

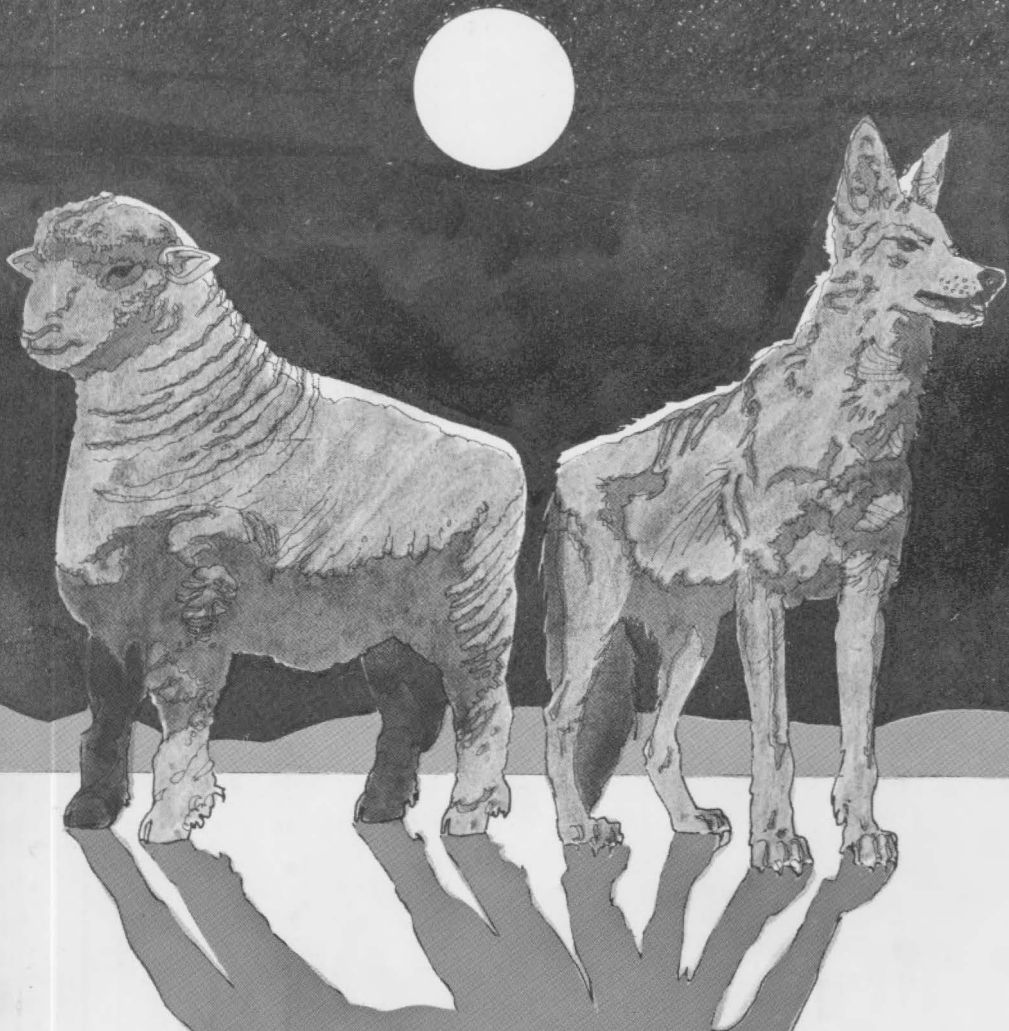
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Coyotes and Sheep

Frederic H. Wagner



44th Faculty Honor Lecture

UTAH STATE UNIVERSITY
Logan, Utah

File

COYOTES AND SHEEP

Some Thoughts on Ecology, Economics and Ethics

FREDERIC H. WAGNER

FORTY-FOURTH HONOR LECTURE

Winter 1972

**Faculty Association
Utah State University
Logan, Utah**



FORTY-FOURTH ANNUAL HONOR LECTURE
DELIVERED AT THE UNIVERSITY

A basic objective of the Faculty Association of Utah State University, in the words of its constitution, is:

to encourage intellectual growth and development of its members by sponsoring and arranging for the publication of two annual faculty research lectures in the fields of (1) the biological and exact sciences, including engineering, called the Annual Faculty Honor Lecture in the Natural Sciences; and (2) the humanities and social sciences, including education and business administration, called the Annual Faculty Honor Lecture in the Humanities.

The administration of the University is sympathetic with these aims and shares, through the Scholarly Publications Committee, the costs of publishing and distributing these lectures.

Lecturers are chosen by a standing committee of the Faculty Association. Among the factors considered by the committee in choosing lecturers are, in the words of the constitution:

(1) creative activity in the field of the proposed lecture; (2) publication of research through recognized channels in the field of the proposed lecture; (3) outstanding teaching over an extended period of years; (4) personal influence in developing the character of the students.

Frederic H. Wagner was selected by the committee to deliver the Annual Faculty Honor Lecture in the Natural Sciences. On behalf of the members of the Association we are happy to present Professor Wagner's paper:

*Coyotes and Sheep: Some Thoughts on Ecology,
Economics and Ethics*

Committee on Faculty Honor Lecture

INTRODUCTION

To many persons not in the profession, the term wildlife management largely connotes the husbandry of fish, birds, or mammals for hunting and fishing purposes. Even if we grant an implied breadth in his use of the term "recreation," Leopold's (1933:3) definition of game management in his classic book by the same name tends to foster this impression: ". . . the art of making land produce sustained annual crops of wild game for recreational use."

Today's wildlife manager assumes a broader scope to his field. That scope includes the management of wild animal populations and their environments for a number of values in addition to the recreational. Preservation of rare and endangered species, and of representative, undisturbed areas of the earth's ecosystems fall within his area of responsibility as does the husbandry of fish and game resources purely for food and other products (cf. Das-mann, 1964). Control of wild animals deemed to be nuisances for one reason or another also falls within this area.

Control of animals which prey on livestock or other wildlife is, of course, part of this latter responsibility. Most wildlifers would agree that predator control is potentially a part of any wild-

life management program, and The Wildlife Society in its position statement on animal control ". . . recognized that control of animals to minimize damage caused by animal populations is an essential element in a sound program of wildlife management." (Anon., n.d.). Indeed, intensive predator control has long been an integral part of wildlife management in Europe.

However, the position of many American wildlife managers on predator control is an ambivalent one. For while it is adopted in principle, as in The Society's statement, it is seldom put into general practice as a measure for increasing wildlife populations for recreational use. The reasons are several. First, there is still a great deal of uncertainty about just how influential predators are in affecting the population levels of game species. Second, even if effective, a general predator control program over an area the size of a state would be extremely expensive. Third, most American wildlifers have a strong ecological background which predisposes them to value the full diversity of the natural world, and to be hesitant over very extreme single-value alteration of the biota for game.

This ambivalence is by no means shared by all groups of the American society. One area in which, until recent years, predator control has been carried out without self-doubt is in the support of agriculture for the protection of domestic animals. In most value systems, the production of food and income is ranked above the esthetic and recreational. And the same singleness of purpose which has plowed under major parts of continents has not questioned the extreme reduction, if not elimination, of predatory animals. Reinforced by the deep-seated prejudice against predators pervading Occidental culture (Allen, 1954) and probably most others, the food-producing incentive prompted the organization of a large, federal predator-control organization during World War I.

The organization grew during the 1920's and 30's, coming to be known in the latter decade as the Division of Predator and Rodent Control in the Department of Interior's Fish and Wildlife Service. Reorganized in the 1960's, it is now called the Division of Wildlife Services in Interior's Bureau of Sport Fisheries and Wildlife. Today the Division employs a staff of over 600 personnel, and operates on a budget of some \$8 million. Over three-fourths of this budget is spent on predator control in roughly that part of the United States west of the 100th meridian, and about 60 percent of the cost is paid by the livestock industry.

Despite its unwanted-stepchild aura to so many American wildlife managers, the size of the federal program, plus the resources and effort pumped into state and local bounties and other control measures, make predator control one of the largest, single wildlife management activities in the United States. Yet, predator control receives scant attention in wildlife management textbooks, perhaps because so many persons in the profession are not aware of its extent, perhaps because of the sensitivities surrounding the subject.

Perhaps in part for these same reasons, predator control has not generally received the research attention needed to give a clear picture (1) of the degree to which different predatory species, and combinations thereof, influence wildlife populations, and (2) of the costs, ecological side effects, and game-population responses to predator control (Wagner et al., 1967). In all fairness, one must say that such studies would be complex and quite costly. Many research administrators doubtless question the wisdom of committing major funds to such studies which, even if they demonstrated favorable game responses, might well point to management programs that would be too costly, socially unpalatable, and ecologically undesirable. Nevertheless, the result is a continued inadequacy in our understanding of the role predation plays in the ecosystem.

If we can rationalize to a degree the reasons why we have not had more research on predator control as a game-management tool, it is more difficult to rationalize the lack of research into predator control to reduce livestock losses. Here we have an established program costing several millions of dollars a year. Even if the federal government did not recognize a responsibility to evaluate it, one would think that the self-interest of the livestock industry would pressure for an examination of what benefit it was realizing from its outlay.

The industry has obviously accepted on faith the assumption that the benefits equaled the cost. But Durward L. Allen, former Chief of Wildlife Research for the Fish and Wildlife Service, has told me that he repeatedly requested funds during the 1950's for evaluation of federal predator control, and his requests never received serious consideration, presumably because such research would arouse the concern of the Predator and Rodent Control Division. In more recent years, since the re-organized Division of Wildlife Services has been under the able and objective administration of Jack H. Berryman, research funds to evaluate the program have still been wholly inadequate. And the industry remains convinced that it is getting value received from its expenditure.

It is a growing environmental awareness in the American public which is beginning to raise ecological, economic, and ethical questions about predator control. An increasingly mobile, outdoors-minded populace is becoming aware of its nation's natural heritage, and is experiencing it and enjoying its diversity. Aware that by statute all wildlife in the United States belongs to the people, that public is beginning to assert that predators have positive as well as negative values and that any predator-management program must rightfully acknowledge and take into account these multiple values.

Aware of this rising tide of public opinion, and himself committed to a plurality of values in our natural resources, Secretary of Interior Stewart L. Udall appointed a five-man committee in 1963 to evaluate predator control. Subsequently termed "the Leopold Committee" after its chairman, A. Starker Leopold, the Committee was given a short period to carry out its survey, but no time or resources to conduct any in-depth research. The report (Leopold et al., 1964), while basically holding that some predator control for the protection of the livestock industry was economically and ethically justified, recommended numerous changes in the administration and practice of federal predator control. It was out of the Committee's recommendations that the Division of Wildlife Services was formed, and a professional biologist, Jack H. Berryman, appointed as its chief.

By the early 1970's, the public had become more, not less, restive about predator control. Although Berryman had made major strides in professionalizing and streamlining the work of his Division, and in general had carried out the recommendations of the Leopold Report, there was still a considerable amount of business-as-usual in the operations of the Division. While the Leopold Report concluded that the predator-control efforts in many areas were in excess of the need, it still conceded the need for a sizeable agency employed to carry out widespread control activities in western United States. These activities were not now condoned by much of the public. In addition, militant conservation organizations were unearthing and publicizing cases of insubordinate violations of Berryman's operating procedures. These were often implied to be regular occurrences when in fact such cases were promptly followed by disciplinary action, and in general the operations of the division had been substantially tightened.

In any event, in June, 1971, Chairman Russell E. Train of President Nixon's Council on Environmental Quality, and Secretary of Interior, Rogers C. B. Morton appointed a seven-man Ad-

visory Committee on Predator Control and charged it with examining the entire question within a four-month period. A. S. Leopold was asked to sit on this Committee, and Stanley A. Cain, former Assistant Secretary of Interior, was asked to serve as Chairman.

The Committee, hereinafter called the "Cain Committee," was asked "to review and analyze the predator control, and associated other animal control programs and policies of the United States, evaluating their direct and indirect effects including environmental impacts and alternatives to present practices."

Since my students and I had been carrying out research on coyote ecology in northern Utah and southern Idaho for several years, I as a Cain Committee member was asked to address my attention to the questions of coyote control and sheep losses. These questions needed particular attention because the major *raison d'être* of western predator control is the reduction of sheep losses by reducing coyote numbers. Coyotes are among the most abundant and widespread of predators in western United States. And most livestock predatory losses are incurred by the sheep industry, largely from coyote predation. Cattle are generally too large to be preyed upon to any significant degree, and other domestic animals are either of very limited distribution, or largely protected by enclosure near to farm and ranch houses.

The Cain Committee operated under the same difficulty as the Leopold Committee: inadequate time and resources to mount any actual research program. However, it was possible to delve into existing information from a variety of sources, and use this as a basis for the recommendations made in the Committee's report (Cain et al., 1972).

This lecture summarizes some of the findings we were able to marshal on the questions of coyote control and sheep losses. Some of the material reported herein was included in the Cain Committee report, some was not. The views reported here are my own. For the most part, the members of the Cain Committee were in agreement on the recommendations made. But shades of differences will inevitably occur among seven individuals, and the shades I present here may in a few cases differ slightly in hue from the opinions reached by other members of the group. However, they agree in essence with most points made in the Cain Committee report.

Four basic questions seemed to need answers in order to evaluate this aspect of predator control:

1. What is the effectiveness of individual control techniques,

combinations of these, and how much do the existing controls reduce coyote populations?

2. What is the magnitude of sheep losses and how much do existing control measures reduce those losses? How might these losses differ with different patterns of control? A corollary question is the relationship between coyote population density and the magnitude of sheep losses?
3. What are the ecological side effects of coyote control?
4. What are the conflicting values — economic, ecological, ethical, and esthetic — which might be weighed in making any decision on predator control. No decision will satisfy all of these values, but whichever is made should be in the interest of the long-range, maximum collective benefit for society and the environment which sustains that society.

The evidence reported herein was marshalled to answer those questions. None is answered unequivocally, but the patterns that develop in the data suggest hypotheses which can serve as bases for interim action and point the way for sound research.

SOURCES OF DATA

NEEDED DATA

In traditional scientific methodology, answers to questions like Nos. 1-3 posed above are obtained through experimentation. The factor whose influence we wish to understand would be manipulated, and we would observe the effect of that manipulation on the entity or process which the factor supposedly affects. In this context, answers to question Nos. 1-3 would be obtained by setting up experimental areas in which we would use different combinations and intensities of control measures and observe the effects on (1) coyote populations, and (3) non-target predatory species; and in which we (2) would manipulate coyote numbers and observe the effects on sheep-loss rates.

Populations of coyotes and other predatory species are undoubtedly influenced by a number of variables besides artificial control, and sheep are lost to a variety of causes besides predation. In the physical sciences, extraneous variables such as these are

controlled in the laboratory to prevent any unwanted "noise" in the experimental results. In the field situation facing many ecologists, such extraneous variables usually cannot be controlled. Consequently, each experiment must be replicated a number of times and carried out over a number of years in order to average out the effects of these variables, and permit the experimenter to separate their effects from those of the ones under examination.

Coyotes and other predatory species are highly mobile, and undergo long-range, annual population dispersal. Experiments such as these would require very large areas — e.g., major portions of states — in order to avoid variation imposed by emigration and immigration. Knowlton's (1972) evidence suggested major influx into areas the size of counties in Texas. In addition to the need for large experimental areas, reliable methods for counting coyote and other animal numbers would be needed, as well as reliable methods for counting sheep losses.

Even though experiments like these have not been purposefully designed, they have been approximately and inadvertently set up. The federal predator-control operations in each state have varied over time, and their programs differ between states. But they have kept records of these programs as well as data which can provisionally be used to indicate changes in the populations of coyotes and other carnivorous mammals. The Division of Wildlife Services, the U.S. Forest Service, and the Federal-State Crop and Livestock Reporting Services have made estimates of sheep losses which can be compared with indicated changes in coyote populations. Each state for a period of years with a given coyote control regime, or with a given mean coyote density, becomes an experimental replicate and the several western states each for two or more time periods constitute a number of such replicates.

DIVISION OF WILDLIFE SERVICES RECORDS

Indices of Predator Populations. — Field agents of the Division of Wildlife Services keep tallies of the number of coyotes known to have been destroyed by the various control techniques, and the annual totals for each state are kept on file in each state office. These do not purport to be the total number of animals killed, as many of those destroyed by toxicants are never seen because they die at some distance and time after consuming the poison. But these totals can perhaps be viewed as the resultant of the state control group's effort, and if that can be standardized — i.e., if the kill can be placed on a coyotes-killed-per-man-year

basis — the success of the group can perhaps be expected to bear some relationship to the number of coyotes existing in a state and be usable as an index thereof. Since the division has also kept careful, annual records of the number of men employed each year, the data are available for calculating a standardized index.

There is some risk in such calculations in that the different control techniques have not been used with equal intensity over the years. Thus, trapping was important in the 20's and 40's. Coyote "getters" (to be described below) were important in the 1950's; and in the 1960's and 1970's there has been an increased effort in shooting from ground and air, and in finding and destroying spring dens. But these are the techniques which take animals that are recorded. It is a basic premise of this study that these were used sequentially, and that each compensated for the others in its respective period of use. The result is something approaching constancy in those techniques which kill animals that are found. And the success of those techniques can consequently be used as indices of population abundance.

One small test can be made of the validity of the coyotes-killed-per-man-year indices. The values for Utah can be compared with the annual number of coyotes bountied in the state, the assumption being that the annual number bountied also reflects the size of the coyote population. (The bountied animals are not the same as those taken by Division employees who are not permitted to bounty the animals which they kill.) This comparison shows a close similarity in trend suggesting that we are looking at real indices of coyote population change in the state (Figure 1).

Records of Control Activities. — In addition to maintaining annual records of the numbers of predatory animals taken, the division has kept records of the number of men employed annually (man-years of effort) for the past 30 to 40 years. It has also kept records in most states, but often for shorter time intervals, on the number of traps, poison baits, and other control measures used each year. These have been extremely useful in exploring the effects of some control measures on coyote populations.

Records of Sheep Losses. — From the early 1940's to the time of his retirement in 1965, Owen Morris, former Utah director of the division, made a concerted effort to tally predatory losses in the state each year. At the end of each year, he personally contacted a leading sheep rancher in each county of Utah and asked him to contact the sheepmen in his county and obtain reports of all sheep lost. These were then compiled and reported in

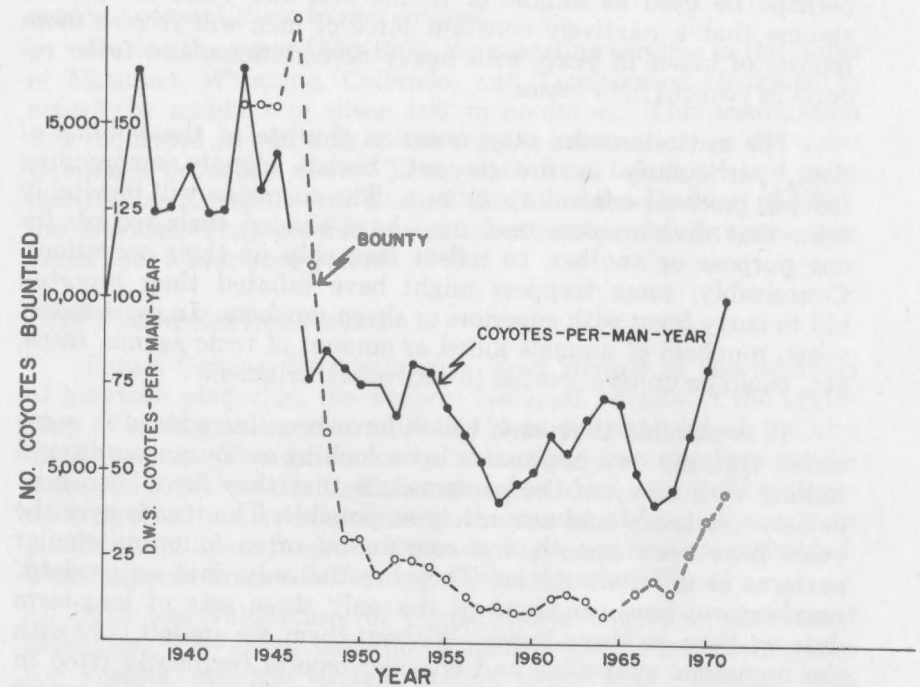


Figure 1. Comparison of Annual Coyotes-Killed-Per-Man-Year Indices from Division of Wildlife Services Records and Annual Number of Coyotes Bountied in Utah.

