

An analysis of game damage and game damage complaints in Montana
by Raymond John Adkins

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University
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Abstract:
The mountainous regions of western Montana are well known for their abundant deer and elk populations. The movement of these animals from high-elevation summer ranges on public lands to private lands at lower elevations in winter, along with the success of wildlife managers and public interest groups in restoring wild ungulate numbers in Montana, has led to an increasing number of, conflicts between wild ungulate populations and agriculture. In order to deal with these conflicts, wildlife managers need information on the extent of game damage to agricultural crops and the attitudes of farmers and ranchers towards indigenous ungulates on their land. The goal of this study was to gain information on game damage to crops on private lands and on farmers' attitudes toward wildlife populations on private lands. First, the timing and extent of wildlife damage to grass/alfalfa hay fields in the Yellowstone River Valley of Montana was determined using movable wire cage exclosures. Ungulate grazing reduced crop yields by as much as one-third. The extent of damage was directly related to the number of animals using a field. Most damage occurred during the early spring or late summer. Secondly, multiple regression analysis was used to examine the possible factors influencing game damage complaint levels and to develop a model that could be used to predict complaint levels. Agricultural prices and winter weather conditions were identified as important variables. Agricultural prices were particularly important in areas where the major crops were not eligible for government price and income supports. Finally, game damage complaint forms filed over the last 5 years in all areas of Montana were examined in order to gain quantitative information regarding the consequences of private landowners posting their property against hunting.

A significantly higher proportion of complaints was from areas involving some degree of posting than from areas with no posting.

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of

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in

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APPROVAL

of a thesis submitted by

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

The mountainous regions of western Montana are well known for their abundant deer and elk populations. The movement of these animals from high-elevation summer ranges on public lands to private lands at lower elevations in winter, along with the success of wildlife managers and public interest groups in restoring wild ungulate numbers in Montana, has led to an increasing number of conflicts between wild ungulate populations and agriculture. In order to deal with these conflicts, wildlife managers need information on the extent of game damage to agricultural crops and the attitudes of farmers and ranchers towards indigenous ungulates on their land. The goal of this study was to gain information on game damage to crops on private lands and on farmers' attitudes toward wildlife populations on private lands. First, the timing and extent of wildlife damage to grass/alfalfa hay fields in the Yellowstone River Valley of Montana was determined using movable wire cage exclosures. Ungulate grazing reduced crop yields by as much as one-third. The extent of damage was directly related to the number of animals using a field. Most damage occurred during the early spring or late summer. Secondly, multiple regression analysis was used to examine the possible factors influencing game damage complaint levels and to develop a model that could be used to predict complaint levels. Agricultural prices and winter weather conditions were identified as important variables. Agricultural prices were particularly important in areas where the major crops were not eligible for government price and income supports. Finally, game damage complaint forms filed over the last 5 years in all areas of Montana were examined in order to gain quantitative information regarding the consequences of private landowners posting their property against hunting. A significantly higher proportion of complaints was from areas involving some degree of posting than from areas with no posting.

INTRODUCTION

The mountainous regions of western Montana are well known for their abundant deer (mule deer, Odocoileus hemionus and white-tailed deer, O. virginianus) and elk (Cervus elaphus) populations. Although high-elevation public lands provide adequate summer ranges, most deer and elk move to mostly private lands at lower elevations in order to find favorable snow conditions and an adequate food supply in winter (Reed 1981, Wallmo and Regelin 1981, Lyon and Ward 1982, Adams 1982, Moen 1983). In addition, the development of modern irrigation systems has allowed agriculture to expand into arid mountain valleys that have historically served as deer and elk winter ranges (NAS 1970, Reed 1981, NRC 1982). These 2 factors, along with the success of wildlife managers and public interest groups in restoring ungulate populations in the West, have led to an increasing number of conflicts between agricultural interests and wild ungulate populations (Reed 1981, Lyon and Ward 1982, Peek et al. 1982, Matschke 1984, Conover and Decker 1991).

To address these conflicts and properly manage wild ungulate populations, wildlife managers need information on both the extent of game damage to agricultural crops and

information on the attitudes of farmers and ranchers towards indigenous ungulates on their property. The goal of this study was to gain information related to both these needs by examining 3 aspects of game damage in Montana.

Field Evaluation of Game Damage

Damage to alfalfa/grass hay fields by wild ungulates is a problem in many areas of the United States (Conover and Decker 1991), including Montana (Grover 1985). Although several studies have examined the impact that wild ungulates have on crop yield (Cole 1956, Boyd 1960, Egan 1960, Tebaldi 1979, Palmer et al. 1982), none have examined the possible compensatory growth response of hay crops to grazing (McNaughton 1979 and 1983).

Objectives of this part of the study were to determine: 1) the seasonal timing of deer and elk use of alfalfa/grass hay fields, 2) the impact that deer and elk grazing has on alfalfa/grass hay production, and 3) whether alfalfa/grass hay exhibits a compensatory growth response when grazed by wild ungulates under natural conditions.

Factors Influencing Game Damage Complaints

When wild herbivores consume plants perceived as forage or crop material vital to the economic survival of farmers or ranchers, game damage complaints ensue. As a result, compensation and/or damage control programs have been

established by most state wildlife agencies (Spencer 1984, Western Association of Fish and Wildlife Agencies 1985). In Montana, no direct monetary compensation for game damage is provided to landowners. By law, a Montana landowner must accept and assume the cost of a certain level of game damage (Montana Legislative Council 1986). However, if the level of damage in a particular situation becomes unreasonable, the Montana Department of Fish, Wildlife and Parks (MDFWP) may hold special early or late season hunts, issue kill permits directly to the landowner, or provide the landowner with materials to prevent damage (e.g. repellents, scare devices, or fencing).

Programs for game damage control/compensation are difficult to budget because demand for such programs varies widely from year to year (Reed 1981, Greene 1985). Although game damage complaints are frequently assumed to be driven by an interaction between animal population levels and weather (Boyd 1960, Reed 1981, Matschke 1984, Decker et al. 1984, Greene 1985, Scott and Townsend 1985, Hygnstrom and Craven 1987, Conover and Decker 1991), attempts to explain game damage levels using variables associated with these 2 factors have had little success (Tebaldi 1979, Lyon and Scanlon 1985). A few authors have acknowledged that a third factor, agricultural economic conditions, may also be important in influencing landowner tolerance and in determining the number of complaints filed (Boyd 1960,

Carpenter 1967, Decker et al. 1984, Lyon and Scanlon 1985). However, the role of this factor has not been fully investigated.

Specific objectives of this part of the study were: 1) to quantify the importance of game population levels, weather, and agricultural economic conditions in determining game damage complaint levels, and 2) to develop a model that would assist wildlife management agencies in planning and allocating funds for game damage programs.

Landowner Posting and Game Damage Complaints

The posting of private land against hunting is a growing problem in many states (Peek et al. 1982, Bromley and Hauser 1984, Guynn and Schmidt 1984, Brown et al. 1984, Wright and Kaiser 1986, Wigley and Melchiors 1987, Wright et al. 1988). Although some studies have discussed the reasons behind landowner posting and the problems associated with decreased recreational, hunting, and management opportunities, the possible connection between posting and game damage complaints has not been investigated.

The objective of this part of the study was to obtain quantitative information regarding the relationship between landowner posting and game damage by examining existing game depredation reports.

DESCRIPTION OF STUDY AREAS

Field Evaluation of Game Damage

All 3 study sites were located on the east side of the Upper Yellowstone River Valley between Gardiner and Livingston, Montana (Figure 1). The valley is approximately 84 km in length and from 0.6 to 13 km wide. It is bounded by the Gallatin Mountain Range on the west and the Absaroka Mountain Range on the east. Yellowstone National Park forms the southern boundary. Elevations along the river range from approximately 1800 m in the southern end to 1400 m at the northern end. Several peaks in each range rise above 3000 m.

Soils along the river valley are generally deep, well drained soils of the Chernozem and Herozen types (Southard 1969). The mountain ranges are characterized by grey wooded and brown Podzolic soils that are shallow to deep and well drained. The general topography of the valley floor is a series of moderately to steep sloping terraces and fans (Southard 1969). Average annual precipitation is approximately 38 cm (recorded at the U.S. Dept. of Commerce weather station in Livingston, MT). Approximately 27 cm is received during the growing season (April-September). The normal frost free period is 116 days.

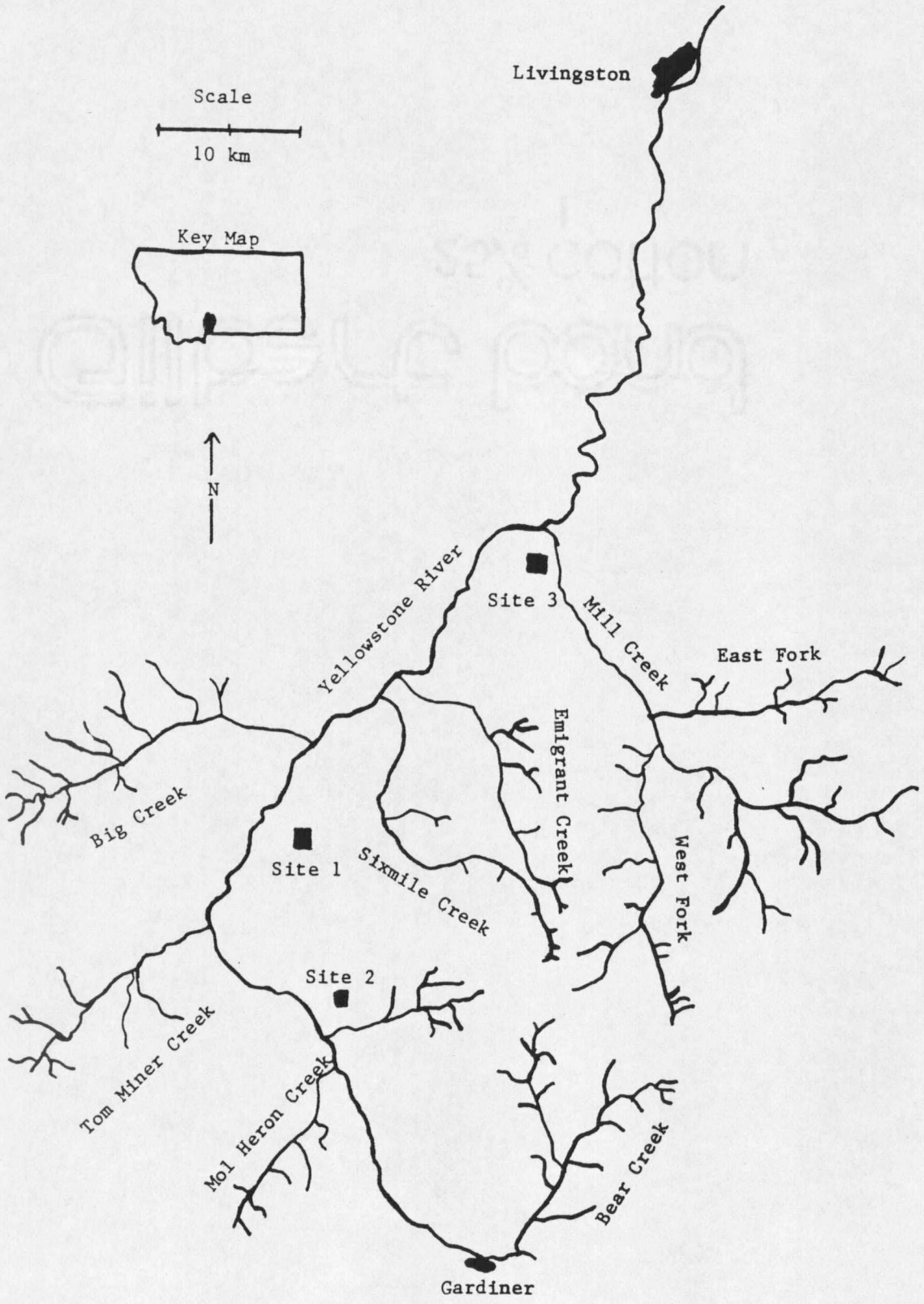


Figure 1. Map of the field study locations.

The vegetation types found in the valley were described by Hook (1985). These descriptions were used to define the following general habitat types.

A river bottom type is found along the Yellowstone River and major tributary streams. It contains a cottonwood overstory (Populus spp.) and an understory of willow (Salix spp.), alder (Alnus spp.), rose (Rosa spp.), and juniper (Juniperus spp.).

Grass and grassland cover types are found in the drier portions of the valley between the riparian and conifer types. The major grass species include: Idaho fescue (Festuca idahoensis), bluebunch wheatgrass (Agropyron spicatum), bluegrass (Poa spp.), cheatgrass brome (Bromus spp.), and needle-and-thread (Stipa comata). The major shrub species is big sagebrush (Artemisia tridentata).

Agriculture is limited to lowland areas where the major crop is hay. Wheat, barley, and oats are also present but far less important. Most (> 75%) of the harvested crop land is irrigated.

Conifer habitat types are found in the higher elevations above the grassland and agricultural types. The area has stands dominated by lodgepole pine (Pinus contorta), Douglas fir (Pseudotsuga menziessi), spruce (Picea engelmannii), and subalpine fir (Abies lasiocrpa).

Study Site 1 was a 16-ha irrigated alfalfa/grass (Bromus spp.) hay field located on the 1090-ha Dome Mountain

Wildlife Management Area. This area was managed as an elk winter range by the Montana Department of Fish, Wildlife and Parks. The area is closed to public access between February and May. The study field occupied a corner of a larger 57-ha field. The remaining 41-ha were planted to an oat/barley mixture. This field received year round use by mule deer and winter use by elk. Willow and sagebrush stands were present on the northern edge of the field. No other fields, houses, or major roads were in the immediate vicinity.

