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MOUNTAIN GOAT POPULATION CHANGES IN RELATION TO ENERGY EXPLORATION ALONG MONTANA'S ROCKY MOUNTAIN FRONT

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Abstract: A mountain goat (Oreamnos americanus) study was initiated in 1981 along the east slope of Montana's Rocky Mountains (823 km²) to quantify population parameters and monitor energy exploration activity. Twenty-four radio-marked goats provided seasonal home range information. Observations of the radio-marked and 8 neckbanded goats provided reproductive histories for adult females, and annual survey efficiency. The adult female population trend was stable in the Birch-Badger segment but declined significantly in the Teton-Dupuyer segment. Kid:adult female (K:ADF) ratios in the Birch-Badger segment dropped 81% from 1983 to 1984, and 62% in the Teton-Dupuyer segment from 1982 to 1983. Beginning in 1981, energy exploration dramatically increased. From 1981 to 1985, about 579 km of seismic lines were shot within mountain goat habitat. This activity peaked during 1983 and 1984. Radio-telemetry information did not indicate abandonment of home range, however the peak in seismic activity did coincide with declining adult female numbers, kid numbers, and productivity in the Teton-Dupuyer segment. Differences in population characteristics in the Birch-Badger and Teton-Dupuyer segment appear to be attributable to differences in levels of human disturbance within each area. Other factors were addressed which may have influenced mountain goat population characteristics, including weather, hunter harvest, livestock grazing, timber harvest, and disease. The added impact of seismic activity, over and above other human activities in the Teton-Dupuyer segment, appeared to be the primary cause of changing population characteristics.

Native mountain goats of Montana's Rocky Mountain Front (RMF) occur along the theoretically petroleum-rich Overthrust Belt. Industrial and recreational projects have been implicated in declines of native mountain goat populations throughout North America (Chadwick 1973, Hebert and Turnbull 1977, Kuck 1977, Pendergast and Bindernagle 1977, Foster and Rahs 1983, Rice and Benzon 1985). Therefore, concern about human impacts from energy exploration has focused upon mountain goats along the RMF as the pace of exploration accelerates and gas/oil field development begins. Research on mountain goats from 1981 through 1986 was conducted to describe the mountain goat population along the RMF, document changes in population parameters, and describe the upsurge of human activity within the area and the possible consequences of human-induced stress upon the population.

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STUDY AREA

The RMF study area (Fig. 1) occured in the Sawtooth Mountains of northcentral Montana. Lying along the east slope of the Continental Divide, the study area extended some 82 km south of Glacier National Park to the main Sun River and was bordered on the east by the prairie. The study area was divided into 3 segments (Fig. 1) based on relatively autonomous mountain goat population segments. The Deep-Sun segment is not considered in this analysis because it was not intensively surveyed and was therefore not comparable.

Geological forces shaped the magnificent reefs of the RMF. The awesome cliffs and ridges of the RMF are composed primarily of Madison limestone from the Cambrian era, although the bulwark of the mountains is Precambrian sedimentary rocks (Alt 1985).

Gale-force chinook winds, often blowing over 100 km per hour, melts and blows away snow on the eastern slopes and exposes forage. The coldest average winter temperatures (January) range from -8.9°C at East Glacier to -6.0°C at the Sun River's Gibson Dam. The warmest average summer temperatures (August) range from 15.9°C to 16.7°C, respectively. Yearly precipitation averages 59.7 cm at East Glacier and 47.0 cm at Gibson Dam (Nat. Oceanic and Atmos. Admin. 1980-1985). Maximum snow pack occurs in April with depths (from north to south) averaging 252.5 cm at Badger Pass (2103 m), 168.1 cm at Mount Lockhart (1951 m), and 148.3 cm at Wrong Ridge (2073 m) (U.S.D.A. SCS 1922-1985) (Fig. 1). Meteorological data indicate a subtle gradient toward warm and dry, moving from north to south along the RMF. Detailed descriptions of vegetation, habitat types and landtypes are described in Harvey (1980), Thompson (1980), Holdorf et al. (1980) and Holdorf (1981).