Morris's annual reports. They were reported as totals and not converted to percentages, a fact that may allay suspicion that the trends in percentages shown later were colored to support his Division's efforts. For the purpose of this report, the annual loss totals have been divided by the yearly total number of sheep in the state estimated by the Federal Crop and Livestock Reporting Service, and converted to percentage killed by predators.

In addition to these Utah records, division personnel in several western states have kept annual records of reported sheep losses

which they have seen. These have not been the systematic efforts that Morris carried out in Utah, and hence they do not purport to be anywhere near complete tallies of the losses. They have also not been maintained continuously over the years. But, they can perhaps be used as indices of trends over the years if one can assume that a relatively constant force of men will receive more reports of losses in years with heavy depredations, and fewer reports in years of light losses.

The critical reader may question the use of these kinds of data, particularly in the present, hostile climate surrounding federal, predator-control operations. The suspicion will inevitably arise that division personnel may have shaded their records for one purpose or another, to reflect favorably on their operations. Conceivably, some trappers might have inflated their reported kill to curry favor with superiors or sheep ranchers. In more recent years, numbers of animals killed or amount of toxic agents, traps, etc., could be under-reported to ease public criticism.

It is possible that such biases have been introduced in some cases. But, my own impression upon looking at these records, and talking with many of the personnel, is that they have been kept as conscientiously and accurately as possible. The trends over the years have been smooth and continuous, often following similar patterns in different states. They are the only data on predator numbers we have, and one of the only three sets of long-term data we have on sheep losses. Without them, we are left only with the numerous subjective and episodic reports frequently cited in the contemporary media. It is a major hypothesis of this report that these data can be used with some reservation to shed light on the questions at hand.

THE FEDERAL-STATE CROP AND LIVESTOCK REPORTING SERVICE ESTIMATES

Sometimes termed the U.S. Department of Agriculture Statistical Reporting Service, this agency sends questionnaires each year to large samples of stockmen in each state. These questionnaires are the basis for estimating total numbers of sheep in each state annually, the lamb crops produced, and the number of sheep lost to all causes. This valuable 50-year set of data has been extremely useful in analyzing total losses due to all causes over the years.

These would appear to be some of the most reliable estimates available, for they only entail counting and no interpretations of

the causes of loss. They do not provide any estimate of predator losses, but they do place a ceiling on any such estimates in that the predator losses cannot exceed the total. Like Morris's and the Forest Service estimates (see below) these statistics have only been recorded as numbers of animals, no attempt having been made to convert them to percentages.

During the years 1966-1969, the reporting services in the states of Montana, Wyoming, Colorado, and Texas asked stockmen to report the numbers of sheep lost to predators. This information was requested in addition to the regular information on the questionnaires described above. These data were tabulated and summarized by Reynolds and Gustad (1971) of the Division of Wildlife Services. They provide one set of estimates of sheep predatory losses over a four-year period.

J. S. FOREST SERVICE RECORDS

Forest Service district rangers keep records of the numbers of livestock placed on the western National Forests at the beginning of each grazing year, and the numbers removed at the end of the season. The difference between these two numbers constitutes the total loss during the season due to all causes. The stockmen involved are asked to assess the causes of loss, as nearly as possible, and hence predator losses during the period are estimated. These records are available over several decades.

The loss values are, of course, lower than the year-round estimates. The sheep have borne lambs prior to movement onto the Forests, and the lambing-ground losses have therefore been sustained prior to this season. Winter losses, which may be a substantial part of the annual total, are also not included in these grazing-season estimates.

As in the case of the Division of Wildlife Services estimates, one needs to consider the possibility that these estimates are consciously or unconsciously shaded to reflect favorably on some aspect of predator control. This seems quite improbable. Forest Service personnel have no vested interest in any particular control technique, or in control itself. Further, their data, like the division's, are compilations of reports by individual stockmen over the state as a whole. The stockmen's reports are made to the numerous District Rangers who then transmit the information to the regional office for compilation. The compilations are of total numbers of sheep lost, and it is for the purpose of this report that total number of sheep lost has been divided by the total number of sheep grazed on the National Forests to derive annual *percentages* or loss rates.

ACKNOWLEDGEMENTS

Compilation of material for this report was made possible only with the generous cooperation of a number of people. Personnel of the Division of Wildlife Services could not have been more helpful and cooperative in making their files available and in contributing advice. Persons who helped include Jack H. Berryman, Division Chief; Homer S. Ford and George S. Rost, Regional Supervisors; and State Supervisors Milton Caroline (Texas), Vernon Cunningham (New Mexico), Mitchell Sheldon (Arizona), Robert Reynolds (Colorado), Thomas L. Hutchinson (Wyoming Assistant State Supervisor), Norton Miner (Montana), Warren Ahlstrom (Idaho), Donald Donahoo (Utah), and Joseph Miner (Nevada). Mike Gaufin, Assistant Regional Forester of the U.S. Forest Service, and Grant Lea, Utah State Director of the Crop and Livestock Reporting Service were especially helpful in providing access to their information. C. Val Grant spent many hours in compiling and analyzing information. Frederick Knowlton, Research Biologist of the U.S. Bureau of Sport Fisheries and Wildlife provided information, advice, and stimulating discussion. Thadis Box gave critical advice on an early draft.

The President's Council on Environmental Quality provided financial assistance to cover the expenses of this study, and the other members of the Council's Advisory Committee on Predator Control — Stanley A. Cain, John A. Kadlec, Durward L. Allen, Richard A. Cooley, Maurice G. Hornocker, and A. Starker Leopold — all interacted in its meetings to provide the climate in which the various aspects of this report were developed.

CHRONOLOGY AND METHODS OF COYOTE CONTROL

Had experiments been designed to measure the effectiveness of different kinds and intensities of coyote control, various techniques would have been employed at carefully controlled levels in replicated fashion, and population responses measured. In fact, the variation has come as predator control has changed in institutional structure, and as new control techniques have been developed and replaced, to a degree, older methods. All of this has occupied a number of decades, in some cases predating any records which can be used for measurement. Some of the techniques have been used in combination. Overall, the data are too confounded, or wanting, to enable evaluation of any but a few aspects of the total problem. Yet, one or two generalizations can tentatively be drawn.

Coyote control has taken place under private, state and federal sponsorship. Some western ranchers employ their own trappers to conduct control operations on their lands, or in some cases public land. Sport hunting and fur trapping also contribute to what must be considered private control operations. State departments of agriculture and state bounties give impetus to control at the state level. Except perhaps for bounty and some state records, no data exist on the nature and magnitude of this complex variety of efforts, and it is impossible to evaluate its influence.

The federal effort, on the other hand, has been documented as described above. And since this has been the largest and most systematic control effort in most states, an evaluation of its

effects is tantamount to an evaluation of coyote control as largely practiced in most states.

A number of recent publications (cf. Evanson, 1967; McNulty, 1971; Olsen, 1971) as well as the Cain Report have reviewed the history of federal predator control, and that history need not be repeated here. Suffice it to say that, since its institutionalization in the early part of this century, the effort has annually entailed a full force of men in each of the western states up to the present. For example, in fiscal 1971, the equivalent of about 54 men were employed in Wyoming, 48 in Colorado, and 30 in Utah.

Although some recent critics have charged that the Division of Predator and Rodent Control and its successor the Division of Wildlife Services, has been an aggressively expanding organization owing to its own self-promoting activities, the Division's records do not bear out this contention, as the Cain Report clearly showed. There has been some state-to-state variation, but in general the number of men employed by the Division has declined steadily from around 1,500 men in the early 1940's to the approximate 600 field men employed today (Cain et al., 1972). It is true that the expenditures for the Division have risen steadily over this same period from about \$2.7 million to about \$8 million. But this increase has largely gone into salary increases and increased operating costs that have characterized all sectors of the economy during the period.

Four basic methods are used in coyote control, each with some variation in the manner or form in which it is used: (1) trapping, (2) "denning," (3) shooting, and (4) poisoning. Trapping, of course, involves the use of steel traps baited with various scents or the carcasses of dead animals.

Denning is a spring operation in which coyote dens are located on foot, on horseback, or from the air during the breeding season. Once located, they are dug out and the pups destroyed. In recent years, carbon monoxide cartridges are ignited, tossed into the den which is then covered with dirt, and the pups asphyxiated.

Shooting is a year-round technique. Coyotes are shot during chance encounters by field men, or they are lured within shooting range by different calling techniques. They are also shot from the air, especially in winter.

Several toxicants have been used. One of the oldest is strychnine which is impregnated into small suet or tallow balls known as "drop baits." The "coyote-getter" is a small pipe imbedded in

the ground, and equipped with a trigger release which fires a pistol cartridge. The cartridge is loaded with cyanide crystals which are fired into the mouth of the coyote which trips the trigger. The animal is attracted to the device by a scent placed on it. The newer, spring-ejected "M-44" is less hazardous to humans and has substantially replaced the "getter." Two highly lethal toxic agents — sodium monofluoroacetate, or "1080," and thallium — are spread upon or impregnated into portions of a sheep or other animal carcass and placed for animals to feed upon during winter.

The use chronology of these techniques has varied. Prior to the early 1940's the major techniques were trapping, shooting, denning, and "drop baits." The coyote getter was developed in the early 1940's and was immediately put to widespread use. Thallium and 1080 appeared in the latter years of the decade. Thallium was soon abandoned in most states because of its high toxicity and nonselectivity. But 1080, which is more toxic to Canidae than other animals, has persisted to the present as a bread-and-butter control technique.

In the view of professional control personnel, shooting and denning are the only techniques which are totally selective for coyotes. Traps, thallium, and strychnine are least selective, while coyote getters and 1080 are intermediate in selectivity. The latter gains its selectivity not only because of its canid selectivity; but also because 1080 baits are placed, one per township, to attract the wide ranging coyote but avoid attracting a major portion of the other, less mobile animals in the landscape. And its use only in the winter protects hibernating and migrating species.

These control methods are variously used for two basic strategies. The first is general population reduction on the premise that sheep losses are some function of general coyote population density and if that density is reduced, sheep losses will be reduced. The second strategy is that of apprehending specific, offending animals. A pair of coyotes may den near a lambing ground, and begin regular killing of lambs. If they can be apprehended, or the den destroyed, the depredations cease.

Perhaps the only control method used almost exclusively for one of the strategies is 1080. Placed in township-square networks over major portions of a state, and out only in winter, this method is used almost entirely as a population depressant.

Traps today are used primarily to apprehend offending animals. However, prior to the 1950's, huge numbers of traps were set over the landscape in what essentially was aimed at population

reduction. Shooting, too, is used for both purposes. Some workers comb large regions by air in winter for population reduction. But offending animals around lambing grounds are sometimes hunted and destroyed from the air. Denning also serves the same dual use.

Coyote getters and drop baits are used more as population depressants. But at times they may be concentrated early in the year in areas that will be used for lambing grounds in order to reduce later lamb kills in such areas. This type of concentrated, preventive use approaches the trouble-shooting strategy.

In general, the trend over the years in the Division's efforts has been toward greater specificity for coyote control in the reduction of trap and getter use, in the increased effort spent in denning and shooting, and in the heavy reliance on 1080. That reliance has simply come with the reduction of other techniques, and not through any increase in 1080 use. Contrary to the charges of recent critics, the level of 1080 use was relatively constant between the dates of its initial use in the 1940's and the mid to late 1960's (Cain et al., 1972). In the last few years, there has been an actual reduction in 1080 use.

One exception to the increased specificity has been the periodic, heavy use of strychnine. In the three states of Utah, Colorado, and Wyoming, drop baits were heavily used in the 1940's, were used to a much lesser extent in the 1950's, then once again gained attention in the 1960's (Cain et al., 1972).

FINDINGS

EFFECTIVENESS OF CONTROL IN REDUCING COYOTE NUMBERS

Response of Animal Populations to Exploitation. — The sincere, and well intentioned concern on both sides of the predator-control controversy is producing a large number of assertions about the effects of control on coyote populations which are not based on adequate evidence or do not take into account the way in which animal populations function. Some stockmen and trappers assume that the removal of virtually any numbers of animals will reduce the populations and ameliorate livestock losses. On the other side of the question, some critics of control enumerate the numbers of animals taken by the Division of Wildlife Services annually, photograph dead coyotes hanging on fences, and conclude that the survival of the species is endangered in many, if not most, areas.

The basic problem on both sides of the question is two-fold. It is first a lack of any quantitative or statistical appraisal of the situation over the vast reaches of western United States. The evidence marshalled on both sides has been largely episodic and localized. And the problem, secondly, is a failure to take into account the population processes which characterize most animal species, and by which they absorb exploitive removal.

To begin with, the coyote is a common and ubiquitous animal in western United States. By comparison, the number of control personnel is small over these large states. For example, the number of personnel in Utah in recent years has numbered around 34 per year. The area of the state is 82,000 square miles. By comparison with the number of control personnel, the number of hunters in the state who kill small game and deer exceeds 100,000.

It is impossible to determine precisely what the impact of control is upon the Utah coyote populations, but several figures are instructive. Clark (1972) estimated somewhere between 200 and 500 coyotes annually on his 700-square-mile study area on the Utah-Idaho border in the late 1960's and 1970's. The population was at its lowest density among the years of the study in 1968, and increased each succeeding year. Hence, the higher value is perhaps realistic for 1970, but let us conservatively estimate 350 in that year, or one coyote per two square miles. This may well be conservative as it is at the lower extreme of the commonly cited coyote densities for North America (Knowlton, 1972). One per square mile is not an unusual density.

The Utah portion of the study area is in Box Elder County, a county of some 5,600 square miles. If the county-wide densities were similar to those of Clark's study area — and this seems reasonable on the basis of our knowledge of the area — the coyotes in Box Elder County may have numbered a conservative 2,800 in 1970. In fiscal 1971, hunters presented 563 Box Elder County coyotes for the \$6 bounty paid by the State. In the same year, Division of Wildlife Services personnel reported killing 180 animals in the county. The total of the two figures is 743, or about one fourth of the estimated population size.

It is quite probable that not all of the coyotes killed by non-Division personnel were bountied. And Division kill estimates are conservative because a good proportion of the coyotes killed by 1080 are never retrieved. Hence, 743 may underestimate the number killed by human activities. However, our population estimate may also be conservative and hence the 25 percent value may remain as a reasonable estimate of the proportion killed. In



1968, the kill was lower with 155 bountied, 120 taken by Division personnel, and the combined values totaling 275.

Over the state as a whole, the picture is similar. It would of course not be valid to assume a comparable mean density over the state similar to that in Curlew Valley, although 96 percent of the state area is uncultivated desert and mountain terrain as in the Valley. Yet, it seems entirely possible that there are a very few tens of thousands of coyotes in the 82,000-square-mile state. The combined bounty (4,400) and Division kill (3,388) total 7,828 for 1971, and are probably a limited fraction of the statewide population.

What might be the effect of an annual removal of perhaps 25-30 percent of the animals on the coyote population? The average coyote litter size is about six young in Utah, and under good food conditions and low densities, most of the first-year females may breed (Clark, 1972). The result is that the species is capable of nearly quadrupling its numbers each year through reproduction. This is a high rate of increase similar to that of many small birds and mammals. Clearly, the species must sustain a high annual mortality rate to prevent it from increasing indefinitely. F. W. Clark's data (unpublished) suggest a mean, annual mortality rate of somewhere near 60-65 percent per year in northern Utah. Knowlton's (1972) data suggest comparable rates, even in areas where no artificial control is carried on.

Clearly, the species is constituted to absorb large losses and maintain itself through reproduction. Furthermore, nearly every animal species—and Knowlton's (1972) data suggest this for the coyote — possesses some degree of population resilience by virtue of density-dependent responses in reproductive and mortality patterns. As a species incurs heavy losses and suffers some population reduction, other sources of mortality ease their impact, and/or reproductive rates increase, and the species strikes a new equilibrium with which it absorbs the new cause of mortality.

This is not to say that a species cannot be overexploited and extirpated. But, it does not necessarily follow that, because large numbers of animals are killed, the species is endangered or its numbers materially reduced. It is density-dependent population responses such as those described which make it possible for man to remove a sustained yield over a long period of time through sport hunting and fishing, or commercial fishing. And it is in this way that a prey species in a primeval situation can withstand continued removal of individuals by a predatory species without its survival being seriously imperilled or numbers greatly altered.

The coyote is a ubiquitous species with a high reproductive rate, distributed over a vast region of North America. We cannot easily deduce the effects of control measures from the numbers of animals taken by control agents, or from the sight of a few dozen or few hundred dead coyotes. The need, once again, is for experimentation.

Effects of Control Prior to the 1930's. — There appears little doubt, on the basis of historical records summarized by Dobie (1950), that coyotes were a very abundant animal in primeval North America. They continued at relatively high numbers around the turn of the 20th century, judging by reports summarized in Palmer (1897:45) and Seton (1929), although Seton suggests that by this time they had been hunted to the point of some reduction.

There are few long-term records which help to depict the trends in the early part of the present century up to the time of institutionalized predator control in the 1930's or 1940's. One perhaps instructive series of data is that reported by Keith (1963: 167), who summarized fur returns of trappers in the three Prairie Provinces of Canada. These show strong, annual catches starting in 1919 and continuing, but perhaps in slightly declining numbers, to the middle 1940's, and generally dwindling at a more rapid rate thereafter to about 10 percent of the earlier catches. While this decline may in part be attributable to the decline in fur value, its severity might suggest some population decline.

The widespread impression exists that the species was less numerous by the 1930's and 40's than in earlier times. Few people alive today have witnessed anything like the primeval numbers described by Dobie (1950). Yet, it is still an abundant and widely distributed animal in many areas, and has extended its range in North America during this century to a number of previously unoccupied areas (Seton, 1929; Goldman, 1933). On the whole, it is nearly impossible to separate the relative roles of artificial control, and the profound land changes that have taken place on the continent in the last century and a half, in affecting coyote numbers.

Effects of Control Since the 1930's. — Some aspects of coyote control can be tentatively evaluated for the period of the 1930's to the present for two reasons: (1) The Division of Wildlife Services records are fairly continuous through this period and provide a basis for measurement. (2) The newer toxicants — 1080 and coyote getters — were introduced in the 1940's. The years preceding the introduction of these methods can thus be considered as a pre-experimental control period, while the years following

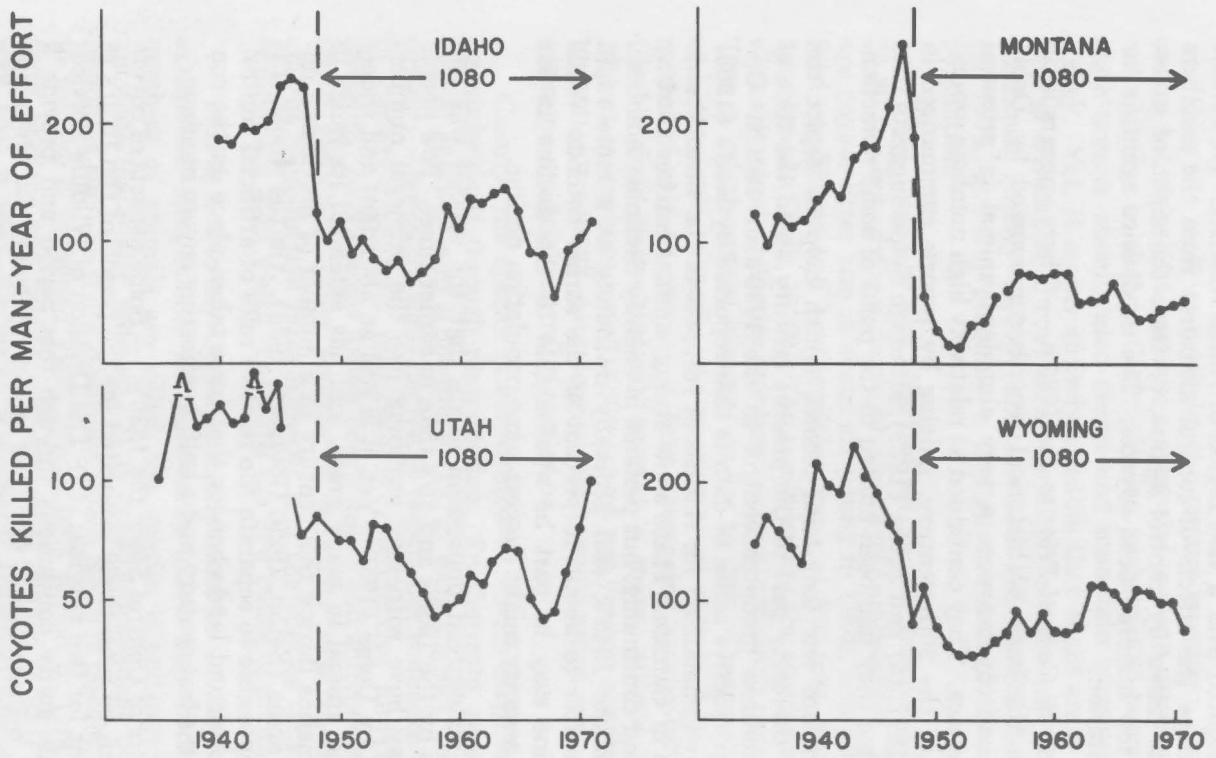


Figure 2a.
Annual, Coyote Population Trends in Four Northern States as Shown by Coyotes-Killed-Per-Man-Year Indices from Division of Wildlife Services Records.