Study Site 2 was an 8.5-ha irrigated alfalfa/grass hay field located on the Franklin Rigler Ranch approximately 15 km north of Gardiner, MT. This field received year round use by mule deer and winter use by elk. Topographical and sagebrush cover was present on most edges of the field and provided extensive hiding and resting areas for animals during the day. No other fields, houses, or major roads were in the immediate vicinity.

Study Site 3 was a 4.5-ha sub-irrigated alfalfa/grass hay field located on the David Rigler Ranch approximately 3 km east of Pray, MT. Another 7-ha hay was field was immediately adjacent. The area received year round use by deer (both mule and white-tailed) and elk. Treeline cover was approximately 150-200 m from the eastern edge of the field. These stands provided hiding and resting cover during the day. Several other fully irrigated hay fields

were within 1 km and may have attracted animals away from the study field.

Factors Influencing Game Damage Complaints

Data were collected from 2 of the 7 MDFWP administrative regions (Figure 2): Region 3 (southwestern Montana) and Region 4 (northcentral Montana). A general description of the land uses and animal distributions in each region is given in Table 1.

Region 3 contains several major mountain ranges and river valleys. Major mountain ranges include the Absaroka, Gallatin, Madison, Bridger, Crazy, Tobacco Roots, Gravelly, and Bitterroot ranges. Major rivers include the Yellowstone, Madison, Shields, Gallatin, Missouri, Boulder, and Big Hole rivers. Agriculture is found mainly in the lower mountain valleys. Most (> 70%) of the harvested cropland is irrigated. The most important crop is hay. In 1988, out of approximately 260,000 ha harvested, 69% was hay, 17% wheat, 13% barley, and < 1% oats (Montana Department of Agriculture 1990). The normal frost free period for the entire region is approximately 100 days.

The topography of Region 4 is generally less rugged with fewer mountain ranges and river valleys. The east front of the Rocky Mountains forms the western boundary of the region. The Big Belt and Little Belt Mountains occupy the southwest corner. The remainder of the region is

characterized by a mixture of rolling hills, open plains, and badlands breaks. Major rivers include the Missouri, Judith, Marias, and Teton rivers. Most (> 80%) of the harvested crop land is non-irrigated. The most important crop is wheat. Out of the approximately 925,991 ha harvested in 1988, 57% was wheat (mostly winter wheat), 27% barley, 15% hay, and < 1% oats (Montana Department of Agriculture 1990). The normal frost free period for the entire region is 118 days.

Landowner Posting and Game Damage Complaints

Data were collected from each of the 7 MDFWP administrative regions (Figure 2). A description of the land uses and animal distributions in each region is given in Table 1. The western regions (1, 2, and 3) are generally more mountainous, more heavily forested, and contain less private land and less farmland than the eastern regions (4, 5, 6, and 7).

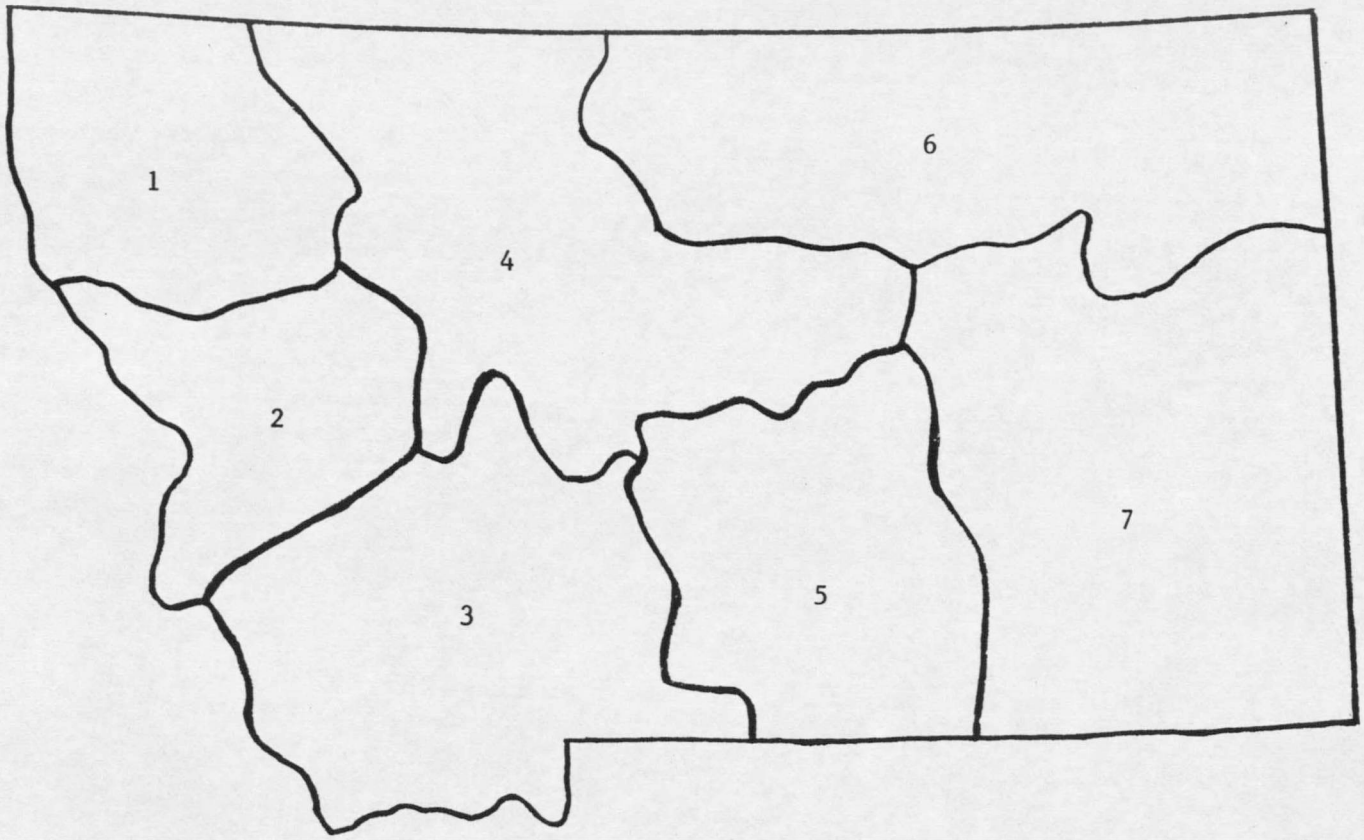


Figure 2. Map of the 7 Montana Department of Fish, Wildlife and Parks administrative regions.

Table 1. Land area, uses, and animal distributions for the 7 Montana Department of Fish, Wildlife and Parks administrative regions.

Description	Administrative Region 1	2	3	4	5	6	7
Land Area (1000 ha)	4124	2653	4819	7169	4153	7460	7128
% Farmland	29	24	50	75	87	74	83
% Cropland	8	5	9	30	17	34	12
# of Farms	2936	1927	2735	5325	3464	5094	3088
% of Farms w/ Livestock	56	62	71	56	68	49	74
% of Area Used by Mule Deer	95	92	96	91	99	75	94
% Private	22	32	36	69	77	44	75
% of Area Used by White-tailed Deer	76	56	12	30	9	14	36
% Private	30	42	91	85	93	82	78
% of Area Used by Elk	95	83	55	21	11	4	0
% Private	25	27	16	33	38	4	
% of Area Used by Antelope	0	0	33	62	58	66	57
% Private			73	84	90	52	79

Sources:
U. S. Department of Commerce 1989.
Montana Department of Fish, Wildlife and Parks 1977.

METHODS

Field Evaluation of Game Damage

The amount of herbage consumed by deer and/or elk was determined using the methods outlined by Milner and Hughes (1968). Summer sampling to determine the timing and extent of damage occurring during the growing season (April-September) was conducted on Sites 1 and 2 in 1990 and on Sites 2 and 3 in 1991. Winter sampling (October-March) to determine the amount of residual crop material consumed was conducted on Site 1 during the winters of 1989-90 and 1990-91. The main factor determining site selection was the willingness of a landowner to allow access.

On each study site, deer and/or elk grazing of randomly selected plots was prevented using movable wire cage exclosures constructed from 10x20 cm mesh fencing wire. Circular cages 100 cm in diameter and height were used on all study sites except Site 1, where rectangular 100x60x60 cm cages were used due to the low height of the irrigation system. Over a given time period, the amount of herbage consumed was determined by clipping 2 20x50 cm plots. One plot was centered inside the cage and the other was located outside but within 1 meter of the cage. All plots were clipped to ground level with hand shears. The clipped

material was dried at 80^{0}C in a forced air oven for 48 hours and weighed to the nearest gram. The amount of herbage consumed was calculated by subtracting the weight of the material clipped outside the cage from the weight of the material clipped inside the cage. The paired-sample t-test using the MSUSTAT statistical package (Lund 1991) was conducted to test the hypotheses:

Ho: The weight of material clipped inside a cage was equal to the weight of the material clipped outside a cage.

Ha: The weight of material clipped inside a cage was not equal to the weight of the material clipped outside a cage.

Cages were randomly placed in each study site using a 2-stage cluster design (Scheaffer et al. 1990). Each site was divided into 9 to 12 blocks, depending on field size. Placement of individual cages was determined by randomly selecting a block and then randomly selecting a plot within that block. This method increased the probability that all areas of a field were sampled while insuring random placement of cages. A presample conducted in the spring of 1990 indicated that approximately 7 cages were needed for the desired accuracy. More cages than needed were placed in each field since several cages were expected to be damaged by deer and elk or removed to avoid conflicts with the

irrigation system. Therefore, the sample sizes used in the analyses for different sites and dates varied.

For summer sampling, all cages were placed in a study site at the beginning of the growing season (mid-April to early May). Approximately half of these cages were randomly chosen to be 'stationary'. Stationary cages were clipped once < 1 week prior to the first cutting of hay to determine the net effect of grazing on harvest yield. After the plots were cut the cages were removed. The remaining cages were considered 'movable'. These cages were clipped once during the growing season, moved to a new location, then clipped and removed prior to the first cutting. Moveable cages were used to determine the timing of grazing by wild ungulates and to examine the possibility of compensatory growth.

After the first cutting, the cages were replaced and left in place until < 1 week prior to the second cutting. At this time, the cages were clipped and removed. For winter sampling on Study Site 1, all cages were put in place in October and clipped only once in late March.

The possibility of increased production in the protected plots due to 'cage effect' (Cowlishaw 1951, Grelen 1967, Owensby 1969) was examined by placing 10 cages in a larger 3x5x2 m rectangular area which excluded ungulates. Plots outside the cages were compared to plots protected by the cages. The larger exclosure was constructed on Site 3 with the same wire used to make the smaller cages. Sampling

for cage effect took place during the first part of the 1991 growing season using the same hypotheses and statistical test used with grazed areas.

Periodic dawn and dusk counts were conducted to determine the approximate number of animals using each site. Counts took place from approximately 30 minutes prior to dusk to approximately 30 minutes after dusk or from 30 minutes prior to dawn to 30 minutes after dawn. Counts were aided by a pair of 7x35 binoculars, a 10-45 power spotting scope, and a 300,000 candlelight spotlight.

Factors Influencing Game Damage Complaints

Variables in 4 areas (game population levels, agricultural economic conditions, sociological factors, and weather) were tested as predictors of game damage complaint levels. Data were collected relative to 3 species (mule deer, white-tailed deer, and elk) and from 2 of the 7 MDFWP administrative regions (Region 3, southwestern Montana; and Region 4, northcentral Montana; see Figure 2).

All data sets were compiled from public data bases. This approach was adopted to avoid additional impositions on landowners, to limit biases due to small interview samples or analysis of subjective feelings of game damage, and to see how useful existing data bases could be in explaining the variation in the number of game damage complaints filed from year to year. In addition, these sources would be

readily available to agencies for planning if they elected to use any of these models. Data sets used in the analyses are given in Tables 30 through 42 in the Appendices.

The number of game damage complaints filed involving deer and/or elk were compiled from records at the MDFWP regional headquarters in Bozeman (Region 3) and Great Falls (Region 4). Complaints involving mule deer and white-tailed deer were grouped. The number of complaints filed were separated by fiscal years (July 1 to June 30). This approach was used so that the models developed would best match the MDFWP budgeting periods. With the exception of hay, this time period (July 1 to June 30) also matched the market year price for the agricultural crops used in the analyses. The market year for hay extends from June 1 to May 30. In Regions 3 and 4, complaints were collected for fiscal years 1974-75 through 1990-91, and 1972-73 through 1990-91, respectively. Game damage complaint records prior to these dates were incomplete.

Crop prices and crop production figures were collected from the annual Montana Agricultural Statistics Bulletins (Montana Department of Agriculture 1970 to 1991). Market year prices in both nominal and real dollars (base year = 1982) for oats, wheat, barley, hay, and calves were used in the analysis. The GNP Implicit Price Deflator (Economic Report of the President 1971 to 1991) was used to adjust prices for inflation by averaging the quarterly indices

corresponding to the market year. Market year prices (in both nominal and real dollars) for the current year, a 1 year lag of the current prices, and the current year's price minus the previous year's price, were used as independent variables in the different models used to estimate complaint levels.

Weather data were collected from Climatological Data: Montana bulletins (NOAA 1972 to 1991). Data for monthly precipitation, maximum monthly snow depth, and minimum monthly temperature were compiled by averaging the readings of several weather stations in each administrative region. Specific weather stations used in the compilations were chosen on the basis of their location and completeness of recordings over the time period examined.

