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REPORT

ON

PREDATOR DAMAGE MANAGEMENT IN THE WEST



Prepared by

U.S. Fish and Wildlife Service

DEPARTMENT OF THE INTERIOR

May 5, 1978

ADDRESS ONLY THE DIRECTOR,
FISH AND WILDLIFE SERVICE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
WASHINGTON, D.C. 20240

FOREWARD

This draft report is the result of a study begun in January 1978, by the U.S. Fish and Wildlife Service on the problems of animal predation on western livestock. This draft report is the forerunner of a final report and a Secretarial option paper which will be completed in July of this year. This draft is being made available to the public at this time to stimulate commentary which may be used in the revision and finalization of this report and in the preparation of the option paper.

A select, external advisory committee, the Animal Damage Control Policy Study Advisory Committee, has been appointed to review and help validate the use and interpretation of data obtained by this comprehensive Federal study, the primary emphasis of which is on the problems of coyote depredation on sheep and cattle in the West.

The committee's duties are solely advisory. Decisionmaking remains the prerogative of the Director, U.S. Fish and Wildlife Service; the Assistant Secretary for Fish and Wildlife and Parks; and the Secretary of the Interior.

Additional public input will be provided through hearings. This report will be the subject of these hearings later this month on the following dates and at the specified locations. Each hearing will begin at 9:00 a.m.

May 22, 1978	Boise, Idaho, Main Ballroom, Boise State University, 1910 University Drive
May 23, 1978	Casper, Wyoming, Main Ballroom, Ramada Inn, I-25 and Center Street
May 25, 1978	San Angelo, Texas, Main Ballroom, Houston-Harte Center, San Angelo State University
May 31, 1978	Washington, D.C., Auditorium, Department of the Interior, 18th & C Streets, NW.

Both oral or written testimony will be taken on substantive aspects of the study and report. Any person wishing to testify orally should submit a written notice of intent no later than May 15 to Ms. Sheila Minor, Office of the Assistant Secretary for Fish and Wildlife and Parks, Department of the Interior, Washington, D.C. 20240 (202/343-4945). Oral testimony will be limited to 15 minutes for each witness. A witness list indicating the order of witness participation will be sent to all those desiring to testify and will be posed in the hearing room vicinity one day prior to the hearing. Written comments not exceeding 10 double-spaced pages in length may be filed also and must be submitted no later than the close of the final hearing on May 31 in Washington, D.C. Persons wishing further information about the public hearings or who wish to submit written statements should contact Ms. Minor.

We hope you find the draft report of interest and look forward to whatever comments you may wish to make.

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I. DEFINITION OF THE PROBLEM

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As primary steward of Federally owned natural resources, the Secretary of the Interior is often faced with potential conflicts among his responsibilities. The 1931 Animal Damage Control Act mandates a Federal program of predator control to reduce losses of livestock and other sorts of predator damage. Increased awareness of environmental concerns in the 1960's resulted in the passage of the National Environmental Policy Act in 1969 and the Endangered Species Act in 1973, both of which emphasize the Secretary's responsibilities for all wildlife species and their environments. These and other legislative mandates, interwoven with economic pressures and public concern for wildlife form the basis of the problems of livestock predation in the West.

There have been two major policy studies dealing with animal damage control -- the "Leopold Report" (1964) and the"Cain Report" (1972). The Leopold Report was initiated by Secretary Udall to investigate the role and practices of the Federal government in animal damage control, and to recommend changes, if needed, to ensure an environmentally sound and socially acceptable Federal Animal Damage Control program. In response to increasing controversy over the use of toxic chemicals for predator control, the Department of the Interior and the Council on Environmental Quality sponsored a 1971 study of the entire predator damage situation in the United States; this became known as the Cain

Report. Soon after that study was completed, Executive Order 11643 banned the use of toxicants for predator control on Federal lands and by Federal agencies. Subsequent action by the Environmental Protection Agency severely limited the availability of toxicants for state and private predator control use. In 1975, the M-44 cyanide ejector was registered for limited use in coyote control by government personnel and certified private applicators.

Western livestock interests contend that their losses to predators, primarily coyotes, are now at unacceptable levels, and that such losses have been a major cause of the decline of the range sheep industry during the past three decades. There are reports of increasing coyote predation on cattle in the west in recent years. Predator losses are said to cause substantial direct economic loss to producers as well as to consumers who must pay higher prices for curtailed supplies of beef, lamb and wool. The livestock interests want the Federal control program intensified, and predacides such as compound 1080 added to the list of permissable control methods.

Other groups and individuals concerned over the predator control issue argue that predation is a natural phenomenon and a necessary factor in maintaining ecological balance. They contend that claims of livestock loss to coyotes are exaggerated, that there is no good evidence that controlling coyotes reduces losses, and that most losses are balanced

by the beneficial effects of coyotes as a control on populations of rodents and other small mammals that damage crops and rangeland. It is also argued that predator control, particularly toxicant use, directly or indirectly results in deaths of non-target wildlife including endangered and threatened species. Others feel that any systematic killing of wild animals is wrong except under extreme circumstances.

In addition to questions about the extent of livestock losses and whether they can be reduced or mitigated without excessive environmental hazard, questions have been raised about the proper role of Federal and state governments and the private sector in predator control. Some livestock interests contend that a system of Federal grants to state-run predator control programs backed up by Federal research and extension activities would be more flexible and better able to meet local needs than the current system. Those who favor Federal control and funding of the operational component contend that only qualified professionals without close ties to local interests and working under guidelines and policies set at the national level can objectively determine the need for control and the best method or combination of methods to use in a given situation. Others believe that if livestock producers were made to bear a larger portion of the cost of the control, it would be more equitable and would make producers less prone to ask for assistance to solve what could be minor predator problems.

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The central policy question is how should the Secretary balance the livestock interests' requests for an intensified predator damage control effort with environmental concerns and budgetary constraints. The purpose of this study is to seek answers to that question by examining the nature and scope of predation problems affecting the western livestock industry, with emphasis on data and research accumulated since the Cain Report. Issues that will be addressed include the environmental impacts of damage control program operations, the economic effects of livestock losses on consumers and producers, the proper role of the Federal Government, and public opinion toward predator damage control.

The five principal components of the report are summarized below:

Economics of the Western Livestock Industry: Available data on the level of livestock losses to predators in the West and estimates of the economic value of the loss will be reviewed. To evaluate the impact of predator losses on the range livestock industry, the report will consider livestock prices and profits, trends in the structure and composition of the industry, husbandry practices, and other factors determining the effect of predator loss on the economic viability of the western sheep and cattle industries.

ADC Service Delivery Approaches: Alternative control strategies and devices will be evaluated with respect to selectivity, effectiveness in reducing livestock losses, cost, environmental impacts, public acceptability, and legal or institutional constraints. Both lethal and non-lethal methods will be considered. Alternatives to direct

control will be evaluated including public range use policies, insurance programs, usbsidies, and extension/training programs.

Ecological/Environmental: In addition to the effects on non-target species and other environmental effects of particular control methods, the study will analyze data on the short and long term effects of predator damage control on populations of predators and other non-game and game species, and on other ecological relationships.

Proper Federal Role: The study will review the various arguments for and against different degrees of Federal involvement in predator damage control. The pros and cons of Federal funding and direct involvement in operational damage control, research, and extension components of a control program will be evaluated.

Public Perceptions Toward Predation and Control: The recent literature concerning public views and opinions toward predation damage and control suggests distinct differences among population groups in terms of their attitudes toward wildlife and the acceptability of predator damage control practices. This information will be evaluated and made an integral part of the report.

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The Secretary of the Interior's responsibilities for wildlife management includes resolution of problems caused by wildlife depredations. This can only be accomplished by integrating all of the existing relevant information. The primary focus of this study is the Animal Damage Control Program as it relates to the coyote predation on western livestock.

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II.A. Review of Previous Policy Studies

A growing environmental awareness in the early 1960's was one of the factors that led Secretary of the Interior Stewart Udall in 1963 to ask his five-man Advisory Board on Wildlife Management to evaluate predator control. The subsequent report (Leopold et al., 1964) adopted two basic tenets: (1) all native animals are resources of inherent interest and value to the people of the United States; basic governmental policy, therefore, should be one of husbandry of all forms of wildlife; and (2) local population control is an essential part of a management policy where a species is causing significant damage to other resources or crops, or where it endangers human health or safety.

The Advisory Board unanimously agreed that control at that time was in excess of that justified in terms of public interest (Leopold et al., 1964, p. 29). They also concluded that control should be limited to the troublesome species, and preferably to the troublesome individuals, and in any event, to the localities where substantial damage or danger exists.

The Advisory Board recommended: The appointment of a longer term Advisory Board on Predator and Rodent Control with members from all major commercial and public interest groups; that the Branch of Predator and Rodent Control change its name and reassess its function and purpose to better reflect the changing public attitudes and knowledge about wildlife; a new

explicit set of criteria to guide control decisions; a greatly expanded wildlife research program; and the close regulation of the use of 1080 or any other poison capable of having severe secondary effects on non-target wildlife species.

Subsequently, although a continuing Advisory Board was not formed, the program was renamed the Division of Wildlife Services, and a wildlife biologist was appointed as its chief. Despite this, and the feeling that in general the operations of the division had been substantially improved along recommended lines, "...by the early 1970's the public had become more, not less, restive about predator control" (Wagner, 1972, p. 6). As a result a seven-man Advisory Committee on Predator Control was appointed and charged with reviewing and analyzing animal damage control programs and policies in the U.S.

The result of that effort, the "Cain Report" (Cain, et al., 1972), acknowledged that general progress had been made in updating predator control activities, and made a number of recommendations dealing with predator damage control. These are shown below along with an assessment of the degree to which they have been acted on.

- Federal-state cooperative program funding should be exclusively by Congressional and state legislative appropriation. Colorado dropped the Federal-state cooperative program in 1974. Washington and South Dakota have cooperative programs based on Federal contracting of control responsibility to the states with no Federal operational role. Counties and associations still provide part of program funds directly to the cooperative programs conducted in 13 other Western States.

- All existing toxic chemicals should be removed from registration and use for Federal operational predator control, with similar restrictions at the state level. In 1972 the use of toxicants to control predator damage was banned on Federal lands and in Federal control programs by Executive Order 11643. Soon after, the U.S. Environmental Protection Agency cancelled the registrations of all predacides, effectively halting their legal use. Beginning in 1974, limited use of the M-44 cyanide ejector was permitted, first for experimental, and then operational use.

- Division of Wildlife Services Staff should be professionalized by emphasizing employment of qualified wildlife biologists. Currently, nearly all (91 percent) of state and district supervisory staff have at least bachelors degrees in wildlife biology.

- Cooperative trapper-trainer extension programs should be established in all states. Missouri and Kansas are the only western states that rely primarily on predator extension programs, both pre-dating the Cain Report. Extension is an integral part of the cooperative program in all western States. Federal wildlife-related extension activities are discussed in section II.D.1.

- Congress should provide some means of alleviating the economic burden on livestock producers who experience heavy losses to predators. No action has been taken.

- Federal grazing permits and leases written by Federal land management agencies should provide for possible suspension or revocation of grazing privileges if regulations governing predator control are violated. The only clause in grazing regulations that deals specifically with predators prohibits poisoning of eagles on public lands.

- All methods of predator control should be prohibited on statutory Wilderness Areas. No action has been taken. Predator damage control to reduce livestock losses is conducted on Wilderness Areas within the statutory limits of wilderness designations.

- Federal and state legislation should make the shooting from aircraft of wildlife, including predators and game animals, illegal except under exceptional circumstances and then only by authorized wildlife biologists of the appropriate Federal and state agencies. Such legislation has been enacted at the Federal level and by most Western States. Aerial hunting is prohibited in Arizona and Kansas.

- That provisions be made to suspend or revoke the license of a private pilot and confiscation of the aircraft when he is knowingly involved in illegal predator control. Federal aviation regulations and the regulations of most Western States have been changed accordingly.

- Recommended initiation of long-term Division of Wildlife Services research program covering the gamut of ecological problems associated with predators. Relevant research is described in section II.D.4.

- Recommended that a detailed socio-economic study of cost-benefit ratios of predator control be undertaken by the Division of Wildlife Services. Specific studies of this nature have not been undertaken. Closely related studies of control versus no-control loss rates are discussed in section II.D. Research on public attitudes towards predation and wildlife is discussed in section II.I.

- Division of Wildlife Services should be delegated the responsibility for the study of the epidemiology of rabies in the field by a team of specialists provided with adequate funding. Epidemiological studies of rabies are being conducted by the U.S. Department of Health, Education and Welfare.

- Congress should give the Secretary of the Interior authority to take measures necessary to protect all species of predators that have been placed on the Endangered Species List by the Federal Government. This was accomplished by the 1973 Endangered Species Act.

- The states should take measures to supplement the Federal protection of rare and endangered species by enacting laws and taking measures to protect locally rare populations. A number of states enacted such legislation, and the Federal program was substantially strengthened by the 1973 Endangered Species Act.

To summarize, most of the recommendations of the Leopold and Cain committees have been acted on while others are no longer relevant because of other events and actions that have occurred since they were made. One of the purposes of this report is to review the evidence, both new and old, with respect to the recommendations and conclusions of these previous analyses to determine whether they are still appropriate.

II.B. Description of the Western Sheep Industry

The purpose of this section is to review the recent history and current status of the western sheep industry. Trends in the size of the industry, its use of public lands, incentives, practices, problems, and profitability will be covered. The final section will include the outlook for the industry.

II.B.1. Number of Sheep and Producers

The sheep industry in the 17 Western states supplies a major portion of the nation's mutton, lamb, and wool. In 1978, the population of stock sheep in these states totalled approximately 8.7 million head located on 47 thousand farms and ranches. This accounts for 80 percent of total sheep production and 39 percent of the producers nationwide (Table B-1).

Some areas of the West are major sheep production centers while extensive areas produce few, if any, sheep. The variance in sheep density areas can be seen in Figure B-1. Of the 1,059 counties in the 17 Western states, only 343 had over five sheep per square mile; 348, had one to five sheep per square mile; and the remaining 368 counties had less than one sheep per square mile. Heavy sheep densities (40 or more per square mile) occurred in only 40 counties, representing only 3.1 percent of the land area in the 17 states (Pearson, 1975). The actual location of the

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Table B-1 Stock sheep and sheep producers in the 17 Western States, 1960, 1972, 1978

	Stock Sheep (thousands)		
STATE	1960	1972	1978
Texas	5,738	3,125	2,310
Wyoming	2,248	1,561	1,010
South Dakota	1,521	1,031	670
California	1,712	1,011	915
Montana	1,767	900	470
Utah	1,249	891	470
Colorado	1,434	720	450
New Mexico	1,127	682	546
Idaho	1,071	678	525
Oregon	863	426	310
Arizona	454	412	378
North Dakota	592	307	165
Kansas	494	240	140
Nebraska	375	204	152
Nevada	335	176	110
Washington	295	112	56
Oklahoma	222	90	68
17 Western States	21,497	12,566	8,745
Other States	7,352	3,250	2,029
Total Stock Sheep	28,849	15,816	10,774
	(thousands)		
Sheep producers	115.0	60.1	46.6[1/]
Other States	223.0	102.3	73.1[1/]
Total Producers	338.0	162.4	119.7[1/]

1/ Data are for 1977, the latest year available.

Source: Sheep and Goats, Economics, Statistics, and Cooperatives Service, U.S. Department of Agriculture, 1960, 1972, 1978.

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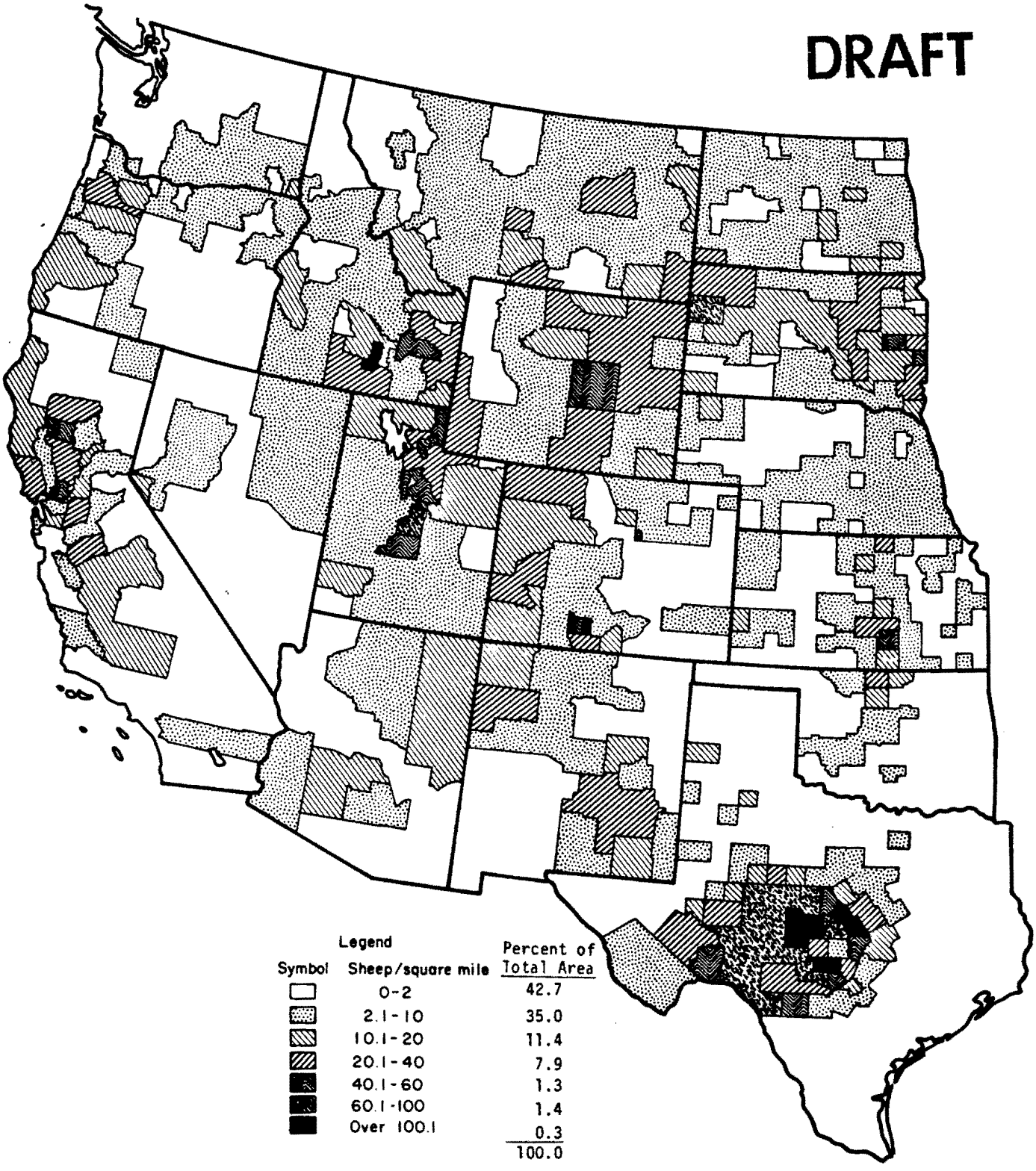

Figure B.1 Density of Sheep in 17 Western States, by Counties.

Source: Erwin W. Pearson. "Sheep Raising in the 17 Western States: Populations, distribution, and trends," Journal of Range Management 28(1), January 1975.

flocks may be 100 miles or more away from the locations shown on Figure B-1 depending on the time of year. With this limitation Figure B-1 gives a reasonably accurate overview of the location of the major production centers in the West.

Texas is the leading sheep producing State with 27 percent of the West's total stock sheep and 19 percent of the producers (Table B-2). Other leading States include Wyoming, California, South Dakota, Utah and New Mexico. States with the fewest sheep are Washington and Oklahoma, each with less than one percent of the West's total.

Western sheep production is dominated by enterprises with large herds. Fifty-six percent of the ewes are in herds of 1,000 head or more and are managed by just six percent of the producers. Herds of less than 200 ewes represent only 17 percent of the total inventory but involve 80 percent of all producers (Table B-3).

Some changes in the distribution of breeding ewes by herd size occurred between 1969-74 (Table B-3). There was a shift in inventory size from small herds to larger ones with herds of 200 - 2,499 ewes receiving the greatest percentage increase in inventory. This may indicate a trend toward a more "economic" unit size as costs, prices, and management needs change over time.

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Table B-2. Numbers of stock sheep and sheep producers in each of 17 western States, 1977

States	Stock Sheep		Sheep Producers 1/		Sheep per producer (average)
	Number	Percent of West	Number	Percent of West	
	Thousands	Percent	Number	Percent	Number
Texas	2,360	26.7	9,000	19.3	262
Wyoming	1,071	12.1	1,400	3.0	765
California	900	10.1	4,500	9.7	200
South Dakota	625	7.0	6,000	12.9	104
Montana	490	5.5	2,100	4.5	233
Utah	560	6.3	2,300	4.9	243
Idaho	490	5.5	1,900	4.1	258
Colorado	500	5.6	2,400	5.2	208
New Mexico	536	6.0	1,400	3.0	383
Arizona	374	4.2	280	.6	1,336
Oregon	310	3.5	4,300	9.2	72
North Dakota	174	2.0	2,100	4.5	83
Nebraska	100	1.1	2,800	6.0	36
Kansas	140	1.6	2,500	5.4	56
Nevada	120	1.4	270	.6	444
Washington	64	0.7	1,500	3.2	43
Oklahoma	59	0.7	1,800	3.9	33
Total	8,873	100.0	46,550	100.0	191

1/ Assumed to be the same as the number of farms and ranches with sheep.

Source: Gee, C. Kerry and Richard Magleby, Characteristcs of Sheep Production in the Western United States, AER 345, August 1976. U.S. Department of Agriculture, Economic Research Service.

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Table B-3. Percent distribution of farms and breeding ewes by herd size, 17 Western States, 1974.

Herd size Ewes 1 year and older	Proportion of: Farms			Ewes 1 year and older		
	1969	1974	Change	1969	1974	Change
Head	Percent					
1- 24	33	35	2	16	2	-14
25- 99	32	32	0	8	7	-1
100- 199	15	13	-2	9	8	-1
200- 499	11	10	-1	10	14	4
500- 999	4	4	0	8	13	5
1,000-2,499	3	4	1	19	23	4
2,500-4,999	1	1	0	16	18	2
5,000 and over	1	1	0	14	15	1
Total	100	100		100	100	

Source: 1969 and 1974 Census of Agriculture.

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Diversified or joint enterprises with both sheep and beef cattle (56 percent of commercial producers) are more common among commercial sheep producers than are specialized enterprizes of sheep only (Table B-4).

Table B-4. Enterprise Diversification in the 17 Western States

Type of enterprise	Percent of commercial Producers	Sheep
Sheep only	31	32
Sheep and beef cattle only	56	50
Sheep and goats only	2	1
Sheep, goats, and cattle	11	17
	100	100

Source: Gee and Magleby, 1976, p. 13.

Diversified enterprises with cattle permit fuller range utilization, diversification of income and risk, and flexibility to vary the mix of sheep and cattle in line with changing prices, costs, labor availability, and predator activity. In past years, many producers have reduced the number of sheep and increased the number of cattle. Some have dropped sheep production entirely in favor of cattle. Current (1977-78) favorable prices for lambs compared with calves could cause some producers to shift production back to more sheep.

The extent of diversification of commercial sheep producers (50 or more sheep) into other enterprises is further illustrated by their sources of income. On the average, commercial sheep producers receive nearly half their income from sales other than sheep, lambs and wool (Table B-5).

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Table B-5. The Contribution of Farm Sales to Commercial Sheep Producers Income, 17 Western States

Source of farm sales	Percent of producer income
Sheep, lambs, and wool	54
Beef cattle	26
Goats and mohair	1
Other livestock and poultry	3
Crops	16
	100

Source: Gee and Magleby, 1976, p. 14.

Small operations tend to be more diversified, while large operations are more specialized. Commercial producers with 50-99 head of sheep obtain only 38 percent of their gross agricultural sales from sheep, lambs, and wool, compared with 78 percent for producers with 5,000 head or more sheep. The sale of sheep, lambs, and wool make up 54 percent of commercial producers income on the average.

In summary, the trend in both the number of sheep and enterprises is down considerably in the 17 Western States. The number of sheep have gone from 15 million head in 1968 to approximately 8.7 million in 1978. During the same time period the number of producers declined from 68 thousand to 47 thousand. Sheep densities and number of producers is highest in Texas with 9 thousand producers and 2.4 million sheep in 1977.

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II.B.2. The Role of Public Land

The use of public lands for grazing sheep varies considerably in the West. In order to discuss the importance of public lands to the sheep industry, the West was divided into seven sheep producing areas based on geographic and economic similarities (Figure B.2.). Over one-half of the feed for western commercial sheep in supplied by private range areas, with supplementary feed (22%) and public range (18%) providing most of the remaining requirements. The relative importance of the different feed sources varies among the sheep production areas. Public rangeland is the major source of feed in the Mountain and Great Basin areas (Table B.6), providing 41 percent and 51 percent, respectively, of the annual feed of commercial producers (producers with 50 or more stock sheep). In the other five areas, private range is the predominant feed source with the exception of the California-Arizona and Plains-Wheat-Corn areas where the percent of "other" feed sources are higher than for private range.

Table B.6. The use of Public Range for Western Commercial Ewes, 1974

Area	Public Range	Private Range	Other
	---- Percent of Feed Supply ----		
Mountain	41	32	27
Great-Basin	51	26	23
Pacific Coast	6	64	30
California-Arizona	13	36	51
Texas-New Mexico	4	73	23
Plains-Wheat-Corn	1	47	52
Northern Plains	18	56	26
TOTAL	18	51	31

Source: Gee and Magleby 1976 p. 28.

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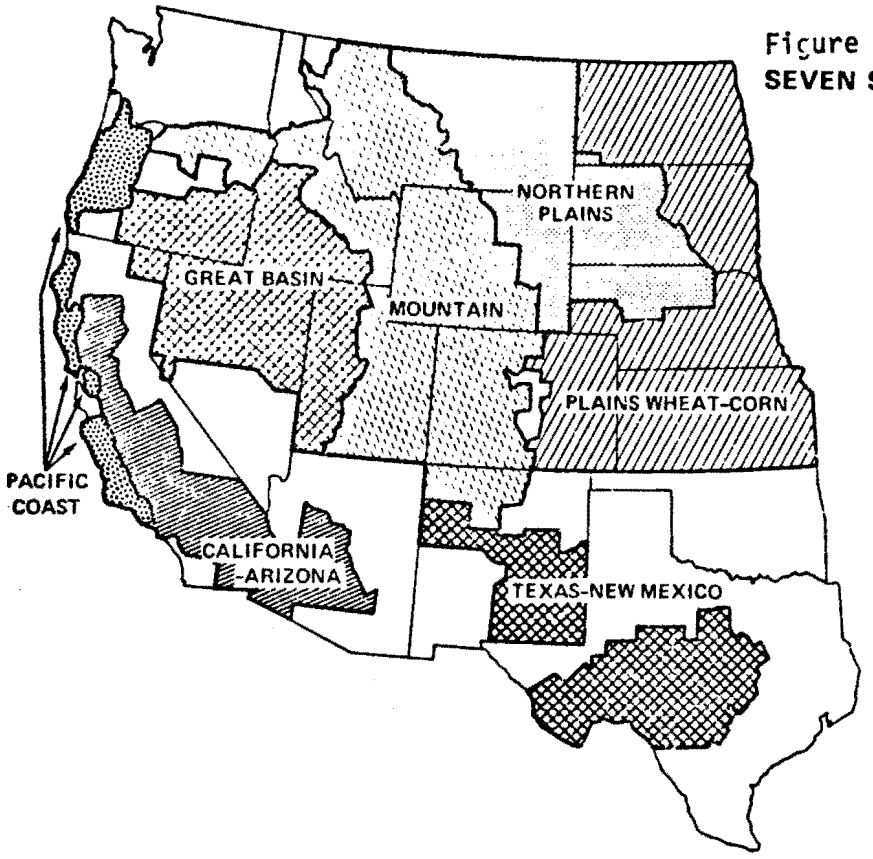

Figure B.2.
SEVEN SHEEP PRODUCING AREAS OF THE WESTERN STATES

Percent of Producers

23 Plains Wheat-Corn: rolling prairies of North Dakota, eastern South Dakota, Nebraska, Kansas, and eastern Colorado.

14 Northern Plains: dry desert and plains portions of western South Dakota, eastern Wyoming, and eastern Montana.

20 Texas-New Mexico: Edwards Plateau of Texas and central and southeastern New Mexico.

25 Mountain: mountainous portions of Montana, Oregon, Idaho, Utah, Wyoming, Colorado, and New Mexico.

5 Great Basin: primarily the dry desert terrain of southern Oregon, northern Nevada, and western Utah.

3 California-Arizona: central valleys of California and southwestern Arizona.

10 Pacific Coast: coastal mountain ranges of California and Oregon.

Federal ranges, including Bureau of Land Management and National Forest Service lands, are used by about one-fifth of the commercial producers and provide some feed for nearly one-half of the West's commercial stock sheep (Table B.7).

The use of Federal range varies considerably among areas according to availability. In the Mountain and Great Basin areas, where Federally-owned lands are plentiful, over three-fourths of all commercial stock sheep use Federal lands (Table B.8).[1/] In the Northern Plains and California-Arizona areas two-thirds of the commercial sheep and one-half of the commercial sheep, respectively, use Federal lands. Because of limited availability, Federal range is grazed by few sheep in the Texas-New Mexico, Plains-Wheat-Corn, and Pacific Coast areas.

1/ These are over-estimates of the actual proportions of sheep using Federal lands since they include all stock sheep of commercial producers who use the specific type of range even though some producers may not place all of their sheep on this range.

Table B.7 - Use of Federal range by western commercial sheep producers, 1974

Subregion or size of operation	Commercial producers using:				Ewes of producers using: 2/			
	BLM land	National Forest System land	Both BLM and National Forest System land	Total Federal range	BLM land	National Forest System land	Both BLM and National Forest System land	Total Federal range
	Percent of total 1/							
Subregion								
Mountain	32	27	22	37	71	57	52	76
Great Basin	38	24	23	39	84	49	49	84
Pacific Coast	1	1	1	1	8	8	8	8
California-Arizona	26	11	10	27	45	22	17	50
Texas-New Mexico	2	0	0	2	3	0	0	3
Plains Wheat-Corn	1	0	0	1	4	0	0	4
Northern Plains	39	3	1	41	61	6	1	66
Size of operation by number of animals								
50-99	2	--	--	2	2	1	--	3
100-299	5	3	1	7	7	3	--	10
300-999	24	10	8	26	37	16	13	40
1,000-2,499	35	14	13	36	41	15	12	44
2,500-4,999	46	25	24	47	49	31	29	51
5,000 and over	50	29	28	51	53	32	29	56
All subregions and sizes	19	8	7	20	44	25	22	47

1/ Percent of all commercial producers or commercial ewes in the West. May add to more than 100 because of the producers using both BLM and National Forest System lands.

2/ Includes all of the ewes of commercial producers who use the specific type of Federal range, even though some producers may not place all of their sheep on this range. Thus the figures overstate the actual proportions of sheep grazing on Federal ranges.

Source: Gee and Magleby 1976, p. 29.

Grazing on Federal ranges is very important to many of the larger operations. Nearly half of the producers with over 2,500 head of sheep use Federal range. On the average, Federal range for these producers provides 42-45 percent of the annual feed for their sheep. Most of these producers have few feasible alternatives for this major portion of their feed supply.

Commercial producers depend on Federal range for about one-third of the annual feed required for their sheep. This average dependence is somewhat greater on BLM lands than on NFS lands, 31 percent of annual feed compared with 19 percent, because sheep are grazed longer during the year on the former (3-4 months on the average) than the latter (2-3) months average).

In the Mountain and Great Basin areas and to a lesser extent in California-Arizona, grazing on BLM lands drops off during the summer when herds move onto available forest lands, then picks up again in fall when the herds move down again off the high elevations. Only in the Northern Plains area, where little forest land exists, does grazing on BLM lands increase during the summer, as compared to spring, fall, and winter.

Open (unfenced) range grazing is practiced by only one-fifth of the West's commercial producers, but nearly one-half of the region's commercial sheep are involved (Table B.8).

Table B.8 Type of Grazing Activity by Season, 17 Western States - 1974

Type of grazing	Spring and summer period		Fall and winter period	
	Producers	Sheep	Producers	Sheep
	Percent			
Fenced pasture/range	85 1/	58	82	53
Open range	19 1/	42	18	47
	100	100	100	100

1/ Some producers use both.

Source: Gee and Magleby 1976 p. 18.

Use of open range or fenced pasture and range frequently depends on land tenure. Producers who run sheep mainly on privately-owned land usually have the grazing area fenced. This is particularly true of operations with fewer then 1,000 head of sheep. In the Texas-New Mexico and Plains Wheat-Corn areas which have little public land, practically the entire sheep population is grazed in fenced areas. In contrast, in the Mountain and Great Basin areas where there are large public land holdings, most of the commercial ewe population is grazed on open range.

Public lands play a major role in grazing sheep in the West. Of the 157 million acres of BLM lands available for all livestock grazing approximately 17 million acres were used for grazing sheep and goats in 1976. The national forest system lands had 58.9 million acres suitable for grazing and 9.4 million acres were used for sheep and goats in 1970 (the latest year that data are available). Public range is used extensively in the Mountain and Great Basin Areas, with 37 and 39 percent of the commercial producers grazing up to a maximum of 76 and 84 percent

of the commercial ewes on public land in each area respectively. Commercial producers in these areas may graze some of their flocks in different areas so the figures given are the maximum possible. Commercial operations with fewer than 1,000 head of sheep who graze sheep on private land normally fence the grazing area.

The number of sheep and goats grazed on BLM lands decreased by 40 percent between 1960 and 1976 and on NFS lands by 42 percent between 1960 and 1974. The percentage decreases in sheep and goats grazed on these Federal lands has been less than the 50 percent overall drop in sheep numbers in the West during the 1960-75 period, suggesting some competitive advantages to use of these lands, particularly for the larger producers.

The decreased grazing of sheep and goats on BLM lands is not associated with any significant decreases in grazing area available or increases in grazing by other livestock. Thus, there has simply been a decrease in utilization of these lands, some of which are not considered suitable for cattle use. BLM lands would be available for sheep if sheep numbers should increase.

On NFS lands, however, the decreased grazing by sheep in correlated with about a one-fourth drop in the net area classified as suitable for grazing. The movement of these lands into recreational uses, water development projects, and other uses has occurred since 1960 along with regulations imposed on sheep numbers grazed in some areas and increased grazing by other livestock.

Grazing fees for sheep on NFS lands more than doubled between 1960 and 1974, while those on BLM lands increased by four times. The grazing fees increased again in 1976 by approximately 50 percent for both NFW and BLM lands. The basic fees for sheep are $.30 per sheep per month on BLM lands and $.32 on NFS lands. As reported by Gee et al. (1977), however, grazing policies were not major factors in the decreased grazing of sheep on Federal lands.

As was noted above, the number of sheep grazing on National Forest System ranges has declined since 1960. However, the U.S. Forest Service is encouraging the continuation of sheep grazing and expects the stabilization of sheep numbers grazing on Forest Service lands in the near future (letter to Director, FWS, March 27, 1978). the projected increase in livestock grazing in animal-unit-months on Forest System lands in 44 percent by 1980 and 81 percent by 2000. It is expected that sheep will make up only a small proportion of this projected use.

The comparable increase in the use of BLM lands is 30 percent, as measured in animal-unit-months, by the year 2000. Translated that would mean going from 12 million AUM's to an estimated 16 million AUM's by the year 2000.

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II. B.3. The Wool Incentive Payment Program

The National Wool Act of 1954 was enacted by Congress to support the price of wool and encourage domestic production. It followed the belief that

> ". . .Wool is an essential and strategic commodity which is not produced in quantities and grades in the United States to meet the domestic needs and that the desired domestic production of wool is impaired by the depressing effects of wide fluctuations in the price of wool in the world markets."1/

Payments are made when the support price for wool exceeds the national average price received by producers. Incentive payments, financed by the CCC (Commodity Credit Corporation), are made with funds, collected from import tariffs not to exceed 70% of specific and ad valorem import duties on wool and wool manufactures for the same period. The Wool Act, originally meant to encourage annual production of 300 million pounds of shorn wool, has been extended from its original expiration date of 1977 to 1981. The purpose of the extension is to strengthen the economic vitality of the wool industry. The support price for 1977 was increased from 72¢ (where it had been set since 1970) to 99¢ per pound. In 1978 the support price was increased to 108¢ per pound (grease basis). Predicted support prices for 1979, 1980, and 1981 are $1.15, $1.21, and $1.26 respectively (ESCS, USDA, January 19, 1978).

1/ Sec. 702 National Wool Act of 1954 (7 U.S.C. 1781)

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Table B.9 illustrates the yearly incentive prices for shorn wool since the passage of the Act in 1954.

Table B.9 Incentive Price for Shorn Wool - 1955-1978

Year	Incentive price cents per pound
1955-65	62
1966	65
1967	66
1968	67
1969	69
1970-76	72
1977	99
1978	108

Source: Gee, 1978 p. 19

Historical wool incentive payments (Table B.10) have fluctuated over the years.

The payment rates derived from the market and incentive prices are used to calculate the producers incentive payments. For example, in 1977 the incentive payment rate of 33.8 percent multiplied by the producers net proceeds from the sale of shorn wool will be his incentive payment for that year.

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Table B.10 - Shorn Wool Payment Rates, 1955-1978

Year	Average Market Price for Shorn Wool (cents per pound)	Incentive Price (cents per pound)	Shorn Wool Incentive Payment Rates (percent of market price)
1955	42.8	62	44.9
1960	42.0	62	47.6
1965	47.1	62	31.6
1970	35.5	72	102.8
1971	19.4	72	271.1
1972	35.0	72	105.7
1973	82.7	72	0
1974	59.1	72	21.8
1975	44.7	72	61.1
1976	65.7	72	9.6
1977	74.0	99	33.8
1978 (estimated)	79.0	108	36.7

Source: Gee (1978) p. 21. From 1976 on computed from "Cotton and Wool Situation" reports. ESCS, USDA, Feb. 19, 1977, 1978 and unpublished data.

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Responsibility for setting support prices rests with the Secretary of Agriculture after he has conferred with representatives of the wool producers and has considered changes in the costs of sheep production. The Secretary has some discretion in setting prices for various types of wool. In the case of shorn wool, the Act states that the support price shall be 72¢ per pound, grease basis until December 31, 1976. For pulled wool, the Secretary determines what support is needed to maintain normal marketing practices. This price has usually been set at 80% of the rate for shorn wool because of the differences in quality of the type of wool involved. CCC payments for both shorn and pulled wool are expected to total 26 million dollars in 1977 and 30 million dollars in 1978, thus leaving net government tariff revenue at $133 million for 1977 and $145 million for 1978. The amount of shorn wool produced in the U.S. has dropped from 200+ million pounds just over a decade ago to 106 million pounds in 1977. Production declined despite support prices which have been above the market price for all years but 1973 and protection of wool import duties which are currently 25½¢ per lb.

Nearly 75 percent of all wool imported into the U.S. comes from Australia. Total imports have declined along with the domestic wool industry as only 38 million pounds of raw apparel wool were imported in 1977, compared to 163 million in 1966.

In addition to wools, the importation of live sheep and lambs totaled 8,545 head in 1977, compared to 4,607 in 1976. Over 21 million lbs. of lamb and mutton were imported as opposed to 4.6 million pounds exported. In 1977, the U.S. exported 205,000 live sheep and lambs compared to 244,000 in 1976. The trend in the net export of live sheep and lambs increased from 1972 to 1975 to 335,000 animals and then decreased to approximately 200,000 animals in 1977.

Import duties and incentive payments do not directly prevent foreign wool from entering U.S. markets, but rather, raise the price for consumers. At higher prices wool becomes less competititve with synthetic fibers. The tariff on woven wool fabric valued at over $2.00 per pound is 37.5¢ per pound of this type fabric. Tariffs on wool, clean basis, are currently 25.5¢ per pound.

In summary, with the use of incentive payments, the U.S. wool industry is encouraged to increase both the quanity and quality of wool production. If the result of production increases is a lower market price, below the incentive price, then the industry is compensated for the difference in price by incentive payments. Any lowering of import duties, which finance incentive payments, have the effect of stimulating wool imports and tend to lower domestic prices. Incentive payments paid by tariff revenue, however, would compensate U.S. wool growers for their lost revenue. Since wool accounts for only 15-20 percent of gross returns to sheep raising there would be a minor impact on the sheep industry if import duties were reduced.

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II. B.4. Descriptions of Husbandry Practices

Some of the major factors in sheep husbandry include the use of sheep herders, lambing practices, and selective breeding to increase multiple births. In a study of the use of sheep herders, (Fritsch et al., 1978) certain herder practices were found to help reduce predation losses. They included herders (1) spending more time with the herd, (2) killing coyotes, (3) making noise and thus making presence known, and (4) keeping sheep close together while grazing. While not having a major effect in reducing predator losses, the use of herders was credited, by producers surveyed, with having a noticable effect on loss rates when these practices were followed (Fritsch et al.,1978) The use of full time sheep herders, by commercial enterprises is shown in Table B.11 for the major production areas.

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Table B.11 Use of Full-time Herders by Commercial Producers - 1974

Area	Percent of Total Commercial Producers With Full-time Herders	Percent of Total Ewes of Commercial Producers with Full-Time Herders 1/
Mountain	16	68
Great Basin	24	84
Pacific Coast	3	19
California-Arizona	32	88
Texas-New Mexico	11	31
Plains-Wheat-Corn	0	0
Northern Plains	1	10
Enterprise by Number of Animals		
50-99	0	0
100-299	2	5
300-999	11	21
1,000-2,499	31	40
2,500-4,999	67	76
5,000 and over	72	78
All areas and Enterprises	9	44

1/ May be overstated since all producers may not put all their sheep under the care of a herder

Source: Conrad Fritsch, C. Kerry Gee and Richard S. Magleby "Full-time Labor use by Western U.S. Sheep Producers," Draft NRED Working paper, unpublished, 1978.

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The two management systems for lambing in the West are shed-lambing and range-lambing. Shed-lambing requires pens for holding at least 10 percent of the ewes, enclosed sheds to house them after their lambs are born, supplemental feed, and adequate labor to feed, move, and care for the ewes and their newborn lambs. This intensive care usually results in more lambs saved than under the range-lambing system, where ewes and lambs have less protection from the elements and predators. Also, shed-lambing permits earlier lambing, and either earlier marketing of the lambs or sale at heavier weights. Costs and returns in 1974 for shed vs. range lambing were estimated by Gee (1978). A comparison is made in relation to Federal grazing in estimating the total cost per ewe as shown in Table B.12.

Table B.12 Production and Returns - Shed Vs. Range Lambing - 1974

		Federal Grazing Permits		No Federal Grazing Permits
	Unit	Range-lambing	Shed-lambing	Shed lambing
Lambs born/ewe	number	1.08	1.39	1.38
Lambs sold/ewe	number	.70	1.02	1.08
Labor/ewe	hours	2.91	3.90	3.63
Total cost/ewe	dollars	43.76	46.34	52.96
Returns above cash cost/ewe	dollars	9.26	18.34	15.58

Source: Gee 1978 p. 15.

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The data indicates a comparative advantage for shed-lambing. The higher costs for labor are more than offset by the lambs marketed per ewe. For those areas where Federal grazing is possible the returns are nearly 3 dollars higher per ewe reflecting savings from the use of public grazing lands.

The use of shed-lambing may be limited in some situations by the ability of producers to obtain skilled labor during lambing season, their ability to finance the cost of constructing and maintaining sheds, and their need to move their sheep from one grazing area to another.

The distribution of lambing practices is given in Table B.13 for the major sheep production areas and size of enterprises.

Table B.13 Shed Lambing on Western Commercial Sheep Operations - 1974

Area	Commercial Operations which Shed-Lamb	Commercial Ewes which are Shed-Lambed
	----------Percent of Total----------	
Mountain	81	47
Great Basin	79	27
Pacific Coast	45	21
California-Arizona	33	9
Texas-New Mexico	7	1
Plains-Wheat-Corn	92	88
Northern Plains	66	35
Enterprise by number of Animals		
40-99	71	65
100-299	78	67
300-999	66	58
1,000-2,499	45	28
2,500-4,999	51	22
5,000 and over	50	8
All areas of enterprise	60	38

Source: Gee and Magleby 1976 p.42

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Most lambs in the West are born in February through May. However, in the Pacific Coast and California-Arizona areas considerably lambing occurs in November, December, and January.

Shed-lambing is practiced by more commercial producers (60 percent) than pasture or range-lambing in the 17 Western States. However, the number of ewes involved (38 percent) is considerably less (Table B.14).

Table B.14 Shed vs. Range-lambing in the West - 1974

Type	Percent of Producers	Percent of Ewes
Shed-lambing	60 1/	38
Pasture and range-lambing	49 1/	62

Source: Gee and Magleby 1976 p. 20

The differences in the proportions between producers and ewes are due to more frequent use of pasture- and range-lambing by large-scale enterprises. Range-lambing also is more common in the warmer than colder areas of the West. Nearly all of the commercial ewes are range-lambed in the California-Arizona and Texas-New Mexico areas, whereas only half of the ewes in the Mountain region are range-lambed.

1/ About 9% of commercial producers use both methods.

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For some migratory sheep operations in the Mountain and Great Basin areas, shed-lambing is not practical due to continuous movement of the sheep. For large enterprises it may be that shed-lambing is not widely used because of the additional investment and labor involved.

Selective breeding of ewes to produce multiple births is a management practice that may mean higher risks in some production areas as well as higher profits. The care of multiple lambs by one ewe on the open range as well as the smaller size of the lambs increases the probability of predation losses in areas of high coyote densities.

Use of full-time hired herders varies widely by size of operation. About two-thirds of the large sheep enterprises of 2,500 sheep or more hire full-time herders, compared with about one-third of those with 1,000-2,499 sheep, and 11 percent or less of those under 1,000 head. Usually a herder handles 1,000 or more sheep. One-third of the full-time herders handled 1,500 sheep sheep or more in 1974 (Fritsch et al., 1978).

Producers in the Mountain, Great Basin, and California-Arizona areas are the most dependent upon hired herders because of considerable open and Federal range grazing areas. The proportions of the total commercial producers using full-time hired herders in these areas are 16, 24, and 32 percent, respectively.

Problems in obtaining adequate numbers of capable herders can result in producers changing husbandry practices in one of the following ways. First, size of sheep herds under the care of each herder might be increased. This could result in less care per animal and higher depredation and other losses. Second, the size of operation (number of sheep) could be reduced to a level which can be handled by the number of herders available. Third, some sheep could be taken off the open range and placed in fenced areas. A fourth alternative is to fence more of the open ranges. This is usually impractical because of the cost involved in fencing vast areas, and the restriction on the movement of wildlife. A fifth course of action is to go out of the sheep business. Some producers are reportedly doing this because of the labor problems, usually in conjunction with depredation losses and other problems (Gee et al., 1977).

Western sheep producers have historically had difficulty finding and retaining sufficient numbers of sheep herders. In recent years, there have been proposals of new working and on-site living conditions regulations to protect the health and safety of herders that some producers have felt are too costly to implement. These labor dimensions are important for two reasons; first, because labor costs as much as any factor contribute to the profitability and economic viability of the sheep industry and, second, because of the positive effect that level of herder supervision of sheep seems to have in reducing predator loss. If one way to reduce those losses is to increase the number of sheep herders, the feasibility of such an option clearly depends on the availability of herders and the costs to producers of hiring them.

Immigrant workers, primarily Basques from Spain have provided a significant portion of the sheepherders in the west since the mid-1800's. Since 1957, herders have been imported on a temporary basis under special legislation, exempting them from the quotas of U.S. immigration regulations. Alien herders are given temporary certifications that can be extended for up to three years during which they are required to work as herders. At the end of the three year period they are eligible to apply for permanent-resident status.

In summary the use of selected management practices by the Western sheep industry can improve profits and reduce predation losses. A more extensive use of full-time herders by large enterprises in the Mountain, Great Basin, and California-Arizona areas would probably lower the percentage of the lambs in those areas lost to predators.

Shed-lambing is practiced mainly by smaller enterprises and those in the Mountain, Great Basin, and Plains wheat-corn area because of its labor requirements and cost. Nearly 75 percent of the enterprises with less than 300 head of sheep use shed-lambing as compared to enterprises with

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over 5,000 head of sheep who have only 8 percent of their ewes shed-lambed. The smaller percent of ewes shed-lambed by large enterprises is directly related to the use of public range for grazing. With the trend toward larger enterprises (Table B.3), labor shortages, initial cost and the need to move sheep from one grazing area to another, it is expected that shed-lambing will not become widespread in the near future in spite of higher economic returns, estimated at $9 more per ewe, over range-lambing on public lands.

II. B.5. Economics

Western commercial sheep producers have a high percent of equity in their real estate (76 percent), livestock (79 percent), and equipment (81 percent) (Gee and Magleby 1976). A high percentage of equity suggests that sheep enterprises have an equity to debt ratio which enables the sheep industry to continue operations through bad years as long as returns cover cash costs. High equity-to-debt ratios is also a characteristic of an industry with a high proportion of older owners. High real estate equity may also be partially due to increasing land values. Equity positions were not significantly different among the different production areas except for the California-Arizona area which was consistently above the other areas. In addition to equity the proportion of operating capital borrowed increased with the size of the enterprise with small operators (50-99 head of sheep) borrowing 20 percent of their operating capital and large enterprises (5,000+ head of sheep) borrowing an average 67 percent of operating capital.

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The production of lamb and mutton has been inversely related to farm level lamb prices (Table B-15). Historically, production increases have been associated with price declines and visa-versa. Prices usually adjust to a level that will clear the market of all lamb produced. It appears that expanded production between 1950-60 exerted a downward pressure on lamb prices forcing them to extremely low levels. Per capita consumption was high, possibly indicating an increase in number of people eating lamb as well as an increase in consumption by established lamb consumers. Starting in 1960, production began falling which has continued to the present. Reduced supplies and higher prices caused per capita consumption to fall.

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Table B.15 - Lamb, mutton, and wool production and prices, United States, 1950-78

Year	Lamb and Mutton				Wool	
	Production	Lamb Price		Per Capita Consumption	Production (grease basis)	Farm Price
		Farm 1/	Retail			
	Million lbs.	Dollars per Hundred Weight	cents/lb.	Pounds	Million lbs.	Cents
1950	597	27.30	68.38	4.0	249.3	62.1
1955	758	20.04	56.27	4.6	282.9	42.8
1960	768	19.09	61.06	4.8	298.9	42.0
1965	651	23.89	66.92	3.7	224.8	47.1
1970	551	27.20	89.17	3.3	176.8	35.5
1971	555	26.68	92.70	3.1	172.2	19.4
1972	543	29.58	100.41	3.3	168.6	35.0
1973	514	36.04	113.46	2.7	153.2	82.7
1974	465	40.51	123.73	2.3	138.7	59.1
1975	410	44.45	141.66	2.0	125.4	44.7
1976	371	49.81	156.82	1.9	113.9	65.7
1977	341	54.28 1/	158.02	1.7	110.6	74.0
1978 (1st qtr)	N/A	67.67	173.23	N/A	N/A	79.0

1/ Annual average for slaughter lambs. San Angelo as reported in Livestock and Meat Situation.

Source: Econ. Res. Serv., U.S. Dept. Agr., Livestock and Meat Statistics, Various years and Wool Statistics and Related Data, 1930-69, SB 455, supp. for 1973 and 1974, January 1976, April 1978.

A statistical analysis of demand for lamb at the farm level indicates that lamb prices are significantly affected by the quantity of lamb marketed (Usman and Gee,1978). Prices are affected to a lesser extent by supplies of other meats entering the market and by the level of per capita income in the United States.

Concurrent with the recent rise in farm prices for lamb was an increase in the cost index for production, interest, taxes and wage rates. From 1972 to 1976, the last year available, costs of production increased by 58 percent while prices rose 69 percent during the same time period. This is an indication that the profitability of raising sheep has improved.