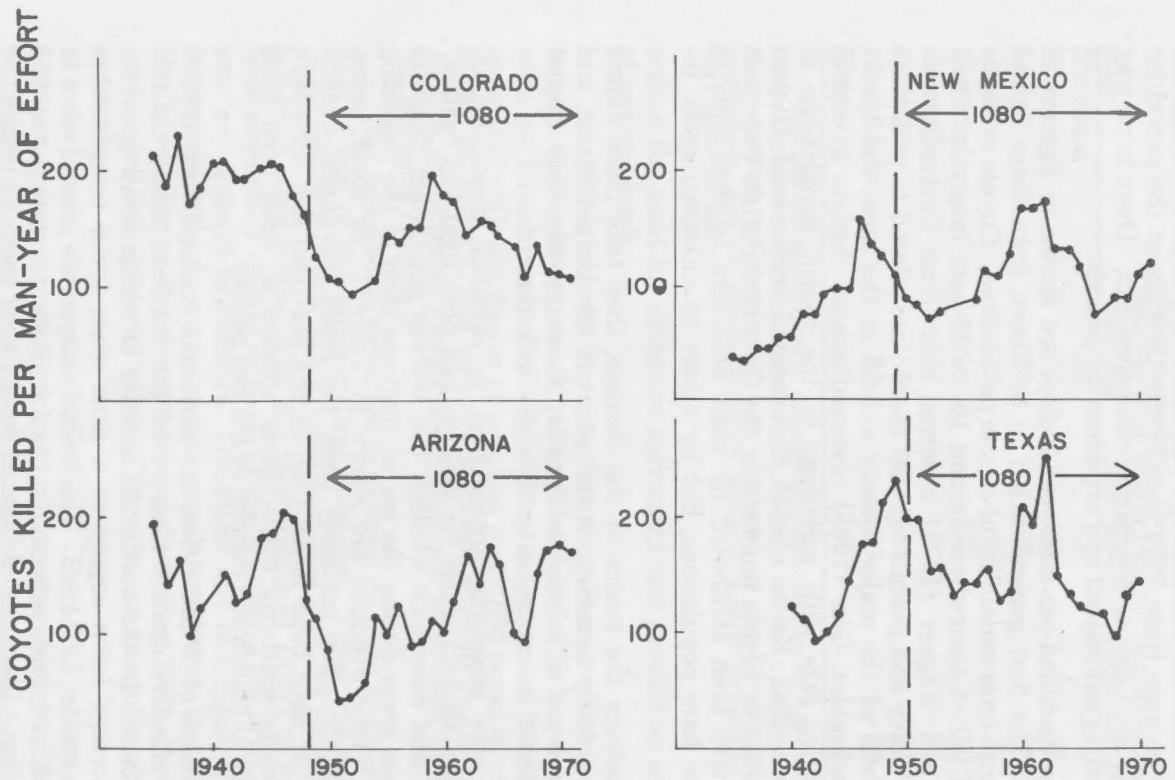


Figure 2b.
Annual, Coyote Population Trends in Four Southern States as Shown by Coyotes-Killed-Per-Man-Year Indices from Division of Wildlife Services Records.



their introduction can be considered the period in which the coyote-control variable is manipulated. It is not possible with available data to evaluate the effects of trapping, shooting, and denning because these have been in use throughout the period for which we have coyote population measurements. There is no way of separating out control and experimental periods.

Coyotes-killed-per-man-year indices are shown in Figures 2a and 2b. The first generalization to be drawn from these figures is the short-term variability of coyote populations. Coyote numbers rise and fall at somewhere around 10- to 15-year intervals. Clark (1972) and Wagner (1972) observed short-term fluctuations in Curlew Valley and postulated that these were related to variations in numbers of the major dietary animal in the area, the black-tailed jackrabbit. Gier (1968) observed annual changes in coyote reproductive rate with variations in the rodent populations of that area. And Keith (1963) documented widespread 10-year periodicities in coyote numbers in the Canadian Prairie Provinces which have been attributed by some observers to variations in snowshoe hare populations, but by others to unknown cyclic influences.

Whatever the source of the changes, they take place during periods of fairly constant control effort in the United States, and in the absence of control in Canada. Consequently, they cannot be attributed to control efforts, or the lack thereof.

A more promising approach is to calculate mean, annual population (index) levels for the pre- and post-1080 and "getter" periods, and determine whether the average population densities have been lower during the era of 1080 use than in the preceding period. These averages are shown in Table 1. In some states, primarily the more northerly ones, the mean population density appears to have been lower than in the pre-1080 era. However, in the more southerly states there appears to have been little difference in population density in the two periods.

Division of Wildlife Services personnel contend that 1080 is a more effective control measure in the northern states than in the southern. In the north, the severity of winter weather causes food shortage for a coyote at a time when lower temperatures create a greater food need. The animals may move around more in search of food, and increase the chances of their contacting a 1080 bait station. Shortage of natural food forces them to utilize the poison-impregnated carrion of the station. In the southern states, milder climates and a greater abundance of food in the form of plant fruits and greater faunal diversity (Wagner, 1971) may

TABLE I—Comparison of Mean, Annual Population Indices for Years Previous to, and During, the Use of 1080 Poison¹

State	Mean, Annual No. Coyotes Taken Per Man-Year of Effort		% Change Between Pre-1080 and 1080 Means
	Pre-1080	1080 Period	
Montana	156	48	-69
Wyoming	178	86	-52
Idaho	196	102	-48
Utah	128	66	-48
Nevada	216	167	-23
Colorado	184	134	-27
Arizona	155	116	-23
New Mexico	83	106	+29
Texas	153	149	-3

¹See text for calculation of coyotes-per-man-year index based on records of the Division of Wildlife Services. The indices are not comparable between states because the number of men employed by the Division, the coyote populations, and the extent to which different control techniques are used vary between states.

reduce the need for extensive movement and provide an adequacy of natural foods.

All of this may be the case, but there has also been less 1080 used in the southern states, perhaps because of its lower effectiveness, as Division records show. When the extent of 1080 used is compared with the degree of pre- and post-1080 population change shown in Table 1, the evidence is rather strongly suggestive that 1080 is an effective population depressant when used in substantial amounts (Figure 2).

This raises some suspicion in my own mind as to the effectiveness of any of the other control measures. Texas has used comparatively little 1080, but has compensated with far heavier getter use than other states. Yet, the populations of 1950's to 60's have been essentially similar to those of the pre-getter era. Other measures are difficult to evaluate. Doubtless any technique, if applied intensively enough, would reduce population levels. But the question is whether or not the techniques other than 1080, as presently used, have any material effect. There is no unequivocal answer available.

Security of Coyotes as a Species. — Critics of predator control sometimes fear that control has brought the species to the brink of extinction, or at least placed it on the endangered list. As the evidence in Figures 2 and 3 suggests, there is some question that the control efforts of the past four decades have materially influenced numbers in some areas. Indeed, the Cain Report (Cain,

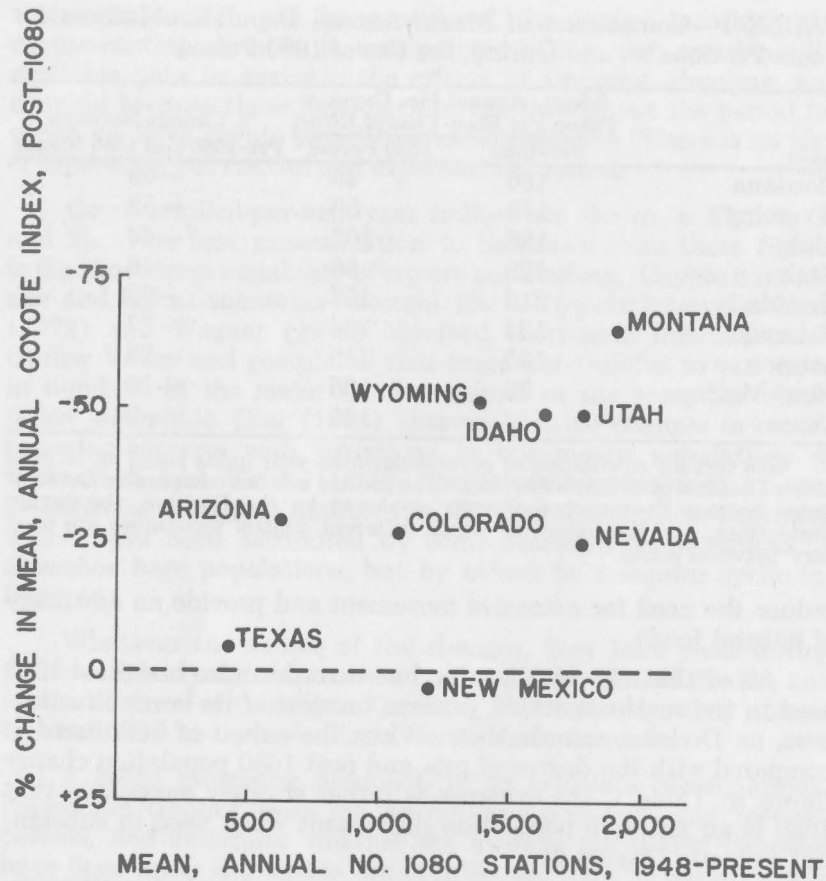


Figure 3.
Percent Change Between Mean, Annual Coyotes-Killed-Per-Man-Year Indices for the Pre-1080 and 1080 Years As a Function of the Amount of 1080 Used Annually, Nine Western States.

et al., 1972) pointed out that as many coyotes have been taken over the country in recent years by the Division of Wildlife Services as were being taken 30 to 40 years ago, and suggested that the net effect of control might be that of a sustained-yield removal with little impact on population levels.

Even in such states as Idaho, Wyoming, and Utah, where there is some evidence of post-1080 reduction, that reduction may be no more than half the pre-1080 density. Since the reduction, it would appear that the populations have achieved a new equi-

brium and are fluctuating within new limits at these lower densities.

It seems likely that the currently used control techniques will decline in effectiveness as time passes. Division trappers claim that the effectiveness of coyote-getters declined within a decade or so after their introduction, possibly because the animals learned to avoid them. Similarly, 1080 may select an increasingly resistant gene pool much as other biocides have done with other species. Division personnel decry the fact that coyotes too often will not use a 1080 bait, especially if natural foods are available. The implication of this might be a learning process.

On the whole, the coyote is an extremely adaptable, flexible, and ubiquitous species in western United States. It inhabits a wide variety of environments from the tops of mountain ranges (including winter) to the bottoms of the deserts, and most intervening types. It flourishes on the fringe of agricultural areas, and has moved into the suburban areas of a number of cities. There is evidence that control has affected its numbers in some areas, primarily the more northerly states. But this effect may be less extreme than profound land changes of spreading urbanization and cultivation. There is reason to believe (cf. Clark, 1972; Wagner, 1971; Frederick Knowlton, Unpub.) that food availability and quantity may be a more important determinant of density than human control measures in some areas, and in general food availability is probably an important ingredient in coyote numbers in all areas. Clark (1972) and Wagner (1971) concluded that if more food were available in their Utah-Idaho study area, coyotes would be more numerous even in the face of existing control measures.

Coyote Increases of the Early 1970's. — As this is written in early 1972, there is a great deal of concern among stockmen over the evident increases in coyote numbers of the past two to three years. In implementing the recommendations of the Leopold Report (Leopold et al., 1964), the Division of Wildlife Services reduced to some degree the amount of 1080 used (cf. Cain et al., 1972), and restricted coyote control in areas where there is little sheep grazing. The fear is that this easing of control activities has led to the recent coyote increases. The view is shared by many Division personnel.

While one cannot rule out the possibility that the reduction in 1080 use may be partly responsible, it does not seem likely that this is the entire, or even the main, influence. The Utah coyote population had declined from 1964 through 1967 (Figure 2a) — a

period in which the amount of 1080 used had been constant, and obviously this decline did not relate to any change in 1080 use. Rather, the decline was probably one of the naturally occurring fluctuations that characterize coyote populations as described above.

Similar population declines (Figure 2a) had occurred in Utah between 1943 and 1947 (note that 1080 was first used in the state in 1948), and between 1953 and 1958 (when 1080 use was constant). Following each of these declines, the population increased again as oscillating populations characteristically do. The increases occurred in the face of 1080 use, as the present increase is doing even if the 1080 use has been reduced by one-third.

It seems entirely possible that the present coyote increase is part of the natural fluctuation pattern. And if it is, we can probably look for another decline period within a few years, say two to four. The effect of reduced 1080 use will more likely be a slight increase in the range of densities through which the population fluctuates over a period of years. Figure 3 would suggest that, if 1080 use continues for a period of years at a level of about 1200 stations, as in 1969 and 1970, the mean coyote population level would be about 40 percent lower than the pre-1080 period instead of the 50 percent reduction that has characterized the 1949 to 1971 period.

PATTERN OF SHEEP LOSS AND EFFECTS OF CONTROL

The basic questions for which we need answers are about three-fold under this topic: (1) What is the magnitude of sheep losses to predation? (2) How does that magnitude relate to coyote abundance? (3) How is the magnitude influenced by coyote control? Answers to these questions again fall back on the problems of measurement. Questions (2) and (3) can be answered to some degree by biased estimates of losses, as long as the degree of bias is constant, or by indices of losses much as we used indices of coyote population density above to analyze the impact of control measures on coyote numbers. And once again, answers to these questions require an experimental situation: manipulation of the coyote-density variable, or of the predator-control variable, and observation on the effect of this manipulation on sheep loss levels.

Question (1) requires accurate estimates of the number and proportion of sheep lost to predation. Any analysis of loss economics, or of the cost-benefit economics of predator control, depends on accurate loss measurement. Such accuracy is difficult to obtain, and most of the existing estimates are challenged by opponents of predator control. The credibility problem lies in the

fact that most of the existing estimates depend on interview data from stockmen, and the judgment of the interviewee as to the cause of death. As is well known, sheep die from a variety of causes: genetic birth defects, inadequate mother's milk, diseases and parasites of various kinds, accidents, inclement weather, toxic plants, and predators. In addition, losses occur when animals stray from flocks and when inadvertently left on summer range after removal in fall.

Separating predator losses from among these is often difficult. A lamb that died of birth defects or malnutrition, and was scavenged by predators, may appear to have been a predator kill. Or a weakened animal that would have died from other causes, might fall prey to a predator.

Another source of bias may be in the self-protective behavior of some sheep herders and other employees. A herder who, through lack of proper care, loses some animals may protect his position by claiming that the animals were killed by predators. In addition, it is conceivable that some ranchers may overestimate predator losses under the influence of the present, heated predator-control climate. Consequently, it is difficult not to assume some inflation of nearly all interview data on sheep losses.

For the most part, the sheep industry has operated on faith that predator control reduces sheep losses sufficiently to warrant funds in excess of the \$4 million which it expends annually on the effort. That assumption needs to be examined in the light of evidence that control efforts may have little impact on coyote numbers in some areas, and because of the possible detrimental effects of control.

Magnitude of Sheep Losses. — The Nielson and Curle (1970) study may provide the best estimate of sheep losses available because of the pains taken to minimize the biases. Based on a 20 percent sample of Utah sheep ranchers, these investigators gathered their data through personal contact and oral interview. Sheepmen were asked to estimate their total losses during fiscal 1968-69, and using particular care, to report the number of sheep lost to predators.

The results showed an average predator loss of 61 ewes and lambs per 1,000 ewes. Since lamb losses made up about two-thirds of the total, these data suggest about 20 ewes lost per thousand ewes (or 2 percent) and about 40 lambs lost per thousand ewes. Figures were not reported on the lamb crop but, based on typical lamb-crop figures, it probably fell somewhere between 800 and 1,000 lambs per 1,000 ewes. On this basis, lamb loss approached

4 to 5 percent, and overall sheep losses approached 3 percent of the flocks. Coyotes were reported as being the major cause of predatory loss. It should be noted that this loss was estimated for a single year in which statewide coyote numbers were relatively low (Figures 1 and 2).

The Crop and Livestock Reporting Service estimates summarized by Reynolds and Gustad (1971) were based on a mailed questionnaire to a sample of stockmen in four western states. The estimates from this poll varied between 3.6 and 7.9 percent loss of sheep to predators in different states and different years. Once again, coyotes were reported as being the major offender.

The Morris estimates described above produced loss figures that ranged mostly between 7 and 10 percent prior to the 1940's. From the late 1940's to the mid 1960's, after which Morris retired, predator losses were estimated to fall mostly between 2 and 4 percent. This agrees very closely with the Nielson-Curle estimates.

The Forest Service estimates for the level of predator losses occurring during the summer grazing season on the National Forests range between 0.4 and 1.5 percent. Nielson and Curle found the heaviest losses occurring on the lambing grounds and on the winter ranges in Utah. Hence the Forest Service estimates are in accord with the Nielson-Curle estimates in that the former takes place between these two seasons of heaviest loss, and for a period of perhaps no more than about 4 months out of the year.

Except for the Reynolds and Gustad (1971) study, the Crop and Livestock Reporting Service estimates only the magnitude of losses due to all causes. Predator losses are not asked for on their questionnaires or estimated separately. However, these estimates are of value because they place an upper limit on predator loss since the latter obviously cannot exceed the total. And since sheep die from a variety of causes, it must be true that the losses due to predators lie to some unknown degree below the total-loss rates. Furthermore, as mentioned above, these total-loss estimates may be the most reliable estimates we have because they involve no interpretation of the cause of death. They require only that the rancher have a reasonably accurate count of his first-of-the-year inventory, his lamb crop, the number of lambs he sells during the year, and his year-end inventory. The difference between these values must be the total losses due to *all* causes.

A word is in order as to how the percentages were estimated for this report. At the suggestion of Grant Lea, the number of "stock" sheep, as reported in the Statistical Reporting Service's

annual summary entitled "Livestock and Poultry," was used as the number of breeder sheep in the calculations in order to avoid counting feeder lambs (the latter are included in the first-of-the-year "total" sheep counts) because these lambs are kept in feed lots and have little exposure to predation. To the number of "stock sheep" was added the item termed "lambs saved" in the annual publications from the Bureau of Agricultural Economics for each year in each state. This is the number of lambs docked. Docking takes place some time after lambing—e.g., as much as two months in Texas. Hence use of the docking count to estimate lamb losses gives no provision for losses between lambing and docking. The sum of "stock sheep" and "lambs saved" was taken as the total number of sheep for the beginning of each year, and this sum was divided into the sum of the two values "sheep deaths" and "lamb deaths." This provided a yearly estimate for each state of the percentage of "stock sheep" and lambs lost during the year to all causes.

These annual percentages were then averaged for the period 1924 to 1970 for nine western states (Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Texas, Utah and Wyoming). The percentages are remarkably constant over the years, and between states. The lowest state was Idaho at 7.9 percent, and the highest Nevada at 11.3. All of the others fell between 8.5 and 10.6. Predator losses on the average, must therefore be some unknown degree less than about 8 to 11 percent in these states, on the average. In light of this, Morris's estimates of 7 to 10 percent prior to the late 1940's seem improbable, and this may cast some doubt on the accuracy of the later, but lower, estimates.