Deer and elk population trends in each region were assessed using yearly harvest and population survey data. Harvest data for deer and elk included total harvest figures, days per kill, and hunter percent success figures obtained from MDFWP hunting and harvest reports (MDFWP 1970 to 1991). Population trend counts for various hunting districts in each region were compiled to determine an overall population trend index for both deer and elk in each region. The first year of analysis in each region was set to 100. From each year to the next, the percent change in the number of animals counted was determined by dividing the number of animals counted in the second time period by the

number of animals counted in the first time period. Only hunting districts surveyed in both time periods were used. The index value for the second time period was calculated by multiplying the first year's index value by the percent change.

The overall mood of farmers and ranchers was also tested as a factor influencing the number of complaints filed. Several sociological factors were used as indirect indices of mood. The factors used were the rates of alcoholism, suicide, homicide, divorce, and marriage. These rates were obtained from the Montana Vital Statistics Bulletin (Montana Department of Health and Environmental Sciences 1991).

Initial analyses involved the construction of correlation matrices (Lund 1991). In each region, variables associated with weather, population levels, sociological factors, and economic conditions which were highly correlated with game damage complaint levels were selected for further analysis. Intercorrelation of variables was examined and specific variables were deleted or retained based on their biological or economic relevance.

Multiple regression analysis, using the SHAZAM econometrics computer program (White 1978), was applied to the remaining variables to determine the percentage of variation in complaint levels that could be explained and to determine the precision with which complaint levels could be

predicted. For each region, models to predict the number of deer complaints, the number of elk complaints, and the total number of complaints (deer and elk) were developed. A stepwise procedure was used to select the best variables (Draper and Smith 1966). The Durbin-Watson statistic and the von Neuman ratio were used to test for autocorrelation (Johnston 1984). The runs test was used to test for serial correlation (Gujarati 1978). All tests were conducted at the 0.05 level of significance.

In each region, the regression model was constructed using past data (1972-73 to 1987-88 for Region 4; 1974-5 to 1987-88 for Region 3) and then tested for prediction accuracy using data for the 3 years 1988-89, 1989-90 and 1990-91. The mean absolute error and the root mean square error of prediction for each model were computed as a means of assessing prediction accuracy and comparing different models (Kennedy 1986). Standardized coefficients were used to determine the relative importance of each explanatory variable included in a regression model (Zar 1984).

Landowner Posting and Game Damage Complaints

When a landowner in Montana files a game damage complaint with the MDFWP, the investigating biologist or warden completes a game depredation report. These reports contain information on the extent of posting on both the complainant's property and on the adjoining properties.

Game depredation reports filed with the 7 MDFWP administrative regions (Figure 2) were analyzed to determine: 1) the proportion of complaints from landowners whose property was posted against hunting, 2) the proportion of complaints from landowners who had at least 1 adjoining neighbor with posted land, and 3) the proportion of complaints from situations where either the complainant, 1 of the adjoining neighbors, or both had posted land.

Only complaints filed between January 1986 and June 1991 involving deer, elk, or pronghorn antelope (Antilocapra americana) were used in the analyses. Since several game depredation reports contained posting information for the complaining landowner only, the sample sizes used to determine each of these proportions varied.

A landowner's property was considered posted only when all types of hunting (including archery) were prohibited on all or part of the property. Landowners that leased their property to outfitters, permitted hunting by family or friends, or allowed hunting when asked, were considered to have nonposted property. A landowner had a posted neighbor if all types of hunting were prohibited on any part of an adjoining property. Complaints from nonagricultural properties, such as complaints involving damage to ornamentals in a subdivision, were not used in the analyses.

The following 3 hypotheses were tested using an equality of 2 proportions test based on the normal

approximation of the binomial distribution (Zar 1984, p. 385):

1) Ho: The proportion of complaints from landowners with posted land equaled the proportion of complaints from landowners with nonposted land.

   Ha: The proportion of complaints from landowners with posted land did not equal the proportion of complaints from landowners with nonposted land.

2) Ho: The proportion of complaints from landowners who had at least 1 adjoining neighbor with posted land equaled the proportion of complaints from landowners who did not have any adjoining neighbors with posted land.

   Ha: The proportion of complaints from landowners who had at least 1 adjoining neighbor with posted land did not equal the proportion of complaints from landowners who did not have any adjoining neighbors with posted land.

3) Ho: The proportion of complaints from areas where either the complainant's property, 1 of the adjoining properties, or both was posted equaled the proportion of complaints from areas where neither the complainant's property nor any of the adjoining properties was posted.

   Ha: The proportion of complaints from areas where either the complainant's property, 1 of the

adjoining properties, or both was posted did not equal the proportion of complaints from areas where neither the complainant's property nor any of the adjoining properties was posted.

A statistically valid test of these hypotheses required that each data point be an independent observation. Therefore, the following 2 assumptions were made: 1) the filing of a game damage complaint by 1 landowner does not influence the probability of another landowner filing a complaint, and 2) the filing of a complaint does not influence the probability of that landowner filing another complaint in the future.

The validity of these assumptions was extremely difficult to assess. Two factors, however, may add to their plausibility. First, over the time period examined, only a small number of landowners filed more than 1 complaint. Second, given the MDFWP long standing policies regarding responses to game damage complaints, it is likely that most landowners are at least familiar with these practices. Therefore, the actions of 1 landowner should have little influence on the actions taken by other landowners.

RESULTS

Field Evaluation of Game Damage

The test for the possibility of cage effect (Table 2) indicated that the cages did not significantly influence the rate of plant growth in the protected plots. The weight of the material clipped inside the cages was not significantly different from the weight of material clipped outside the cages ($p = 0.88$).

Table 2. Paired t-test results for dry matter weights (g) of alfalfa/grass yields clipped inside and outside cages during test for cage effect on Study Site 3 during 1991.

Study Site 3 - David Rigler Ranch.

Dates		Mean	Std-Error	% Dif	
5/27 to 7/9 (n=10)	In	56.10	17.26	-2.1	Mean Dif = -1.20
	Out	57.30	9.68		Std-Error = 7.65
					P-Value = 0.88

The timing and extent of crop depredation occurring during the growing season was assessed on 3 fields (Tables 3 and 4). Damage prior to the first cutting was similar on all study sites for both years. The first clipping of movable cages in mid-June resulted in statistically significant differences ($p < 0.05$) in the weight of material

Table 3. Paired t-test results for dry matter weights (g) of alfalfa/grass yields clipped inside and outside cages during 1990.

Dates		Mean	Std-Error	% Dif		
Study Site 1 - Dome Mountain Wildlife Management Area						
5/6 to 6/6	In	37.93	8.17	21.4	Mean Dif	= 8.13
Movable	Out	29.80	5.86		Std-Error	= 1.60
(n=15)					P-Value	= <0.01
6/6 to 7/3	In	44.07	16.47	0.6	Mean Dif	= 0.27
Movable	Out	43.80	13.04		Std-Error	= 4.24
(n=15)					P-Value	= 0.95
5/6 to 7/3	In	76.71	22.75	30.5	Mean Dif	= 23.43
Stationary	Out	53.29	11.25		Std-Error	= 5.90
(n=7)					P-Value	= 0.01
-- First Cutting By Rancher --						
7/21 to 8/26	In	48.75	13.65	17.5	Mean Dif	= 8.55
Stationary	Out	40.20	13.29		Std-Error	= 1.99
(n=20)					P-Value	= <0.01
-- Second Cutting By Rancher --						
----- **Study Site 2 - Franklin Rigler Ranch** -----						
5/12 to 6/10	In	33.71	11.01	29.2	Mean Dif	= 9.86
Movable	Out	23.86	7.27		Std Error	= 2.19
(n=7)					P-Value	= <0.01
6/10 to 7/7	In	37.91	11.48	4.8	Mean Dif	= 1.82
Movable	Out	36.09	15.55		Std-Error	= 2.94
(n=11)					P-Value	= 0.55
5/12 to 7/7	In	34.86	10.33	25.8	Mean Dif	= 9.00
Stationary	Out	25.86	7.76		Std-Error	= 2.69
(n=7)					P-Value	= 0.02
-- First Cutting By Rancher --						
7/27 to 9/8	In	32.22	10.13	23.5	Mean Dif	= 7.56
Stationary	Out	24.67	5.59		Std-error	= 2.34
(n=18)					P-Value	= 0.01
-- Second Cutting By Rancher --						

Table 4. Paired t-test results for dry matter weights (g) of alfalfa/grass yields clipped inside and outside cages during 1991.

Dates		Mean	Std-Error	% Dif	
------- Study Site 2 - Franklin Rigler Ranch -------					
4/20 to 6/12	In	58.91	9.92	32.3	Mean Dif = 19.00
Movable	Out	39.91	8.41		Std-error = 4.06
(n=11)					P-Value = <0.01
6/12 to 7/5	In	84.53	20.83	-4.6	Mean Dif = -3.87
Movable	Out	88.40	29.41		Std-Error = 5.69
(n=15)					P-Value = 0.51
4/20 to 7/5	In	108.30	32.72	34.4	Mean Dif = 37.23
Stationary	Out	71.08	26.22		Std-Error = 4.24
(n=13)					P-Value = <0.01
-- First Cutting By Rancher --					
7/23 to 8/7	In	37.50	8.34	-12.5	Mean Dif = -4.70
Movable	Out	42.20	9.26		Std-Error = 3.33
(n=10)					P-Value = 0.19
7/23 to 9/3	In	97.91	17.89	29.8	Mean Dif = 29.18
Stationary	Out	68.73	22.89		Std-Error = 5.60
(n=11)					P-Value = <0.01
-- Second Cutting By Rancher --					
------- Study Site 3 - David Rigler Ranch -------					
5/27 to 6/15	In	37.67	9.63	18.8	Mean Dif = 7.07
Movable	Out	30.60	7.02		Std-Error = 1.99
(n=15)					P-Value = <0.01
6/15 to 7/7	In	47.00	10.69	-10.0	Mean Dif = -4.73
Movable	Out	51.73	12.33		Std-Error = 2.70
(n=15)					P-Value = 0.10
5/27 to 7/9	In	56.53	16.97	21.2	Mean Dif = 12.00
Stationary	Out	44.53	15.09		Std-Error = 3.34
(n=15)					P-Value = <0.01
-- First Cutting By Rancher --					
7/25 to 9/7	In	7.35	3.00	-2.1	Mean Dif = -0.16
Stationary	Out	7.51	4.03		Std-Error = 0.73
(n=12)					P-Value = 0.83
-- No Second Cutting By Rancher --					

clipped inside and outside the cages on all sites in both years. The amount of crop material lost during the early part of the growing season ranged from 19 to 32% of potential crop yield. The second clipping of moveable cages in early July did not result in statistically significant differences in the weight of clipped material ($p > 0.05$) for any site in either year. Clipping of vegetation in the stationary cages in early July, just prior to the first cutting by the farmer/rancher, revealed significantly lower yields in unprotected plots on all sites in both years. Differences ranged from 21 to 34% of potential crop yield.

The timing and extent of damage occurring after the first cutting was similar on 3 of the 4 study sites. Between the first and second cuttings (mid-July to late August/early September), significantly lower yields were found in the unprotected plots on Sites 1 and 2 in 1990 and on Site 2 in 1991. Differences ranged from 17 to 29 % of potential crop yield. Only Site 3 in 1991 did not have a statistically significant difference in potential crop yield between the first and second cuttings. No animals were observed using this field during the periodic dawn and dusk counts conducted during that time period.

The number of animals observed grazing in each field during periodic dawn and dusk counts varied over the course of a growing season (Table 5). The highest counts were obtained during the spring (late April to mid-May) and late

Table 5. Number and type of animals counted on each of the 3 study sites.

Study Site 1 - Dome Mountain Wildlife Management Area

Date	Deer
5/6/90	50
5/19/90	31
6/6/90	16
6/16/90	3
6/22/90	2
7/3/90	5
7/21/90	20
8/10/90	35
8/19/90	42

Study Site 2 - Franklin Rigler Ranch

Date	Deer	Date	Deer
5/06/90	50	3/30/91	45
5/12/90	35	4/19/91	45
6/10/90	3	5/04/91	51
7/07/90	7	5/23/91	32
7/28/90	7	6/12/91	11
8/04/90	3	6/27/91	4
8/25/90	14	7/05/91	5
9/08/90	18	7/23/91	3
		8/07/91	24
		8/25/91	22
		9/03/91	23

Study Site 3 - David Rigler

Date	Deer	Elk
5/25/91	7	55
6/03/91	4	20
6/15/91	4	1
7/07/91	4	0
7/23/91	0	0
8/07/91	0	0
9/03/91	0	0

summer (mid-August to early September) on all sites except Site 3, which received heavy use only during the spring.

Winter sampling on Study Site 3 indicated a significant proportion of the crop residual remaining after the final cutting in fall was removed by deer and/or elk during both winters (Table 6). However, the amount removed varied greatly. During the winter of 1989-90, 77.1% of the crop residual was removed compared to 17.5% during the following winter. Therefore, the amount of crop material present at the beginning of the 1990 growing season was substantially less than what was present to start the 1991 growing season.

Table 6. Paired t-test results for dry matter weights (g) of alfalfa/grass yields clipped inside and outside cages during winter sampling on Study Site 1 during winters of 1989-90 and 1990-91.

Study Site 1 - Dome Mountain Wildlife Management Area.

Dates		Mean	Std-Error	% Dif	
10/27/89	In	29.36	6.05	77.1	Mean Dif = 22.64
to 3/31/90	Out	6.73	3.80		Std-Error = 2.61
(n=11)					P-Value = <0.01
10/6/90	In	34.20	8.97	17.5	Mean Dif = 6.00
to 3/30/91	Out	28.20	8.98		Std-Error = 1.66
(n=20)					P-Value = <0.01

Factors Influencing Game Damage Complaints

Correlation coefficients and p-values for correlations between each of the explanatory variables and complaint levels in Region 3 varied widely (Tables 7 through 12).