Since 1950 wool prices to farmers have averaged about 49 cents per pound (Table B.15). They ranged from a high of 82.7 cents in 1973 down to 19.4 cents in 1971 suggesting considerable fluctuations. There is very little trend evident in wool prices received by farmers. Time series analysis indicates an average annual drop in wool prices of .6 percent since 1950. A new interest in wool for apparel which began during 1976 may continue, in which case wool prices may strengthen during the next few years. Rising foreign wool price levels will also favorably affect future prices received by U.S. farmers.

Although average farm level wool prices have been variable, producer income from wool has been stabilized through the wool incentive payment program. An incentive price has been in use since 1955. From 1970-76 it stood at 72 cents per pound but increased to 99 cents for 1977 and $1.08 per pound for 1978. Therefore, sheepmen have not been subject to the wide fluctuations in market prices for wool but have been receiving a total price for their wool of 72¢ per pound from 1970 to 1976; 99¢ in 1977, and $1.08 per pound in 1978.

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Wool production and consumption exhibit a downward trend similar to sheep numbers (Table B-15). Production has been dropping steadily since 1960. Development of synthetic fibers as well as decreased production have caused much of the drop in consumption.

In summary, recent increases in lamb prices and the increase in the wool incentive price have made sheep producing a profitable business. Costs and returns were estimated by Gee (1977) for the major sheep areas of the 17 Western States. Average sheep enterprises are covering all costs including a return to family labor. With the exceptions of the Plains wheat-corn area (-$4.96) average enterprises are receving at least some return to invested capital (Table B-16).

The current situation has not always existed. As recently as 1974, 35 percent of producers did not have income to cover cash costs and 65 percent paid cash costs but not an adequate wage for operator and family labor (Gee 1977). Only 27 percent received any return on capital invested in land.

Higher returns since 1974 are the result of decreasing supplies of lamb. High prices may stimulate an expansion in sheep numbers which will increase lamb supplies. This in turn could reduce prices in the future.

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Table B-16 -- Estimated sheep enterprise costs and returns per breeding ewe, western sheep producing Area, 1977.

Item	Area						
	Plains						
	Northern Plains	Wheat-corn	Texas-New Mexico	Mountain	Great Basin	California-Arizona	Pacific Coast
	(Dollars Per Ewe)						
Total sales[1/]	38.17	40.00	35.13	54.71	39.57	55.89	41.80
Total cash costs[2/]	23.99	35.18	24.68	28.01	26.41	40.70	28.99
Total non-cash costs	3.20	3.07	3.26	2.72	3.11	3.16	3.06
Total cash & non-cash costs	27.19	38.25	27.94	30.73	29.52	43.86	32.05
Oper./family labor	3.30	6.71	1.27	1.78	3.25	9.44	4.11
Interest on all invested capital	28.71	30.29	24.49	25.98	22.92	12.41	24.56
All costs	59.20	75.25	53.70	58.49	55.69	65.71	60.75
Return above cash costs	14.18	4.82	10.45	26.70	13.16	15.19	12.81
Return to oper./family labor & invest. capital	10.98	1.75	7.19	23.98	10.05	12.03	9.75
Return to invested capital	7.68	-4.96	5.92	22.20	6.80	2.59	5.64

1/ Sales include lambs, cull ewes, and wool.
2/ All cash expenses except operator and family labor, depreciation, and interest on invested capital.

Source: Gee (1977)

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In summary the economic stability of the Western sheep industry has increased since 1974. The high equity-to-debt ratios in real estate, livestock and equipment and the low amount of borrowed operating capital suggest an industry characterized by older owners and an ability (of the industry) to sustain reasonable losses as returns are above cash costs. Declining production and higher prices for lamb have increased returns in recent years but this increase has been partially offset by high costs of production. The net result is that the index of prices for lamb increased 11 percent more than the index for costs of production from 1972 to 1976.

The production of wool has followed declining stock sheep numbers. However, increasing incentive payments have stabilized farm income from wool. (The incentive price has been increased to $1.08 per pound of wool for 1978.) The estimated cash returns above costs for the different production areas reflects the differences in lambs born per ewe with the Mountain area having the highest rate (1.41) followed by the Great Basin (1.36). The Mountain and Great Basin Areas combined contain approximately 32 percent of the total sheep in the West. They also have the highest rate of lambs born per ewe. The effect of decreasing the percent of lamb losses in these areas will have the greatest impact on the western sheep industry if there are no changes in grazing fees and related factors regulating the availability and use of public lands.

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II.B.6. Outlook and Summary

The western sheep industry has been declining in size since 1960. However, the reduction in sheep and lamb numbers in 1978 was only 2 percent below that of 1977. This is in contrast to 3.5 percent reduction from 1976 to 1977. With fifteen states nationwide showing an increase in lambs and sheep over 1977 (primarily eastern and central states) the sheep industry is optimistic that its "Blueprint for Expansion Program" is beginning to reverse the downward trend in the size of the industry (Blueprint, July 1976). Eighteen states currently have expansion programs and eight more states are either developing or beginning to develop programs of their own.

An indication that the sheep industry may be increasing its potential to produce more lambs and wool is the number of ewe lambs retained to increase the size of the herds. In 1976, 1977, and 1978, the ewe lambs retained increased from 1.3 to 1.4 to 1.5 million head. The lag time before actual production increases could be expected from the increasing number of ewe lambs is two years.

The age distribution of commercial sheep producers found in study by Gee and Magleby (1976) indicates that fewer young persons are involved in sheep production than in prvious years. Commercial producers under 40 years of age make up 32 percent of the owners while those between 41 and 60 years of age make up 51 percent of the owners. The remaining 19 percent are over 60 years old. Ten percent of the sheep producers are facing imminent

retirement and another ten percent may retire within the next ten years. At the current rate of recruitment, there are an insufficient number of young owners to replace those that are retiring.

Prices in March, 1978, are up to $76.69 per hundred weight for choice slaughter lambs and $80.85 per hundred weight for choice feeder lambs in San Angelo, Texas. High prices have produced higher net returns to the sheep industry. In addition to high prices for lamb, the price incentive payment for wool was increased to $1.08 per pound for 1978 and is expected to increase further for 1979. The stimulus of high prices for lamb and wool could bring a gradual expansion of the sheep industry and increase the recruitment of young owners.

Summary

There has been a long-term decline in the number of stock sheep and sheep enterprises in the 17 Western States. The number of sheep have gone from 15 million head in 1968 to approximately 8.7 million in 1978. During the same time period the number of producers went from 68 thousand to 47 thousand.

In proportion of herd sizes with ewes one year and older changed from 1969 to 1974. The shift in inventory was toward larger size herds maintaining a higher percent of ewes with herds of 200-2,500 head of sheep increasing at the highest rate.

The diversification of enterprises reflects the sources of income for most sheep farms and ranches. Sheep and cattle enterprises are the most common (56 percent of the producers). The sale of sheep, lambs, and wool make up 54 percent of farm income on the average. Producers with 5 thousand head of more of sheep received 78 percent of their total income from the sale of sheep, lambs, and wool compared to smaller producers (less than 100 head of sheep) who received 38 percent.

Public lands play a major role in grazing sheep in some areas of the West. Of the 157 million acres of BLM lands available for all livestock grazing approximately 17 million acres were used for grazing sheep and goats in 1976. The national forest system lands had 58.9 million acres suitable for grazing and 9.4 million acres were used for sheep and goats in 1970 (the latest year that data are available). The Mountain and Great Basin areas

use public range extensively with 37 and 39 percent of the commercial producers grazing up to a maximum of 76 and 84 percent of the commercial ewes on public land in each area respectively. Commercial operations with fewer than 1,000 head of sheep who graze sheep on private land normally fence the grazing area.

The number of sheep and goats grazed on BLM lands decreased by 40 percent between 1960 and 1976 and on USFS lands by more than 42 percent between 1960 and 1974. The percentage decreases in sheep and goats grazed on these Federal lands has been less than the 50 percent overall drop in sheep numbers in the West during the 1960-75 period, suggesting some competitive advantages to use of these lands, particularly for the larger producers.

The decreased grazing of sheep and goats on BLM lands is not associated with any significant decreases in grazing area available or increase in grazing by other livestock. Thus, there has simply been a decrease in utilization of these lands, some of which are not considered suitable for cattle use.

BLM lands would be available for sheep if sheep numbers should increase. On NFS lands, however, the decreased grazing by sheep is correlated with about a one-fourth drop in the net area classified as suitable for grazing. Between 1960 and 1974 grazing fees for sheep on NFS lands more than doubled, while those on BLM lands has increased four-fold. The grazing fees increased again in 1976 by approximately 50 percent for both NFS and BLM lands. The basic fees for sheep are $.30 per sheep per month on BLM lands and $.32 on

NFS lands. As reported by Gee et. al. (1977), however, grazing policies were not major factors in the decreased grazing of sheep on Federal lands. Grazing livestock on both BLM and NFS lands will increase by 30 percent and 81 percent respectively by the year 2000.

Incentive payments are used to encourage the U.S. wool industry to increase wool quality and production. Compensating the wool industry for the difference between the average market price and the incentive price sets a price floor by which the wool industry is guaranteed a minimum compensation. Making payments based on an enterprise's value of sales gives the incentive to increase quality of production thereby increasing sales value and hence payments. The revenue for wool incentive payments is derived from import duties collected. The lowering of import duties would stimulate wool imports and tend to lower domestic prices. Incentive payments paid by tariff revenue, however, would compensate U.S. wool growers for their lost revenue. Since wool accounts for only 15-20 percent of gross returns to sheep raising there would be a minor impact on the sheep industry. The incentive price, currently $1.08 per pound grease basis, is expected to increase in 1979-81 as the cost of production continues to increase.

The use of selected management practices by the Western sheep industry can improve profits and reduce predation losses. A more extensive use of qualified full-time herders by large enterprises in the Mountain, Great Basin, and California-Arizona areas would lower the probability that lambs in those areas would be lost to predators. Only 9 percent of commercial enterprises used full-time herders in 1974 with 44 percent of the

ewes. Seventy-two percent of the large enterprises had full-time herders. Nearly 75 percent of the enterprises with less than 300 head of sheep use shed-lambing as compared to enterprises with over 5,000 head of sheep who have only 8 percent of their ewes shed-lambed. The smaller percent of ewes shed-lambed by large enterprises is directly related to the use of public range for grazing. With a trend toward larger enterprises it is expected that shed-lambing a larger percent of the ewes will not occur in the near future in spite of higher economic returns over range-lambing on public lands.

A shortage of qualified labor appears to be a constraint to the increased use of herders and shed-lambing in the 17 Western States.

The economic stability of the Western sheep industry has increased since 1974. A high equity-to-debt ratio and a low amount of borrowed operating capital suggests an industry characterized by older owners and an ability (of the industry) to sustain reasonable losses as long as returns are above cash costs. Declining production and higher prices for lamb have increased net returns in recent years but this increase has been partially offset by high costs of production. The net result is that the index of prices for lamb increased 11 percent more than the index for costs of production from 1972 to 1976.

The production of wool has followed declining stock sheep numbers. However, increasing incentive payments have stabilized farm income from wool.

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II.C. Estimating Livestock Losses to Predators

Cain et al. (1972) found that little or no progress had been made in determining the extent of livestock loss to predators even though the report by Leopold et al. (1964) had strongly recommended such research in 1964. This section summarizes several loss studies that have been completed since the Cain report and other studies currently in progress.

II.C.1. Measuring Loss

Methods of determining extent of livestock loss to predators fall into three categories: mail questionnaire surveys, interview surveys and direct field studies. Mail surveys are based on the written responses from a sample of livestock producers and often deal with a range of topics in addition to questions on predator losses and predator control efforts. Interview surveys generally gather the same information but are based on personal interviews of a sample of livestock producers. Field studies involve daily searches by research workers to locate dead livestock, and necropsies to determine cause of death.

Each of the three approaches listed above has certain design and sampling problems. For mail surveys, and to a lesser extent interivew surveys, non-response can be a significant problem. If producers suffering high predator losses are more likely to respond to a survey than those with minor losses, as seems plausible, then loss rates based on the sample responses will overestimate the true parameter. This sort of bias can

also be a problem for field studies that intensively monitor a small number of ranches. Such studies require the approval and cooperation of the livestock producers, and it seems equally plausible that ranchers who suffer serious predation will be more willing to cooperate than will others for whom predation is not serious.

Response error is a particular problem for mail and interview surveys which rely on the producer for identification of cause of death, often asking him to recall losses for an entire year. Separating losses due to predators from losses to other causes can be difficult. What may appear to an untrained observer to be an animal killed by a coyote could have been one that died from other causes and was later scavenged, or it could have been a weak animal that would soon have died in any case. Alternatively, some predator kills may go unrecognized. Herders and producers may also over-state predator losses either to shift blame of the loss from poor management practices, or to gain more intensive predator control, or both. These possible sources of bias need to be kept in mind in evaluating the accuracy of loss estimates in which cause of loss is determined by other than trained personnel.

Field studies by research workers produce verified predation loss figures. In such studies, however, there are frequently substantial numbers of missing sheep, whose fate is never determined. The resulting estimates of predator loss based only on verified kills are lower than the actual predator losses. Moreover, field research is expensive,

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so that only small numbers of ranches can be surveyed. The small number of field studies limit the applicability of the results to the industry as a whole. If for any reason the ranches selected are not representative of livestock operations in that state or region, the extrapolation of results to a larger population of producers can be misleading.

II.C.2. Sheep Losses to Predators

Table C-1 is a summary of sheep loss studies, nearly all of which have been completed since the Cain Report. The table includes relevant information about the type of study, the study setting, and the degree of predator control in the study area. The studies are grouped and listed in the table as follows: Field surveys in areas with and without predator control are numbers 1-4 and 5-6, respectively; studies 7-11 were based on questionnaires. The average percent losses ($\bar{X}$) are shown in the table for each group.

The intensive field studies in Table C.1, with predator control in effect, show total sheep losses ranging from 9 to 11 percent. Losses to coyotes were 2.1, 2.3 and 3.6 percent of the sheep, while total predation losses ranged up to 4 percent. Predation on lambs is always greater than on ewes when both age classes are present, and the lower ewe predation rates tend to conceal the higher rates of lamb losses when both are averaged together. On each ranch, normal predator control was in effect

Table C-1. Sheep Loss Studies

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Study Identification			Setting			
Source	Location	Year	Selection Logic	Predator Control	Husbandry	Other
1. Nass 1977	Idaho	1973-75	Shed lambing operations	Yes	Shed lamb Range graze	Herders
2. Tigner & Larson 1977	Wyoming	1973-75	Range lambing	Yes	Range lamb Range graze	Herders
3. McAdoo & Klebenow 1976	Nevada	1973	Range sheep losses	Yes	Range lamb Range graze	Herders
4. Davenport et al. 1973	Utah	1972	Range sheep losses	Yes	Range graze	Herders and no herders
5. Henne 1975; Munoz 1976	Montana	1974, 1975	No predator control study	None before lambs sold	Shed lamb Fenced pastures	No herders
6. Delorenzo & Howard 1976	New Mexico	1974, 1975	No predator control study	No	Fenced range	No herders
7. Nesse et al. 1976	California	1974	State survey	Some ranches	All types	Herders and no herders
8. Early et al. 1974	Idaho	1972-73	Sample range sheep ranchers	Yes	Range graze	Herders
9. Reynolds & Gustad 1971	MT, WY, CO, TX	1966-69	Economics of predation	Some ranches	All types	Herders and no herders
10. deCalesta 1977	Oregon	1976-77	Characterize losses	Some ranches	Fenced pastures	Herders and no herders
11. Gee et al. 1977	Western U.S.	1974	Survey many sheep areas	Some ranches	All types	Herders and no herders

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Table C-1. Sheep Loss Studies (Cont'd)

Source	Characteristics		
	Type	Scope	Design
1.	Biological	9 sheep bands 17,000 sheep/year	Monitor sheep all year
2.	Biological	5 sheep bands 10,000 sheep/year	Monitor sheep all year
3.	Biological	1 band 2,405 sheep	Monitor one cycle
4.	Biological	10 bands 17,453 lambs	Monitor spring and summer
5.	Biological	2 bands; 2,041 and 3,427 sheep (1974 and 1975, respectively)	Monitor sheep one production cycle, and repeat in second year
6.	Biological	1 band; 972 and 959 sheep (1974, 1975 respectively)	Monitor sheep daily for 8 months in 1974 and for 11 months in 1975
7.	Questionnaire, interivew (little biological)	140 ranches	Sample the state of California
8.	Questionnaire	44 ranches	Sample one production cycle
9.	Questionnaire analysis	4 states	Compilation and analysis
10.	Questionnaire	181 ranches	Monitor losses for 17 months
11.	Questionnaire, interview	West wide	Survey losses

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Table C-1. Sheep Loss Studies (Cont'd)

Source	Losses (%)								
	Total Losses			Total Predation			Coyote Predation		
	Ewes	Lambs	Both	Ewes	Lambs	Both	Ewes	Lambs	Both
* Field Studies With Control									
1.	6.7	13.2	10.6	1.6	2.9	2.3	1.4	2.7	2.1
2.	4.0	18.0	11.0	0.6	5.5	3.0	--	--	2.3
3.	--	--	9.0	0.1	6.5	4.0	--	--	3.6
4.	--	9.5	--	--	1.5	--	--	1.5	--
$\bar{X}$	5.4	13.6	10.2	0.8	4.1	3.1	1.4	2.1	2.7
Field Studies Without Control									
5.	12.2	36.7	26.6	8.2	26.8	19.2	7.8	26.5	18.8
6.	5.5	26.2	13.4	0.4	13.8	5.7	0.4	12.1	5.4
$\bar{X}$	8.8	31.4	20.0	4.3	20.3	12.4	4.1	19.3	12.1
Questionnaire Surveys									
7.	7.6	10.4	9.0	1.1	2.7	1.9	0.9	2.2	1.7
8.	8.6	15.5	12.5	2.8	3.8	3.0	2.2	3.2	--
9.	--	--	21.3	--	--	5.3	--	--	--
10.	4.5	6.7	--	2.0	4.8	--	1.6	3.8	--
11.	10.4	23.2	16.8	3.4	11.4	7.4	2.5	8.1	5.3
$\bar{X}$	7.8	14.0	14.0	2.3	5.7	4.4	1.8	4.3	3.5

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Table C-1. Sheep Loss Studies (Cont'd)

Source	Loss Validation	Comments: Merits	Comments: Limitations
1.	Adequate	Constant monitoring of sheep all year	Unaccounted for losses did occur.
2.	Adequate	Constant monitoring of sheep all year	Summary shows seasonal means instead of yearly means.
3.	Adequate		No ewe counts before lambing or on lambs born.
4.	Adequate - Herded bands had fewer losses than unherded bands		Underestimation of predation losses many unaccounted for losses.
5.	Adequate	Sheep losses with no predator control	
6.	Adequate	Fenced range - no predator control	Adjacent ranches carried out intensive predator control.
7.	Very little	Large sample	Many unaccounted for losses. Data only on docking counts.
8.	No	Large sample	
9.	No	Large sample	
10.	Partial	Large sample	
11.	No	Large sample	

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during these field studies, but the effect of such control upon the reported predation rates can only be assumed by comparison with other studies in which no control was practiced.

In two biological studies (Table C-1, numbers 5 and 6) no predator control or limited predator control was in effect. For each study, the values shown are the averages of 2 years' data. Coyotes killed 5.4 percent of all the sheep in one study and 18.8 percent in the other. An average of 19.3 percent of the lambs was killed. These losses represent a substantial increase over the rates recorded with predator control in effect. It should be noted that the differences in loss rates cannot be tested for statistical significance because of the very limited numbers of ranches in the two groups.

The five questionnaire and questionnaire combination studies shown in Table C-1 (numbers 7-11) are based on much larger sample sizes than the biological studies. Large samples of sheep ranchers will include some with no predator losses and some with severe losses. On the average, however, most of these studies yielded predation rates similar to those from intensive field studies in the presence of control; that is, two to four percent of the lambs were killed by coyotes. But, one of these studies (Gee et al.,1977; number 11 in Table C-1) showed substantially higher losses than the others. This study is also the most comprehensive one made to date and therefore it deserves further discussion.

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The Gee et al. (1977) survey is the only one that considered sheep losses in all Western States. That survey indicates an 8.1 percent lamb loss to coyotes and an 11.4 percent lamb loss to all predators in 1974. Of the adult sheep 2.5 percent were reported killed by coyotes and 3.4 percent were killed by all predators. Loss rates by state for the West are shown in Table C-2. Lamb loss rates to coyotes range from a low of 1.7 percent in Nebraska to a high of 29.0 percent in Nevada. Sheep loss rates range from 0.2 percent in South Dakota to 11.6 percent in Nevada. The number of ranches in each state upon which the individual state loss rates are based is not given. The survey results as a whole are derived from 8,910 responses to a mail questionnaire that was sent to 28,000 producers representing all types and sizes of operations in the 15 Western States. Because the rate of response was low (32 percent), because it relied on the producers' determination of the cause of loss, and because it asked respondents to recall losses for the previous year this survey should be used with caution.

A second survey reported by Gee et al. (1977) consisted of personal interviews with 911 commercial (50 head or larger) sheep producers, a completion rate of 90 percent from an initial sample of 1,012. In addition to loss data, this survey gathered detailed information about management practices and costs of production. These survey data were used to derive the frequency distribution of loss shown in Table C-3. Thus, 23 percent of the producers reported losing 10 percent or more of their lambs while 63 percent lost 5 percent or fewer. Forty-five percent reported no lamb loss to coyotes. Loss rates for ewes were uniformly

Table C-2. Percent Lambs and Sheep Lost to Various Causes, 15 Western States, 1974.

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State	Cause of Loss: Coyotes	Other Predators	Other Known	Unknown	All Causes
	Percent of Lambs				
Arizona	9.7	11.2	7.1	9.2	37.2
California	6.0	3.7	6.9	4.0	20.6
Colorado	15.0	1.5	7.8	3.8	28.1
Idaho	5.2	0.6	8.4	2.4	16.6
Kansas	3.2	0.2	5.9	1.8	11.1
Montana	13.3	4.2	10.2	4.1	31.8
Nebraska	1.7	0.1	16.0	2.8	20.6
Nevada	29.0	1.4	2.2	3.0	35.6
New Mexico	11.3	5.8	26.1	3.9	47.1
North Dakota	3.1	.4	4.9	4.4	12.8
Oregon	6.0	3.1	7.4	3.0	19.5
South Dakota	2.1	.9	8.0	2.8	13.8
Texas	5.8	6.0	4.8	3.0	19.6
Utah	11.7	1.2	6.8	4.2	23.9
Wyoming	9.3	2.4	6.0	3.2	20.9
Averages:					
15 Western	8.1	3.3	8.2	3.6	23.2
34 Other[2]	[1] NA	NA	NA	NA	14.3
United States	NA	NA	NA	NA	21.2
	Percent of Adult Sheep[3]				
Arizona	.6	.8	4.3	2.7	8.4
California	1.5	1.2	4.2	1.1	8.0
Colorado	3.5	1.3	4.4	1.2	10.4
Idaho	1.8	.2	5.2	1.2	8.4
Kansas	3.4	.4	3.9	.9	8.6
Montana	5.3	.7	6.9	1.8	14.7
Nebraska	.9	.1	10.1	.6	11.7
Nevada	11.9	.1	1.4	.5	13.6
New Mexico	2.8	3.1	7.1	3.0	16.0
North Dakota	1.1	.3	6.0	3.9	11.3
Oregon	2.0	4.0	4.2	2.3	12.5
South Dakota	.2	.2	5.7	1.4	7.5
Texas	2.2	.7	3.7	2.3	8.9
Utah	4.2	1.0	4.7	1.5	11.4
Wyoming	2.9	.6	7.1	2.1	12.7
Averages:					
15 Western	2.5	.9	5.1	1.9	10.4
34 Other[2]	[1] NA	NA	NA	NA	12.4
United States	NA	NA	NA	NA	10.9

1/ Not available.
2/ Data not available for Hawaii.
3/ Stock sheep, one year and older, January 1, 1974.

Source (Gee et al., 1977 pp. 13, 15). Estimates based on mail survey responses from 8,910 farmers and ranchers.

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lower. The distribution of losses is remarkably similar to results of two other studies reported by Balser (1974) and shown in Figure C-1. For the majority of producers predation losses are relatively minor, but for some,predation loss accounts for a significant proportion of the flock.

When size and method of operation were considered the Gee et. al. data show that most small sheep operations do not have predation losses although losses may be relatively high for those who do. Large scale sheep producers incur greater losses in part because their sheep graze on open ranges and in large pastures where the possibility of sheep-coyote encounters is high. Shed lambing and grazing on private land were associated with low to medium predation rates, while range lambing and grazing in public land were associated with medium to high predation rates (Gee et al., 1977, p. 30).

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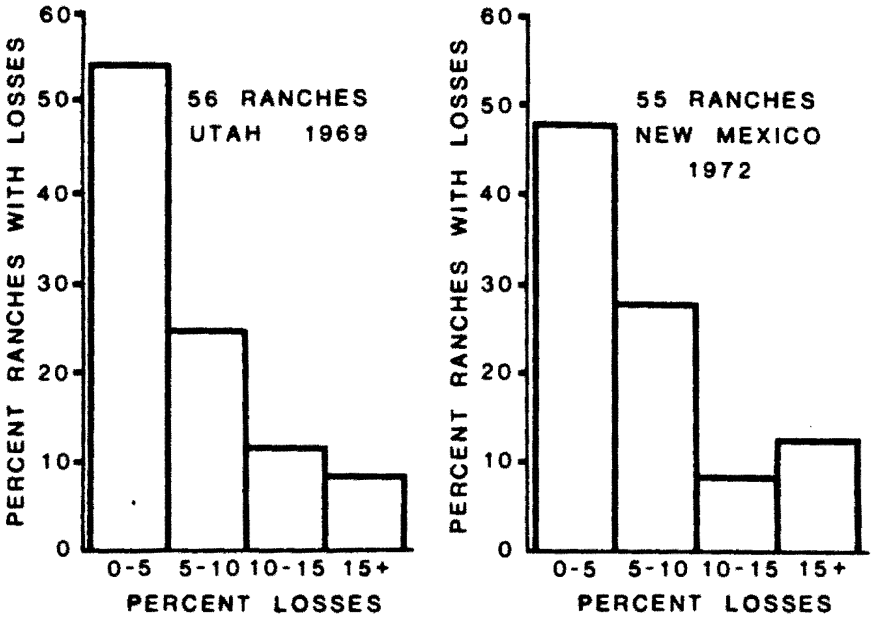
Table C-3. Distribution of Coyote Depredation Among Western Commercial Sheep Producers

Percent of lambs or sheep lost to coyotes	Percent of producers losing: Lambs	Sheep
No loss	45	67
0.1 - 5	18	25
5.1 - 10	14	5
10.1 - 15	7	1
15.1 -20	6	1
20+	10	1
Total	100	100

Source: Gee et al. (1977, p. 8).

Figure C-1. Distribution of Sheep Losses to Predators.



Source: Balser (1974).

Finally, with regard to the reliability of their loss survey estimates the authors note that ". . . the total number and proportion of producers affected (without regard to loss level) by coyote predation are probably quite realistic, since most producers know whether or not coyotes are preying upon their herds. The numbers and percentages of sheep and lambs lost to coyotes and number of producers with different levels of loss must be considered more cautiously since the degree of producer judgment is higher." (Gee et al., 1977, p. 6). With these reservations, and considering comparisons with loss rate estimates from other sources, the ERS estimates of sheep and lamb losses reported in Gee et al. (1977) are too high.

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Loss Rates Over Time:

In addition to the data reviewed above, Statistical Reporting Service (SRS) officials in Colorado, Montana, Nebraska, South Dakota, Texas and Wyoming have assembled data on lamb and sheep losses by cause in one or more years prior to the ERS comprehensive survey in 1974. The data are based on responses by sheep producers to mail questionnaires and so are subject to the same sorts of possible bias noted above. The bias, if any, would tend to be constant from year to year making the time series reasonably reliable as an indicator of changes over time. The Montana and South Dakota series provide only two years of data prior to 1974. The Colorado, Nebraska, Texas and particularly Wyoming data are more complete. For Texas and Wyoming, 1976 data are available. For each of the six states, loss rates were calculated for predation and other causes as a percentage of either lambs (Table C-4) or adult sheep (Table C-5).

Lamb losses to predators in 1974 were above earlier levels in five of the six states. The exception was Nebraska, where predation dropped in 1974 after increasing in 1971-1973. Nebraska was without an ADC program

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Table C-4. Loss rates of lambs to predators and other causes, selected States and years for which data are available.

State and cause of loss	1966	1967	1968	1969	1970	1971	1972	1973	1974 2/	1975	1976
	Percent of lambs born 1/										
Colorado											
Predators	8.2			4/	7.2	4/ 7.7			16.5		
Other causes	10.0			4/	5.8	4/ 5.2			11.6		
All causes 3/	18.2			4/	13.0	4/ 12.9			28.1		
Montana											
Predators			7.8	6.1					17.5		
Other causes			15.1	23.3					14.3		
All causes 3/			22.9	29.4					31.8		
Nebraska											
Predators						7.0	8.0	8.7	1.8		
Other causes						9.7	11.0	14.4	18.8		
All causes 3/	15.3	14.6	17.1	16.7	18.3	16.7	19.0	23.1	20.6	20.0	
South Dakota											
Predators	5/1.2				2.3				3.0		
Other causes	5/7.3				10.2				10.8		
All causes 3/	5/8.5	12.5	11.1	11.9	12.5	13.0	12.5	10.7	13.8	13.9	
Texas											
Predators						7.3	5.3	6.0	11.8	8.0	12.2
Other causes						6.8	7.2	5.5	7.8	5.3	6.6
All causes 3/						14.1	12.5	13.5	19.6	13.3	18.8
Wyoming											
Predators	5.6		4.6	6.8	7.7	7.4	7.9	10.0	11.7	10.8	11.7
Other causes	11.1		11.0	10.2	8.2	9.0	9.7	11.5	9.2	13.7	11.9
All causes /:	16.7		15.6	17.0	15.9	16.4	17.6	21.5	20.9	24.5	23.6

1/ Includes both before- and after-docking losses as a percentage of lambs born.
2/ Gathered as part of the 15-State sheep loss mail survey (see table 6).
3/ These loss rates to all causes differ from the historical series in Appendix table 4 because the latter are based on lambs docked and losses after docking only.
4/ Survey conducted by Colorado Department of Agriculture.
5/ 1963 data.

Source: Gee et al., 1977, p. 21.

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Table C-5. Loss rates of adult sheep to predators and other causes, selected States and years for which data are available.

State and cause of loss	1966	1967	1968	1969	1970	1971	1972	1973	1974 2/	1975	1976
	Percent of sheep 1/										
Colorado											
Predators	2.5				3/ 2.2	3/ 3.5			4.8		
Other causes	7.1								5.6		
All causes	9.6	8.5	10.1	9.1	8.8	9.4	10.8	12.8	10.4	10.3	
Montana											
Predators			1.6	1.5					6.0		
Other causes			8.7	17.8					8.7		
All causes	9.5	12.8	10.3	19.3	11.2	11.6	13.2	13.0	14.7	15.7	
Nebraska											
Predators						3.0	3.5	4.6	1.0		
Other causes						8.8	10.2	11.7	10.7		
All causes	9.5	10.0	11.7	10.1	12.0	11.8	13.7	16.3	11.7	15.0	
South Dakota											
Predators	4/ 1.0				1.1				.4		
Other causes	4/ 8.9				8.6				7.1		
All causes	4/ 9.9	11.0	9.5	10.0	9.7	9.1	10.3	6.3	7.5	7.1	
Texas											
Predators		1.9				3.1	1.7	2.4	2.9	1.7	2.1
Other causes		10.7				6.1	6.2	5.5	6.0	3.2	3.3
All causes	14.1	12.6	12.6	11.5	11.7	9.2	7.9	7.9	8.9	4.9	5.4
Wyoming											
Predators	2.3		1.6	2.3	2.2	1.7	1.8	2.9	3.5	2.8	3.9
Other causes	7.7		9.8	11.6	9.8	10.0	9.5	17.0	9.2	12.9	10.7
All causes	10.0	12.3	11.4	13.9	12.0	11.7	11.3	19.9	12.7	15.7	14.6

1/ Based on losses of sheep 1 year and older as a percent of Jan. 1 inventory of stock sheep 1 year and older.
2/ Gathered as part of the 15-State sheep loss mail survey (see table 7).
3/ Based on survey conducted by Colorado Department of Agriculture. Loss rates to all causes are based on SRS data.
4/ 1963 data.

Source: Gee et al., 1977, p. 22.

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in 1970-1971. Lamb predation rates in 1975 were lower than in 1974 in both Texas and Wyoming, but in 1976 the rates were up again in both states.

In Wyoming, the data from nine consecutive years indicate that predation on lambs increased in that state. In Colorado and Montana, predation rates in 1974 were more than double those existing six to nine years earlier (there are no data in between), suggesting predation may have caused the increase in total loss rates in those states as well.

U.S. Forest Service data shown in Table C-6 provide additional information on predator losses over time. The loss rates are for sheep and goats grazing on Forest Service land based on permit holders' questionnaire responses at the end of the season. In 1974, approximately 14 percent of the sheep in the West used Forest Service land (Gee and Magleby, 1976). Sheep are typically grazed on these lands for only part of the year, usually the summer months, so the percent loss rates are lower than loss rates based on the whole year. The percent predation losses vary significantly from year to year. From 1969 to 1976, the latest year for which data are available, predator loss rates are somewhat higher, particularily for the years 1972-1975.

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Table C-6. Sheep and Goat Losses on U.S. Forest Service Lands, 1940-1976.

Year	Total Grazed	Claimed Causes of Losses				Predation Losses	
		Poison Plants	Predators	Other	Total Losses	% of Total Grazed	% of Total Lost
1940	4,959,577	26,492	67,280	58,564	152,336	1.36	44
1941	4,792,794	25,160	65,282	53,426	143,868	1.36	45
1942	4,761,022	23,675	62,372	52,365	138,412	1.31	45
1943	4,541,876	23,345	66,474	49,197	139,016	1.46	48
1944	4,283,767	21,344	63,233	45,664	130,241	1.48	49
1945	3,892,604	17,989	65,561	39,568	123,118	1.68	53
1946	3,730,520	20,418	59,507	39,721	119,646	1.60	50
1947	3,404,596	14,743	46,092	37,165	98,000	1.35	47
1948	3,324,465	14,918	30,477	35,600	80,995	0.92	38
1949	3,095,665	12,620	28,855	32,281	73,756	0.93	39
1950	3,010,665	10,602	23,847	27,107	61,556	0.79	39
1951	3,016,218	11,725	25,224	31,265	68,214	0.84	37
1952	3,004,862	11,560	24,502	30,829	66,891	0.82	37
1953	2,967,236	11,346	24,362	30,621	66,329	0.82	37
1954	3,016,556	11,281	29,189	30,048	70,518	0.97	42
1955	2,922,031	10,787	25,462	27,906	64,155	0.87	40
1956	2,827,929	11,178	27,240	33,706	72,124	0.96	38
1957	2,709,875	9,452	21,660	25,972	57,084	0.80	38
1958	2,696,760	9,629	22,675	25,951	58,255	0.84	39
1959	2,589,614	8,881	23,108	25,973	57,962	0.89	40
1960	2,573,580	9,009	28,481	23,661	61,151	1.11	47
1961	2,490,577	9,257	25,534	25,284	60,075	1.03	43
1962	2,367,084	8,531	24,865	19,577	52,973	1.05	47
1963	2,286,265	8,104	27,616	20,256	55,976	1.21	49
1964	2,203,016	7,121	26,082	18,865	52,068	1.18	50
1965	2,099,815	7,057	26,183	20,543	53,783	1.25	49
1966	2,071,228	7,399	30,747	20,188	58,334	1.48	53
1967	1,972,759	6,907	26,785	21,791	55,483	1.36	48
1968	1,910,878	6,560	27,235	17,653	51,448	1.43	53
1969	1,865,434	5,828	34,953	21,944	62,725	1.87	56
1970	1,780,357	6,000	32,639	16,175	54,814	1.83	60
1971	1,737,172	5,318	32,075	19,386	56,779	1.85	56
1972	1,702,189	5,516	40,686	19,672	65,874	2.39	62
1973	1,515,362	6,457	31,331	19,786	57,574	2.07	54
1974	1,422,766	5,502	36,967	19,219	61,688	2.60	60
1975	1,465,492	3,922	31,766	14,049	49,737	2.17	64
1976	1,748,163	4,609	32,879	15,405	52,893	1.88	62

Source: Unpublished Forest Service data.

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SUMMARY:

In conclusion, it is difficult to obtain precise overall estimates of sheep losses to predators. There are limitations and possible sources of bias with all the methods of loss assessment discussed above. A best judgment estimate based on available evidence is that average lamb and sheep losses to coyotes were from three to five percent and one to two percent, respectively, over the period 1972 to 1978 in the western states that participate in the ADC program. The losses are unequally distributed both geographically and among producers. Losses vary both between and wthin states. Most producers suffer no or minor losses while a relatively small percentage of producers suffer losses that are significantly higher than the average losses noted above. Evidence indicates that open range grazing, use of public lands and range lambing are all associated with above average losses.

So far as changes over time are concerned, comprehensive reliable information is, again, lacking. Based on available evidence, however, it appears that percentage rates of coyote predation on sheep have increased since 1972. During this same period, however, sheep numbers have continued to decline, as have coyote densities, measured by scent-post indices. This suggests that there is a relatively stable relationship between coyotes and sheep with a constant or somewhat smaller coyote population now preying on fewer sheep. Because of the decrease in sheep numbers, even an increase in the predation rate, unless substantial, translates into a decline in the annual number of sheep lost.

II.C.3 Review of Data on Cattle Losses to Coyotes

The Economics, Statistics and Cooperatives Service, USDA included questions on cattle losses to predators as part of a comprehensive survey of the beef breeding industry in 1976 (E.S.C.S., 1978). Statistics on losses for the 1975 calendar year were compiled through personal interviews with a random sample of 1,800 ranchers and farmers throughout the nation. The survey relied on the producers to recall their losses and to determine the cause of death. As with sheep loss surveys of this sort, the accuracy of the survey hinges on the ability of producers to recall oosses and to distinguish between cattle killed by predators and those which were scavenyed after dying from other causes. As noted previously, that can be difficult for an untrained person. There are no intensive field studies of cattle depredation losses as a basis for comparison.

The population of beef cattle producers included all those in major feeder cattle regions of the continental United States with 20 or more beef breeding cows who marketed feeder calves or yearlings during 1975. This excluded farms where cattle are fed for slaughter and farms with no beef breeding cows. The ESCS has identified five feeder cattle regions (Figure C-2). These include all continental states except 11 in the Northeast which have only a small proportion of the nation's beef cattle inventory. The population as defined for estimating losses to predators included 80 percent of total beef breeding cows in the 50 States. Numbers of beef breeding cows in each of the regions are in Table C-7.

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Figure C-2. Feeder cattle regions of the United States.

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Table C-7. Beef breeding cows in survey population and United States, 1975.

Geographical area	Beef cows in herds of 20 head or more where feeder calves and yearlings are produced	Total beef cows
	1,000 head	
Region:		
Southeast	9,368	10,959
Northcentral	6,041	10,459
Great Plains	7,193	8,413
Southwest	10,477	11,004
West	3,414	3,865
All regions	36,493	44,700
Outside of regions		772
U.S. total		45,472

Source: E.S.C.S. (1978).

Predators killed less than one-tenth of one percent of the January 1 inventory of beef cattle (550 lbs. and over) in the survey populations in 1975. The highest losses were in the Southwest with a loss to all predators of one-tenth of one percent. The majority of thoses losses were attributed to other than coyotes and dogs. Compared to a loss rate of 2.1 percent to disease, theft and other causes, predation on beef cattle is insignificant.

Losses of calves (less than 500 lbs.) to predators occur at a higher rate than losses of cattle but are still relatively minor compared to losses to other causes (Table C-8). Reported losses to coyotes in the Western States range from .4 percent in the Great Plains region to .8 percent in the Southwest. The highest loss to all predators, 1.1 percent, also occurs in the Southwest. By comparison, calf losses to theft, disease and other causes are substantially higher, ranging from 3.6 percent in the Southwest to 9.1 percent in the Great Plains region. The data indicate that range beef-cattle operations have the greatest predator problems. Calves in the first six to eight weeks of life are particularly vulnerable. If they can get through that period, the probability of predation decreases to nearly zero by weaning time.

Losses of calves to coyotes and other predators are unequally distributed as shown in Table C-9. In the three Western regions the proportions of producers reporting any losses to coyotes ranged from 14 percent in the Great Plains to 26 percent in the West. Two percent of respondents in the Southwest and one percent in the West reported losses to coyotes of more than five percent of calves born. Thus, as with sheep losses, most producers suffer no loss or only minor losses, but there is a small percent of beef cattle producers who have significant losses to coyotes.

Table C-8. Calf Losses to Predators and Other Causes Between Birth and Weaning as a Percentage of Calves Born Alive, 1975 1/

	Southeast	North Central	Great Plains	Southwest	West	All Regions
			(percent)			
Dog	0.5	0.1	*	0.1	0.3	0.1
Coyote	0.1	0.2	0.4	0.8	0.6	0.4
Other Predators	0.2	*	*	0.2	*	0.1
All Predators	0.8	0.3	0.5	1.1	0.9	0.6
All Other Causes	3.3	5.3	8.7	2.6	5.7	4.9
Total Losses	4.1	5.6	9.1	3.6	6.6	5.5

* Less than one-tenth of one percent after rounding.

1/ Totals may not sum, due to rounding.

Source: E.S.C.S. (1978).

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Table C-9. Farms and ranches with different levels of calf losses before weaning, feeder cattle businesses, U.S. beef cattle regions, 1975.

Loss interval[1/] (percent)	Region					
	South-east	North-central	Great Plains	South-west	West	All regions
	Dogs--percent of farms and ranches					
No loss	90	96	98	96	99	96
Up to 5.0	9	4	2	4	1	4
Over 5.0	1					2/
Total	100	100	100	100	100	100
	Coyotes--percent of farms and ranches					
No loss	98	94	86	85	73	88
Up to 5.0	2	6	14	13	26	12
Over 5.0				2	1	2/
Total	100	100	100	100	100	100
	Other predators--percent of farms and ranches					
No loss	96	100	99	96	98	98
Up to 5.0	3		1	4	2	2
Over 5.0	1					2/
Total	100	100	100	100	100	100

1/ Calves lost before weaning as a percentage of calves born alive.

2/ Values greater than zero but less than one when rounded to whole numbers.

Source: E.S.C.S. (1978).

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II.D.4. Economic Impact of Predation Losses

There are two ways to evaluate the economic impact of predation losses on livestock producers; the impact on producer receipts and the impact on net enterprise returns, or profits, of representative livestock producers.

The impact on producers' receipts is two-fold. On the one hand, those producers suffering the losses have fewer animals to market. On the other hand, those same producers as well as others suffering no predator loss get slightly higher prices for the animals that they do sell as a result of the curtailed supply.

Using an average rate of lamb loss to coyotes of four percent in 1977, 267,000 fewer lambs were marketed in the 17 Western States as a result of coyote depredation. Assuming a 105 lb. weight for slaughter lambs the loss represents a market value of $14.4 million, based on the average 1977 price of slaughter lambs ($51.34 per cwt.). The 1977 price was about 0.6 percent higher because of the predator curtailed lamb supply. The decrease in receipts because of depredation on ewes is estimated at $5.0 million based on a loss rate of 1.5 percent and a market value of $40 per ewe. The total loss of sheep producers in 1977 as a result of coyote depredation is, therefore, approximately $19 millions.

The value of cattle and calf losses to coyotes in 1975 has been estimated at $16.4 million based on the ESCS survey data discussed previously. Thus, even though the estimated predation rates are low for calves and cattle, total herd size is so large that the value of the predation loss is substantial. That loss needs to be kept in perspective in terms of the size of the industry. The $16.4 million represents only .02 percent of cash receipts from feeder cattle production, and 4 percent of calf and cattle losses to all causes.

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The impact of depredation losses can also be examined in terms of enterprise budgets calculated for representative producers. Table C-10 shows costs and returns per ewe at different levels of lamb loss to coyotes for sheep producing enterprises in seven regions of the West. Similar data for beef cattle enterprises are not available.

The costs and returns show the same significant differences between regions as was seen in Section B (Table B-16) with the highest return above cash cost in the Mountain area and the lowest in the Plains-Wheat-Corn area. The effect on net returns of a change in lamb loss rates can be seen by comparing return per ewe above cash costs at different levels of loss. For example, in the Mountain region return per ewe with an 8 percent lamb loss is some $1.74 less than it is with a 4 percent loss, representing a 6 percent decrease in the return. The table illustrates quite clearly the effect of a change in loss rates on the economic viability of sheep producers. While the "enterprises" in the table represent a composite, or representive sheep producer, the data show that at 1977 prices sheep producers in most regions receive a significant return per ewe even if lamb losses to coyotes are as much as 8-10 percent. The return per ewe in 1977 can be compared to 1974 when only 35 percent of the commercial producers in the Western States had returns high enough to cover cash costs (Gee and Maglegy, 1977).

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Table C-10 - Estimated enterprise costs and returns with different levels of coyote loss, Western States, 1977

	Loss Level--Percent of Lamb Crop					
	0	2	4	6	8	10
	Dollars Per Ewe					
Northern Plains						
Total Sales	40.59	39.99	39.15	38.54	37.82	37.21
Cash Costs	23.99	23.99	23.99	23.99	23.99	23.99
Return above cash costs	16.60	16.00	15.16	14.55	13.83	13.22
Plains Wheat, Corn						
Total Sales	41.06	40.44	39.71	39.09	38.48	37.86
Cash Costs	35.18	35.18	35.18	35.18	35.18	35.18
Return above cash costs	5.88	5.26	4.53	3.91	3.30	2.68
Texas/New Mexico						
Total Sales	36.06	35.24	34.74	34.22	33.70	33.00
Cash Costs	24.68	24.68	24.68	24.68	24.68	24.68
Return above cash costs	11.38	10.56	10.06	9.54	9.02	8.32
Mountain						
Total Sales	60.68	59.71	58.38	57.61	56.64	55.48
Cash Costs	28.01	28.01	28.01	28.01	28.01	28.01
Return above cash costs	32.67	31.70	30.37	29.60	28.63	27.47
Great Basin						
Total Sales	46.75	46.02	45.29	44.56	43.83	43.09
Cash Costs	26.41	26.41	26.41	26.41	26.41	26.41
Return above cash costs	20.34	19.61	18.88	18.15	17.42	16.68
California/Arizona						
Total Sales	57.75	56.80	55.50	54.55	53.59	52.64
Cash Costs	40.70	40.70	40.70	40.70	40.70	40.70
Returns above cash costs	17.05	16.10	14.80	13.85	12.89	11.94
Pacific Coast						
Total Sales	44.70	43.98	43.27	42.54	41.83	40.84
Cash Costs	28.99	28.99	28.99	28.99	28.99	28.99
Returns above cash costs	15.71	14.99	14.28	13.55	12.84	11.85

Source: Gee, (1978)ESCS, USDA unpublished data.

II.D. U.S. and Canadian Programs for Mammal Predation Control and Research

II.D.1. Federal-State Cooperative Animal Damage Control

II.D.1.a. History of the ADC Program

The U.S. Fish and Wildlife Service (USFWS) Animal Damage Control (ADC) program is designed to (1) ensure ecologically sound, socially acceptable animal damage control activities, and (2) to assist in reducing wildlife damage to man's interest. Control of mammal predation on livestock is a long-standing Federal Government activity, and represents the major part of the total ADC program.

The current program is implemented pursuant to the Animal Damage Control Act of March 2, 1931 as amended (7 U.S.C. 426-426b; 47 Stat. 1468). Significant legislative and executive actions that have affected the program are listed below:

1915 First Federal Appropriation for Predator Control

1925 Division of Predator and Rodent Control is formed

1931 Animal Damage Control Act

1939 Predator and rodent control moved from USDA to USDI

1964 Leopold Report

1965 Division of Wildlife Services is formed

1972 Cain Report

1972 Executive Order 11643 bans toxicants on Federal lands. EPA cancels registration of 1080, sodium cyanide and strychnine.

1974 M-44 permitted for emergency use

1975 M-44 registered for use by certified applicators

1976 Division of Animal Damage Control is formed

1976 Executive Order 11917 allows operational use of M-44

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II.D.1.b. Federal-State-Local and Private Roles

The Federal Government has by treaty and law the primary management responsibility for migratory species. The 1931 Animal Damage Control Act extends that responsibility by directing the Federal conduct of research and programs for the control of injurious wild animals.

The current ADC program is conducted under 700 cooperative agreements with state and county governments, livestock associations, Indian tribes, other Federal agencies, universities, private organizations, and individuals. Master project agreements with state governments provide the legal basis and terms under which the program is conducted. The program currently operates in the 48 contiguous states by means of (1) direct Federal-state cooperative operations, (2) education or extension projects, and (3) Federal-state contracts.

Federal-State Cooperative Programs

Federal-state cooperative damage control programs currently operate in 13 Western States.[1/] Operational predator damage control activities are conducted by approximately 450 District Field Assistants (DFA's) who are either Federal or cooperative program employees. All operations are Federally supervised. Operational services are provided only upon request and with the approval of the landowner or operator, or officials of resource management agencies. The large majority of operational activities involve control of predator damage to livestock.

1/ Arizona, California, Idaho, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, Texas, Utah, and Wyoming.

Funding for the cooperative programs is provided by Federal appropriations and cooperator funds from a variety of sources that can include state appropriations, counties, and local livestock associations, depending on the state in question. Some cooperator funds are made available for predator control from the 12½ percent of grazing fee receipts returned to the states under the Taylor Grazing Act. These funds are expended by the state legislatures for the benefit of the counties in which the public lands that produce the fees are located. Predator damage control is one use of such funds.

An annual work plan is prepared for each state in which a cooperative program is conducted. Each plan describes how, where and when the program will be conducted and sets forth specific objectives. The plans are developed cooperatively with other Federal and state agencies having direct responsibility and/or official interest in the program. The plans are coordinated with Forest Service and Bureau of Land Management multiple use plans, and with the management objectives of other agencies, landowners and lessees when consistent with ADC program policy.

Extension-Education:

Extension-education activities are an integral part of the ADC program. The extension approach is used wherever applicable and provides information and demonstrations of safe, selective and effective control techniques. Extension is the primary mechanism for program conduct in the Eastern States. The FWS has offices on 11 university campuses across the country and works with university personnel in almost all other states. In

addition, a cooperative agreement provides the mechanism for disseminating information and providing assistance to some 8,000 county agricultural extension agents.

Federal-State Contracts:

Predator damage control programs in Washington State and South Dakota are currently carried out under Federal-state contract arrangements. Operational damage control is conducted by the states under terms of contracts with the Federal ADC program. The contractural agreements include Federal standards for identifying control needs, the manner in which these needs are met, and documentation of the extent and accomplishments of the program. The contracts provide a flexible cost-sharing formula with a maximum Federal share of 60 percent.

II.D.1.c. Funding and Manpower

Table D-1 presents total ADC funding as well as the Fish and Wildlife Service and cooperator components for the year 1968-1978. The table also gives total program funding in terms of constant (1968) dollars. Columns (3) and (4) show that while funding in current dollars has increased substantially over the years, there has been virtually no change when measured in constant dollar terms. Man-years of effort in the ADC program are illustrated in Figure D-1. There has been a significant and continuing decline in man-years since 1950 reflecting primarily the increased use of aircraft in predator damage control. The Federal share of total man-years increased from 16 percent in 1950 to 27 percent in 1972 and 39 percent in 1977.