METHODS

Repeated, systematic helicopter surveys were conducted on that portion of the population north of the Middle Fork Teton River (823 km^2, Fig. 1). Surveys were flown during July, from 1981 through 1986, during morning and evening hours, by the author in a G3 47 Bell helicopter. Subsequent to each helicopter survey, a radio-relocation flight was made to determine the presence or

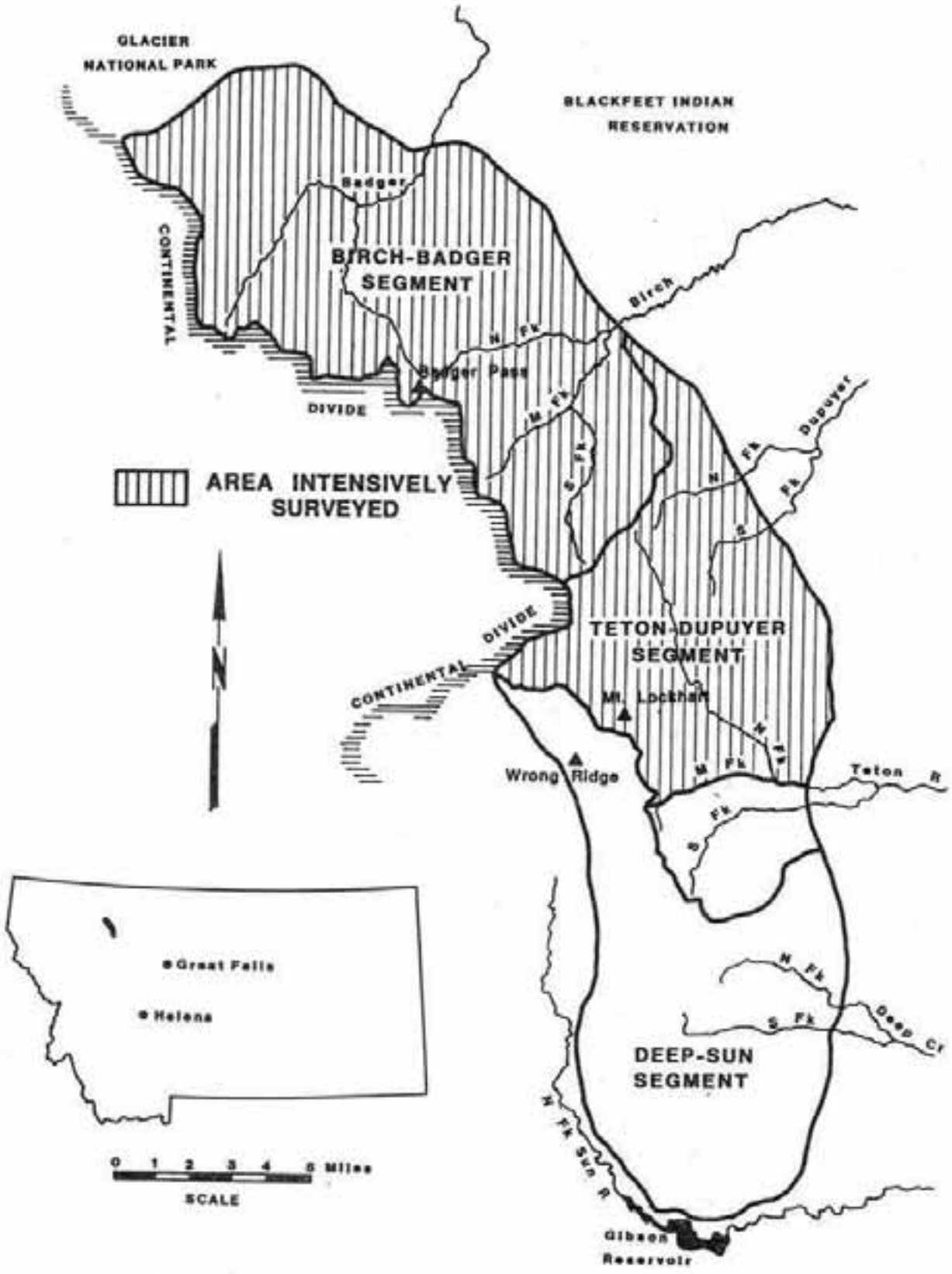

Figure 1. Rocky Mountain Front Study Area.

absence of radio-marked goats within the Teton-Dupuyer area. The percentage of radio-marked and neckbanded animals observed during annual surveys provided the basis for establishing survey efficiency.

Thirty-five mountain goats in the Teton-Dupuyer segment were fitted with radio collars (23), neckbands (8), and eartags (4), from 1979 through 1982 (Joslin 1986). Nine and 6 adult males, 8 and 2 adult females, and 6 (4 females and 2 males) and 0 subadults were marked with radio-collars and neckbands, respectively. Four male kids were eartagged. All radio-collars placed on subadults were expandable elastic collars which were not observable from the air. During aerial telemetry, observations of radio-marked animals were obtained when possible. Both air and ground observations provided data on the reproductive histories of 11 radio-marked and 2 neckbanded females. Mountain goats were classified as adults (male or female), 2-year-olds, yearlings, and kids based on morphological features, molting patterns, and group association.