Statistical Distribution of Losses. — One cannot meet with stockmen's groups on the subject of predator control without hearing a number of these sincere and forthright men attest to heavy predator losses. Yet the growing evidence seems to point in many cases to the conclusion that such losses, on the average, are relatively light. This seeming paradox can perhaps be resolved by a look at the frequency distribution of the losses.

The only raw data available were those generously provided by Dr. Nielson which were obtained in the Nielson and Curle (1970) study. These are shown in Figure 4, and may resolve the question. The majority of ranchers in Nielson's and Curle's sample experienced relatively light losses: 80 percent of this sample sustained losses of 50 ewes and lambs per 1,000 ewes or less. If we use the same formula for converting these to percentages as used above, four-fifths of the ranchers sustained predator losses of 2.5

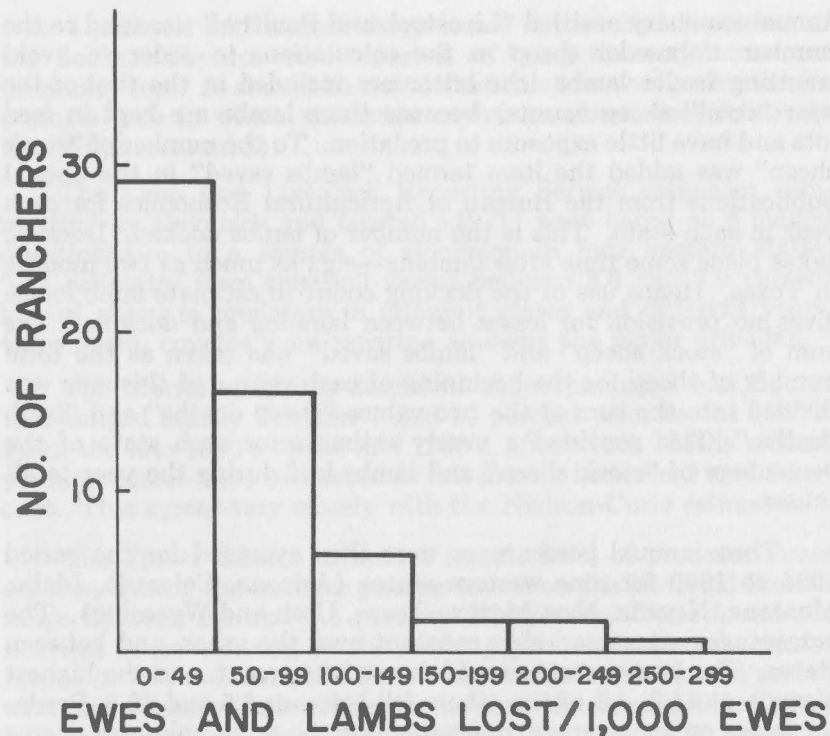


Figure 4.
Frequency Distribution of the Number of Ranchers Losing Different Numbers of Ewes and Lambs to Predators in Utah (Data from Nielson and Curle, Unpub.).

percent or less in Utah in 1968-69. Only 20 percent sustained losses in the higher range. If this is a typical, annual distribution, then some ranchers will sustain heavy losses each year. On the basis of these results, they will be a minority, percentagewise. But the number of sheepmen in Utah must approximate 300 to 400. Twenty percent of that total is 60 to 80, and in any group there will always be a number of individuals who have had sizeable losses.

Effectiveness of Control in Reducing Sheep Losses. — As discussed above, coyote-control activities potentially can reduce sheep losses in two ways: (1) In the trouble-shooting type of control where a coyote preying on a flock is apprehended, and (2) in the general population reduction of coyotes on the assumption that the level of sheep losses is some function of coyote density.

Division of Wildlife Services personnel are repeatedly confronted with situations in which one or a few coyotes prey upon a sheep flock. When these offending animals are removed, the losses stop and there seems little question that control has, in these instances, reduced the level of loss that would have been experienced without apprehension of the offenders.

Yet, the effectiveness of this mode of reduction is almost impossible to measure. The real question we wish to ask is the extent to which losses are reduced with trouble-shooting control below what they would be without that kind of control. No one would advocate that control be withheld and that losses be allowed to continue in order to provide the "with" and "without" measurements. Hence, the evidence is not at hand to evaluate trouble-shooting control quantitatively.

Some tentative indications can be gained on the contribution of population control. The cyclic rises and falls of coyote populations, as well as generalized reduction through control efforts, constitute de facto experiments. For one can measure sheep losses as coyote densities vary and determine whether or not, and to what extent, sheep losses vary.

The various predator-loss figures of the Division of Wildlife Services, including the Morris estimates, and those of the Forest Service are plotted over time in Figure 5 for Utah, Wyoming, and Colorado. All of these sources of data suggest a reduction in the level of sheep predatory losses, whatever their true magnitude, in the late 1940's. This reduction coincides with the decline in coyote numbers in these states at about the same time (Figure 2).

The Morris data suggest a reduction of sheep predatory losses in the late 1940's roughly similar in magnitude to the reduction in Utah coyote populations: i.e., somewhere near one-half or more. Hence, if abandoning 1080 use and whatever else promoted the 1949-50 decline enabled the coyote population to return to the level of the early 1940's, Utah sheep predatory losses, whatever their true magnitude, might increase by a factor of two or more.

These combined sets of data suggest that there is a correlation between coyote population density and the level of sheep losses. And it follows that generalized coyote population reduction does appear, at least on the basis of these data, to reduce the level of sheep predatory losses.

The remaining set of data to be examined is the Crop and Livestock Reporting Service annual estimates of total loss that were described above. In the final analysis, it is the degree to

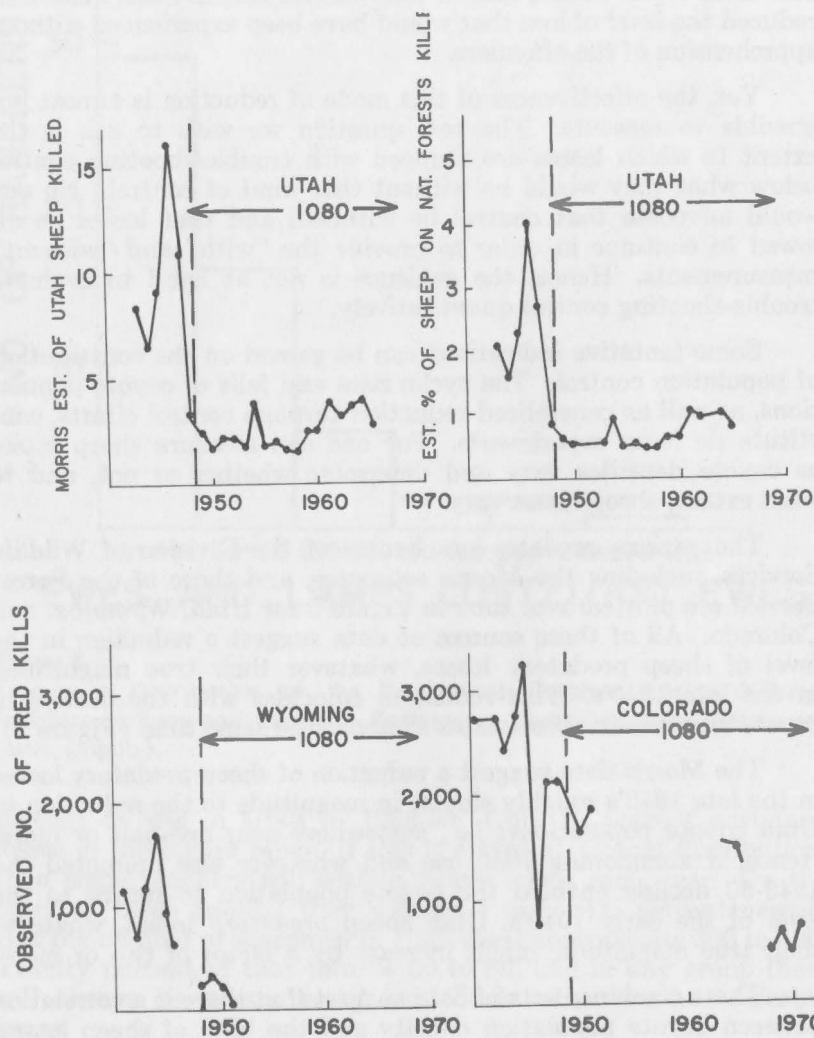


Figure 5. Predation Losses of Sheep in Three States Reported by Division of Wildlife Services and U.S. Forest Service (See Text for Sources).

TABLE 2—Mean, Annual Percentage of Sheep Dying from all Causes Previous to, and During, the Use of 1080 Poison¹

State	Mean, Annual Percent of Sheep Lost		
	1924-39	1940-49	1950-70
Montana	8.5	8.4	10.3
Wyoming	9.1	7.9	8.4
Idaho	8.6	8.4	7.0
Utah	10.9	11.1	9.4
Nevada	12.2	11.7	10.3
Colorado	10.2	9.4	9.1
Arizona	10.3	8.6	7.9
New Mexico	10.9	10.5	10.8
Texas	9.4	10.3	11.3
Mean	10.0	9.6	9.4

¹The percentages are calculated from the records of the U.S.D.A. Crop and Livestock Reporting Service. The 1940-49 is considered to be the decade immediately preceding widespread, general 1080 use. The substance has been in general use throughout the 1950-70 period.

which predator-control operations reduce total losses that they make their economic contributions. We discussed above the possibility that biases may enter into the estimates of predatory losses, but that the total-loss estimates may be free of these biases. We saw that predatory loss estimates appear to vary with coyote density and control activities, but if these estimates do prove to be substantially biased, it is conceivable that total-loss estimates are not correlated with coyote numbers.

Annual, total-loss rates for nine western states are summarized in Table 2, and are averaged for the periods 1924-1939, 1940-1949, and 1950-1970. There are uncertainties as to how uniform a set of data that goes back nearly 50 years may be. Hence the breakdown between an early era, a 10-year period immediately prior to 1080 use, and a 21-year period during which 1080 has had continuous use.

These results show little, if any, change in the level of sheep lost between the 1940's, and the 1080 period. Among the more northerly states in which some reduction in coyote numbers was suggested in Figure 2, three showed some reduction in losses (Idaho, Utah, Nevada), two showed increase (Montana, Wyoming), and one showed essentially no change (Colorado). Among the southern states which showed little change in post-1080 coyote numbers, one state showed decrease (Arizona), one no change (New Mexico), and one showed increase (Texas). Grouped together, they suggest little if any change in sheep losses.

Those which do show a reduction only experienced a reduction of around one-and-a-half percent.

The loss rates are amazingly constant over the years, and in those states in Figure 2 which suggested 2- to 3-fold fluctuations in coyote numbers, there is no parallel change in annual percentage of sheep lost to all causes.

General Discussion on Effectiveness of Control in Reducing Sheep Losses. — There have now been completed a number of coyote food-habits studies covering much of the western half of the United States (cf. Clark, 1972; Ellis and Shemnitz, 1958; Ferrel et al., 1953; Gier, 1968; Young and Jackson, 1951). None of these has ever shown livestock to be a major part of the diet. Coyotes characteristically feed primarily on rodent, rabbits, and carrion, and in some areas on plant material.

But the opponents of coyote control cannot take encouragement in this fact alone, nor should the proponents take exception. It has been pointed out repeatedly that the frequency of a prey item in the predator's diet — whether based on stomach and scat analyses, remains around dens, or remains in nests of raptors — is no criterion of the impact of predator on prey (cf. Latham, 1950; Wagner et al., 1967). Rather, the important criterion is the percentage of the prey population taken, and this depends not only on the frequency of kill per predator, but also on the numbers of both predators and prey.

To use the case of Utah sheep as an example, there were roughly 1,700,000 sheep in the state in 1970. If there were 20,000 coyotes in the state in the same year, as seems entirely possible, and each killed 3 sheep that year, the total kill of 60,000 would be roughly 3 percent of the total, the percentage as calculated by Nielson and Curle (1970). Yet if the sheep meat only appeared 3 days in each animal's diet, it appeared in less than 1 percent of the 365 days in the year. A food-habits study would find sheep remains to be an extremely rare dietary item.

The problem is to determine the percentage of sheep killed by coyotes, and the degree to which coyote population control measures affect this percentage. There is no evidence available to assess the degree to which pre-1980 control measures reduced coyote populations. One cannot avoid the suspicion that measures other than toxicants are of limited effectiveness—indeed there is some indication that toxicants themselves have limited effectiveness in some areas — but this is largely speculation. The evidence does suggest that 1980 achieved some measure of population reduction

in some states. And there is some evidence that sheep predatory losses are correlated with coyote population density. Hence, any reduction in coyote populations would occasion reduction in sheep predatory losses.

Yet, the evidence on total sheep losses shows little, if any, correlation with coyote population density and the use of control measures which reduce that density. Several explanations can be suggested to explain this paradox: (1) One or both sets of data may have inherent statistical biases which render the comparison invalid. (2) The true level of sheep predatory losses may be so low that cutting it in half does not materially change the level of total losses. (3) The predatory and non-predatory losses are somewhat compensatory. For example, coyotes may often take sheep which would die anyway due to sickness, malnutrition, or other causes. The result is that the loss level would be much the same with or without predatory loss. There is almost certainly some degree of competing probability among the various causes of loss. Obviously, some animals saved from one cause of death will die from another.

There is no basis for selecting from among these alternatives at present. Truth may consist of some combination of them. They do, however, introduce a good deal of uncertainty as to what the true picture is. And they raise a valid question as to just how important predatory losses are, and how much value is derived from generalized coyote population control.

EFFECTS OF CONTROL ON OTHER ANIMALS IN THE ECOSYSTEM

The two most likely ways in which coyote control activities might affect other animals in the ecosystem are (1) by direct, inadvertent reduction of nontarget species, especially carnivores, which are caught or poisoned by devices placed over the landscape for coyotes; and (2) by the increase of prey species formerly held in check by coyote predation (or predation of other carnivores inadvertently reduced by coyote control). In both of these cases, an experimental perspective is again in order: (1) What were the densities of nontarget carnivores before and after institution of control measures? (2) What are prey animal densities at different coyote population levels, and therefore different predation levels of coyotes?

Here again it is important that we maintain a population perspective. In their well-placed concern for our fauna, opponents

of predator control have noted with alarm that some nontarget animals have been found dead in the vicinity of 1080 stations. And some advocates of control have pointed to the desirable animals killed by coyotes. But as we have seen above in the case of the coyote, one cannot judge the effect on a species from the loss of some individuals. A quantitative overview is essential for an understanding of what is happening to a species.

Effects on Nontarget Carnivores. — The Division of Wildlife Services has kept annual records of the number of carnivorous mammals of different species which they have taken inadvertently each year during the course of predator-control operations. These can be calculated on a predators-taken-per-man-year basis, as in the way we treated the coyote data above.

The animals are largely taken in traps set for coyotes, and variations in the degrees to which traps have been used poses a bias. There has been a gradual reduction of trap use over the past few decades, and a very abrupt reduction in the last 10 years. Thus, in Utah the Division used 4,026 traps in 1961, and 1,572 in 1970, a reduction of nearly two thirds. Hence, this source of bias must be borne in mind in interpreting the results. And again as in the case of the coyote, the early predator-control measures of trapping, using strychnine, and some shooting developed gradually before records were available to evaluate the effects. Hence, our attention must be turned largely to the pre-1080 and 1080 years for which we have "before" and "after" data, and which serve as the control and experimental phases of our experiment.

The number of animals caught per man-year of effort for several species (Figure 6) shows a strong increase in Utah and Wyoming in the late 1940's at about the time 1080 was first used and coyote populations were declining (Figure 2). These are states with heavy 1080 use (Figure 3). Montana and Colorado data show the same pattern, as do Nevada and Idaho data for bobcat. Nevada data for other species are incomplete, while Idaho data do not show similar trends for other carnivores.

The increasing catch for these species would seem to imply population increase, contrary to the claims of many authors that their numbers are being reduced by predator control. Indeed, since the period shown in Figure 6 was one of declining trap use, the true extent to which these species increased may be underestimated. The sharp decline in catch in the 1960's coincides with the abrupt reduction in trap use described above.

These cases bear out a frequent claim made by Division personnel that reduction of one carnivorous species in an area

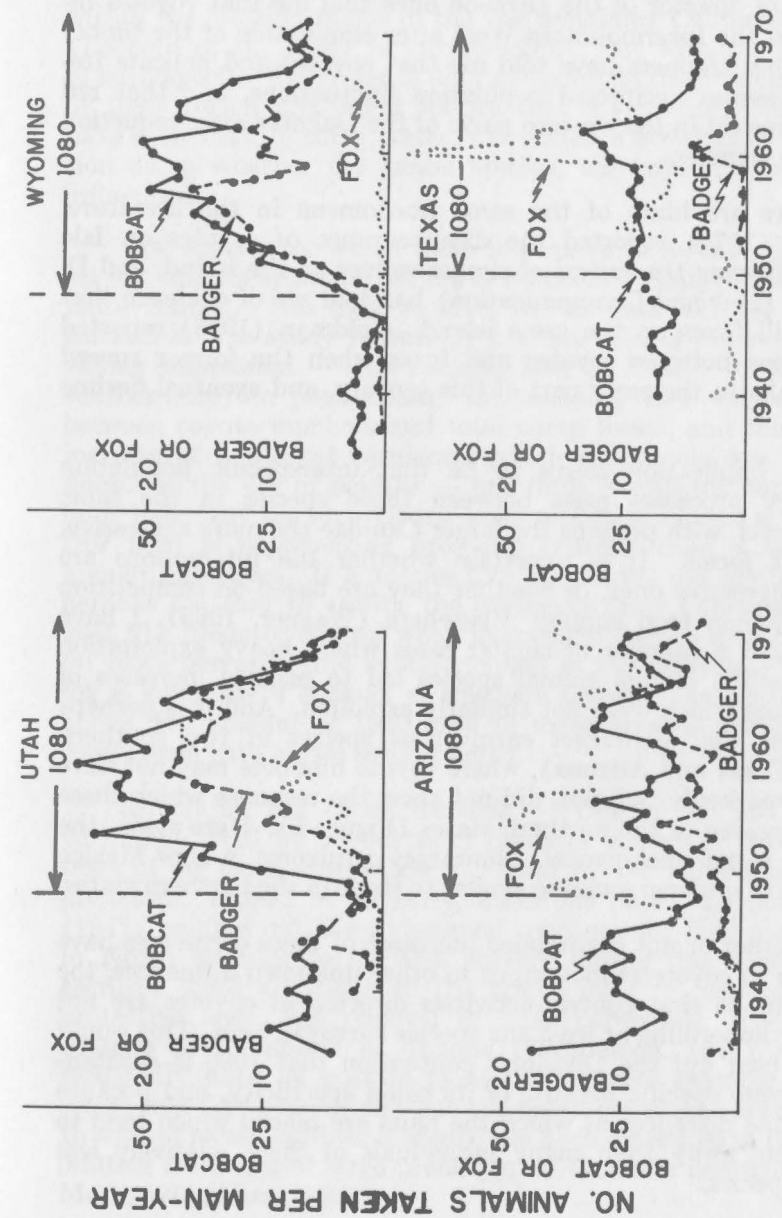


Figure 6. Annual Population Trends of Bobcats, Badgers, and Foxes in Two Northern and Two Southern States as Shown by Animals-Taken-Per-Man-Year Indices from Division of Wildlife Services Records.

results in the increase of another. Thus, Owen Morris, former Utah state director of the Division once told me that coyotes increased in the Intermountain West after elimination of the timber wolf. Other trappers have told me that coyotes and bobcats frequently display reciprocal population fluctuations, and that red foxes increased in the western parts of the Dakotas after reduction in coyote numbers.

There are hints of the same phenomena in the literature. Krefting (1970) reported the disappearance of coyotes on Isle Royal following the arrival of timber wolves on the island, and D. L. Allen (Personal Communication) has told me of evidence that wolves kill foxes on the same island. Goldman (1933) reported altercations between coyotes and foxes when the former spread into Alaska in the early part of this century, and eventual decline of foxes.

The implication seems to be that interspecific population regulatory processes exist between these species in the same trophic level, with perhaps the larger Canidae the more aggressive, dominant forms. It is uncertain whether the interactions are direct, aggressive ones, or whether they are based on competition for a common food supply. Elsewhere (Wagner, 1969), I have summarized a number of similar cases where heavy exploitation and reduction of one animal species led to marked increases of competitors which were not similarly exploited. And it is perhaps significant that nontarget carnivorous species in two southern states (Texas and Arizona), where coyote numbers may not have been so markedly reduced, did not show the response which these species showed in the northern states (Figure 6). Here again, the evidence is not unequivocal. Nontarget carnivores in New Mexico did seem to undergo increase similar to those in the northern states.