Table 7. Correlation coefficients (r) and p-values for correlations between agricultural market year prices in nominal dollars and game damage complaint levels in Region 3 (1974 to 1990; n = 16).

	Number of Complaints					
	Deer		Elk		Both	
Market Year Price	r	p	r	p	r	p
Current Year (t):						
Hay	0.87	<0.01	0.46	0.07	0.85	<0.01
All Wheat	0.23	0.40	0.11	0.69	0.21	0.45
Barley	0.24	0.37	0.16	0.55	0.23	0.39
Oats	0.38	0.15	0.28	0.30	0.39	0.13
Calves	0.45	0.08	0.43	0.09	0.47	0.07
Lagged One Year (t-1):						
Hay	0.31	0.25	0.11	0.68	0.28	0.30
All Wheat	-0.19	0.49	-0.30	0.26	-0.23	0.39
Barley	0.04	0.89	-0.14	0.60	-0.01	0.97
Oats	0.29	0.27	0.15	0.59	0.26	0.33
Calves	0.34	0.20	0.28	0.29	0.34	0.20
First Difference (t-(t-1)):						
Hay	0.49	0.05	0.31	0.24	0.49	0.06
All Wheat	0.42	0.11	0.42	0.11	0.44	0.49
Barley	0.16	0.55	0.24	0.37	0.19	0.27
Oats	0.05	0.85	0.09	0.75	0.08	0.76
Calves	0.20	0.47	0.25	0.35	0.23	0.40

Note: All wheat includes spring, winter and durum wheat.

Table 8. Correlation coefficients (r) and p-values for correlations between agricultural market year prices in real dollars (base = 1983) and game damage complaint levels in Region 3 (1974 to 1990; n = 16).

	Number of Complaints					
	Deer		Elk		Total	
Market Year Price	r	p	r	p	r	p
Current Year (t):						
Hay	0.13	0.63	-0.19	0.49	0.07	0.80
All Wheat	-0.42	0.11	-0.43	0.10	-0.45	0.08
Barley	-0.44	0.09	-0.45	0.08	-0.48	0.10
Oats	-0.45	0.08	0.45	0.08	0.47	0.07
Calves	0.05	0.86	0.24	0.37	0.09	0.75
Lagged One Year (t-1):						
Hay	-0.38	0.14	-0.46	0.08	-0.43	0.10
All Wheat	-0.56	0.03	-0.59	0.02	-0.60	0.01
Barley	-0.53	0.04	-0.56	0.03	-0.57	0.02
Oats	-0.51	0.04	-0.52	0.04	-0.56	0.03
Calves	-0.18	0.51	-0.15	0.59	-0.19	0.48
First Difference (t-(t-1)):						
Hay	0.48	0.06	0.32	0.23	0.48	0.06
All Wheat	0.24	0.37	0.19	0.49	0.24	0.37
Barley	0.21	0.43	0.26	0.33	0.08	0.75
Oats	0.06	0.82	0.07	0.80	0.08	0.75
Calves	0.22	0.43	0.37	0.16	0.27	0.31

Note: All wheat includes spring, winter, and durum wheat.

Table 9. Correlation coefficients (r) and p-values for correlations between crop production figures and game damage complaint levels in Region 3 (1974 to 1990; n = 16).

	Number of Complaints					
	Deer		Elk		Total	
Variable	r	p	r	p	r	p
Crop Production:						
Hay	-0.09	0.75	0.27	0.32	-0.03	0.92
All Wheat	-0.44	0.09	0.01	0.99	-0.38	0.15
Barley	-0.12	0.66	0.45	0.08	-0.01	0.99
Oats	-0.25	0.36	-0.12	0.66	-0.25	0.36

Note: All wheat includes spring, winter, and durum wheat.

Table 10. Correlation coefficients (r) and p-values for correlations between sociological variables and game damage complaint levels in Region 3 (1974 to 1990; n = 16).

	Number of Complaints					
	Deer		Elk		Total	
Variable	r	p	r	p	r	p
Alcoholism Rate	-0.41	0.11	-0.27	0.32	-0.39	0.13
Suicide Rate	0.26	0.33	0.23	0.38	0.28	0.30
Homicide Rate	-0.30	0.26	-0.48	0.06	-0.35	0.19
Divorce Rate	-0.55	0.03	-0.34	0.20	-0.54	0.03
Marriage Rate	-0.50	0.05	-0.26	0.34	-0.48	0.06

Note: All wheat includes spring, winter, and durum wheat.

Table 11. Correlation coefficients (r) and p-values for correlations between weather variables and game damage complaint levels in Region 3 (1974 to 1990; n = 16).

	Number of Complaints					
	Deer		Elk		Total	
Variable	r	p	r	p	r	p
Monthly Precipitation:						
Oct	-0.14	0.61	-0.20	0.46	-0.18	0.51
Nov	0.53	0.04	0.69	<0.01	0.61	0.01
Dec	-0.14	0.60	0.27	0.32	-0.08	0.78
Jan	0.25	0.34	0.03	0.92	0.23	0.39
Feb	0.20	0.45	-0.09	0.75	0.16	0.56
Mar	0.09	0.74	-0.04	0.88	0.08	0.77
Apr	-0.03	0.92	<-0.01	0.99	-0.04	0.90
Oct-Apr (total)	0.18	0.51	0.14	0.60	0.18	0.52
Jul-Sept (total)	-0.16	0.56	0.20	0.46	-0.09	0.73
Apr-Sept (total)	-0.48	0.06	0.03	0.90	-0.40	0.12
May-Jun (total)	-0.49	0.06	-0.44	0.09	-0.51	0.05
Maximum Monthly Snow Depth:						
Oct	0.03	0.91	-0.10	0.71	-0.07	0.98
Nov	0.20	0.47	0.17	0.53	0.22	0.41
Dec	0.45	0.08	0.54	0.03	0.49	0.05
Jan	-0.03	0.92	-0.06	0.81	-0.03	0.92
Feb	0.19	0.49	-0.06	0.83	0.16	0.57
Mar	<0.01	0.99	-0.03	0.90	<-0.01	0.99
Apr	-0.25	0.35	-0.32	0.22	-0.27	0.31
Nov-Mar (mean)	0.18	0.52	0.09	0.75	0.19	0.51
Mean Minimum Temperature:						
Oct	0.14	0.60	0.22	0.43	0.15	0.57
Nov	-0.21	0.43	0.14	0.61	-0.17	0.54
Dec	-0.51	0.04	-0.73	<0.01	-0.59	0.02
Jan	0.18	0.51	0.06	0.83	0.15	0.59
Feb	-0.52	0.04	-0.34	0.20	-0.52	0.04
Mar	0.32	0.23	0.29	0.28	0.33	0.22
Oct-Mar (mean)	-0.27	0.30	-0.26	0.33	-0.31	0.25
Nov-Feb (mean)	-0.44	0.09	-0.39	0.13	-0.47	0.07

Table 12. Correlation coefficients (r) and p-values for correlations between population variables and game damage complaint levels in Region 3. (1974 to 1990; n = 16).

	Number of Complaints					
	Deer		Elk		Total	
Variable	r	p	r	p	r	p
Deer Population Indices:						
Deer Harvest	0.59	0.02	0.43	0.10	0.60	0.01
Days Per Kill	-0.54	0.03	-0.57	0.02	-0.58	0.02
Hunter % Success	0.67	0.01	0.60	0.01	0.70	<0.01
Trend Surveys	0.61	0.01	0.48	0.06	0.62	0.01
Elk Population Indices:						
Elk Harvest	0.75	<0.01	0.62	0.01	0.77	<0.01
Days Per Kill	-0.67	<0.01	-0.65	0.01	-0.70	<0.01
Hunter % Success	0.81	<0.01	0.67	0.01	0.83	<0.01
Trend Surveys	0.59	0.02	0.56	0.02	0.61	0.01
Combined Indices:						
Total Harvest	0.65	0.01	0.49	0.05	0.66	0.01
Days Per Kill	-0.57	0.02	-0.57	0.02	-0.61	0.01
Hunter % Success	0.76	<0.01	0.63	0.01	0.78	<0.01

The variable most highly correlated with the total number of complaints filed was the current year market price for hay in nominal dollars ($r = 0.87$, $p < 0.01$, Table 7). Other agricultural prices, including lagged prices and prices in real dollars, were also correlated but not as strongly as nominal hay prices.

Of the sociological factors tested (Table 10), only the rate of divorce ($r = -0.54$, $p = 0.03$) was significantly correlated with complaints. The marriage rate ($r = -0.48$,

$p = 0.06$) approached significance. Both rates were also correlated with time ($r = -0.68$, $p < 0.01$ for divorce; and $r = 0.80$, $p < 0.01$ for marriage), as were the number of deer complaints ($r = 0.64$, $p = 0.01$), elk complaints ($r = 0.53$, $p = 0.03$), and total complaints ($r = 0.65$, $p = 0.01$).

Variables associated with winter severity that were significantly correlated with complaints included: November precipitation ($r = 0.61$, $p = 0.01$), maximum snow depth during December ($r = 0.49$, $p = 0.05$), and the mean minimum temperature during December ($r = -0.59$, $p = 0.02$) and February ($r = -0.52$, $p = 0.04$, Table 11). Precipitation during May and June was negatively correlated with complaints ($r = -0.51$, $p = 0.05$).

All population indices tested were significantly correlated with complaint levels (Table 12). The population variable with the highest correlation was hunter percent success ($r = 0.78$, $p < 0.01$). Both the deer ($r = 0.89$, $p < 0.01$) and elk ($r = 0.93$, $p < 0.01$) population trend indices were positively correlated with time, indicating a general region-wide increase in ungulate populations. The deer ($r = 0.85$, $p < 0.01$) and elk ($r = 0.91$, $p < 0.01$) harvest figures were also positively correlated with time.

The model that explained the highest percentage of the variation in the total number of deer and elk complaints filed had the current year hay price (in nominal dollars), November precipitation, and precipitation in May and June as

independent variables (adjusted R^2 = 0.85, F = 26.20, p = < 0.01, Table 13). Hay price and November precipitation had positive coefficients while the coefficient for May-June precipitation was negative. The standardized coefficients indicated that hay price was the most important variable in the model (standardized coefficient = 0.612) followed by November precipitation (standardized coefficient = 0.394) and May-June precipitation (standardized coefficient = -0.333). For 3 years of prediction, the mean absolute error was 13.33 and the root mean square error equaled 25.02.

The deer model had the same independent variables as the overall model but with a slightly poorer fit (adjusted R^2 = 0.82, F = 21.12, p < 0.01, Table 14). Over 3 years of prediction, the mean absolute error was 10.67 and the root mean square error equaled 20.98.

The independent variables for the elk model included the market year price of calves, November precipitation, and mean December minimum temperature (Table 15). The fit of this model (R^2 = 0.76, F = 14.85, p < 0.01) was poorer than the fit for either the deer or total models. Over 3 years of prediction, the mean absolute error was 7.67 and the root mean squared error equaled 14.32.

The statistics for an alternative elk model using the same variables as the deer and total models are given in Table 16. Although the fit of this elk model (R^2 = 0.45,

Table 13. Statistics for the regression model used to predict the total number of deer and elk damage complaints filed during a fiscal year in Region 3.

Dependent Variable = Total Complaints (deer and elk)

Fit:

Variable	Part-R	Std-B	B	SE(B)	T	P
Hay Price:	0.869	0.612	1.042	0.187	5.546	<0.01
Nov Precip:	0.746	0.394	24.919	7.037	3.541	0.01
May-Jun Precip:	-0.728	-0.363	-5.579	1.663	-3.356	0.01
Intercept:	-0.324	<0.001	-15.690	14.494	-1.083	0.30

Adjusted R^2 = 0.853

Analysis of Variance:

Source	DF	S.S.	M.S	F	P
Regression	3	5510.0	1836.7	26.204	<0.01
Residual	10	700.9	70.1		
Total	13	6210.9	477.8		

Autocorrelation Tests:
Durbin-Watson = 1.8317 (no autocorrelation)
Von Neuman Ratio = 1.9726 (no autocorrelation)
Runs Test: 6 Runs, 6 Positive, 8 Negative
(no serial correlation)

Prediction Analysis:

Year	Predicted	Std-Error	Actual	Error
1988-89	87	10.53	108	21
1989-90	47	9.77	58	11
1990-91	44	9.05	36	-8

Mean Absolute Error = 13.33
Root Mean Square Error = 25.02

Table 14. Statistics for the regression model used to predict the number of deer damage complaints filed during a fiscal year in Region 3.

Dependent Variable = Deer Complaints

Fit:

Variable	Part-R	Std-B	B	SE(B)	T	P
Hay Price:	0.876	0.696	1.005	0.175	5.743	<0.01
Nov Precip:	0.581	0.276	14.785	6.552	2.257	0.05
May-Jun Precip:	-0.671	-0.341	-4.435	1.548	-2.865	0.02
Intercept:	-0.508	<0.001	-25.190	13.495	-1.867	0.09

Adjusted R^2 = 0.823

Analysis of Variance:

Source	DF	S.S.	M.S	F	P
Regression	3	3849.2	1283.1	21.116	<0.01
Residual	10	607.6	60.8		
Total	13	4456.8	342.8		

Autocorrelation Tests:
Durbin-Watson = 2.4064 (inconclusive)
Von Neuman Ratio = 2.5915 (no autocorrelatio)
Runs Test: 7 Runs, 5 Positive, 9 Negative
(no serial correlation)

Prediction Analysis:

Year	Estimate	Std-Error	Actual	Error
1988-89	64	9.80	82	18
1989-90	35	9.09	44	9
1990-91	30	8.43	25	-5

Mean Absolute Error = 10.67
Root Mean Square Error = 20.98

Table 15. Statistics for the regression model used to predict the number of elk damage complaints filed during a fiscal year in Region 3.