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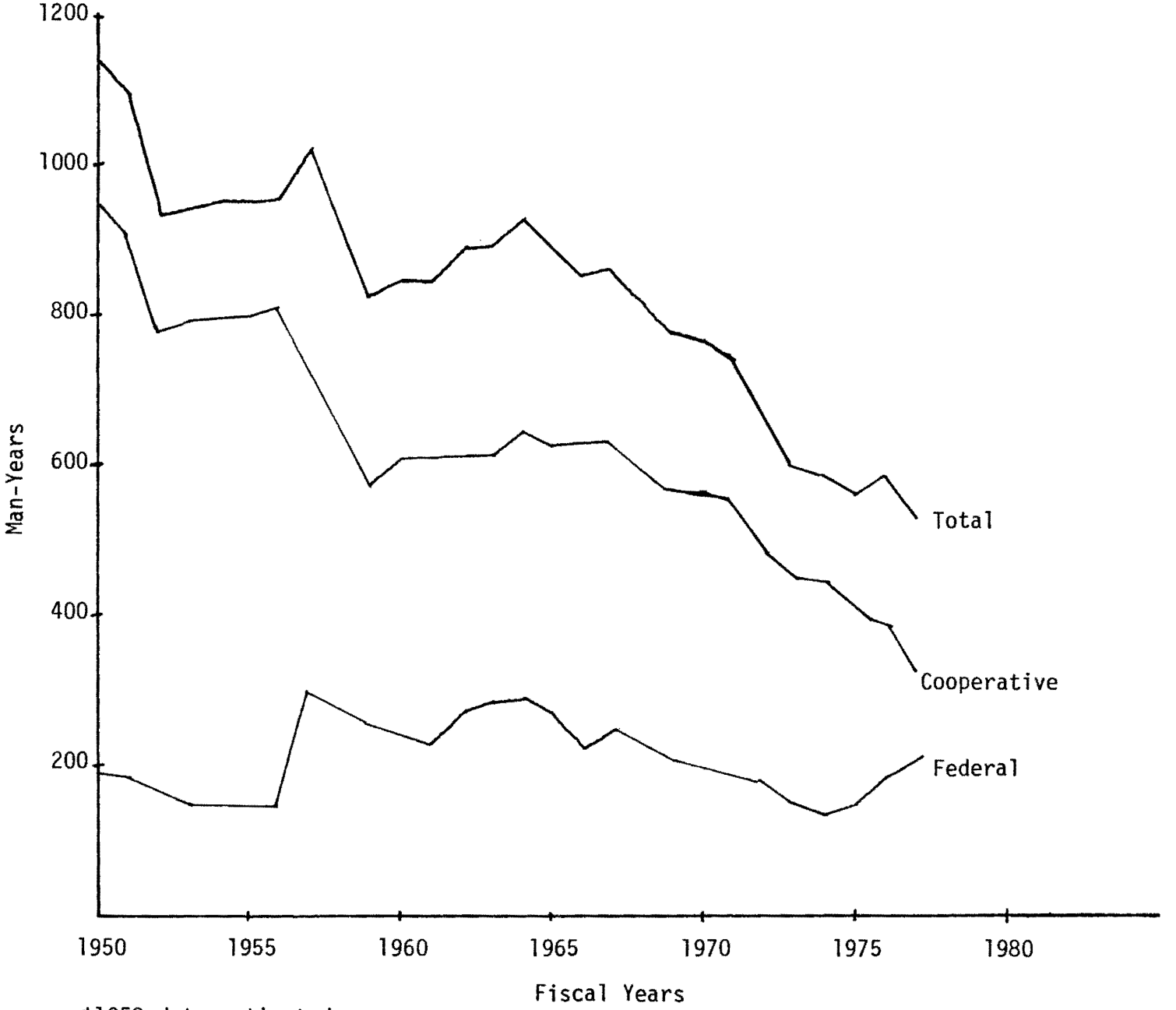
Table D-1. Funds Expended by the U.S. Fish and Wildlife Service and Cooperators for the Nationwide Animal Damage Control Program Fiscal Years 1968-78

Year	Service Dollars[1/]	Coop Dollars	Total Dollars	Constant Dollar Value[3/]
1968	$ 2,955,000	$ 4,340,314	$ 7,295,314	$ 7,295,314
1969	3,034,000	4,231,617	7,265,617	6,893,087
1970	3,267,000	4,266,050	7,533,050	6,750,044
1971	3,461,000	4,693,300	8,154,300	7,005,412
1972	3,840,000	4,292,840	8,132,840	6,766,089
1973	3,585,000	4,775,735	8,360,735	6,547,169
1974	4,027,800	4,707,800	8,735,600	6,164,855
1975	5,980,100	4,956,200	10,936,300	7,069,360
1976	7,329,000[2/]	5,076,100	12,651,300	7,733,068
1977	7,983,000[2/]	5,569,517	13,552,517	7,802,255
1978	7,932,000	6,177,736	14,109,736	
1979	7,793,000[4/]			

1/ Research funds and overhead for Washington and regional offices not included.
2/ Includes $1.4 million USDA funds.
3/ Constant, 1968, dollars (deflated by Consumer Price Index).
4/ Preliminary.

Figure D-1. Animal Damage Control Man-Years 1950-1977*



*1958 data estimated

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The funding and manpower levels discussed above represent totals for the ADC program including such varied activities as rodent damage to sugar cane in Hawaii and blackbird roosting problems in the East. Estimates of ADC cooperative program funding for predator control in 15 Western States for fiscal years 1968 to 1978 are shown in Table D-2. Total predator control spending has nearly doubled since 1972, reflecting both the effects of inflation and increased use of non-chemical control following the ban on toxicants in that year. In terms of the number of stock-sheep in those 15 states, predator control expenditures per sheep increased from $.38 in 1968 to $.72 in 1977 measured in constant (1968) dollars.

Table D-2. ADC Predator Control Funding in Fifteen Western States, FY 1968-1978[1/]
($000)

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State	1968	1979	1970	1971	1972	1973	1974	1975	1976*	1977	1978
Arizona	128.4	107.9	110.8	97.9	125.0	104.3	77.0	126.8	196.0	261.5	240.6
California	974.1	911.8	1,007.2	900.4	922.5	907.4	983.6	1,166.4	1,372.8	1,511.7	1,660.4
Colorado	415.4	444.3	445.8	447.0	447.7	362.9	**				
Idaho	318.2	337.5	326.4	384.4	425.0	439.7	417.0	486.9	552.8	550.2	618.3
Montana	324.6	345.3	356.7	355.3	361.8	346.1	388.2	514.4	577.8	478.2	615.5
Nebraska	46.9	55.0	66.8	76.5	113.1	92.6	97.7	101.2	234.5	286.4	286.6
Nevada	364.9	350.3	326.3	335.7	385.1	393.5	556.2	646.3	703.5	696.5	851.0
New Mexico	210.8	170.7	296.7	301.1	320.1	301.3	415.7	559.7	676.2	750.3	669.2
North Dakota	109.0	103.9	111.3	112.5	136.4	128.5	124.6	188.9	185.2	249.4	229.0
Oklahoma	229.6	225.5	243.0	235.5	267.6	260.4	301.1	418.3	465.8	470.3	405.5
Oregon	432.5	457.2	473.9	442.2	418.4	434.5	497.2	657.6	633.2	712.8	745.0
South Dakota	172.6	167.8	153.2	151.6	122.0	118.4	159.1	89.5	211.0	211.0	211.0
Texas	839.8	869.1	953.7	978.6	1,033.2	1,266.9	1,285.6	1,535.7	1,791.6	1,920.8	2,023.5
Utah	274.5	274.5	308.3	344.4	336.3	298.7	358.5	534.1	634.5	771.2	816.8
Wyoming	333.2	328.2	411.9	419.4	421.8	474.2	439.2	777.1	979.4	1,026.4	921.5
Washington	133.2	132.2	143.4	144.3	149.1	129.0	140.7	168.0	300.0	300.0	300.0
Total	5,307.7	5,281.2	5,735.4	5,716.8	5,985.0	6,058.4	6,241.4	7,970.9	9,500.3	10,296.7	10,593.9

** Colorado dropped the Federal-state cooperative program in 1974.

* South Dakota and Washington State switched to a Federal-state contract program in 1976.

1/ Estimates of total Fish and Wildlife Service, other Federal, state, and other cooperator funding of the cooperative program used for predator control. Fish and Wildlife Service Washington and regional office overhead costs are not included.

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II.D.1.d. Control Methods and Animals Killed

As suggested in previous sections, the mechanical and chemical methods used to take coyotes and other predators has varied over the years. Currently (FY 78), the program relies heavily on trapping and aerial gunning with relatively limited use of the M-44 device, the only predicide currently approved for ADC operations. State regulations and traditional patterns of use also influence the degree to which control methods are used in a given state. For example, aerial gunning, the most widely used method in Wyoming, is not permitted in Arizona. Terrain, vegetation and other factors also influence the effectiveness and extent of use of alternative methods, as reflected in use patterns among the states. This is illustrated in Table D-3 which shows the percent of man-years and funds expended for predator control in FY 77 by control method.

Control of damage by coyotes and other predators is conducted primarily for the purpose of reducing livestock losses. Table D-4 shows how the FY 77 control effort was allocated between protection of sheep, cattle and poultry, by state.

Table D-5 presents total numbers of animals taken by the ADC program in the West from 1970-77. There are two sources of error that should be considered in interpretation of these numbers. First, in the years prior to 1972, 1080 was used extensively, which means that the number of animals taken in those years may be underestimated because of the difficulty of measuring kill by such a slow-acting poison. Second, as noted in the table, there was no operational program in Nebraska in 1970-1971, and the ADC program was terminated in Colorado in 1974. This makes it difficult to identify and interpret any changes in animals taken.

Table D-3. Percentage of Predator Control Field Effort Expended by Methods in FY 1977

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States	Trapping	Aerial Shooting	M-44	Denning	Calling & Shooting	1/ Dogs	Snares	2/ Other
Arizona								
% of Manpower	93	3/	5		2			
% of Funds	93		5		2			
California								
% of Manpower	82	4	3	3	7	1		
% of Funds	82	4	3	3	7	1		
Idaho								
% of Manpower	65	10	8					17
% of Funds	46	40	5					9
Montana								
% of Manpower	35	25	5	5	20		10	
% of Funds	24	47	4	4	14		7	
Nebraska								
% of Manpower	77	10	7	4			2	
% of Funds	77	10	7	4			2	
Nevada								
% of Manpower	70	15	1			6		8
% of Funds	50	35	5			6		4
New Mexico								
% of Manpower	75	5	10	5	5			
% of Funds	75	10	10	2.5	2.5			
North Dakota								
% of Manpower	29	47			24			
% of Funds	35	47			18			
Oklahoma								
% of Manpower	92	5	2	1				
% of Funds	83	15	1	1				
Oregon								
% of Manpower	66	15	7	1	2		9	
% of Funds	60	24	5	1	3		7	
Texas								
% of Manpower	33	3	31				32	1
% of Funds	28	18	25				28	1
Utah								
% of Manpower	26	29.5	0.5	11.9	16	16	0.1	
% of Funds	19	37.0	2.1	10.6	15.1	15.1	1.1	
Wyoming								
% of Manpower	15	45		25	15			
% of Funds	15	55		20	10			

1/ Includes dogs used to take bear, lion, and coyote.

2/ Includes denning, calling, shooting, dogs, snares - but is a small percentage in those States that lump these methods as "other."

3/ Aerial hunting is prohibited by Arizona State law.

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Table D-4. Percent of Livestock Protection Effort - FY 77
(operational and extension)

State	Cattle	Sheep 1/	Poultry
Arizona	35	56	9
California	41	52	7
Idaho	4	96	0
Montana	28	71	1
Nebraska	40	52	8
New Mexico	30	68	2
Nevada	7	92	1
North Dakota	30	65	5
Oklahoma	57	16	27
Oregon	34	58	8
South Dakota 2/	15	80	5
Texas	30	65	5
Utah	10	89	1
Washington 3/	0	0	0
Wyoming	5	95	0

1/ Includes goats.

2/ Federal-state contract - data reflects Service's extension-type efforts in the State.

3/ Federal-state contract - all efforts of Service devoted to bird work.

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Table D-5. Animals Taken in Fish and Wildlife Service ADC Operations in Fifteen Western States, 1970-1977[1/]

	1970*	1971*	1972	1973	1974	1975	1976[2/]	1977*
Coyotes	73,162	75,661	71,300	76,454	71,777	81,910	84,499	67,330
Bobcats	8,580	6,608	5,351	5,239	3,811	2,709	2,298	1,151
Bears	431	234	191	196	107	117	100	99
Mountain Lion	125	80	49	29	25	39	49	60

* Preliminary figure.

1/ No operational program in Nebraska in 1970 and 1971. Cooperative program in Colorado was terminated in 1974. Does not include animals taken by contract programs in South Dakota and Washington which began in 1978.

2/ Transition quarter July 1 - Sept. 30, 1976 not shown.

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Requests for ADC assistance in the West for the years 1970-1977 are presented in Table D-6. The number of requests may reflect both levels of predation loss as well as the capability of the ADC program to respond to requests. If for example, ranchers know that a request will result in no effective response they are unlikely to make it even though they have a serious problem. There may also be variations between states and even years within a state in terms of the criteria used to measure "requests" and the care with which they are recorded. These caveats suggests that little weight be given these data as a measure of program output.

II.D.2. Commercial Coyote Harvest

Table D-7 shows the relationship between numbers of coyotes harvested commercially and those taken by predator control efforts from 1971 to 1976. The table also shows the dramatic increase in the average value of coyote pelts over the period; from $13 in 1971 to $45 in 1976. In 1978, Montana coyote hides have brought as much as $200 apiece (Associated Press, 1978).

Table D-6. Requests for ADC Assistance in Fifteen Western States, 1970-1977.

State	1970	1971	1972	1973	1974	1975	1976	1977
Arizona	*	*	576	485	691	658	493	590
California	3,853	7,363	8,198	8,617	9,009	9,717	13,169	10,333
Colorado	*	*	2,091	1,354	346	0	142	70
Idaho	1,841	1,306	1,076	912	1,071	886	1,721	1,094
Montana	2,188	1,996	2,068	1,829	1,920	1,910	2,892	1,828
Nebraska	0	0	3,055	2,161	1,369	1,614	2,505	1,032
New Mexico	575	388	327	301	472	341	428	301
Nevada	406	390	441	560	666	895	852	569
North Dakota	1,809	1,853	2,210	1,756	2,503	2,414	2,986	2,186
Oklahoma	1,777	1,583	1,171	1,057	977	928	1,432	991
Oregon	1,513	1,277	984	1,028	1,362	1,338	1,573	11,034**
South Dakota	2,293	1,934	1,734	746	790	0	0	510
Texas	1,977	2,098	1,560	1,621	1,594	1,291	4,641	3,202
Utah	1,000	1,183	1,263	1,079	556	970	779	1,239
Wyoming	412	449	562	739	608	478	861	618
TOTAL	19,644	21,820	27,316	24,245	23,934	23,440	34,474	35,597

* Not available.
** The increase in Oregon in 1977 reflects primarily a change in the method of recording request.

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Table D-7. Coyote Harvest and Average Fur Value

Year	Commercially*	Predator Control		Average Fur Value*
		Federal** State	Airborne*** Hunting Act	
1971	32,131	75,661		$ 13.00
1972	30,010	71,091	547	$ 18.00
1973	55,683	76,459	1,574	$ 20.50
1974	116,524	75,097	3,418	$ 17.00
1975	137,412	88,697	6,866	$ 17.00
1976	172,427	91,573	7,780	$ 45.00

* Fur Resource Committee, International Association of Fish and Wildlife Agencies (unpublished data).

** Annual reports States of Colorado, South Dakota and Washington and the Division of Animal Damage Control, U.S. Fish and Wildlife Service.

*** Annual reports of aerial hunting statistics as required by Airborne Hunting Act. Excludes data from the States of California, Nevada, Texas, Wyoming and Nebraska because coyote taken in Federal-state programs are duplicated in airborne hunting act statistics.

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The figures demonstrate that as coyote pelts increased in value, the number of animals taken commercially and under the Airborne Hunting Act increased several fold, while those taken by Federal and state control programs varied only slightly. Commercial harvest of coyotes, as any other fur bearer, is affected by market value. The higher fur prices apparently increased fur trapping and hunting effort, resulting in a larger commercial harvest. It may also be, however, that the higher fur prices mean that a higher proportion of furs of coyotes killed by sport hunters are sold and recorded. If that is the case, the number of coyotes killed has not increased as rapidly as the number of furs sold. Salvageable hides taken by the ADC program are sold at auction with the proceeds of the sale returned to the cooperative program and/or state agencies with the method of distribution depending on the particular state involved.

Coyotes harvested commercially are seldom associated with livestock damage situations. To have any commercial value, coyotes must be harvested in late fall or winter when furs are prime. Livestock damage is usually at a minimum during this time. Moreover, commercially harvested coyotes usually come from areas with high coyote densities and low livestock numbers.

II.D.3. Canadian Predator Control

Livestock depredation is a problem in specific areas of all the Provinces of Western Canada. Canada relies heavily upon the United States for research information on damage control methods and technology. Accordingly, damage control efforts in the past and present closely parallel the program efforts of the United States. The following is a description of the damage control programs of the Western Provinces:

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Manitoba: Manitoba historically made fairly large scale use of 1080 and strychnine for predator damage control, but such use of toxins has diminished to only minimal levels at the present time. It is believed that higher prices for long-haired furs and the resulting intensive fur harvest efforts has reduced the local populations of coyotes and foxes to the point where the extent of damage they cause is no longer a serious problem.

Saskatchewan: Coyote predation is recognized as the most persistent hazard in all sheep enterprises. The current use in Saskatchewan of lithium chloride baiting to establish aversive conditioning of coyotes to avoid feeding on sheep appears to have produced encouraging results (Saskatchewan Agriculture, 1978). Other non-Canadian studies, however, have not been able to achieve comparable reduction in losses when lithium chloride was tested.

1080 for controlling coyotes was widely used in the past, but such use has diminished considerably in recent years. Compound 1080 is used in population "knock-down" control, with the toxin being exposed in large baits of horse meat injected with the material. Less than 100 bait stations were placed per year during the past three years; only 40 baits were placed in the Province last winter.

Dr. J. R. Jowsey (Problem Wildlife Specialist with Agriculture) indicates that the use of 1080 has produced generally poor results with replacement animals moving back in before, during, and after the critical season begins. Dr. Jowsey hopes to be able to experiment with smaller single-dose baits, and attempt to reduce bait shyness which appears to be developing on horse

meat by using sheep. He also plans to continue the experimental use of 1080 in the summer where specific animal kills are treated in the hopes of killing the coyote when it returns to feed.

Saskatchewan Agriculture, through the Animal Industry Branch, will pay to a cooperating rural municipality 75 percent of the coyote damage control costs involving the use of compound 1080. If the rural municipality does not participate, such payment will be made to the individual livestock producer.

Individual predators and/or local population reduction is accomplished. through hunting, trapping, snares, denning, and use of toxicants (compound 1080); current laws do not permit the use of the coyote getter or M-44 device. Use of toxicants, aerial hunting, snares and snow toboggan (snowmobile) pursuit requires prior approval of both the Department of Tourism and Renewable Resources and the Animal Industry Branch of Saskatchewan Agriculture; such approval is dependent upon acceptable efforts made to resolve the problem with other available damage control methods.

Alberta: The sheep industry is on the up-swing in Alberta where approximately 40 percent of the sheep in Canada are raised. The Province of Alberta has a predator damage compensation program which pays 80 percent of the market value of an animal on a confirmed kill and 50 percent of the market value on animals missing and suspect of having been killed by predators, provided that there has been at least one confirmed kill experienced. The compensation program is in addition to traditional coyote damage control efforts.

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The Predator Damage Control Program is administered under a joint agreement between Agriculture and Fish and Wildlife. The Provincial Government provides 60 percent of the total funds expended for predator damage control personnel and the municipalities provide the remaining 40 percent.

There are eight Predator Specialists, one in each of the eight regions of the Province who train the 65 field men and their assistants in the application of various predator damage control methods. Such methods consist of steel traps, coyote getters, strychnine, compound 1080, den hunting, guard dogs, aerial gunning, and use of snowmobiles. Electric fencing is being tested on an experimental basis and looks promising for resolving predator damage problems in some situations.

Investigations and inspections of claims are primarily conducted by Predator Specialists, but agricultural field men and certain Fish and Wildlife officers are also qualified to perform such inspections. The investigator makes a judgment in each case as to whether the landowner or producer is doing his share in attempting to reduce predator damage--including proper animal husbandry and management practices. If the landowner or producer does not employ recommended practices, future claims may not be honored.

Traditionally, compound 1080 injected in horse meat baits was used as a remedial control tool in reducing high coyote populations in areas of high reported losses. In the late 50's and early 60's, up to 700-750 horses were used in a single year. During the past 10-15 years, compound 1080 has been used as a last resort, and only 2-3 horses have been used during the last five years.

This year, planned use of 1080 will involve single lethal injections in animals killed by predators, and will involve the summer season, whereas previous use was primarily restricted to the winter. There are also plans to test the effectiveness of the toxic collar in severe damage situations.

Steel traps are available for use by landowners and producers to control predator damage to domestic livestock. Resident permits are also available for trapping and selling wild animal furs.

Permits to use coyote getters and strychnine are issued by Predator Specialists to trained landowners and producers for coyote damage control on their property when they can demonstrate their ability to use the devices safely and effectively. The M-44 device was tested and dropped due to troublesome malfunctions and lack of effectiveness. It can not be legally used by landowners and producers. Aerial hunting is prohibited, even for the government program.

British Columbia: Coyotes are classified both as game and fur bearers in British Columbia, so the taking of coyotes is subject to both hunting and trapping regulations of the Province. Although ranchers in possession of a hunting license may shoot coyotes, damage control is basically the responsibility of the Fish and Wildlife Branch.

All complaints are investigated by Branch personnel. In areas of sporadic damage, control work is done in response to individual requests for assistance. In recognized historic problem areas, preventive damage control is practiced on a site specific basis by certified Branch personnel.

Compound 1080, strychnine, and sodium cyanide are used in predator damage control. Due to adverse publicity, use of 1080 is very restricted. Both large meat baits (up to 25 lbs.) and small single-dose baits are used. In areas close to settlements, steel trapping of problem coyotes is the preferred control method.

Regional problem wildlife management advisory committees assist the Fish and Wildlife Branch in identifying problem areas and developing appropriate damage control programs. These committees include representatives of regional producers and conservationist organizations, as well as personnel of the Fish and Wildlife Branch and the Ministry of Agriculture. The committees help to ensure that damage control efforts are effective to curtail losses and selective to protect other wildlife resources.

Summary:

All the Provinces have shifted away from general reliance upon the use of compound 1080 for predator damage control, apparently as a result of a lack of local public acceptance. The Provinces are each experimenting with various other approaches for alleviating conflicts between wildlife and man.

The geographic attachment of Canada and the United States would generally indicate an advantage in coordinating predator damage control activities. The difference, however, in laws regulating the use of toxicants, aerial hunting, snares, M-44's, etc., would greatly handicap a cooperative approach involving predator problems which overlap boundaries, but a sharing of information on problem areas and technical advances in resolving conflicts

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would be mutually beneficial. Coordinating damage control activities involving threatened and/or endangered species may be critical to the proper management and protection of some species.

II.D.4. Predator Research

Historical Summary

Predator research probably began as experiments to determine the proper strength of strychnine to use in baits put out to remove wolves in the mid-1800's. In the late 1800's the Bureau of Biological Survey, USDA, experimented with poisons to kill coyotes, bobcats, jackrabbits, prairie dogs, rats, and other mammals that were destroying or damaging property. The Bureau expanded between 1914 and 1920 to specifically include Predator Animal and Rodent Control, and in 1931 added a Food Habits Laboratory.

Fish and Wildlife Service Predator Research

Predator research in the modern era probably began in 1940 when the Control Method and Food Habits Laboratories at Denver combined to form the Division of Wildlife Research in the newly-created Fish and Wildlife Service of the Department of Interior where most Federal predator research remains today. Funding for all ADC research and for Federal predator research is shown in Table D-8. Predator research currently accounts for about one-fourth of the total ADC research budget. USDA also has a substantial predator research program, discussed in a later section.

Initially research consisted primarily of experiments with lethal baiting techniques, and follow-up studies of the effects on predator and other wildlife populations of strychnine, thallium, 1080 and anticoagulant bait stations (Robinson, 1961, for example). Their effectiveness was compared with the steel trap, and seasonal migrations of coyotes were followed between a no-control area and areas with predator controls (Robinson and

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Table D-8. Fish and Wildlife Service Total Research, and Predator Research of FWS, USDA, and EPA, FY 1970-FY 1978

($000)

Fiscal Year	Total ADC Research[3/]	Predator Research	
		FWS	USDA
1970	1,559.0	98.2 (6)*	--
1971	1,758.1	121.0 (7)	--
1972	1,735.0	130.0 (7)	89.0
1973	2,746.0	350.8 (16)	190.0
1974	1,680.0	823.7 (18)	641.0
1975	2,715.2	848.2 (20)	652.0
1976	2,866.7	1,135.0 [1/] (20)	638.0
1976A**	[2/]	231.1 (20)	159.5
1977	3,380.6[2/]	839.0 (21)	447.0
1978	3,480.0	842.4 (21)	726.0

* Permanent full-time employees in parentheses.
** Transition quarter, July 1 - Sept. 30, 1976.
1/ Includes $300K from EPA for toxic collar research.
2/ Transition quarter included in FY 1977 total.
3/ Overhead costs not excluded.

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Cummings, 1951). Experiments with the coyote-getter took a back seat to the highly successful toxic bait stations during the 1940-60 period.

Population control with reproductive inhibitors was the principal focus of predator research at the Denver Wildlife Research Center (DWRC) from 1961-68. This was largely unsuccessful because extensive field applications could not deliver the inhibitor to enough coyotes to effect population reduction (Balser, 1964; Linhart, Brusman, and Balser, 1968). From 1964 to 1973 a DWRC field station in Texas continued predator-prey relationshp studies begun in Denver, and began investigations of census techniques and coyote dispersal movements (Knowlton, 1972).

Following the 1972 ban on use of poisons in the cooperative Federal program, additional research monies were made available (Table D-10). Control methods research efforts were increased and a much-needed balance of investigations into documenting livestock losses and coyote biology, ecology, and behavior were begun as had been strongly recommended by the Leopold and Cain committees in 1964 and 1972 respectively. Table D-9 shows FWS funding for these basic types of predator research from 1970 to 1978. Results of this expanded research effort are cited extensively in other sections of this report.

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Table D-9. Fish and Wildlife Service Predator Research by Type of Research, FY 1970-FY 1978
($000)

Fiscal Year	Methods	Predator Ecology and Behavior	Damage Assessment	Total
1970	32.0	66.2	--	98.2
1971	54.0	67.0	--	121.0
1972	54.3	67.2	8.5	130.0
1973	105.2	210.5	35.1	350.8
1974	253.0	310.7	260.0	823.7
1975	269.0	305.2	274.0	848.2
1976	254.5	320.5	260.0	835.0
1976A*	70.5	87.8	72.8	231.1
1977	374.0	360.0	105.0	839.0
1978	378.0	345.0	119.4	842.4

* Transition quarter, July 1 - Sept. 30, 1976.

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USDA Predator Research:

The Agricultural Research Service (ARS) has funded or conducted a number of types of predator research projects. ARS predator research has included aversive agents, reproductive inhibitors, guard dogs, attractants and electric fencing.

The Economic Statistics and Cooperatives Service (ESCS), formerly the Economic Research Service, recently completed an extensive study of various aspects of the western sheep industry. The results of this effort, discussed elsewhere in this report, focus on levels of sheep and lamb losses, reasons for the decline of sheep production in the West, costs and returns of western sheep production, and the nature of predator control programs. One product of the research is a computer simulation model of the relationships between coyote populations, damage control efforts, and sheep losses. An evaluation of the model is included as Appendix C.

State, University, Other Predator Research

The role of states, universities, and private individuals or groups engaged in predator research is not clear. Therefore, an example of research projects underway at one time were obtained from abstracts of talks given at the Coyote Research Workshop, November 14-17, 1974 (Linhart, 1975), and are shown in Table D-10. Sources of funding were seldom shown in abstracts of papers presented, so sources were assigned based on available information.

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Table D-10 Funding and Types of Coyote Research as Determined from Abstracts of presentations at a Coyote Research Workshop, November 14-17, 1974 (Linhart, 1975).

Funding Source	Types of Research				Number of Resrch Reports
	Damage Assessment	Depredations Control	Behavior	Ecology	
Federal - Denver Wildlife Research Ctr., FWS	3	4	3	4	14
Federal - USDA (ERS, ARS, etc).	5	7	4	1	17
Federal - Other FWS (Coop. Units, Contracts)	2	1		3	6
Federal - Other				2	2
States		1	1	3	5
Universities	1	1	3		5
State & University	1			1	2
University & Private		1			1
Federal, State, & University			1		1
Canadian	1			2	3
Unknown	2		1	5	8
TOTALS	15	15	13	21	64

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II.E. Review of Fish and Wildlife Service Predator Damage Control Methods

The basic control methods used in the Service's Coyote Depredation control Program are: (1) trapping, (2) shooting from aircraft, (3) shooting from the ground, (4) snaring, (5) denning, (6) dogs, (7) the M-44, (8) frightening devices, and (9) husbandry recommendations. These control methods are used in various combinations and degrees of intensity.

Each method has advantages and disadvantages; each is effective in some situations but not in others. These methods may be used singularly or in combination, by Service and/or cooperative personnel, directly or indirectly, depending upon existing Federal, State and local laws, policies, guidelines, regulations, and the circumstances involved.

Usually damage by carnivores, including coyotes, bobcats, mountain lions, and bears, is caused by local populations or individual animals. Control is directed toward the offending individual, or local offending populations where possible, by choosing the time, location, method and application of the control technique. Methods are chosen for their selectivity, safety, humaneness, and efficacy.

Generalizations regarding the relative merits of one technique over another are not always valid. For example, in parts of Texas aerial hunting is effective only when the leaves are off the trees and bushes. Depending upon the wildlife species present in a given area, steel

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traps can be very selective or non-specific. For such reasons, a variety of control methods are needed to handle damage complaints in different areas and under a wide range of circumstances. The advantages and disadvantages of each of the commonly used methods in relation to general efficiency, selectivity, humaness, safety, ecological/environmental impacts, social acceptance and legal constraints are ranked in Table E-1 and are summarized below.

Table E.1 -- Ranking of ADC Operational Control Methods with Regards to Application, Selectivity, Humaneness, Safety, and Environmental Conservation

Control Method	General Efficiency: Offending Individual	General Efficiency: Population Reduction	Selectivity[a/]	Humaneness[b/]	Safety[c/]	Ecological Environ. Impacts	Legal Constraint
Steel Traps	Good	Poor	Fair	Poor	Excell.	Slight	State laws on visitation requirements.
Aerial Hunting	Fair	Good	Excellent	Good	Fair	Slight	Fed. and/or State permits required. State control on time and/or location.
Calling and/or Shooting	Fair	Very Poor	Excellent	Excellent	Excell.	Slight	None
Den Hunting	Good	Poor	Excellent	Good	Good	Slight	Prohibited on BLM lands.
Toxic Chemicals:[d/]							
M-44	Fair	Good	Good	Excellent	Good	Slight	Subject to (EPA) Regis. restrictions. Restricted from some Federal lands. Prohibited on most BLM lands.
Toxic Collar	Excellent	Poor	Excellent	Good	Good	Slight	No Registration (EPA)
Single Lethal baits	Fair	Good	Fair	Good	Good	Some	No Registration (EPA)
Bait Stations	Poor	Excellent	Fair	Good	Good	Some	No Registration (EPA)

a/ For target species.
b/ Subject to perceptions of suffering, pain.
c/ Refers to human hazards associated with each control method.
d/ Judgements vary depending upon chemical and pharmalogical properties of toxicant as well as method, timing, and location of application.

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Trapping

The steel leg-hold trap is the most versatile, widely used tool for corrective control. Its advantages are that it can be set under a wide variety of conditions for taking the most wary animals using bait, scent, or blind sets. Tension devices of various types are used to prevent animals smaller than target animals from springing the trap. Care in selection of trap location can also make the trap more selective. A significant advantage is that it usually permits safe release of non-target animals which may be captured inadvertently. Successful use of the steel trap in taking offending animals requires a knowledge of scents and animal behavior, proper training, and experience.

The disadvantages of steel traps include the difficulty of keeping them in operation during rain, snow, and freezing weather, a general low overall capture success of one coyote per 100-200 trap nights, and a lack of selectivity (Robinson, 1943; Cain et. al., 1972) when improperly set or in situations where non-target species abound.

With few exceptions coyotes are too wary to be enticed into live traps and killer traps cannot be concealed. Moreover, killer traps large enough for coyotes pose a serious hazard to pets and humans (Berryman, 1973; Thompson, 1976) and are not designed for safe release.

Beasom (1974) compared the selectivity of M-44 devices, strychnine baits and steel traps in south Texas, and found that steeltraps took more individuals and species of animals than any other control method used.

He also found that selectivity was a function of how the trap was used. Open scent sets were least efficient for catching predators and most non-selective in catching other animals. Blind trap sets were more efficient than scent sets for taking coyotes, bobcats, raccoons, and striped skunks, but they also caught more game birds and rabbits. Trap sets baited with carrion alleviated most of the problem of catching game animals while still catching more predators than scent traps, but they also took more raptors and vultures.

Steel traps are an indispensible tool in many situations but are of little value in general population reduction because of the amount of work and time involved. Their use presents low risks to humans and minimal adverse environmental effects when properly used.

Aerial Hunting

The use of aircraft in coyote control is a comparatively recent development in mechanical methods (Young 1951).

Aerial hunting has a great advantage in species selectivity and for immediate control where livestock losses are severe, providing weather, terrain, and cover conditions are favorable.

Aerial hunting can be effective in removing offending coyotes which have become "trap-shy" or are not susceptible to calling and shooting. Local depredation problems can sometimes be most readily solved by the use of aircraft. Fixed-wing aircraft are useful over flat and gently rolling terrain. Due to their greater maneuverability, helicopters have greater utility over brushy ground, timbered areas, or broken land where animals

are more difficult to spot. In broken timber or deciduous ground cover, aerial hunting is more effective in winter, when snow cover improves visibility, or in early spring before trees leaf out. Aircraft are used to intercept and shoot coyotes at locations where they have killed livestock. Aircraft are also used in searching for coyote dens (USDI, 1950; Berryman, 1973; Lemm, 1973). This method may also be used to reduce local coyote populations in lambing and calving areas with a history of coyote depredation (Berryman, 1973; Wade, 1976).

Good visibility is required for effective and safe aerial operations; therefore, relatively clear and stable weather conditions are necessary. Hot summer weather limits effective aerial hunting by reducing coyote activity and visibility due to vegetational cover. High temperatures also reduce air density and the safety of low-level flight which further restrict aerial hunting.

Aerial hunting is prohibited in some states and strictly controlled in states where it is allowed. Aerial hunting is most effective when ground support crews direct the aircraft by radio to the general location of the animals which have been located by eliciting coyote howls with human voices, sirens or recorded coyote howls.

A rigid Service aircraft use policy has been developed to insure that aerial programs are conducted in a safe and an environmentally sound manner in accordance with Federal and state laws. Pilots and aircraft must be reviewed and approved using established Departmental procedures. Only approved and properly trained Service employees are utilized as gunners.

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Aerial hunting has largely replaced the use of toxicants to control coyotes in problem areas. In 1976, 40 percent of the coyotes taken by ADC program personnel were taken by aerial hunting. This technique has the advantage of being humane since death is usually instantaneous. However, there is an inherent risk to aerial hunting crews. Aerial hunting has a negligible effect on the environment.

Shooting from Ground

Some predators are shot from the ground, with or without the aid of predator calls. However, relatively few coyotes are taken in this manner (6 percent in FY 76). Ground shooting is selective for offending individuals and has an advantage in that it can be directed at specific damage situations. This procedure is time consuming and requires special aptitudes, skills, and experience, not readily available. Humaneness is good except in occasional instances of crippling.

Denning

The usefulness of denning as a damage control method is limited since coyote dens are difficult to locate in many parts of the country and den use by coyotes is restricted to about two months during the spring.

The primary purpose of denning is to remove offending adults whose increased food requirements to feed pups causes serious loss problems. The removal of pups, however, will often stop kills even though the adults are not taken. When the adults are taken it is desirable to still take the pups to prevent their abandonment or starvation. Denning is highly selective for the target species and damaging family groups.

Den hunting for adult coyotes and foxes and their young is often combined with still hunting and calling.

In 1976, denning accounted for only 6 percent of the coyotes taken by ADC personnel. Given an average of 5-6 pups per den, approximately 950 dens were taken in the Western States during that year through the ADC program. Denning is a tool of limited applicability and has value in only certain situations and areas.

Toxicants

Although a variety of chemicals have been used to control depredations only three have been used extensively in the past, strychnine, sodium cyanide, and sodium monofluroacetate (compound 1080). The manner in which these chemicals are used is generally more important than the nature of the chemical in determining non-target and environmental risks as well as human safety. Historically, poisons have been used almost exclusively in scent or carrion type baits. The potential for more selective applications (e.g., toxic collars on sheep, or timing and duration of baiting) has arisen only recently.

The use of toxic chemicals for predator control in the United States began at least as early as 1847 when strychnine was introduced. Both the alkaloid and sulfate forms were used extensively in wolf and coyote control (Young, 1951; Crabtree, 1962) until 1972 (Berryman, 1973). Thallium sulfate was first used experimentally for coyote control during field studies in 1937. These gradually expanded to limited operational use some

ten years later, primarily by the FWS in the Mountain States (Robinson, 1948). However, the discovery of sodium monofluoroacetate (compound 1080) as an effective pesticide and the more hazardous aspects of thallium terminated its use. As an operational method, thallium was officially cancelled by the FWS in 1967 although its use had actually been discontinued much earlier (Gottschalk, 1967; Berryman, 1973).

In 1973, use of chemicals to control predator damage were banned on Federal lands and in Federal programs by Executive Order 11643 and by withdrawal of predator damage control toxicant use registrations by EPA.

M-44

The M-44 is a mechanical-type replacement for the humane coyote getter which is typically baited with fetid meat scent. When triggered by predators, the device mechanically expells sodium cyanide into the animals mouth; coma and death follow within a few seconds (Robinson, 1943). The M-44 is very selective for canids (members of the dog family) primarily as a result of the attractant (rotted meats) and the requirement that the device be triggered by a tug with the teeth. During FY 75, 87 percent of 4,639 animals recovered from M-44 devices were canids (Table E-2). Units were used in standard census lines in Texas between 1965 and 1971, and coyotes and foxes represented 97 percent of the animals recovered (Table E-3).

From the late 1940's until the mid-1960's coyote getters were used extensively for coyote population reduction purposes. Their use declined with increased public use of rangelands and eventually policy changes shifted use to the M-44.

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Sodium cyanide was re-registered for FWS use in the M-44 by EPA in 1975 but the 26 conditions attached to the registration (see Appendix D) greatly limited field use of the device. Only 6 percent of the coyotes taken in FY 76 were taken by this means. The M-44 is selective, environmentally safe, and poses little risk to humans when used in accordance with its registration label. However, domestic dogs occasionally are killed by the device.

Table E-2 - **M-44 Selectivity**
Animals Taken
June 1, 1974 - October 31, 1975
in the ADC Program

Species	No. Taken by M-44	Percent of Total
Coyote	3,443	74.2
Fox (gray & red)	603	12.9
Dog (Feral)	84	1.8
Opossum	209	4.5
Skunk	207	4.5
Raccoon	79	1.7
Ringtail Cat	5	Trace
Raven	3	Trace
Bobcat	2	Trace
Badger	1	Trace
Dog (Domestic)	1	Trace
Armadilo	1	Trace
Calf	1	Trace
Totals	4,639	100.0

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Table E-3

Percent Distribution of Animals Recovered From
U.S. Fish and Wildlife Service
Standard Coyote Census Lines, by Unit
Types in Texas, 1965-1971

	Coyote Getter	M-44 Devices	Devices Combined
No. of unit nights	23,739	44,344	68,083
No. of units discharged	1,348	2,138	3,486
No. of animals recovered	954	1,495	2,449
Species:			
Coyote	76.93	93.24	86.89
Dog	0.31	0.00	0.16
Fox	13.31	4.28	7.79
Raccoon	0.83	0.66	0.73
Skunk	0.94	0.53	0.69
Opossum	7.33	0.33	3.06
Wood Rat	0.31	0.80	0.61
Turkey	0.00	0.06	0.04

Compound 1080

Sodium Monofluoro Acetate (1080) was found to be as effective as thallium, more selective toward the canid species and safer to handle and use. It was developed during World War II as a rodenticide to replace other compounds in short supply due to the war. Experimental use of 1080 for coyote control began in 1944 in Colorado. Successful field experiments led to its operational use in impregnated meat baits for coyote control from 1946 to 1972 (Robinson, 1948; USDI. 1950; Berryman, 1973).

Compound 1080 is very highly toxic to canids and rodents, and somewhat less so to other species. Atzert (1971) presents LD_{50} dosage data for numerous species, as well as data on the amount of properly treated coyote bait (1.6.gm 1080 per 45.4 kg of bait material) that selected species must consume in order to obtain a median lethal dose (Table E.4)

Prior to 1972, 1080 was used in large meat baits. The chemical was injected into the eviscerated carcass or carcass portion of a domestic or nongame animal averaging 50 to 100 pounds,at the rate of 1.6 gm of Compound 1080 per 100 pounds of bait material (35 ppm). This low toxin concentration improved the selectivity of the bait station for coyotes, and reduced the hazards to carnivorous, nontarget avian and mammalian species that are more tolerant to the poison than are canids. Low 1080 concentrations in bait carcasses served both to reduce the possibility of nontarget species receiving lethal doses from the bait itself, and reduced the danger of their receiving fatal doses from secondary sources such as poisoned carcasses and vomitus (Atzert, 1971). Based on his work on lethal bait stations impregnated with 1080 during the 1940's, Robinson concluded that while some accidental and

Table E-4 - LD_{50}, average weight, and amount of properly treated coyote bait (1.6 g. of 1080/45.4 kg. of bait material) that selected species must consume in order to obtain a median lethal dose. a/

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Species	LD_{50} mg/kg	Average Weight lbs.	Amount of Properly Treated Coyote Bait Containing LD_{50} ozs.
Coyote	0.1	30	1.4
Cat (Domestic)	0.2	3	0.3
Fox	< 0.3	12	< 1.6
Bobcat	< 0.66	22	< 6.6
Bear	0.5-1.0	300	68.0-136.0
Mink	~1.0	3	~1.4
Marten	~1.0	3	~1.4
Magpie	0.6-1.3	0.5	0.1-0.3
Badger	1.0-1.5	19	8.0-13.0
Man	0.7-2.1	150	47.6-142.8
Golden Eagle	1.25-5.0	7	4.0-15.9
Hawks	~10.0	2.5	~11.3
Great Horned Owl	~10.0	3.5	~15.8
Black Vulture	15.0	5	34.0
Turkey Vulture	<20.0	6	<54.0

a/ Table extracted from Atzert (1971)

secondary poisoning of nontarget birds and mammals would inevitably occur on a small scale, the selectivity of 1080 bait stations was much higher for coyotes than for other wildlife species (excepting foxes); furthermore, 1080 stations killed fewer nontarget species than did lethal bait stations utilizing thallium. Atzert (1971:29) states that the hazard of acute poisoning of nontarget species from secondary sources is reduced with properly treated 1080 bait stations: "a seven-pound golden eagle would have to consume the internal organs of from 7 to 30 coyotes killed by Compound 1080 to receive a median lethal dose (1.25 to 5.00 mg/kg) - assuming the coyotes ingest an LD_{50} (0.1 mg/kg) and do not excrete, detoxify, or regurgitate any of the toxicant and that as in rats approximately 40 percent of the dose is present in the internal organs at death."

Bait station placement further increased the selectivity for coyotes and assured maximum protection for nontarget species (Robinson, 1949, 1953; Atzert, 1971). Control methods aimed at general coyote population reduction are much more effective in winter, before coyotes whelp. than in other seasons; this factor dictated late fall and winter placement of 1080 stations with removal and complete destruction in early spring (Atzert, 1971; Robinson, 1949). Winter-only use of 1080 stations also avoids exposure of hibernating animals such as bears (Robinson, 1949). To assure spring recovery, baits were securely fastened to immovable objects when set out, and their exact location described in writing and known to at least two persons (Atzert, 1971).

Division of Wildlife Service policy restricted 1080 bait placement to established crossings and driftways having maximum use by coyotes, in habitat having minimum use by nontarget carnivorous species. In conjunction with low-density bait placements (normally, by Division policy, no more than an average of one bait per township) this practice precluded most nontarget carnivores from ever encountering the bait stations, considering their generally much smaller home ranges (Atzert, 1971). Atzert (1971) cited unpublished data of the Bureau of Sport Fisheries and Wildlife as indicating that populations of nontarget carnivorous species did not measurably decrease in the vicinity of Bureau control activities in the 30 years of 1080 use in coyote control. Robinson (1953) indicated that with proper precautions, 1080 stations could be employed without seriously damaging populations of martens, weasels and minks. For marten safety, bait stations must be well removed from timber or brush cover. While field trails showed that matterns would not go to meat placed 50 to 75 yards from timber, these distances increased for maximum safety. Because of hazards to martens and red foxes in mountainous habitat, bait station placements were best limited to lower elevations. The limited movements of weasels reduced their vulnerability to 1080 stations; avoiding brushy areas in the placement of lethal bait stations further minimized dangers to these animals. Incomplete data suggested that bait stations placed further than one-quarter mile from riparian habitat would endanger very few minks, but placements should be at much greater distances for maximum safety (Robinson, 1953). Foxes were probably more susceptible to 1080 bait stations than were the mustelids, because of the similarity of their habits to coyotes. The more

limited movements of foxes reduced their vulnerability where 1080 stations were widely spaced; further data which suggested that placement of 1080 stations in lower elevations could still control coyotes effectively while reducing the danger to foxes (Robinson, 1953). Generally, more favorable sites for 1080 bait stations existed on plains, deserts and non-forested foothills than in mountainous regions (Robinson, 1953).

The prospect for an EPA registration of 1080 for use as a predacide is discussed below under the applicable sections of the Federal Insecticide, Fungicide, and Rodenticide Act.

Section 5 Registration (Experimental Use Permits)

The purpose of an experimental use permit pursuant to section 5 is to gather information to support the registration of a product. Furthermore, a Section 5 registration is the only legal means for an applicant to obtain the "substantial new evidence" required by regulation for reconsideration of a cancellation or suspension order, when such evidence can only be obtained by using the pesticide. EPA can approve the issuance of an experimental use permit for a previously suspended or cancelled chemical such as 1080, as long as it is subject to such restrictions as necessary to insure the occurrence of only mininal adverse environmental effects and is aimed at gathering "substantial new evidence" as required by regulation to support reconsideration of the prior suspension/cancellation order.

Section 3 Registration

Prior to any consideration of a section 3 registration with respect to 1080 for predator control, data necessary to address the concerns set forth by

EPA in PR Notice 72-2 must be addressed. The major concerns expressed by the EPA are as follows:

a. Primary hazards to non-target species.

b. Secondary hazards to non-target species

c. The lack of reliable data on the efficacy of poison baiting, especially in relation to economic loss caused by predators to the sheep industry.

   1. lack of reliable data on the amount of predator control achieved by the use of 1080.

   2. lack of reliable data as to the loss of sheep that might occur without a predator control program using pesticides or of the real effect of such losses on the general economic health of the sheep industry.

d. The non-selectivity of the use pattern (bait station)

Section 18 Registration (Emergency Exemptions)

The EPA may exempt from the requirements of FIFRA, as amended, a federal or state agency if it determines that emergency conditions exist which may require such as exemption. An emergency will be deemed to exist when: (a) a pest outbreak has or is about to occur and no pesticide registered for the particular use, or alternative method of control, is available to eradicate or control the pest, (b) significant economic or health problems will occur without the use of the pesticide, and (c) the time available from the discovery or prediction of the pest outbreak is insufficient for a pesticide to be registered for the particular use. In determining whether an emergency condition exists, the Agency will also give consideration to such additional facts requiring the use of Section 18 as are presented by the applicant. 1/

1/ This information was supplied by EPA in a memorandum dated March 28, 1978 at the request of the Department of the Interior.

Thallium Sulfate

The use of the toxin thallium sulfate, once common in predation damage control activities, declined with the introduction of Compound 1080 in 1944. When compared with 1080, Thallium had several drawbacks. It was much less toxic to coyotes than 1080 and more expensive to use. Its relative insolubility in water made it more difficult to apply properly to bait carcasses than the highly water-soluble 1080. Thallium was much less selective for coyotes than 1080, and the consequent danger of poisoning nontarget animals was greater. Small feedings on thallium baits could cause lethal poisonings of nontarget species; this danger is reduced when a properly treated 1080 bait was used. Secondary poisonings may also have posed a somewhat greater threat to wildlife when thallium was employed in toxic baits. While large doses of thallium often killed within 24 hours, smaller but still lethal doses may not be fatal for 2 to 5 days or longer. Recovery from sublethel doses requires several weeks during which there is partial disability, emaciation and loss of hair. Thallium is much less humane than Compound 1080 (Robinson, 1949).

Strychnine

Strychnine has been most often employed in egg, meat and tallow baits, with application either by ground or aerial methods. Selectivity was influenced by the care taken in bait placement. Robinson (1949) remarked that after an initial period of success in strychnine bait use, coyotes learned to detect the toxin in the baits, and its effectiveness declined.

Beasom (1974) found that strychnine meat baits were noticeably less effective in killing target carnivores in south Texas than either M-44s or shooting. Nontarget groups mainly affected were raptors including Harris' hawks, marsh hawks, caracaras and great horned owls, and rodents including cotten rats, deer mice, grasshopper mice, pygmy mice and harvest mice. Predators all died within 30 yards of the bait site except one coyote which was found about 200 yards away.

Other Control Methods

Snaring

Snares of flexible wire cable are occasionally used where coyotes crawl under or through fences to prey on domestic animals. They are used primarily in areas of extensive woven or net wire fencing. Snaresare especially useful during wet weather and in the winter when snow and ice interfere with effective trapping. A loop in the snare is placed to encircle the coyote's neck as it passes through or under the fence and fhe snare is anchored to a solid object. A simple locking device holds the loop closed on the animal's neck. (Bateman, 1973; Wade, 1973).

Nontarget animals can be taken in snares if they are not set properly and if placement sites are not selected by knowledgeable animal damage control specialists. The snare is used in both perventative and corrective situations as indicated.

Dogs

The use of dogs in predator control is extremely limited except on occasion for severe lion and bear complaints. Dogs trained for denning are occasionally

used either to locate dens or to lure defending adults to be shot. Training of guard dogs to protect livestock has met with limited success (USFWS Research Project). The use of dogs is humane and has no ecological or environmental impact.

Frightening Devices

Automatic exploders and blinking lights are sometimes recommended to temporarily frighten coyotes and other predators from problem areas to allow a few days lead time for conventional control methods to be applied. Scaring devices have only short-term effectiveness on mammalian predators, where they are effective at all. These devices present no detrimental environmental effect, except for temporarily moving the carnivores and possibly other animals to other feeding ranges.

Husbandry Recommendations

The only nonlethal control method that is consistently effective is total exclusion of predators. Production of poultry and hogs in total confinement are examples (Henderson, 1973). Fencing is impractical for large land areas such as the arid ranges of the western states due to present costs of construction and maintenance (Nesse, et al., 1976). In addition, effective exclusion implies and requires removal of predators from within the confines of such fences. Physical, legal, social and political factors limit the use of fencing as an approach for much of the United States. Opposition to fencing which could affect migration of antelope, deer and elk herds is one example of social and political pressures (Outdoor News Bulletin, June 20, 1975), and environmental problems that could occur.

Other

Other recommendations include corraling livestock at night to improve the efficiency of mechanical control tools. Also, pen or shed lambing helps to reduce early predator losses in some areas. However, proper range utilization, reduced animal efficiency, and construction costs of sheds and pens, cause this alternative to have limited application. Close herding is also beneficial but is costly and requires the use of qualified herders that are in short supply. For more discussion on husbandry practices see section II B.4 and Gee and Magleby (1976).

Cost Effectiveness

Relative use of the various animal damage control methods and related costs for taking coyotes to resolve specified depredation problems during FY 1976 are found in Table E.5. Clarification is necessary as to what these data do and do not represent. These data do not measure efficiency in reducing coyote depredations on livestock. Information is lacking with which to qualify this specific relationship.

