every three square miles the estimate would amount to 600,000 coyotes. At one for two square miles it jumps to 900,000 and at one per square mile 1,800,000. Many other states have numbers of coyotes and some areas such as Kansas, Nebraska, Texas, Oklahoma, and Arizona have the highest indicated densities so the numbers could exceed one million in most years at the peak season.

When compared to recorded harvests by control, which rarely exceed 100,000 annually, one can be assured there is little effect of control on total coyote populations. A major consideration that is not understood is that intensive predator control to protect livestock is currently applied mainly to intensive livestock production areas. This amounts to one-fourth to one-third of the land area. Other areas receive only occasional or spot control while still other areas receive no control. It is worthy to note that out of 142,728,000 acres of National Forest land, only 15,359,000 acres are grazed by sheep for an average of 2-1/2 months. The assumption that control blankets the West or has a major impact on coyote populations is in error.

Knowlton (1972) estimated annual mortality rates for adult coyotes at 50 percent and later estimated juvenile mortality at 60 percent. With such mortality rates, population reduction through control efforts is largely replacing later natural mortality and generally is of little significance. Predator control to prevent livestock losses need not be equated with damage to predator populations, particularly when control is applied only on a verified complaint basis.

The studies on coyote population dynamics, predator-prey relations are well underway but must be carried out over the long-term before firm conclusions can be drawn.

Behavior studies were mentioned earlier and the following is an outline of some of the major areas of behavior that are under review.

III. Predator Behavior

A. Behavioral profile of sheep lost
B. Prey selection
C. Prey-switching by coyotes
D. Intraspecific mechanisms
E. Coyote sensory capabilities

Again, behavior studies have many crossties and are of particular need in the area of depredations control. Much of this work is new, but it is being accelerated rapidly at both Denver, Colorado, and Logan, Utah.

Depredations control research is at present concentrated on nonlethal methods, although concepts of selective lethal techniques are not ruled out since they may be ultimately needed. The following outline covers some of the areas under consideration.

IV. Predator Depredation Control

A. Exclusion (fencing)
B. Aversive agents and/or repellents
C. Fright responses of coyotes
D. Chemical screening (toxicants)
E. Application techniques (chemicals)
F. Chemosterilants
G. Anaphylactic sensitization
H. Evaluation of existing techniques
I. Sheep management vs predation

The above plus literally hundreds of ideas have been brainstormed over the years and suggested from many sources. Again, the problem is in sifting and sorting and working on the few that show the most promise. It would be impossible to carry on research in detail on more than a few at a time.

Our current priorities are on repellents, aversive agents, electric fencing, and tranqui1izers -- in that order. One must recognize, however, that to apply repellents, aversive agents, or electric fence to protect upwards of 20 million sheep scattered over about one-fourth to one-third of the 1,800,000 square miles may be mathematically much more impractical and costly than to respond to complaints as they occur and remove offending animals. We have learned over the years that the application techniques are just as important and often more difficult to develop than control tools or chemicals. This applies to traps, toxicants, the airplane, and every other method.

There is often too much attention placed on the control methods and not enough on their application. Whether one likes it or not, the greatest potential in new control methods seems to be in developing selective lethal methods using biodegradable chemicals such as proposed in earlier probes with a lethal collar. This provides little or no environmental exposure or hazards to nontarget species or animals and removes only coyotes that kill sheep. It attacks the problem right at the interface; when the coyote throttles a lamb by the neck.

Regulation of control methods should be through use and application rather than a ban on specific tools or chemicals. Automobiles and guns are not outlawed, but their use may be regulated and abuses punished. Any new control methods will not last unless they are properly applied and administered.

We have left many areas of research untouched and many questions remain to be asked. Before we can answer the necessary questions in all phases of predator damage research, we will need to explore the problems both in greater breadth and depth. In all animal damage control problems we must first know the extent of damage, then we must examine the alternatives for solving the problem. In selecting the controls, equal consideration must be given to effectiveness, safety, selectivity, and environmental impact. And last, when these requirements are satisfied, the needed damage control can be applied. Certainly we would not want the costs of control to be added to or exceed the losses. Nor do we want to cause additional problems through the control efforts. In retrospect, there seems to be times when the above order has been reversed -- apply the control, ask questions later.

We have learned that solving animal damage problems involves more than finding a new control agent or method. And, in the case of the coyote-sheep problem, we have also learned that damage situations cannot always wait for research to come up with all the answers or the ideal control. A proper balance must be maintained between use of existing knowledge and the development of new technology.

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