Whether or not the implied increases of these carnivores have been due to coyote reduction, or to other unknown influences, the main point is that control activities directed at coyotes are not seriously imperilling at least the species surveyed here. This would tend to bear out the Division's contention that 1080 is substantially coyote specific because of its canid specificity, and because of the wide distances at which the baits are placed which tend to keep them away from many individuals of these relatively less mobile species.

The point is not intended to disarm concern for endangered species, or those for which we have no data. McNulty's (1971) concern for the black-footed ferret's plight is certainly well taken,

as is the concern of Leopold et al., (1964) for the Sierra del Nido grizzly bear. And the fact that 1080 should have been placed within the cruising radius of the few remaining California condors (Leopold et al., 1964) is inconceivable. But with the exception of such species, the evidence does not point to the profound effects of 1080 use on non-target species that is sometimes feared. We have seen that, in some states, the evidence even raises the question as to whether the target species, the coyote, is materially influenced.

One species for which there is concern in recent years is the kit fox, and its apparent decline in numbers is charged against predator control. This may be true, but as data like the ones unearthed in this study repeatedly produce results contrary to prevailing impression — the seeming lack of impact of control on southern coyote populations, the seeming lack of correlation between coyote numbers and total sheep losses, and the seeming increase of nontarget carnivores which supposedly are being reduced by the use of poisons — one finds it difficult not to withhold judgment on such claims until critical evidence is at hand. Our land is experiencing profound changes from a variety of human influences. If a species like the kit fox has declined, it is perhaps too easy to ascribe the change to some unpopular scapegoat like predator control when in fact the decline may be due to far more pervasive and subtle changes in the ecosystem. The kit fox is primarily a denison of southern deserts. As we have seen above, the amount of 1080 used in these areas is rather low by comparison with states farther north.

Effects on Big Game Animals. — One of the justifications commonly cited by advocates of predator control is that populations of big game species are increased by the reduction of large predators. Indeed in an early, milestone paper, Leopold et al., (1947) pointed out the widespread tendency for deer populations in North America to increase sharply during this century, and ascribed these eruptions to the triumverate of habitat change, protective laws, and removal of large carnivores. The Kaibab Plateau deer eruption in Arizona (Rasmussen, 1941) has been repeatedly cited ex post facto as the classical example of what occurs in a deer population when the predatory checks are removed. In several recent studies, evidence has been presented of the actual limiting influence of large predators on ungulate populations (cf. Mech, 1966; Hirst, 1969).

Yet, there probably are more studies which find predation by large carnivores to have little impact on ungulate densities (cf.

Leopold, 1955; Talbot and Talbot, 1963; Pimlott, 1967; Hornocker, 1970). And upon recent reanalysis of the available evidence, Caughley (1970) raised a serious question as to whether removal of predators did play a significant role in the Kaibab deer eruption. The basic problem is that in most cases of North American deer eruptions, predation has not been the only variable manipulated. The other, and perhaps more important, variable has been the improvement of habitat and food supply: Cutting and regrowth of mature forests in the East, and invasion of shrubby species into grazing lands in the western part of the continent. The result is to create a considerable amount of uncertainty as to the role of predators in limiting ungulate populations, especially the versatile and fecund deer species.

Many Divisions of Wildlife Services personnel and some western game biologists strongly suspect that coyotes are a significant influence on deer numbers. The former commonly attribute the increase in deer in the first half of this century to their control efforts.

The general view among perhaps a majority of game biologists is that coyotes are inept animals at preying on deer, and that kills are infrequent. Division men challenge this view and aver that coyote predation on deer is a more common event than is widely believed.

These men are among the most skilled field observers in the wildlife field. Their observations would almost certainly carry weight even with the realization that their vested interest may shade their interpretation of the observations. By late winter, deer are weakened by food shortages, and in deep snow are vulnerable to predation.

But the problem here again is that of drawing inferences from observations on individual kills to the significance of total population phenomena. Historically, deer populations increased over much of the United States in the 1920's, 1930's and 1940's. Overpopulation symptoms were common in the 1940's (Leonard, 1946; Leopold et al., 1947). In Utah, deer were scarce when European man arrived in the state in the 19th century. They increased during the first half of this century, and probably reached a peak in the late 1940's (Anon., 1966). Since such coyote-control agents as coyote-getters, 1080, and thallium were first put in use in the latter 1940's, most of these deer increases had taken place before coyote reductions induced by these toxicants.

I would certainly not suggest that there may not be some deer herds in western United States which are materially influenced

by coyote predation. Knowlton (1964) and Cook et al. (1971) have presented a convincing case for the Welder Refuge on the Texas coast with an especially heavy coyote density. But, on the basis of existing evidence, one is inclined to remain uncertain that coyote predation is of wide, general significance. And the implication is to question how much coyote control contributes to deer management. I do not wish to imply that I view the question of the role of predation or ungulate populations anywhere near a closed issue. Most of the existing studies are on single predatory species: wolves, mountain lions, or coyotes. The realities of a pristine, multi-species predatory pressure on deer — wolves, mountain lions, bobcats, coyotes, and bear — may be a very different story from the effects of any one of these.

There is some, although not unequivocal, evidence that coyote predation acts as a depressant on pronghorn antelope populations (cf. Udy, 1953; Arrington and Edwards, 1951; recent unpublished evidence of Frederick Knowlton). Knowlton (Personal Communication) has pointed out that the Wyoming antelope populations did not really begin to thrive until the beginning of 1080 use. Workers in several other states have not found similar evidence, but the question runs like a thread back through the literature to early accounts cited by Seton (1929) and Dobie (1950). The frequency and distribution of the observations make it seem a real possibility that coyotes do, in some cases, exert some limitation on antelope numbers.

Effects on Small Prey Species. — Opponents of predator control have contended that the practice is unwise because predators hold small mammal populations in check. These species allegedly erupt into pest status in the absence of predatory restraint. These contentions bring us into an area that is even more complex and fraught with uncertainty than the question of predatory restraints on ungulate numbers. That uncertainty arises from the same reasons as the uncertainties existing in the subjects discussed above: The absence of effective measurement, and the infrequency with which an experimental approach is used. Although there has been a great deal of research on predation, and a vast literature exists on the subject, answers to the difficult population questions still remain uncertain: To what extent do individual predatory species, and combinations thereof, influence the density of prey populations, and under what circumstances?

Time and space do not permit lengthy exposition of the subject here, but there is a strong body of opinion among animal ecologists that highly fecund small mammal species undergo pro-

found population changes which relate largely to weather, food and habitat conditions, and disease and parasites. The influence of any one predatory species in this complex may well be, more often than not, relatively minor. At best, perceptible predatory influence may require the impact of aggregates of predator species (cf. Craighead and Craighead, 1956).

In particular, rodent population densities over western United States seem to be importantly influenced by vegetation changes, often those associated with grazing. This subject was reviewed at some length by D. L. Allen in Section III-D of the Cain Report.

Our own studies of recent years give some clue to the effectiveness of coyote predation on black-tailed jackrabbit populations (Stoddart, 1970, 1971; Wagner and Stoddart, 1972) in north-western Utah and southern Idaho. The jackrabbit is the dietary staple for the coyote in this area, and in some years coyote predation was by far the major cause of jackrabbit mortality. However, the coyote population fluctuates, apparently because its food supply does so as well. As coyotes decline, their impact on the simultaneously declining rabbits eases. The point is eventually reached at which the rabbit population is released. With a higher reproductive rate than the coyotes, they need but a year or two of relatively unrestrained increase and the coyotes can no longer catch them even though they too have now begun to increase.

The eventual curtailment and initial decline of jackrabbits appears due perhaps to the onset of disease, perhaps exhaustion of the food supply, perhaps self-induced reduction in reproductive rate due to stress of high density and social unrest, or some combination of these. Once the rabbits have begun to decline, the now abundant coyotes once again exist in a high ratio to rabbit numbers, and their predation begins once again to have a material impact.

Hence, the effect of the coyote appears to be primarily one of hastening and deepening the decline phase of the rabbit population oscillation. The maximum densities to which the rabbits increase do not appear influenced by coyote predation, and in total coyote predation does not appear to be a significant determinant of rabbit numbers. This conclusion appears supported by Palmer's (1897:45) early report of high rabbit and coyote number in this same area prior to any kind of institutionalized predator control.

In short, I am rather skeptical of the effectiveness of coyote predation alone in determining the density of small mammal populations, and by inference the claim that coyote control has been a

significant influence in producing pest populations of small mammals. Collective, interspecies predator populations may be a different story.

ECONOMIC CONSIDERATIONS

Obviously the major emphasis of this report is in the ecological aspects. I have neither the economic expertise nor any great deal of new information to make any major addition to what has already been said about the economic aspects of the question. Yet, the economic considerations begin with the ecological: What is the magnitude of sheep loss and what are the costs of any given degree of reduction in coyote numbers and in sheep loss. Some of the findings from this study shed some light on several economic considerations.

COST-BENEFIT ANALYSES

Several comparisons have been made of the costs of predator control and the economic value of the sheep lost to predators (cf. Evanson, 1967, for review of such comparisons). The implication seems to be that this is tantamount to a cost-benefit analysis, with a high ratio of sheep-loss value to control cost implying a favorable cost-benefit situation. Viewed in this way, and with the existing estimates of predatory loss (cf. Reynolds and Gustad, 1971), the ratios are usually quite favorable.

For example, the Nielson-Curle (1970) study suggested a 3 percent predatory loss rate, and a total sheep loss in Utah valued at a little over \$1 million. In this same year, Division of Wildlife Services records show a total budget of about \$300,000 of which sheepmen contributed about half plus an additional \$56,000 of privately financed control (Nielson and Curle, 1970). Hence, regardless of whether we contemplate the ratio of public funds or of industry funds, or of the total control outlay to sheep loss, it is a favorable one. (It should be pointed out that Nielson and Curle did not make this type of cost-benefit comparison. I have only used their data here to illustrate this type of comparison.)

However, this would seem to be a specious comparison, for the funds spent on predator control clearly are not preventing the 3 percent loss. Hence, the economic value of that loss can hardly be viewed as a *benefit* of the control cost. The proper comparison would seem to be the cost of control weighed against the value of *sheep that would be lost without that control*. This latter is clearly

a difficult figure to obtain, and no definite answer can be obtained. But two sets of figures can be the basis for speculative comparisons, at least for the degree of control achieved by 1080.

In the more northerly states, 1080 may have cut coyote populations roughly in half (Figure 3). And those sets of data on sheep predatory loss which extended over some years of both the pre-1080 and 1080 periods (Figure 5) suggest a reduction of about one-half. Hence, on the basis of these figures abandonment of 1080 might conceivably witness a two-fold increase in coyote populations and sheep predatory losses, *whatever their true level*. And herein lies the key consideration.

If the Nielson-Curle estimate of 3 percent is near the truth, then sheep losses might be expected to increase 3 percent. And in this case, we would arrive at the same cost-benefit ratio calculated above for Utah.

But in the analyses above, the total-loss rates of sheep in northern states hardly changed following 1080 use (Table 2). Losses in some states declined slightly, increased in others suggesting some statistical variation and raising the question of whether total loss rates were changed at all by the use of 1080. At best, the reductions were no more than 1 or 1.5 percent lower, implying that if 1080 were abandoned, the total losses would rise by no more than this amount at best. At 1 percent increased loss of Utah sheep, the ratio of present predator-control cost to value of sheep saved now becomes about 1:1, or in other words no gain on the expenditure.

All of this is speculative, of course, because of the uncertainties surrounding the available loss estimates. These uncertainties emphasize the need for critical, carefully taken measurements of losses.

LIVESTOCK INSURANCE

A great deal has been said about the possibility of loss insurance as an alternate means of economic protection to predator control. Most opponents of predator control wish no economic hardship on sheep men, and many indicate a willingness to support an insurance program as an alternate. This possibility was discussed at some length in the Cain Report, and will only be touched on briefly here.

To begin with, the prospect of an insurance program to cover predatory losses alone seems forbidding. It is difficult to

identify predator kills in many cases, and the cost of investigating all such claims would seem to be prohibitively expensive. With several hundred sheep ranchers in each major sheep state, each sustaining some predatory losses each year, the claim adjustment problem seems out of the question.

However, total-loss insurance would seem to have more promise. Sheepmen now lose animals from a variety of causes, perhaps averaging somewhere around 8 to 11 percent (Table 2). These are losses for which they have no protection, and which cut substantially into their profit margin. The administrative advantage of total-loss insurance is that no interpretations of the cause of loss are required and the claim adjustment problem greatly simplified.

Losses could perhaps be ascertained by comparing January 1 inventories plus the lamb crop with the number of lambs sold each year, plus the December 31 inventory. The difference would be the number of sheep lost to all causes. Verification of figures could perhaps be coupled with tax assessment which also requires an inventory and which could provide a check.

Some critics of the insurance idea contend that fraudulent claims would scuttle such a plan, or that inept and inefficient operators would benefit at the expense of skilled sheepmen who maintained their losses at low levels. Premiums could perhaps be adjusted to an operator's loss record, and be subject to annual review. This would enable the better, more successful operators to enjoy the benefit of lower rates.

Some speculative figures for the state of Utah might be as follows: Utah ranchers grazed roughly 1.7 million sheep in the state in fiscal 1970-71 (incorrectly given in the Cain report as 1 million). Losses in recent years (Table 2) have averaged about 9 percent, but let us use 10 as a round figure and on the possibility that some abatement of predator control would permit some increase in predation. Hence, the losses due to all causes would be roughly 170,000. At a mean value of \$20 per head, the value of the losses would approach \$3.4 million. On a statewide basis, a levy of roughly \$2 per head would fully underwrite such losses.

On the average, this outlay would return to the industry as payment of claims, and the industry *as a whole* would suffer no loss. However, as we saw above (Figure 4) most operators suffer below-average loss. In any one year, a typical operator might be assessed a premium based on a 10 percent average industry

loss, but realize only a 5 percent return based on losses of that magnitude. The exceptional operator with a 20-percent loss, and who had paid premiums based on a 10-percent average expected loss, would realize a profit.

Presumably these inequities would average out to some degree over a period of years as heavy losses moved by chance from operator to operator. And the variability of total losses may be less than that given in these hypothetical examples, and as seem to be true of predator losses (Figure 4). No total-loss raw data were available at the time this was written, and before any program was developed such data would need careful scrutiny.

There are three possible ways of reducing the premium costs. One would be to establish a deductible clause which provided that no claims below a certain minimum would receive payment. This would affect a large number of operators if the total-loss distribution is at all similar to the predator-loss pattern (Figure 4).

A second means for reducing the premiums would be to question the \$20-per-head value assigned above. Some of the losses are among very young lambs. One may question whether a very small lamb should be appraised at the full market value of a large, fall lamb. Nielson and Curle (1970) have contended that a young lamb should receive such valuation, but it is perhaps an arguable point.

A third means for reducing the premium cost would be a partial government subsidy. Premiums would be reduced to the degree that the cost was subsidized.

All of this is speculative and needs careful study by actuarial experts in collaboration with industry spokesmen. But it would seem to have sufficient promise to bear thorough scrutiny.

THE QUESTION OF SUBSIDIES

The mention of partially subsidizing insurance premiums raises the entire question of subsidy. Many critics of predator control decry the practice because they are paying in part for something with their own tax dollars which they object to on principle in the first place. In the next section, I will suggest that the public bears some moral obligations in this direction, but for the present let us consider the question of subsidy on purely economic and social grounds.

It is true that the industry is subsidized in several ways: The public funds used in predator control; the tariff on foreign wool

which maintains American wool products at higher prices than would exist if foreign products were allowed free competition; and a grazing fee charged to stockmen for the use of public lands which in the eyes of some critics is below the real value received for such grazing privileges. Some critics imply that such subsidies are somehow unethical, and that meat and wool products should somehow be left to unsupported competition. If the industry falters in the process, then this is simply the realities of life in a laissez-faire situation.

This point is arguable on principle, but pragmatically it is a somewhat anachronistic view in an era when our economy is anything but laissez-faire, and is perfused with an untold number and variety of subsidies. The point is especially well made by Evanson (1967:210-211):

The fact that sheepmen try to get as much subsidization as possible to carry out control programs is a matter of political reality in a mixed economy wherein the 'gravy train' is a generally accepted mode of socio-economic conveyance. Criticism of sheep-raisers for their willingness to seek maximal public assistance must be tempered with recognition of the similar lobbying and pressure tactics of countless other interest groups, from the farmers and cattlemen who compete with the sheepmen for land to the trade unions whose successes contribute to the rising costs of all labor inputs including herders, wranglers and shearers. The pressures exerted by woolgrowers for general predator control are assailable not on grounds of political immorality but on their economic and ecological unsoundness.

To these points one may only add that any subsidy is, in principle, tacit acknowledgement of marginal economic viability. It is justified, not per se on the enhancement of profit margins for the institution to which it is directed. Rather, it is justified on (1) the benefits of continued survival of that institution and its goods and services to society; and (2) in a socially conscious society, the concern for preventing the institution's individuals from suffering economic and social upheaval. Wool, lamb, and mutton are desirable products for our society. One may argue that foreign products could outcompete our own. But it seems desirable to perpetuate the capacity for producing them in this country against a future time when an expanded world population will make demands on all areas capable of producing food and fiber.

The sheep industry has declined markedly in the past 30 years. In the states discussed in the preceding pages, the number

of sheep grazed today is only one-third to one-half the number grazed in the 1930's or early 1940's when the industry reached its peak. This reduction has occurred because of increasing economic squeeze, growing operational problems (e.g., difficulty of getting competent herders), and particularly in those states with large amounts of public land, reduction in grazing quotas in the interest of range improvement. Like many of the criticisms of predator control, comments on range degradation caused by the sheep industry have almost reached cliché status. In the past, such degradation has certainly taken place, and some is still going on. But the general trend, at least on public lands, has gradually been reversed, and continued improvement can be expected in the years ahead. Management of public lands by the public agencies still undoubtedly has considerable room for advancement, but it is increasingly competent and there has been a great deal of progress in the past 20 years.

Whatever the causes, it is clear that the U.S. sheep industry operates on a narrow economic margin. Any increased cost would make more difficult an already strained situation. It is for this reason that subsidy has a role, if we grant that the industry is a desirable part of our society.

ETHICAL CONSIDERATIONS

There is more to the rising public opposition to predator control than the ecological and economic issues. Indeed, there is a strong moral tone to that opposition, and for this reason the ethical aspects of the question bear scrutiny. It is quite possible that these aspects will carry more weight in the decisions that are ultimately made than the purely ecological and economic, although we shall see below that what may be ecologically wise and economically beneficial to the stockman takes on the elements of a moral "ought."

The last century and first half of this one constitute an era in which the pursuit of a high, material living standard was the socially approved, major preoccupation of the nation's citizenry. That living standard had to be extracted from the natural environment; and while the environment was richly endowed with resources it often posed hardships which had to be overcome in order to reach the goal of material wealth. Hence, any resistance in the environment was viewed from a single-value, utilitarian perspective as an obstacle to be pushed aside. Except for a few voices

crying in the wilderness like Thoreau and Leopold, this utilitarian view of the world was seldom questioned. Predatory animals fell in this category. They were viewed largely as an impediment to profit-taking by the livestock industry, and hence, were a useless thing to be reduced if not extirpated. Although wildlife of all kinds in the United States have been considered a public resource since the beginning of the republic, few voices were raised against this destruction of public property by a minority of the populace.

In recent years, the combined disenchantment with material values and realization that the quest for those values is depleting our resources and threatening irrevocable damage to our environment have led to serious questions, if not rejection, of the century and-a-half-old American value system. These growing doubts have been paralleled by a rising romanticism; and by an awakening to, and growing love for, the nation's natural heritage. Paradoxically, the latter has been made possible by the mobility and leisure time afforded by our high standard of living.

