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Estimating Domestic Sheep Losses to Mountain Lions'

Frederick G. Lindzey and Connie WilberV

Abstract.--Large, native-range pastures were searched for dead domestic sheep in the Southern Bighorn Mountains of Wyoming. The proportion of dead sheep that had been killed by mountain lions was 23%. Search methods, however, resulted in unequal probabilities of finding sheep that were killed by mountain lions and sheep that died of other causes.

INTRODUCTION

Mountain lions (Felis concolor) will kill most species of domestic livestock although sheep and cattle occur most commonly in depredation incidents. Cattle losses are highest in Arizona and New Mexico with the frequency of depredation problems involving cattle generally decreasing northward in the mountain lion's range (Shaw 1979). **Shaw felt that** this phenomenon largely could be explained by husbandry practices; losses are greatest where calves are born in mountain lion habitat. Sheep, on the other hand, appear to be killed anywhere they graze in areas occupied by mountain lions with lambs being killed more often than adults. It is common to have more than 1 sheep killed in a single incident (Sitton 1978, Bowns 1984); 59 sheep were killed in 1 night in Nevada (Suminski 1982).

Nation-wide, sheep losses to mountain lions appear small enough to be of little economic importance. For example, Suminski (1982) determined that average losses of range sheep to mountain lions in Nevada averaged only 0.29 percent. Not all woolgrowers share these losses, but rather, a few sustain heavy losses which can have a severe impact on their operations.

Historically, the potential for depredation resulted in widespread mountain lion control and eradication programs. When states began to assume management authority for mountain lions in the 1960's (Nowak 1976), management programs included very liberal depredation provisions aimed at allowing livestock owners to protect their animals. Although states currently vary in their approach to the problem of mountain lion predation on domestic livestock, all include some provisions in their management programs that address this problem. Wyoming is one of 2 states that reimburses owners for livestock killed by mountain lions (Bowns 1984). Wyoming Statute 23-1-901 stipulates that the Wyoming Game and Fish Department "investigate and allow payments for damages to livestock caused by trophy game animals."

Problems encountered in Wyoming in reimbursing livestock owners for animals killed by mountain lions are twofold. First, there are, and likely always will be disagreements over cause of death of individual animals. Secondly, woolgrowers wish to be reimbursed not only for sheep that are documented as killed by mountain lions, but sheep that are not accounted for and that may have been killed by mountain lions. There is general agreement that some of the sheep that do not return from summer pastures are likely to have been killed by mountain lions, but significant disagreement on the proportion of lost sheep attributable to mountain lion predation. The literature provides little assistance in resolving this problem. Studies that have quantified loss of sheep to predators have typically not been done in areas where mountain lions were expected to be a major predator (Klebenow and McAdoo 1976, Nass 1977, Tigner and Larsen 1977, Taylor et al. 1979). Shaw's (1977) work in Arizona, although probably the best investigation of mountain lion predation on livestock, dealt with cattle. Bruscino and Norelius (1987) studied cause-of-death of domestic sheep in the southern Big Horn Mountains of Wyoming **and pro**vided the first insight into the potential impact of mountain lions on sheep herds in this region. Their results indicated that 27% of the dead sheep found had been killed by mountain lions.

The primary objective of this study was to locate and determine cause of death of dead domestic sheep on pastures on the east slope of the southern Bighorn Mountains. Secondarily, we wished to evaluate whether our sampling approach provided a representative sample of dead sheep.

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Study Area

The study was done on the east slope of the southern Bighorn Mountains in Johnson County, Wyoming. Searches were conducted within large, native-range pastures grazed by domestic sheep. Pastures varied in the amount of cross-fencing present and thus the degree to which sheep movements were controlled. Pastures are largely privately owned although some grazed areas are leased from the Bureau of Land Management.

Elevation ranges from 1980 to 2500 m. At lower elevations mountain mahogany (Cercocarpus ledifolius) and Utah juniper (Juniperus oste-osperma) are interspersed with areas of sagebrush (Atremisia spp.) and open grasslands. Numerous small, dry canyons and several large, deeper canyons run east and west through the area (Bruscino and Norelius 1987). Higher elevations are dominated by mixed stands of ponderosa pine (Pinus ponderosa) and younger stands of limber pine (Pinus flexis). Common juniper (Juniperus communis) is abundant in the understory of dense conifer **stands.** Small quaking aspen (Po ulus tremuloides) and lodgepole pine (Pinus contorta stands occur occasionally in the higher elevations that are dominated by grasslands. The area contains vegetation and topography preferred by mountain lions (Logan and Irwin 1986, Laing 1988).