Dependent Variable = Elk Complaints

Fit:

Variable	Part-R	Std-B	B	SE(B)	T	P
Mean December Minimum Temp:	-0.761	-0.614	-0.580	0.157	-3.707	<0.01
Calve Price:	0.420	0.200	0.069	0.047	1.465	0.17
Nov Precip:	0.559	0.350	6.396	3.003	2.130	0.06
Intercept:	0.649	<0.001	13.990	5.193	2.694	0.02

Adjusted R^2 = 0.762

Analysis of Variance:

Source	DF	S.S.	M.S	F	P
Regression	3	423.1	141.0	14.851	<0.01
Residual	10	95.0	9.5		
Total	13	518.1	39.9		

Autocorrelation Tests:
Durbin-Watson = 2.4106 (inconclusive)
Von Neuman Ratio = 2.5961 (no autocorrelation)
Runs Test: 8 Runs, 7 Positive, 7 Negative
(no serial correlation)

Prediction Analysis:

Year	Estimate	Std-Error	Actual	Error
1988-89	22	3.95	28	6
1989-90	15	3.62	20	5
1990-91	25	3.90	13	-12

Mean Absolute Error = 7.67
Root Mean Square Error = 14.32

Table 16. Statistics for an alternative regression model used to predict the number of elk damage complaints filed during a fiscal year in Region 3.

Dependent Variable = Elk Complaints

Fit:

Variable	Part-R	Std-B	B	SE(B)	T	P
Hay Price:	0.121	0.082	0.040	0.105	0.384	0.71
Nov Precip:	0.683	0.636	11.605	3.929	2.954	0.01
May-Jun Precip:	-0.382	-0.273	-1.213	0.928	-1.306	0.22
Intercept:	0.357	<0.001	9.770	8.093	1.208	0.25

Adjusted R^2 = 0.452

Analysis of Variance:

Source	DF	S.S.	M.S	F	P
Regression	3	299.5	99.8	4.558	0.03
Residual	10	218.5	21.9		
Total	13	518.0	39.9		

Autocorrelation Tests:
Durbin-Watson = 1.7993 (no autocorrelation)
Von Neuman Ratio = 1.9377 (no autocorrelation)
Runs Test: 8 Runs, 8 Positive, 6 Negative
(no serial correlation)

Prediction Analysis:

Year	Estimate	Std-Error	Actual	Error
1988-89	25	5.88	28	3
1989-90	14	5.45	20	6
1990-91	16	5.05	13	-3

Mean Absolute Error = 4.00
Root Mean Square Error = 7.35

$F = 4.56$, $p = 0.03$) was poorer than the elk model described above, its prediction accuracy was better (mean absolute error = 4.00, root mean squared error = 7.35)

The correlation coefficients between each of the explanatory variables and game damage complaint levels in Region 4 also varied widely. Only variables related to winter severity were significantly correlated with complaint levels (Table 17). The weather variables with the highest correlation coefficients were monthly mean minimum temperature from November to February ($r = -0.77$, $p < 0.01$) and mean monthly maximum snow depth from November to March ($r = 0.80$, $p < 0.01$). Variables associated with agricultural prices, sociological factors, and population levels were not significant (Tables 18 through 22).

As in Region 3, both the deer ($r = 0.89$, $p < 0.01$) and elk ($r = 0.92$, $p < 0.01$) population trend indices were positively correlated with time. The deer ($r = 60.0$, $p = 0.01$) and elk ($r = 0.81$, $p < 0.01$) harvest figures were also positively correlated with time. The number of deer complaints ($r = 0.16$, $p = 0.54$), elk complaints ($r = 0.33$, $p = 0.18$), and total complaints ($r = 0.17$, $p = 0.50$) were not significantly correlated with time.

The independent variables identified in the best model to predict the total number of game damage complaints filed in Region 4 were the current market year hay price (in nominal dollars) and the mean monthly maximum snow depth

Table 17. Correlation coefficients (r) and p-values for correlations between weather variables and game damage complaint levels in Region 4 (1972 to 1990; n = 18).

	Number of Complaints					
	Deer		Elk		Total	
Variable	r	p	r	p	r	p
Monthly Precipitation:						
Oct	-0.18	0.49	-0.18	0.47	-0.18	0.48
Nov	0.33	0.18	0.46	0.06	0.36	0.14
Dec	0.42	0.08	0.29	0.24	0.41	0.09
Jan	0.20	0.42	0.38	0.12	0.24	0.34
Feb	0.36	0.14	0.72	<0.01	0.45	0.06
Mar	-0.06	0.81	-0.17	0.50	-0.11	0.67
Apr	0.15	0.55	0.22	0.38	0.16	0.52
Oct-Apr (total)	0.35	0.15	0.48	0.04	0.38	0.12
Jul-Sept (total)	0.14	0.58	0.45	0.06	0.21	0.42
Apr-Sept (total)	-0.14	0.59	0.06	0.80	-0.11	0.67
May-Jun (total)	-0.39	0.11	0.15	0.56	-0.36	0.15
Maximum Monthly Snow Depth:						
Oct	-0.17	0.51	-0.19	0.45	-0.17	0.50
Nov	0.42	0.08	0.44	0.07	0.45	0.06
Dec	0.69	<0.01	0.52	0.03	0.69	<0.01
Jan	0.67	<0.01	0.63	0.01	0.70	<0.01
Feb	0.53	0.02	0.67	<0.01	0.58	0.01
Mar	0.42	0.09	0.31	0.22	0.40	0.10
Apr	-0.27	0.28	-0.26	0.31	-0.27	0.27
Nov-Mar (mean)	0.80	<0.01	0.77	<0.01	0.80	<0.01
Mean Minimum Temperature:						
Oct	-0.10	0.70	0.23	0.35	-0.05	0.84
Nov	-0.17	0.51	-0.44	0.07	-0.24	0.34
Dec	-0.73	<0.01	-0.39	0.11	-0.71	<0.01
Jan	-0.36	0.15	-0.20	0.42	-0.35	0.16
Feb	-0.38	0.12	-0.44	0.07	-0.40	0.10
Mar	0.02	0.92	0.19	0.46	0.07	0.79
Oct-Mar (mean)	-0.70	<0.01	-0.53	0.03	-0.71	<0.01
Nov-Feb (mean)	-0.75	<0.01	-0.64	<0.01	-0.77	<0.01

Table 18. Correlation coefficients (r) and p-values for correlations between agricultural market year prices in nominal dollars and game damage complaint levels in Region 4 (1972 to 1990; n = 18).

	Number of Complaints					
	Deer		Elk		Total	
Market Year Price	r	p	r	p	r	p
Current Year (t):						
Hay	0.37	0.13	0.41	0.09	0.38	0.12
All Wheat	-0.08	0.75	-0.15	0.56	-0.11	0.67
Barley	0.07	0.77	-0.04	0.88	0.05	0.86
Oats	0.14	0.57	0.15	0.55	0.14	0.58
Calves	0.04	0.89	0.19	0.44	0.04	0.85
Lagged One Year (t-1):						
Hay	0.11	0.67	0.27	0.28	0.13	0.62
All Wheat	-0.05	0.85	-0.06	0.83	-0.06	0.83
Barley	0.09	0.72	0.11	0.67	0.09	0.72
Oats	0.11	0.66	0.23	0.37	0.12	0.62
Calves	-0.13	0.60	-0.07	0.77	-0.15	0.55
First Difference (t-(t-1)):						
Hay	0.23	0.36	0.11	0.68	0.22	0.38
All Wheat	-0.02	0.93	-0.07	0.79	-0.03	0.89
Barley	-0.03	0.92	-0.14	0.58	-0.05	0.84
Oats	0.01	0.96	-0.11	0.67	-0.01	0.97
Calves	0.24	0.33	0.39	0.11	0.28	0.25

Note: All wheat includes spring, winter, and durum wheat.

Table 19. Correlation coefficients (r) and p-values for correlations between agricultural market year prices in real dollars (base = 1983) and game damage complaint levels in Region 4 (1972 to 1990; n = 18).

	Number of Complaints					
	Deer		Elk		Total	
Market Year Price	r	p	r	p	r	p
Current Year (t):						
Hay	0.09	0.73	-0.05	0.84	0.08	0.77
All Wheat	-0.27	0.29	-0.41	0.09	-0.30	0.24
Barley	-0.21	0.41	-0.39	0.11	-0.24	0.34
Oats	-0.14	0.58	-0.27	0.29	-0.16	0.53
Calves	0.20	0.42	0.19	0.44	0.21	0.40
Lagged One Year (t-1):						
Hay	-0.05	0.86	-0.05	0.87	-0.04	0.86
All Wheat	-0.21	0.40	-0.29	0.25	-0.22	0.37
Barley	-0.12	0.64	-0.19	0.46	-0.12	0.62
Oats	-0.05	0.86	-0.04	0.87	-0.04	0.88
Calves	-0.14	0.59	-0.18	0.48	-0.15	0.56
First Difference (t-(t-1)):						
Hay	0.12	0.66	<-0.01	0.98	0.10	0.69
All Wheat	-0.06	0.80	-0.15	0.56	-0.09	0.74
Barley	-0.12	0.65	-0.27	0.29	-0.15	0.55
Oats	-0.11	0.66	-0.26	0.30	-0.14	0.58
Calves	0.35	0.15	0.39	0.11	0.38	0.12

Note: All wheat includes spring, winter, and durum wheat.

Table 20. Correlation coefficients (r) and p-values for correlations between crop production figures and game damage complaint levels in Region 4 (1972 to 1990; n = 18).

	Number of Complaints					
	Deer		Elk		Total	
Variable	r	p	r	p	r	p
Crop Production:						
Hay	-0.30	0.24	-0.38	0.12	-0.32	0.20
All Wheat	-0.09	0.73	-0.17	0.50	-0.11	0.67
Barley	<0.01	0.98	-0.07	0.77	-0.02	0.94
Oats	-0.06	0.82	-0.16	0.54	-0.07	0.77

Note: All wheat includes spring, winter, and durum wheat.

Table 21. Correlation coefficients (r) and p-values for correlations between sociological variables and game damage complaint levels in Region 4 (1972 to 1990; n = 18).

	Number of Complaints					
	Deer		Elk		Total	
Variable	r	p	r	p	r	p
Alcoholism Rate	-0.26	0.30	-0.10	0.68	-0.23	0.35
Suicide Rate	0.08	0.76	0.38	0.12	0.11	0.65
Homicide Rate	-0.07	0.80	0.13	0.62	-0.02	0.94
Divorce Rate	0.15	0.56	0.20	0.42	0.18	0.47
Marriage Rate	-0.02	0.92	-0.31	0.22	-0.06	0.82

Note: All wheat includes spring, winter, and durum wheat.

Table 22. Correlation coefficients (r) and p-values for correlations between population variables and game damage complaint levels in Region 4. (1972 to 1990; n = 18).

	Number of Complaints					
	Deer		Elk		Total	
Variable	r	p	r	p	r	p
Deer Population Indices:						
Deer Harvest	0.23	0.37	-0.07	0.77	0.17	0.51
Days Per Kill	-0.17	0.49	<-0.01	0.99	-0.13	0.60
Hunter % Success	0.21	0.41	<0.01	0.99	0.17	0.51
Trend Surveys	0.12	0.64	0.24	0.34	0.12	0.63
Elk Population Indices:						
Elk Harvest	0.23	0.35	0.26	0.30	0.22	0.37
Days Per Kill	-0.23	0.36	-0.19	0.44	-0.22	0.38
Hunter % Success	0.29	0.24	0.24	0.34	0.28	0.27
Trend Surveys	0.10	0.71	0.22	0.38	0.10	0.69
Combined Indices:						
Total Harvest	0.24	0.35	-0.04	0.88	0.18	0.47
Days Per Kill	-0.13	0.60	-0.04	0.89	-0.09	0.72
Hunter % Success	0.26	0.30	0.01	0.97	0.21	0.40

from November to March (adjusted R^2 = 0.70, F = 18.59, $p < 0.01$, Table 23). The snow variable (standardized coefficient = 0.749) was more important than hay price (standardized coefficient = 0.324).

The models used to predict the number of deer complaints (adjusted R^2 = 0.63, F = 13.91, $p < 0.01$, Table 24) and elk complaints (adjusted R^2 = 0.59, F = 11.82, $p < 0.01$, Table 25) have the same independent variables as the

Table 23. Statistics for the regression model used to predict the total number of deer and elk damage complaints filed during a fiscal year in Region 4.

Dependent Variable = Total Complaints (deer and elk)

Fit:

Variable	Part-R	Std-B	B	SE(B)	T	P
Mean Nov-March Max Snow Depth:	0.824	0.749	7.745	1.479	5.237	<0.01
Hay Price:	0.532	0.324	0.800	0.353	2.264	0.04
Intercept:	0.562	<0.001	49.564	20.219	2.451	0.02

Adjusted R^2 = 0.701

Analysis of Variance:

Source	DF	S.S.	M.S	F	P
Regression	2	12011.0	6005.6	18.595	<0.01
Residual	13	4198.6	323.0		
Total	15	16210.0	1080.7		

Autocorrelation Tests:
Durbin-Watson = 1.7693 (no autocorrelation)
Von Neuman Ratio = 1.8873 (no autocorrelation)
Runs Test: 7 Runs, 6 Positive, 10 Negative
(no serial correlation)

Prediction Analysis:

Year	Predicted	Std-Error	Actual	Error
1988-89	68	21.52	52	-16
1989-90	43	19.51	24	-19
1990-91	40	19.30	26	-14

Mean Absolute Error = 16.33
Root Mean Square Error = 28.51

Table 24. Statistics for the regression model used to predict the number of deer damage complaints filed during a fiscal year in Region 4.