Within this growing romantic and naturalistic climate, all parts of nature are viewed with a new set of values. It is the land as a whole which collectively built the riches and beauty of the continent, and predatory animals are inextricably a part of this total system which we call the land. One cannot cherish some parts and reject others, for the whole is only what it is with all of its parts. Leopold (1953) stated the view very well in his characteristically lyric prose:

By land is meant all of the things on, over, or in the earth. Harmony with land is like harmony with a friend; you cannot cherish his right hand and chop off his left. That is to say, you cannot love game and hate predators; you cannot conserve the waters and waste the ranges; you cannot build the forest and mine the farm. The land is one organism. Its parts, like our own parts, compete with each other and cooperate with each other. The competitions are as much a part of the inner workings as the co-operations. You can regulate them—cautiously—but not abolish them.

The outstanding scientific discovery of the twentieth century is not television, or radio, but rather the complexity of the land organism. Only those who know the most about it can appreciate how little we know about it. The last word in ignorance is the man who says of an animal or plant: "What good is it?" If the land mechanism as a whole is good, then every part is good, whether we understand it or not. If the biota, in the course of aeons, has built something we like but do not understand, then who but a fool would discard



seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering.

The American public, now awakened to its statutory ownership of the wildlife resource, and cherishing it from a broader, less utilitarian perspective, will no longer unquestioningly accept the reduction of that resource by any minority of the population.

Yet, the public ownership of wild animals would seem to carry with it some element of responsibility, or even liability. Where one's possessions cause loss to those of another, the owner seemingly bears some obligation to the person affected. There are already a number of precedents for this principle in the case of wildlife. In many states, where deer, elk, beaver, or other wild animals cause damage to agricultural crops or other private property, the state assumes responsibility either for compensation to the property owner for his loss, or for removal of the offending animals.

This same principle would seem to apply in the case of predatory animals killing livestock. The situation seems quite clear-cut in the case of livestock losses on private land. Losses on public land, where stockmen pay for seasonal grazing rights, pose a somewhat less clear-cut case, but may still fall within the principle. This right to redress for property damage is another justification for public subsidy of some form, as discussed above. Alternatives include predator control, compensation with public funds for losses, or partial subsidy of an insurance program.

There is, however, more to the moral indignation over predator control than the loss of public property at the hands of a minority. There evidently is a widespread feeling that predator control, particularly those techniques which cause violent death, is morally wrong in some deep sense. Many of the persons holding this view undoubtedly do not stop to ask why it is wrong, but simply maintain the conviction on strong, unquestioned emotional grounds.

It is fair to ask the authoritative basis for such convictions. We live, after all, in an era when few moral premises have gone unchallenged, and when many have been rejected. And if such convictions are to be strong forces in policy decisions, it is reasonable to enquire about their bases.

There would seem to be only two answers to the philosophical question of what makes a certain act right or wrong. The first is Divine Edict which carries the teleological implication that the rightness or wrongness of an act is judged according to its place in some Grand Plan for existence.

We live, however, in an increasingly secular and humanistic age when even the traditional, institutionalized religions are making concessions to "situation ethics." In this second, alternative answer to the question of rightness and wrongness, morality increasingly takes on a pragmatic role. Those acts which promote survival, happiness, and social order for the individuals in a society are deemed to be right or moral. Those acts which create unhappiness, disorder, and threats to survival are deemed to be wrong.

In this context, predator control seems implicitly to be deemed immoral on two counts. The first is on the count of humaneness, and killing animals in this way is implied to foster a callousness which may carry over into the way human beings relate to each other. Although the research and control divisions of the Bureau of Sport Fisheries and Wildlife have made progress in the direction of making coyote control species-specific and humane, no one including Division of Wildlife Services field agents, denies that the symptoms of 1080 poisoning are grim to behold in a dying coyote.

Dobie (1950) has argued that engaging in such control activities tends to perpetuate a callous attitude toward animals developed during the frontier era in much of American society. Himself a seasoned outdoorsman, rancher, and horseman, Dobie advocated the transition to a more "civilized perspective" which includes a feeling of sympathy and tolerance for animals other than our own species. The implication seems to be that we will become more tolerant, restrained, and civilized in our relations with our fellow man.

The second count on which predator control is deemed immoral is the risk that it incurs for continued environmental health. Whether one accepts alarmist or conservative predictions of the effects of human activities on the environment, there seems little doubt that we cannot continue to exploit and despoil at our present rate without sooner or later imperiling our existence. As Leopold states in the passages cited above, we still do not have sufficient understanding of the complexities of the ecosystem. Hence, it seems desirable to perturb that system as little as possible in order to minimize the risks of unforeseen, irrevocable change (Wagner, 1969). If we can derive our needs and comforts without a given perturbation, such would seem to be desirable. The information in Table 2 suggests that we might be able to forego some aspects of widespread intensive predator control, e.g., use of toxic agents.

Leopold (1933a, 1947) suggested that such restraint would not be attained until we develop a new ethic in which we extend

the same ethical precepts to the land that we now extend to other human beings:

A thing is right only when it tends to preserve the integrity, stability, and beauty of the community, and the community includes the soil, waters, fauna, and flora as well as people.

WHAT COURSE OF ACTION?

We now come to the point of decision between several courses of action. We have weighed the available evidence and considered a number of aspects of the problem. To the scientist, the evidence leaves much to be desired for much of it does not come from carefully planned and executed research, and that which does may well be fraught with biases of unknown form and magnitude. Yet, with all its uncertainties, the available evidence would seem to be a better basis on which to make decisions than the many impressions, emotionally loaded biases, and misconceptions which abound on this subject.

In review, the evidence we have examined suggests the following: (1) Coyote control does reduce coyote numbers to some degree in some areas. (2) This reduction in coyote numbers does not appear to reduce total sheep losses materially, and by implication increases in coyote numbers might not be the economic *coup de grace* that sheepmen fear. (3) Control efforts do not have the marked side effects on the ecosystem which its opponents claim.

These conclusions are drawn for predator control as currently practiced in most states, largely by the Division of Wildlife Services. Greatly intensified effort, either by the existing control groups, or by large numbers of private individuals might well produce a very different picture.

What, then, are the alternate decisions? One can consider first the extremes: Intensification of control, or total abandonment. If given their choice, most sheepmen would probably opt for intensified control. But in view of the public pressures now being brought to bear, this alternative seems out of the question. Moreover, it cannot be advocated seriously on ecological, economic, or ethical grounds. Indeed, it does not seem that the status quo can, or should, be maintained.

What of total abandonment? We have suggested above that the stockman has some right to protection from offending animals. Few critics of predator control go so far as to deny this. One can

suggest a loss payment or insurance program as an alternative to control, but there are uncertainties about the workability of the insurance idea. And, utilitarian view or not, it seems unnecessarily wasteful to stand by and let a coyote kill large numbers of lambs out of a flock and not do something about it.

There is also reason to fear that stockmen would take control into their own hands if no control organization were available. In this event, society would lose control over, and record of, what is taking place. The risk of dire effects would then increase substantially.

Whatever the eventual decision, it seems important to bar the private operator from systematic control except, perhaps, in emergency situations. This can be accomplished best by effective, well-enforced state laws. In the past, state departments of natural resources have been primarily concerned with game species. But as public awareness and appreciation of nature have broadened, these agencies are more and more recognizing a responsibility for the protection and husbandry of all wild animal species. Predators have increasingly received this recognition. Mountain lions have been placed on the game animal list in Utah, and timber wolves have been afforded complete protection in states where they are nearing extinction.

The more common predators, like coyotes, could be similarly protected by state laws which made sport hunting and fur trapping legal under license, season, and bag provisions. And such laws could provide for control activities by authorized, government employees, either state or federal. The Cain Report recommended additional deterrents to private control. One was a ban on shooting from planes by unauthorized persons. And it recommended revocation of public grazing permits for individuals who engaged in illegal predator control on public lands.

If the extremes among the alternative courses of action seem to have shortcomings, what of the other alternatives? Nothing would convince stockmen more effectively that abandonment of generalized coyote population reduction, especially the use of toxic agents, does not result in prohibitively increased stock losses than to see it demonstrated on a limited basis. The same can be said of the success of an insurance venture. If stockmen in three or four western states would volunteer to accept a 5-year experimental abandonment of poisons and seriously try the insurance idea, they could assume a leadership role and remove some of the public ill will that has built up against them in recent years. If as successful as anticipated, this plan could ease the transition to

complete abandonment of toxicants at the end of 5 years. It should be accompanied by careful evaluation through well-designed research, and the enactment of state laws described above.

Although the evidence we have reviewed suggests that sheep losses viewed as a state-wide or region-wide statistical phenomenon may be less than stockmen commonly believe, there is no question that some ranchers experience heavy, concentrated losses. The number of such losses could conceivably increase with relaxation of control. If we have any sense of social concern, we will not deny that these individuals deserve some measure of protection from such losses. Hence, it seems desirable to retain some mechanism that can carry out a trouble-shooting type of control. That effort can best be provided by some governmental organization, either state or federal, with a trained group of control agents.

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[1975]

ANNOUNCEMENT

Today the President has amended Executive Order 11643 to permit expanded experimental predator control research on Federal lands and in Federal programs. The purpose of the amendment is to allow the development of economically feasible and environmentally acceptable methods to protect livestock producers from coyote predation.

BACKGROUND

- The livestock industry is suffering losses from coyote predation.
- Losses run as high as 30% annually for some Western producers.
- 55.2% of Western range land is owned by the Federal government.
- Federal regulation now bars all methods employing chemical toxicants for predator control, except in emergency circumstances or in certain restricted experimental programs.
- A 1972 Executive Order bans use of chemical toxicants on Federal lands and in Federal programs.
- EPA suspended Federal registration of all chemical toxicants used for predator control.

CURRENT FEDERAL PREDATOR CONTROL ACTIVITY

- DOI operates a combined coyote research and control program with FY 75 budget authority of \$5 million.
- Control methods are largely mechanical (trapping, shooting).
- Experiments are being conducted with the M-44 device and other control mechanisms employing sodium cyanide such as toxic collars.
 - M-44 is a spring-loaded device which propels sodium cyanide into the predator's mouth.
 - Selective control devices are those which work primarily on the coyote attacking the sheep. For example, the toxic collar is placed on target sheep and releases a lethal dose of sodium cyanide when a predator bites the collar.
- EPA has granted experimental M-44 use permits to seven Western states and DOI.

POLICY

The Federal policy of restricting the use of chemical toxicants on Federal lands and in Federal programs remains unaltered. However, in recognition of the plight of the livestock industry, the President, in compliance with all existing statutes, is (1) expediting research efforts which promise low cost control without adverse environmental impact and (2) strengthening the conventional predator program.

ACTIONS TAKEN

-- To enhance our national capacity to conduct research to develop environmentally acceptable and selective processes of predation control, the President has made the following decisions:

- (1) Request EPA's expedited decision as to the registration of sodium cyanide in the M-44 device for the purpose of predator control. The EPA decision will be made by September 15, 1975.
- (2) Implement an expanded experimental program for the research on methods for using sodium cyanide for predator control and at the same time strengthen conventional control programs. These expanded programs are now being put in place and should be fully implemented by September 1, 1975.
- (3) Amend Executive Order 11643 to allow expanded experimental use of chemical toxicants on public lands and in Federal programs. The amended Executive Order was signed by the President on Friday, July 18, 1975.

-- Certain chemical toxicants administered through selective devices could offer an environmentally acceptable method of control for two reasons:

- (1) If the devices prove successful, only actively predating animals would be killed;
- (2) Sodium cyanide is a non-persistent chemical. For this reason, it neither harms the environment nor possesses a secondary kill capacity.

EXPANDED PROGRAM BREAKDOWN

- Will increase research and conventional control personnel up to 25% for each category.
- Will expand experimental program to give maximum results.

Costs: \$2.948,000

Financing: The expanded program represents the cooperative efforts of the following organizations:

Agriculture -	\$1,400,000
Interior	\$1,248,000
EPA	\$ 300,000

* * *

THE WHITE HOUSE
WASHINGTON

April 29, 1975

PRESIDENTIAL MEETING WITH
NATIONAL WOOLGROWERS ASSN.

RE: Predator Control



United States Department of the Interior

FISH AND WILDLIFE SERVICE
WASHINGTON, D.C. 20240

FORM
ADDRESS ONLY THE DIRECTOR,
FISH AND WILDLIFE SERVICE

FEB 22 1975

In Reply Refer To:
FWS/ADC
FSF 3707

FEB 24 1975

Dear Senator McClure:

This responds to your January 20 letter on behalf of Mr. Larry Bourret concerning the item on "Predator Control" in the Council on Environmental Quality's Fifth Annual Report.

The following is our evaluation of the report's contents:

- I. The charge is made that "Predator control programs on grazing lands... are responsible for putting species such as the northern Rocky Mountain wolf, eastern timber wolf, red wolf, kit fox, eastern cougar, and Utah prairie dog on the Endangered Species list." This highly subjective statement leads to the conclusion that "predator control" alone is responsible for the status of these species and incriminates all systems of predator control (i.e. bounties, sport hunting, organized professional, extension, and private) regardless of the relative values and objectives of each. The wide variety of factors having bearing on the status of these species are interwoven with the common threads of changing land uses, increasing civilization, and decreasing and modified wildlife habitat. However, this explanation is too general, and it is helpful to examine the status of each of these species in more detail.
 1. The northern Rocky Mountain wolf (Canis lupus irremotus) is a subspecies which is presently reported adjacent to and in areas of Glacier and Yellowstone National Parks in the States of Montana, Wyoming, and Idaho. The population size and range are definitely restricted from their original dimensions. Loss of habitat through human habitation advance has been important in restricting this species. Wolf control programs of all types have played an important role in bringing this species to its present status.
 2. In the lower 48 States, approximately 750 eastern timber wolves (Canis lupus lycaon) are found in northern Minnesota and a few remain in northern Wisconsin. This is a marked reduction from the original populations and range which included most of the Northeastern States and extended as far south as Florida.



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Predator control programs have been directed at the wolf and have undoubtedly been an important cause for their present status. However, the eastern timber wolf is gone from much of its former range where no Fish and Wildlife Service (FWS) animal damage control programs were conducted. A factor that probably has had as much or more effect on the wolf has been the loss of habitat and resulting encroachment of civilization, because the wolf is a wilderness species.

3. The red wolf (Canis rufus) formerly occurred throughout most of the Southeastern United States and west to about the 100th meridian in Texas and Oklahoma. Pure red wolves appear to be presently confined to a small area of southeast Texas to southwest Louisiana and possibly parts of Arkansas and Mississippi. The dwindling population of red wolves is threatened by changes in land use, including agricultural development and ever-expanding industrial facilities, and the red wolf does not appear to be as adaptable to change as the coyote. However, the greatest immediate threat is probably interbreeding with coyotes and domestic dogs; hybridization may be inevitable.

In the FWS's efforts to save the red wolf, we have been live trapping, moving and releasing depredating individuals since 1968; these efforts have been largely confined to Chambers and Liberty Counties in Texas. In local situations, depredation control operations may have reduced populations of red wolves; however, our control efforts were never exerted in much of the original red wolf range. On the contrary, the selective removal of limited numbers may have been instrumental in their preservation, for without this selective control, ranchers losses would have been more severe, and private, nonselective control efforts might have been intensified.

4. Kit foxes (Vulpes macrotis ssp.) of which there are several species in the Southwest, are reported to be: common and increasing in the eastern plains areas of their range; static over much of their western range; and possibly decreasing in portions of Arizona. Dr. S. D. Durrant cites a population increase in western Utah. Only the San Joaquin kit fox (V. m. mutica) is considered endangered.

The present range of the San Joaquin kit fox is approximately 3,000 square miles--confined primarily to the valley and foothill areas below 2,000 feet elevation in the southern portion of the Sacramento Valley. The present population is approximately 2,000 individuals.

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Swick (1973) reported the following after evaluating an aerially applied 1080 grain ground-squirrel-control project in the San Joaquin kit fox range: "Factors which might limit the San Joaquin kit fox populations include: (1) encroachment of agriculture; (2) illegal shooting; (3) road kills; and (4) incidental poisoning...." He also reported that the only dead fox found in his observation of the squirrel control operation was a road kill.

Land development and local agricultural practices have reduced the areas of native habitat for this species by 34 percent during the 10-year period from 1960 to 1970.

In about 1968, U.S. game management agents and State game wardens found a single pile of 27 San Joaquin kit foxes in Kern County, California. The foxes had been shot and their tails removed, a practice which varmint calling associations use as proof of a kill.

We have no knowledge of deaths of this species by private predator control efforts, and only on one occasion was animal damage control directed toward this species by the FWS. In 1970, a poultry depredation request was resolved in cooperation with the California Department of Fish and Game. Depredating individuals were live trapped and transported 15 to 20 miles away and released. Prior to Executive Order 11643 in 1972, the FWS did not use toxic materials in damage control operations for other species where this species was known to exist. In addition, traps set for coyotes within the known range of this species are modified to reduce the chances of kit foxes being caught. To our knowledge, there have been no accidental deaths of the San Joaquin kit fox attributable to animal damage control work conducted by the FWS.

5. The eastern mountain lion (Felis concolor ssp.) enjoyed wide distribution in the Eastern States during the early history of this Nation. Currently, it is reported in Florida with scattered sightings in Virginia and in the Northeastern States. The major cause of their present status is well-stated in the 1971 report of the Advisory Committee on Predator Control. "Habitat shrinkage is a factor in maintaining populations of lions. More multiple use of lion habitats--where roads are built, where plant communities are changed, where human use is increased--affects lion populations drastically." In the Western States, mountain lions have been and are taken by a variety of the previously mentioned "predator control systems," and healthy populations remain. Conversely, there are many former lion ranges in the Eastern States where they were not subjected to organized or intensive control. The major difference is in the habitat change in the East and lack of habitat change in vast areas of the West.

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6. The Utah prairie dog (Cynomys parvidens) presently occurs in five counties of its former nine county range. According to Dr. Durrant, populations over its present range have remained about the same for the past 20 to 30 years. Federal control operations directed at this species were discontinued in 1963 except for limited removal from an airport runway where they are a safety hazard. Control operations on other species of rodents have not been conducted in the prairie dog towns.

Predator control operations do not affect prairie dogs. Collier and Spillet (Status of the Utah Prairie Dog, April 1971) conclude: "It is our opinion that the current status of the Utah Prairie Dog is a direct result of past (prairie dog) control operations--both Government and private, as well as perhaps by habitat modifications resulting from livestock grazing or other agricultural practices. There is also a good possibility that disease has been an important contributing factor."

- II. The statement is made that "persistent poisons had been widely applied to range and forest lands." This implies that all toxicants used in the FWS program (strychnine, cyanide and 1080) were stable and long-lasting in the environment. Thalium which was used in earlier years was discontinued due to its persistent and cumulative characteristics.

Strychnine is a highly stable compound that is not readily broken down by environmental forces. It can be expected to remain effective as long as the bait material remains intact. However, strychnine was used mainly in a perishable bait of tallow or lard and sugar that would deteriorate with temperature increases or precipitation.

Compound 1080, the most extensively used toxicant by the Federal animal damage control program prior to February 1972, is not a persistent poison. Herviche (1960) and David and Gardner (1966) demonstrated that sodium monofluoroacetate breaks down in the soil, and concluded that there are no apparent reasons for condemning this compound because of a build up of toxic residues in the soil. It is also highly soluble in water.

Sodium cyanide, which was used in M-44's, is not a persistent toxicant either. The breakdown of cyanide salts to hydrocyanic acids occurs quite rapidly in the presence of moisture. This rapidly breaks down into innocuous residues.

- III. It is further stated that these toxicants were employed "without adequate knowledge of how they affect the environment," and "they represented a threat to beneficial wildlife and entire ecosystems." Although FWS use

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of toxicants has taken individuals of nontarget species, there is no evidence that this use had an imminent or serious affect on the environment, or on a beneficial species' population, or on an entire ecosystem.

- IV. The reference in the report to "the new policy" directing control at offending individual predators rather than at whole populations, and that past Federal policy sought to "exterminate" predators is misleading to the reader. It was not the objective of Federal programs to exterminate any species, but to reduce damage through management of wildlife populations involved in damage situations. FWS policy pertaining to this is stated in "Man and Wildlife, a Policy for Animal Damage Control, 1967": "It is an objective of the Service to reduce animal depredations as selectively as possible, and to direct control at the depredating individual or local depredating population. Animal damage control will be conducted to achieve definite planned goals."

Control may be directed at depredating individuals in isolated situations, especially with certain species such as bear or mountain lion. It is not a practical management technique in most instances where local populations of predators, such as coyotes, are causing damage. Control in these situations must be directed at the population within the area where damage occurs.