The data do reflect the relative amounts of use and cost in terms of dollars and man-years that is devoted to each method. From this information, a comparison can be made of the efficiency of the various control methods for taking coyotes but only under the specific condition existing at that time and this does not necessarily relate to the efficiency in the control of predator damages. Conditions include: taking of coyotes in depredation areas only; taking coyotes to stop depredation regardless of time and effort required; and method used tempered by applicator's and management's judgement of

environmental factors. The efficiency of a method for taking coyotes is only one of the factors to be considered, and often is not the deciding factor. The data is more a reflection of environmental conditions (coyote density, weather, human activities, etc.) and applicator's efforts to accommodate those conditions than it is a measure of the efficiency of each of the methods.

Cost effectiveness is normally determined by measuring the dollars spent to attain a specified goal. In the traditional ADC Program to protect livestock this would be most accurately represented by a tabulation of dollars expended reltative to the amount and value of livestock saved. Total program costs, as reported annually, can be expanded to reasonably accurate estimates of field expenditures by method. However, the relative effect in damage reduction achieved by any given method is far more difficult to determine because several methods of control are normally applied simultaneously and the measurement of prevented or controlled predator damage is not easily determined. To do so, missing livestock must be located and the cause of death identified since all do not die from predation. Carcasses may be concealed by vegetation, terrain, snow, or be very thinly scattered over vast areas or occur in terrain that is difficult to travel, or carcasses may have been completely removed by predators or scavengers. Field personnel routinely evaluate a depredation complaint to firmly establish cause, but manpower and fund limitations preclude making determinations of total predator caused damage.

According to the U.S. Fish and Wildlife Service data for Fiscal Year 1976 (Table E.5)., steel traps took the largest percentage (37%) of coyotes taken by the Program, followed by helicopters (28.6%) and fixed-wing airplanes

Table E.5 Method Use and Efficiency for
Coyotes Depredation on Livestock
Fiscal Year 1976 1/

	Coyotes Taken		Cost	Mantime			Dollar Per	Coyotes Taken Per
	Number	&	Dollars Expended	Percent Dollars Expended	Man Years Expended	% Man Year	Coyote Taken	Manyear Expended
Trap	30,988	37.0	2,777,745	43.7	228.26	55.7	$89.64	135.7
M-44	5,258	6.3	45,667	7.2	46.34	11.3	8.68	113.5
Gr. Shot	5,307	6.3	211,145	3.3	17.79	4.3	39.79	298.3
Snare	3,187	3.8	437,024	6.8	45.32	11.1	137.13	70.3
Den	5,220	6.2	283,853	4.5	24.33	5.9	54.38	214.5
Dog	204	0.2	11,274	0.2	0.84	0.2	55.26	242.9
Ground Total	50,164	59.8	4,174,708	65.7	362.88	88.5	83.22	138.2
Fixed Wing	9,692	11.6	538,119	8.5	22.74	5.6	55.52	426.2
Helicopter	23,934	28.6	1,639,502	25.8	24.19	5.9	68.50	989.4
Air Total	32,626	40.2	2,178,621	34.3	46.93	11.5	66.78	695.2
Grand Total	83,790	100.0	6,353,329	100.0	409.81	100.0	75.82	204.5

1/ Data from U.S. Fish and Wildlife Service ADC Program field operations for FY 1976 (excluding the Transition Quarter) in Arizona, California, Idaho, Montana, Nebraksa, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, Texas, Utah, Wyoming.

(11.6%). Nationally a larger percent (59.8%) of the coyotes were taken by methods applied on the ground than by aerial methods (40.2%). Minor percentages were taken by M-44's (6.3%), ground shooting (6.3%), and denning (6.2%). However, these minor methods are cumulatively significant. The percent of coyotes taken by snares (3.8%) and dogs (0.2%) were also minor. The data point out that the two major control methods relied upon by ADC were the steel trap and aircraft and that their combined usage accounted for over 75 percent of all coyotes taken during that year.

Although the data is not displayed tabularly, the geographical distribution of the relative roles of each method is interesting and important. Traps took a significant percentage of coyotes in all states except North Dakota (6%). The percentage of coyotes trapped equalled or extended the National percentage (37%) in Arizona (85%), California (70%), Nebraska (37%), New Mexico (57%), Oregon (42%), and Texas (38%). Coyotes taken by M-44's exceeded the National percentage (6.3%) in Texas (18%) where private land-ownership and weather conditions are conducive to their use, Oklahoma (8%) and New Mexico (8%). The percentage of coyotes taken by ground shooting ranged from a low in Texas (3%) to a high in Oklahoma (11%) with all other states falling between them.

The percentage of coyotes taken by snares was significantly only in Texas (13%) where there are extensive fences associated with private lands, and New Mexico (5%) where there are fences associated with private and BLM lands. No coyotes are taken by fixed-wing aircraft in the States of Arizona (because aerial shooting is prohibited by State law), Texas, Oklahoma or Oregon. Fixed-wing aircraft were important in Idaho (15%) Nevada (25%) and Utah (19%)

for coyote removal and exceptionally so in Montana (40%) Nebraska (35%), North Dakota (76%) and Wyoming (31%). No coyotes were taken by helicopter in Arizona, Nebraska or North Dakota. Helicopters were close to or exceeded the national percentage (28.6%) for coyote removal in Idaho (58%), Montana (35%0, Nevada (36%), New Mexico (24%), Oklahoma (36%), Oregon (37%), Texas (26¢), Utah (40%0 and Wyoming (62%). The major use of aircraft is in the Intermountain area.

A comparison of the distribution of expenditure and cost efficiency by method shows that 65.7 percent of the field funds were sent on ground control methods to take 59.8 percent of the coyotes at a cost of $83.22 per coyote. At the same time 34.3 percent of the field funds were expended on aerial hunting taking 40.2 percent of the coyotes at a cost of $66.78 per coyote. Aircraft appear to be more efficient for taking coyotes in spite of the high cost per hour for helicopters. Traps utilized 43.7 percent of the field funds to take 37 percent of the coyotes at a cost of $89.64 per coyote, a higher cost per coyote taken than any other ground method except snaring. The percent of funds expended on the M-44, (7.2%), ground shooting (3.3%), snaring (6.8%) and denning (4.5%) were not significant as single items. In terms of coyotes taken per man-years of effort, aerial methods exceeded ground methods by 557 coyotes per man-year expended.

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II.F Effectiveness of Control in Reducing Livestock Losses

There is a continually increasing body of evidence that coyote control definitely does reduce sheep losses. Most of the evidence comes from intensive biological studies of a small number of ranches, with and without control, and from experiments to test alternative control methods. This "case study" evidence is quite convincing.

Case Study Evidence:

The loss studies discussed in Section C above in which biological studies with control were compared to others without control show significantly lower predation rates with control. These studies are the basis for the comparison in Table F-1. The data show that with control losses were .8 percent of ewes and 4.1 percent of lambs compared to 4.3 percent and 20.3 percent, respectively, without control. The controls used were a mix of methods done both privately and by the ADC program. As noted previously, the small numbers of ranches in the two groups preclude tests of the statistical significance of the difference.

Some additional case studies are examined below:

Case #1. The Cook Ranch, Florence, Montana

The Cook ranch is a famous example of documented, heavy sheep losses to coyotes in the absence of predator control. The fact that predation losses were much reduced in the third year of the study, when experimental control methods were being tested, has received less publicity.

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Table F-1. Comparison of predator caused sheep losses in control versus no-control field studies

	Ewes	Lambs	All Sheep
Field Studies With Control			
Predation rates (%)	0.8	4.1	3.1
Predator killed sheep	438	2,624	3,681
Field Studies No-Control			
Predation rates (%)	4.3	20.3	12.4
Predator killed sheep	2,081	11,198	12,707
Control-no control ratios	1:5.37	1:4.95	1:4.0

Source: Summary of studies listed in Table C-1.

In 1974, sheep losses to all causes on the Cook ranch were monitored by Don Henne (1975) of the Montana Cooperative Wildlife Research Unit. The rancher was reimbursed at market value for all predator kills, in exchange for his cooperation in withholding predator control. Between March 15 and September 30, 1974, coyotes killed 330 lambs plus 33 ewes, or 17.8 percent of the sheep on this ranch (Table F-2).

Even more sheep were killed in the second year of the study. However, the percentage of the flock that was lost to coyotes was lower (13%) because the rancher increased the size of his flock between 1974 and 1975.

In the fall of 1975, predator control was started when it appeared that losses might exceed the funds available for reimbursement. Forty-six coyotes were removed from the 8,000-acre ranch (plus a 1-mile buffer zone) from October 1975 through March 1976.

Table F-2 Verified coyote kills on the Cook ranch, Florence, Montana, 1974-1976 [1/].

Year	Sheep on Range	Coyote Kills [2/] Lambs	Ewes	Total	% of Herd Killed
1974	2,041	330	33	363	17.8
1975	3,427	394	50	444	13.0
1976	2,602	214	13	227	8.7
Total	8,070	938	96	1,034	---

1/ Sheep loss data from Brawley (1977:18).

2/ From March 15 through September 30 of each year.

In 1976 the research agreement was renewed for a third year so that the Section of Predator Damage, DWRC, could use this ranch for tests of the toxic collar and Komondor guard dogs. Some aerial shooting of coyotes was done as well. Predation losses in 1976 were substantially lower than those in 1974 and 1975 (Table F-2).

The verified loss on the Cook ranch due to coyotes in 1974 and 1975 averaged 404 sheep per year, or about 15.5 percent. The loss in 1976 was 227, or 8.7 percent. This 44 percent reduction in predation losses was probably due to the combined effects of the conventional and experimental control techniques that were used on the ranch in 1976.

Case #2. The Honn ranch, Whitman County, Washington

As background information for a study on the effectiveness of lithium chloride for reducing coyote predation on sheep, Lee Stream (1976), of the Washington State Department of Game, summarized both sheep losses and predator control activities for the 7-year period 1970-1976 on the Honn ranch. The data show substantial year-to-year variation in both the numbers of sheep killed by coyotes and the number of coyotes killed by the government trapper (Table F-3). The length of the grazing season varied between 8 and 12 weeks in different years, but the losses among years can be compared if they are corrected for the length of the grazing season. The number of sheep killed per week varied between 2.0 and 8.3 in various years.

The interesting feature of these data is the apparent inverse relationship between the number of sheep killed and the number of coyotes taken. Simple regression analysis (Figure F-1) reveals a significant, negative correlation between the rate of predation and the number of coyotes removed:

as the coyote harvest increased, coyote predation on sheep decreased. Approximately 66 percent of the variation among years in the predation rate was explained by concurrent variations in the number of coyotes taken.

Table F-3 Sheep kill and coyote removal data from the Honn ranch, Endicott, Washington. 1/

Year	No. of Sheep	Weeks on Range	Sheep Killed	Sheep killed per Week	Coyotes killed by Gov't Trapper (Jan-May)
1970	1,875	10	20	2.0	23
1971	1,920	8	17	2.1	20
1972	1,710	9	75	8.3	9
1973	1.420	12	76	6.3	13
1974	1,040	12	61	5.1	10
1975	835	11	47	4.3	16
1976	630	8	38	4.8	8

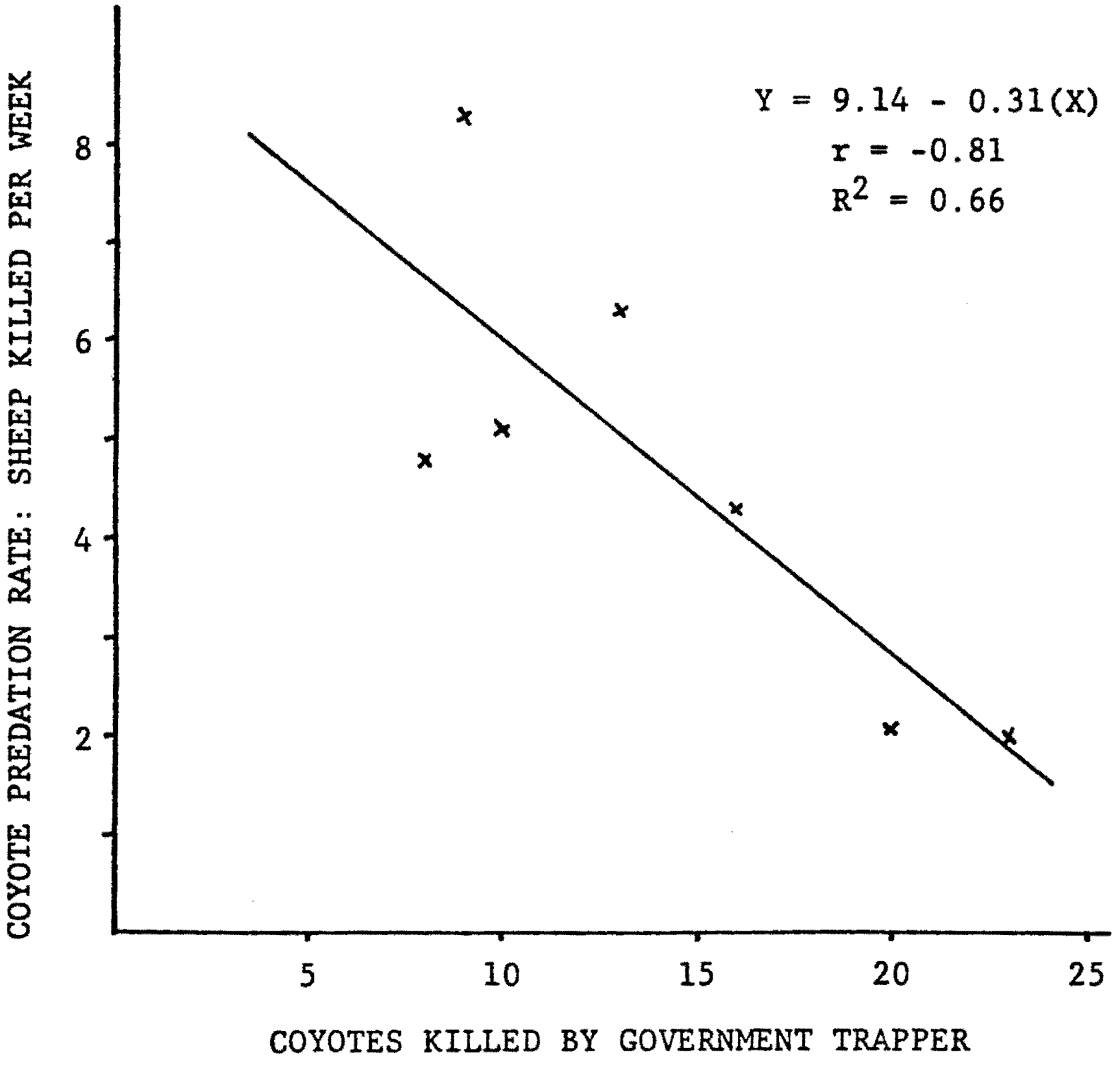
1/ Data from Stream (1976).

This analysis, of course, does not prove a cause and effect relationship between coyote control and lower sheep losses. However, in this case it is reasonable to assume that increased predator control resulted in reduced predation on sheep. If one makes this assumption, the regression coefficient can serve as an estimate of the number of sheep saved per coyote killed. This estimate is 0.31 sheep per week, or 3.1 sheep over a 10-week grazing season, for each coyote killed.

The 95 percent confidence interval on this estimate is 0.05 to 0.58 sheep per week, or between 0.5 and 5.8 sheep saved over a 10-week grazing season for each coyote killed.

Figure F-1

THE RELATIONSHIP BETWEEN PREDATOR CONTROL AND PREDATION ON THE HONN RANCH, WHITMAN COUNTY, WASHINGTON,1970-1976



Case #3 Toxic Collar Experiments

McBride (1974) developed a toxic collar consisting of a toxicant-filled rubber bladder. He attached collars filled with 1080 on 15 to 20 lambs on ranches in Texas where depredations were occurring, and either corralled or moved the remainder of the flock. On 13 of 14 ranches where collars were used, sheep kills stopped after depredating coyotes punctured one or more collars. Other research, discussed elsewhere, has found toxic collars less effective than this, however. The McBride results are noted here as another controlled case study where coyote control did reduce sheep losses.

In addition to the case studies cited above, there are innumerable examples from trappers' experiences where control work in response to specific complaints stopped depredation on sheep or other livestock.

Other Evidence:

While evidence is convincing that coyote control can effectively reduce livestock loss in specific situations, the case studies are too few in number to serve as a basis for generalizations to the West as a whole. There is no reliable evidence that can be used to evaluate the westwide effectiveness of coyote control in reducing livestock losses.

There are two ways that effectiveness of control can be inferred rather than proven, both of which rely more on intuition than quantitative evidence. First, since research has shown that a significant proportion of coyotes are at least potential livestock killers, any significant reduction in coyote populations in sheep producing areas is certain to eliminate at least some of the livestock loss. Second, since livestock producers willingly pay for the control program through their associations and

livestock head taxes, they must be satisfied that coyote control does reduce their losses. Neither of these arguments is very convincing, however, and the fact that they are mentioned at all underscores the lack of good data on the effectiveness of control in reducing livestock loss.

To summarize, case study and anecdotal evidence based on trappers' experiences is convincing that corrective control does reduce loss in specific instances. However, there is currently no definitive evidence of a westwide or aggregate nature to prove or disprove the basic premise that the coyote damage control program reduces livestock loss.

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II.G. Coyote Biology

II.G.1. Distribution and Trends in Abundance of Coyotes

Historians concur that the range of the coyote expanded with the settlement of the West as a result of environmental alterations brought about by grazing livestock, farming and logging. By 1950, according to Young and Jackson (1951) the range of the coyote extended from 10° north latitude (Costa Rica) to 70° north latitude (northern Alaska and Canada) and throughout Mexico, Canada, and the Continental United States with the exception of the Atlantic seaboard. More recently coyotes have spread even into the northeastern and southeastern states, although Bekoff (1977) suspects some of the latter resulted from transplants.

A variety of methods have been used to assess trends in coyote abundance in local areas and usually for brief periods, including: (1) catch-per unit effort (Clark 1972, Wagner 1972, Knowlton 1972, Linhart and Robinson, 1972; Knudsen, 1976); (2) scat and/or track counts along predetermined routes (Alcorn, 1972, Clark, 1972, Knudsen, 1976); (3) roadside or aerial transect counts of coyotes or dens; (4) bounty payment records (Wooster 1938, Bennitt, 1948); (5) questionnaires (Krause et al., 1969); and (6) siren-elicited howling response (Alcorn, 1972; Carley, 1973; Wolfe, 1974; Quinton, 1976). Most of these techniques have not been evaluated, nor have they been used often enough to provide meaningful population trend information. Wagner (1972) used the numbers of coyotes killed per ADC-man-year as an index of abundance to (1)

suggest general rises and falls in coyote populations at 10- to 15-year intervals, and (2) demonstrate that the use of compound 1080 from the late 1940's through the 1960's may have depressed coyote populations, particularly in the northwestern states.

Survey of Predator Abundance

In 1972 the Fish and Wildlife Service initiated an annual survey of predator abundance in the Western States using the frequency of coyote visits to scent stations as a relative measure of coyote abundance (Linhart and Knowlton, 1973). The survey is currently run each September at over 400 locations in 19 states. Each survey line consists of 50 scent stations at .3 mile intervals immediately adjacent to an unpaved road for a total length of 15 miles. The scent stations consist of a scent capsule in the center of a three foot circle of raked earth. The stations are visited once a day for four days. Animal visits are recorded based on tracks and the circle is raked smooth once again.

Results from individual states (Figure G-1) generally show small fluctuations from year to year, rather than drastic changes in abundance. The six-year mean index of all lines run each year in each state (Figure G-2) reflects relative differences in coyote indices between states, suggesting a north to south gradient of increasing coyote visitations. With the exception of Iowa and Nebraska, the indices show a decrease in abundance in 1977 for all the states. The 1977 index for the West in general was eight percent lower than that in 1972, and 26 percent lower than its high point reached in 1974.

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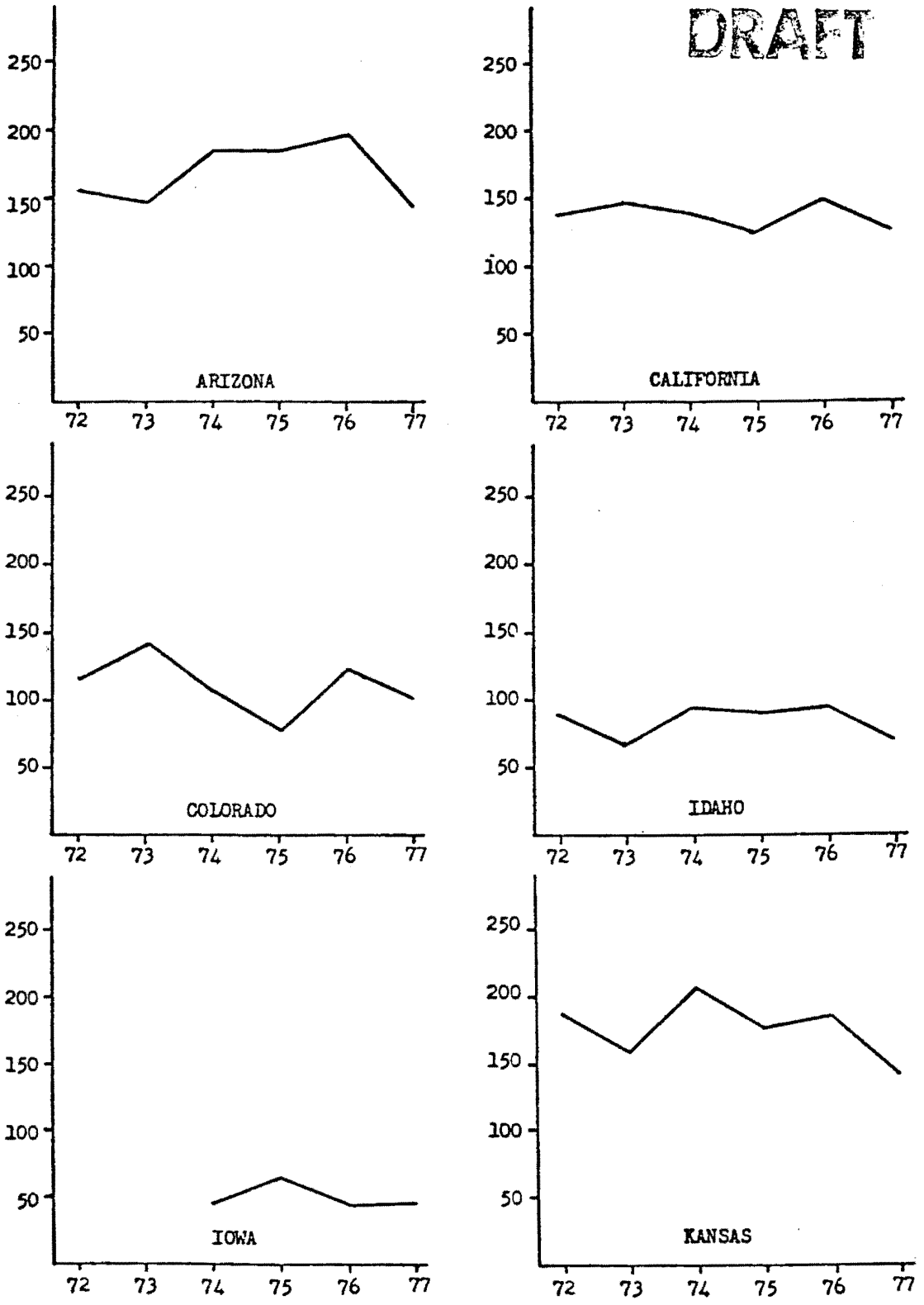

Figure G-1. Changes in coyote indices by state 1972-through 1977

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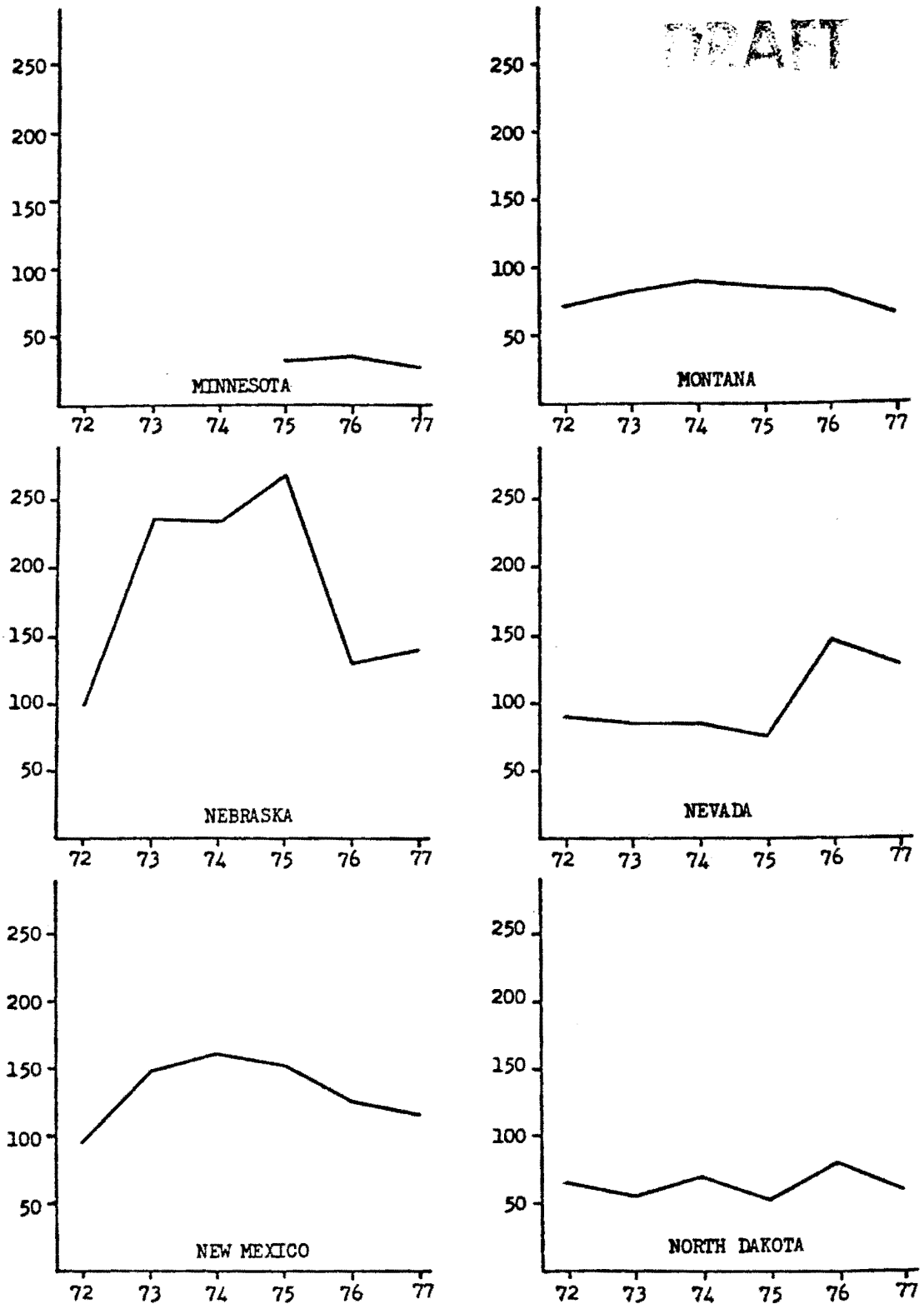

Figure G-1. (continued)

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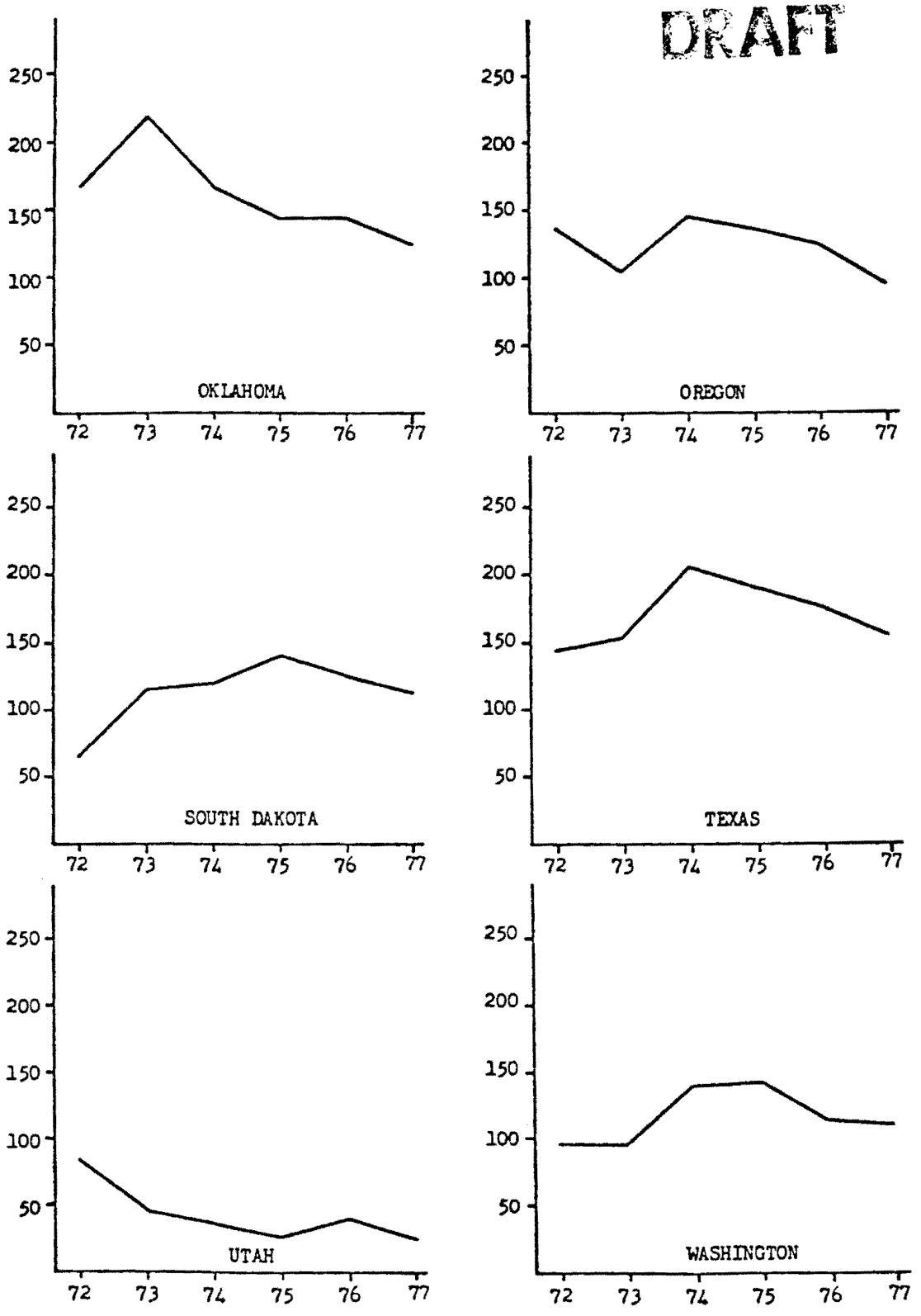

Figure G-1. (continued)

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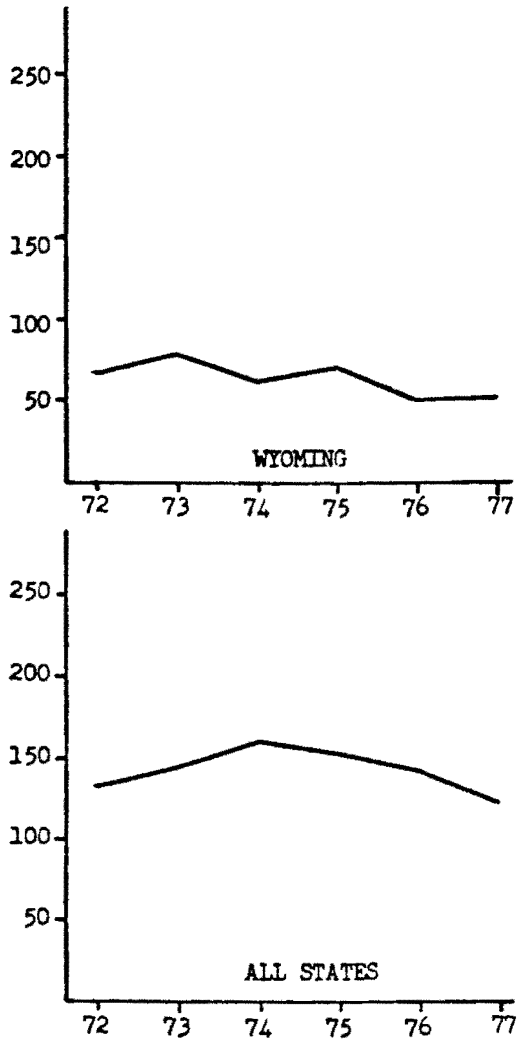

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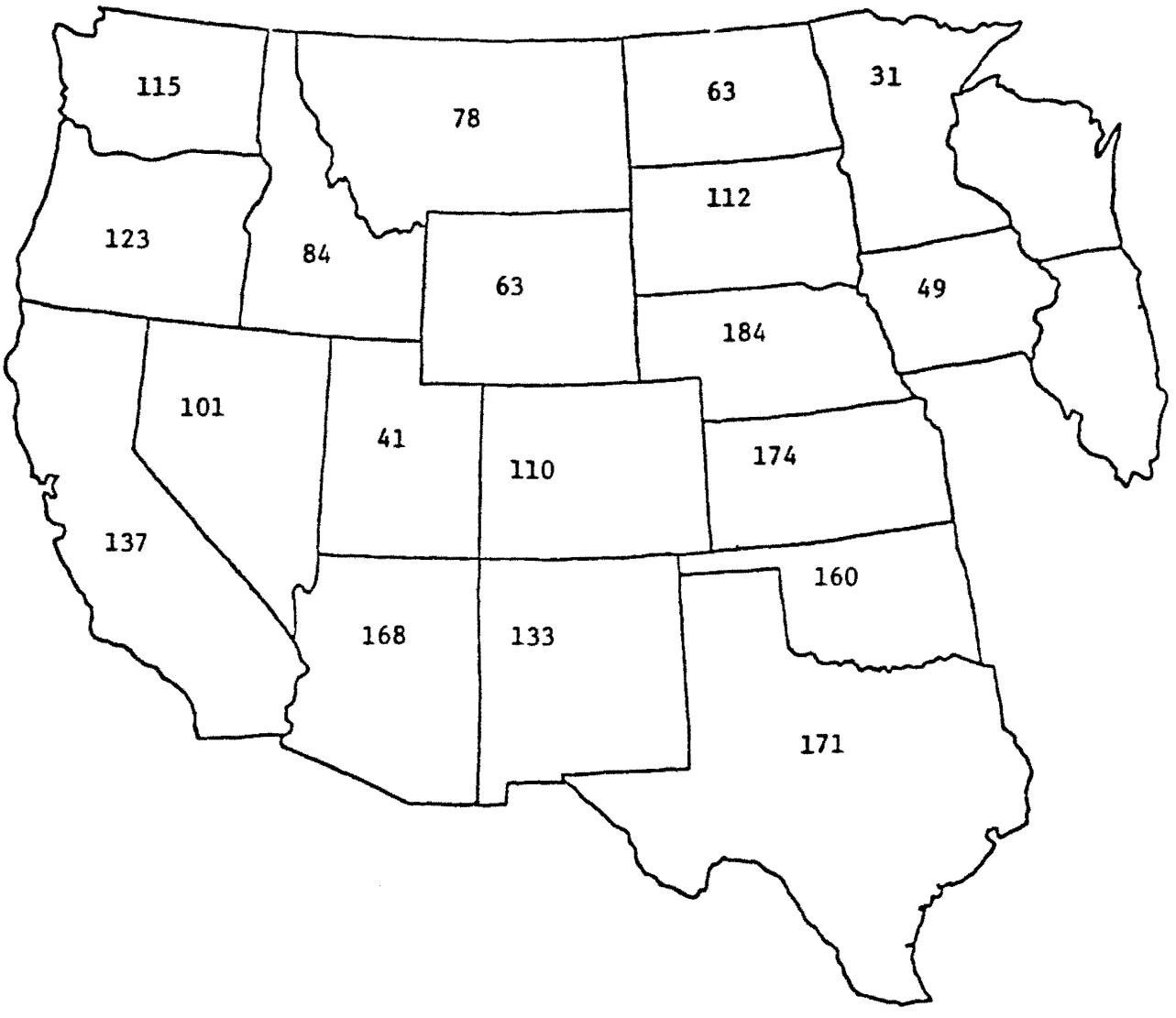

Figure G-2. Mean index, by state, for all lines over all years.

Attempts at estimating actual coyote densities have been less productive. The methods typically used include: (1) Petersen index calculations (Clark, 1972; Knudsen, 1976; Nellis and Keith, 1976; Davison unpubl.); (2) minimum count tallies based on number of pups denned or trapped (Clark, 1972), a numbers of animals killed on given areas over short periods to minimize effects of immigration (Young and Jackson, 1951; Gier, 1968; Beasom, 1973); (3) aerial counts (Wolfe, 1974); (4) bounty records calculations (Wooster, 1938; Gier, 1968; Mathwig, 1973); (5) elicited howling responses (Wolfe, 1974); and (6) subjective estimates (Bennitt, 1948; Ozoga and Harger, 1966; Gier, 1968; Clark, 1972; Knowlton, 1972; Balser, 1974; and Henderson et al., 1977). Such estimates commonly give densities of 0.2 to 1.5 coyotes per square mile, with 5 or even 10 coyotes per square mile reported in some areas (Table G.1).

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Table G-1. Estimated coyote densities (coyotes/sq mi) based on a variety of estimation methods.

Investigator	Location	Method	Area (mi^2)	Coyote estimates		Remarks
				Total no.	Density	
Knowlton 1972	Western U. S.	educated guess	---	---	0.5-1.0	
Wolfe 1974	Colorado(northeast)	elicited howling	400	---	0.1-0.18	breeding and postwhelpir
Wolfe 1974	Colorado(northeast)	aerial count	400	---	0.18	August
Davison unpubl.	Idaho(Butte Co.)	Lincoln index	550	390	0.7	isotope tagged feces
Mathwig 1973	Iowa(Monona Co.)	bounty records	---	---	0.3-0.7	breeding population
Gier 1957	Kansas(statewide)	educated guess	---	---	1.5	breeding population
Gier 1957	Kansas(statewide)	educated guess	---	---	2.0	postwhelping population
Gier 1975	Kansas(central)	not specified	4.6	26	5.7	unusual case
Henderson et al. 1977	Kansas(statewide)	educated guess	---	---	1.0	normal
Henderson et al. 1977	Kansas(statewide)	educated guess	---	---	5-6	ideal conditions
Ozoga and Harger 1966	Michigan(Beaver I.)	home-range calc.	55	---	0.5	island in Lake Michigan
Ozoga and Harger 1966	Michigan(northern)	home-range calc.	70	---	0.25	mainland
Bennitt 1948	Missouri(statewide)	bounty records	---	---	0.07-0.56	various regions
Alcorn 1972	Nevada(statewide)	elicited howling	---	---	0.9-1.1	
Beasom 1973	Texas(south)	total kill	9	129	6.5-14.3	winter-spring
Young and Jackson 1951	Texas(Maverick Co.)	total kill	375	611	1.6	October 1946
Young and Jackson 1951	Texas(Maverick Co.)	total kill	256	340	1.3	January 1947
Young and Jackson 1951	Texas(McMullen Co.)	total kill	5	56	11.2	5 days in April 1947
Knowlton 1972	Texas(south)	educated guess	---	---	4-6	fall population
Knudsen 1976	Utah(Curlew Valley)	Lincoln index	700	1061	1.5	tagged pups, 1972
Knudsen 1976	Utah(Curlew Valley)	Lincoln index	700	155	0.2	tagged pups, 1973
Knudsen 1976	Utah(Curlew Valley)	Lincoln index	700	350	0.5	tagged pups, 1974
Clark 1972	Utah(Curlew Valley)	Lincoln index	700	---	0.3-0.7	tagged pups, 1966-70
Nellis and Keith 1976	Alberta(central)	Lincoln index	50-77	---	0.7-1.6	helicopter transects

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II.G.2. Coyote Population Biology

Coyotes fluctuate in abundance due to changes in rates of birth, death, immigration, and/or emmigration. Birth rates depend both on the percent of females that breed and the average litter size. Under favorable circumstances, females may breed before they are a year old, but this is not typical. The proportion of females that breed may vary between 32 and 91 percent in different populations, or in different years within a population (Linhart et al., 1968). At the same time, the average litter size may range from 2.8 to 8.9 young (Knowlton,1972). About 10 percent of the fetuses are lost prior to birth. The causes of these changes have not been precisely identified, but both nutrition and social stresses related to density are probably important influences (Knowlton and Stoddart,1978). As the level of nutrition improves, so does reproductive performance. On the other hand, increased social stress probably inhibits the reproductive process. Coyote numbers can increase 3-fold in one year under ideal conditions of abundant food and low densities. Under very poor conditions, less than 45 pups may be produced by 100 adults. But more typically, a population of 100 coyotes would produce 180 young each year.

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Calculations based on the age distribution of coyote populations show annual survival rates of 40 to 50 percent of the adult coyotes (Table G.2).High death rates have also been shown in four telemetry studies involving 437 coyotes over five months of age; 47 percent of the marked animals are known to have died (Table G-3). Despite appreciable environmental differences between areas and the attempt to situate two of the studies among unexploited populations, the known death rates were between 38 and 56 percent. More surprising, a consistently high percent (71 to 94) of the deaths were due to human-related causes. Most were killed for sport or fur, and a few by vehicles and dogs. Only 14 of the 326 recorded mortalities were due to Animal Damage Control activities (two of the four areas studied were appreciable distances from routine ADC programs).

Coyote pups die at even higher rates than adults. Five studies showed an average loss of 57 percent of the pups between birth and 5 to 7 months of age; much of the loss probably occurs soon after birth (Table G-4).

Dispersal of surplus, young coyotes is the main factor that keeps coyote populations within the carrying capacity of their habitat. Such dispersal not only removes the surplus animals from lightly hunted populations, but also repopulates the ranges where man has

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Table G-2. Adult coyote survival rates calculated by Chapman-Robson techniques (age ratios).

Source	Location	Survival rate[1/]
Mathwig (1973)	Iowa	.36
Dow (1974)	California:	
	a. coastal	.65
	b. foothills	.65
	c. valley	.59
Nellis and Keith (1976)	Alberta	.24
Tzilkowski (unpubl.)	Wyoming	.65
Knowlton (1972)	Texas	.59
Knudsen (1972)	Utah:	
	a. 1970-71	.44
	b. 1972-73	.50
	c. 1973-74	.58
Cherry (unpubl. data)	Idaho:	
	a. Sept. 1977	.76
	b. winter 1975-76	.71
	c. winter 1976-77	.67

1/ Percent of population surviving for one year.

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Table G-3. Rates and causes of mortality of coyotes from four telemetry studies.

	No. instrumented	% known dead	% deaths man-related
Laredo, Texas[a]			
1974	36	19	100
1975	28	57	79
1976	30	43	44
Total	94	38	71
Jackson Hole, Wyoming[b]			
Dec. '73	2	100	100
Apr. '74	27	41	100
Sep. '74	20	55	91
Sep. '75	18	39	71
Aug. '76	25	40	100
Total	92	45	93
INEL, Idaho[c]			
1975	22	48	100
1976	29	34	90
1977	49	45[e]	95[e]
Total	101	43[e]	84[e]
Curlew Valley, Utah			
1972-73[d]	87	60	100
1976[c]	35	46	90
1977[c]	28	57[e]	88[e]
Total	150	56[e]	94[e]
Grand Total	437	47[e]	88[e]
Mean Percentages		48	89

[a]Unpubl. data from H. Leroy Anderson
[b]Unpubl. data from W. Tzilkowski
[c]Unpubl. data from Robert P. Davison
[d]Knudsen (1976)
[e]Incomplete data

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Table G-4. Post-natal losses of coyote pups

Source	Location	Year	Period of assessment		% loss
			From	Through	
Nellis and Keith (1976)	Alberta	1964-68	Whelping 40 days	40 days to 1 year	8.6 68
Gier (1968)	Kansas	?	Whelping	July	50
Hallet (1977)	Missouri	1976	May	Fall	56
Anderson (unpubl.)	Texas	1976	Whelping	November	52
Knudsen (1976)	Utah	1973	Whelping	December	72
Knudsen (1976)	Utah	1974	Whelping	December	41

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"artificially" reduced coyote numbers. One study compared dispersal from heavily hunted and lightly hunted coyote populations; only 30 percent of the pups from the hunted group dispersed more than 25 km while at least 23 percent remained alive in the vicinity where they were initially captured and marked (Table G-5). In the lightly hunted population, 48 percent of the pups dispersed and only nine percent were known to have remained in the area where they were captured. Dispersal, therefore, can be regarded as a "safety valve" that tends to keep both exploited and unexploited coyote populations near the carrying capacity of their habitat. Among stable, unexploited populations, a few pups remain to replace older animals which have died, but most pups are forced to leave, presumably as a result of social intolerances.

The preceding discussion shows how coyote densities are regulated by the changing rates of birth, deaths, and movements in and out of populations. The factors influencing those parameters are also of interest. Social intolerances and available food supplies, probably working synergistically, may be the most important regulated factors. Camenzind (1978) described territorial confrontations among neighboring coyotes; each group tried to exclude other coyotes from its territory. His observations are supported by radio-tracking studies of coyote movements (Chesness and Bramicker, 1974; Hibler, 1977;

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Table G-5. Comparative aspects of dispersal among coyote pups in exploited populations[a].

	released	% moving 25 km	% remaining alive in area	% dying on the area	% expt'l error
Curlew Valley, Utah (exploited):					
1976	14	29	29	36	7
1977	21	29	19	33	19
Totals and means	35	29	23	34	14
INEL, Idaho (unexploited):					
1975	10	50	10	40	0
1976	10	70	0	0	30
1977[b]	26	39	11	35	15
Totals and means	46	48	9	28	15

[a]Davison (unpubl. data)
[b]Incomplete data

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and Andelt, 1976) which show few, or no, areas of common use by adult members of the same sex. More graphically, as depicted by Hibler (1977) each pair or group of coyotes has a "territory" were they are typically found. Infrequently, these animals make brief excursions into the surrounding areas, but usually they return within a matter of hours to their habitual haunts. A few individuals seem to be transients, wandering over appreciably larger areas, but seldom staying or returning to specific locations. The severity of the territorial imperative is illustrated in several pen studies (Knowlton, et al. unpubl.). In one instance, a trio of dominants eventually killed three subordinates in a 2.5-acre pen. In another instance, in a 15-acre pen, a dominant pair restricted the movements of a subordinate female to less than half an acre. Presumably the inpetus for dispersal originates at lower intensities of social stress than described here.

Territorial boundaries acquire added significance with the observations of Hibler (1977). Less than 10 percent of his animals were initially trapped well within their territorial boundaries. Forty percent were trapped within 0.5 km of the boundary and 50 percent were trapped more than 0.5 km outside ($\bar{x}$ = 3.6 km). Similarly, none of the animals were eventually killed within their home ranges. Nearly 30 percent were within 0.5 km of the border and the rest were well outside the area ($\bar{x}$ = 10.8km). The full implications of these findings with regard to animal behavior and animal damage control practices will require elaboration through further research.

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Available food supplies may also be a strong arbiter of coyote population processes. Todd and Keith (1976) describe an experiment in which they removed agricultural carrion from a one-township area. Two results were noted: (1) egress of coyotes from the treated area occurred earlier than on control areas, and/or (2) the treated areas maintained appreciably lower densities over winter than the controls. In Jackson Hole, Wyoming, Weaver (1977) noted that the summer distribution of coyotes approximated the winter distribution of ungulate carrion (Fig. G-3). No definitive relation between summer abundance of rodents, or even the offal from hunter-killed ungulates was readily apparent. In another study, Stoddart (1977) presented evidence that over a 14-year period, coyote population trends reflected changes in the abundance of jackrabbits (Figure G-4). Jackrabbits constitute 65 percent of the winter coyote diet in that area even in years when jackrabbit densities are low. The importance of carrion in sustaining coyote populations in areas with rigorous winters may partially explain the greater reponse of coyote populations to the initiations of 1080-treated bait stations in the northern states compared to Southern areas (Wagner, 1972). The generally higher coyote population densities in the Southern states may be due to a larger food base there, and less dependence on carrion.

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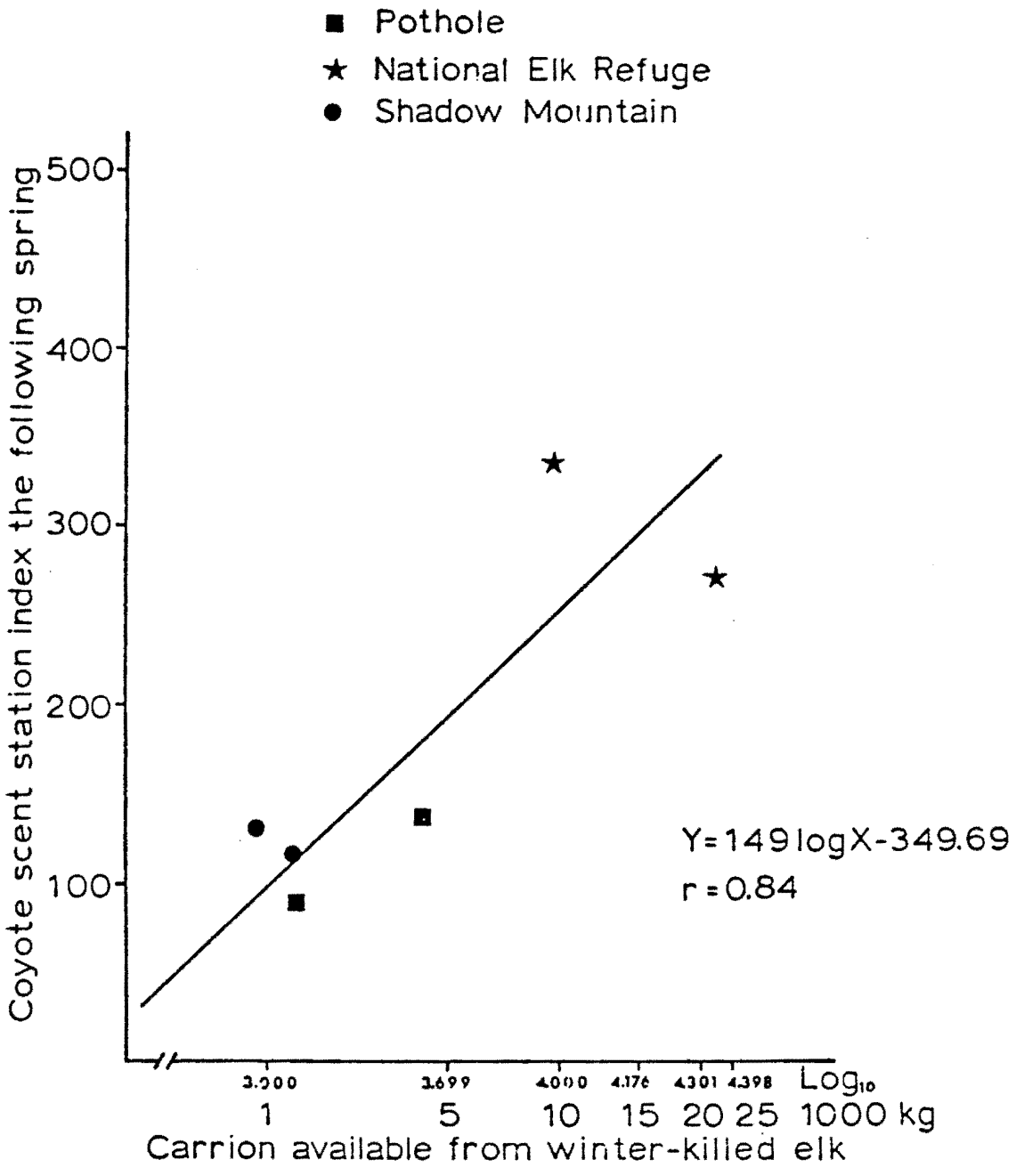

Figure G-3. Spring coyote index as a function of carrion available from winter-killed elk in Jackson Hole, Wyoming (from Weaver, 1977).