Seasonal home range sizes (convex polygons) of 24 radio-marked mountain goats were calculated based on bi-monthly radio-relocation flights. Average number of fixes used in calculating home ranges for adult animals was 56 (range 25-120).

Snow depth information was collected from 3 snow survey sites which occur in the Birch-Badger, Teton-Dupuyer, and Deep-Sun segments of the study area, respectively (Fig. 1). These sites occur either within mountain goat winter range, or in the case of Badger Pass, which is at the edge of the study area, at an elevation which coincides with mountain goat winter range.

Information concerning energy exploration activities was provided by the Rocky Mountain Ranger District, Lewis and Clark National Forest. The term seismic activity, as used here, includes all ground and air activity associated with seismic line set up, shooting, and clean up.

RESULTS

Population Characteristics

Home range information was collected for 9 adult females, 9 adult males, and 6 subadults in the Teton-Dupuyer segment (Joslin 1986). Comparing adults for which at least 2 years of information was available, the largest yearlong home range was 181.5 km^2 for a male while the smallest was 16.0 km^2 for a female. Only 1 male had a yearlong home range (22.9 km^2) smaller than the average for females (34.9 km^2), while all female ranges were smaller than the average for males (89.4 km^2). The average female summer range (19.2 km^2) was slightly smaller than the average winter range (22.2 km^2), but the reverse was true for males (48.5 and 46.4 km^2). Although goats tended to adjust their

movements over the course of the study, none were known to abandon their established home range.

All marked goats generally confined themselves to the Teton-Dupuyer segment. Over the course of the study, observability of marked adult females was higher (80%, SD=13) than marked adult males (30%, SD=18) (Table 1). Because observability of adult females was consistently high, population trends were based on actual number of females and kids observed in both the Teton-Dupuyer and Birch-Badger population segments.

Table 1. Observability of marked adult mountain goats, July 1981 - 1986.

YEAR	MARKED FEMALES	NO. OBSERVED	% OBSERVED	MARKED MALES	NO. OBSERVED	% OBSERVED
1981	3	2	67	3	0	0
1982	7	6	86	11	4	36
1983	7	5	71	8	1	12
1984	7	7	100	10	5	50
1985	4	3	75	8	4	50
Total	28	23	399	40	14	148
Average			79.8			29.6

Population trend of female goats in the Teton-Dupuyer segment from 1981 through 1986 is presented in Table 2. The decline in adult females in this segment (Fig. 2) was significant ($R=-0.851$, $p < .05$). The trend in the Birch-Badger segment on the other hand was not significant ($R=-0.833$, $p > .1$) (Table 3 and Fig. 3). At the beginning of the study, numbers of adult females in both population segments were similar, but by 1986, adult females in the Teton-Dupuyer segment had dropped about 50%.

Table 2. Summer helicopter surveys of mountain goats in the Teton-Dupuyer segment, 1981-1986.

YEAR	TOTAL	ADM	ADF	SA	KID	K:100ADF
1981	75	13	33	17	12	36.3
1982	60	16	25	10	9	36.0
1983	43	13	22	5	3	13.6
1984	58	15	28	9	6	21.4
1985	37	12	18	3	4	22.0
1986	32	9	15	6	2	13.3

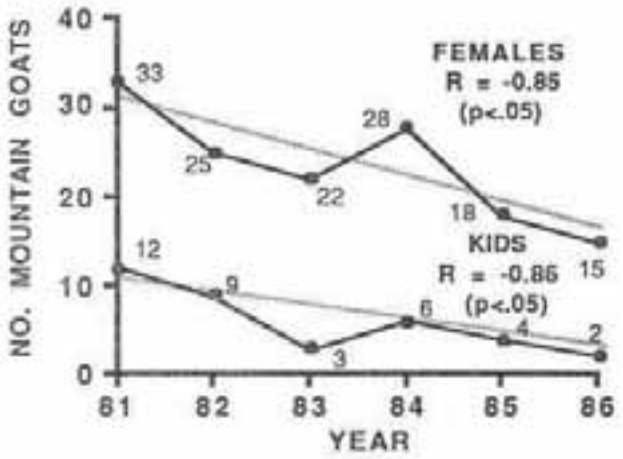

Figure 2. Adult female and kid mountain goats observed during annual surveys of the Teton-Dupuyer segment.