Timing of grazing on the pastures is largely determined by weather. Sheep are typically trailed onto the mountain after shearing and docking in late May and early June. Although not generally herded, they are visited regularly for inspection. Sheep are trailed from the mountain in October or November depending on snowfall.

METHODS

Pascures were selected for inclusion in the study based on several factors. These included: 1) the willingness of owner-operators to cooperate in the study; 2) proximity to other study pastures; 3) historical level of mountain lion depredation problems; 4) vegetation and topography representative of the southern Bighorn Mountains and; 5) access.

Search blocks were about 130 ha in size. Location of blocks in the pastures was based on spatial use of the pasture by the sheep since t previous search as indicated by reconnaissance the pasture and or discussions with the owneroperator. Each search block was oriented to in a representative sample of the vegetation and topography in the area used by the sheep. Iran were spaced at 91.4 m intervals within the block generally oriented across the shortest dimension the block. Transects were followed using an on ering compass. Search block locations and trans starting points were identified by distance paci and topographic features. New search blocks wer identified each time a pasture was returned to.

Transects were walked or ridden on horsebac either 1 or 2 observers. When walked or ridden only 1 observer, every fifth transect was walked again in the opposite direction. Only carcasses judged to be from the 1988 grazing season were i cluded in analyses. Presence or absence of woun or tooth marks, predator sign, stage of decomposi tion, sex and age and position of the carcass we noted. Slope, aspect, topography and vegetation type were determined for the carcass site and su rounding area. Distance at which the carcass was first seen, its perpendicular distance to the transect line, and the distance it could be seen from the 4 cardinal directions was measured. Eac carcass found was marked with red paint and a nu bered tag.

Cause of death for each carcass was determi based on a key. The key was developed from info tion in the literature (Shaw 1987, Bowns 1976) and suggestions from persons experienced in animal d age control, and reviewed by ranchers and Wyoming Game and Fish Department (WGFD) personnel. Our intention was simply to determine if a sheep had been killed by a mountain lion or not.

Transects were generally double sampled by th first observer flagging the route and the second observer following the flagged transect and retrie ixg the flags. Each carcass found by either obseni er was investigated as described above. Carcasses; were painted only on the underside by the first observer to prevent it being detected by the second observer because of the paint marking.

RESULTS

Four pastures, averaging 1830 ha in size, were included in the study (table 1). Nineteen search blocks were sampled; 32% were double sampled (table 2). The first search block was sampled in mid-June the last block was sampled in mid-October 1988. Te percent (n=18) of the transects in the single sampled blocks were walked twice by the same observer. Fifty-two sheep carcasses were found (table 3). Twelve (23%) of these sheep were killed by mountain lions. Sixty percent of all carcasses found (n=31) were lambs; all sheep killed by mountain lions were lambs. Sex of the dead lambs was determined for only 29% of the carcasses (6 males, 3 females).

Sheep killed by mountain lions were found in areas of dense conifer overstory, sage-grass and

grass vegetation types (table 4). Sheep that died of other causes were found in all vegetation types **e:eept** those dominated by a conifer overstory. **Carcasses** of sheep killed by mountain lions were **visible** from the 4 cardinal directions at significantly shorter distances than carcasses of **sbeep that** died of other causes (t=19.3 df=188) (table 5). This difference was most obvious in lage-grass and grass vegetation types (t=-6.14 **dfu78,** t=5.38 df=106). Although dead sheep were **found** on slopes up to 40 degrees, most (88%) were **located** in areas ranging from level to 20 degree **slope.**

Table 1.--Pasture size, stocking level and percent of sheep missing the after grazing season on the Southern Bighorn Mountains, Wyoming.

Pasture	Size(ha)	Sheepa		% lossb
1	809	Ewes	1345	8
		Lambs	1074	3
2	1619	Ewes	1468	3
		Lambs	1710	4
3	3173	Ewes	1523	2
		Lambs	1003	8
4	1716	Ewes	1217	6
		Lambs	880	13

a Number of sheep on pasture b Percent of sheep reported as missing by operator after grazing

Table 2.--Number of search blocks and transects sampled for dead domestic sheep in the southern Bighorn Mountains, Wyoming (June-Oct. 1988).

Pasture	Search blocks	Transects
1	6 (2)a	63 (79)b
2	4 (1)	38 (48)
3	5 (2)	34 (63)
4	4 (1)	36 (45)
Totals	19 (6)	173 (235)

aNumber double sampled. bKilometers of transects. Does not include double sampling or back-walking transects.