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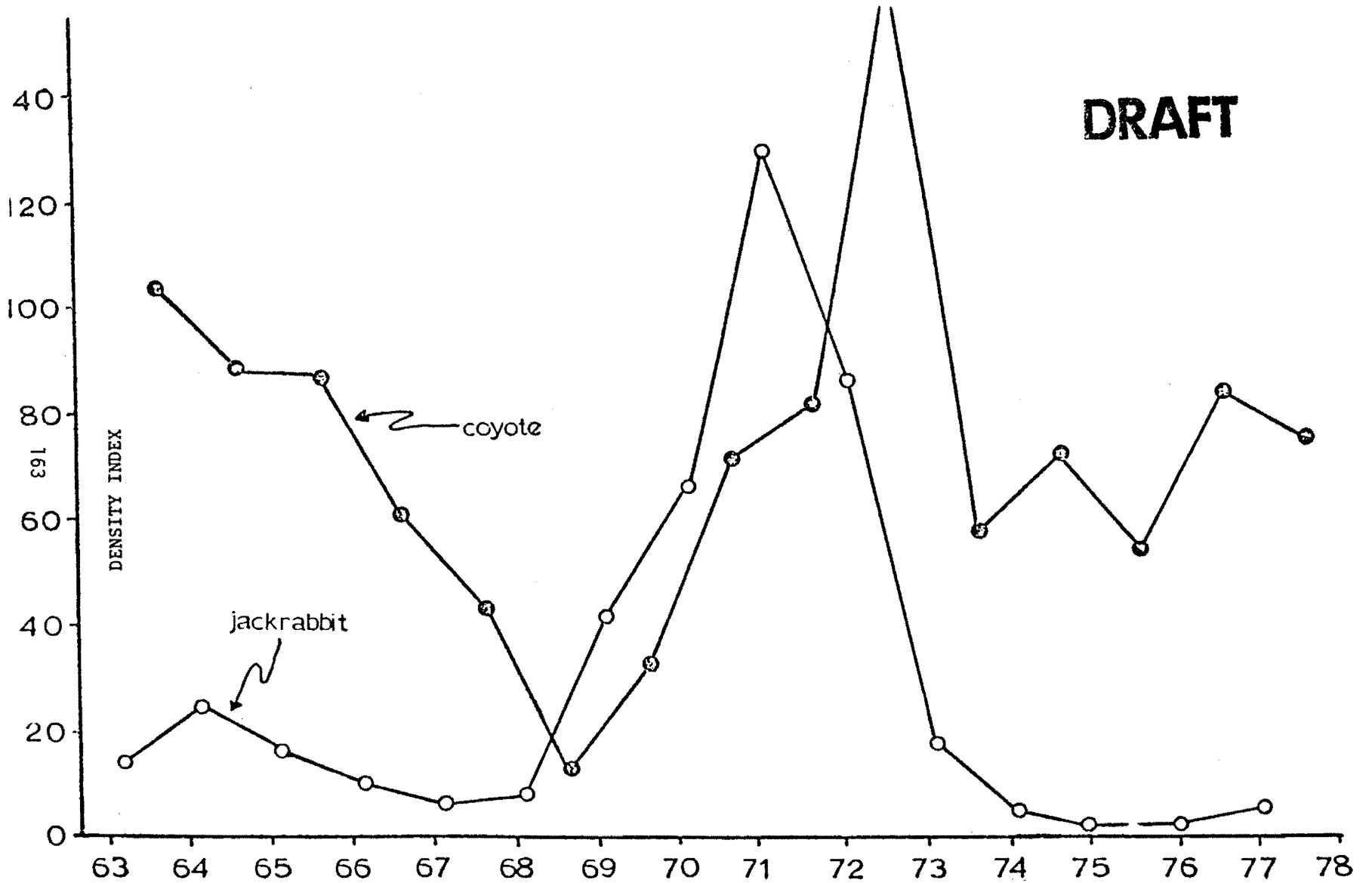

Figure G-4. Indices of abundance of jackrabbits and coyotes in Curlew Valley, Utah, 1963 through 1977 (Stoddart,1977).

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In all probability, social intolerance, as mediated by abundance and availability of food is a primary controlling variable of coyote populations. In the absence of exploitation, younger and/or subordinate individuals are harassed and/or excluded from the areas defended by established residents. The outcasts are relegated to habitats where survival is uncertain due to a shortage of the resources required for living or an environment made unsuitable by the exploitive actions of man. The dispersal process also contributes to the repopulation of adjoining areas where coyote populations have been reduced for one reason or another.

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II.G.3 Behavioral Characteristics of Coyotes Related to Livestock Predation.

Coyotes are genetically adapted, morphologically and behaviorally to seek, chase, and kill prey but their skills at identifying, capturing, killing and eating prey are shaped through learning experiences (Fox, 1969; Jansen, 1974; Lehner, 1976). Coyotes evolved primarily as predators on medium-sized prey (up to the size of a jackrabbit). Catching and killing insects and birds is typical among small pups, whether they are reared with or without parental influence. Captive pups frequently kill small rodents on first presentation, especially if the prey moves (Fox, 1969; Vicent and Bekoff, 1978; Knight unpubl.; Burns unpubl.). Through experience coyotes may learn to capture larger and/or more difficult prey. Thus, some acquire the ability to capture and kill prey as large as antelope, deer, sheep and calves. Since all coyotes do not have the same experience, they all do not develop the same capabilities, particularly in capturing larger or more difficult prey.

Accordingly, it is not suprising to find young lambs more frequently killed than ewes (Nass, 1977; Tigner and Larson, 1977; Nesse et al., 1976; McAdoo, 1975; DeLorenzo and Howard, 1976). In the case of goats, Guthery (1977) reported that coyotes took the smallest nannies as well as the youngest and smallest kids. Some wild-caught as well as pen-

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reared coyotes learning to make their first kills in captivity took lambs weighing 15 to 25 pounds after refusing to kill larger lambs (Griffith's unpubl. data).

Not all coyotes kill sheep. Based on an estimate of 1,300,000 coyotes in 15 Western states (.75/square mile) and 957,000 sheep killed in 1974 by coyotes (Gee et al., 1977) in the same area, at best only half the coyotes could be sheep killers. This is obviously tempered by the fact that many coyotes never see sheep and others kill two or three at a time. In pen experiments, Connolly et al. (1976) noted that only 8 of 11 pen-raised coyotes kill sheep and found that 38 of 54 wild-caught adult coyotes killed sheep when placed in a 1 hectare pen with them. The remainder did not kill sheep even when food-deprived for several days. Beasom and Gober (1975) observed high levels of coyote activity in pastures where no livestock losses were reported. In one instance in Texas about 500 coyotes were trapped from the same pasture where only 13 of nearly 700 goats turned up missing. Thus, at least some coyotes do not kill sheep. However, most coyotes that are regularly exposed to sheep, especially small lambs or sheep carcasses, will probably learn to kill sheep.

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A related topic is the contention by some that coyotes select the "biggest, healthiest and fattest lambs." In comparing the condition of coyote-killed lambs with other members of the flock, Henne (1975) could not find differences in animal health or condition. On the other hand, differential predation with respect to animal size has been documented. In addition, Henne (1975) noted that all four black lambs in his study were killed by coyotes. Brawley (1977) reported that 9 handicapped sheep in the open were killed by coyotes and 3 in dense cover were not. Apparently there are many subtle selective factors operating because Gluesing (1977) reported that any of several factors which placed lambs on the periphery of the bedground significantly increased the probability of attack by coyotes. These included: (1) lambs with impaired mobility; (2) lambs of ewes with impaired mobility or other infirmity; (3) lambs without ewes; (4) lambs displaying aberrant behavior; (5) a twin lamb more active than its sibling; and (6) newly introduced lambs (without ewes) that had not become socialized into the herd. Many of these characteristics would not be evident after the animal was killed, and while the coyote may not have been specifically selecting for less fit animals, a variety of subtle influences apparently places some individuals in more vulnerable situations.

II.G.4. Summary

This section has discussed coyote population trends, a number of factors that influence coyote populations, and certain aspects of coyote behavior as they relate to predation. The population data indicate significant variation in coyote densities across the Western States with the overall index of coyote abundance eight percent lower in 1977 than it was in 1972, and 26 percent lower than 1974. Coyote reproduction rates were shown to be dependent on a complex of food and density relationships that tend to maintain populations within habitat carrying capacity. These same carrying capacity and social relationships influence dispersal rates of young coyotes to other territories with excess capacity. Thus, there is no singularly important factor in the determination of coyote population level in a given area. Rather, there are a number of influences that keep populations at or near habitat capacity, making man's efforts to control coyote populations necessarily a continuing activity. Finally, behavioral studies show that while not all coyotes are potential sheep killers, most will learn to kill sheep, particularily lambs, if regularly given the opportunity.

II.H. Environmental Impacts of Predator Control

Environmental impacts of predator control and associated ecological issues can be stratified into the following major areas: Effects on the target species, primarily coyotes; direct and indirect effects on non-target wildlife including rare or endangered species; impacts on air, soil and water; and health and safety of humans and domesticated animals. These major areas of environmental impacts are discussed below.

II.H.1.a. Effect of Control on Coyote Populations

The ADC program annually takes from 70 to 85 thousand coyotes by all methods combined in the 13 western states with ADC cooperative operational programs. The ecological and environmental implications of this control effort must be related to its effect on animal populations rather than individuals as it is the population that is important, both biologically and in an evolutionary sense. As Richens (1977) states; "The loss of one individual may only mean that another may survive or be added to the population; whereas the loss of a population means a reduction in the species distribution or species extinction." There are several ways of examining the possible impact of control on coyote populations.

First, as noted in a previous section, coyote populations have the reproductive capacity to recover rapidly following a reduction in their numbers--regardless of whether these reductions are a result of natural causes (e.g., disease, food availability) or of man's activities. Given an average litter size of five to seven offspring, it is evident that an

annual population reduction of about 70% can take place without an overall decrease in numbers. Using similar-type data, Connolly and Longhurst (1975) developed a simulation model to examine the probable effects of control on coyote populations. They concluded that "...the primary effect of killing coyotes is to reduce the density of the population thereby stimulating density-dependent changes in birth and natural mortality rates" and that "Tests of varying levels of control kills showed that a coyote population can maintain itself and even increase its numbers except at the very highest levels of control. If 75 percent of the coyotes are killed each year, the population can be exterminated in slightly over 50 years." They further state, "In this model, coyote populations reduced by intensive control recovered to precontrol densities within three to five years after control was terminated. Under current conditions, considering the restrictions placed upon control methods, coyote densities probably cannot be significantly reduced except in limited geographical areas." (Connolly and Longhurst, 1975)

A second major consideration is the number of coyotes taken annually by the ADC program as compared with the estimated <u>total</u> annual coyote harvest by fur trappers and sportsmen. According to Pearson (in press), in fiscal year 1974 the entire ADC program took 71,572 coyotes, or about 24.2 percent of the total estimated 1974 westwide harvest of 295,400 coyotes. No absolute figures are available as to the number of coyotes present in the Western United States. However, Knowlton (1972), Johnson and Sargeant (1977), and others have suggested winter densities of one adult coyote per 1 to 3.1 square miles (average estimate of one per 2.3 square miles). These estimates exclude juveniles, which, in the fall, when the coyote take is probably

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the highest, constitute approximately 50 percent of the total population (Knowlton, 1972). A realistic estimate of the fall coyote population present in the 17 western states (1,832,213 sq. mi.) is therefore about 796,000 juveniles and an equal number of adults (total 1,592,000). This population estimate is more than five times the total 1974 coyote harvest more than 22 times the ADC coyote take, and far below the 75 percent kill figure calculated by Connolly and Longhurst (1975). Thus, as regards the ADC coyote harvest, it seems reasonable to conclude that the program annually takes about four percent of the westwide fall coyote population.

A third way to evaluate the effects of predator control on coyotes is to compare the total land area on which the ADC program applies control with the overall geographic range of the species. While coyotes are most numerous in the Western United States, their range also includes portions of Alaska, Canada, and the North-Central States (Hall and Kelson, 1959). Their numbers and distribution in the Central and Eastern portions of the country have increased in recent years (USFWS, Denver Wildlife Research Center, 1975; Severinghaus, 1974; Richens, 1977). Coyote control by the cooperative ADC program is currently conducted in 13 Western States where, using all control methods combined, it is estimated that control took place on 11 percent of the land area in 1977, based on estimates provided by ADC state supervisors.

In terms of long-run effects, Division of Wildlife Service's records provide probably the only means for judging coyote population trends since the 1930's. With some reservations discussed in Cain et al. (1972), the data can be used in the form of coyotes-taken-per-man-year to obtain approximate indexes of coyote numbers. The rationale behind the use of this index is that the more coyotes there are, the more that will be taken

per man-year of control effort. Unfortunately, control methods, policies and other factors also change over time, raising questions about the usefulness of the index as an indicator of coyote population. These data (Figures H-1 and H-2) as presented by Wagner (1972) indicate a general decline, at least in some states, of coyote numbers in the late 1940's. The reduced densities were apparently maintained through the next two decades. The decline in density came at about the time "coyote-getters" and 1080 came into general use. Since the degree of decline appears to be roughly proportional to the number of 1080 stations employed as shown in Figure H-3, it is possible that the toxicant was effective in reducing coyote numbers. However, since the 1972 ban on toxicant use in predator control, an increase in coyote numbers that would be expected has not been evident (Roughton, 1977). In fact, based on scent-post indices discussed previously, coyote densities increased from 1972 to 1974 and have since decreased, with the most recent (1977) index some eight percent below the 1972 level. This lack of response may possibly be attributed to (1) increased use of other control measures, (2) coyote populations responding to other environmental factors such as reduced food supplies, (3) 1080 not being responsible for the apparent decline in the early 1950's, or (4) inadequacy of the scent-post data as reliable indicators of population change.

Effective coyote removal over small areas is apparently possible. Beasom (1973) essentially eliminated coyotes for a short time from a 90 square-mile study area in south Texas with intensive trapping, M-44, and other poisoning efforts (Figure H-4). The Edwards Plateau in Texas was apparently kept virtually free of coyotes for many years by intensive control measures (Shelton and Klindt 1974). But these are extreme cases. Based on available evidence it seems clear that predator control as now practiced will not significantly reduce coyote numbers over extensive areas in the West.

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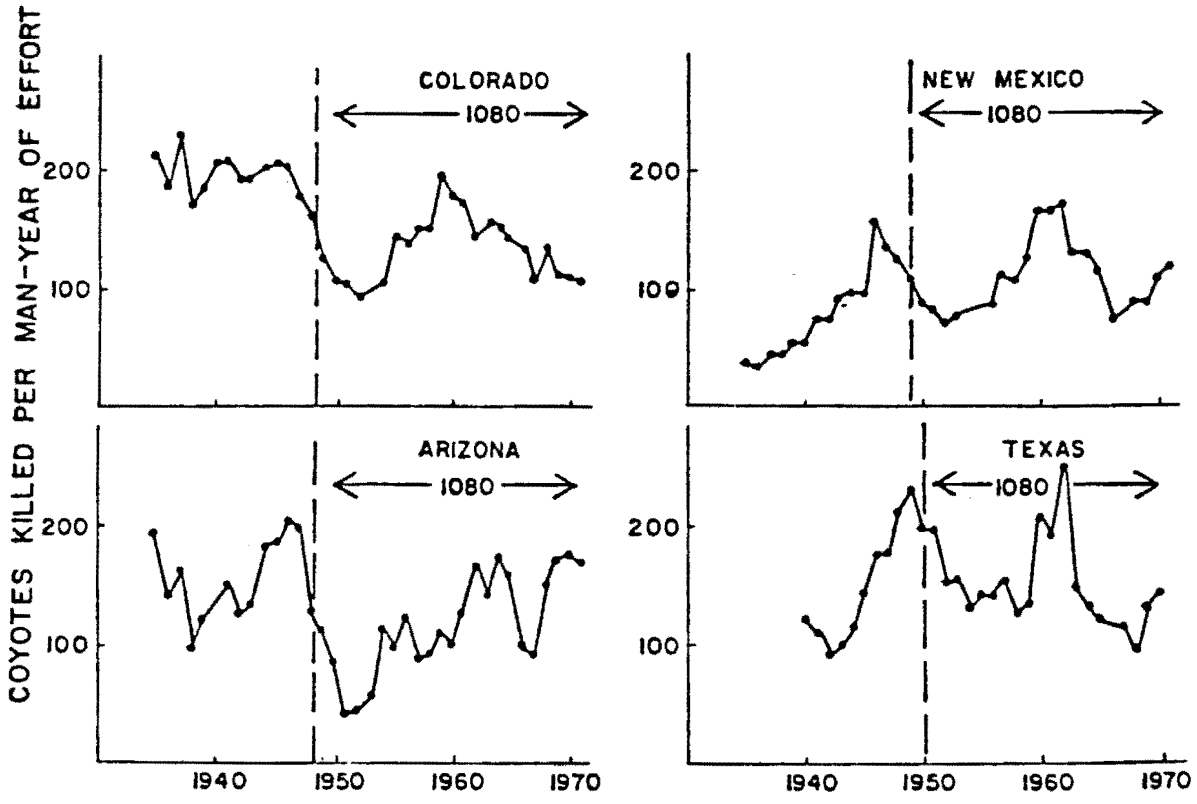

Figure H-1. Annual coyote population trends in four southern states as shown by coyotes-killed-per-man-year indices from Division of Wildlife Services Records. (From Wagner, 1972)

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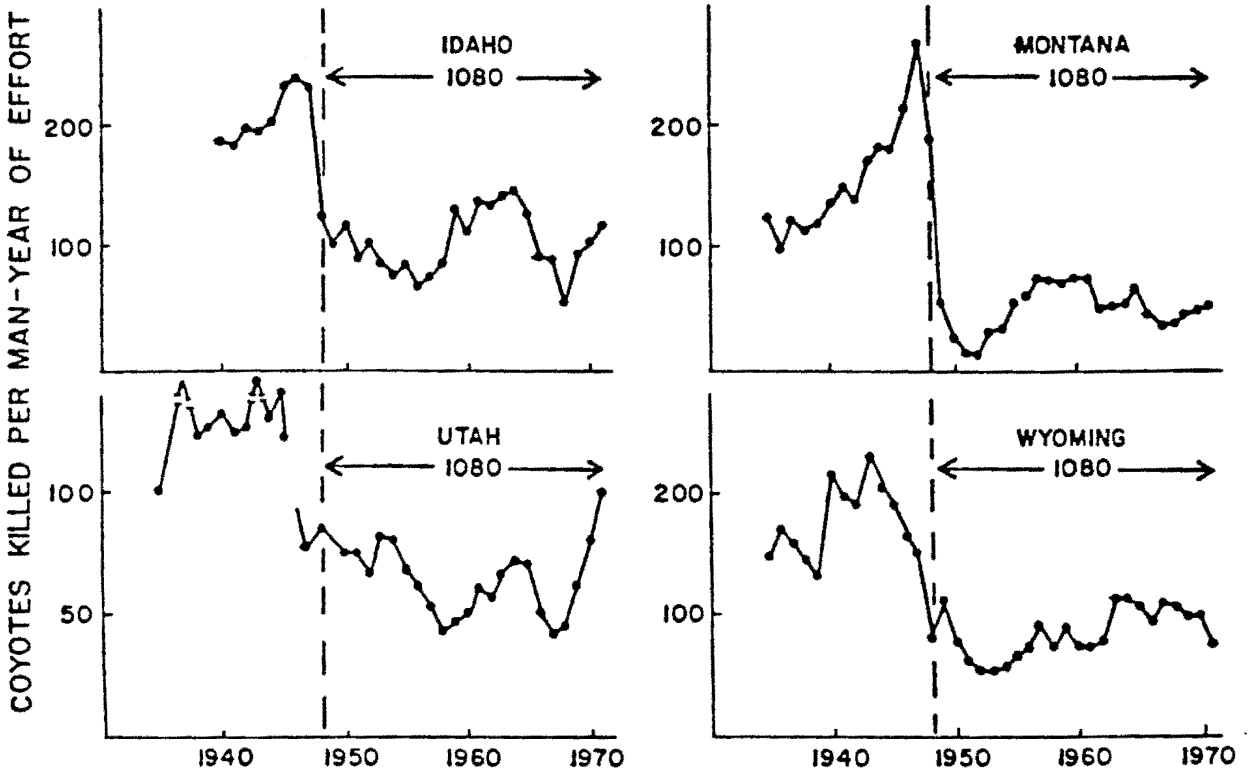

Figure H-2. Annual coyote population trends in four northern states as shown by coyotes-killed-per-man-year indices from Division of Wildlife Services Records. (From Wagner 1972)

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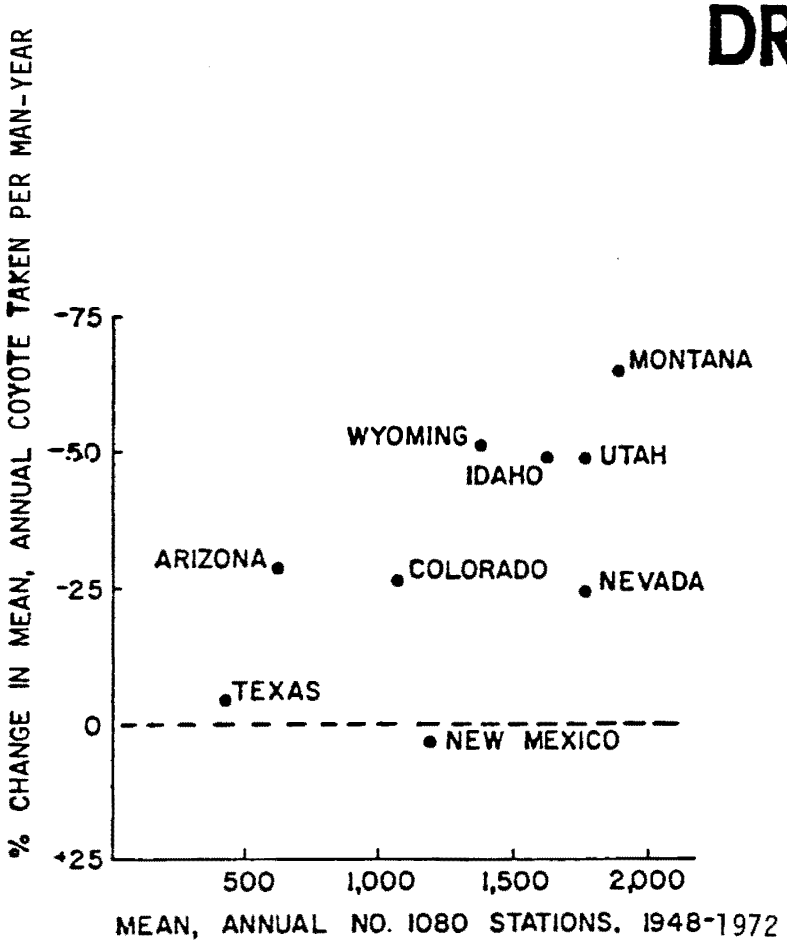

Figure H-3. Percent change between mean annual coyotes-killed-per-man-year indices for the pre-1080 and 1080 years as a function of the amount of 1080 used annually nine western states. (From Wagner 1972)

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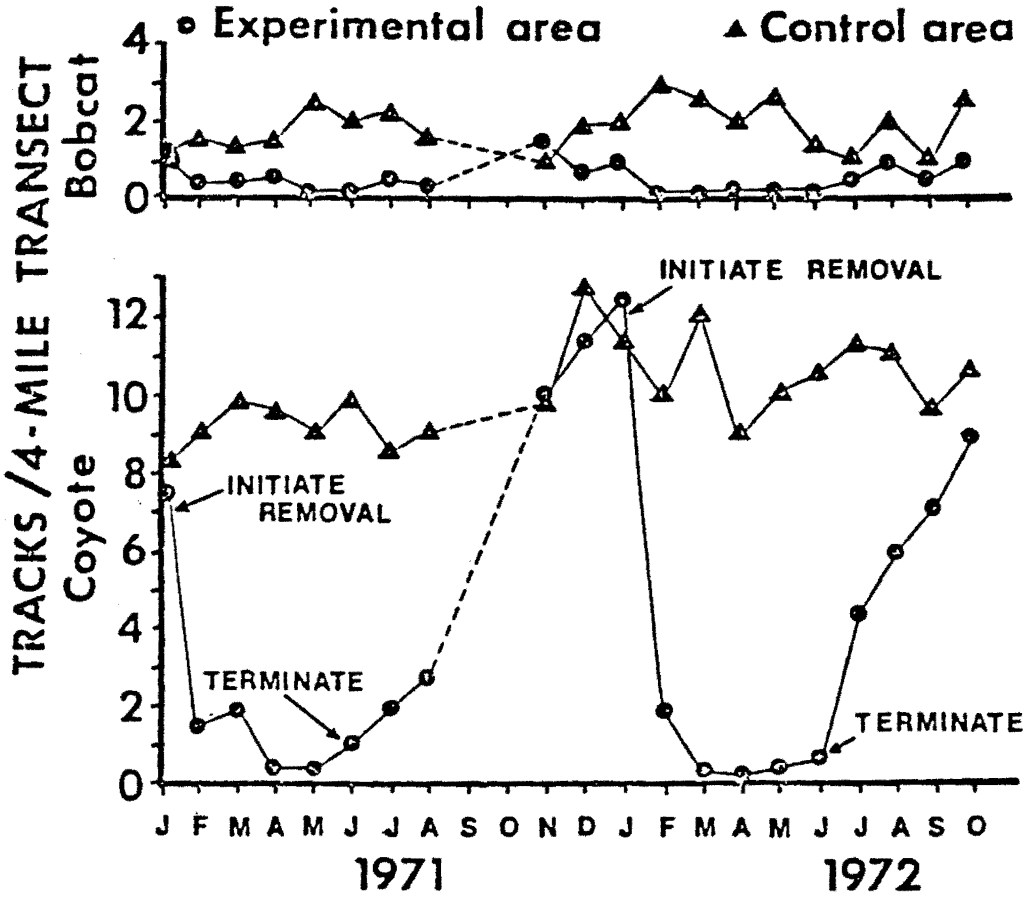

Figure H-4. Coyote and bobcat tracks per 4-mile road count transect on the South Texas experimental predator removal and control areas from January, 1971 to October, 1972. (From Beasom 1973)

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II.H.1.b. Direct Effects on Other Carnivores

Table H-1 shows the number of carnivores taken in the 13 Western States in FY 1976 by the ADC program. Most of these carnivores were taken because of livestock or poultry depredations or for disease suppression (primarily rabies). Others, in lesser numbers, were inadvertently taken in traps, by M-44's, or in snares set for coyotes. Regardless, the environmental and ecological impact of their removal must be related to the probable effects, if any, upon the populations of these species. One method of evaluating the impact of their removal is to compare the ADC take in the Western States with the total estimated fur harvest, as reported by state fish and game agencies in those same states. Such a comparison is shown in Table H-2.

Even though the fur harvest data is incomplete and thus provides a very conservative estimate[1/], it is obvious that the ADC take constituted a small proportion of the total number of each species harvested. Preliminary indications are that the 1977-78 fur harvest will be even greater, particularly for coyotes and other species for which pelt prices are significantly higher.

1/ For example, Utah reported the fur harvest for only three species of fur bearers; beaver, mink, and muskrat. Thus, the take of other species is not known or included.

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Table H-1. ADC Take of Carnivores, in FY 1976, By Method

Species	Traps	M-44	Called & Shot/Shot	Dens	Snares	Aircraft	Dogs	Live Traps	TOTALS
Badger	1,247	0	20	0	15	0	0	0	1,282
Bear, black	1	0	4	0	77	0	17	1	100
Bobcat	1,924	0	63	2	146	144	19	0	2,298
Coyote	31,581	5,328	5,347	5,226	3,187	33,626	204	0	84,499
Dog, domestic	418	3	161	0	0	0	0	0	582
Fox, red/ gray	2,635	216	195	222	232	175	0	9	3,684
Mt. Lion	5	0	1	0	2	0	41	0	49
Raccoon	1,376	5	9	11	41	0	9	296	1,747
Skunk, striped/ spotted	3,711	60	98	0	10	0	0	1,509	5,388

Source: U.S. Fish and Wildlife Service, Division of Animal Damage Control Records, (FY 1976).

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Table H-2. Total Estimated Fur Harvest and ADC Harvest of Certain Carnivores in 13 Western States in 1976

Species	Total Est. 1975-76 Fur Season Harvest	ADC FY 1976 Take	Percent Taken by ADC Program
Badger	9,372	1,282	13.7
Bobcat	24,900	2,298	9.2
Fox, red/gray	89,605	3,684	--
Raccoon	489,757	1,747	0.4
Skunk, striped spotted	20,643	5,388	26.1

Source: ADC take from Fish and Wildlife Service records. Total fur harvest abstracted from the International Association of Fish and Wildlife Agencies preliminary report, 1977.

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II.H.2. Direct Effects of Coyote Control on Non-Target Species

One of the adverse effects of a coyote control program is the direct effect on non-target wildlife that are accidentally killed or injured in the conduct of the control activities. Total non-target wildlife caught and released, or destroyed as a result of the ADC program in FY 1977 are shown in Table H-3. The totals shown here are substantially lower for some species than those shown in Table H-2. There are two reasons for the differences: (1) the data are for different years, FY 1976 and FY 1977, although the effect of that difference should not be large; and (2) certain species, red and gray fox for example, are taken as target species under some circumstances and so are not, in those cases, included in the non-target totals.

II.H.2.a. Endangered Species

The use of some control techniques (e.g., steel traps) within the range of certain species that have been designated as rare or endangered constitutes some measure of hazard. Such species include the San Joaquin kit fox, red wolf, northern rocky mountain wolf, eastern timber wolf, and bald eagle. To insure that these animals are not taken the FWS has issued policy guidelines and provided specific instructions to field personnel directing them not to place potentially hazardous devices in areas where rare or endangered species are known or believed to be present. For example, one of the restrictions placed on the M-44 at the time it was registered was that none should be set in areas where threatened or endangered species might be affected and that applicators be issued a

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Table H-3. Non-Target Animals FY 1977

Species	Destroyed Incidentally	Released
Bobcat	27	270
Fox (Red & Gray)	587	272
Badger	579	284
Skunk	1966	62
Opossum	1302	368
Raccoon	914	1457
Porcupine	854	46
Muskrat	9	1
Dog	55	135
Feral Cat	9	42
Kit Fox	67	17
Swift Fox	8	7
Javelina	27	36
Deer	12	15
Rabbit	97	21
Ringtail	1	14
Ground Hog	1	
Beaver	1	2
Armadillo	4	
Crow	1	
Mink	1	1
Nutria	2	
Mountain Lion		3
Squirrel	1	
Buzzard	3	

map that clearly indicates such areas. Such a map was issued to the ADC program district field assistants in Texas showing the reported range of the red wolf and ocelot and directing them not to use M-44's in those areas.

The regulations published in January 1977 implementing Section 7 of the Endangered Species Act provide for further protection. Under these provisions all Federal agencies must review their activities and programs and identify any that may affect listed species or their habitats. When any activity or program is identified that may have either a beneficial or adverse effect, a formal Section 7 Consultation is required. This procedure includes a detailed written description of such factors as objectives of intended activity, location, explanation of impacts of actions, conclusions, and recommendations. Although there is no evidence to suggest that ADC activities have, in recent years, adversely affected any rare or endangered species, Section 7 will further restrict their options with respect to control efforts and the methods used to control coyotes and other species causing damage.

II.H.2.b. Other Species

The effects of coyote control on other species are summarized below:

Marsupials: The only marsupial present in the United States is the opposum. Its range is primarily restricted to the eastern half of the country. However, it is also found (Hall and Kelson, 1959) in the following states having ADC programs: Nebraska, Oklahoma, Texas, western California and western Oregon. Opossums are

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occasionally taken in steel traps and a few in M-44's, but the number is insignificant in relation to their widespread distribution and abundance. For example, in FY 1976 a total of 1843 were taken in the 13 Western States (1703 by steel traps; 38 by M-44's 7 by snares, and 95 by live traps).

Rodents and Insectivores: Rats, mice, moles, and shrews are not affected by any of the coyote control methods used by ADC. The commonly held belief that coyotes significantly reduce the number of injurious rodents has no basis in fact. With an average estimated density of one coyote per 2-3 square miles, it is apparent that the total biomass of rodents present, in addition to their high rates of reproduction, far exceed the predatory capability and food requirements of the coyote. Most research indicates, in the case of rodents at least, that prey abundance determines the density of coyotes and not the reverse (e.g. see Gier, 1957, and 1975).

Porcupines are sometimes inadvertently taken in steel traps (1385 taken westwide in FY 1976); however, this species is distributed throughout almost the entire United States and the limited numbers caught is insignificant in relation to the total population.

Rabbits: Only 316 rabbits were reported as taken westwide in FY 1976. The relationship between coyotes and rabbits with respect to food base and population densities is discussed in Section G.

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Hoofed Mammals: Peccary, elk, deer, moose, antelope and other hoffed mammals are not affected by ADC coyote control methods. A number of studies have attempted to define the effects of coyote predation upon certain big game species and these investigations are discussed elsewhere in this report.

Raptors: Of the control methods used in the past, some applications of toxicants represented the greatest hazard to raptors since their application was associated with visual baits such as meat-impregnated 1080 stations. Traps and M-44's, unless set adjacent to animal carcasses, are normally not a problem as raptors locate food visually, whereas odor attractants are generally used to draw coyotes to traps and M-44's. In the past, unpublished field reports occasionally mention finding dead raptors at or near toxic bait stations. Most of these instances were due to improper placement of strychnine. However, little or no information has been reported as to the probable total mortality, nor the proportion of various raptor populations that might have been affected, although the percent was most likely much lower than deaths caused by other human factors, primarily shooting and power lines.

Reidinger and Crabtree (1974) reported on organochlorine residues in 169 dead golden eagles found between 1964 and 1971. On the basis of necropsy or residue analyses probable causes of death were determined, as shown on Table H-4. In six percent of the cases where a cause of death was determined, toxicants (cyanide and strychnine) were identified as the primary cause. An additional 17 percent may have been caused by compound 1080. Sixteen were attributed to trapping.

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Table H-4. Results of Analyses of Cause of Golden Eagle Deaths, 1964-1971.

Probable Cause of Death	Number
Shooting	18
Impact on power line or electrocution	15
1080 (sodium monofluoroacetate)	11*
Trapping	10
Collision with vehicle	5
Strychnine	2
Cyanide	2
Unknown	106
Total	169

*Indicates traces were found that may or may not have been primary cause of death.

Source: Reidinger and Crabtree (1974).

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During the period 1970-1975, a total of 127 dead bald and golden eagles were analyzed by the Denver Wildlife Research Center to determine cause of death. The results are shown in Table H-5. Thallium and strychnine were identified as the cause of death in 29 and 4 cases, respectively. No deaths were attributed to compound 1080.

It is not known how many, if any, of the eagle deaths discussed above were caused by ADC predator damage control activities. Traps are widely used by commercial trappers and other non-ADC personnel. The deaths attributed to thallium are believed to be the result of illegal poisonings of eagles by private individuals in Wyoming in 1971.

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Table H-5. Results of Analyses of Cause of Eagle Death, 1970-1975.

Cause of Death	Golden	Bald	Total Analysed
Electrocution	15	0	15
Shot	8	3	11
Fowl Cholera	2	0	2
Starvation	1	0	0
Thallium	19 a/	10 b/	
Strychnine	1	3 c/	4
Barbituates	2 d/	0	2
Unknown	53	10	63
TOTALS	101	26	127

a/ 17 positive for Thallium, 2 possible Thallium

b/ 9 positive for Thallium, 1 possible Thallium

c/ 1 positive strychnine, 2 possible strychnine

d/ 1 positive barbiturate, 1 possible barbiturate

Source: Unpublished data, Denver Wildlife Research Center.

II.H.3. Indirect Effects of Control

The coyote plays an important role in a complex of predator-prey relationships. The ADC coyote control program has, therefore, the potential to change these relationships causing indirect impacts on other taxonomic groups. These are discussed below.

II.H.3.a. Indirect Effects on Rodent and Lagomorph Populations

Rodent populations characteristically fluctuate, sometimes spectacularly. There are basically two schools of thought as to the factors responsible for the fluctuations. One is that populations are self regulated through behavior, stress, and genetic changes (Christian 1961, Chitty 1967, Myers and Krebs 1975); the other is regulation by environmental factors such as food and predation (Pitelka 1957, Fuller 1969). In recent years both schools have converged somewhat in their thoughts concerning the effects of predation on population fluctuations of both lagomorphs and rodents (Keith,1974). These are basically: (1) during prey population declines, predation is inversely density-dependent, having a greater and greater depressive effect as the prey are reduced. As a result, the prey population may decline to and be held for some time at relatively low densities, (2) prey populations escape this control when predator numbers also decline in response to the reduced food base, (3) because prey are generally able to increase at a faster rate than their predators, some other factors must initiate the prey decline at peak numbers before predators can again begin to depress the prey population. The effect would then be to increase the amplitude of the cycle by reducing prey numbers more than would otherwise occur and

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to lengthen the interval between peaks (Keith 1974). The exact response of the predator and prey populations would be a function of the complexity of the ecosystem involved which would generally encompass several interrelated predator and prey species.

No long-term studies have been made to determine how these ideas relate to coyote predation on rodents. In two studies conducted in South Texas (Beasom,1974, and Guthery and Beasom,1977), intensive short-term predator removal was employed to test the response of game species to reduced coyote abundance. At the same time rodent and lagomorph species were monitored. A marked reduction in coyote numbers apparently had no noted effect on the populations of any species in either study. However coyote food habits were not investigated in either of these studies so the degree to which these species were being utilized by coyotes is not known.

Densities of other mammalian predator species may increase in response to long-term coyote control (Cain et al. 1972, Linhart and Robinson 1972, and Wagner 1972). As a result, total utilization of rodent and other small mammal species by all predators may actually increase. Because of the extreme complexity of the interactions, the long-term effects of coyote population suppression on rodent populations can be determined only through studies specifically designed to test for these effects. Studies of this nature simply have not been made.

Gross et al. (1974), Clark (1972) and Stoddart (1977) measured coyote numbers and jackrabbit numbers on a 250 square-mile study area

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in northern Utah from 1962-1978. Coyote and rabbit numbers have changed markedly through the course of this study (Fig. 5). Analysis of the jackrabbit demographic data indicates that most of the variation in rabbit numbers is due to changes in jackrabbit mortality. Jackrabbit mortality was partitioned into 3 life stages; (1) mortality of the population from October-March, (2) adult mortality from April-September, and (3) juvenile mortality from birth-September. These mortality rates were then regressed on either the coyote/rabbit ratio or coyote density. The interpretation (Stoddart 1977) is that 87%, 78%, and 72% of the observed variation in the 3 rabbit mortality rates can be accounted for by coyote predation. Further theoretical analysis of the data indicates that with the observed functional and numerical response of the coyote population to changing jackrabbit density, the general trend of the observed jackrabbit cycle, including initiation of the decline, can be accounted for by coyote predation alone.

Rodent and lagomorph species have habitat preferences that are generally related to vegetation, soil, and climatic factors. High rodent and jackrabbit populations are commonly associated with deteriorating rangeland while cottontail rabbits generally have an affinity for higher successional stages (Vallentine,1971, and Sanyal,1975). Sanyal in a study of a heavily grazed and a moderately grazed sheep pasture in southwest Texas found rodent species diversity to be greater on the heavily stocked pasture in summer. In winter however, numbers and diversity were lower on the heavily stocked pasture. Conversely, Guthery (1974) found that range retrogression decreased rodent abundance and species diversity in northcentral Texas.

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II.H.3.b. Indirect Effects on Game Species

Predator control for the protection of livestock has little indirect effect on game species, except in those few cases where areas with livestock depredations problems also have concentrations of game. Where such control does affect game species, the effect would probably be beneficial.

A more important issue is the conduct of predator control work expressly for the benefit of game species. Even though predator control to protect other wildlife is not a major function of the ADC program, the effects of predation on game species are a persistent concern to sportsmen. A discussion of the effects of coyote control on game species is given in Appendix B.

II.H.3.c. Indirect Effects on Other Carnivores

The numbers of other carnivores taken by the ADC program were considered in a previous section. There is evidence that the more significant effects of coyote control occur indirectly, however, as a result of competition between predators.

The Division of Wildlife Services records of the numbers of several carnivorous mammal species inadvertently taken each year can be used as an index (in the form of predators-taken-per-man-year) to density of these species (Wagner 1972) The data (Figure H-5,) indicate that in several states some species of predators began to increase in the

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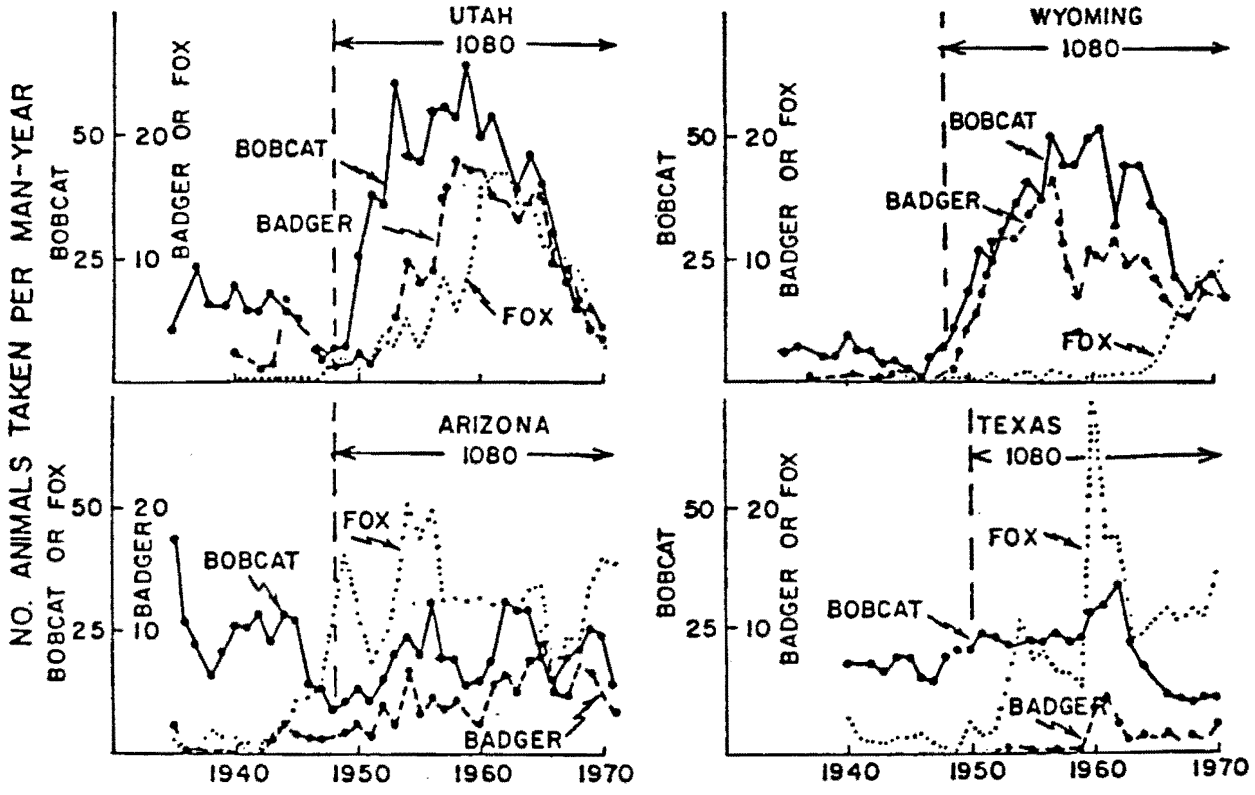

Figure H-5. Annual population trends of bobcats, badgers, and foxes in two northern and two southern states as shown by animals-taken-per-man-year indices from Division of Wildlife Services Records. (From Wagner, 1972).

early 1950's about the time coyote populations were presumably reduced through the use of 1080. These data imply that an interspecific regulatory process exists between these species. This result is consistent with several other cases where reduction of one animal species led to increases with its competitors (Wagner 1969).

Catch/unit effort data have also been collected for several carnivores, including coyotes, on seven traplines in New Mexico, Colorado, and Wyoming (Robinson 1961; Linhart and Robinson, 1972). The traplines were operated four times over a 30-year period (once at the beginning of each decade) from 1941-1970. In all three states there was a significant decline in the coyote index between 1941 and 1951, the period when 1080 came into general use. At the same time significant increases were observed in bobcat, skunk, badger, and raccoon densities (Table H-6). These results again point to increased numbers and diversity of other predators when coyote populations are suppressed. The effect of these changes on prey species, however, is not known.

II.H.4. Effects on Air, Soil and Water

All but one of the control methods currently used by the ADC program are mechanical in nature. Thus, with the exception of the M-44 device there are no effects or contamination, direct or indirect, of the air, soil, water, or vegetation. The M-44 is the only control technique that presently employs a chemical (sodium cyanide). It's use and the numbers of devices permitted per land unit area are regulated by a recent (1975) EPA registration. Numbers are restricted to a maximum of 10 M-44's per 100 acres, or no more than 12 per square mile. The device must not be set within 200 feet

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Table H-6.

Carnivore catches from survey traplines in New Mexico, Colorado, and Wyoming, 1940–1970 (data for 1940–41, 1951, and 1960 taken from Robinson, 1961). Trap-set days are given parenthetically under each year. (From Linhart & Robinson 1972)

	New Mexico								Colorado								Wyoming							
	1941 (2625)		1951 (2759)		1960 (2734)		1970 (2740)		1940 (4134)		1951 (3851)		1960 (3874)		1970 (4033)		1940–41 (9491)		1951 (9681)		1960 (9913)		1970 (9787)	
Species trapped	No. taken	Index no.	No. taken	Index no.	No. taken	Index no.	No. taken	Index no.	No. taken	Index no.	No. taken	Index no.	No. taken	Index no.	No. taken	Index no.	No. taken	Index no.	No. taken	Index no.	No. taken	Index no.	No. taken	Index no.
Coyote (*Canis latrans*)	14	100	0	–**	16	110	20	137	26	100*	11	43**	24	99*	46	181	37	100**	7	19	3	8	8	21
Bobcat (*Lynx rufus*)	7	100	1	14	6	82	3	41	1	100	13	1396	2	213	6	613	3	100**	8	261**	80	2553**	49	1584
Skunk (*Mephitis mephitis*)	3	100	10	317**	0	–	1	32	7	100	4	61	5	76	3	44	20	100	34	167**	70	335**	14	68
Badger (*Taxidea taxus*)	3	100	10	317	10	320	5	160	9	100	13	155	18*	213	14	159	14	100**	28	196*	130	889*	46	319
Raccoon (*Procyon lotor*)	2	100	16	701**	2	96	2	96	0	–	0	–	1	–	0	–	0	–**	2	–	9	–	7	–
Swift fox (*Vulpes velox*)	0	–	0	–	1	–	2	–	1	100	0	–	8	854*	1	102	0	–	0	–	0	–	0	–
Red fox (*Vulpes vulpes*)	0	–	0	–	0	–	0	–	0	–	0	–	0	–	1	–	0	–**	0	–**	1**	–	57	–
Weasel (*Mustela frenata*)	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	2	–	0	–

* Indices significantly different from corresponding 1970 data at the 0.05 level.
** Indices significantly different from corresponding 1970 data at the 0.01 level.

of water bodies or streams, nor can they be set in areas where food crops are planted. Sodium cyanide, when exposed to the environment, breaks down or decomposes rapidly into harmless by-products. A detailed description of its chemical properties was filed with the EPA at the time of registration application and is available upon request.

II.H.5. Health and Safety of Humans and Domesticated Animals

The adverse effects of coyote control on man and his domesticated animals relate almost entirely to accidental exposure to mechanical devices or, in the case of the M-44, to sodium cyanide. The safety of the various control methods is discussed in more detail in section E; however, all currently used methods have been applied for many years in many areas of the west with little or no hazard to humans or livestock. The only two exceptions are human fatalities that have occurred in conjunction with aerial hunting (i.e., pilot and/or gunner), and the inadvertent capture of dogs in steel traps or their exposure to M-44's. Service regulations require signed agreements with landowners before setting out the latter devices, as well as prominent warning signs to be posted at entrances and pasture gates and also within six feet of M-44's. Thus, dogs taken by these devices are obviously not under the control of their owners. Where necessary, control devices are removed from the field during the hunting season.

II.I. American Attitudes Toward Predator Control

On March 2, 1931 the "Eradication and Control Of Predatory and Other Wild Animals" Act was signed into law (46 Stat. 1468; 7 U.S.C. 426-426b). Section 1 of the Act authorized the Secretary of Agriculture to

> conduct such investigations, experiments, and tests as he may deem necessary in order to determine, demonstrate, and promulgate the best methods of eradication, suppression, or bringing under control . . . mountain lions, wolves, coyotes, bobcats, prairie dogs, gophers, ground squirrels, jack rabbits and other (injurious) animals . . .; and to conduct campaigns for the destruction and control of such animals . . . .

Accounts of the House debate on H.R. 9599 (the proposed Act), which occurred the preceding December, suggest that Congress strongly favored doing anything necessary to control, if not eradicate, the aforementioned animals. At least there was no clear-cut distinction between "eradication" and "control" -- in the words of one legislator "the degree of control would vary with the necessities of the case." Earlier, when a question was raised about the possible differential treatment of predatory animals and rodents, a Montana Representative noted:

> Of course, those who are interested in the control of predatory animals from the standpoint of protecting the products of mankind run counter to the theoretical ideas of many who seem to feel that the rights of wild animals are greater than the rights of domestic animals.

On February 2, 1931--the date H.R. 9599 was passed by the full House--one dissenting voice was heard from Missouri. Concerned about the potential impact of the program on constituents in the fur trade,

Representative Cochran observed:

> At a glance it is doubtful what fitting title should be given to the bill, but it certainly can be classified as a destructive measure. Its purpose is to destroy--destroy everything in the way of wild animals from a mountain lion to a field mouse . . . Fur-bearing animals, not destructive in any way, are being killed by the thousands due to the fact that they eat the poison that is scattered around for the ground squirrels, prairie dogs, jack rabbits, pocket gophers, woodchucks, porcupines, field mice, and so forth.

There is little doubt that passage of the Act by Congress was a reasonably accurate reflection of the mood of citizens concerned about animal pests. However, as previously noted, the debate also brought to light two areas of growing concern today which have a direct bearing on the public's perception of predator control: the issue of "animal rights" and the impact of various control methods on non-target species.

Recent research on the attitudes of Americans toward animals in general, and wildlife in particular, suggests that some fundamental changes or shifts may be occurring. Urbanization, environmentalism, and the influence of the mass media represent some of the factors which may be contributing to a decline in a purely utilitarian view of animals, and also in the number of people who express indifference or disinterest in animal welfare; however, such attitudes are still common among the public at large (Kellert, 1976). Conversely, attitudes which reflect a desire for increased contact with wildlife and the outdoors, concern about the survivability of wildlife species and natural habitat, and interest in and affection for individual animals (primarily pets) appear to be increasing. In fact, Kellert's data suggest that a "humanistic" orientation is the most pervasive attitude toward animals in American society today; roughly 70% of the public share

this trait. Indirect evidence of these trends can be seen in the growth of protectionist groups and the animal rights movement, and continued support for legislation such as the Marine Mammal Protection Act and the Endangered Species Act. Although longitudinal data (repeated measurement over longer intervals) are needed to substantiate the direction and intensity of such trends, indicatioons are that these shifts in attitude are continuing.