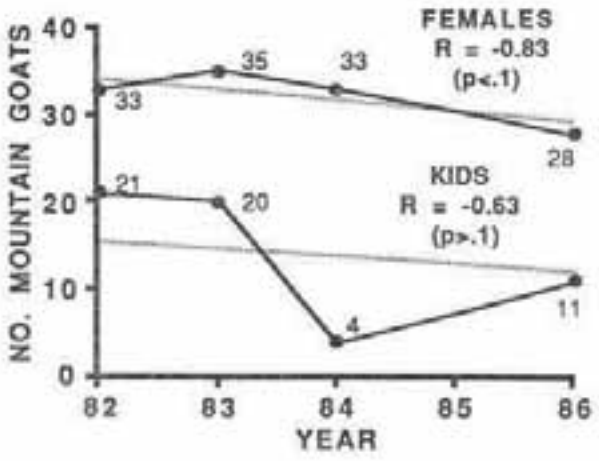

Figure 3. Adult female and kid mountain goats observed during annual surveys of the Birch-Badger segment.

Table 3. Summer helicopter surveys of mountain goats in the Birch-Badger segment, 1982-1986.

YEAR	TOTAL	ADM	ADF	SA	KID	K:100ADF
1982	77	15	33	8	21	63.6
1983	80	9	35	16	20	57.1
1984	56	10	33	9	4	12.1
1986	72	21	28	12	11	39.3

Even though population levels were similar at the onset of this study, kid production levels were not. In the Teton-Dupuyer segment, kid:adult female (K:ADF) ratios in 1982 were over 40% lower than in the Birch-Badger segment. By 1983 and 1984, kid production dropped 62% and 81% in the Teton-Dupuyer and Birch-Badger segments, respectively. By 1986, kid production in the Birch-Badger segment appeared to be recovering and had more than tripled from a low of 12 K:100ADF (Fig. 3). But kid production in the Teton-Dupuyer segment improved only slightly in 1984 and 1985, then dropped back to the low of 13K:100ADF in 1986 (Fig. 2).

Reproductive histories of 11 marked adult female goats indicates the possible cause of decline in both females and kids in the Teton-Dupuyer segment. From 1 to 6 years of reproduction information was documented for each marked adult female (Table 4). Potentially 42 young could have been born to these females over the course of the study, assuming 1 kid born per female per

year. Six of 18 kids that were born died, while the fates of 4 others were undetermined. No twins were produced. Sixty percent of the kids that died did so between July and September. Production ranged from a maximum of 100% (N=3) in 1979 to 0 (N=5) in 1984. Recruitment was highest prior to initiation of this study (Thompson 1980), then it dropped to 0 (1984-86). Apparently, the consistently low kid production and poor recruitment resulted in a lack of reproductive females being recruited into the population, and therefore, the population continued to decline.

Table 4. Reproductive history of 11 marked female mountain goats.

Radio #	Age Marked (Yrs.)	1979	1980	1981	1982	1983	1984	1985	1986
1172	4	K→Y	K→Y	K-died	K-died	0	0	Trans[a]	
1082	4	K→Y	?	?	?	0 Trans			
1052	3	K-died	K→Y	K-died	K Trans				
1222	3		K→Y	K→Y	K→Y	Trans			
1290	AD				K-died	K	Dead[b]		
1230	AD				K→Y	0	0	0	0
42[c]	5				0	0	0	0	0
32[c]	AD				0	0	0	K	0
1240	2				---	0	0	0	0
1814	4				K-died	K/Dead[b]			
492	3					0			

[a] = transmitter failed
[b] = adult goat died
[c] = neckband

Energy Exploration

Seismic exploration activity along the RMF has increased 37 fold from the 1960-1980 period when an average of 9.5 km of line was shot per year, to 1981-1984 when an average of 351.0 km of line was shot per year (Fig. 4). Wildcat drilling in the 59 years between 1921 and 1980 amounted to an average of 1 well drilled every 2.7 years. From 1981-1984 an average of 1 well per year was drilled. Although only a portion of this seismic and drilling activity occurred within the study area, the trend is clear. Nearly all of the 579 km of seismic lines which were shot in the mountain goat study area since 1981 were helicopter supported. An estimated 21.7 man days and 6 to 8 helicopter km are associated with each km of helicopter based seismic line shot

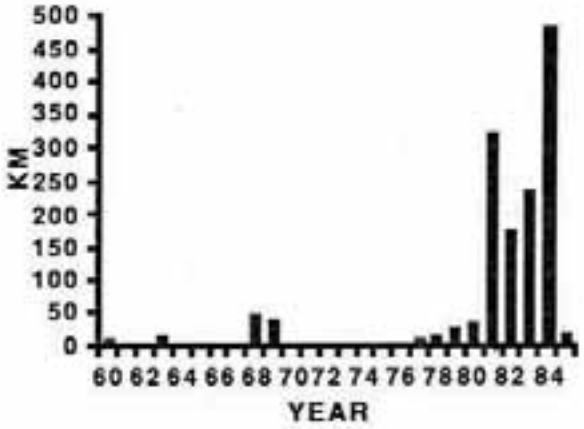

Figure 4. Rocky Mountain Front seismic exploration.