Table 3.--Dead domestic sheep found and cause of death of these sheep on the east slope of the southern Bighorn Mountains, Wyoming 1988.

Pasture	Mountain lion	Other causes	Totals	% of lossa
1	0	14	14	10
2	7	16	23	21
3	0	3	3	3
4	5	7	_12	7

aPercent of the sheep reported as missing by operators found on transects.

Table 4.--Vegetation types in which domestic sheep carcasses were found on the east slope of the southern Bighorn Mountains, Wyoming (1988).

	Mountain lion		Other causes	
	No.	%	No.	%
Conifer	2	17	0	0
Dense sage	0	0	2	5
Sage-grass	3	25	17	42
Mahogany-grass	0	0	1	3
Grass	7a	58	20	50

aFour of these carcasses were found together on the same bedground.

Only 1 carcass of a lion-killed sheep was intact, while 20 carcasses (50%) of sheep that died of other causes were whole when found. Intact carcasses of sheep that died of causes other than mountain lion predation were visible at significantly greater distances (x=30.6 m s.d.=30.5) than those that were scattered (x=16.3 s.d.=21.3, t=-2.8 df=106). Eighteen of the carcasses of sheep that died of causes other than mountain lion predation, and not found intact, had been fed upon by other animals. Over half (58%) of the carcasses were first detected by seeing the carcass itself, 19% by first detecting wool fragments, 12% by finding bone fragments, 10% by smell and 2% (n=1) by seeing a scavenger at the site.

Only 1 additional sheep carcass was found on the transects that were walked a second time by a single observer. Two of 11 sheep carcasses were found by only 1 of the 2 observers during double sampling efforts. The 2 sheep that were found by only 1 observer died of causes other than mountain lion predation. These carcasses were found in grass and sage-grass habitats, initially sighted,at 6.4 and 11 m. and were visible from 26.2 and 21 m respectively.

Table 5.--Mean distance in meters (s.d.) that dead domestic sheep were visible in differing vegetation types on the east slope of the Bighorn Mountains, Wyoming (1988).

Veg. type	Initial sighta		Cardinal dir.b	
	Mt. lion	Other	Mt. lion	Other
Confer	8.4c		7.8(4.8)°	
Dense sage		8.5c		9.8(10.5)
Sage-grass	2.0(0.9)°	53.3(73.8)	3.4(2.2)	42.6(50.9)
Mohogany-grass		3.1c		24.8°
Grass	22.1(6.8)	39.8(64.6)	33.9(17.4)	41.2(60.9)
Totals	14.1(10.4)	42.5(90.7)	22.2(19.9)	36.8(54.7)

aDistance carcass initially sighted from. bAverage distance carcass visible from 4 cardinal directions. cSmall sample size (n<5).

DISCUSSION

Fewer dead sheep were found this year than found last year by Bruscino and Norelius (1987) in the Southern Bighorns (52 vs. 77) and a slightly smaller percentage was attributed to mountain lion depredation (23% vs 27.3%). Proportionately fewer lambs (60% vs 75%) occurred in the sample in 1988 than in 1987. The smaller number of sheep examined may be due, in part, to the fact that only half the number of ranches was surveyed this year. Reported average loss of sheep on the 4 pastures was 6%, but ranged from 4 to 9% compared to an average loss of 8.3% reported by Bruscino and Norelius (1987).

Our data support Bruscino's and Norelius' findings that few sheep which die of causes other than predation are found in timbered areas. The proportion of all lion-killed sheep found in timber was 17% this year and 19% last year. Most sheep that die of causes other than mountain lion predation, on the other hand, were found in sage or grass habitats.

The reduced .risibility of carcasses of sheep killed by mountain lions probably resulted from a number of causes. Proportionately more carcasses of lion-killed sheep were scattered than were carcasses of sheep that died of other causes, and intact carcasses were detected at significantly greater distances. Secondly, carcasses of lionkilled sheep appeared to be found in areas of denser vegetation even within the same vegetation type.

Differential visibility of carcasses in the various vegetation types and the tendency for lion-killed sheep to be detected at shorter distances are 2 identified forms of bias that may influence the degree to which the sample of dead sheep we found is representative of all the sheep that died during the grazing season in these pastures. Although, by design, our transects travere vegetation types in proportion to their occurrence in the search blocks, because of differential viai bility, the area actually searched in each vegetation type was often not proportional to its occurrence in the search block. The potential for bias in the sample occurs because the proportion of li killed sheep appears to differ with vegetation type. The difference in detectability of sheep killed by mountain lions and those that died of other causes presents a similar problem. Due to t spacing of transects (91.4 m), we effectively searched less area for lion-killed sheep than we d' for sheep that died of other causes.