Dependent Variable = Deer Complaints

Fit:

Variable	Part-R	Std-B	B	SE(B)	T	P
Mean Nov-March Max Snow Depth:	0.782	0.718	6.507	1.437	4.530	<0.01
Hay Price:	0.477	0.310	0.672	0.343	1.957	0.07
Intercept:	-0.539	<0.001	-45.294	19.640	-2.306	0.04

Adjusted R^2 = 0.633

Analysis of Variance:

Source	DF	S.S.	M.S	F	P
Regression	2	8477.3	4238.7	13.909	<0.01
Residual	13	3961.7	304.7		
Total	15	12439.0	829.3		

Autocorrelation Tests:
Durbin-Watson = 1.8719 (no autocorrelation)
Von Nueman Ratio = 1.9976 (no autocorrelation)
Runs Test: 7 Runs, 6 Positive, 10 Negative
(no autocorrelation)

Prediction Analysis:

Year	Predicted	Std-Error	Actual	Error
1988-89	54	20.90	40	-14
1989-90	32	18.95	19	-13
1990-91	30	18.75	19	-11

Mean Absolute Error = 12.67
Root Mean Square Error = 22.05

Table 25. Statistics for the regression model used to predict the number of elk damage complaints filed during a fiscal year in Region 4.

Dependent Variable = Elk Complaints

Fit:

Variable	Part-R	Std-B	B	SE(B)	T	P
Mean Nov-March Max Snow Depth:	0.760	0.706	1.348	0.319	4.222	<0.01
Hay Price:	0.430	0.288	0.131	0.076	1.719	0.11
Intercept:	-0.259	<0.001	-4.223	4.367	-0.967	0.36

Adjusted R^2 = 0.591

Analysis of Variance:

Source	DF	S.S.	M.S	F	P
Regression	2	356.1	178.1	11.818	<0.01
Residual	13	195.9	15.1		
Total	15	522.0	36.8		

Autocorrelation Tests:
Durbin-Watson = 1.6606 (no autocorrelation)
Von Neuman Ration = 1.7713 (no autocorrelation)
Runs Test: 8 Runs, 8 Positive, 8 Negative
(no autocorrelation)

Prediction Analysis:

Year	Predicted	Std-Error	Actual	Error
1988-89	16	4.65	16	0
1989-90	11	4.21	9	-2
1990-91	11	4.17	9	-2

Mean Absolute Error = 1.33
Root Mean Square Error = 2.83

total model. The hay price variable was not significant in either model, although it did increase the overall fit of both models. When the hay price variable was included, the adjusted R^2 increased from 0.56 to 0.63 in the deer model, and from 0.53 to 0.59 in the elk model.

In order to test the universality of the models developed for each region, the variables used to predict the total number of complaints in Region 3 were applied to Region 4 and vice versa. In each case, the resulting fit and prediction accuracy was poorer than the original model. In Region 3, the resulting model had an adjusted R^2 of 0.62 ($F = 11.36$, $p < 0.01$), a mean absolute error of 14.67, and a root mean squared error of 29.56. In Region 4, the resulting model had an adjusted R^2 of 0.28 ($F = 2.91$, $p = 0.08$), a mean absolute error of 23.33, and a root mean squared error of 51.21.

Landowner Posting and Game Damage Complaints

Except for Region 1, the proportion of game damage complaints filed by landowners with posted property (22%) was significantly less than the proportion of complaints filed by landowners with nonposted property (78%, $p < 0.01$, Table 26). In Region 1, the proportion of complaints from landowners with posted property (44%) was not significantly

different from the proportion of complaints filed by landowners with nonposted property (56%, p = 0.36).

Table 26. Proportion of landowners filing game damage complaints with posted and non-posted land.

Region	% Posted	% Not Posted	Std-Error	n	P-Value
1	44.3	55.7	5.6	79	0.36
2	29.7	70.3	3.3	195	<0.01
3	34.6	65.4	3.3	214	<0.01
4	35.1	64.9	3.3	205	<0.01
5	11.2	88.8	1.3	587	<0.01
6	7.3	92.7	2.4	124	<0.01
7	18.8	81.2	2.7	218	<0.01
Total	21.9	78.1	1.0	1622	<0.01

The exact opposite relationship was found for the land adjoining the complainant's property (Table 27). Sixty-four percent of the complaining landowners had at least 1 adjoining neighbor with posted property. This proportion was significantly greater than the proportion of complainants not having an adjoining neighbor with posted property (36.5%, p < 0.01). This pattern existed in all regions except Regions 6 and 7. In Region 7, the proportion of complainants who had at least 1 neighbor with posted property (55%) was not significantly different from the proportion of complainants that did not have an adjoining neighbor with posted property (45%, p = 0.18). In Region 6, the proportion of complaining landowners that had a neighbor with posted property (36%) was less than the proportion of

complainants that did not have a neighbor with posted property (64%).

Table 27. Proportion of landowners filing game damage complaints who had at least 1 adjoining neighbor with posted land.

Region	% Posted	% Not Posted	Std-Error	n	P-Value
1	65.2	34.8	5.9	66	0.01
2	75.8	24.2	3.1	190	<0.01
3	87.6	12.4	2.4	193	<0.01
4	72.3	27.7	3.3	184	<0.01
5	56.4	43.6	2.1	548	<0.01
6	36.0	64.0	4.6	111	<0.01
7	55.0	45.0	3.5	200	0.18
Total	63.5	36.5	1.3	1492	<0.01

In individual regions, there were 64 to 547 complaints for which each of the 4 possible combinations of complainant and neighbor posting could be evaluated (Table 28). Overall, the highest proportion of complaints (45%) were from landowners with nonposted property but who had at least 1 adjoining neighbor with posted property.

When complaints from situations involving some posting (i.e. either the complainant, 1 of the adjoining neighbors, or both had posted property) were compared with those involving no posting (Table 29), a significantly greater proportion of the complaints were from areas with some degree of posting (66%, $p < 0.01$). This relationship existed in 6 of the 7 administrative regions. In Region 6, however, the result was reversed; a greater proportion of

the complaints was from situations where neither the complainant's property nor any of the adjoining properties were posted (63%, p = 0.01).

Table 28. Proportion of game damage complaints from the 4 possible combinations of posting of complainant's and neighboring properties.

Region	% PP	% NP	% PN	% NN	n
1	36.0	28.1	7.8	28.1	64
2	24.3	50.8	4.9	20.0	185
3	33.7	54.2	2.1	10.0	190
4	28.4	43.7	7.1	20.8	183
5	10.0	46.2	1.0	42.8	547
6	5.4	30.6	1.0	63.0	111
7	15.0	40.0	4.0	41.0	200
Total	18.6	44.7	3.0	33.7	1480

PP = Complainant and 1 adjoining neighbor posted.
NP = Complainant not posted, 1 adjoining neighbor posted.
NN = Complainant and adjoining neighbors not posted.
PN = Complainant posted, adjoining neighbors not posted.

Table 29. Proportion of game damage complaints from areas where either the complainant, 1 of the adjoining neighbors, or both had posted property.

Region	% Posted	% Not Posted	Std-Error	n	P-Value
1	71.9	28.1	5.7	64	<0.01
2	80.0	20.0	3.0	185	<0.01
3	90.0	10.0	2.2	190	<0.01
4	79.2	20.8	3.0	183	<0.01
5	57.2	42.8	2.1	547	<0.01
6	37.0	63.0	4.6	111	0.01
7	59.0	41.0	3.5	200	0.01
Total	66.3	33.7	1.2	1480	<0.01

DISCUSSION

Field Evaluation of Game Damage

The results of other studies that have examined the extent of game damage to alfalfa crops are mixed. A few authors (Boyd 1965, Egan 1965) have reported finding no damage while others have reported variable (Cole 1956, Tebaldi 1979) or extensive damage (Palmer et al. 1982). In this study, significant damage occurred during the spring on all study sites and during both years. Significant summer damage occurred on 2 of the 3 study sites.

There was a strong relationship between the number of animals observed using a field over a given time period and the extent of damage found. Periods with high deer/elk counts (early spring and late summer) had significant damage while periods with low counts (mid-summer) did not have significant damage. These findings support the theory that the intensity of crop damage is directly related to the number of animals using a field (Matschke et al. 1984). Tebaldi (1979) also reported a direct relationship between deer numbers and damage levels.

The variation in the amount of residual crop material removed from Study Site 1 during the 2 winters of sampling was also directly related to animal numbers. During the

winter of 1989-90, over 2000 elk were counted on this site compared to a maximum count of approximately 800 elk during the winter of 1990-91.

The lack of animal use in Site 3 during the second half of the 1991 growing season may be due to the lack of irrigation. This field was sub-irrigated during the first part of the season, but left dry following the first cutting. After this cutting, several deer were observed using the other irrigated hay fields in the immediate vicinity but none were seen in the study field. A similar finding was reported by Tebaldi (1979).

An increase in crop production due to the possible stimulating effects of grazing was not found on any study site in either year. Plots clipped in the stationary cages prior to the first cutting by the farmer/rancher had significantly greater amounts of vegetation than unprotected plots on all study sites. Clipping of vegetation in the movable cages revealed that this difference was due to animal use during the first few weeks of the growing season.

Most depredation occurred during the spring and late summer. No damage occurred during mid-summer on any study site. These findings agree with the movement pattern of both mule deer and elk in the area. Elk and mule deer generally summer at higher elevations and move to lower elevations in winter (Constan 1975). The tendency of alfalfa to initiate growth early in spring may also account

for the heavy use of these fields in spring. Late summer damage may result from the irrigated fields acting as a attractant at a time when the surrounding natural vegetation is dry. Nybereg (1980) and Dusek (1984) also noted heavy use of agricultural crops by deer in early spring and late summer.

Factors Influencing Game Damage Complaints

The high degree of correlation between hay prices and game damage complaint levels in Region 3 supports the hypothesis that agricultural economic conditions can influence the number of complaints filed by landowners. The positive correlation indicates that landowners complain more as the economic loss caused by game damage increases. Since hay is an intermediate good on most ranches, the economic loss is greatest when the market price is high. When hay is in short supply on a ranch it is often due to drought and/or a lack of irrigation water. Under such conditions, the rancher is extremely sensitive to the high cost of replacing damaged or lost hay. Several other authors (Carpenter 1967, Brown et al. 1978, Tanner and Dimmick 1983, Decker et al. 1984, Purdy 1987) have also reported a direct relationship between increasing economic loss and decreasing landowner tolerance.

Government income transfers for wheat, barley, and oats may explain some of the lack of correlation between the

price of these program crops and game damage complaint levels. The presence of these income transfers, which are earned on eligible lands from planting (and not necessarily from harvesting) the crop may buffer the monetary losses caused by game damage. Therefore, the incentive to complain about game damage on economic grounds may be lessened.

However, care must be taken in interpreting how these income transfers might buffer a farm manager's apprehensions about game damage. If a farm manager perceives a fairly stable market price and associated income transfer for the crop being damaged, he may not be prone to file a complaint. On the other hand, if the farmer perceives a rapidly rising market price for the crop being damaged, he might file a game damage complaint since the deficiency payment would be reduced (the deficiency payment usually being the difference between the target price, which is politically determined, and the national average market price). Therefore, one would expect the willingness of a farmer to file a complaint to increase during periods of rising market prices.

Considerably lower levels of correlation between agricultural prices and game damage complaint levels were found in Region 4 than in Region 3. There are substantial differences in the agricultural enterprises and in the land uses existing in the 2 regions. In Region 3, a significantly higher proportion of the cropland is in hay, while in Region 4 a significantly higher proportion of the

cropland is in program crops such as wheat, barley, and oats. For example, in 1987, 44% of the cropland in Region 3 was in program crops compared to 85% in Region 4 (U.S. Department of Commerce 1989). The proportion of farms with cattle operations in Region 4 (56%) is also less than the proportion in Region 3 (71%). In addition, in 1987, 25% of the total cash receipts for farms in Region 4 were in the form of government payments, compared to 7% in Region 3 (Montana Department of Agricultural 1988).

If the presence of program crops decreases the economic incentive to complain, fewer complaints per farm would be expected in Region 4 than in Region 3 . From fiscal years 1986-87 to 1990-91, there were 3.6 times more complaints per farm in Region 3 than in Region 4 (0.096 complaints/farm in Region 3 compared to 0.026 in Region 4). Dusek (1984) reported that game damage complaints along the lower Yellowstone River in eastern Montana were more numerous from areas where the production of livestock and hay were the major agricultural activities.

Two other factors may also contribute to the greater number of complaints in Region 3 than in Region 4. First, wheat, barley, and oats are stored in grain bins on farm after harvest or sold off the farm at harvest. Therefore, the length of time that these crops are exposed to potential game damage is less than that of hay, which is often stored in unprotected stacks after harvesting. Second, the ratio

of cropland acres to deer and elk numbers is approximately 3 times higher in Region 3 than in Region 4.

The results of this study also support the hypothesis that game damage complaint levels are influenced by winter weather conditions. In each region, variables associated with maximum snow depth, precipitation levels, and minimum temperatures during the winter months were correlated with complaint levels.