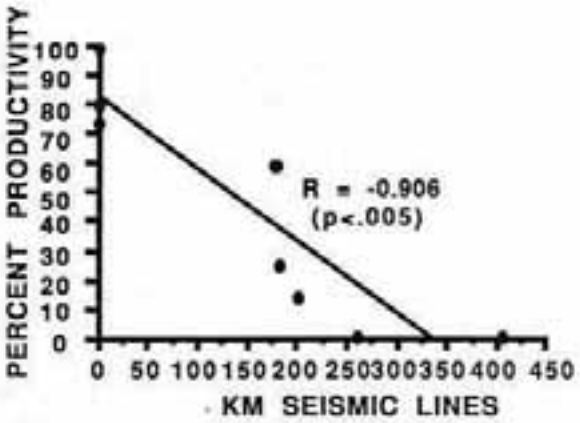

Figure 5. Productivity of radio-marked adult females in relation to cumulative seismic activity (2 previous years).

within mountainous terrain along the RMF. This equates with 12,564 man days and about 4,053 km of helicopter activity within the study area since 1981.

Declines in adult females, kids, and productivity of marked adult females in the Teton-Dupuyer segment were negatively correlated with the amount of seismic activity occurring in mountain goat habitat within the study area from 1979 to 1986. A regression of the amount of seismic activity occurring 1 year prior to the July annual population survey, and the number of females observed during that survey, accounted for 71%(R^2) of the variability in adult females ($R=-0.846$, $p < .05$) over the course of the study. The number of kids present in the population segment was inversely correlated ($R=-0.875$, $p < .05$) with the sum of seismic activity occurring 2 years previous to the year in which the population was surveyed, i.e. km of seismic line in 1979 plus 1980 were compared to the number of kids present in 1981. As might be expected, number of kids in the segment was positively correlated with number of females in the population segment ($R=0.874$, $p < .05$). As the number of adult females declined so did numbers of kids, indicating that compensatory reproduction was not occurring. This was also illustrated by reproductive information from marked adult females. Although the correlation between productivity and seismic activity that year, or the previous year was weak, the correlation of productivity and seismic activity for two years prior to the birth year was highly significant ($R=-0.906$, $p < .001$) (Fig. 5). Thus, the amount of seismic activity during 2 years explained 82% (R^2) of the variation in productivity during the birth year.

DISCUSSION

The objective of this study was to evaluate changes in the RMF mountain goat population in relation to energy exploration. At

the beginning of this study, kid production was higher in the Birch-Badger segment than the Teton-Dupuyer segment. Reasons for this difference are not fully understood, although it may be related to the degree of human activity historically occurring in these areas. The Birch-Badger segment is relatively inaccessible, and has not been greatly influenced by human activities. In contrast, the Teton-Dupuyer segment has had a much higher level of human activity, including a seasonal ranger station, timber harvest, and developed recreation involving a downhill ski resort, a guest ranch, groomed snowmobile trails, developed campgrounds, and major trail head parking facilities. This has resulted in traditionally more motorized access and use.

Prior to the increase in helicopter based seismic activity along the RMF in 1981, it appeared that the Birch-Badger segment contained an undisturbed mountain goat population that had good reproductive performance, while the Teton-Dupuyer segment was comparatively more heavily utilized by people and contained a mountain goat population that had relatively low reproductive performance. The number of adult females in the Birch-Badger segment remained relatively stable from 1981 to 1986, but declined in the Teton-Dupuyer segment. During this period, the total number of kids in the Teton-Dupuyer segment declined, while the number of kids in the Birch-Badger segment showed a sharp decline in 1984, and then some increase in 1986 (although still substantially below 1982-1983 levels). The reproductive decline appeared coincident with the peak in seismic activity along the RMF from 1981 through 1984. The recovery of kids in 1986 in the Birch-Badger segment also appears coincident with the cessation of seismic activity in 1985. However, kid production, number of kids, and number of adult females in the Teton-Dupuyer segment continued to decline through 1986. The Teton-Dupuyer population did not respond as the Birch-Badger population had, once seismic activity ceased, possibly due to the long-term additive effects of several stressors upon the Teton-Dupuyer segment.