Paying for sheep that are not documented, but possibly killed by mountain lions presents numerous problems. Differences in opinion on the proportion of missing sheep killed by mountain lions will be common and the proportion of lion-killed sheep will likely differ between years and pastures. Formulae to determine the proportion of missing sheep killed by mountain lions will need to reflect the uniqueness of years and pastures if they are to gain general acceptance. If samples of dead sheep are to used in formulas to determine numbers of lion-kill sheep, sampling schemes must be designed to avoid biases such as those we identified.

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Evaluating Mountain Lion Depredation of Domestic Sheep'

Mark Bruscinw

Abstract.--In 1987, 171 domestic sheep (Ovaris aires) killed by mountain lions (Felis concolor) were examined in the Bighorn mountains of north-central Wyoming. Lions typically killed the sheep by attacking the head or neck regions. Feeding usually started with entering through the brisket and consuming the heart, lungs and liver. Feeding continued with the leg bones sheared above the hock and knee. Most of the carcasses that were moved by the lion were found in shrub or timber type vegetative habitat and in relation to rimrock topography.

INTRODUCTION

The Wyoming state legislature reclassified mountain lions from predator to trophy game status in 1973. The change in classification transferred management responsibility from the Wyoming Department of Agriculture to the Wyoming Game and Fish Department. Since 1981 the Wyoming Game and Fish Department has been responsible for reimbursing stockmen for livestock killed by mountain lions. From $6, 858.30 to $55, 717.70. Although the majority of the claims have been for losses of domestic sheep, dep.°edation claims for cattle and horses have increased as well.

The Wyoming Game and Fish Department personnel are responsible for determining the cause of death of livestock claimed to have been killed by lions. It has become necessary to be able to accurately evaluate livestock losses to equitably reimburse the stockmen and responsibly manage the department's damage fund.

STUDY AREA

Research was conducted in Johnson and Washakie counties in the southern Bighorn Mountains of north-central Wyoming. The area is a **mixture** of private and public lands used primarily for pasturing livestock in the summer. The southern Bighorn Mountains is the largest sheep producing area of the state.

Due to winter snow conditions, livestock **grazing** is restricted to June through early November. Most sheep operations consist of large fenced pastures. The sheep are not herded and are selected to scatter throughout the pastures to equally use the range. The sheep are generally found in the open grass areas for shade during the warmest part of the day. Sheep are rarely found in the rougher terrain due to poor habitat conditions and natural barriers.

Elevations in the area range from 4500 ft. to 8200 ft. above sea level. The area is characterized by open gentle slopes traversed with frequent small canyons and rimrocks. Several large, deep canyons highlight the topography.

MATERIALS AND METHODS

Two search plots were chosen on each of eight ranch operations ranging in size from 249 to 6094 sheep at docking. Ranches and plots were chosen based on historical depredation incidences or suspected problem areas. Search plot ranged in size from 160 to 500 acres depending on the difficulty to inspect the area. An attempt was made to search each area as thoroughly as possible for dead animals. North-south and east-west routes were traveled on successive days for each study plot. Searches were conducted on horseback and foot. In addition, all carcasses in the southern Bighorns reported by stockmen or incidentally discovered by department personnel were also included in the sample.

When a carcass was located, the immediate surrounding area was searched for signs of predators in the form of scat, scratch piles or tracks. Indicators that the animal had been moved, scavenger sign and carcass position were noted. Carcass location, distance to cover, and if the animal was covered was recorded. Stage of decomposition, location and type of external injury, and areas fed upon were examined.

A field necropsy was performed to locate and document subcutaneous trauma, internal trauma, and skeletal fractures. **Puncture wounds** spacing from canine teeth were measured.

-Paper presented at the Ninth Great Plains Wildlife Damage Control Workshop. (Fort Collins, Colorado, April 18-19, 1989) .

-Mark Bruscino, Game Warden, Wyoming Game and Fish Department, Lovell, Wyoming.