Given the apparent changes occurring in perceptions of wildlife, attitudes toward predators and predator control cannot be fully appreciated without viewing them in a larger context. Not only predator control but also many other wildlife management issues are affected by public sentiment about animals. Kellert's (1976) exploratory study of "American Attitudes Toward Animals" provides this broader context; however, his research does not specifically address the topic of predator control. Fortunately, in addition to Kellert's work, two other definitive investigations have greatly enhanced our understanding of the predator control issue. The first is a study of ranchers' attitudes toward predator control by Buys (1975); the second is a much more comprehensive investigation of national attitudes toward coyote control conducted by the Economic Research Service, U.S. Department of Agriculture (Stuby, Carpenter, and Arthur, 1978). Taken together, the data from these three efforts comprise the bulk of the discussion in this section.

Perceptions of Animals in American Society

Kellert's study of American attitudes toward animals was based largely on personal interviews with a national sample of 553 randomly selected Americans. The results of the investigation provided solid support for the existence of distinct types of attitudes toward wildlife among members of the general

public. No attempt will be made to discuss the attitude typology (see Kellert, 1976, for a concise presentation of the typology and its implications); however, the results of other aspects of this study have a direct bearing on the issue of predator control and provide useful socio-demographic data not available in the other two investigations previously mentioned.

Among other things Kellert's investigation underscored:

- The importance of direct experience with pets as a determinant of attitudes toward wildife and animals in general;
- The strong differences in attitudes toward animals between Americans 18-29 years of age, and those over 65 (the former were were far more interested in wildlife, and were more likely to be opposed to hunting and concerned about animal welfare issues; the latter were less likely to show affection for animals and more likely to be supportive of animal damage control);
- The concern of women, much more so than men, about protecting animals from suffering;
- The role of formal education in molding attitudes toward animals (those with less than eighth grade education are much more likely to be either disinterested in or fear animals; college educated respondents manifest greater concern for wildife and are more knowledgeable about animals and their behavior;

- The striking differences in attitudes between students and farmers (students are much less likely to support animal damage control activities than farmers);

- The relevance of place of birth (both population size and urban/rural location) as a factor in determining attitudes toward several wildlife-related issues including predator control.

Three questions which appear in Kellert's survey indirectly touch on the issue of animal damage control and emphasize the significance of the variables just described. Respondents were asked to indicate the degree to which they agreed or disagreed with the following items: (1) "There is nothing wrong with using steel traps to catch fur-bearing animals," (2) Predatory animals like coyotes or foxes should not be protected when they kill farm animals;" (3) "I favor protecting some kinds of wildlife even if it hurts the economic livelihood of farmers."

With respect to the use of steel traps opposition was strongest among respondents who were raised in cities with a population of 1,000,000 or more; pet owners, white females, bird watchers, back packers, students, anti-hunters, and residents of the Pacific Coast and the Middle Atlantic states. Support for using steel traps was more likely to be found among people who were raised in areas with a popultion of 2,000 or less, black males, farmers, livestock raisers, hunters, trappers and residents of the West Central states.[1/]

Those who favored the protection of predators which killed farm animals were more likely to have been brought up in large urban areas and who reside within Standard Metropolitan Statistical Areas (usually in cities of 1,000,000 or more); such attitudes were also found to be strongest among

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1/ It should be understood that the discussion of these and similar findings reported in this section cannot always be expressed in quantitative terms (e.g., national percentages). Sometimes the data were extracted from three-way contingency tables; in other instances different scaling procedures were used which are not adaptable to tabular presentation.

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young Americans 18-29, white females, students, those with college educations, single persons, pet owners, bird watchers, back packers, and anti-hunters. Persons who agreed with the premise that predators who kill farm animals should not be protected were more likely to have been raised in small towns and who currently reside in similar areas, or at least outside Standard Metropolitan Statistical Areas (SMSA's); additionally, those opposing protection for predators were more likely to be married, and pro-hunting; support was also strong among farmers, Blacks, livestock raisers, trappers, and those with less than an eighth grade education.

Similarly, single persons, residents of large urban areas, youth (18-29), students, the college educated, professionals, bird watchers, back packers, and anti-hunters were more apt to favor the protection of wildlife even if farmers should be hurt economically. Married persons (particularly those with children), farmers, livestock raisers, trappers, those over 65 years of age, persons with less than an eighth grade education, rural residents and hunters were more likely to be against protecting wildlife that have an adverse economic impact on farmers. In addition, those in favor of protection were more likely to come from the Middle Atlantic, East Central, and Pacific Coast states. Those opposing protection were generally from the West Central, South Central and Rocky Mountain states.

All the findings reported above (i.e., the relationships between socio-demographic characteristics and stance on three issues) were statistically significant.

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Predator Control and Ranchers' Attitudes

Buys (1975) mailed questionnaires to 900 cattle and sheep ranchers randomly selected from "approximately 2500 New Mexico livestock owners possessing grazing permits on public land from the Bureau of Land Management (p. 87)." Approximately 43% completed the questionnaire which was concerned with seven issues related to predator control and ranchers' perceptions:

- predator damage to their (respondents) own livestock
- damage to livestock in general
- damage to other wildlife inflicted by coyotes
- effectiveness of toxic and non-toxic control methods
- ecological importance of predators
- perceived necessity of predator control
- agencies responsible for predator control

As hypothesized, coyote damage was perceived as severe by cattle and sheep ranchers; however, Buys noted a tendency by respondents to regard damage to livestock in general as greater than that occurring to their own operation. The author suggests that this tendency may be regarded as further evidence that ranchers tend to overestimate damage inflicted by predators. Buys also noted that ranchers, when queried, described dogs as highly destructive to livestock even though dog predation was seldom mentioned in the context of other responses.

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Some differences were noted between the attitudes expressed by cattle and sheep ranchers. Sheepmen, more so than cattlemen, believed that coyotes inflicted heavy damage on wildlife. Likewise, sheepmen (92%) much more so than cattlemen (55%), were of the opinion that a large amount of predator control is necessary for the survival of the industry. Ranchers, in general, saw predators (i.e., coyotes, bears, mountain lions, and bobcats) as having little appreciable value in the ecosystem.

Table I-1 which represents only one portion of a larger table presented by Buys shows the extent to which cattle and sheep ranchers "endorse" the effectiveness of toxic and non-toxic methods of coyote control:

TABLE I-1

Percent of Ranchers Who "Endorse Effectiveness" of Control Procedures[a]

Method	Sheepmen	Cattlemen
poison	74%	50%
trapping	53%	63%
aerial gunning	60%	25%
denning	26%	20%
greyhound dog packs	21%	25%
bounty	54%	45%
chemical repellents	51%	36%

[a] Adapted from Buys (1975, p. 89).

Compared to their endorsement of poison, sheep ranchers appear to be considerably less enthusiastic about the effectiveness of non-toxic control methods (cattlemen, on the other hand, considered trapping to be somewhat more effective than poison). It is interesting to note that the practice of denning, a focal point of considerable opposition by some wildlife protection groups, was perceived as one of the two least effective methods of coyote control by both sheep and cattle ranchers.[2/]

Public Attitudes Toward Coyote Control

By far the most comprehensive study of attitudes toward predator control was conducted by the Economic Research Service of the U.S. Department of Agriculture. During the months of May-June, 1976, a telephone survey was conducted in the 48 continguous states and the District of Columbia (Arthur, 1978). A total of 2041 people were interviewed, the response rate was 78%. The overall purpose of the study was to develop an information base for use in policy development generated from public attitudes toward coyote control on western sheep ranges.

According to Stuby et al. (1978), despite the fact that respondents had a reasonably good understanding of the predatory nature of coyotes, less than half the people interviewed were aware of the coyote control issue. Moreover, whether they were previously aware or not, less than half considered the issue to be important. In all, less than one fourth of the people interviewed were aware of the issue and considered it to be important. Over one third of the respondents had not heard of

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2/ In the absence of additional data it is difficult to estimate how much "effectiveness" might have been confounded (or influenced) by other factors such as social acceptability.

the issue, and after being informed of its existence, still felt it was relatively unimportant to them personally. It should be noted, however, that for the bulk of the questions asked on the survey, those formerly unaware and who remained indifferent to the coyote control issue (718 respondents) were not asked to respond to specific items pertaining to coyotes and sheep.

Some of the more important findings in this study can be summarized as follows:

(1) The public as a whole values sheep much more highly than coyotes; however, the results also showed that people generally appeared just as concerned about the killing of coyotes as they were that coyotes kill sheep.

(2) Although three out of every four people surveyed felt that farmers should have the right to kill specific wild animals which killed farm animals, approximately three out of every five disagreed with the premise that farmers should have the right to kill other (non-target) animals of the same type to prevent future losses.

(3) People do not support lethal means of controlling coyotes with any degree of enthusiasm. Generally speaking, however, they do not object as strongly to the use of quick-acting poisons or to shooting coyotes from the ground. The public is strongly antagonistic toward the use of leg-hold traps, slow-acting poisons, denning, and shooting coyotes from the air. (see Figure I-1).

(4) In general, the public appeared much more concerned about the "humaneness" of predator control methods (people were particularly disturbed

by the amount of perceived suffering involved) and their "specificity" than they were about the fact that coyotes were killed or the "cost" of control. However, it should be noted that the options of compensating ranchers for sheep losses, and subsidizing ranchers to go out of business, were deemed generally unacceptable. With respect to "specificity" of control methods, the public appeared quite concerned about possible harm to pets and to other wild animals, more so than to other coyotes.

(5) When presented with scenarios depicting increased loss rates of livestock (5-40%), people became more willing to accept lethality and the risk of death of other animals as loss rates increased. It is important to note, however, that humaneness and cost-effectiveness were not considered in the scenarios.

Study Limitations

Considerable caution should be exercised in the interpretation of opinion and attitude studies. While the data reported in the above investigations are for the most part complementary, and the results consistent, the studies nevertheless were done at different times, used different techniques, employed different samples, and questions were worded differently. All these variables can profoundly affect results; hence, it would be prudent to avoid any sweeping generalizations.

Perhaps some specific examples of limitations might prove useful. The Kellert (1976) study, while technically sound, was based on a relatively small sample size for a nationwide investigation; moreover, a few of the reported significance levels are at the .07 level. What this means, is, that the probability that the results might have been

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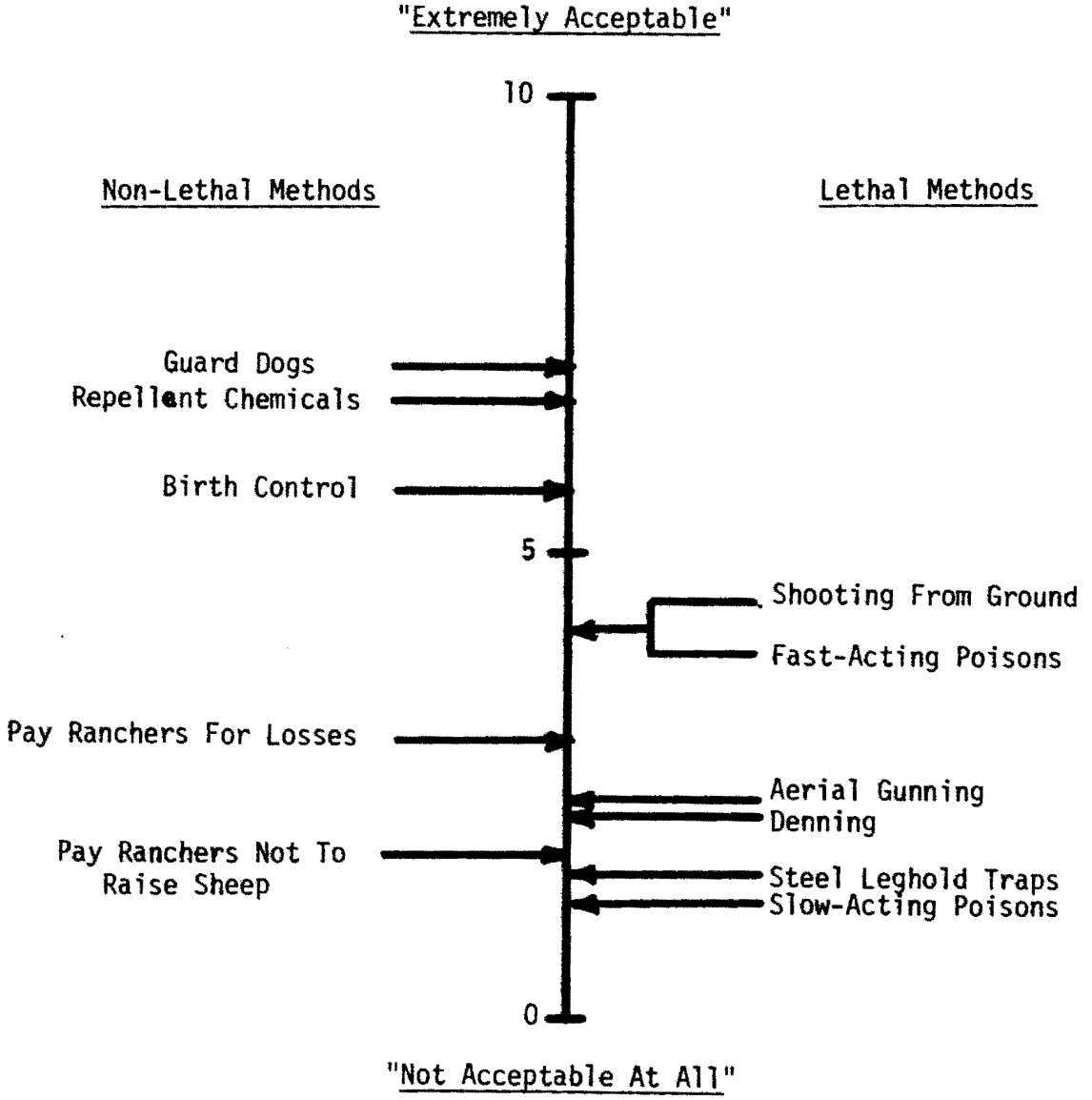

Figure I-1. Acceptability of Coyote Damage Control Methods Expressed As National Averages (Adapted from Arthur, 1978, pp. 5-6)

achieved by chance alone are seven out of one hundred. While levels of significance are somewhat arbitrary, researchers and statisticians would report results greater than .05 only with special qualifying and explanatory language. Buys (1975) sample is confined to New Mexico ranchers and is not a regional sample. Furthermore, although the return rate for his survey is as good as that encountered in most mail surveys, 57% of his original sample refused to participate. One can question whether non-respondents differed from respondents in any way that might have biased results. In addition, it is not clear that some of Buys' conclusions are warranted from the data presented in his tables. The Department of Agriculture study (Stuby et. al., 1978) also might be critized on the basis of data attrition (i.e., the loss of 718 respondents in addition to the 22% refusal rate from the original sample). However, the authors do provide a sound statistical rationale for the probable effects of non-respondents on the study results. Nonetheless, one might seriously question some of the relatively sophisticated responses which were required from the telephone interviews.

Implications

Despite some technical problems the investigations cited above contain the best available information on the general public's attitudes toward predator control; moreover, the findings of Kellert and Stuby et al. are generally consistent, thereby lending greater credence to their validity. Kellert's view that lack of interest or indifference to animal issues is still very prevalent among Americans also seemed to be reflected in the Department of Agriculture study, i.e., the number of respondents who had neither heard of the coyote controversy nor considered it to be particularly important to them personally. On the other hand, both studies

brought out the "humanistic" orientation of many respondents: concern about pet animals and the welfare of non-target species, the humaneness and specificity of predator control methods.

Taken together, the results of the two national studies suggest that there may be increasing opposition to lethal methods of coyote control, particularly among residents of urban centers in the Middle Atlantic states, the Northeast and the West Coast; support for predator control in general is more likely to come from the major livestock producing states in the South, Southwest, North Central and Rocky Mountain regions. Although the public values sheep much more highly than coyotes, people are concerned about the killing of coyotes, especially if the methods used are perceived to cause great suffering. It might be hypothesized, for example, that the antipathy toward leghold traps paramount in both national studies is a reflection of the perceived suffering of animals possibly left without water or food for long periods of time. It is difficult to project any appreciable degree of popular support for renewed use of 1080. There is likely to be far greater support for what are viewed as "target specific", quick-acting methods of coyote control in concert with accelerated research on non-lethal techniques (e.g., aversive conditioning) and changes in herding or grazing practices. In sum, it it quite likely that the attitudes and values of the public will play a substantial role in the future of predator control in this country.

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II.J. Alternatives to Traditional Control Methods

II.J.1. Compensating Sheep Producers for Coyote Depredation

This section evaluates the feasibility of insurance, indemnification (subsidies) and emergency loans as a means of reducing the economic burden of coyote predation on the western sheep producing industry.[1/] The compensatory methods could be implemented in a variety of ways, ranging from replacements for present coyote damage control programs to supplements to any number of alternative control strategies.

To the extent that a compensation scheme is substituted for a corrective coyote damage control program there will most certainly be some increase in livestock losses. Since the relationship between level of control and livestock losses is largely unknown, it is difficult to predict with accuracy how much higher losses would be with less control as compared to the current situation and, therefore, how costly a compensation program would be. If compensation is used along with present control programs the level of loss would remain the same and the cost of a compensation program would be more easily estimated.

Insurance

Insurance against predator loss has been suggested by Cain et. al. (1972, p. 8) and others as a means of helping sheep producers weather predator losses. Contacts with a number of private insurance companies in 1975 indicated predator loss insurance was not generally available in the West.

1/ This section draws heavily on Christiansen et al. (1976), Wagner (1972), and an unpublished 1973 Council on Environmental Quality Staff paper on predator damage insurance.

The reasons why insurance companies do not provide such coverage can be explored by considering criteria commonly used to determine insurability. These are shown below along with an assessment of the degree to which they are met in the case of sheep depredation losses:

1. The risk should be measurable with a pre-determined level of reliability:

   Risk is reasonably measurable, and predictable from year to year over a large number of flocks and sheep. Losses are unevenly distributed among producers; some have significant losses every year while others never do.

2. Losses must be accidental:

   Sheep losses are not entirely accidental since management practices and extent of predator control influence loss rates.

3. Cause of loss must be determinable:

   Losses to predators can be identified fairly accurately if the carcass is found and examined soon after death. On open range or large pastures this can be an expensive and time consuming process.

4. Loss must not be subject to catastrophic peril, defined as an extreme deviation from the expected loss rate:

   Catastrophic peril due to predation is highly unlikely over large numbers of sheep under normal management conditions.

5. The potential loss must warrant protection:

   Potential predator loss does warrant protection as evidenced by high loss rates reported by some producers.

6. The probability of loss must not be too high (i.e., the premium needed to cover the risk must be economically feasible):

   The probability of loss, and therefore premiums, appears to be too high for some producers, particularly large open-range operations.

Based on these insurability criteria, sheep and lamb losses to predators appear to be only marginally insurable, at least in terms of the insurability criteria used by the private insurance industry.

Administrative Alternatives: In view of the nature of sheep depredation losses and the private sector's reluctance to provide insurance, some government involvement would be needed to make insurance a viable option. There are two basic alternatives, both involving the Federal Crop Insurance Corporation (FCIC) which is a prime candidate for such a role because it is an existing agency with experience in agricultural insurance and re-insurance.

One alternative is insurance provided by the private sector with FCIC providing re-insurance. This would protect the private companies from excessive losses and would allow lower premiums for sheep producers. Private companies already provide livestock insurance of other kinds and this would fit well with their experience and administrative capabilities. A re-insurance role for FCIC would require legislative authority.

The second alternative would also require legislation to broaden the role of FCIC such that it could provide depredation insurance directly, as it has provided voluntary crop insurance for decades. Basic problems with a Federal insurance program include whether it should be voluntary or mandatory and, if voluntary whether sufficient numbers of producers would participate.

Loss Coverage and Premiums: Certain controls and safeguards should be considered in designing a depredation loss insurance program

- Coverage of sheep and lamb losses to all causes above some "normal" loss rate would avoid the expense of verifying cause of death. Normal losses by region and type of operation can be established and adjusted periodically using loss surveys.
- Even if losses from all causes are covered, measuring loss and avoiding fraudulent claims may be difficult. Losses could be measured by comparing first of year inventories plus the lamb crop with the number of lambs sold plus the end-of-year inventory (Wagner, 1972, p. 47).
- The incentive for exaggerated claims and lax management practices can be reduced by compensating above normal losses at less than 100 percent of market value.
- Premium rates should be based on region and type of operation so that the cost of insurance reflects the size of the expected loss. This will reduce adverse selection in a voluntary program whereby only those with high depredation loss would participate.
- Management practices that reduce losses can be made a prerequisite for participation or could be a factor in determining premiums with lower cost for those using them. Premiums could also be adjusted over time based on individual producers' loss records, as a further incentive for good management.

Indemnification

The Agricultural Stabilization and Conservation Service (ASCS) makes indemnity payments to dairy producers and bee keepers facing losses from pesticide contamination. ASCS also administers the wool price support program

and has the contacts with sheep producers and administrative set-up to handle direct indemnity payments to sheep producers to compensate them for coyote depredation losses. The indemnity program would face some of the problems facing an insurance program. The expense of verifying cause of loss could be avoided by limiting indemnity payments to above normal losses, as in the case of insurance. Likewise, good management practices could be made a prerequisite for payment, and compensation fixed at less than market value.

Administrative costs in other ASCS indemnity programs have averaged about ten percent of annual indemnity payments. ASCS has an inspection system for investigating applications for indemnity payments, with the claimant paying the cost of the inspection. This suggests that administrative costs for a predator loss indemnity program would be equally low.

Emergency Loans

Emergency loans to sheep producers are a third alternative for reducing the economic burden of coyote depredation. The Farmers Home Administration (FHA) makes emergency loans to farmers where floods and other disasters result in temporary need for credit not available from other sources. Legislation also permits emergency loans to livestock producers experiencing a severe drop in prices. The loans cover purchase of items needed to maintain normal operation with a schedule set for repayment. New legislation would be needed to permit emergency loans for predation losses as such losses do not fall under current "disaster" provisions.

Predator losses are a long-term sheep management problem and fundamentally different from the short-term problems as implied in the emergency loan program. The long-term nature of predator loss would make such emergency loans a recurring if not annual need for some producers, making it unlikely that they could repay them.

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II.I.2. Extension Education for Coyote Control

An extension program for animal damage control consists basically of providing information and training to farmers and ranchers so that they can solve their own depredation problems. The potential of extension in predator control is discussed in Cain et al. (1972, pp. 71-74), and Henderson and Boggess (1977).

An extension program for coyote control would involve a relatively small number of wildlife specialists responding to requests for assistance. The professionals would work with individual ranchers and groups of ranchers to teach them how to identify coyote damage and how to eliminate the offending animals. Instruction could also include husbandry practices and management methods to reduce livestock losses.

An extension program would generally require fewer employees and less expense as compared to a program of direct government coyote control. Moreover, because the cost in time and equipment is borne by the sheep producer, there is a built-in incentive to limit coyote control to those instances where control is most needed.

A drawback to an extension program is that actual control is carried out in most cases by ranchers who may not be adequately trained and attuned to the environmental hazards posed by some control methods. The danger posed by the use of toxicants by nonprofessionals is apparent. Traps are the most widely used control method in existing extension programs. Although they pose little risk to man, if used incorrectly traps can be quite inhumane and seriously impact non-target species. There may also be a tendency for ranchers to take those coyotes that are easiest to get, but which are not the ones doing the damage.

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The Missouri and Kansas Programs: Missouri and Kansas are two states with relatively high coyote densities that rely primarily on extension education programs as a means of solving coyote depredation problems. The Missouri system, begun in 1945, works through agreements between the University of Missouri Extension Service and County extension directors. Farmers are taught how and where to trap for damage causing animals, with most training done on site. Traps and related equipment are sold by the state at near-cost which provides some influence on the kind of traps that are used. Based on experience and the results of surveys, the program is rated as effective and the least expensive method of control under Missouri conditions [Dickneite (1973)].

The Kansas extension program began in 1953 but it was in 1968 that the Kansas State University Cooperative Extension Service was given sole responsibility for wildlife damage control in the State. Working with County Extension agents, extension wildlife damage control specialists train individuals or groups in the trapping process, where to look for predator sign and set traps. Only offset-jaw traps are used. The specialist offers instruction on how to use traps to make them more selective, and on livestock management methods to reduce predator loss. No attempt is made by the program personnel to control the coyote population. The Kansas program is inexpensive. The 1975-1976 program cost $45,000, and employed two specialists and a secretary [Henderson and Boggess (1977, p. 327)].

Federal Extension Programs: The Federal Extension Service and the State Cooperative Extension Services provide a system for information transfer that can potentially reach all sheep producers in the west with information pertinent to agriculture, including wildlife management and depredation. Currently, 88

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Extension wildlife specialists in 48 states provide information on alternative predator control strategies and devices. Alternatives to direct control are also addressed, especially in relation to non-lethal methods and improved husbandry practices to minimize losses.

ADC program works closely with state and county extension personnel. The Fish and Wildlife Service established an Office of Extension Education in 1977 as a point of contact with the Federal Extension Service and the coperative extension service at the state and county level. Predator control information is just one of the broad range of wildlife related education programs the system can accommodate.

Feasibility of Extension for Coyote Control in the West: Extension is currently being successfully used as the primary method of animal damage control in the Eastern states and, as discussed above, is relied upon for coyote control in Missouri and Kansas. Despite the apparent success of these programs, it is widely held among animal damage control experts that extension as the primary means of reducing coyote depredation in the West will not work. The most frequently cited reasons are the larger scale of operations, and the open-range husbandry practices used in Western States. The larger land area means that a producer would have to spend more time and effort identifying coyote sign, setting and checking traps, etc., all of which a professional trapper could do more efficiently. There is the associated feeling that faced with such an exasperating chore, ranchers would apply any method they could, with significant environmental risk.

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The use of public lands for livestock grazing raises the question of who should be responsible for coyote control on public lands. Federal land management agencies are reluctant to have permit holders conduct control activities. It may be that even with an extension system in the west, the Federal Government, as the land owner, would still be conducting control activities throughout many of the western sheep producing areas.

It should be kept in mind that an extension-education program need not be a substitute for a direct predator control program. It may be that under conditions found in the West, an effective damage control program could be built around an extension program to help producers solve most of their coyote depredation problems themselves. However, in some cases where depredation was severe or otherwise unsuitable for private control, as determined by the extension agent, a small cadre of wildlife specialist "trouble-shooters" would conduct the control activities. Thus, extension education is not a question of either or, but rather a matter of degree and form.

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II.J.3. Import Duties and Quota Adjustments

An alternative method of compensating sheep producers for predation losses that could be used either with or without an animal damage control program is to increase import duties on wool and negotiate new import quotas. The intent of such an action would be to raise U.S. prices for wool as a means of off-setting the economic burden of predation loss on producers. However, while raising tariffs and adjusting quotas, it would stimulate domestic production and increase profits of producers. Manufacturers who use wool would face higher prices and lower total supplies of wool in U.S. markets. At a higher price, wool would be less competittive with cotton and synthetic fibers.

As discussed in section C, only a small percent of sheep producers suffer significant losses to predators. Thus, raising import duties or adjusting quotas to raise prices as a means of compensation would benefit all sheep producers regardless of the amount of their predation loss. The additional cost of the higher prices to manufacturers and, ultimately, to consumers, would be substantial.

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II.J.4. Management Methods and Incentive Options

As discussed in previous sections, various sheep management methods, such as shed-lambing, can be effective in reducing losses to predators in some situations. Heavy losses can occur even when the best management methods are used. But as an adjunctto an operational coyote control program, the use of such methods to reduce livestock losses is clearly of interest. Since the effectiveness of some husbandry practices for reducing loss has been known among sheep producers for some time the question arises as to why, if they are effective, are these methods not widely or universally used? Lack of information may be one factor suggesting the need for an intensified extension and demonstration program that teaches ranchers how to reduce loss.

With some methods, it may be the expense of their adoption that limits their use. The disincentive of the cost of using husbandry practices to reduce loss would be particularly strong for ranchers who are used to getting coyote control free or at low cost. This suggests that some means of incentive is needed if husbandry practices are to be effective as a means of reducing livestock loss to predators. Several alternatives are outlined below.

Management Method Guidelines: This approach centers on development of management or technology guidelines describing husbandry practices that are acceptable both in terms of reducing losses and good range management. Different guidelines can be developed for different sizes and types of operations in various parts of the West. The guidelines could be developed by teams of wildlife biologist, university agricultural extension specialists

and others who would consider costs and effectiveness for reducing losses in determining what practices are acceptable. The guidelines may, for example, specify only prompt removal of dead livestock to prevent coyotes from feeding on carrion for a small farm flock in North Dakota. The acceptable practices for a large open-range operation in Utah, however, could be shed-lambing, at least one herder per thousand ewes and other husbandry practices appropriate for that kind of operation. The point here is that the guideline concept would be flexible enough to take into account differences in geography, terrain, and mode of operation. It would also take into account possible adverse environmental impacts in evaluating alternative techniques.

As noted above, it may be necessary to use some form of incentive to gain widespread conformance with the guidelines. As one possibility, guidelines could be made a prerequisite to participation in the ADC program. Unless a rancher could demonstrate that his management methods met or exceeded the guideline requirements for his type of operation program, field personnel would not respond to his requests for assistance. The guidelines could also be linked to participation in the wool price support program in those areas identified as being high coyote depredation areas. For those ranchers not meeting guideline requirements there would be no wool incentive payment.

There would be a significant administrative cost to a loss reduction program based on technical guidelines, particularly during the first stage when the various sets of guidelines are drawn up. There will be the continuing expense of checking periodically to ensure that ranchers meet the requirements. This could be arranged through the cooperative extension network with county agents certifying the individual ranchers. There should be a reduction in the costs of coyote control programs since the guidelines would serve to reduce vulnerability of sheep to depredation. The control cost reduction would tend to offset the cost of developing and implementing the guidelines.

Tax Credits and Accelerated Depreciation: This option would use the same kind of tax incentives commonly used to encourage businesses to make certain types of investments and other business expenditures. In this case, the investments and expenses would be those associated with adoption of husbandry practices to reduce livestock losses to coyotes. A set of qualifying criteria would be needed specifying the type of operation and geographic areas that would be eligible.

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II.J.5. Public Range Use Policy

The purpose of this section is to examine public range use policy and how it might be modified as part of a predator management program. As noted in a previous section, a significant portion of sheep in the west graze for part of the year on Federally owned lands managed by the Forest Service and the Bureau of Land Management. Both agencies use a number of ecological, economic and other factors to determine how many livestock can be grazed in an area, and during which months of the year. Expected livestock loss to predators in the different planning areas is not taken into account.

Grazing Fees: Ranchers grazing their livestock on public land are charged a grazing fee designed to reflect the full market value (FMV) of the forage resource the rancher receives. The fee, based on an animal unit month (AUM), is determined by comparing public land user non-fee costs of grazing with private land lessee non-fee costs plus the lease rate. Predator losses on public lands are taken into account in determining the fee by using a higher death loss on public lands when comparing non-fee costs of public verses private grazing. The result is a lower grazing fee per AUM than would be the case if death losses were considered to be the same on public land and private land. The allowance for excess predator loss is based on results of the 1966 grazing survey, and is uniform for all public lands in the West.

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Variable grazing fees were considered in a recent study of public grazing policies (USDA/USDI, 1977). In the case of depredation, a variable fee system would need estimates of added rancher costs due to predators. The grazing fee would then be reduced to the extent that losses were higher than on private lands. The degree of coyote control, if any, would be determined by the land management agency taking into consideration uses and values of the area other than grazing. This approach would require measuring predator loss on an individual permit holder or limited area basis. Payment could be based on either expected loss before the grazing season begins, or a rebate at the end of the season when the number of sheep lost could be easily determined.

Livestock Management Requirements: It has been noted in previous sections that livestock husbandry practices can have a significant impact on the level of predation losses in some situations. At present, there are no predation related husbandry requirements as a condition of grazing on public lands. Most sheep grazing on public lands are herder controlled, but not as a requirement of the permit.

Federal land management agencies could set up husbandry guidelines that permit holders would have to adhere to as a condition for grazing livestock on public lands. The guidelines could stipulate a maximum number of sheep per herder or require penning at night, for example. The guidelines detailing acceptable husbandry practices could be different for different

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areas of the west depending on coyote population, terrain, etc. The determination of acceptability would take into account adverse environmental impacts and constraints imposed by other uses of the area.

Zoning: Predation losses could be added to the list of factors already considered by BLM and FS in planning livestock grazing patterns; what kind of livestock, how many, and for how long are the kinds of questions asked for each planning unit. Clearly, if anticipated predator loss or the cost of reducing that loss were also taken into account, the answers to the question may well change. Some parts of the National Forest System are not currently grazed even though they produce sufficient forage to justify a grazing use. Instead, they are withheld so that other values, such as municipal water supplies, critical big game winter ranges, and wilderness areas are protected. A similar method could withdraw certain range areas with high concentrations of coyotes for which no grazing permits would be issued.

A modification of this approach would be to delineate various geographic zones where coyote control programs would and would not be carried out. In non-control zones, sheep grazing would not be allowed or would be permitted only on an own-risk basis with the permit holder knowing in advance that no coyotes would be taken. In other areas, particularly suited to livestock grazing, coyote control would be carried out in a way similar to the current program with the aim of keeping predation losses to reasonable levels.

Policy Choices: The above sections have identified a number of ways in which policy governing grazing on Federally owned lands can be used to influence the size of the livestock loss to predators and the economic burden of the loss on producers. A critical factor largely ignored in the

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above is the level of coyote control on public lands, a factor that is now one of several interdependent variables in decisions about predator management on public lands. If, for example, sheep are well protected from coyotes as a result of certain approved husbandry practices or because certain areas of high risk are closed to sheep grazing, there may be little need for a coyote control program to hold livestock loss to a reasonable level. As an alternative policy choice, variable grazing fees could be used as a means of compensating permit holders for excessive livestock losses that may occur if the level of coyote control is reduced on public land.

All of the variations discussed above are probably best used in some combination as a package rather than as individual solutions to predator problems. They are also best suited as supplements to a control program that would be limited to those cases where predation on public lands exceeds some predetermined threshold level.

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II.J.6. Other Alternative Methods of Reducing Loss

There are a number of other alternative methods that have been the subject of research to determine their effectiveness in reducing livestock loss. These are discussed below.

Aversive agents (repellants) - Efforts to develop and evaluate chemical compounds that would deter coyote predation when applied directly to sheep have been discouraging. Many candidate compounds have been tested, including undecenovanyllamide (a very hot compound developed by the University of Wyoming) and crude extract of bitter sneezeweed containing tunulin (an extremely bitter compound). The attractiveness of the aversive agent approach is largely predicated on environmental acceptability, assuming that an effective chemical could be developed that could be safely applied to a food animal for human consumption. Effectiveness of repellants may be dependent on an alternative food base for existing coyote populations. USDA observations indicate that when an alternative food supply is depleted, coyotes will kill sheep regardless of the aversive agent used. Consequently, USDA has given low priority to this area of research.

Reproductive inhibitors - Theoretically, the application of reproductive inhibitors for controlling total coyote populations could provide an effective and environmentally acceptable method for lowering coyote densities. Environmental acceptability would be dependent on host specificity of the delivery system used and prudent use in the field. Research

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in the 1960's by the Denver Wildlife Research Center was unable to deliver enough of the inihibitor to coyotes in field tests to be effective. USDA plans continued research in the area of reproductive inhibitors, but does not anticipate the development of immediately applicable technology.

Several compounds have been evaluated. Cadmium, which causes permanent sterility in most animals, failed to cause sterility in male coyotes, either because of species insensitivity, or because of the low emetic threshold of coyotes, thus limiting the doseage level that could be administered. Alpha chlorohydrin depressed semen quality for only two weeks after a single, oral administration at relatively high levels. Due to the transient effect, alpha chlorohydrin was determined to be unsatisfactory for the purpose intended. Pipecolinomethylhydroxyindane (PMHI) is currently being investigated. PMHI, at low single doseage, causes 50% weight reduction in active coyote testicles. Adverse systemic side effects for PMHI at low doseages have not been observed. Mibolerone, an adrogenic steroid, suppresses estrus in bitches (dogs) when administered at chronic low levels. Single, oral, massive levels of mibolerone failed to suppress estrus in coyote bitches given either prior to or after the onset of proestrus. Consequently, mibolerone was determined to be impractical for the intended application. Research is continuing both as to the type of inhibitor and method of use.

Guard dogs - Both USDA and FWS are evaluating the use of guard dogs as a method of reducing livestock loss. Dogs have been used successfully to protect livestock from predators in Europe and Asia for many centuries. The Hungarian Komondor is a noteworthy example of such use. The U.S. Sheep

Experiment Station, Dubois, Idaho now has 11 Komondorak involved in a project to assess the feasibility of using guard dogs to protect range sheep. USDA has funded an extramural Komondor project with Colorado State University to evaluate behavioral traits of the Komondor in regard to training and effectiveness. Guard dogs would offer absolute environmental acceptability, near immediate availability for application, and economic feasibility.

Attractant Research - Research is being conducted to develop and evaluate chemical attractants (lures) for coyotes. The main thrust of this effort has been to evaluate chemical fractions of estrus (proestrus) coyote urine. The practical application of results from this research would be in conjunction with delivery of reproductive inhibitors, trapping and M-44's.

Electric fencing - Newly adapted electric fencing concepts indicate that properly designed electric fencing can provide effective protection from predators. Obviously, the application of this control method will be limited to farm flock and fenced range operations (approximately 55% of the total U.S. sheep population). Electric anti-predator fencing is usually environmentally acceptable, the exception being where the fence would interfere with migration of certain species of wild animals (antelope). Preliminary figures indicate that new electric fencing cost approximately $1500.00 per mile for materials compared to approximately $2500.00 per mile for conventional sheep fencing. Electric fencing could provide immediate, practical and economically feasible protection to a large segment of the sheep industry.

III. ADC PROGRAM OPTIONS

III.A. Overview

The purpose of this section is to outline alternative courses of action for the ADC program and to discuss the consequences, the pros and cons, of each. In each case, changes in ADC budget, policy, etc. refer only to those parts of the program associated with predator control. The options and sub-options are outlined below and discussed in more detail later in this section.

1. Continue Current Program at Alternative Funding Levels. No change in current policies, mix of control methods, guidelines or assigned responsibilities.
   - 1a. Decrease Federal ADC funding by 50 percent.
   - 1b. Status quo: maintain current levels of support.
   - 1c. Increase Federal ADC funding by 50 percent,
2. Realign Predator Damage Control Responsibilities.
   - 2a. Transfer operational predator damage control to USDA.
   - 2b. Transfer operational program to the states.
3. Change Policies to Limit Areas and Methods of Control.
   - 3a. Modify control policy on public lands.
   - 3b. Emphasize prevention of livestock depredation.
   - 3c. Emphasize corrective control.
   - 3d. Minimize use of lethal controls.
4. Increase Operational Use of Toxicants.
   - 4a. Relax restrictions on the use of M-44.
   - 4b. Increase research on specific applications of toxicants.

5. Modify ADC Funding Mechanisms

   5a. Consolidate state and other cooperator funding.

   5b. Charge a minimum fee for control assistance.

   5c. Federal funding of entire ADC program.

6. Expand the Extension Program

   6a. Funds to Cooperative Extension System.

   6b. Increase the number of FWS ADC extension specailists.

7. Compensation of Predation Losses.

   7a. Insurance.

   7b. Federal compensatory payments.

   7c. Variable grazing fees.

   7d. Increase tariffs on wool.

8. Increase Predator Research

   8a. Additional research on non-lethal methds.

   8b. Additional research on lethal methods of corrective control.

   8c. Modify Executive Order to permit toxicant research on public land.

9. Promote Better Husbandry Practices to Reduce Depredation

   9a. Improve the quality of sheep herders.

   9b. Develop and require minimum husbandry practices.

The set of options listed here represent only part of a large number of possible combinations of the specific actions or policies that are involved. There are many other combinations that could be considered and probably other possible actions that have been left out entirely. In formulating the options, the intent was that they should represent a broad range of

alternatives. Some of the options would result in major changes in the way the ADC program is conducted while others would mean little or no change at all. At this stage in the evaluation of alternatives, the implications and feasibility of all the options have not been fully explored. They are presented here primarily to stimulate discussion that will, hopefully, provide additional information and insights that can be incorporated in subsequent drafts of the report.

III.B. Evaluation Criteria

The consequences of the options and sub-options are evaluated with respect to four principal criteria. Numerical ratings ranging from -3 to +3 are assigned as a means of comparing each of the options when judged in relation to these criteria.

The criteria are described below:

Economic Benefits measures the economic impacts the option would have on livestock producers, consumers and in total. A positive rating means that benefits would increase.

Environmental Impacts are considered in four categories: impacts on target species, primarily coyotes; impacts on non-target species; safety to humans and domesticated animals; and humaneness. The management objective in the case of target and non-target species is assumed to be to minimize the impact on species population; thus a positive rating is interpreted as a reduction in the impact. For safety and humaneness, a positive rating reflects an increase in these two factors.

Control Costs are divided into three categories measuring total spending for damage control by Federal, state and local governments, and by producers. The costs to producers can include both costs associated with the cooperative programs as well as cost of control conducted by individuals. An increase in cost is reflected as a negative rating.

Acceptability indicates the degree to which an option would be acceptable to livestock producers and environmental/conservation groups. A positive rating indicates acceptability. In addition to these two groups, certain aspects of some options that may or may not be acceptable to the general public are also noted.

All options are rated in comparison with the current situation. For example, if an option is expected to result in an increase in livestock losses compared to current levels there will be a decline in economic benefits (a negative rating). No significant change from the current situation is shown by NC.

In the case of options involving additional research, impacts on the environment, effectiveness in reducing loss, and change in economic benefits are all predicated on successful completion of the research with the expected results. For example, research to develop specific uses of toxicants (4b.) is expected to increase effectiveness when it is completed successfully. Clearly, the research itself will not have such an effect. In the interim period, it is assumed that the current control program would be continued.

Finally, it should be noted that these numerical rankings are necessarily arbitrary and subject to debate and revision. The ratings are meant to be consistent with information provided in the background sections. In some cases the link between the two may not be apparent. Why, for example, would a 50 percent decrease in ADC funds result in an increase in non-target impacts and a decrease in the level of humaneness with which coyote control is conducted? The reasoning behind this paradoxical outcome is that if the ADC cooperative program is reduced there would be more taking of coyotes by livestock producers and others without the proper background in predator control. Thus, the ratings reflect the results not just of what the ADC program does or does not do, but also the results of what other agencies and/or individuals may do in conjunction. The evaluations are often based on some key assumptions about how other agencies and individuals would react, how effective various methods would be in reducing losses, etc. If the assumptions are not valid, the result could well be a marked change in the ratings in some cases.

III.C. Discussion of Options and Consequences

1. Continue Current Program for Coyote Damage Control at Alternative Funding Levels. There would be no change in current policies, no change in the mix of control methods (e.g., 40 percent aerial gunning, 30 percent trapping, etc.), and no change in guidelines or assigned responsibilities. The sub-options below all reflect the same kind of program but at alternative funding levels.

   1a. Decrease Federal ADC funding by 50 percent. It is assumed a reduction will result in the following: (1) the number of state and district supervisory ADC personnel would be cut back with a lesser reduction in field personnel who are mostly paid by cooperator funds; (2) the overall reduction in cooperative program

control would be less than 50 percent as the non-Federal contribution is increased; (3) there would be more control conducted by individiuals as response by ADC to requests for assistance deteriorates.

1b. Status quo: Maintain current levels of support. The ADC program would continue as is with funding increases only to offset effects of inflation.

It is assumed that the following would occur: (1) the state-cooperator contribution would not change appreciably; (2) there would be some increase in control by private individuals.

1c. Increase Federal ADC funding by 50 percent. More funds would be available to expand the program with no significant change in the way things are done. It is assumed that the following will occur: (1) the state-cooperator contribution would decrease so the increase in overall program effort would be less than 50 percent; (2) the ADC program would be increasingly dominated by the Federal presence and associated with the FWS; (3) the ratio of supervisory to field personnel would increase, improving the monitoring of field operations.

Consequences of Option 1

Economic: With a decrease in funding, 1a., economic benefits to producers and consumers would decline (-2) because even with more state-cooperator funding and private control efforts, livestock losses will increase somewhat. With the status quo, 1b., there would be no appreciable change in benefits as

the rate of predation continues at its current level. A 50 percent increase, 1c., would increase economic benefits to both groups (+3) because an increased effort with no change in control methods would reduce livestock losses.

Environmental

Target species: The effect on coyotes of the three budget levels reflect the change in the level of ADC and other control effort as discussed above: 50 percent reduction (+1); status quo (NC); and 50 percent increase (-2).

Non-target species: Assuming the 50 percent reduction results in more control by non-professionals (ranchers, etc.) there will be higher impact on non-target species (-2). Status quo will result in some increase if non-professionals increase their control efforts (-1). A 50 percent increase will also increase non-target impacts (-1) as a result of an intensified ADC effort with the current mix of control methods.

Safety: A 50 percent reduction would reduce safety (-1) as more control is done by non-professionals. There would be no appreciable change (NC) associated with status quo. A 50 percent program increase would reduce safety (-1) as more aerial gunning and other control methods are used.

Humaneness: Humaneness would decrease (-1) as a result of a 50 percent reduction, not change (NC) with the status quo, and decrease (-1) with a 50 percent increase, again assuming the mix of methods does not change.

Control Costs

Federal cost: The effect is directly related to the change in the ADC budget; 50 percent increase (-2), 50 percent decrease (+2), status quo (NC).

State/local cost: If the Federal funds are reduced, state/local contributions would go up (-2). With a status quo Federal budget, state/local costs will not change appreciably in response to producer requests. If Federal funds are increased state/local contributions would probably decrease (+1) or remain the same.

Producer costs: A reduction in Federal funds would increase producer costs (-1) as they increase their own control activity when they can no longer rely on the ADC program. A status quo budget may also increase (-1) producer costs as they do more to control increasing losses. With a 50 percent increase, producer costs would fall as they rely increasingly on the ADC program for their control needs (+1).

Acceptability

Acceptability by producers would be low for a 50 percent reduction (-3) and status quo (-1), but high (+3) for a 50 percent increase.

A 50 percent reduction would be only moderately acceptable (+1) to most environmental groups as they would rather have the Federal Government involved than others. A status quo budget would be neutral (NC) and an increase unacceptable (-3) unless it led to a matching decrease in state and cooperator funds.

Most if not all of the consequences discussed above hinge on the assumption that no changes would be made in the current mode of operations in response to changes in funding. That is probably not an all-together plausible assumption, but it could be if the ADC program strictly controlled the way field operations reacted to the change in funds. Nonetheless, a decrease in funds may result in a reduction in expensive control methods such as aerial gunning, and more use of inexpensive, less selective methods. This would increase the environmental impacts of that sub-option. By the same token, an increase in funding could result in more emphasis on expensive and selective methods, with less environmental impact than would occur if the mix of methods was held constant.

2. Realign Predator Damage Control Responsibilities:

   2a. Transfer operations to USDA. FWS would retain its predator research and monitoring responsibilities. It is assumed that the current ADC structure, including most supervisory and field personnel, would simply be taken over by USDA; there would be little interruption in field activities. The Federal budget would not be changed.

Consequences of 2a:

Economic: There will be no major change (NC) in effectiveness of the operational program after an initial transition period as essentially the same program would be continued.

Environmental: The program would continue at about the same level with the same control methods so there should be no change (NC) in any of the

environmental ratings. Over time there could be an increase in environmental impacts and a decline in humaneness and safety if FWS is unable to effectively monitor the program.

Costs: There would be no change in the three categories of costs.

Acceptability: A switch to USDA would be acceptable to producers (+2) as USDA is viewed as more receptive than USDI to the needs of agriculture. A move would be unacceptable to environmental groups (-3) because USDA is considered by them to have a mediocre record in handling pesticide related environmental hazards in the past.

The above discussion assumes that there would be little difference in the way the field operations are conducted and treatment of environmental risks if the operational program is moved to USDA. That may be incorrect. It may be that monitoring the program from the outside by FWS or anybody else would be ineffective, and that USDA would put more emphasis on reducing losses with less concern for environmental safeguards. Such a change might be expected in view of the differences in perspective between the two agencies; a wildlife perspective for FWS and an agricultural perspective for USDA.

2b. Transfer operations to the states. Federal contracts would provide up to 60 percent of the funds. FWS would continue its predator research, and disseminate information and results to the state operational program. This separation of research and operations would make the necessary coordination more difficult. Some states would require enabling legislation.

Consequences of 2b:

Economic: Assuming total program funding remains constant, effectiveness and therefore economic benefits would probably decrease (-1) as this new responsibility would overburden the capabilities of some states.

Environmental: Impacts on non-target species would worsen (-1) as it would be difficult to monitor and influence state efforts to minimize environmental risks. Safety and humaneness would decrease (-1). Predacide use would still be subject to EPA regulations.

Costs:

Federal costs would increase (-2) if the maximum Federal share of 60 percent were used (current Federal share is 39%) and the total program effort remained constant.

State/Local Costs should decrease (+2), consistent with a rising Federal share.

Producer Costs would not change (NC).

Acceptability:

Transfer to the states would be marginally acceptable to producers (+1) and unacceptable to environmental groups (-2) who doubt the ability of the states to monitor environmental hazards. This option may not be widely accepted by the states as the opportunity for them to take over operations by means of Federal-state contracts was provided in the recent past but only two states, South Dakota and Washington State, did so.

The above discussion assumes that a state controlled operational program would be less effective in reducing losses and less sensitive to adverse environmental impacts. Those may not be valid assumptions. It is sometimes argued that because they are less constrained by regulations designed for a nationwide program, a state run effort would be more efficient, more flexible as to what control methods are used and when, and still be sensitive to actual field-level environmental effects.

3. Change Policies to Limit Areas and Methods of Control. These sub-options will require only minimal changes in Federal funding as noted below. Most of the changes, such as an increase in preventive control, would involve reprogramming of ADC funds with a reduction in use of other control techniques.

   3a. Modify control policy on public lands. Coyote control on public land would be limited to cases where verified livestock losses exceed a predetermined level (e.g., 10 percent). Some areas would be closed to sheep grazing. Specified husbandry practices (e.g., constant herder supervision, night corralling) would be required on public lands as needed, depending on the situation. This option would be phased in to reduce impact on current permit holders.

Consequences of 3a:

Economic: Would result in increased predation losses with negative economic impact on producers and consumers (-1) as control on public lands is reduced and some areas closed to sheep.

Environmental: All environmental ratings would improve (+1) as a result of less control on public land.

Costs: Would lower Federal control costs but reduction would be offset by cost of increased monitoring and measurement of losses to see when control is justified, and to verify husbandry practices. Management requirements would increase cost of using public lands to producers (-1). State costs would not change.

Acceptability: Would be unacceptable to producers (-2), and very acceptable to environmental groups (+3).

It is assumed above that a reduction of control on public land would lead to increased losses even with improved management techniques. It may be that the husbandry practices can sufficiently reduce losses so that predation rates and therefore economic benefits would not change appreciably from current levels.

3b. Emphasize prevention of livestock depredation. There would be increased use of control methods that are effective in population reduction (aerial gunning, M-44) and less use of methods that are basically corrective. There would be no change in funding. Research would focus on development of aversive agents, and repellent devices to reduce loss. Other research would be reduced as needed to keep total research funding constant.

Consequences of 3b:

Economic: An increase in preventive control should reduce losses (+1) but this is difficult to predict as the effectiveness of population reduction has not been established.

Environmental: More use of M-44 will increase impacts on target and non-target species (-2) and reduce safety for pets (-2). Humaneness should increase (+1) with less reliance on traps.

Control Costs: There should be no change in costs.

Acceptability: Acceptable (+2) to producers and unacceptable to environmental groups (-2). The environmental group rating could be improved if the research on non-lethal methods is a significant effort meant to replace the lethal methods when development is completed.

The essence of this option is more emphasis on population reduction as a means of preventing losses instead of corrective control focused on offending individuals or localized populations. There is no good evidence as to the effectiveness of population reduction as a control strategy. Hence, the reduction in losses above, may not materialize. The environmental impacts of such a population reduction program if conducted intensively enough to be effective (e.g., 25-50% reduction in population in selected areas) would be substantial.

3c. Emphasize corrective (offending animal only) control. Field personnel would be increased to speed up response to requests for control. Development of methods of removing offending individuals would be stepped up. Employment patterns would be adjusted to match seasonal requirements of corrective control (i.e., more temporary/intermittent, fewer permanent full-time personnel). Training programs in corrective control methods would be conducted for cooperative personnel. Funding would not change.