Other factors which may have influenced mountain goat population characteristics include weather, hunter harvest, livestock grazing, timber harvest, and disease. Several authors have documented an inverse correlation between winter snow depths and kid survival (Chadwick 1973, Rideout 1974, Smith 1976, Bailey and Johnson 1977, Thompson 1980, Johnson 1983, Swenson 1985). The average of March, April and May snow depths from 3 snow survey sites in or near mountain goat winter range along the RMF from 1980 through 1985 indicated that winter snow pack has been at or below normal during 5 of 6 years. A regression of Teton-Dupuyer kid:non-kid ratios upon snow depth showed little correlation ($r=0.5$, $df=5$, $p > 0.1$). The relatively low snow depths apparently did not have an influence on kid survival.

Cool wet summers are also known to affect survival of newborn young (Brandborg 1955, Johnson 1983). Temperature and precipitation data during June, July and August from 1980 to 1985

indicated that summers have generally been slightly warmer and dryer than average. The month of June in particular, is critical, but 1981 was the only year slightly cooler than normal (-0.4 C below average), and 1983 and 1984 were the only years slightly wetter than normal (1.0 cm and 0.1 cm above the average, respectively). A combination of abnormally cold and wet conditions did not occur during the course of the study.

Numbers of hunting permits issued for the 2 districts along the RMF have varied from 15 to 8 between 1978 and 1985, and currently stand at 8. An average of 4 to 5 mountain goats have been harvested per year. Since the beginning of this study in 1981, when population levels were first estimated (Joslin 1986), mountain goat harvest has not exceeded 4% of the population, and has averaged 3%. Females have composed 46% of the harvest, or between 2 and 3 per year. Analysis of harvest indicated that adult females in the Birch-Badger segment were neither negatively nor positively influenced by existing harvest levels ($R=0.321$, $p < .5$). A positive correlation between number of females harvested and number of females in the Teton-Dupuyer segment indicated that females were harvested in proportion to their abundance ($R=0.876$, $p < .05$). Hunting, therefore, does not appear to be responsible for the observed kid decline, although it is possibly a contributing stressor to the Teton-Dupuyer population segment.

Livestock grazing peaked along the RMF in the early 1900's. Changes in allotment size, duration of use, species use, and management systems have helped reduce livestock competition with wildlife. Generally, livestock use is now at its lowest level in 50 to 80 years, and the current level of use has been maintained since the most sweeping changes were instituted in allotment use 10 to 20 years ago. Although livestock grazing continues to be a significant land-use activity along the RMF, the extent and degree of use has not appreciably changed in the last 2 decades, and would not appear to have created a new or increased stress upon the mountain goat population.

Approximately 7,600 cubic meters (1 million board feet) per year of timber has been removed from the RMF over the past decade (USDA Lewis and Clark National Forest Plan 1986). All of the few logging roads that created access into mountain goat range occurred in the Teton-Dupuyer segment, but timber sales have generally not been located in critical mountain goat range. The decline in kid production in the Birch-Badger segment was not related to timber harvest since none occurred in this area. However, limited harvest in the Teton-Dupuyer segment may have indirectly affected that area's population.

The drop in mountain goat kid production in 1983 and 1984 tends to parallel the pattern of bighorn sheep decline due to a pneumonia die-off along the RMF in 1983 and 1984 (Hook 1986).

Onderka and Wishart (1984) indicate that in bighorns, some adults initially succumb of respiratory disease complex, while others may survive to become carriers and thus bare a poor lamb crop.

Mountain goat deaths as a result of respiratory disease complex were not documented, although 2 possible cases were discovered. In 1983, 2 mountain goats were found dead along the RMF, one along the South Fork Teton River in Green Gulch (T. Bivins 1983, pers. commun.) and the other near Many Glacier in Glacier National Park (K. Keating 1985, pers. commun.). The Teton goat, a 5-6 year old male, was diagnosed as having fibrinopurulent bronchopneumonia (Corynebacterium sp.) (J. Rhyan, DVM, Lab Rpt. No. 8-470 Veterinary Lab, Bozeman, MT). The Glacier goat also suffered from severe suppurative pneumonia (M. Harries DVM, Path. No. L83-3228-H Alberta Animal Health Division, via Glacier National Park, MT). Harries noted that the pathological changes in the Glacier goat were essentially similar to those of the bighorn sheep which had been suffering from a Pasteurella hemolytica biotype T pneumonia in areas of Alberta, British Columbia, and the RMF of Montana. Although significant bacteria could not be isolated, similar organisms to those of the sheep had very likely been present (op. cit.).