- V. It should be clarified that the "new techniques" used to control predator damage basically involved the increased reliance on techniques which the FWS had used for many years. The only considered exception may be the use of the helicopter, which--although used prior to 1972--was used sparingly because suitable (safe) machines were not generally available at a cost the FWS could afford to pay.

Fixed-wing aircraft have been used for many years; however, they were not relied upon as heavily as they are in the current program because of the hazards involved for the gunners and pilots and of the high cost of operation in relation to other methods available--primarily chemical toxicants. With the loss of chemical toxicants for predator damage control, increased funding allowed greater reliance on the use of aircraft. Close adherence to established safety regulations has held accidents to a bare minimum.

The number of coyotes reported taken in the FWS's animal damage control program has remained about the same both before and after the ban on the use of chemical toxicants; however, the figures are not comparable. It must be recognized that the number of coyotes taken by chemical toxicants was not known, and, therefore, not included in the number of animals taken in the FWS's program. On the other hand, control methods used in the current program allow enumeration of nearly all coyotes taken. It is

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understood, of course, that the number of animals taken is not a valid basis for measuring the effectiveness of a damage control operation; effectiveness must be measured in relation to the success in reducing losses.

Except for small study areas, we have not gathered data on sheep losses caused by coyotes throughout the West. It is true that some ranchers have suffered losses in areas where aircraft could be used effectively. Losses were severe in some situations where use of aircraft was not feasible--for example, rough, brushy terrain or adverse weather conditions. Studies currently underway in Idaho, New Mexico, Montana, and Wyoming to measure livestock losses to predatory animals on 16 selective flocks of sheep indicate that, under a generally intensive predator control program, approximately 20 percent of the ranchers sustain heavy losses; the remaining 80 percent suffer a loss range somewhere between 1 and 4 percent.

- VI. Data are not available to support the statement that coyote populations increased throughout the 17 Western States prior to the poison ban. Until the FWS's Wildlife Research Center located at Denver initiated the 1972 Predator Survey, no organized effort had been made to measure broad predator population trends. Prior to the 1972 survey, reports from our field personnel indicated that coyote populations were high in some localized areas, but did not show that coyote numbers had increased throughout the West.

A comparison of the 1972-1973 data indicates that significant changes in the population status of the coyote did occur within the intervening year. Eight States east of the Continental Divide showed an increase in coyote numbers. Currently, we are uncertain whether increases in these areas represent more young coyotes or better survival of the older ones. Additionally, the data suggested appreciable declines in coyote numbers in three Western States, apparently associated with low birth rates coinciding with a dramatic decline in jackrabbit populations. Coyote numbers have increased in those areas where mechanical control tools have not been effective in controlling livestock depredations. However, it is our opinion that it will require at least 3 to 5 years of data collection to determine the real effect that the poison ban will have on the overall population trend of coyotes in the Western States. Unfortunately, the results of the 1974 survey are not yet available.

While Executive Order 11643 initially stopped the use of chemical toxicants for controlling wild predators, it also forced an attempt to resolve such problems without the use of lethal chemicals. Our efforts, significantly increased through supplemental funding, have demonstrated that depredation losses can be

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controlled in most instances through the use of mechanical means--primarily through the increased use of aircraft. However, there are some situations where mechanical methods are not effective in halting coyote depredations.

Regarding Mr. Bourret's letter, the photograph of several dead sheep dogs contained in the report appeared in an article entitled, "Lamb Chops and Cyanide" in the April 1974 issue of the Defenders of Wildlife Magazine. It is attributed to Mr. Dick Randall, a former employee of the FWS, who is currently a representative for the Defenders of Wildlife.

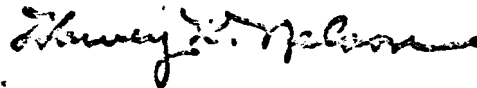
The average annual percentage decline in sheep and lamb numbers in the decade prior to the issuance of Executive Order 11643 (January 1, 1962 to January 1, 1972) was 5.0 percent. The annual percentage declines in 1972 (5.3 percent) and 1973 (6.7 percent) are within the range of annual percentage declines for the previous 10 years. (The Department of Agriculture has not yet released January 1, 1975, sheep and lamb figures; therefore, we are unable to calculate the 1974 percentage changes.)

Apparently, Mr. Bourret arrived at 4.0 percent for the average annual percentage decline from January 1, 1962, to January 1, 1972, by dividing the total decline in sheep and lamb numbers during that 10-year period (12,259,000) by the total number of sheep and lambs as of January 1, 1962, (30,969,000) and then dividing by 10. This technique does not provide an accurate average.

The statistical method used to obtain an accurate average of percentages that have different bases (and in this case, the bases are different since the number of sheep and lambs was less each succeeding January 1) is to add the numerators (the decrease in the number of sheep and lambs in a given year) and the denominators (number of sheep and lambs as of the first of that year) separately, and then divide. The enclosed Appendix 1 contains these calculations.

If we can be of further assistance, please call on us.

Sincerely yours,



Acting Associate Director

Honorable James A. McClure
United States Senate
Washington, D.C. 20510

Enclosure

Animal Damage Control: Research and Progress

The Executive Order, No. 11643, issued by President Nixon on February 8, 1972, and Environmental Protection Agency (EPA) orders issued on March 9, 1972, effectively removed chemicals for use in control of predators which prey on domestic animals. The Executive Order prohibited chemical control of predators on federal lands and by federal employees to control mammals, birds or reptiles except under certain emergency conditions. The order issued by the EPA cancelled registration of the chemicals (strychnine, sodium cyanide and sodium monofluoroacetate) and prohibited interstate shipment for predator control. Such restrictions have not yet been applied to their use in rodent control although the EPA initiated hearings in 1973 to amend or cancel their registration as rodenticides and later withdrew that action.

~~One result of these orders has been the need to rely much more heavily~~ on mechanical methods to alleviate predation by coyotes and other species. The Department of Interior (USDI) has indicated that these methods alone are not adequate by its request in 1973 for emergency use of the M-44 cyanide device to protect sheep and goats on western ranges. The EPA granted the permit in June 1973 for use of the M-44 where losses were high and intensive application of mechanical controls alone did not control predation. This program was not designed as a research project, but some indication of M-44 efficacy can be gained from the USDI report on its emergency use in 11 western states from June through October 1973. The report states that the M-44 was not effective on 41 percent of the damage areas where it was applied;

Presented by Dale A. Wade, Extension Wildlife Specialist, University of California, at the California Livestock Symposium, Fresno, California, May 29, 1975.

it was partially effective on 46 percent of the areas; and was the only effective method on 13 percent of the areas in alleviating damage. Average losses were 3.2 percent prior to use of the M-44 and 0.4 percent following its use for a total average loss from June through October 31, 1973, of 3.6 percent of the livestock in the depredation areas. Individual confirmed losses as high as 60 percent were reported during this time period.

The M-44 was used concurrently with mechanical methods on these areas because of high predation rates; therefore, the exact value of each method in correcting predation cannot be determined. However, a total of 573 coyotes, 119 foxes and 6 feral dogs were taken by M-44's while 515 coyotes, 7 feral dogs, 5 foxes, 46 bobcats and 5 black bear were taken by nonchemical means. Selectivity of the M-44 was 95 percent for the canine species (698 from a total of 735 animals). ~~The report points out that concurrent killing by~~ more than one species occurred and that it was necessary to remove these animals, in addition to coyotes, to alleviate losses.

Proliferation of several types of research related to predator damage has also occurred since the Executive Order. Research now underway includes studies of predator populations and behavior, predator-prey relationships, losses caused by predation and other factors and possible alternative methods of control. Because of the many factors which affect predation, such research is difficult, costly and slow. It is not likely that rapid, simple solutions will be found to this economic-biological problem that is so heavily affected by sociological and political pressures. Because it is such a complex problem, research is necessarily highly diverse and only a cursory review of major areas is presented here.

Population studies now underway will attempt to determine coyote numbers by geographic area and habitat type by using track counts and howling surveys,

in addition to actually counting coyotes where this can be done. Survey and census methods are being evaluated to determine the most effective means of measuring coyote populations. It is believed that by establishing an annual coyote population index, and actual numbers where possible, population changes can be measured to determine if a correlation exists with livestock losses and other available food supplies. The U.S. Fish and Wildlife Service has compiled an annual index since 1972 in the western states based on track counts obtained at coyote scent stations. Data for 1974 are not yet available; however, the California index was 8 percent higher in 1973 than in 1972.

Litter size, survival, dispersal of young coyotes and population age structure are also under study. Coyote population models have been developed to attempt to measure and predict the effects of various methods and levels of control on the percent of females producing young, litter size, survival, age structure and other factors. With refinements to be added as more information becomes available, such models would be useful in predicting changes in populations, possible predation rates on domestic and wild prey with changes in the food base and the effects of control on population structures.

Behavioral studies include all aspects of individual and social coyote activities. Of particular interest to those who suffer predation, including livestock producers and pet owners in suburban areas, in addition to damage control agencies, are behavioral responses which might allow application of specific control methods such as potential repellent techniques, attractants for use with reproductive inhibitors, or other methods.

Attack and killing behavior by coyotes has been documented in several research projects to provide baseline data for evaluation of potential

repellents and attractants. This has provided confirmation of the typical coyote attack at the throat of prey. Some coyotes have shown significant variation by attacking the face, sides, or rear quarters of prey in a manner similar to that of dogs. Such variations have also been shown by coyotes which habitually preferred to attack the throat but killed by attacking other body areas if the throat of prey animals was protected. These variations have been known by damage control agents for many years and have now been confirmed by research. This type of behavioral alteration points to the coyotes ability to adapt and to the difficulty of mechanically repelling them from prey animals they select.


Research in predator-prey relationships will attempt to measure changes that occur in predator or prey populations that result from changes in the other. Densities of predators, wild prey species, and livestock, in addition to other sources of food are among the factors that affect livestock predation. This should not be surprizing since coyotes are adaptable and opportunistic, qualities which continue to insure their survival as a species. It has often been said that coyotes prefer natural prey; however, it must be understood that to the predator, nearly any animal of suitable size in his environment is natural prey. Other real factors that affect livestock predation are availability as compared to other sources of food, size and vulnerability of potential prey, the coyote's energy demand and individual food preference. Highly variable factors like these make research extremely difficult.

Predator damage assessment studies are being carried out in several western states in attempts to determine the levels and costs of losses to producers and the states economy. A statewide survey recently completed in California indicates that the average predation loss for all ewes and lambs

was 1.9 percent for the 1973-74 production year, with coyotes responsible for 82 percent of the loss. Dog predation (14.1 percent) was found primarily on sheep ranges close to populated areas. Nine percent of the sheep operations surveyed reported no losses to predators and nine percent reported losses greater than 10 percent. The survey covered approximately 29 percent of all the ewes pastured in California during the year and data gathered from the six different production regions were projected across the balance of the sheep population.

Most surveys, like this one done in California, are conducted in the presence of damage control programs. Many of the surveys to determine the number of animals that die and the reasons for death find a large percentage of losses from undetermined causes. In most cases, the undetermined loss is due to difficulty in finding animals in rough terrain and heavy vegetation and to rapid decomposition of carcasses. However, some indication of loss levels predation can cause where control is not practiced can be gained from the results of a western Montana study reported at the Coyote Research Workshop in Denver, Colorado, on November 16, 1974, (preliminary progress report).

The research was conducted by the University of Montana Wildlife Research Unit on a band of approximately 800 ewes and 1255 lambs on pasture from spring to November 9, 1974, where coyote control was not practiced. Dead animals were necropsied by veterinarians to determine the cause of death. Total field mortality for the time period covered was 387 lambs and 70 ewes (457 total). Deaths from natural causes were 29 lambs and 21 ewes (50 total). Four lambs died of undetermined causes. Predator kills included 354 lambs and 49 ewes (403 total) of which 2 were killed by eagles, 2 by foxes, and 399 by coyotes. Predators killed 32.1 percent of the lambs and were responsible for 88.2 percent of total field mortality. An additional 23 lambs and 2 ewes were sacrificed due to severe injuries.



Losses confirmed in this study and during the emergency M-44 program in 1974 indicate that average losses of 2 to 10 percent reported are not unrealistic. However, it must be recognized that predation is not distributed evenly across livestock operations and that some have none or minor losses while others may be extremely high as observed during the M-44 emergency program.

The U.S. Department of Agriculture Economic Research Service is now conducting a study of the sheep industry in the western states and factors affecting its status. Included are the effects of predation on producers, the industry and the states economy. The report is scheduled for completion in 1976 and is expected to provide a thorough evaluation of the major factors affecting the industry.

Research on techniques of alleviating predation has yet to produce new methods which can be applied effectively in field operations. Repellents and aversive agents which might be used to reduce predation have not shown conclusively that they are effective. Sonic repellent techniques have shown very little promise so far. Chemicals applied directly to livestock to repel predators by odor or taste present substantial problems since continued effectiveness in the presence of sun and rain is difficult to achieve. Predators have shown also that they adapt readily to most odors and some potential taste repellents applied directly could prevent marketing animals because of residues. Effective repellents which are economically practical, are safe to apply, and leave no residue in the animal have not yet been found. Aversive chemicals that cause illness in predators when eaten as bait are being evaluated but adequate data to show effectiveness in field use and for registration by the EPA have not been developed.

Reproductive inhibitors for coyotes appear to be receiving little attention at present. This is partially due to the need for compounds effective over a greater part of the reproductive cycle and for more effective methods of delivery. Additional difficulty is caused by the need for efficacy data and effects on nontarget species prior to any possible registration by the EPA. Current interest and research in control of dog and cat populations by this method may provide useful information to develop control of predator reproduction in the future.

Toxic chemical control methods now under review include the M-44 on which experimental data is being gathered in several western states for possible registration by the EPA. Some results will be available in 1975 on these experimental projects which are not associated with the emergency program use of the M-44 by USDL.

Also being evaluated by the Denver Wildlife Research Center is a toxic collar which is designed to kill the predator attacking the neck of the prey animal. Preliminary tests have apparently indicated some degree of success but results have not been released.

In summary, it may seem that little has been done since 1972 despite well over 100 research projects related to predators and predation. Nonetheless, there has been substantial progress considering the relatively short time period since chemical controls were restricted. The growth of predator research is only one example. There is now administrative recognition that a predator problem exists and research is well underway to outline its extent and effects on the industry and the economy. There is also official recognition that mechanical controls alone are not adequate and that management of predator populations may in fact be essential to protect certain agricultural crops.

Testing of alternative techniques and methods to prevent predation has provided some essential information on those which are likely to be ineffective for various reasons, while predator population surveys have provided ample evidence that the coyote is not an endangered species. The orders issued to restrict chemical controls and subsequent policy statements demonstrate that these concepts were not accepted as fact in 1972.

Additional concepts which cannot be attributed to the predator controversy still bear directly on the need to insure survival of agricultural resource units. Pressures for land use zoning to maintain land in agricultural production reflect a growing concern over critical food shortages in many parts of the world where human starvation is real. Eventually, that concern must include animal damage control to prevent excessive waste of food.

Similarly, energy demands and the use of natural fuels to produce synthetic fiber must lead to concern over production and waste of natural fiber provided by photosynthesis rather than by oil and coal.

Other reasons expressed for land use zoning include the desire to curb urban sprawl and the destruction of aesthetic values associated with agricultural land now covered by concrete and subdivisions. The importance of agricultural land to game and nongame wildlife species has not been fully appreciated. There is, however, growing recognition of its contribution to the public benefit by preserving much of the land and habitat essential to wildlife and to outdoor recreation, a contribution far greater than that of any other private sector within the United States.

Political Factors in Animal Damage Control

Most of you here are perhaps well aware of the kinds of problems caused by animal depredations and that vertebrate animals, particularly the carnivores, seem to generate the greatest degree of interest and emotion. Most people seem either to support or oppose the concept and programs dealing with predator control. Few seem to be indifferent or to have no opinion.

The effects of political and administrative influence on direction and effectiveness of such programs are often thought to be clear and obvious. In reality such influences and results are usually complex and often obscure. Any attempt to analyse, document and thoroughly discuss such cause-effect patterns would require an immense amount of time and voluminous writing. Perhaps, therefore, a relatively simple discussion of trends, programs and the cancellation process for the three major chemicals employed in predator control may serve to illustrate a rather complex pattern.

Animal damage control has always been an essential element in protection of human interests. No country, including this one, could have progressed from a primitive stage without such practices and control has been employed in the United States since the first European settlers arrived. Indian history records some similar activities.

Early in this century professional rodent and predator control was initiated by the U.S. Department of Agriculture (USDA) Bureau of Biological Survey on federal lands for protection of agricultural interests. It grew during the first World War in the interest of providing essential food and fiber for a nation at war. It continued under USDA direction until 1939

Presented by Dale A. Wade, Extension Wildlife Specialist, University of California, at the Seminar, "Advancements in Pesticides," Helena, Montana, September 17, 1975.

when the program was transferred to the Department of Interior (USDI) and became the Branch of Predator and Rodent Control (PARC) but with little change in responsibilities. Its purposes remained primarily those of protecting agricultural crops, animal and human health, forest and range, wildlife and other resources. It continued with these duties and programs for 26 years.

Following recommendations of the Leopold Committee (1964), in 1965 PARC was given a new name, Division of Wildlife Services (DWS), with increased duties in wildlife enhancement and management. These have continued to the present time with a greater emphasis on enhancement and a lesser emphasis on damage control.

Prior to 1915, animal damage control had primarily been the responsibility of individuals, producer groups, counties or states, with additional effort by municipalities and public health agencies. Growing federal involvement by USDA, USDI, and public health agencies has occurred since that time. Concern for human health and safety, cleanliness of human food, public utilities, aircraft safety and other factors have dictated more extensive and intensive state and federal involvement for several decades.

Gradually, various cooperative arrangements have evolved between federal, state, county and municipal agencies. Producer and other interest groups have often been a part of such programs. Several types of programs exist, from professional federal, state or county activities, to Extension predator control, or completely independent efforts. In most localities, professional control is augmented by individual effort, producer groups and sport hunters. Bounty programs still exist in some areas although they appear to be losing their appeal. In general, they seem to be considered expensive, wasteful, ineffective and often abused. This seems particularly true where highly intelligent problem animals exist and continue to cause depredations.

Until recently, USDI-DWS had contracts with state and county agencies in 16 of the 17 western states. Kansas was the exception. Some USDI officials have repeatedly expressed a desire to return these program responsibilities to the states. Since 1972, several bills have been introduced in Congress in attempts to accomplish this change. Federal funding to supplement state efforts has been proposed in most of these in the attempt to secure congressional and local support. In most of these bills, however, some reservation of authority to direct or control the extent of damage control and methods to be employed by the states has been reserved to USDI.

For different reasons, therefore, agricultural and environmental groups have occasionally found themselves aligned in opposing similar bills. Usually, this has meant opposition to state-controlled programs by environmental groups because they foresee a loss of their influence if state programs are more responsive than USDI to agricultural concerns. In contrast, agricultural groups have often opposed these bills because they felt that proposed restrictions on control methods were too severe.

As a result, no federal bill has become law, although the states of South Dakota, Colorado and Washington have adopted state control programs in the past two years. Thus, there appears to be at least a partial return toward more state and local responsibility in such programs, although far greater restrictions by federal regulations and policy have been imposed and options in control are largely limited to mechanical control methods.

Methods employed in predator control may include exclusion by fences, some repellent techniques, ^{close} ^{of} herding/livestock, guard dogs and lethal mechanical or chemical techniques. Lethal chemicals have been severely restricted since 1972, however. Repellent techniques have shown little but short term benefits and effective reproductive inhibitors have not been developed. Taste aversive

agents and collars containing toxic chemicals are being evaluated but are not proven effective methods. There has been a great deal of political and administrative pressure recently to adopt the toxic collar, however.

Suggestions for control methods and sources of program funding are many and varied, including those denying that a problem exists and insisting that damage control is not needed. Others prefer a return to the so-called "balance of nature" in the belief that this would provide an immediate and painless solution. Opposition to predator control is at least partially due to the tremendous shift of population to metropolitan areas during this century. More than 90 percent of Americans now reside in urban centers, some removed by several generations from an interest in or concern for the agricultural sector.