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Consequences of 3c:

Economic: Losses would be reduced and economic benefits increased (+1).

Environmental: Selective methods focusing on the offending individual would reduce non-target and non-offending coyote impacts (+1). Safety and humaneness unchanged.

Control Costs: Costs should not change. Increases in corrective control can be achieved by reductions elsewhere in ADC predator program.

Acceptability: Would be acceptable to most environmentalists (+1) because it focuses on offending individuals. Would be acceptable to producers (+1).

3d. Minimize use of lethal controls. The program would establish damage thresholds, or reasonable levels of loss, and conduct corrective control only when damage exceeds the threshold. The thresholds concept would require some system of measuring loss at the time they are occurring (different than compensation where loss is measured over the season). The program would also establish minimum husbandry requirements that ranchers must meet to qualify for Federal control (e.g., shed lambing, herder supervision, corralling at night). Requirements would be set according to area and type of operation. There is precedent for requirements for participation in other agricultural programs (e.g., acreage limits, set-asides).

Consequences of 3d:

Economic: The minimization of lethal control measures would result in decreased coyote take, increased losses and decreases in economic benefits (-2), at least initially. Long run consequences are highly speculative.

Environmental: Environmental impacts (+2), safety (+1) and humaneness (+1) should all improve. But the effect on environmental impacts depends on reaction of producers to reduction in ADC use of control (they may increase their control efforts to fill the gap), and how effective husbandry requirements are in reducing losses.

Acceptability: Very acceptable to environmental groups (+3) but not to producers (-3).

The consequences of this option depend on several factors about which there is much uncertainty: (1) how much losses will go up if use of lethal control is limited to severe cases; (2) how producers and the states will react to the reduction, and how much they will increase their own control efforts; and (3) how effective the required husbandry practices will be in reducing livestock loss.

4. Increase Operational Use of Toxicants.

   4a. Relax restrictions on the use of M-44. More M-44's would be used and in less restricted circumstances. The budget would not be changed.

   4b. Increase research on specific applications of toxicants. Modify Executive Order to permit toxicant research on Federal lands. Increase research on toxicant uses such as single lethal baits, toxic collar, etc. Generate data needed for EPA registrations.

To the extent possible, funding would be obtained by reducing other predator research. The ratings of this sub-option are based on the assumption that the research is successfully completed and the resulting methods implemented in the operational program.

Consequences of 4a and 4b:

Economic: Both sub-options should increase effectiveness of damage control and reduce losses, benefiting both producers and consumers (+1).

Environmental: Environmental impacts of more M-44 use would be positive (+1), as it is relatively selective and humane, assuming other control methods are used less. Environmental impacts of the toxicant research depend on what kinds of use are developed and put into operational programs. If emphasis is on selective, fast acting toxicants rating should be positive (+1).

Control Costs: All costs would decrease somewhat (+1) with more use of the M-44 which is an inexpensive control method. There would be no effect on state/local or producer costs.

Acceptability: This option is highly unacceptable to environmental interests (-2) and acceptable to producers (+2); there is more disagreement about this option than any other.

The above discussion assumed that funding for additional toxicant research and generation of data needed for EPA registration could be obtained by reprogramming funds from other predator research. That assumption may not be valid. The cost of the research and additional data may be substantial, requiring a significant increase in Federal funding.

5. Modification of ADC Funding Mechanisms. This option assumes the method by which ADC programs are funded would be changed. Only state-Federal cooperative agreements would exist and all public control activities would be conducted under the aegis of those agreements. The mix of methods currently used in the ADC programs would not change but the location of program activities would be distributed according to greatest need within each cooperating state. Funding would be either from state and Federal sources (5a) or solely Federal (5c). It is assumed for both of the following sub-options that there will continue to be some producer control activities, but that these will not be significant statewide and confined to only private lands. States may develop some mechanisms for deriving funds from producers, but this will have no impact over expenditures of funds, which shall proceed according to a joint state-Federal predator management plan, which will exist whether funding is joint state-Federal (5a) or Federal (5c).

   5a. Consolidate state and other cooperator funding. Under this option, local, association and individual cooperator funds would not go directly to the cooperative program. State legislatures would decide the level of state funding. It is assumed this would make program operations less dependent on local livestock interests for support.

Consequences of 5a:

Economic Benefits: One fund per state would allow ADC efforts to be used where most needed in the state, instead of only where individual producers

or counties have cooperative agreements. This would decrease losses to coyotes statewide and produce economic benefits for both the industry and consumers (+1).

Environmental: Having one fund per state would allow the flexibility needed to direct control efforts only towards offending coyotes (+1). This would reduce the chance of non-target species being taken (+1). There would be an associated increase in both safety (+1) and humaneness (+1).

Control Costs: As the prime feature of this option is to redirect the use of funds and their productivity, it is expected that in the near term there would be no change in control costs to either the Federal or state goverments or the producers (NC).

Acceptability: A single state fund would not be agreeable to many producers who would anticipate the possibility of losing control of the allocation of control efforts, with some receiving more assistance and some less. Negative reaction would be based primarily on uncertainty (-2). Environmental interests would favor this approach as there would be more concentration on offending coyotes (+1). There may be a reduction in the influence of local interests as to how control is conducted, with control limited to the most serious instances.

5b. Charge a minimum fee for control assistance. Producers requesting assistance would be required to pay for control done for their benefit. A precedent for this option has been established in Alberta.

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Consequences of 5b:

Economic Benefits: Charging a fee for ADC services would give producers an incentive to restrict requests for assistance to cases when losses are serious and beyond the producers' control. It is assumed that this will lead to a reduction in control and a slight increase in losses leading to decreases in benefits to producers and consumers (-1).

Environmental: Giving the producers the incentive to do more ADC on their own could lead to more non-offending coyotes and non-target species being taken (-1). Humaneness and safety would also be reduced (-1).

Control Costs: As the fees collected would be channeled back to help fund the program, Federal control costs would be reduced (+1) and producers share of cost would rise (-1). This could be viewed as more equitable in that those who benefit would pay.

Acceptability: Charging fees would be resisted by producers (-2) as these fees would be over and above their contribution to the current pogram. Environmentalists would favor this approach (+1), as beneficiaries of the program would pay. However, the increase in negative environmental effects would temper this judgment.

5c. Federal funding of the entire ADC program. A requirement for participation would be that states not have a program of their own. It is assumed that producers would conduct some control activities on their own land but that total control would not exceed current levels.

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Consequences of 5c:

Economic Benefits: A total Federal program would be able to distribute ADC activities to those states and regions where the need is greatest leading to lower losses overall. Producers (+1) and consumers would benefit (+1).

Environmental: An ADC program totally under Federal control would tend to reduce environmental impacts by taking fewer non-offending coyotes (+3), and fewer non-target species (+3) by not overly concentrating the program in certain areas. There would be an improvement in the humaneness and safety of the control program (+3).

Control Costs: A significant increase in the Federal ADC program (-3) would result as state programs are phased out (+1).

Acceptability: Producers would not favor such an option as local control of funds and ADC efforts would be lost (-2).

Environmental groups would favor the approach as more control would be the
at/Federal level, where more environmental influence is exerted (+2).

That element of these sub-options that involves restriction on state programs, especially (5c), may surface a states rights, constitutional confrontation. Any modification of the current funding and operating mechanisms may require some form of both state and Federal legislation and therefore could not be implemented rapidly. Such an option would have to be phased over time on a state-by-state basis. The feasibility

of these sub-options is particularly sensitive to the level of Federal control funding which cannot be guaranteed for any future year. Using general revenues to finance programs in place of producer contributions may not be viewed by the general public as particularly equitable.

The key to these options is the shift from multiple arrangements and responsibilities to a more simplified, direct, and centralized mode of animal damage control. The impacts described here depend upon the assumption that state programs will not evolve separately and that producers will not proceed on an independent path. If this assumption does not hold then not only will the consequences differ, but chaos will likely result.

6. Expand the Extension Program. This option would involve an increased use of extension specialists to provide information and demonstrate effective methods of reducing livestock losses. Most of the operative control would be conducted by the producers themselves. ADC would conduct control in cases of severe loss where private control is not appropriate. Under this option two alternative sub-options are considered.

   6a. Funds to Cooperative Extension System. Appropriations for predator control extension program through existing USDA State Cooperative Extension system.

   6b. Increase the number of FWS extension specialists. Would increase level of extension component of existing program.

Under both sub-options extension specialists would have the same responsibilities. Under (6a) the specialist would work for the existing network of county agents and under (6b) work for the Fish and Wildlife Service's ADC program. Shifts towards an increased extension effort would involve reprogramming of funds from current control efforts, with no change in total budgets.

Consequences of 6a and 6b:

Economic Benefits: Funding predator control extension programs would teach livestock producers how to control problem coyotes and how management methods can help to reduce losses. Because operational ADC control would be reduced somewhat there may be an initial increase in losses (-1) as the extension program gets up to speed. With time, however, it is expected that with the help of extension specialists the private sector can control coyote damage with only occasional help by ADC.

Environmental: Similar environmental impacts are expected from both sub-options. There would initially be a decrease in the total coyotes taken (+1). The change in non-target species taken (-1) would result from more non-professionals conducting ADC activities thereby decreasing the safety and humaneness of the entire effort (-1). The long-term situation could reverse these consequences.

Control Costs: Both sub-options would have similar program control costs with start-up costs being somewhat higher if extension is conducted by the Fish and Wildlife Service (+1).

In the longer run Federal costs should be reduced if extension can reduce losses while lowering FEderal involvement in operational control. Costs to producers would increase (-2) as they would shoulder much of the control burden now carried by ADC. In either case state contributions would not change (NC).

Acceptability: Both producers and environmental groups would accept these sub-options either through USDA or FWS as being positive efforts on their behalf in the long-term. However, with no budget increase and therefore lower direct control efforts the initial producer reaction would be neative (-2). Environmentalists would view it as a positive gain (+2) whereby more information about safe use of control methods is distributed to producers along with information on husbandry practices to reduce losses.

7. Compensation of Predation Losses. The compensation of ranchers for livestock losses due to coyotes would be at something less than full market value and would apply only to above "normal" loss. The Federal control program would still be continued in cases of excessive loss, at the discretion of program supervisors. The method of compensation would be one of the following methods.

   Initially it is assumed that these devices will alter the form of the Federal involvement in predator losses. To ease the shock of the institutional associated changes they would be designed so that there would be no change in any economic (cost) dimensions. This

recognizes that once initiated these devices can all be used to shift the burden of control (or losses) from the public to the private sector or from the producer to the consumer (taxpayer) as deemed appropriate.

7a. Insurance. Various types, with and without deductible losses, voluntary/required, etc.

7b. Federal compensatory payments. Direct payment for confirmed losses in excess of some minimum level (e.g., 3 percent).

7c. Variable grazing fee. Public land grazing fee dependent on expected predator loss, with lower fees in areas where loss is expected to be high (ex ante) or control uneconomical. Alternatively, could rebate portion of fees if predator losses are proven to be higher than some minimum (ex post). In most cases, there would be no coyote control on public lands.

7d. Increase tariffs on wool. Would raise prices and profits for producers, offsetting effect of losses to predators.

Consequences of 7a-d:

Economic Benefits: The various methods of compensating for predation losses would not uniformly change net economic benefit to all producers (NC). The purpose of these devices would be to stablize the economics of sheep ranching to isolate producers from extreme variability in losses while allowing them to assume a portion of the normal burden of that loss as part of the cost of doing business. Consumer benefits would also be unchanged.

Environmental: The expected environmental impacts would be similar for sub-options 7a and 7b with fewer coyotes taken (+2), non-target species taken (+2), and an increase in safety (+1) and humaneness (+2).

Similar environmental impacts occur for sub-options 7c and 7d. Somewhat of a decrease in coyotes taken (+1) and non-target species (+1) with resulting increases in safety (+1) and humaneness (+1).

Sub-options 7a and 7b would stress a lower total ADC effort than 7c and 7d thereby producing more environmental benefits.

Control Costs: All sub-options do not affect state funding (NC).

Producers would only increase control costs (-1) under sub-option 7a where part or all of the insurance premium would be paid by them. In sub-options 7b, 7c, and 7d there would be no change in producer's control costs (NC).

The Federal share of control costs varies by sub-option. In 7a, the financing of insurance would be expensive (-1) but not as expensive as a direct subsidy under 7b (-2). Changing grazing fees would mean less revenue collected and increased personnel to verify losses (-1). Changing import tariffs would lower duties collected to a small extent (-1) as wool incentive payments would also decline as prices increased. All these cost increases are offset by the substantial reduction of Federal expenditures for direct control.

Acceptability: The acceptability of using mechanisms for compensating predation losses would vary by method employed. The use of insurance would be acceptable to both producers (+2) and environmental groups (+1). Producer acceptability is based on Federal subsidy of insurance premiums. Using a direct subsidy would be very acceptable to producers (+2) but would set a precedent for compensating losses that environmental groups see as a cost of doing business (-1). The use of a variable grazing fee would not be acceptable to producers without some coyote control (-1) but would be favored by environmental groups as few coyotes would be taken on public lands (+2) in most cases. Increasing the tariff on imported wool would be viewed as a protection measure by producers and be favored (+2). Environmental groups would not favor any increase in consumer prices to compensate the small percentage of producers with high losses (-2).

The essence of the several different ways to compensate losses is that producers would be willing and able to tolerate losses and there would be less "demand" for ADC control. Environmental impacts should be reduced. Livestock losses would increase but the impact on producers would be minimal. Consumer impacts and taxpayer costs would show only slighty perceptible increases, even should total costs increase.

8. Increase Predator Research. With the number of unsolved questions regarding the efficacy and efficiency of ADC control methods to reduce livestock losses, additional research may be needed in one of the following areas. In each case, it is assumed that the current

program would be continued until the research is completed and the results incorporated into the operational program.

8a. Additional research on non-lethal methods.

8b. Additional research on lethal methods for corrective control -- chemical and non-chemical methods.

8c. Modify Executive Order to permit toxicant research on public land.

Sub-options 8a and 8b would require an increase in the current research budget. Sub-option 8c may require less funding then the current level as testing could be conducted on Federal lands without compensation to private interests. Research on private lands would be reduced accordingly.

Consequences of 8a-c:

Economic Benefits: Research into either lethal or non-lethal methods for coyotes would not decrease losses to producers in the short run. Therefore, there would be no effect on economic benefits until methods are perfected and used in the operational program (NC). Modifying the Executive Order only to permit research on toxicants would also lead to no change (NC) in the near term. Long term consequences of any of these options could be substantial, but are truly unpredictable at this time.

Environmental: Research efforts on non-lethal methods would have favorable effects for all environmental indicators. Ultimately fewer coyotes would be taken (+2), fewer non-target species (+2), a more humane program

(+2) as fewer animals would be taken and there would be a concentration on methods that either kill faster or that allow animals to be released unharmed. The safety of the program would increase accordingly (+2).

Under sub-options 8b and 8c, the concentration of research efforts on lethal methods would focus on solving problems like impacts on non-target species, humaneness, and safety. Assuming success, these are all ranked (+1).

Control Costs: The only changes in Federal control costs from the current program would be for research under sub-options 8a and 8b. The Federal budget (-1) for both sub-options would increase. There would be no change (NC) for either states or producers under this option.

Acceptability: There would be acceptance by both producers (+1) and environmental groups (+3) for non-lethal methods as long as they prove to be effective.

Producers would favor lethal methods (+2) under sub-option 8b because of their greater likelihood of being effective. This would be supported by environmental groups (+1) if non-target effects can be reduced as a result of this research.

Option 8c, modifying the Executive Order to ban toxicant research on public land, would be favored by producers (+1) in the expectation that this would ultimately result in lower losses to predators. Testing toxicants on public lands would be opposed by environmental groups (-1).

Opposition would be even greater if it were not made clear that one of the principal purposes of the research was to develop toxicants that are environmentally safe and humane.

In summary, additional research in non-lethal methods of control contains more uncertainty as to its probability of success at reducing losses than does research on lethal methods. However, the implementation of any research results would not be rapid as field testing is a slow process. Results of non-lethal research might not be forthcoming for 2-4 years and research on lethal methods or toxicants might not produce usable results for 5-15 years. No legislative actions are required to implement these options and the only coordination needed would be with the EPA for toxicant research under sub-option 8c.

9. Promote Better Husbandry Practices to Reduce Depredation. Under this option, the ADC program would continue at its current level of funding and personnel. No changes would be made in the use or in the mix of the control methods now employed. The promotion of better husbandry practices would be an additional activity added to the total ADC program. Two variations on this option are presented below:

   9a. Improve the quality of sheep herders. This assumes a relaxation of the immigration laws to allow more alien sheep herders to be employed. Also assumed is the establishment of herder training programs to teach predation prevention and coyote control techniques.

Consequences of 9a:

Economic benefit: The improvement in the quality and quantity of herders will help to reduce losses, thereby increasing producer benefits (+1). The increased production will reduce prices to consumers somewhat (+1).

Environmental: With the use of more and better qualified herders there should be a reduction in the need for taking coyotes in general (+1) and a resulting decrease in the take of non-target species (+2). The reduced level of coyote control will result in a more humane (+1) and safe (+1) program.

Control Costs: The Federal budget for ADC will increase for herder training programs (-1). Producer costs for hiring additional herders will also increase (-1). State funding would not change (NC).

Acceptability: A greater availability of qualified herders would be viewed favorably by both producers (+1) and environmental groups (+2).

9b. Develop and require minimum husbandry practices. Establish husbandry practices that would be required as a prerequisite to ADC assistance. It would also be a requirement for permits to graze livestock on public lands. As with sub-option 9a there would be no change in the mix of control methods currently employed in the ADC program.

Consequences of 9b:

Economic Benefits: The requirement for minimum husbandry practices would reduce losses, and so increases benefit produces (+1) and consumers (+1).

Environmental: As with option 9a there would be reduced environmental impacts on coyotes in general (+1), non-target species (+2), a safer program (+1), and a more humane approach taken toward ADC (+1).

Control Costs: Federal control costs would increase (-1) while minimum husbandry practices and guidelines are developed and monitored. The states would not be affected (NC) by this option. Producer costs would increase (-2) in order to adopt the management practices required for ADC services and to obtain permits to graze sheep on Federal lands.

Acceptability: Such an option would not be acceptable to producers as they would bear the initial cost to reach a minimum level of husbandry practices (-2). This option would be acceptable to environmental groups (+2) as the requirement that producers do more to protect their own livestock is in keeping with the attitude that losses are a part of doing business in agriculture.

Option 9 in total does not require any legislative changes. It does require, however, coordination between governmental agencies and producers and, therefore, could not be implemented rapidly. In the short run it is not known how effective this option would be in reducing losses. The relaxation of restrictions on alien herders should reduce the cost of

herders to producers. The effect on losses of minimum husbandry practices is very uncertain. There is no firm information on how much losses can be reduced by better management and at what cost. As with previous research results which have been translated to the industry by the use of an extension program, it is presumed that positive results will eventually be forthcoming.

This option may very well be part of any other option. It is only sensitive to the amount of coordination required between governmental agencies and producers and the level of expenditure that producers would have to make in order to qualify for ADC services.

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III.D. Summary

Table III-1 presents a summary of the options and their consequences as discussed above. The ratings based on the scale of -3 to +3 for the four criteria groupings are also shown. In addition, there are three columns indicating whether the option requires legislative action, involves considerable coordination with other agencies,and could be implemented with reasonable speed.

The positive and negative ratings must be interpreted in terms of the criteria column headings. For example, a negative rating on non-target species impacts means that those impacts would be increased as the management objective is assumed to be to minimize those impacts. The ratings are all made in comparison with the current situation.

It should be noted that no meaningful comparison of the options can be made by adding up the ratings to get the options' total scores. The problem with comparing overall ratings is that the criteria are most certainly not of equal importance from a decision-making point of view. At some point in time it may be feasible to estimate the "correct" weight for each,in which case the total score would have meaning.

If total scores are not meaningful for comparisons, how then can the table be used to compare options? One way is to decide which of the criteria is most important and then use the table to see what costs or trade-offs would be involved if an option with a high rating in that column where implemented. Suppose, for example, that economic benefits is the primary criterion. There are currently only two options with

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TABLE III-1. Evaluation of Options

OPTIONS	ECONOMIC BENEFITS OF CONTROL			ENVIRONMENTAL IMPACTS				CONTROL COSTS ($, MY)			ACCEPTABILITY		LEGISLATIVE ACTION	COORDINATION OTHER AGENCIES	RAPID IMPLEMENTATION
	PRODUCER	CONSUMER	TOTAL	TARGET SPECIES	NON-TARGET SPECIES	SAFETY	HUMANENESS	FEDERAL	STATE	PRODUCERS	PRODUCERS	ENVIRONMENTAL GROUPS			
1. Cont, Current Program															
1a. Decrease 50%	-2	-2	-2	+1	-2	-1	-1	+2	-2	-1	-3	+1	No	No	Yes
1b. Status quo	NC	NC	NC	NC	-1	NC	NC	NC	NC	-1	-1	NC	No	No	Yes
1c. Increase 50%	+3	+3	+3	-2	-1	-1	-1	-2	+1	+1	+3	-3	No	No	Yes
2. Transfer Operational Control															
2a. USDA	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	+2	-3	Yes	Yes	Yes
2b. States	-1	-1	-1	NC	-1	-1	-1	-2	+2	NC	+1	-2	Yes	Yes	No
3. Limits on Area and Methods															
3a. Modify Control on public land	-1	-1	-1	+1	+1	+1	+1	NC	NC	-1	-2	+3	Yes	Yes	No
3b. Emphasize prevention	+1	+1	+1	-2	-2	-2	+1	NC	NC	NC	+2	-2	No	No	Yes
3c. Emphasize correction	+1	+1	+1	+1	+1	NC	NC	NC	NC	NC	+1	+1	No	No	Yes
3d. Minimize lethal control	-2	-2	-2	+2	+2	+1	+1	NC	NC	-1	-3	+3	No	No	Yes
4. Increase Toxicant Use															
4a. More M-44 use	+1	+1	+1	+1	+1	+1	+1	+1	NC	NC	+2	-2	No	Yes	Yes
4b. Reseach on Toxicant uses	+1	+1	+1	+1	+1	+1	+1	+1	NC	NC	+2	-2	No	Yes	Yes
5. Modify ADC Funding Mechanisms															
5a. Consolidate State Funding	+1	+1	+1	+1	+1	+1	+1	NC	NC	NC	-2	+1	Yes	Yes	No
5b. Minimum Fee for Assistance	-1	-1	-1	-1	-1	-1	-1	+1	NC	-1	-2	+1	Yes	Yes	No
5c. Total Federal Funding	+1	+1	+1	+3	+3	+3	+3	-3	+1	+1	-2	+2	Yes	Yes	No

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OPTIONS	ECONOMIC BENEFITS OF CONTROL			ENVIRONMENTAL IMPACTS				CONTROL COSTS ($, MY)			ACCEPTABILITY		LEGISLATIVE ACTION	COORDINATION OTHER AGENCIES	RAPID IMPLEMENTATION
	PRODUCER	CONSUMER	TOTAL	TARGET SPECIES	NON-TARGET SPECIES	SAFETY	HUMANE-NESS	FEDERAL	STATE	PRODUCERS	PRODUCERS	ENVIRONMENTAL GROUPS			
6. Expand Extension															
6a. USDA/ State System	-1	-1	-1	+1	-1	-1	-1	+1	NC	-2	-2	+2	Yes	Yes	No
6b. FWS extension	-1	-1	-1	+1	-1	-1	-1	+1	NC	-2	-2	+2	No	No	No
7. Compensate Losses															
7a. Insurance	NC	NC	NC	+2	+2	+1	+2	-1	NC	-1	+2	+1	Yes	Yes	No
7b. direct payments	NC	NC	NC	+2	+2	+1	+2	-2	NC	NC	+2	-1	Yes	Yes	No
7c. Variable grazing fee, reduce control on public land	NC	NC	NC	+1	+1	+1	+1	-1	NC	NC	-1	+2	No	Yes	No
7d. Increase tariffs, reduce control	NC	NC	NC	+1	+1	+1	+1	-1	NC	NC	+2	-2	Yes	No	No
8. Increase Predator Research															
8a. Non-lethal methods	NC	NC	NC	+2	+2	+2	+2	-1	NC	NC	+1	+3	No	No	No
8b. Lethal methods	NC	NC	NC	+1	+1	+1	+1	-1	NC	NC	+2	+1	No	Yes	No
8c. Modify Executive Order	NC	NC	NC	+1	+1	+1	+1	NC	NC	NC	+1	-1	No	Yes	No
9. Promote Better Husbandry															
9a. Improve herders	+1	+1	+1	+1	+2	+1	+1	-1	NC	-1	+1	+2	No	Yes	No
9b. Husbandry requirements	+1	+1	+1	+1	+2	+1	+1	-1	NC	-2	-2	+2	No	Yes	No

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with ratings of +3; a 50 percent increase in ADC funding (1c), and increased use of toxicants in specific applications (4b). Considering the other criteria, more toxicant use fares less well in terms of environmental impacts but would add less to Federal control costs. Both options would be acceptable to livestock interest but not well received by those representing environmental interest. The total of these trade-offs may be considered too costly, in which case other options such as more emphasis on corrective control (3c) would be considered, etc.

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IV. SUMMARY AND CONCLUSIONS

The principal focus of the above materials has been an attempt to fully utilize all of the information that is new since the Cain Report of 1972. In this context the principal subject areas have been (1) economics of the western livestock inventory, (2) ADC Service delivery approaches, (3) ecological/environmental effects, (4) proper Federal role, and (5) public perceptions toward predation and control. Whether it be scientific questions, control options, or public attitudes one goal of this effort has been to leave no stone unturned. A measure of the success of this effort therefore will be the answers to the question of whether all available, pertinent information has been utilized in this report.

The importance of this approach cannot be overemphasized, because the prime motivation for this study is the two-fold assertion by some that (1) there have been some dramatic recent changes in the predatory-prey relationship which merit new consideration, and (2) that there is some new evidence concerning certain control options. Vigorous arguments have been presented by the livestock industry claiming that there have recently been substantial increases in predator losses. These claims have been coupled with observations that the original decision to ban the use of 1080 was ill-founded and that subsequent reexamination of both old and new information will confirm that observation.

Thus the exact form and magnitude of the predator problem and the current viewpoints of the scientific regulatory community regarding certain control techniques have been the focus of this report.

With the assistance of an ADC Policy Study Advisory Committee composed of representatives of the public and private sector the study began with the development of a study plan which included a comprehensive statement of the problem, the preparation of a comprehensive background section on all pertinent components to the problem, an examination of all operational components of existing animal damage control efforts, with particular emphasis on the programs of the U.S. Fish and Wildlife Service, and then a discussion and evaluation of several optional strategies in terms of several biological, technical, environmental, institutional, and public acceptability criteria.

Consistent with the desire to obtain and utilize all information pertinent to the broad policy question being examined and also that information which was new since 1972, the study procedure was to obtain information by soliciting all Federal agencies with operational, research, or control responsibilities in predator damage control. These included:

1. Denver Wildlife Research Center, FWS
2. Division of Animal Damage Control, FWS
3. Bureau of Land Management, USDI
4. Office of Pesticide Programs, EPA
5. Economics, Statistics and Cooperatives Service, USDA
6. U.S. Forest Service, USDA

In addition, an initial public meeting of the ADC ADvisory Committee was held and further input was solicited through the Federal Register. The full schedule (Appendix A) for this study includes a second Advisory Committee meeting and four additional public hearings in May, and a third Advisory Committee meeting in June, all of which are part of the continuing process of providing multiple opportunities and mechanisms for input of all pertinent information in the conduct of this study.

Several interrelated questions surface for simultaneous consideration. They range from debates over whether there really is a predator problem and if so of what magnitude, to the preferred form and nature of actual animal damage control. This study and report could take none of these matters for granted. Thus it has been necessary to ascertain with as much accuracy as possible the exact predator-prey relationship between coyotes and sheep (and even cattle). Do all coyotes kill sheep? When? How? Why? Where? Has there been some change through time? What is the current status of the interrelationshp?

The other side of the coin relates to coyote control. Has there been any measurable impact of coyote control on coyote populations? Has control impacted losses? Are there any certain relationships between control, population levels and losses? How does all of this relate to the question of control directed toward problem animals only as compared to general population reduction or even the reduction of localized populations? If control does provide relief from livestock losses, which control methods work "best" and what are the associated environmental/ecological tradeoffs and many other dimensions, which may be characterized by the following:

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Predator Control Strategy Components and
Criteria for Evaluating Them

Predator Control Components	Evaluation Criteria
1. Direct control (traditional program orientation)	
a. trapping	a. cost effectiveness
b. aerial shooting	b. relative humaneness
c. denning	c. public acceptability
d. ground shooting	d. legal constraints
e. M-44's	e. ecological/environmental impacts
f. toxicants	f. selectivity
g. others	g. possible roles for other Federal entities and the states
2. Alternative to direct control	h. integration of lethal and non-lethal control methods and alternatives to direct control methods
a. indemnity plan options	i. safety
b. management incentive options (e.g., through taxation or through allocation of ADC services)	
c. public range use policy	
d. extension	
e. import duties and tariff adjustments	
f. improved husbandry practices	
g. others	

This report has been prepared to highlight the principal information currently available for each of the above dimensions, with an attempt to consider every component of predator control in light of every evaluation criteria that could apply.

Another dimension is the economic importance of predator losses. What are they? How significant are they, to producers and consumers? How do these losses relate to the current and long-term viability of the industry? Who benefits and who gains from predator control?

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This has led naturally to an examination of "proper role." Who should control (manage) predators? Where is the dividing line in the sharing of public and private responsibilities? How "much" should be done by each sector and which are the proper functions for each? In the public sector what are the roles of the USFWS, USBLM, USDA, states and counties in management and control?

The final element, public perceptions, surfaces many questions relating mostly to humaneness, selectivity, environmental concerns, safety and proper Federal role with respect to assistance to the industry. Is killing of coyotes necessary? What are the most humane control methods? Can a program based solely on non-lethal, humane techniques, be successful? Can negative impacts on other animals and the environment in general, be avoided? Public perceptions focus on 1080, trapping, shooting and denning.

The above report provides a synopsis of what are beleived to be the salient points on these many issues/questions. Where possible and appropriate existing data and reports have been supplemented with some additional analysis. In most instances a summary interpretation has been provided for each major section or subsection of the report. What follows is a summary of the highlights from each section above which has been devoted to assembling all pertinent information on major topics and then a summary of the consequences of pursuing certain strategy options in light of this information.

Background Highlights

II.A. Review of Previous Policy Studies

- Offending animal only recommendation by Leopold and also (though not as explicitly) by Cain is still subject to variable interpretation. At one extreme some would argue that only those coyotes caught in the act should be designated as offending animals. Others argue that any animal found in an area where there has been a history of depredation has a high likelihood of being or becoming an offending animal. This argument has been extended to include adult pairs with pups, based on the belief that the pair will increase their hunting activity to support the pups. Killing of one of the pair, especially the female, will cause a desperate increase in the activity of the male, necessitating its removal. Disposal of the pups is argued to be the only humane action feasible, as they will not in all likelihood be able to fend for themselves and will be lost to other predators or starvation.

  Coyotes in areas where sheep are about to be moved are also considered offending animals and on occasion these areas are "cleared" of coyotes before sheep are moved in. With these variable interpretations it is possible to support many viewpoints regarding compliance with an offending animal only policy and recommendation.

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- Important recommendations in the Cain Report have not been implemented:
  - ADC funding by appropriation only (no county or association funds). Would allow allocation of effort within a state more in line with a balance of immediate needs and the long-run goals and objectives of an internally consistent, centrally coordinated control effort.
  - Expansion of extension program in the West.
  - Congressional action to alleviate burden of predator loss.
  - The relationship between illegal predator control and the revocation of leases to graze Federal land has not been fully spelled out.
  - It has not been deemed prudent to fully implement the recommendation to eleminate all predator control in Wilderness Areas.

- A majority of the recommendations in the Cain Report have been implemented. These are:
  - A continuing cooperative program, in thirteen western states. Washington and South Dakota conduct a control program under contract to the Federal overnment.
  - Toxic chemicals were removed from use and have only returned via the registration process for some limited purposes.
  - There has been dramatic progress in the professionalization of Fish and Wildlife Service Animal Damage Control staff.
  - Legislation has been passed and implemented to control aerial hunting.

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- Research efforts have been initiated as recommended, within the constraints of funding limitations.
- Research on socio-economic dimensions of predator control, including cost/benefit analysis, have been increased dramatically.
- Epidemiological studies of rabies are being conducted by the U.S. Department of Health, Education and Welfare.
- Endangered or threatened predators are now protected by the Endangered Species Act.

II.B. A Description of the Western Sheep Industry

- There has been a continuation of the downward trend in sheep and enterprise members in the West, from 21.5 million sheep and 115 thousand producers in 1960 to 8.7 million sheep and approximately 46 thousand producers (estimate) in 1978. There is some signs that the sheep industry is increasing the size of its ewe population to increase production in the future. The decline in stock sheep may be slowing down (1978 dropped only 2 percent). Recent continuing declines in numbers of lambs marketed has been associated with dramatically increasing farm prices to such elevated levels that verbal reports of renewed interest and entry into sheep ranching is intuitively logical. The nature of trend measurement is such that it will be several months before it will be possible to determine with any certainty whether the long-term decline in this industry has finally bottomed out, and several years before any confirmation of a fundamental revival can be made.

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Other principal characteristics of the present industry are:

- Western sheep industry is economically stable, with a high equity/debt ratio. It can survive with returns to cover only cash costs. It is characterized by older owners, as recruitment of young owners has not been sufficient to replace retirees over the next ten years.
- The price index for lamb increased 11 percent more than the cost-of-production index from 1972-1976. Prices for choice lambs are up to $80.85 per cwt in San Angelo in March 1978. Mountain and Great Basin areas have the highest lambs per ewe ratio and highest returns per ewe. High prices for lambs and wool may cause an increase in production in future, attacting young owners into the industry. Improved economic outlook may also see some changes back from cattle to sheep in some areas where these joint enterprises prevail.
- 56 percent of sheep producers also keep cattle. For those identified as sheep ranchers the sale of sheep, lambs and wool make up 54 percent of farm income on the average. Large enterprises received 78 percent of income from sheep, lambs, and wool. Small enterprises received 38 percent of income from sheep, lambs, and wool.
- Public lands play a major role in sheep grazing in the West.
  - BLM has 17 million acres used for sheep and goats.
  - Forest Service has 9.4 million acres used for sheep and goats.
  - Grazing on BLM and FS lands has been decreasing. Both agencies indicate that the decline has ended. USFS expects a 30 percent increase in the next decade, with sheep grazing stablizing and cattle grazing accounting for all of the

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increase. USBLM expects a 41 percent increase, with no indication of how this will be shared by cattle and sheep. All such predictions must be deemed highly speculative and not totally consistent with other predictions regarding the future form and magnitude of the cattle and sheep components of the livestock industry.

- Larger herds tend to use public lands for grazing.
- Decreased grazing on public lands is not associated with decreases in available grazing area.
- In mountain and Great Basin areas, 76 and 84 percent respectively of all ranchers have their ewes on public land.
- Grazing fees increased by 50 percent in 1976. Fees are 30¢ per sheep per month on BLM lands and 32¢ on FS lands.

- Support prices for wool, which are translated into actual payments based on retail prices and import levels, increased from 72¢/lb. in 1976 to 108¢/lb. in 1978. These support prices are expected to increase further in 1979-81. Resulting Commodity Credit Corporation payments to the sheep industry are expected to be $30 million in 1978. Wool incentive payments help to stablize farm income from wool.
- 75 percent of imported wool comes from Australia. Imports of wool have declined from 163 million pounds in 1966 to 38 million pounds in 1977. Wool accounts for 15-20 percent of gross farm returns to sheep raising.
- No expected industry impact if tariffs are lowered. Importation of either live sheep and lambs or derived meat products has no effect on the domestic industry. Net effect of tariff decrease

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on wool growers will also be negative, although treasury surplusses resulting from collected tariffs will decrease and consumer prices for wool products will decline.

- 9 percent of commercial producers use full-time herders. 44 percent of ewes of commercial producers have full-timer herders. 72 percent of large enterprises have full-time herds.
- Shed-lambing increases net returns to the industry. Use of shed-lambing decreases as the size of the operation increases. 47 percent of commercial producer's ewes are shed lambed in mountain region. Overall, 60 percent of producers use shed-lambing and 38 percent of ewes are shed-lambed. Shed-lambing is not expected to become more widespread in face of trend toward larger enterprises.
- Selective breeding of ewes to produce twins increases both profits and losses to depredation in certain regions.

II.C. Estimating Livestock Losses to Predators

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- No totally satisfactory methodology has been estbalished for estimating losses associated with documented causes. Field studies can correctly identify predator kills, but are too expensive and time consuming to obtain large enough samples for defensible generalization. Interview studies rely on producers to determine cause of death, and ask for recall for a long period of time. Questionnaire surveys may have non-response bias, and have the same drawbacks as interview studies noted above.
- The Economic Research Service survey by Gee et al. (1977) is most comprehensive. It appears accurate for differences in losses between regions, management methods, etc. and in terms of distribution of loss (e.g., 10% of producers suffer heavy loss), but levels of loss are too high based on comparison with loss estimates from all other sources.
- Based on available evidence from all studies during 1972-77, a best judgment estimate of average loss to coyotes for the 17 Western States for the period is 3 to 5 percent for lambs and 1 to 2 percent for ewes. These modest numbers disguise the fact that some producers and some regions have much higher loss rates and others no loss to coyotes at all. Typically larger operations on open range, public lands have higher loss rates than smaller operations on private lands, perhaps because they are less likely to shed-lamb, more likely to utilize public grazing lands and utilize other management methods that tend to reduce vulnerability.

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- Regarding loss rates over time, although ERS and Forest Service data may both be biased upward as they are based on producer response, the bias should be consistent over time. Thus the increase in loss rates in recent years shown by this data does support industry contentions.
- The above conclusion needs to be reconciled with constant or lower coyote abundance (scent post indices). The answer may be fewer sheep, plus the same number of coyotes, equals a higher rate of loss. A 5 percent overall loss rate in 1977 would equal a 3½ percent loss rate in 1972, given the decline in sheep numbers. It could be that the number of sheep lost is less even though the loss rate has increased!
- While total cattle losses are noteworthy, few producers seem to suffer from significant predation as is the case with sheep.
- Compared to losses to disease and other causes, predator loss is a minor problem for the cattle industry.

II.D. U.S. and Canadian Programs and Predator Research

- ADC (not just predator) operational funding: Federal share up from 41% in 1968 to 59% in 1977. Federal share of total man-years in cooperative programs increased from 27% in 1972 to 39% in 1977. Predator control funding in the West: cooperative program expenses per sheep are up from about $.38 in 1968 to $.72 in 1977 in constant 1968 dollars. Requests for assistance are up sharply in 1976 and 1977 but it is unclear whether this reflects supply or demand for control services.

- The percent of livestock predation control funds expended on cattle compared to sheep ranges from 4% in Idaho to 57T in Oklahoma. Arizona, California, Nebraska, New Mexico, North Dakota, Oregon and Texas, in addition to Oklahoma, are states where 20% or more of the control funds are spent on cattle.
- Commercial fur harvest and prices increased dramatically in recent years, from 30,000 pelts at $18.00 average in 1972 to 172,427 pelts at $45.00 in 1976. Some of the coyote number reported in later years may not reflect increased kill levels as pelts were not harvested in earlier years. Value of "salvageable by-product" furs from ADC program should be analyzed. Since this money reverts in a variety of ways to the cooperative program this may influence the magnitude and form of the control effort.
- Canadian control programs are diversified.
  - Lithium chloride used as aversive agent in Saskatchewan.
  - Alberta compensates producers for losses. Inspectors recommend husbandry and control practices that producer must follow to be eligible for future claims.
  - A broad range of toxicants, including 1080, are used when needed. Increasing public pressures are causing some reduction in the use of 1080.
- Predator research gets one-fourth of total ADC research funding. Predator research funding has declined in real terms.
- The Executive Order banning research on toxicants on public land was costly in terms of time. The FWS is just now beginning to field test 1080 and other toxicants in specific selected methods. Thus, little more is now known about how to use toxicants or their environmental effects than the information available in 1972.

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II.E. Review of Fish and Wildlife Service Predator Control Methods

- In 1976 43.7 percent of ADC operational expenditures were devoted to trapping and 34.3 percent to aerial gunning, taking 37 percent and 40.2 percent of coyotes harvested in control operations in that year. The remaining harvest was by ground methods, including M-44 (6%), ground shooting (6%), denning (6%), and snaring (4%).
- In 1976 cost per coyote taken were $8.68 (M-44), $39.79 (ground shooting), $54.38 (denning), $55.26 (dog), $89.64 (trapping), $137.13 (snaring) for ground methods and $55.52 (fixed-wing aircraft), $68.50 (helicopter), for aerial methods. As methods are used in a complementary fashion and there is no data indicating cost-effectiveness as related to the relative problem nature of individual coyotes those data cannot be used as is to guide program investments.
- Aerial and ground shooting are selective and humane. Steel traps are not selective or humane. Denning and M-44 are humane.

II.F. Does Control Reduce Losses

- Case study evidence and experiences of trappers is convincing that corrective control can reduce or stop losses.
- Given a liberal interpretation of the offending animal only policy there is the opportunity for a control program which utilizes both population (preventive) control and corrective control. Preventive control can reduce losses and reduce the burden on corrective control. While aggregate evidence on a westwide basis is not convincing that population control works, there is evidence that

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corrective and even preventive control does reduce losses. The current program is consistent with a liberal interpretation of the offending animal only policy.

II.G. Coyote Biology

- The scent post index of coyote abundance has decreased by 8 percent since 1972 and 26 percent since 1974. Coyote densities vary significantly between regions of the West.
- Coyote reproductive rates depend on many factors that act to maintain populations close to habitat carrying capacity. Thus, reductions due to control are easily compensated for. Coyote population can recover from major reductions (50% or more) within 3-5 years.
- Not all coyotes kill sheep but most will if regularly given the opportunity. The vulnerability of sheep, especially lambs, is important, as related to management and husbandry practices.
- Coyotes do not just kill the sick and weak.

II.H. Environmental Impacts of Control

- Conclusion: there is virtually no adverse environmental impact resulting from the control program as now conducted.
  - Target species: a minute percent of total coyote population are taken each year. There is no threat to coyote population in any significant area of the west.

- Non-target: non-target impacts are limited to insignificant percentages of species that are abundant. Recent concern has been voiced about impact of control efforts on bobcat populations. Raptors are not significantly impacted currently as compared to 10-20 percent of autopsied eagles which showed toxicants present prior to 1972.
- Safety: only risk to humans is pilots/gunners. There is some risk to pets, especially from M-44 and traps.
- Humaneness: control methods do differ in terms of an arbitrary definition of humaneness which is based primarily on length of a period of suffering.

II.I. Public Attitudes

- Attitudes toward predators and predator control should be viewed in the context of American attitudes toward animals in general.
- The most dominant orientation toward animals among members of American society today is "humanistic"--strong interest in and affection for individual animals, principally pets (approximately 70% of the American public share this trait (in common).
- In general, the public appears much more concerned about the "humaneness" of predator control methods and their "specificity" than they are about the fact that coyotes are taken or the "cost" of control measures. With respect to "specificity," the public appears quite concerned about possible harm to pets and to other "non-target" wild animals, more so than to other coyotes.

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- The public does not support lethal means of coyote control with much enthusiasm. The public is strongly antagonistic toward the use of leg-hold traps, slow-acting poisons, denning, and shooting coyotes from the air. Generally speaking, however, they do not object as strongly to the use of quick acting poisons or to shooting coyotes from the ground. The public as a whole would be much more receptive to further research and implementation of non-lethal control methods.
- The public values sheep much more highly than coyotes; however, people appear just as concerned about the taking of coyotes as they are that coyotes kill sheep.
- People appear more willing to accept lethal predator control methods and risk of death to other animals when presented with scenarios showing significant increases in loss rates (up to 40% of the livestock).

II.J. Alternatives to Traditional Control

- Compensation of losses by insurance sounds appealing but there are some operational difficulties
  - Need to verify losses (even if all losses were covered).
  - If government subsidized (a necessity) insurance for predation loss is provided, there would need to be some consistent application to other agricultural losses. This applies to subsidies as well.
  - Predation loss is not really an insurable loss as some areas and ranches suffer losses year after year while others never do.

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- Extension programs would place increased responsibility with the producer, while teaching management methods as well as control. It would relate primarily to management and husbandry practices, the most popular approach to the problem. In those Western States dominated by a vast expanse of public land, the applicability of the extension techniques may be limited.
- Import duties are a grossly inefficient and inequitable way to compensate for losses.
- Changes in management methods may not greatly reduce total westwide losses, but they may make a substantial impact in problem "hot spots."
- Incentives and requirements. A specific set of rules and regulations, primarily relating to husbandry and management practices, can be utilized as preconditions to receiving predator control aid. The Canadian Province of Alberta has some requirements of this form.
- Public range policy. Possibilities include:
  - Predation loss should be a factor in identifying grazing areas. Some areas should be closed.
  - Variable grazing fee or auction of grazing rights to areas of high loss would make reduced coyote control more acceptable to producers.
  - Management method requirements could easily be made a part of the grazing agreement.

Because these would involve Bureau of Land Management, Forest Service and strong vested interests this would require an extensive effort and would likely always be only a small incidental part of debates on broader issues in public range management and utilization.

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An array of options and sub-options have been presented and discussed. These options have been specified to allow the widest possible range of considerations in the configuration of future ADC programs. Even so, we recognize that there are many additional permutations and combinations of program elements that could be made. If this should be desirable in future deliberations regarding program direction it is our hope that the information presented for these options will be sufficient to provide ready evaluation of any additional options.

These options have been prepared to highlight alternative strategies which are reflective of the following dimensions.

1. A range of alternative budgets, both in terms of total budget levels and also in terms of the components of these budgets (research vs. program operations as an example).

2. Institutional considerations. Varying roles are considered for different Federal agencies, the states in the public sector, and the private sector (primarily the producers).

3. Environmental/toxicological considerations. Here the primary emphasis is on the question of whether a given program component increased or decreased risks of these types.

4. Public opinion/humaneness. This recognizes that there must be consideration of this dimension, that it has played a major role in the past and that it will in the future.

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5. Speed. Some options or sub-options can be implemented almost immediately. Others would require long lead time, especially if dependent on research or the development of new technology. This factor must be considered.

6. Economic consequences. One of the prime motivations for this study are the presumed economic losses being experienced due to predation. Each option must be evaluated according to its impact on producers and consumers.

These options were then evaluated by the application of four criteria: economic benefits; environmental impacts, damage control cost; and acceptability. A numerical ranking system was utilized as a common reference mechanism when judging how each(option or sub-option) ranked for each of the four criteria. Having considered each option in this light the following are the conclusions that can be extracted about the principal characteristics of each major option.

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Strategy/Options

1. Continue Current Program at Alternative Funding Levels: No change in mix of control methods, operational policies, etc.

   - A 50 percent reduction in funding for the ADC program would lead to increased losses, more non-target species taken and a less safe and humane program as more control is done by non-professionals.

   - Retaining the ADC program at the current levels fails to resolve issues relating to loss levels, program effectiveness and the usefulness and appropriateness of alternative control methods.

   - A 50 percent increase in the ADC program would reduce losses, increase economic benefits to producers and consumers, increase the take of both target and non-target species and increase the visibility and hence the controversy concerning the appropriateness of the program and its components.

   - A relaxation of the assumption that there will be no change in the mix of program strategies and policies could lead to substantial changes in the relative emphasis of certain methods, with related differences in economic, environmental, cost and acceptability characteristics. Most likely candidates for elimination include certain high cost, less selective and less productive ground methods in favor of lower cost, more selective, aerial methods. At decreased and fixed funding levels increased expenditures for one method must be accompanied by a decrease for other methods.

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2. Realign Predator Damage Control Responsibilities: Total program funding remains unchanged.

   - The transfer of operational control to USDA would not initially change losses or economic benefits, or environmental impacts, but over time could result in more concern for industry needs, and less attention to environmental consequences as well as safety and humaneness.

   - Transfer of control to the states would result in similar consequences as transfer to USDA, with greater variability and uncertainty for each dimension from state-to-state. Greater attention to the role of coyotes in resident wildlife management would presumably result. Many states presently do not have the capability to assume greater coyote control responsibilities so initial inefficiencies and decreased program effectiveness would result.

   These consequences presume that the multiple wildlife/environmental authorities and programs of the Fish and Wildlife Service, plus the magnitude and flexibility of its many operational, research, monitoring and enforcement programs make it the clear choice to carry out these responsibilities. There may be selected or even substantial exceptions to this judgment, wherein transferring certain functions to the USDA or the states would generate long term positive consequences.

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3. Change Policies to Limit Areas and Methods of Control

- Limiting control of coyotes on public lands would increase livestock losses and reduce environmental impacts. To the extent that required management practices on public lands reduce losses, the economic impacts may be kept at a reasonable level.
- Concentrating ADC activities on population reduction would reduce populations of both target and non-target species, but not necessarily losses of sheep since there would be less control of offending coyotes. The effectiveness of population reduction has not been verified. Losses could be reduced only with budget increases which would maintain existing control programs directed towards offending coyotes. Hazards and environmental impacts would likely increase, as would adverse public reaction.
- Limiting ADC activities to offending coyotes only would decrease adverse public reaction associated with increased humaneness and decreased safety hazard and environmental impacts. With constant budgets sheep losses would decrease resulting in increased economic benefits to both producers and consumers. Public reaction to increased trapping and airborne hunting could be negative if not balanced against safety and environmental dimensions.
- Minimization of the use of lethal control measures would result in decreased coyote take, increased losses and associated economic

consequences, at least initially. Higher budgets would also be required initially. Environmental safety and humaneness factors would be positive. Full utilization of non-lethal methods would require a long transition period. Long run consequences are highly speculative.

4. Increase Operational Use of Toxicants

- An increase in M-44 use and the development of specific applications of other toxicants would reduce livestock losses. There would be more environmental hazards and more danger to man and domesticated animals. Humaneness would increase as less reliance is placed on traps and denning. Environmental impacts would, in the final analysis, depend on what kinds of toxicant application devices are developed and made operational. This option is highly unacceptable to environmental interests and acceptable to producers; there may be more disagreement about this option than any other.

5. Modify ADC Funding Mechanisms

- Consolidating cooperative agreements and associated funding would provide increased flexibility in the delivery of ADC services to priority needs.

- A producer ADC service fee serves two purposes. It provides an incentive to the producer to utilize all available management techniques to reduce his need to acquire these services and it also provides a source of funding directly linked to specific

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clientele.

- Total Federal funding of a consolidated program maximizes program response capability across wide geographic regions while enhancing the likelihood of maximum consideration of environmental and humaneness dimensions.

6. Expand the Extension Program

- This option is an off-shoot of a long-standing, demonstrated, conviction that agricultural extension programs have contributed substantially to the sophisticated, technically advanced state of American agriculture. It is presumed that there is untapped capability for utilizing extension techniques to alleviate predation problems.

- Extension can reduce losses while lowering Federal involvement in operational control. During transition, when direct control would still be utilized in addition to developing extension programs, federal costs would probably increase at first. Producer's costs would ultimately increase as they adopted new techniques. Initially there would be some increase in environmental impact with more non-target species taken, and a decrease in humaneness, both the result of more control done by non-professionals.

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- The potential of west-wide extension programs notwithstanding, its applicability may be somewhat limited on some public lands in the West.

- There is no perceptible difference between placing this extension capability in the FWS or USDA.

7. Compensation of Predation Losses

- o The essense of the several different ways to compensate losses is that producers would be more willing and able to accept losses and there would be less "demand" for ADC control.

- o Compensation through insurance or a subsidy could increase program costs, depending on what level of loss would be covered, at what percent of market value, and what contribution producers make to the fund.

- o There is precedent for a subsidy in the Alberta compensation program, and, for example, in payments to bee keepers and dairy farmers who suffer pesticide contamination.

- o Compensation, if accompanied by lower levels of control, would reduce all the adverse environmental impacts.