Limited evidence indicates that broncho-pneumonia might have been a contributing factor in the observed mountain goat population changes. Respiratory disease complex is often stress-induced (Onderka and Wishart 1984). If this stress-related pneumonia was latent in mountain goats along the RMF, it is possible that this disease, and the stress-inducing effects of seismic disturbance could have acted in concert to cause the observed decline in females and kid production.

The correlation between mountain goat productivity and seismic activity in previous years, suggest that the stress induced by this seismic activity is cumulative over the years. The 4 year period of very intensive activity probably created more stress than it would have, had the individual years of activity not been consecutive. Stemp (1983) indicated that pre-natal stress is of particular concern because the extreme sensitivity of the young is related to their rapid development, and the most rapid development of a mammal takes place as a fetus. Particular organs and behaviours are especially susceptible during the critical periods in which they are maturing most rapidly (Scott 1962). Changes in development can be so pronounced that the individual's emotionality and behavior, phenotype, and even viability can be profoundly and permanently altered (Stemp 1983).

A number of researchers have reported upon behavioral and physiological response of wildlife to helicopter harassment. Helicopters, sonic booms, gunshots, people on foot, stopped

occupied vehicles, and domestic dogs elicit strong behavioral and/or heart rate responses from a variety of wildlife (Horejsi 1976, Ward and Cupal 1979, Gunn et al. 1983, Stemp 1983, Irwin and Gillin 1985). MacArthur et al. (1982), Stemp (1983), Ward and Cupal (1979) and others have indicated that behavioral response does not necessarily reflect physiological response to harassment. Despite the animals outward behavior, Stemp (1983) reported that heart rate of bighorn sheep was significantly elevated and remained elevated as long as helicopter activity occurred in their vicinity. Up to 45 minutes was required after the disturbance was gone for heart rate to return to normal. He indicated that "behavioral response can be extremely misleading: helicopters can sensitize bighorns and can produce marked and prolonged physiological responses in the absence of pronounced--or even any--behavioral reaction".

To avoid stress-inducing disturbance, an animal may withdraw, but withdrawal is also costly because exertion demands increased energy expenditure. Also, injury is a risk during escape attempts, and the opportunity to feed at that location is removed. If animals withdraw from key habitat areas, carrying capacity can be reduced (Geist 1975). During this study, mountain goats generally moved away from human activity, and used topographic relief to screen themselves from line-of-sight disturbance. Although they did redistribute themselves within their home ranges to avoid disturbance, fidelity to familiar terrain was strong and none abandoned their traditional home ranges.

Abundant literature exists detailing the maladaptations that may result from repeated or prolonged stress stimulation, including decreased resistance to infection and disease (Hudson 1973, Stein et al. 1976), and impaired or complete failure of reproductive function (Geber 1962, 1970; Petropoulos et al. 1972, Sontag 1970 - in Stemp 1983). Stemp (1983) indicated that "any stressor sensitizes the individual to other stressors. Moreover, a prolonged stress response decreases an individuals ability to cope psychologically (Shanan et al. 1976) which is likely to make them more susceptible to subsequent stressors". This is particularly evident in the Teton-Dupuyer segment where seismic activity appeared to be additive to other long-term, human-induced stressors. A constant level of stress may explain why kid production in this area did not improve, even though seismic activity ceased in 1985. Although the Birch-Badger segment was relatively immune from long-term stressors, it appeared that seismic activity did cause a decline in kid production in 1984. Once seismic work ended, productivity improved. In comparison, mountain goat populations in adjacent Glacier National Park (where no seismic activity occurred) appeared to be stable (K. Keating 1985, pers. commun.)

This study indicates that efforts should be made to reduce human activities in the Teton-Dupuyer segment in order to allow

mountain goat population recovery. If the Birch-Badger segment remains inaccessible and relatively free of human activity, it appears that it might be able to recover from temporary, short-term disturbance. Monitoring will be necessary to determine whether mountain goat production returns to pre-1981 levels along the RMF.

Detailed multi-agency guidelines were developed to ameliorate the effects of energy exploration activities upon wildlife along the RMF (Interagency Rocky Mountain Front Wildlife Guidelines 1984). One objective of the guidelines was "to avoid or minimize human related activities which may adversely impact selected species of wildlife". The mountain goat population declines suggest that the guidelines were insufficient to maintain pre-development kid production and female population levels in the face of intense human activity. Application of the guidelines was particularly deficient in controlling distribution of seismic activity. If the mountain goat population is to increase and be maintained at or above the 1980 level, managing the timing and intensity of human activity within mountain goat habitat will be critical.