In Region 3, complaint levels were correlated with winter weather variables in specific months (i.e. November precipitation, December snow levels and mean minimum temperature). In Region 4, however, complaint levels were correlated to winter weather variables over a period of several months (i.e. November to March maximum snow depths). The time-specific correlations in Region 3 may be due to the more mountainous terrain of the region. Bad weather (i.e. high precipitation, deep snow, and cold temperatures) early in the winter might force the movement of ungulates from high elevation summer ranges to lower elevation winter ranges.

The negative correlation between precipitation in May and June in Region 3 may indicate that wild ungulates make greater use of irrigated fields when the natural vegetation is dry. A lack of precipitation in May and June may retard the early growth of natural vegetation and the corresponding movement of deer and elk to higher elevation summer ranges.

The lack of correlation between May and June precipitation and complaint levels in Region 4 may reflect the lack of irrigated fields in that region (< 20% of the cropland in Region 4 is irrigated, compared to > 80% in Region 3).

The Region 4 models had a lower overall fit, higher standard errors, and a lower prediction accuracy than the corresponding models for Region 3. However, the value of any prediction model depends in part on the required accuracy of the prediction. In actual practice, the models developed for both regions should provide wildlife managers with valuable information regarding the general relationships which might lead to high game damage complaint levels.

A drawback to applying these models for yearly prediction purposes is the temporal association of the dependent and explanatory variables. The models perform well in explaining last year's complaints but they will have limited use in forecasting the coming year's complaints since the data related to the explanatory variables cannot be collected until winter. Some of this problem can be avoided. The majority of complaints (> 85%) in both regions are filed between October and June. By tracking the market year price of hay (which begins June 1) and assessing the possible severity of a winter by November or December, the models could be used to give estimates of

the relative number of complaints that will be filed during the first half of following year (January to June).

Landowner Posting and Game Damage Complaints

The methods used in these analyses involved sampling only those landowners that had filed a game damage complaint. The true proportion of posted and nonposted lands was not known. Since the conditions surrounding complaining landowners may not be representative of the conditions surrounding noncomplaining landowners, inferences were limited to the subpopulation sampled. However, from a wildlife manager's perspective, information regarding complaining landowners should be of great value since this subpopulation requires the most time, effort, and money. Within these constraints, the results of these analyses support some commonly held assumptions regarding landowner posting and game damage.

First, it is commonly believed that the most effective means of controlling crop depredation problems is population control through hunting (Halls 1978, Brannon 1984, Aderhold 1984, Matschke et al. 1984). In order for hunting to be effective, landowner cooperation via hunter access is essential. In this study, 66% of the complaints filed involved situations where either the complainant's land, 1 of the adjoining properties, or both were posted. This information supports the hypothesis that areas with

inadequate hunter access are more likely to have game damage problems than areas with hunting opportunities.

Second, several authors have noted that population control is ineffective when handled on a farm to farm basis (Erickson and Giessman 1989) or when the focus is on harvesting animals only from the damage site (Aderhold 1985). The findings of this study support both these statements. Of the 4 possible posting/nonposting situations, the highest proportion of complaints (45%) was from landowners with nonposted property but who had a neighbor with posted property. A possible explanation for this finding may be the creation of refuge areas on the properties where hunting is prohibited. Lyon and Scanlon (1985) also noted the problem of increased game damage problems on properties adjacent to areas with little or no hunting. The low proportion of complaints from landowners with posted land (21.9%) may result from the MDFWP policy of providing assistance only when reasonable hunter access is allowed by the landowner. If a landowner is aware of this policy and unwilling to allow access, he would have little to gain by complaining. In written testimony presented to the Montana Legislative Council's Joint Interim Subcommittee on Agricultural Problems, the Montana Department of Fish, Wildlife and Parks (1985) stated that "neighbors not allowing hunting and creating refuges during the hunting season" was a cause of game damage that should be addressed.

CONCLUSIONS

In addition to providing wildlife managers with information that should assist them in dealing with game damage problems, the results of this study fail to refute some commonly held assumptions regarding game damage. The field part of this study found that high animal numbers can significantly reduce crop production on alfalfa fields. The late spring and early summer were identified as critical periods for potential crop damage. Winter weather severity and agricultural economic conditions were identified as major factors influencing the number of game damage complaints filed. Agricultural prices appear to be particularly important in areas where the major crops are not eligible for government price supports and income transfers. Finally, analysis of game damage complaint forms revealed that the posting of land against hunting can contribute to game damage problems, not only on the posted property but also on the neighboring properties.

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APPENDICES

APPENDIX A

COMPLAINT DATA

Table 30. Number of deer, elk, and total game damage complaints received in Regions 3 and 4 by fiscal year (July 1 to June 30).

	Number Of Complaints					
	Region 3			Region 4		
Fiscal Year	Deer	Elk	Total	Deer	Elk	Total
1972-73				7	2	9
1973-74				12	4	15
1974-75	5	9	13	14	7	20
1975-76	7	12	18	9	9	18
1976-77	2	6	8	25	8	33
1977-78	20	18	36	62	22	83
1978-79	32	24	53	87	22	107
1979-80	12	9	21	8	12	20
1980-81	10	17	24	17	8	25
1981-82	16	14	30	23	7	28
1982-83	16	17	31	10	6	16
1983-84	40	30	66	69	17	84
1984-85	40	21	60	86	11	95
1985-86	70	14	83	35	19	54
1986-87	19	18	37	8	11	17
1987-88	9	15	23	12	11	22
1988-89	82	28	108	40	16	52
1989-90	44	20	58	19	9	24
1990-91	25	13	36	19	9	26

Note: Some complaints involved both deer and elk and are listed in both columns, but only once in the total column. Therefore, the deer and elk columns do not always sum to the total column.

APPENDIX B

POPULATION TREND INDICES

Table 31. Deer and elk population trend index values.

	Region 3		Region 4	
Year	Deer	Elk	Deer	Elk
1972-73			100.0	100.0
1973-74			94.1	93.6
1974-75	100.0	100.0	100.7	113.0
1975-76	94.7	114.7	113.6	118.0
1976-77	99.4	71.0	114.5	138.0
1977-78	119.2	118.3	145.5	112.3
1978-79	151.1	109.1	137.8	122.5
1979-80	141.1	130.1	151.6	148.3
1980-81	167.3	140.8	168.3	142.6
1981-82	201.1	192.1	223.9	174.7
1982-83	213.6	213.5	199.0	143.4
1983-84	200.0	202.4	223.5	153.6
1984-85	145.5	224.5	164.1	174.0
1985-86	247.6	183.6	167.4	165.5
1986-87	204.9	209.4	195.9	171.6
1987-88	218.0	230.0	204.3	191.0
1988-89	224.5	274.5	225.8	202.0
1989-90	238.5	317.5	244.2	175.5

APPENDIX C

WEATHER DATA

Table 32. Monthly precipitation data for Region 3. (Inches)

	Month					
Year	Jan	Feb	Mar	Apr	May	Jun
1974	0.68	0.42	2.05	0.82	2.02	0.47
1975	1.24	0.90	1.19	2.21	2.61	2.72
1976	0.67	0.63	0.79	2.19	1.58	3.29
1977	0.77	0.17	1.39	0.49	2.81	2.33
1978	1.00	0.99	0.35	1.36	2.74	1.68
1979	0.77	0.82	1.04	1.64	1.34	1.60
1980	1.02	1.06	1.28	0.77	4.91	2.62
1981	0.32	1.05	0.99	1.41	5.18	2.53
1982	1.01	0.60	2.03	1.73	2.36	2.86
1983	0.35	0.62	1.33	0.85	1.19	2.98
1984	0.41	0.56	1.21	1.62	1.82	2.94
1985	1.97	0.56	1.29	0.49	2.08	0.92
1986	0.62	1.36	0.97	1.68	1.70	2.17
1987	0.44	0.42	0.72	0.56	3.86	1.62
1988	0.61	0.41	0.90	1.82	2.59	1.08
1989	1.29	0.64	1.42	1.23	2.40	1.46
1990	0.95	0.35	1.15	1.40	2.23	1.69
1991	0.27	0.26	1.32	1.79	3.40	2.26

Year	Jul	Aug	Sept	Oct	Nov	Dec
1974	0.73	1.54	0.48	1.16	0.58	0.94
1975	2.76	1.43	0.60	2.66	1.17	0.91
1976	1.55	1.66	2.76	0.86	0.18	0.30
1977	1.84	1.75	2.55	0.76	0.77	1.30
1978	1.85	0.85	2.79	0.33	0.96	0.93
1979	0.65	1.66	0.13	1.21	0.53	0.31
1980	1.40	1.22	2.62	0.80	0.79	0.60
1981	1.01	0.39	1.04	1.56	1.16	0.88
1982	1.46	0.96	2.41	1.02	0.74	1.48
1983	2.71	2.30	2.18	1.41	1.54	1.06
1984	1.72	2.10	1.31	1.08	0.92	0.62
1985	1.26	1.49	2.53	0.94	1.02	0.39
1986	1.78	2.05	2.09	0.45	1.09	0.19
1987	3.95	1.98	0.38	0.02	0.49	0.74
1988	0.38	0.41	1.25	0.36	1.42	0.62
1989	1.16	1.76	0.81	1.84	0.49	0.57
1990	1.23	1.78	0.42	0.82	0.86	0.65

Source: National Oceanic and Atmospheric Administration monthly climatological data 1974-91. Readings are from the southwestern divisional recording.

Table 33. Monthly precipitation data for Region 4. (Inches)

	Month					
Year	Jan	Feb	Mar	Apr	May	Jun
1973	0.18	0.22	0.33	1.77	0.96	2.30
1974	0.61	0.27	0.75	0.83	3.75	1.01
1975	0.83	0.39	1.06	2.64	3.31	4.38
1976	0.29	0.36	0.37	1.48	1.10	3.49
1977	0.69	0.18	0.90	0.24	2.46	1.31
1978	1.18	0.80	0.34	1.58	3.59	1.87
1979	0.58	0.64	0.71	1.62	1.18	1.99
1980	0.69	0.67	0.77	0.93	3.31	3.27
1981	0.25	0.28	0.84	0.35	5.68	2.04
1982	0.95	0.72	1.21	0.82	3.68	2.59
1983	0.28	0.20	0.92	0.54	1.86	2.13
1984	0.59	0.42	0.90	1.11	1.10	1.96
1985	0.19	0.38	0.98	0.79	1.96	0.62
1986	0.43	1.01	0.51	1.15	2.98	2.07
1987	0.12	0.30	1.45	0.48	2.51	1.51
1988	0.53	0.50	0.74	0.83	1.89	1.60
1989	0.99	0.71	1.08	2.08	2.39	2.39
1990	0.49	0.18	0.96	1.13	2.86	1.33
1991	0.50	0.28	0.90	2.09	2.81	4.66

Year	Jul	Aug	Sept	Oct	Nov	Dec
1972	2.00	2.16	0.84	0.63	0.15	0.67
1973	0.46	1.18	1.45	0.76	0.88	0.65
1974	1.49	3.43	0.75	0.42	0.42	0.35
1975	2.39	2.38	0.66	2.24	0.78	0.50
1976	1.28	1.55	0.93	0.32	0.52	0.29
1977	1.52	1.98	2.10	0.57	0.62	1.56
1978	3.14	1.52	2.93	0.30	1.17	0.79
1979	0.98	1.02	0.37	0.56	0.26	0.46
1980	0.67	1.33	0.97	1.54	0.34	0.56
1981	1.68	0.92	0.48	1.26	0.36	0.39
1982	1.54	0.96	1.97	0.77	0.34	0.78
1983	3.03	0.87	1.40	0.70	0.69	0.64
1984	0.23	1.09	1.42	0.90	0.39	0.84
1985	0.48	3.78	3.48	1.09	1.03	0.30
1986	1.68	1.24	4.04	0.64	0.77	0.22
1987	3.31	1.67	0.63	0.07	0.16	0.32
1988	1.03	0.35	1.95	0.67	0.40	0.58
1989	2.03	3.22	0.96	0.76	1.04	1.28
1990	1.31	1.99	0.11	0.50	0.65	0.44

Source: National Oceanic and Atmospheric Administration monthly climatological data 1972-91. Compiled by averaging the central and northcentral divisional recording.

Table 34. Monthly maximum snow depths for Region 3. (Inches)

	Month						
Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1974-75	0.5	2.0	5.3	14.0	21.8	15.8	17.5
1975-76	5.5	11.5	8.5	10.3	10.0	12.0	5.3
1976-77	0.3	1.8	2.3	9.8	3.3	7.5	6.5
1977-78	1.0	6.8	6.8	17.5	13.0	6.5	3.0
1978-79	2.5	8.8	12.5	16.3	17.3	20.3	10.8
1979-80	0.8	7.0	3.3	11.3	12.3	20.5	17.0
1980-81	6.8	3.3	4.5	3.5	5.3	4.3	0.8
1981-82	2.5	6.5	8.0	13.8	13.8	17.3	20.0
1982-83	1.3	6.3	12.0	11.3	10.4	13.3	14.3
1983-84	0.3	4.8	9.8	7.8	7.8	7.5	9.0
1984-85	3.0	6.0	7.3	5.0	12.3	14.0	5.8
1985-86	5.0	7.8	10.0	9.0	16.8	6.0	7.8
1986-87	0.0	9.0	3.0	6.0	5.8	7.0	5.0
1987-88	0.0	2.3	6.3	7.5	8.8	4.0	4.5
1988-89	0.0	6.5	8.5	12.6	12.0	14.1	4.0
1989-90	2.5	3.0	6.8	7.3	6.0	9.5	3.3
1990-91	0.8	4.3	4.3	5.0	4.0	11.8	12.5

Source: National Oceanic and Atmospheric Administration, monthly climatological data 1972 to 1991. Compiled by averaging the recordings for Bozeman, Livingston, Butte, and Lakeview.