RESULTS

During the 1988 field season 329 domestic **sheep** carcasses were examined by department personnel. Fifty-eight were discovered during **structured** ground searches, 17 were located **incidental** to other field duties and 96 were **reported** by landowners. Of the 329 sheep evalu**sted,** 171 were determined to have been killed by mountain lions. Of the 171 sheep killed by moun**tain lions,** only nine (5.30) had lion sign in the **form** of scat or tracks associated with them. Three (1.7%) of the nine had discernible lion **tracks** nearby. Six (3. 5%) had fresh lion scat **within** 140 ft. of the carcass location. Laboratory analysis found that all six samples had contained domestic sheep wool.

Thirty-one (18.1%) of the sheep carcasses had evidence that the cat had attempted to move the kill. When the lion did move the carcass, 23 (74$) were moved to areas that provided additional vegetative or topographic cover. Of all the sheep killed, 89 (52. 1%) were found in shrub type vegetative habitat, 46 (26.9%) were located in grassland habitat. The remaining 36 (21.1%) were located in timber stands. A significant portion (p .001) , 138 (80.7%) were located in rimrock or canyon type topography, while the remaining 33 (19.3%) were killed on flat or gentle slopes. More than one-third (36.4%) of the lionkilled sheep were found in areas of topographic or vegetative cover thought to be adequate for lion concealment and movement. 139 (81.4%) were located within 160 ft. of cover suitable for lions. In only 11 (6.5%) instances did the cat attempt to cover the kill. Covering was usually done with pine needle litter scraped from the immediate surrounding area.

Of the 171 lion kills, 152 (88.8$) showed evidence of biting on the dorsal or lateral portions of the neck or skull. When adult sheep were bitten on the skull, canine teeth usually caused puncture wounds to the cranium caused by the canine teeth. A bite to the skull of a lamb often resulted in fracturing at the sutures or a crushed skull. In most instances there was evidence of only a single bite indicating death by strangulation, spinal cord damage or hemorrhage. In 33 (19.3%) of the lion kill, the sheep incurred fractures to the cervical vertebrae. Significantly (p .001) more lambs (25) had fractures to the cervical vertebrae than did ewes (8).

Eighty-nine (52.1%) sheep had some evidence of feeding, although only 12 (7.0%) had been completely consumed excluding the hide and some skeletal components. Lambs comprised 10 (83.3%) of the sheep fully consumed. All consumed carcasses were found in relation to topographic or vegetative cover. Initial feeding was usually through the brisket region with a portion of the ribs eaten away to allow access to the heart, lungs, and liver. The rumen was often removed and covered several feet away from the feeding site. Feeding typically continued with the striated muscle from the ventral portion of the front quarter or hind quarter eaten while the hide was peeled back. Often one up to all four leg bones were sheared cleanly through above the knee and hock.

DISCUSSION

Although evidence associated with mountain lion depredation of domestic sheep seems to vary, this study found that there are indicators that can be compiled that will point to lion depredation. Tracks were often difficult to discern due to firm soils and exposed bedrock in the area. Lions do not seem to mark their kills with scat or scratch piles on a regular basis. Lions tended to move the carcasses if they were killed in an area unsuitable for concealment while feeding. Oftentimes, carcasses were abandoned where they were killed with little or no feeding which indicates that they have very poor use of the prey item, or they do not always kill for food.

The significant portion of sheep found in relation to topographic or vegetative cover suggests that lions will not venture far from cover to pursue sheep. Wade (1929) and Van Pelt (1977) found that lions use cover to stalk and attack prey. Sheep are found in this type of habitat usually only during the middle of the day or occasionally bed in that type of habitat at night. It is then likely that most attacks take place during daylight hours. This study found that there was a relationship between habitat selected by sheep and vulnerability to lion attacks. When the sheep remained in large open pastures, the rate of attack was less than for sheep using areas with more cover.

Covering of the carcass seems to occur when lions intended to return to feed as most abandoned kills had no evidence of being covered. The cat will generally recover the carcass after each feeding until they do not intend to return. The majority of the kills were neither covered, cached nor fully consumed.

Sheep appear to be easy prey for lions as there was rarely sign of a struggle. Most sheep were killed with a single bite to the neck or head. As carcasses decompose, evidence of cause of death is lost. Tooth marks in the forms of punctures, grooves, scrapes or fractures to the cervical vertebrae are often indicators in advanced stages of decomposition, although they do not always occur. This study is supported by finding by Nowak (1976) that lions kill by severing the spinal column, breaking the neck, or crushing the skull. Lambs suffered cervical fractures at a higher rate than did adult ewes, likely due to less muscle tissue protecting the vertebrae. Lambs were killed at a higher incidence, likely due to vulnerability.

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