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QUESTIONS AND ANSWERS

Bruce Smith, Wyoming: Gayle, I was interested in your juvenile mortality rates and wonder if you could tell us how you determine those for kids and yearlings. Yours were fairly high.

Gayle Joslin: They were fairly high. They were determined from five consecutive years of actual survey information.

Smith: So it was actual counts of kids during consecutive years and comparing them from year to year?

Joslin: yes and over the course of the year by watching kids of radio-marked adult females from week to week.

Smith: Were you surveying during the winter?

Joslin: No, I surveyed in July.

Smith: You had an inverse correlation between productivity of the goats and the seismic activity, is that right?

Joslin: Right

Smith: Was there any correlation between the mortality rates of kids and yearlings and the activity in the areas you looked at. For example, before the seismic activity increased, did you have lower mortality of kids and yearlings than you did after you had higher levels of activity in the area.

Joslin: Yes. Using both yearly survey data and monthly observation data from marked females which had kids at side, I could see that as consecutive years of seismic activity elapsed, either productivity or survival or both decreased.

Smith: So then there was a correlation?

Joslin: Yes.

Nicki Goodson, Colorado: Do you have any information on distribution activity, or movement patterns of goats relative to disturbance?

Joslin: Regarding distribution, radio-marked goats did not leave established home ranges when disturbance occurred, but they would use topography to screen themselves from human activity by moving out of a drainage where the activity was occurring. I observed four marked goats do this. When disturbed, goats would often watch the activity for quite some time. They would be alert, not feed, and they seemed to chew their cud less, but this was not a behavior study per se, so I don't have quantitative ethological data. Doug Chadwick's thesis gives excellent descriptions of mountain goat response to disturbance. I did not observe anything during this work which was counter to what Chadwick reported.

Jim Bailey, Colorado: How far did they move?

Joslin: They always stayed within their home range, but males would move the greatest distances. It was common for three radio-marked males to travel about nine air miles over the Continental Divide into the Flathead drainage to summer, but that was more of a seasonal movement. Males had the opportunity to avoid the activity more because their home ranges included more wilderness area and were, therefore, more isolated.

Bailey: You said that was a seasonal thing. I was asking in addition to Nicki's question, how far do these animals move in response to seismic.

Joslin: Let me explain a complicating aspect of this work. Several of us who were collecting data along the Rocky Mountain Front at that time will attest that we often did not know where or when a seismic line would be shot. Communication from the Rocky Mountain Ranger District to field biologists regarding seismic activity was limited. So, we were often not aware that a particular line had been shot until it was too late to monitor an animal's response. Relative to those goats which I did observe subsequent to disturbance when I had the opportunity, they would often move no more than a half mile. They would go over a ridge to get away from direct line-of-sight disturbance. It is this kind of limited reaction by goats which elicits a judgment that goats are not affected by disturbance. However, in the case of mountain goats at least, I believe the population data is more revealing than behavioral reaction.

Wayne Heimer, Alaska: Is this exploration over at this point or ongoing?

Joslin: Good question, we would like to know, too. When the price of oil goes back up, I suppose we'll see more exploration. They do have three exploratory wells that are pending right now.

Heimer: The other question is, presuming with the price of oil being low like it is, there won't be anything going on right away, are you going to continue watching to see if the stress goes away if things get better?

Joslin: There's no more funding. No.

Heimer: There ought to be.

Peter Davidson, BC: There was obviously a lot of activity by helicopters in that area. I assume that most of this is done from helicopters judging by the terrain. You mentioned Raymond Stemp's work, University of Calgary, was there any attempt to collect that type of information from these goats?

Joslin: No heart rate response or fecal cortisol information was gathered so there was no direct measure of stress effects.

Davidson: I'm suggesting that the helicopters might have had as much effect as the blast itself or more.

Joslin: I think it had more. That's my personal opinion, but I think it had more. There was a great deal of helicopter activity.

Kirby Smith, Alberta: You said you lost 60% of your kids by September, did I miss the explanation or do you have any explanation? Were you watching kids on cliffs during helicopter passes or anything like that? Do you think it was because of falls or what?

Joslin: I don't know what the exact mechanism of the kid decline was. Of the kids born to marked female goats, six were known to have died. Four of these six disappeared between July and October.

Ted Benzon, South Dakota: After the seismic activity was gone, how long did it take before the goats went back into that area?

Joslin: Some times by evening they would come back. Especially when they were on salt licks. Goats will take big risks when their drive for salt is high. They almost seem suicidal.