Table 35. Monthly maximum snow depths for Region 4. (Inches)

	Month						
Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1972-73	5.4	1.6	7.5	2.7	2.8	1.3	10.3
1973-74	1.3	10.3	5.6	8.1	5.0	3.6	0.6
1974-75	0.3	0.7	2.6	7.8	9.8	7.8	16.1
1975-76	4.5	7.3	6.5	2.6	1.3	4.6	3.6
1976-77	0.3	6.7	4.4	9.2	1.3	8.1	4.2
1977-78	0.7	4.4	9.0	19.2	20.6	12.8	0.3
1978-79	0.0	16.0	12.8	17.2	14.5	7.5	2.2
1979-80	0.0	1.2	3.7	6.2	5.5	5.6	4.8
1980-81	4.8	1.3	3.8	2.2	3.8	6.3	0.0
1981-82	4.3	1.6	2.8	8.4	6.5	9.7	5.8
1982-83	0.2	3.0	4.8	2.9	1.3	2.4	0.1
1983-84	0.3	5.4	8.4	9.0	2.2	3.9	2.7
1984-85	2.1	3.8	10.3	8.1	5.9	8.7	1.4
1985-86	6.4	10.8	10.3	4.0	8.8	0.4	6.9
1986-87	0.3	6.0	4.0	1.3	2.0	5.4	2.7
1987-88	0.0	1.4	2.3	8.2	4.8	2.2	2.3
1988-89	1.4	1.8	3.8	9.0	7.5	10.0	2.7
1989-90	0.9	3.2	10.2	2.4	1.7	6.7	1.7
1990-91	0.3	2.0	6.1	7.9	1.9	4.9	2.7

Source: National Oceanic and Atmospheric Administration, monthly climatological data 1972 to 1991. Compiled by averaging the recordings for Fairview, Fort Benton, Flatwillow, Greatfalls, Helena, Lewistown, and White Sulphur Springs.

Table 36. Monthly mean minimum temperature recordings for Region 3. (^{0}F)

Year	Month					
	October	November	December	January	February	March
1974-75	31.5	24.4	19.4	19.0	7.4	17.0
1975-76	31.8	19.1	18.8	16.0	18.0	16.0
1976-77	29.0	21.2	19.2	7.8	20.5	19.5
1977-78	30.9	20.1	14.4	11.6	15.3	24.1
1978-79	30.3	12.2	3.4	-6.5	13.5	22.3
1979-80	32.5	15.3	20.4	4.7	18.2	20.5
1980-81	30.6	23.1	20.8	19.0	17.6	24.3
1981-82	30.6	23.9	17.4	9.6	11.7	23.1
1982-83	30.7	16.4	12.3	19.3	21.8	25.7
1983-84	31.7	24.0	-1.3	17.8	18.8	25.4
1984-85	26.4	21.6	6.1	5.3	7.7	17.6
1985-86	27.9	6.9	8.7	19.0	16.9	29.0
1986-87	29.3	17.9	12.2	11.3	19.0	24.4
1987-88	27.6	21.6	13.6	9.1	17.7	22.9
1988-89	34.5	22.9	13.1	13.1	-0.3	20.5
1989-90	31.5	26.0	13.4	19.0	14.9	22.3
1990-91	30.3	23.4	2.2	10.1	24.5	21.6

Source: National Oceanic and Atmospheric Administration, monthly climatological data 1974 to 1991. Compiled by averaging the recordings for Anaconda, Bozeman, Butte, Dillion, Virgina City, Townsend, and Livingston.

Table 37. Monthly mean minimum temperature recordings for Region 4. (^{0}F)

	Month					
Year	October	November	December	January	February	March
1972-73	26.7	23.2	4.9	12.3	13.3	22.9
1973-74	34.0	16.2	19.0	7.9	21.7	21.5
1974-75	32.8	24.5	19.0	9.8	1.4	16.2
1975-76	32.8	20.1	18.0	14.9	19.6	18.0
1976-77	30.9	21.3	19.1	7.5	24.0	21.3
1977-78	32.6	18.3	8.1	-1.1	5.7	20.4
1978-79	32.0	13.0	6.2	-5.6	4.8	22.8
1979-80	34.0	19.4	19.0	3.1	15.2	19.5
1980-81	33.9	24.9	13.9	19.9	18.6	23.9
1981-82	31.8	26.6	14.7	-2.9	9.7	19.4
1982-83	33.0	17.1	15.9	19.6	23.4	25.2
1983-84	34.9	24.2	-7.3	18.2	22.9	23.8
1984-85	27.8	22.5	2.1	6.8	9.1	20.8
1985-86	30.9	3.6	13.3	23.9	8.6	30.8
1986-87	33.0	17.9	17.6	16.5	19.8	24.5
1987-88	29.9	25.2	16.5	9.3	14.3	24.8
1988-89	34.8	23.4	15.5	15.0	0.2	17.4
1989-90	32.8	25.5	14.3	19.2	13.5	22.4
1990-91	31.3	23.9	3.8	7.8	26.1	21.5

Source: National Oceanic and Atmospheric Administration, monthly climatological data 1972 to 1991. Compiled by averaging the recordings for Fairview, Fort Benton, Flatwillow, Greatfalls, Helena, Lewistown, White Sulphur Springs, Chester, and Valier.

APPENDIX D

HARVEST DATA

Table 38. Deer, elk, and total harvest data for Region 3.

	Deer			Elk			Total		
Year	H	K	S	H	K	S	H	K	S
1974	13567	18.5	35.0	4139	54.5	12.0	17706	26.9	24.6
1975	8188	24.2	27.0	4883	44.0	15.0	13071	31.6	20.8
1976	4833	35.6	21.0	2495	76.3	10.0	7328	49.5	15.2
1977	8089	22.1	32.0	4675	44.2	17.0	12764	30.2	24.1
1978	8649	19.5	32.0	4519	45.9	15.0	13168	28.5	23.0
1979	9414	21.3	31.0	4554	50.3	14.0	14468	29.7	22.1
1980	12497	13.4	40.0	5188	36.3	16.0	17685	20.1	27.9
1981	13197	13.2	44.0	5311	40.8	16.0	18508	21.1	29.5
1982	14718	12.8	45.0	6027	37.5	17.0	20745	19.9	30.7
1983	16041	11.6	52.0	6581	35.2	20.0	22622	18.5	35.2
1984	19970	10.4	52.0	7293	29.0	22.0	27263	15.3	38.0
1985	21225	9.1	55.0	7547	25.9	23.0	28772	13.5	37.4
1986	21269	8.7	53.0	8327	26.5	23.0	29596	13.7	25.4
1987	19534	12.1	49.0	6785	37.3	19.0	26319	18.6	33.9
1988	19961	10.8	55.0	9936	24.3	27.0	29897	15.3	40.4
1989	16726	12.5	49.0	8812	27.6	24.0	25538	17.9	35.5
1990	17917	12.1	50.0	8952	27.7	23.0	26869	17.3	35.3

H = Total Harvest; K = Days Per Kill; S = Hunter % Success

Source: Montana Department of Fish, Wildlife and Parks
Hunting and Harvest Reports 1974 to 1990.

Table 39. Deer, elk, and total harvest data for Region 4.

	Deer			Elk			Total		
Year	H	K	S	H	K	S	H	K	S
1972	19661	9.0	50.0	1887	47.2	12.0	21548	12.4	38.8
1973	20167	8.8	50.0	2633	38.8	15.0	22800	12.3	39.6
1974	14363	12.8	39.0	1687	70.2	9.0	16050	18.8	28.8
1975	12444	15.2	33.0	2152	49.0	11.0	14596	20.2	25.6
1976	11486	13.5	39.0	1592	65.3	9.0	13078	19.8	27.8
1977	12288	11.9	43.0	2375	45.3	13.0	14663	17.3	31.6
1978	11303	11.3	41.0	2272	46.9	12.0	13575	17.3	29.3
1979	14154	11.8	42.0	1960	56.8	10.0	16114	17.3	30.4
1980	20338	7.2	56.0	2767	34.2	15.0	23105	10.5	41.4
1981	23111	7.3	59.0	2521	41.8	13.0	25632	10.7	43.7
1982	23139	6.7	62.0	2736	36.6	15.0	25875	9.8	46.6
1983	29772	5.9	70.0	2519	42.5	16.0	32291	8.8	54.5
1984	32423	5.3	63.0	3816	23.6	22.0	36239	7.2	52.9
1985	23109	6.7	60.0	3706	25.5	20.0	26815	9.3	47.2
1986	20437	6.6	57.0	3368	30.0	18.0	23805	9.9	42.1
1987	23173	8.3	47.0	2619	43.3	15.0	25792	10.8	37.0
1988	24837	7.0	54.0	4309	25.0	23.0	29146	9.1	44.0
1989	21659	7.0	62.0	3818	29.8	20.0	25477	10.5	46.0
1990	24541	6.6	64.0	3551	31.5	19.0	28092	9.8	47.5

H = Total Harvest; K = Days Per Kill; S = Hunter % Success

Source: Montana Department of Fish, Wildlife and Parks
Hunting and Harvest Reports 1972 to 1990.

APPENDIX E

PRICE DATA

Table 40. Market year prices for agricultural commodities in nominal dollars.

Market Year	Hay	All Wheat	Oats	Barley	Calves
1971-72	27.5	1.23	0.58	0.88	38.1
1972-73	32.0	1.88	0.71	1.22	48.0
1973-74	57.0	4.24	1.17	2.17	58.3
1974-75	45.5	4.24	1.61	2.61	30.4
1975-76	42.0	3.59	1.45	2.10	30.8
1976-77	47.5	2.43	1.44	2.03	36.3
1977-78	56.0	2.38	1.28	1.68	41.4
1978-79	44.0	2.75	1.23	1.70	70.3
1979-80	55.0	3.63	1.45	2.15	89.8
1980-81	62.5	4.14	1.96	2.83	76.8
1981-82	48.5	3.68	1.89	2.32	62.7
1982-83	50.0	3.55	1.53	2.06	60.3
1983-84	63.0	3.69	1.58	2.40	62.4
1984-85	78.0	3.56	1.77	2.41	60.9
1985-86	84.5	3.47	1.50	2.03	62.2
1986-87	51.0	2.52	1.37	1.60	62.6
1987-88	45.0	2.74	1.49	1.82	80.7
1988-89	85.0	3.98	2.26	2.82	90.6
1989-90	69.5	3.64	1.45	2.20	88.4

Note: All wheat includes spring, winter, and durum wheat.

Source: Montana Agricultural Statistics Bulletins (Montana Department of Agricultre 1971 to 1990).

Table 41. Market year prices for agricultural commodities in real dollars (base = 1982).

Market Year	Hay	All Wheat	Oats	Barley	Calves
1971-72	60.3	2.70	1.27	1.93	83.6
1972-73	67.7	3.98	1.50	2.58	101.5
1973-74	109.0	8.11	2.24	4.15	111.5
1974-75	78.6	7.32	2.78	4.51	52.5
1975-76	68.0	5.81	2.35	3.40	48.8
1976-77	73.1	3.74	2.22	3.12	55.9
1977-78	81.5	3.46	1.86	2.45	102.3
1978-79	59.5	3.72	1.66	2.30	121.4
1979-80	68.4	4.51	1.80	2.67	95.5
1980-81	70.6	4.68	2.22	3.20	70.6
1981-82	50.8	3.85	1.98	2.43	63.1
1982-83	50.0	3.55	1.53	2.06	60.3
1983-84	61.2	3.59	1.54	2.33	60.6
1984-85	71.2	3.25	1.62	2.20	55.6
1985-86	75.0	3.08	1.33	1.80	55.2
1986-87	44.1	2.18	1.18	1.38	54.1
1987-88	37.8	2.30	1.25	1.53	67.8
1988-89	68.5	3.20	1.82	2.27	73.0
1989-90	54.0	2.83	1.13	1.71	68.6

Note: All wheat includes spring, winter, and durum wheat.

Source: Montana Agricultural Statistics Bulletins (Montana Department of Agricultre 1971 to 1990). Prices were adjusted for inflation using the GNP Implicit Price Deflator (Economic Report of the President 1971 to 1991).

APPENDIX F

SOCIOLOGICAL DATA

Table 42. Annual rates of the sociological variables.

Year	Alcoholism	Suicide	Homicide	Divorce	Marriage
1972	2.4	12.1	4.5	5.0	10.7
1973	2.8	15.0	6.4	5.2	10.8
1974	1.9	16.6	6.0	5.4	10.5
1975	3.7	15.0	5.6	5.7	9.8
1976	3.1	17.1	5.0	6.4	9.8
1977	3.3	18.8	7.0	6.3	9.9
1978	2.9	15.5	5.1	6.2	10.4
1979	2.8	15.6	5.0	6.5	10.4
1980	3.2	14.7	5.1	6.3	10.6
1981	4.0	17.3	5.9	6.3	10.4
1982	3.7	15.7	4.5	5.8	10.2
1983	2.0	17.5	4.0	5.7	9.9
1984	2.2	16.6	4.5	5.3	9.3
1985	2.4	17.4	5.9	5.2	8.7
1986	3.3	22.1	5.0	5.3	8.2
1987	2.7	19.7	4.8	5.1	8.1
1988	2.7	19.0	4.3	5.0	8.4
1989	2.0	19.7	4.0	5.1	8.4

Note: Alcohol, suicide, and homicide rates are per 100,000 people; divorce and marriage rates are per 1,000.

Source: Montana Department of Health and Environmental Science (1991)

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