8. Increase Predator Research

- o All research must be viewed as providing only long term solutions at best. In that context this option is evaluated on the assumption that all forms of research would be at least marginally productive and would contribute to the control of predators while also achieving critical goals relating to costliness, environmental standards, and humaneness.

- o Non-lethal methods would reduce environmental impacts but would not be as effective in reducing livestock losses as would lethal

controls. Current research on non-lethal methods is minimal.

- o There is more uncertainty about the productivity of non-lethal methods compared to lethal methods.

- o Only through the testing of toxicants on public lands can all questions regarding the feasibility and acceptability to toxicant use on these land types ever be thoroughly evaluated. Absence of this information is a severe handicap in planning and implementing future programs.

9. Promote Better Husbandry Practices to Reduce Depredation

- o Various devices can be appended to control programs to encourage or require certain husbandry practices. As a corally to extension programs, this is designed to maximize the contribution made by the producer to alternating predation losses.

- o In particular,training of sheep herders and compliance with husbandry practice guidelines as a precondition to control assistance offer promise as positive complements to traditional control methods.

Predator control remains a complex issue, one with manifold overtones. The above information has been presented to up-date the body of knowledge available to decisionmakers associated with the control of coyote predation in the West. Consistent with the intent of this effort no attempt has been made to develop one single set of conclusions and associated recommendations in this report. This report is to serve only as a source document

toward that end, as one of any number of ingredients that the Secretary may consider as he makes his decision about the future of the Service's ADC program.

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In this first draft of the report no attempt has been made to properly alphabetize and put into final form the list of references. Thus, the reader should be aware that there are five separate listings in the following section.

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Appendix A

Chronology of Events Leading to Policy Study of Mammal Predation on Western Livestock

This report on Predator Management in the West originated from a letter written to Mr. William Bonde, President of the National Wool Growers Association, by the Secretary of the Interior, Cecil D. Andrus on December 13, 1977. According to that letter, the Assistant Secretary for Fish and Wildlife and Parks, Robert L. Herbst was to "...coordinate all program interests in the Department to develop a study plan for examining the Animal Damage Control program." The Director of the Fish and Wildlife Service delegated direction of the study to the Service's Assistant Director for Planning and Budget. An Animal Damage Control Study Advisory Committee was formed to provide recommendations as to the scope of the study, policy options and other aspects.

Copies of the letter written by the Secretary to Mr. Bonde, the ADC Policy Study Schedule, the original Study Plan, and a list of the ADC Study Advisory Committee members are attached. The Study Schedule notes the most significant dates for the study, including the dates for the Draft Reports and the four regional hearings.

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

DEC 13 1977

Mr. William Bonde
President, National Wool Growers
Association
1776 - F Street, N.W.
Washington, D.C. 20006

Dear Mr. Bonde:

First of all, I want to thank you and the other members of the National Wool Growers Association for sharing your thoughts with me on November 23. I would like to confirm what the Department will do as a result of our discussions.

Basically, you, the National Wool Growers Association, requested me to:

1. Publicly state my support for the industry and concern for losses to predators;

2. Take immediate emergency action to reduce predation;

3. Elevate the status of the Animal Damage Control Program within the Interior Department;

4. Request the emergency use of 1080;

5. Authorize the killing of golden eagles that are causing losses to sheep and goats.

In order for me to fully explore your suggestions--plus some others that concern me--I have asked Assistant Secretary Herbst to take the lead in coordinating all program interests in the Department to develop a study plan for examining the Animal Damage Control Program. The study plan outline should be completed later this month. Mr. Herbst, who will be speaking to your annual convention on January 16, 1978, will share the details of this study plan with you, as well as the process to be followed in the conduct of this examination.

I have also asked Assistant Secretary Herbst to have the completed report and a series of program options to me in the spring of 1978. During preparation of this report, I have directed that your organization be afforded a full opportunity to make a contribution to the effort.

I have asked to review a plan for the management of golden eagles in the near future. This plan will address issues, among others, which are specifically related to the problems of eagles in conflict with livestock.

I also want to be sure that other elements of the livestock industry, as well as other interested conservation agencies and organizations, contribute to the study to assure that I have the best advice possible prior to my final decision on policy issues.

You will be contacted directly by those persons in the U.S. Fish and Wildlife Service who are responsible for this report.

Sincerely,

(Sgd) Cecil D. Andrus

SECRETARY

U.S. FISH AND WILDLIFE SERVICE
STUDY PLAN

FEB 9 1978

POLICY ANALYSIS OF THE PROBLEMS
OF MAMMAL PREDATION ON WESTERN LIVESTOCK

INTRODUCTION

This Study Plan sets forth the purpose, topic outline, and general procedures of the study. The study will be a comprehensive examination of the problems of mammal predation on Western livestock. Primary emphasis will be placed on the Federal role related to the problems of coyote depredation on sheep and cattle.

The analysis will produce two products -- a Report and an Option Paper. The Report will bring together, in an analytical framework, relevant information and data relating to the topic as identified in this study plan. The Option Paper will be derived from the Report and will present the pros and cons of specific courses of action (policy) in brief. The Option Paper will be used as a basic decisionmaking aid at the Secretarial level.

The analysis will focus on:

- An examination of the nature and scope of the problems affecting the Western livestock industry.
- Environmental concerns associated with predator damage control practices.
- An identification of options, including alternatives to direct control methods as well as including various ADC Program levels.
- The consequences of these options.

The study is viewed as having two facets: economic problems of the industry and environmental/ecological concerns. These facets surface quite emotionally as socio-political concerns whenever changes are suggested in animal control activities. The study must rely largely on existing information. Existing data on many aspects of the problem are abundant, but require further synthesis and interpretation. One of the most important tasks is assessing the reliability of this data as well as the findings of the many previous related analyses. The major topics to be investigated are:

Earlier Studies. Numerous studies have been conducted which dealt directly with or related to livestock predation problems. These studies cover several scientific fields, and for the most part, cover specific kinds of livestock and geographical areas.

There have been two major policy studies dealing with animal damage control -- the "Leopold Report" (1964) and the "Cain Report" (1972). The Leopold Report was initiated by Secretary Udall to investigate the animal damage control role and practices of the Federal government, and to make recommendations, if needed, to ensure an environmentally sound and socially acceptable Federal Animal Damage Control program.

In response to rising national controversy over predator control, The Department of The Interior and CEQ jointly sponsored an intensive study and evaluation of the entire predator damage situation in the United States. The results, known as the Cain Report, both addressed and raised many questions which remain controversial. For example, Executive Order 11643, which highly restricted the use of toxic chemicals (predicides) in Federal ADC programs, was based on one of the recommendations.

Proper Federal Role. There are valid arguments for and against Federal involvement in predator control. Economic arguments can be made on both sides. The Animal Damge Control Act of 1931 authorized a control program, but as is common with such legislation, fails to specify control levels. In addition to the question size there are also questions relating to ADC Program objectives, balance, operations, and research. These include, but are not limited to, the mix of direct (usually lethal) control methods, geographic allocation of control efforts, cooperative agreements and funding arrangements, emphasis on direct control methods as opposed to alternatives to direct control, and the development of new "tools" for the fight against predator livestock damage.

Economics. Economics was given scant consideration in the Leopold Report, and only cursory consideration in the Cain Report. This section will concentrate on the economic aspects of the industry (primarily Western sheep and cattle ranching) and the economic benefits to society as a whole arising from animal damage control. Included will be: economic trends and their reasons; the structure and composition of the industry -- past, present, and future; equity considerations (who pays and who benefits); efficiency considerations; (output per unit cost); allocation of ADC resources (geographically, control methods); cost effectiveness; etc. Particular emphasis will be placed on the problems of the industry, with the focus on predation as one of several forces impacting on the industry. One objective will be to determine the economic effects of predation independent of other factors.

ADC Service Delivery Approaches. This section will focus on the various direct control methods and alternatives to direct control, as listed in the outline, individually, and by a cross-analysis of thier cost effectiveness, humaneness, selectivity, acceptability and legality. Because several of the alternatives to direct control fall outside the normal purview of the Department of the Interior, possible new roles for the Department of Agriculture and the States will also be considered.

This section will consider in some depth alternatives such as taxation remedies, changes in public range use policies such as altering grazing fee structures and use patterns, husbandry options, and more conditional delivery of ADC services. The feasibility of using extension activities for alleviating livestock depredation problems in open range states will be evaluated. It will be impossible to evaluate every non-lethal management and public policy option with the depth required to make specific recommendations as to their implementation. The objective will be to delve deeply enough into those options which show the greatest promise, based on the analysis, to be

able to make judgements on their probable feasibility. However, promising alternatives may require further evaluation, beyond this study.

Ecological/Environmental. What are the ecologic (short and long term) impacts from various levels of control and from various kinds (and mixes) of control methods? This is the main question to be addressed in this section. Consideration will also be given to grazing and livestock management practices as they may relate to predation. The selectivity of various control methods and the impacts of control on both target and non-target species and the environment in general will also be evaluated.

Public opinion and perceptions. Public perception and opinion about predator damage and control have not been major topics in previous studies. Recently, however, substantive information has or soon will become available from several sources. This material will be synthesized and made an integral part of the study.

SCHEDULING

The diagram describes the study milestones in terms of the two primary products (the Report and the Option Paper), the Animal Damage Control (ADC) Policy Study Advisory Committee, and public involvement. Briefly, the study will commence in January, 1978; the Advisory Committee will be formed and meet for the first time in early February (1978); a draft report will be available for public review in April; public hearings will be held in May; and, the Report and Option Paper will be delivered to the Secretary in June (1978).

ADC POLICY STUDY ADVISORY COMMITTEE

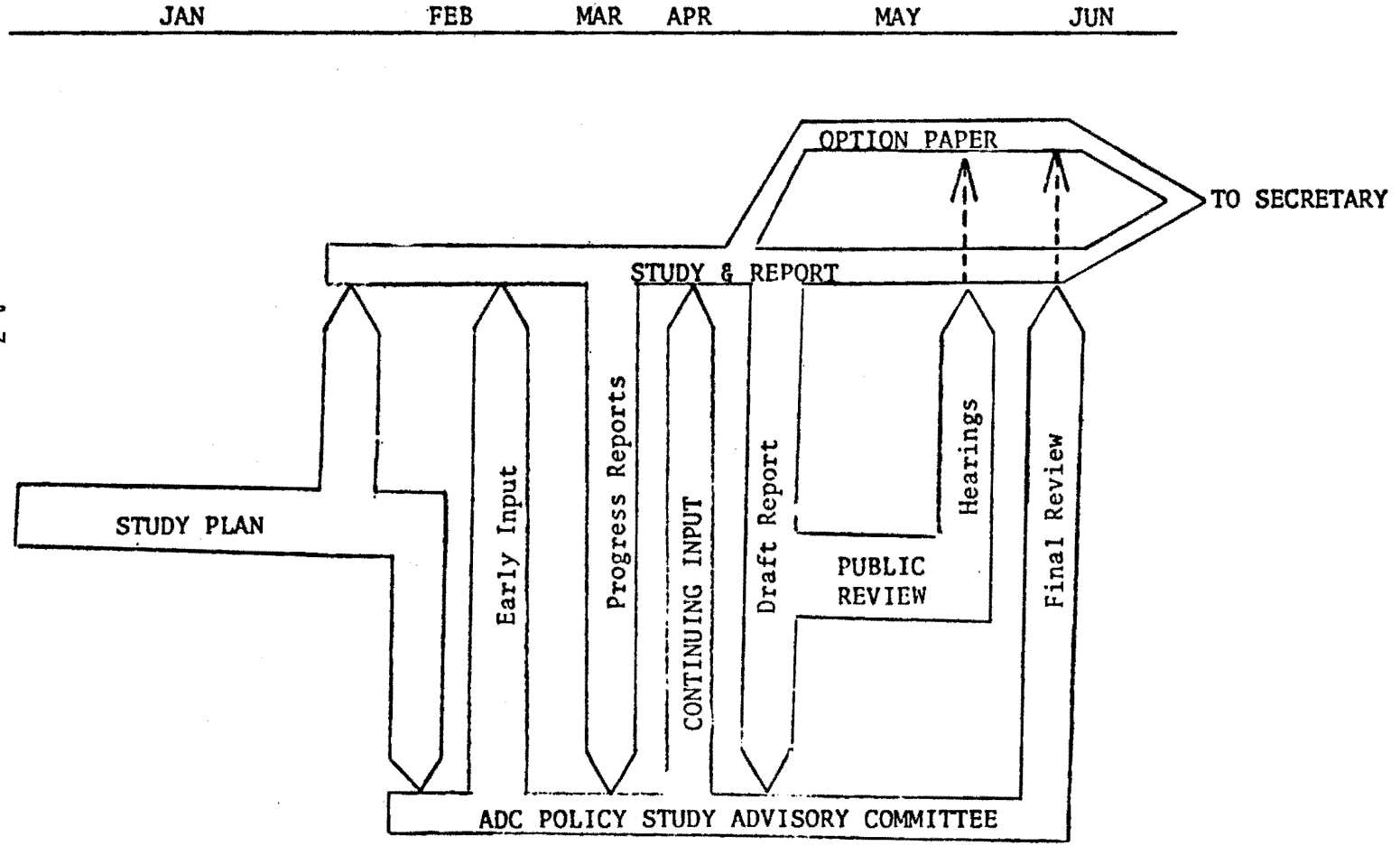
An external advisory committee will be established under the chairmanship of Richard Myshak, Deputy Assistant Secretary for Fish, Wildlife and Parks, to review this study plan and help validate the use and interpretation of data. Although the Committee will make recommendations, eventual decision-making must remain with the Director, U.S. Fish and Wildlife Service, the Assistant Secretary, and the Secretary.

The Committee will help assure that options are properly enunciated, the analysis is technically sound, and that the study is conducted in an open manner. Hopefully, the Committee will also serve to temper the differing concerns of the livestock industry and the conservation and environmental communities. To achieve these aims, and assure fairness, objectivity, and expertise in the conduct of the analysis, the Committee will consist of a balanced cross-section of representatives from the livestock industry, environmental/conservation community, State government, academia, and the Federal government.

The Committee is viewed as a reservoir of diverse talent, and will function primarily in a review capacity. When a component of the study is in readable draft form, it will be sent to each member of the Committee for comment. For the most part, the individual reviews

ADC POLICY STUDY

1978



will take place between the two Committee meetings (between the first of February and early April). Additional meetings may be scheduled, depending on need.

PUBLIC INVOLVEMENT

Many persons are vitally concerned about animal damage control and harbor opinions that deserve consideration during policy-making. This study will afford all who wish to express their opinions on the topic the opportunity to do so, and to have those opinions given serious consideration. As displayed in the diagram, formalized public involvement will begin with the availability of the Draft Report and commence with public hearings as announced in the Federal Register. At that time, three public hearings are anticipated: in Denver, Ft. Worth, and Washington, D.C. These actions will result in opportunities for significant and meaningful public input.

STUDY DIRECTION

The Director of the Fish and Wildlife Service has delegated direction of the study to the Service's Assistant Director for Planning and Budget. In addition to the traditional ecologic/environmental considerations, considerable attention will be directed toward the economics, public opinion, and perception, as they relate to ADC-related policy. This is being done, in part, because of new and/or better information, but also because the importance of bringing together, in one analytical study, all aspects of the problem.

Substantial information and expertise on livestock predation exists within the Service's Divisions of Wildlife Research and Animal Damage Control. This expertise will be utilized extensively in carrying out the study. However, because of the historically controversial nature of animal damage control activities and to guarantee balance and objectivity, it will be necessary to tap outside sources as well, to be used when Service expertise is lacking, or where time does not permit a more comprehensive Service effort.

OPTION PAPER

As noted above, one of the two products will be a Secretarial Option Paper. The paer will briefly review the Report, present a series of options, and state their pros and cons.

2/9/78

STUDY OUTLINE

A. DEFINITION OF THE PROBLEM

1. Balance in fulfilling the secretary's dual responsibilities, predator control and wildlife management
2. Economic effects on consumers and producers
3. Environmental concerns
4. Public perception as a policy component

B. BACKGROUND AND SUB-ISSUES

1. Review of critical literature
2. Review of Federal-state-local-private roles
3. FWS Animal Damage Control Program

   a. Operations, budget and accomplishment history
   b. Comparison to state-local and private efforts
   c. History of operation policies
   d. FWS research, with reference to all ADC research

4. Economics

   a. Recent economic history

      i. of impacted segments of livestock industry
      ii. of entire industry only as affected by impacted segments

   b. Past and present distribution of producer and consumer costs and benefits

5. Ecological/Environmental

   a. Recent history of ecological/environmental issue, actions and related events

      i. Research and findings on alternative predator control strategies and devices
      ii. Federal agency positions on alternative predator strategies and devices (USDI, USDA, CEQ, EPA)
      iii. Related resource use policy, esp., range management policy & USDI, USDA)
      iv. Population characteristics and biological roles of affected target and non-target species

6. Public Perceptions Toward Predation and Control

   a. Public views and opinions
   b. Policy implications

C. ADC OPERATIONAL COMPONENTS

1. Direct control (traditional program orientation)

   a. trapping
   b. aerial shooting
   c. denning
   d. ground shooting
   e. M-44's
   f. toxicants
   g. others

2. Alternative to direct control

   a. indemnity plan options
   b. management incentive options (e.g., through taxation or through allocation of ADC services)
   c. Public range use policy
   d. Demonstration projects
   e. Extension
   f. Import duties and tariff adjustments
   g. Improved husbandry practices
   h. Others

--Analyzed and Compared in relation to--

   a. Cost effectiveness
   b. Relative humaneness
   c. Public acceptability
   d. Legal constraints
   e. Ecological/Environmental impacts
   f. selectivity
   g. possible roles for other Federal entities and the States
   h. Integration of lethal and non-lethal control methods and alternatives to direct control methods
   i. impacts on ecosystem
   j. impacts on recreation
   k. safety

D. DELINEATION OF SPECIFIC OPTIONAL ADC STRATEGIES/PROGRAMS

E. PROS AND CONS OF SELECTED OPTIONS

F. SUMMARY AND CONCLUSIONS

United States Department of the Interior

WASHINGTON, D.C. 20240

February 2, 1978

OFFICE OF THE ASSISTANT SECRETARY

Animal Damage Control Study Advisory Committee

Chairman: Richard J. Myshak, Deputy Assistant Secretary for Fish and Wildlife and Parks, U.S. Department of the Interior

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JOHNNY HORIZON 76

Let's Clean Up America For Our 200th Birthday .

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SCHEDULE FOR ADC POLICY STUDY

ISSUE	STEPS	RESPONSIBILITY	TARGET DATE	COMMENTS
-Conduct a comprehensive examination of the problems of mammal predation on western livestock. Primary emphasis will be placed on the Federal role related to the problems of coyote depredation on sheep and cattle. The analysis will produce two products-a report and option paper. The report will bring together, in an analytical framework, relevant information and data relating to the topic as identified in this study plan. The option paper, derived from the report, will be used as a basic decisionmaking aid at the Secretarial level.	1. Study Plan	Assistant Director (AP) Planning and Budget	January 30	Published in Federal Register
	2. Early Input	ADC Policy Study Advisory Committee	February 8 & 9	Published in Federal Register
	3. Progress Reports	Chief, Division of Program Plans	As Appropriate	--------
	4. Continuing Input	ADC Policy Study Advisory Committee	Continuing	Mostly through individual comment
	5. First Draft Report	Chief, Division of Program Plans	May 5	Announce Availability of Report in Federal Register
	6. Review Draft Report	ADC Policy Study Advisory Committee, Boise, Idaho	May 21	Hearings and Advisory Committee meetings to be announced in Federal Register before April 21.
	7. Public Review	All Interested Parties		
	a. Three Regional Hearings	Boise, Idaho	May 22	
		Casper, Wyoming	May 23	
	b. Washington, D.C. Hearing	San Angelo, Texas	May 25	
		Washington, D.C.	May 31	
	8. Second Draft Report	Chief, Division of Program Plans	June 12	---------
	9. Final Review	ADC Policy Study Advisory Committee	June 22	---------
	10. Draft SID to Departmental Review	ES	July 7	---------
	11. Submit Option Paper to Secretary	A/S Herbst	July 21	----------

Appendix B: The Indirect Effects of Coyote Control on Game Species

The basic question concerning the effect of coyote control on game species is whether or not predators limit the numbers of deer, ducks, pheasants, or grouse and, therefore, limit the numbers of those species available to hunters.

This appendix reviews research results as they bear on that question. Any examination of the literature will reveal some cases where predators had a substantial or limiting effect and others where they did not. In a thorough review of predation on North American ungulates, for example, Connolly (1978) cited 31 documented cases in which predators exerted a limiting or regulating influence, and 27 more instances in which predation was judged not to be limiting the size of ungulate populations. These cases are listed in Tables 1 and 2, respectively.

There is no comparable review of the literature on upland game or waterfowl, but it is believed that the general principles developed from studies of big game also apply to small game.

The main issues and findings are:

(1) Most game populations are subject to predation as one of several limiting or regulatory influences. Predator control, or protection from predation, should therefore be considered as one of the management options whenever increased game production is desired.

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(2) Predators can limit game populations, and are most likely to do so when the ratio of predators to prey is high.

(3) Where predator control does affect game populations the effect is usually beneficial, but that is not always the case. For example, studies by Sargeant (1972) and Johnson and Sargeant (1977) suggest that predator-prey relationships are such that coyote control has an adverse effect on dabbling duck populations. This paradoxical outcome is based on evidence that coyotes and red fox complete as predators in the prairie pothole region, and that fox have a greater impact on duck populations than do coyotes because of their predatory habits and population characteristics. Hence, any change that favors red fox, such as fewer competing coyotes, is likely to disfavor dabbling ducks.

(4) Predator food studies reveal little about the impact of predators on prey populations.

(5) Mortality studies in game populations frequently show predation to be a major cause of loss, but leave unresolved the question of whether or not predation actually limits prey numbers.

(6) Predation is not limited to inferior or sick prey individuals whose death is imminent; healthy animals are taken as well. Predation is frequently selective for certain age or sex classes of the prey, such as fawns, adult males, or nesting hens.

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(7) Game declines due to habitat deterioration or overuse cannot be reversed by predator control. However, this obvious logic may be hard to practice because it is not always possible to determine if a given habitat is overused or deteriorating.

(8) When predator control is not followed by increased game production, one would usually conclude that predation was not the limiting factor in that case. But ineffectiveness can also result from a failure to remove enough predators.

(9) Predator control, at times, may provide long range benefits for the predator that is being controlled. In part of the Superior National Forest (Minnesota), for example, wolves extirpated their major prey, the white-tailed deer. After the deer were gone, the wolf population declined approximately 55 percent. But if wolf numbers had been 25 percent lower in each year, they would not have exterminated their prey (Mech and Karns,1977).

(10) The most valuable studies of predator/game relations are probably those that measure the response of game populations to predator control.

(11) Because predation can be limiting under some circumstances but not others, general principles are hard to apply to specific cases. Each situation must be judged on its own merits, using the best data and expertise available.

From these principles, Connolly (1978) proposed a rationale to guide decisions for or against the use of predator control in specific game management situations. This rationale (Figure 1) was aimed at ungulate management, but probably applies equally well to other forms of wildlife.

It should be frankly recognized that, in the exercise of predator control to protect other wildlife, the most important decisions to be made are political ones. In particular, the responsible authorities must decide that the game to be produced is more desirable or more valuable than the predators to be destroyed. For game populations that are hunted, it must also be decided whether or not man should receive preference over other predators in the use of the harvestable game. Most of the other issues identified in Figure 1 are less political, but because hard data are not usually available these issues place a premium on the professional judgment of the responsible wildlife managers. To justify the exercise of predator control in game management, the game managers should find that hunters will be able to use the increased production of game, that the habitat will support more game, that predator control will permit the game to increase, and that predator control is economically feasible and acceptable in terms of its environmental impact.

SUMMARY

Careful biological justification is required for the exercise of predator control in game management. In general, control is appropriate when

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it will produce substantial increases of more desirable wildlife, at reasonable cost without undue damage to other environmental values, and when the increased game production will be used.

Figure 1. Proposed logic for the use of predator control in ungulate management.

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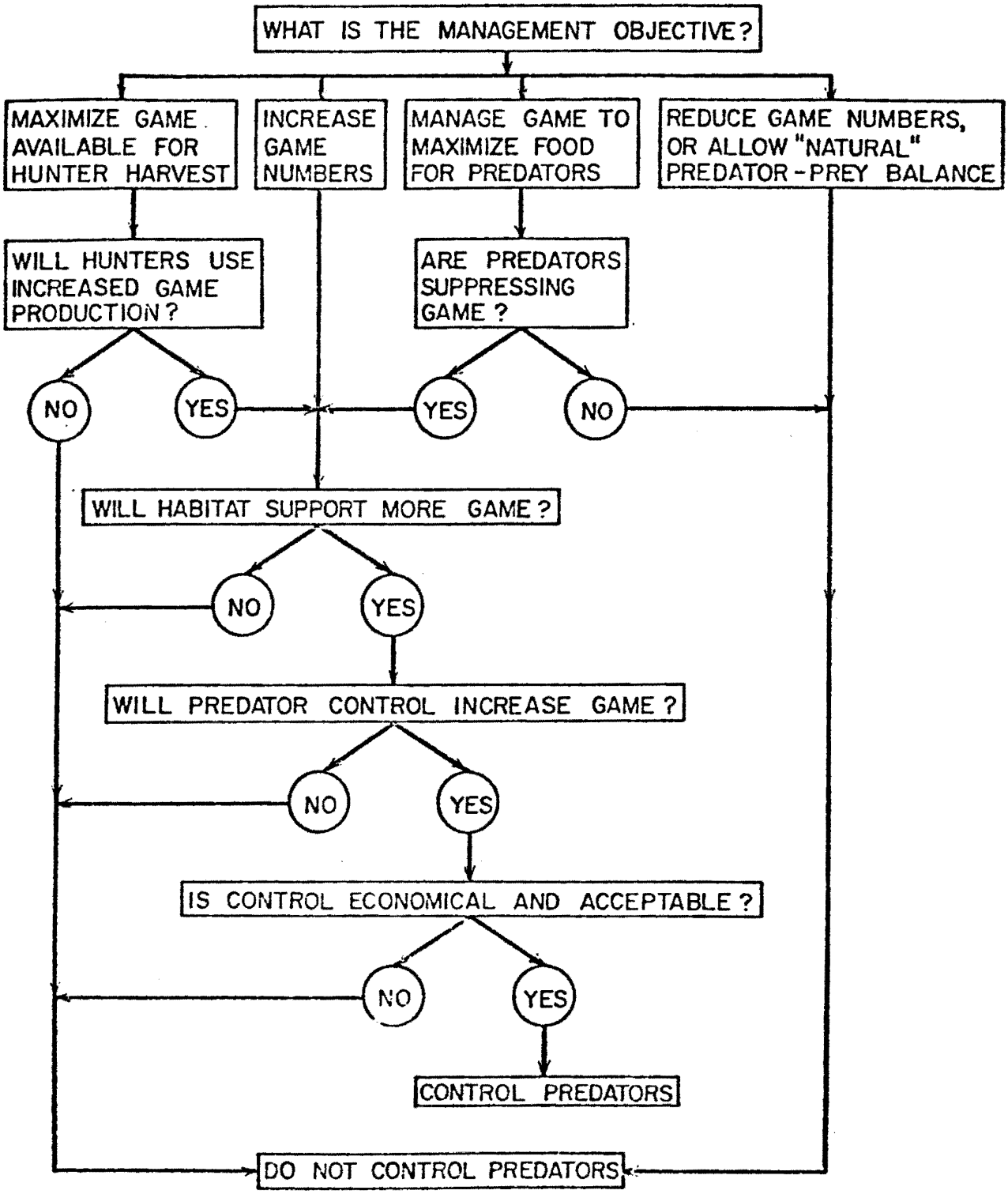

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Table 1. Reports of predation as a limiting or regulating influence on ungulate populations in North America.

Prey	Predator	Location of Study Area	Notes	References 1/
White-tailed deer	Coyote	Texas	Coyotes caused 53% to 80% of the fawn mortality and played a major role in stabilizing deer with their food supply.	(1)
White-tailed deer	Coyote, bobcat	Texas	Following removal of predators, fawn:doe ratios were 300% to 400% higher than in the check area (no control).	(2)
White-tailed deer	Coyote	Texas	Deer were declining due to habitat modification by man. Coyotes caused 10% to 60% of fawn losses in various years. Predator control was recommended to slow the rate of decline.	(3)
White-tailed deer	Wolf	Ontario	Wolves were believed to be capable of controlling deer if there was more than 1 wolf per 100 to 150 deer. Wolf predation was a major deer mortality factor.	(4)
White-tailed deer	Wolf	Minnesota	Deer decline due to other causes was accelerated by wolf predation. A combination of deteriorating habitat, severe winters, and use of alternate prey enabled wolves to literally kill off the deer in part of the Superior National Forest.	(5)
Deer	Wolf, cougar	North America	Removal of predators was implicated as a cause of deer irruptions.	(6)
Mule deer	Coyote, bobcat	Oregon	Predators, mostly coyotes, killed at least 31 of 48 instrumented fawns which died. Coyote control on winter deer range appeared to increase winter survival of fawns.	(7)

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Table 1. (Continued)

Prey	Predator	Location of Study Area	Notes	References 1/
Mule deer	Coyote	Arizona	The number of fawns per 100 does was 16% higher where 1080 was used against coyotes than on areas where toxicants had not been used for 2 years.	(8)
Mule deer	Coyote	Utah	After reduction of coyotes with 1080, the number of fawns per 100 does increased 17% on one range and 7% on another.	(9)
Mule deer	Coyote	Utah	Post-winter numbers of fawns per 100 adults averaged 29 on a range with light predator control and 59 on a nearby range with more intensive control. Pre-winter fawn:adult ratios did not differ.	(10)
Black-tailed deer	Coyote	California	Fawn survival reportedly increased following removal of coyotes.	(11)
Black-tailed deer	Coyote	Washington	Fawn:doe ratios improved on 32,000 hectares (80,000 acres) treated with 1080, but remained low on a no-control area. Density of poison bait stations was one per 2.6 square kilometers (1 mi^2).	(12)
Black-tailed deer	Cougar	California	Following removal of cougars, deer increased and were eventually reduced by disease.	(13)
Sitka deer	Wolf	Coronation Is., AK	Introduced wolves increased, reduced deer drastically, and then declined to extinction.	(14)
Sitka deer	Wolf	Alaska	Wolves appeared to hold deer in balance with habitat during study of Klein and Olson (1960), but later the deer were virtually extirpated by predation and starvation losses during 3 severe winters. As of 1977, wolf populations also were depressed.	(15)

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Table 1. (Continued)

Prey	Predator	Location of Study Area	Notes	References 1/
Elk	Black bear	Idaho	Bears were the main cause of a 68% calf loss from calving through October.	(16)
Moose	Wolf	Isle Royale, MI	In early 1960's wolves and moose appeared stable with wolves holding moose within range carrying capacity. In early 1970's moose vulnerability to wolf predation increased due to severe weather and habitat changes. From 1969 to 1976 wolf numbers increased 250% while moose declined 40%.	(17)
Moose	Wolf	Alaska	Moose declined primarily because of severe winters; wolves appeared to be preventing recovery. Approximately 86% of calves died in their first 2 to 3 months of life.	(18)
Caribou	Lynx	Newfoundland	Lynx predation was the primary mortality factor. Following lynx trapping, improved survival of calves to 2 years of age was documented (by comparison with no-control area).	(19)
Caribou	Wolf, man	North America	The general decline of caribou in the 1800's and early 1900's was due to predation by humans and wolves.	(20)
Caribou	Wolf	Northwest Territories	High calf mortality, due primarily to wolf predation prevented the herd from increasing. Caribou population was well below range capacity.	(21)
Caribou	Wolf, man	Alaska	Western Arctic herd declined from 242,000 caribou to 50,000 between 1970 and 1976 due to predation by humans and wolves. Even without human harvest, wolf predation could continue the decline.	(22)

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Table 1. (Continued)

Prey	Predator	Location of Study Area	Notes	References [1/]
Antelope	Coyote	Texas	Coyote predation on fawns prevented antelope from increasing. Coyote control with cyanide guns, strychnine drop baits, and steel traps failed to reduce coyote numbers significantly and therefore did not reduce the level of predation.	(23)
Antelope	Coyote	Arizona	Predator control caused antelope to increase enough to be hunted. The 1080 program cost $0.12 per square kilometer ($11 per township).	(24)
Antelope	Coyote	Oregon	Antelope herds recovered from about 1,000 in 1920 to 10,000 by 1935 due to protection and elimination of 7,500 predators.	(25)
Antelope	Coyote	Utah	Removal of coyotes increased fawn:doe ratios in small (remnant) herds. Other limiting factors included illegal killing, severe winters, and overgrazing by livestock.	(26)
Antelope	Coyote	Texas	Compared to a range without predator control, the number of fawns per 100 does were 142% and 129% higher (in successive years) where coyotes had been removed.	(27)
Antelope	Coyote	Oregon	Seventeen antelope transplanted to the Umatilla Ordinance Depot in 1969 failed to increase. Following the removal of 135 coyotes (2.1/km^2; 5.4/mi^2) during winter of 1970-71, nine does produced 13 fawns in 1971. Coyote control was continued and the herd increased to about 100 by July 1976.	(28)

Table 1. (Continued)

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Prey	Predator	Location of Study Area	Notes	References 1/
Antelope	Bobcat	Utah	Of 44 instrumented antelope fawns recovered after death, 29 had been killed by bobcats. Bobcat predation was the greatest single decimating factor. Only a few individual bobcats were involved.	(29)
Desert bighorn sheep	Coyote, bobcat	Arizona	Predator control helped raise the lamb:yearling ratio from 100:16 to 100:71.	(30)
Dall sheep	Wolf	Alaska	Wolves held sheep numbers in check even though caribou were their main prey.	(31)

1/ References:

(1) Knowlton (1968), Cook et al. (1971).
(2) Beasom (1974a,b).
(3) Daniel (1976).
(4) Pimlott (1967), Pimlott et al. (1969).
(5) Van Ballenberghe et al. (1975:38), Mech and Karns (1977).
(6) Leopold et al. (1947).
(7) Trainer (1975), Ebert (1976).
(8) McMichael (1970).
(9) Robinette et al. (1977).
(10) Austin et al. (1977).
(11) Horn (1941, Young and Jackson (1951:143). Also see Longhurst et al. (1952:75) and Robinette et al. (1977).
(12) Brown (1961:43).
(13) McLean (1954).
(14) Klein (1959) Rausch (1972).
(15) Klein and Olson (1960), McKnight (1977).
(16) Schlegel (1976).
(17) Mech (1966, 1970), Peterson (1976).
(18) Coady (1976).
(19) Bergerud (1971:53).
(20) Bergerud (1974).
(21) Miller and Broughton (1974).
(22) Anonymous (1976).
(23) Jones (1949:29).
(24) Arrington and Edwards (1951).
(25) Young and Jackson (1951:147-148).
(26) Udy (1953).
(27) Knowlton et al. (1971)
(28) Anonymous (1972), OR Dept. Fish and Wildl. unpub. records.
(29) Beale and Smith (1973).
(30) Halloran (1949).
(31) Murie (1944).

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Table 2. Studies which have found predators not to control or limit the size of ungulate populations in North America.

Prey	Predator	Location of Study Area	Notes	References [1]
White-tailed deer	Coyote	Washington	More deer died from other natural causes than from predation.	(1)
White-tailed deer	Coyote	Michigan	Deer carrion was the primary winter food of coyotes. Few deer were actually killed.	(2)
White-tailed deer	Dog	Missouri	Dogs harassed deer but were negligible as a direct cause of mortality.	(3)
White-tailed deer	Dog	Alabama	Transplanted deer increased greatly in the presence of feral and free-ranging dogs.	(4)
White-tailed deer	Wolf	Wisconsin	An overpopulation of deer developed in spite of the presence of wolves. Wolf density was 1 per 90 square kilometers (35 mi^2).	(5)
White-tailed deer	Wolf	Ontario	During winter wolves removed from 9% to 11% of deer present in late fall.	(6)
White-tailed deer	Several species	Ontario	Deep snow was the limiting factor for deer over much of Ontario.	(7)
Mule deer	Coyote	California	Deer declined in spite of intensive coyote reduction with 1080.	(8)
Mule deer	Coyote	Arizona	Despite heavy predation, fawn survival was correlated with rainfall and winter forb yield.	(9)
Mule deer	Coyote	Nevada	Coyote control with 1080 failed to reverse poor fawn crops due to range deterioration. Any possible effects of predation were masked by the influence of declining range.	(10)

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Table 2. (Continued)

Prey	Predator	Location of Study Area	Notes	References 1/
Mule deer	Coyote, black bear	California	Predators took many deer, yet range remained overpopulated with deer.	(11)
Mule deer	Cougar, coyote	Utah	Predation was the major natural mortality factor but was considered to be beneficial.	(12)
Mule deer	Cougar	Arizona	Deer were below range capacity and lions killed more deer than did hunters. Yet it appeared that lion predation would not keep deer from increasing if other losses could be reduced.	(13)
Mule deer	Several species	Arizona	On most Arizona deer ranges, food was the primary limiting factor.	(14)
Mule deer	Several species	Nevada	Cougars, coyotes, and golden eagles had no notable impact. The effects of bobcat predation was uncertain.	(15)
Black-tailed deer	Coyote, bobcat	California	Predators killed a few deer, mostly fawns, but were not an important deer mortality factor.	(16)
Mule deer, elk	Cougar	Idaho	The density of lions remained constant while deer and elk increased.	(17)
Elk	Cougar	North America	Lion predation was not normally a problem in elk management.	(18)
Elk	Kodiak bear	Afognak Island, AK	Transplanted elk increased in spite of abundance of bears.	(19)
Elk	Grizzly bear	Yellowstone Park, WY	Predation assisted other natural processes that regulated elk numbers.	(20)

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Table 2. (Continued)

Prey	Predator	Location of Study Area	Notes	References 1/
Caribou	Wolf	Canada	After intensive wolf control for 11 years, it remained uncertain whether predator control benefitted the caribou. Overhunting was the main problem; wolves took 5% or less of the caribou each year.	(21)
Antelope	Golden eagle	Utah	Range condition, not predation, was identified as the key to antelope survival. Actual impact of eagle predation was not determined.	(22)
Bighorn sheep	Coyote	Wyoming	Predation caused few lamb losses although coyotes ate most of the sheep that died. Coyotes were reduced 75% by trapping but lamb survival did not improve.	(23)
Bighorn sheep	Several species	United States	Wolves and cougars might have depressant effects if they were present on bighorn ranges. Coyotes and eagles had no significant effect.	(24)
Bighorn sheep	Several species	Colorado	A high rate of lamb mortality was due to disease.	(25)
Several species	Coyote	Yellowstone Park, WY	Ungulate populations were limited by range conditions. Coyotes took only weak and sick animals.	(26)
Six species	Wolf	Rocky Mtn. Parks, Canada	Wolves did not control big game. 300 to 400 ungulates were present for each wolf.	(27)

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Table 2. Footnotes

1/ References:

(1) Ogle (1971).
(2) Ozoga and Harger (1966).
(3) Progulske and Baskett (1958).
(4) Scott and Causey (1973).
(5) Thompson (1952).
(6) Kolenosky (1972).
(7) Cumming and Walden (1970:22-23).
(8) Longhurst et al. (1952:76).
(9) Smith and LeCount (1976).
(10) Robinette et al. (1977).
(11) Leopold et al. (1951:61).
(12) Richens (1967).
(13) Shaw (1976).
(14) Swank (1958:34,57)
(15) Papez (1976:39)
(16) Taber and Dasmann (1958:134)
(17) Hornocker (1970:30)
(18) Murie (1951:314).
(19) Troyer (1960).
(20) Cole (1972).
(21) Kelsall (1968:282).
(22) Hinman (1961).
(23) Honess and Frost (1942:53-55).
(24) Buechner (1960:111-116).
(25) Woodard et al. (1974).
(26) Murie (1940).
(27) Cowan (1947).

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Appendix C

COMPUTER SIMULATION MODELS IN PREDATOR MANAGEMENT

A simulation model is a set of equations that show how something works. A population simulation model forecasts how the number of animals in a population changes over time. Any such model can be as simple or as complex as the modeler wants it to be. Simulation models do not necessarily require computers, but usually they are run on computers.

Simulations have been developed for the coyote, red fox, bobcat, and other predator species, but most predator modeling work has focused on the coyote. Because the coyote is the main target of the ADC predator control program, this discussion is limited to coyote models. The Management Information System, currently under development within the ADC Program, will not be a simulation model but an inventory and record-keeping system. Simulation models, in contrast, combine information with assumptions to generate predictions. Unfortunately, most reports about models expound the predictions at length and give relatively little space to the qualifications that must be attached to the predictions.

Regarding the use of computerized models to aid decisions about predator management, the most important point is that such models must be used with caution. The models are attractive because they offer recommendations and conclusions on some of the key issues in predator management, in a way that, at least superficially, appears to be scientific and objective. But in order to focus on these key issues, the modelers must generalize and simplify the

real world events or phenomena that are being simulated. The simplifications are accomplished both by fabricating data to fit the needs of the model and by using assumptions of unwarranted simplicity. In addition, some important variable are omitted simply because the modelers can't figure out how to get them into the model. For these reasons, any potential user of such a model must not only scrutinize the assumptions and predictive functions in the model, but must also consider what important relationships have been left out. Such scrutiny is more difficult than one might think, because most publications on models fail to spell out the assumptions clearly. And even if the assumptions are qualified in the written report, within the model they are treated as unequivocal, literal truths.

THE MAGIC OF THE COMPUTER

Most simulation models are run on large computers. There are two reasons for this: (1) some models require so many calculations that to do them all by hand would be impossible; and (2) modelers have found that the credibility and acceptance of their models is enhanced by association with the computer.

Even though the computer performs only the bookkeeping, the very fact that a model is run through a computer creates an aura of respectability and glamour that would vanish if the same calculations were performed by hand. Yet, the paper and pencil work is the most important part of any simulation model. The computer is only an accounting slave, reproducing as fact whatever input is fed to it.

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The sole advantage of computers to simulation modeling is their high computational speed. This advantage is at least partly offset by the disadvantage of secrecy--the computer shields the model, the data, and the assumptions from scrutiny by outsiders, and particularly by outsiders who lack expertise with computers.

TWO EXAMPLES OF COYOTE SIMULATION MODELS

There are two arbitrary levels of complexity in the coyote models that have been developed to date. The simplest models are limited to coyote population dynamics; that is, changes in coyote numbers over time with or without the influence of predator control. A much higher order of complexity is seen in the Economic Research Service (ERS) model, that combines coyote population dynamics with a large variety of other variables relating to livestock losses, predator control methods and costs, public attitudes and values, etc., to produce a purportedly comprehensive, decision-making tool. Both types of models are discussed here.

(1) Population dynamics models have been developed by at least 4 different research groups, but only one of these models has been described in a published report (Connolly and Longhurst 1975). This model, and the other three unpublished ones, all assess changes in coyote numbers in response to predator control of various intensities.

The main conclusions of Connolly and Longhurst (1975) were that coyote populations can persist even when 70 to 75 percent of the animals are killed each year, and that populations held down by intensive control can rebuild

to pre-control levels within 3 to 5 years after control is stopped. But to experienced predator control men, these findings are not new. It is common knowledge that coyotes can withstand intensive predator control, and that they can recover quickly if control is stopped. Therefore we must conclude that the Connolly-Longhurst models, and others like it, do not give new information. Rather, they reinforce and quantify the knowledge that is already on hand. The greatest potential for application of these models, in our opinion, lies in the educational and public relations aspects of predator control work. For more detailed discussion about coyote population dynamics models, see Connolly (1978a,b).

(2) The most complicated coyote model ever developed is the work of Gum and Arthur (1977) and their colleagues in the Economic Research Service. The ERS model has not yet been unveiled in public, but several manuscript drafts related to it have been circulated for review. Our present assessment is based on our evaluation of these unpublished reports, together with personal discussions with Dr. Gum and his associates.

From the summary statements that have been circulated about the ERS model, one gets the impression that it is a very powerful model indeed. The abstract of Gum and Arthur (1977) states that 8.5 percent of the lambs (in the western U. S.) were killed by coyotes in 1974 even though $7 million was spent on coyote control. According to the model, the lamb loss would have been only 4 percent if $20 million had been spent on control, using the same mix of methods. Also it was said that both "economic and socio-environmental

benefits" would increase if predator control workers would use more M-44's and aerial gunning and fewer traps.

"With the computerized information system it is possible to evaluate any of an infinite array of alternatives. A decision maker selects any alternative control policy, inputs the expenditures for each method, and immediately receives a summary table of the predicted impacts of the selected policy. More detailed information concerning the predicted lamb losses, coyote population level, socio-environmental impacts, economic impacts on producers and consumers, and trade offs between two impact categories can then be retrieved" (Gum and Arthur 1977).

Unfortunately, the inner workings of this model are a well-kept secret. The reports we have seen do not adequately describe the assumptions and predictive relationships involved. Based on what we do know, however, we are apprehensive that the model could be misused by persons who do not comprehend its limitations. The model incorporates so many unwarranted and/or unsubstantiated assumptions that its predictions are almost certain to be in error. Here are just a few of the assumptions:

(a) In the western United States, coyotes killed about 8 percent of the lambs and 2 percent of the ewes present in 1974. (US Fish & Wildlife Service studies put lamb losses nearer 3 to 4%.)

(b) If there had been no predator control in 1974, coyotes would have killed 20 percent of the lamb crop.

(c) The actual level of predator control in 1974 was just 40 percent of the maximum reasonable level of control.

(d) The selectivity, cost-effectiveness, and feasibility of each predator control method is equal under all conditions throughout the West.

(e) The options for reducing predation are limited to killing coyotes in various ways. Non-lethal methods are not considered.

(f) It is possible to quantify and compare the humaneness of various predator control methods.

(g) It is meaningful to generalize about the impact of coyotes on "other wildlife", without defining what species of "other wildlife" are being considered.

(h) Toxicants such as 1080 can be used in predator control, and $1,000 spent on 1080 will yield $4,000 worth of preventative control.

(i) Every coyote killed, no matter where, when, or how, produces the same amount of reduction in predator losses. The model does not recognize that some coyotes create worse problems than others.

These are only a few of the questionable assumptions that guide the ERS model. Because of these and other shortcomings, our present opinion is that this model will create more problems than it will solve if it is applied to administrative decisions about the ADC Program of the U. S. Fish and Wildlife Service. If the Service is interested in using this model, some people from both research and management groups should be assigned to an in-depth review of it. The review team should be directed to (1) become familiar with the model; (2) decide whether the model or selected parts of

it can be applied to decision-making within the ADC program; (3) modify the model as needed to make it valid; and (4) update the data base from 1974 to 1978. It would probably take two biologists about 3 months of full time work just to become familiar with the model.

We are not optimistic about the application of simulation models to predator management decisions, because such models by their very nature deal poorly with matters that involve value judgments.

SUMMARY

Simulation models are useful tools in research and management, but they do not offer instant solutions to the political problems of predator management. Models are a poor substitute for the understanding and expertise of administrators with predator control experience. Controversial, political issues in general are not amenable to solution by orderly, rational analyses, irrespective of whether or not the analyses are run through a computer. In predator control, simulation models may be useful on trivial matters like population dynamics, but they offer little help on the hard questions.

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APPENDIX D - Restrictions attached to the registration for use of Sodium Cyanide in the M-44 Device by EPA.

1. Use of the M-44 device shall conform to all applicable Federal, State and local laws and regulations.

2. Applicators shall be subject to such other regulations and restrictions as may be prescribed from time to time by U.S. Environmental Protection Agency.

3. Each applicator of the M-44 device shall be trained in: (1) safe handling of the capsules and device; (2) proper use of the antidote kit; (3) proper placement of the device; (4) necessary record keeping.

4. M-44 devices and sodium cyanide capsules shall not be sold or transferred to, or entrusted to the care of any person not supervised or monitored by the U.S. Fish and Wildlife Service or any agency not working under a Fish and Wildlife Service cooperative agreement.

5. The M-44 device shall only be used to take wild canids suspected of preying upon livestock and poultry.

6. The M-44 device shall not be used solely to take animals for the value of their fur.

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7. The M-44 device shall only be used in instances where actual livestock losses due to predation by wild canids are occurring or, based on documented prior experience indicating a recurring or seasonal predator problem in a specific area, where actual livestock losses due to wild canid predators can reasonably be expected to occur. In each case an evaluation will be made and documented so as to include livestock and evidence of depredating species prior to application of M-44 devices.

8. The M-44 device shall not be used in: (a) National or State Parks; (b) National or State Monuments; (c) federally designated wilderness areas; (d) wildlife refuge areas; (e) areas within national forests or other federal lands specifically set aside for recreational use; (f) prairie dog towns; and (g) areas where exposure to the public and family pets is probable.

9. The M-44 device shall not be used in areas where threatened or endangered animal species might be adversely affected. Each applicator shall be issued a map which clearly indicates such areas.

10. One person other than the individual applicator shall have knowledge of the exact location of all M-44 devices in the field.

11. In areas where more than one governmental agency is authorized to place M-44 devices, the agencies shall exchange placement information and other relevant facts to insure that the maximum number of M-44 devices is not exceeded.

12. The M-44 device shall not be placed within two hundred (200) feet of any lake, stream, or other body of water, provided that natural depression areas which catch and hold rainfall only for short periods of time shall not be cosidered "bodies of water" for purposes of this restriction.

13. The M-44 device shall not be placed in areas where food crops are planted.

14. The M-44 device shall be placed at least fifty (50) feet distance or at such greater distance from any public road or pathway as may be necessary to remove it from the sight of persons and domestic animals using any such public road or pathway.

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15. The density of M-44 devices used shall be the minimum necessary to reduce losses as a rule, but the maximum density of M-44 devices in any 100 acre pastureland shall not exceed (10), and in any one square mile of open range shall not exceed twelve (12).

16. No M-44 device shall be placed within thirty (30) feet of a livestock carcass used as a draw station; no more than four (4) M-44 devices can be used per draw station and no more than (3) draw stations shall be operated in any one square mile of area.

17. Supervisors of applicators shall check the records, warning signs, and M-44 devices of each applicator at least once a year to verify that all applicable laws, regulations, and restrictions are being strictly followed.

18. Each M-44 device shall be inspected by the applicator at least once a week to check for interference or unusual conditions and shall be serviced as required.

19. Damage or non-functional M-44 device shall be removed from the field.

20. An M-44 device shall be removed from an area if, after thirty (30) days there is a cessation of losses due to target predators in the area.

21. All persons authorized to possess and use sodium cyanide capsules and M-44 devices shall store such capsules and devices under lock and key.

22. Used sodium cyanide capsules shall be disposed of by deep burial or at a proper landfill site.

23. Bilingual warning signs in English and Spanish shall be used in all areas containing M-44 devices. All such signs shall be removed when M-44 devices are removed.

    a. Main entrances or commonly used access points to areas in which M-44 devices are set shall be posted with warning signs to alert the public to the toxic nature of the cyanide and to the danger to pets. Signs shall be inspected weekly to insure their continued presence and insure that they are conspicuous and legible.

    b. An elevated sign shall be placed within six (6) feet of each individual M-44 device warning persons not to handle the device.

24. Each authorized or licensed applicator shall carry an antidote kit on his person when placing and/or inspecting M-44 devices. The kit shall contain at least six (6) pearls of amyl nitrite and the correct premixed proportions of sodium nitrite and sodium thiosulfate for intravenous injections, together with instructions on the use of each.

25. In all areas where the use of the M-44 device is anticipated, local medical people shall be notified of the intended use. This notification may be through a poison control center, local medical society, the public health service, or directly to a doctor or hospital. They shall be advised of the antidotal and first-aid measures required for treatment of cyanide poisoning. It shall be the responsibility of the supervisor to perform this function.

26. Each applicator shall keep records dealing with the placement of the device and the results of each placement. Such records shall include, but need not be limited to:

    a. The number of devices placed.
    b. The location of each device placed.
    c. The dates of each placement, inspection and removal.
    d. The number and location of devices which have been discharged and the apparent reason.
    e. Species of animals taken.
    f. All accidents or injuries to humans or domestic animals.