The majority of antagonism to damage control is centered in urban areas. Among the reasons often cited are opposition to hunting, trapping, firearms, killing of animals, multiple use of public lands and abuse of land by agriculture interests. Others are a disbelief that damage occurs, or that it is a problem of any magnitude, and often a belief that "management" would solve any problem that does exist. Occasionally, the belief that man is vegetarian by nature and should neither kill animals nor eat meat is given. These beliefs and support by environmental groups, primarily from urban areas, have led to extensive continued efforts to prohibit animal damage control methods and programs.

Such efforts are evident in current restrictions and in bills introduced by state and federal legislators to further restrict chemicals and mechanical control methods, including traps and firearms. Numerous bills to abolish control programs have also been proposed. It has become increasingly apparent that a much greater degree of public understanding and knowledge

of the need for control is essential. Factual information and education programs are obviously the only solution if effective control programs are to continue.

Opposition to predator control programs, particularly to the use of chemicals, increased in the decade prior to 1972. The Leopold Report (1964) increased and focussed attention on these activities and opposition became highly critical with reports of eagle deaths due to shooting and chemicals in 1970-71 in the mountain states. These were apparently major factors in appointment of the Cain Committee in 1971 to review predator control in the western states and in cancellation of the major chemicals used in control programs.

Somewhat unique in the Leopold Report (1964) and the Cain Report (1971) were the differing conclusions, even though there had been no basic change in the livestock industry, the predation problem, the extent of the control programs, the chemicals employed, and the area and techniques for application of control methods. In addition, both committee chairmen served on the other committee.

The Leopold Committee concluded that the steel trap is one of the most damaging control methods in the sense of its being nonselective and that much unnecessary killing of wildlife in the western United States has resulted from the use of such traps in coyote control. It is further stated that when properly applied, 1080 (sodium monofluoroacetate) meat baits are effective and humane in control of coyotes with very little damaging effect on other wildlife.

The Cain Committee did not agree. It stated that the use of chemicals is likely to be inhumane and nonselective and recommended that landowners be trained in the use of steel traps as a major method of coyote control.

Ostensibly, the decisions to cancel predator control chemicals and subsequent orders and actions by the President and agency administrators were based on the Cain Report. This report was released to the public following Executive Order, No. 11643, issued by President Nixon on February 8, 1972. Evidence has gradually accumulated since then, however, indicating that other administrative and political influences were major factors. Some review of chronology is necessary at this point.

The Cain Committee was appointed in early 1971 and apparently began its review in late July under contract to the President's Council on Environmental Quality (CEQ) and USDI. The contract supposedly required completion of the report by October 30, 1972, allowing approximately three months for data gathering, review, and writing of the report. Apparently the report was completed by November and first printed in December 1971, although there are statements of record that it was not printed until January 1972.

On July 9, 1971, at Estes Park, Colorado, USDI Secretary Morton included the following statements regarding the Cain Committee and its findings in his address to the National Wildlife Federation Conservation Summit.

"Well before the Jackson Canyon eagle kill last month, I agreed to cooperate with the Council on Environmental Quality to initiate a complete review of predator control activities to identify problem areas and seek their resolution. This study team will be composed of seven non-governmental professionals recognized for their expertise in the wildlife field...

The Task Force has been charged with the responsibility of examining all aspects of the issue, including poisoning carried on by the private sector and state and local government as well. They have been instructed to examine with care the economics of national insurance programs as a possible alternate to predator control and to recommend any changes which may be needed in our present administration of this program.

Let me add that I absolutely guarantee that the findings of these experts will be given a full hearing and review by wool growers and cattlemen, as well as wildlife interests. The study already has received funding from Interior and the Council on Environmental Quality, and I personally pledge that performance will follow program so that our imperiled predators will not perish in a sea of platitudes."

Although public hearings were "absolutely guaranteed," none were held. The Cain Committee Chairman stated on March 14, 1972, in Mexico City in a panel discussion that "I should say that we first considered public hearings. We decided, however, that there simply was not enough time to hold public hearings, to gather testimony, and to digest it because of the slowness of the hearing process." One is forced to wonder why there was such a shortage of time.

During this same panel discussion in response to a question regarding public hearings not being held, USDI Assistant Secretary Reed stated:

"I would be delighted to give you the answer. I think it is about time that it came right out onto the surface and everybody knew. We all understand the political truths of life. The President received the recommendation sent by the chairman of the Committee to the Secretary of the Interior, and said: 'It's about time I got a recommendation like that and I intend to act upon it. However, I think that it is of such national interest that I reserve it as my right to give it in the Environmental Message which is scheduled for February 8th. There will be no disclosure of the report nor your recommendations to me until that time.'"

If Secretary Reed was accurate in quoting the President, there would appear to have been prior decisions made with regard to cancellation of these chemicals. That this was the case appears to be supported by a stipulation filed in the U.S. District Court for the District of Columbia, apparently late in 1971, in relation to two civil actions filed in that court early in 1971. The relation of the stipulation to the civil actions appears to be as follows:

Civil Action 564-71 was filed with the Court on March 16, 1971. The action filed by Counsel for the Defenders of Wildlife and the Sierra Club against USDI and individuals within the Department contained a series of allegations that USDI activities in damage control were damaging to wildlife including endangered species, particularly with regard to chemicals used in damage control. The action requested an injunction prohibiting USDI from

conducting control activities alleged to be seriously affecting certain wildlife species. A second Civil Action, No. 775-71, was filed in this Court on April 14, 1971, by the Humane Society of the United States and its California branch against USDI and these same individuals. This complaint contained a series of allegations with regard to the use of predacides and requested a permanent injunction to prohibit USDI from conducting such control activities.

The related stipulation was apparently filed in late 1971 with the District Court and contains the following information:

STIPULATION FILED UNDER SEAL

Defendants, by their attorneys, have requested that plaintiffs not pursue, before February 15, 1972, their motions for permanent and/or preliminary injunctions, and have represented to them as follows:

1. That the draft of a study under the direction of Dr. Stanley A. Cain will be finalized and published in early January 1972; and

2. That as a result of recommendations contained in the Cain study and other considerations defendants presently intend to make major changes in policies and programs relating to the existing animal damage control program now conducted by them, and publicly to announce these changes on or before February 15, 1972; and

3. That defendants will need, following publication of the Cain report, additional time, to February 15, 1972, to finalize such plans; and

4. That defendants intend to conclude the present predator control program insofar as killing by poison is concerned, except that defendants intend to continue bird and rodent control programs and animal control research; and

5. That after the changes in policy and programs have been publicly announced, defendants intend to implement such policies and programs as soon thereafter as is practicably possible; and

6. Nothing herein shall be used by any party as an admission or as a statement against interest by any party.

As a result of the foregoing representations plaintiffs agree not to pursue on or before February 15, 1972, their motions for permanent and/or preliminary injunctions and further agree not to pursue, on or before February 15, 1972, other motions or discovery in connection with their lawsuits. In the event that plaintiffs thereafter reactivate their lawsuits, defendants agree to forego any contention that plaintiffs are foreclosed from relief on account of the delay.

This stipulation shall remain in camera and sealed until this litigation is concluded.

The stipulation was signed by counsel for the plaintiffs in both civil actions and was apparently sealed until July 1972.

Disposition of these two Civil Actions apparently was as follows: a stipulation of dismissal of Civil Action 564-71 was filed with the Court in March 1972 stating that "It is hereby stipulated and agreed that the above case is dismissed without prejudice." In May 1972, a similar document dismissing Civil Action 775-71 was filed with the Court. Both documents were signed by counsel for plaintiffs and defendants.

On February 8, 1972, Executive Order, No. 11643, prohibiting use of the major pesticides on federal land and by federal employees was issued by the White House. It provided for emergency use of these chemicals only if in each specific case the head of the agency involved provided written justification for use following consultation with the Secretaries of Interior, Agriculture and Health Education and Welfare and the Administrator of EPA. Additional criteria for emergency use were an essential need for protection of human health and safety, or wildlife species, or "prevention of substantial irretrievable damage to nationally significant natural resources."



On February 10, 1972, USDI issued a news release indicating that it had ceased to formulate, distribute or use these chemicals for predator control on federal lands and had ceased use of any toxic chemicals with secondary effects in control of rodents, birds or other species. Only mechanical methods were authorized/by USDI personnel and chemicals were removed from field use as rapidly as weather conditions permitted.

On March 9, 1972, the EPA Administrator issued orders cancelling and suspending these chemicals (sodium cyanide, strychnine and sodium monofluoroacetate) for use in predator control. In that Order (PR notice 72-2) the Administrator expressed the agency's commitment to review the status of registration for these three chemicals for use in predator and rodent control in rangeland areas. He indicated that "this commitment grew out of grave concern surfaced by the reported deaths of some 20 eagles killed by the misuse of thallium sulfate." Since this compound had not been an operational USDI professional control tool for some 15 years, the "misuse" presumably would have been by non-professionals. Perhaps the interest in reviewing the professional use of chemicals was wholly desirable. It is difficult, however, to see any direct relationship between correct professional use of the three major chemicals and illegal non-professional use of a completely different compound.

In addition, the EPA Administrator cited the Cain report and "a detailed petition submitted to this Agency by several distinguished conservation groups urging that the registration of these compounds be cancelled and suspended immediately." It appears, therefore, that political and administrative influences were significant in the cancellation process.

During this same period and continuing into late 1973, testimony by EPA and USDI administrators at congressional hearings for review of predator

control policy and related matters repeatedly emphasized that chemicals were not needed in such programs since other alternatives such as mechanical methods and livestock management practices were effective and adequate. Testimony, speeches and news releases by administrators also indicated that losses to predators were likely exaggerated and were not as severe or serious as livestock interests considered them to be. Many individuals in livestock production and operational predator control programs disagreed substantially with some of these premises but had little effect on agency or administrative policy.

It appears, therefore, that there are some aspects of the cancellation process for these chemicals which at the least are somewhat unique. In addition to the conduct and dismissal of the civil actions against USDI mentioned earlier, there are others which might be considered. Comparison of the use and cancellation of these chemicals with DDT points to some major differences.

The predacides were used largely in the 17 western states in contrast to DDT which was used nationwide. The amount of DDT used annually exceeded the amount of the predacides used by several thousand fold. DDT has shown adverse effects on several nontarget wildlife species whereas the professional use of the predacides has not shown such effects. DDT was cancelled following extensive public hearings over an extended period whereas no hearings were held prior to cancellation of the predacides. The predacides were cancelled for professional use without prior knowledge by the affected industry and largely due to illegal use of a different compound by non-professionals. Of all the chemicals registered for control of plant and animal species, only those used for predator control were cancelled by executive order.

In the President's message to Congress, August 1972, the restrictions on DDT and the predacides were cited as significant contributions of his

Administration to protection of the environment ; 1972 was a presidential election year and from the revelations of Watergate one is led, inescapably, to wonder what effect election / ^{concerns} had on earlier administrative decisions which were widely supported by environmental groups.

Despite earlier insistence that chemical methods were not needed for predator control, USDI requested and was granted emergency use of the M-44 sodium cyanide device by EPA in May 1974 for protection of sheep and goats where mechanical controls alone were found inadequate. A USDI report on the use of that device for the period from June through October 1974 indicated that in some areas and under some conditions mechanical controls were ineffective and that combined mechanical and chemical predator controls were necessary to prevent or reduce severe livestock losses. Experimental permits for the device were also granted by EPA to several western states in 1974 to determine if it was effective in reduction of losses. USDI has since requested EPA to allow registration and full operational use of the M-44. A hearing on that request for registration and others from several states was held by EPA in August 1975 and apparently registration will be allowed. It appears, therefore, that political and administrative influences were significant in altering predator control methods and programs, first by removing the chemicals and secondly by attempting to bring at least one of them back into operation.

Of additional significance was the notice of intent by the EPA to hold hearings in regard to cancellation of these chemicals for rodent control filed in June 1973. "Informal hearings" were announced and held in September and October 1973 at Washington, D.C., Denver, Colorado, Dallas, Texas and Sacramento, California. All interested parties were invited to produce relevant evidence. The cancellation notice was withdrawn in December 1973

with the following statement as part of the withdrawal:

"Based upon both the informal hearings and the Agency review, EPA has concluded that sufficient valid scientific and economic data do not exist at this time to justify the continuation of the procedures begun by the June 19, 1973, Notice. Accordingly, I hereby withdraw the Notice of Intent to hold a hearing and thereby withdraw the proceedings initiated by that Notice."

The significance of this statement is that far more hard scientific data existed with regard to rodent damage and chemical rodent control than existed on predator damage and chemical control. Therefore, if insufficient evidence existed for cancellation of these chemicals as rodenticides, it is difficult to assume that evidence existed for cancellation of them as predacides.

It seems apparent that a suit brought by the state of Wyoming and other plaintiffs against the EPA and other defendants in regard to cancellation of the predacides was a factor leading to review of the Executive Order (11643) and agency policies. On June 12, 1975, the District Court in Cheyenne, Wyoming, granted the state a temporary injunction setting aside the EPA order which cancelled and suspended registration of these chemicals. The Court also ruled that the EPA was required by its own regulations to follow due process by allowing the livestock interests to be heard and that it must file an environmental impact statement relative to the cancellation of these chemicals. That ruling is now under appeal by the EPA.

A new Executive Order, No. 11870, was issued by President Ford on July 18, 1975. It replaced Order No. 11643 but with few real changes. Section 1(5) adds constraints on devices and additional concerns for individual animals which were not included in No. 11643 and is, therefore, more restrictive than the earlier Order if strictly interpreted. Section 3(c) allows the head of an agency to authorize the use of sodium cyanide on an experimental basis to control predator or bird damage to livestock on federal lands

or in federal programs for no more than one year. Environmental groups appear to feel that except for Section 3(c), there are greater restrictions on use of chemicals than existed in Order 11643.

There appears in reality to be very little real change from Order 11643 since the emergency permit authorized USDI to use the M-44 in protection of livestock, except on federal lands. Insofar as experimental use is concerned, there appears to be no obvious advantage on federal lands since similar conditions for research can readily be found on private or state land.

There is the possibility of different methods of application, i.e.: the toxic collar, which can be used experimentally by USDI under Order 11870. USDI has applied for registration of this device, a toxic collar fitted to the neck of sacrificial sheep, to provide a somewhat different approach as indicated in the following comments from Science, August 1, 1975:

"The Council on Environmental Quality (CEQ) has announced that the government will permit new experimental use of sodium cyanide to kill coyotes that attack sheep. The latest decision is a modification of a 1972 executive order that bans predator poisoning on public lands except under emergency conditions.

Coyotes are responsible for the death of 3 to 5 percent of sheep herds in the West (25 percent in some areas), said CEQ head Russell Peterson. Shepherds find the losses hard to bear, since the sheep industry has been steadily declining since the 1940's.

The simplicity and restraint that characterizes the new idea perhaps explains why it wasn't thought of before. Most coyotes don't like eating sheep (rabbits are their staple), but a few love them, and will attack again and again. They prefer lambs, preferably tethered, and they attack by lunging at the neck. So a poisonous collar--a necklace of sodium cyanide capsules--has been devised. A few lambs will be tethered at the edge of their herd and fitted with the collar. A passing coyote with an eye for sheep will leap at the animal's neck, his teeth will puncture a cyanide pellet, the poison will squirt in his mouth, and voila! he will drop dead. Peterson says tests in large pens show that this works, and furthermore, the lamb generally escapes unharmed. The project has virtues ecologically not only because of its selectivity but because carrion eaters happening upon the dead coyote will not be poisoned by eating the flesh.

Peterson, in answer to a question, said it was possible the technique could have an adverse conditioning effect on whole populations of coyotes--one day, perhaps, breeding an antisheep attitude into the subconscious of the race, as it were.

Defenders of Wildlife, a Washington group that fought for the 1972 poison ban, has criticized the recent action on the grounds that it opens loopholes for indiscriminate poisoning programs to resume. The government argues that relaxing the order to allow experimental programs will permit development of more effective and environmentally sound means of predator damage control."

CEQ appears to have had, and still to have, substantial influence on administrative decisions related to the predacides and appears to be pushing heavily for adoption of the collar as a totally new concept. However, neither the concept or the collar are really new, but came from suggestions of control personnel in field operations and are several years old. Reasons they were not adopted are several, but included are these: physical limitations in applying these to animals weighing from 6 to 150 pounds or more and logistic problems of application, including the number of sheep that must carry collars, or placement of the few sacrificial sheep into suitable locations to intercept the coyotes. Equally as great are the limitations due to intelligence and behavior of the coyote species. However desirable the toxic collar may be, it is questionable that it will be effective as the major method of coyote control.

Experimentally, the toxic collar should be extremely interesting to test and, hopefully, will be at least partially effective. It does seem, however, that widespread application would provide a logistics problem to stagger the imagination, particularly where coyotes are travelling long distances to kill, where their travel routes and direction are unknown, and where they fail to see the attraction in tethered lambs compared to those running free. These factors appear to carry little weight in CEQ if the report in Science is accurate and there remains little doubt that political and administrative factors continue to function; 1976 is also an election year.

Political and administrative actions normally occur in response to the interest, activity and size of pressure groups. In numbers, the rural population is distinctly outweighed. The 1973 census revealed that 4.5 percent (9,472,000) of the total U. S. population (210,036,000) were farm residents. The total number of U. S. farms reported in 1975 was 2,819,000, of which 146,200 were involved in the sheep industry. If one assumes that the rural population is evenly distributed across these farms, approximately 5.2 percent of rural residents were involved in sheep production in 1975, less than one-fourth of one percent (0.23 percent) of the entire U. S. population. It is not surprising, therefore, that agriculture, particularly sheep producers, has relatively little influence on political and administrative decisions.

The livestock industry has been further hampered by a lack of unified, clear, consistent opinions, policies and objectives on the predator issue. Individual violations of laws and regulations, including the use of toxic chemicals, have also contributed to a loss of influence and to increased opposition in all aspects of animal damage control. The extension of opposition to include other wildlife management practices, particularly hunting and trapping, has occurred. In many instances, a lack of understanding of carrying capacities and population dynamics seems to be coupled with a belief that "the balance of nature" is all that is needed.

Particularly critical has been opposition to animal control on public lands, accompanied by growing opposition to multiple use of such areas for hunting, grazing and other purposes. The beneficial effects of hunting to protection of habitat by preventing overuse by game animals and damage to adjacent agricultural crops is often not recognized. Without question, overuse of land by game animals as well as livestock contributes to loss of vegetation, decreased water retention and erosion. However, moderate grazing by livestock

increases forage by reducing wildfires, by suppressing some plant species and stimulating regrowth of others. Grazing, therefore, is not necessarily undesirable. This depends on the intensity of use and moderate use can benefit wildlife in many areas.

Private agricultural land is at least as important to wildlife as public land by providing habitat the year around for many species and critical habitat, particularly in winter, for such species as deer and elk. Thus, the importance of agricultural land to wildlife as well as food production suggests that economic survival of producers is essential.

Given the opposition to control programs and the influence of opposition groups, it is not unusual that "panaceas" such as repellents, aversive agents and "livestock management" are so appealing to legislators and administrators. From any point of view an effective nonlethal method which offered both the relief sought by producers and acceptance by opposition groups would be ideal and highly attractive politically. However, all methods are subject to limitations imposed by physical, biological and climatic factors. From current knowledge of predator biology, behavior, intelligence and adaptability, it is evident that a wide range of options and flexibility in application are essential to solving individual problems. Livestock management, repellents, predator-proof fencing and other nonlethal methods may be useful in many situations but they cannot be effective under all conditions.

Theoretical approaches to "solve" the predator issue have often been directed with little prior knowledge or consideration of limiting factors and many "simple solutions" have been offered. The difficulty in application has been the lack of simple problems to which they apply.

A quote attributed to P. A. M. Dirac, Nobel Laureate, seems particularly appropriate: "It is also a good rule not to put overmuch confidence in the



observational results that are put forward until they have been confirmed by theory." It often appears that this philosophy has been applied with little restraint in administrative approaches to animal damage control over the past several years. It would seem even more valid to apply the inverse, that confidence in theory can only be supported by confirmation in fact.

It is possible that additional new control techniques such as specific attractants and reproductive inhibitors may be developed. Such methods could provide alternatives for management of damaging species and may offer one of the best options for nonlethal control in the future. It is highly unlikely, however, that nonlethal methods can ever provide all necessary control in the immense variety of habitat types, climatic conditions and damage situations that are known to exist. Management of predator populations will be necessary and political reality suggests that this too must be recognized.

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