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BEHAVIORAL RESPONSE AND HABITUATION OF MOUNTAIN GOATS IN RELATION TO PETROLEUM EXPLORATION AT PINTO CREEK, ALBERTA

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Abstract: Two programs of experimental habituation were conducted to condition a wild population of mountain goats (Oreamnos americanus) to noise stimuli representative of petroleum exploration activities. The habituation programs achieved an increase in the goat's awareness of introduced acoustic stimuli and human presence without causing adverse responses. Goats exhibited a tolerance of increased levels of indirect and persistent noise, but continued to investigate any initial or novel sounds. Goats habituated to predictable, continuous stimuli, but were disturbed by sudden, unpredictable stimuli. Nannies were sensitive to stimuli of all kinds during the kidding and post-kidding seasons.

Human-caused disturbance of large mammals is a concern for wildlife managers (Geist 1978, Shank 1979). Disturbances associated with industrial and recreational activities, hunting or other situations can cause modifications in the behavior of animals with repercussions on their physiology, distribution, habitat use, fecundity and population health (Geist 1971). Smith (1982) examined the potential impact of a proposed natural gas well on the forest-dwelling mountain goats of Pinto Creek, Alberta and concluded that habituation might be the only behavioral alternative if the goats were to survive.

Mountain goats have inhabited the Pinto Creek area at least since 1945 (Kerr 1965). Population size appears to have remained fairly constant and probably never consisted of more than 12 animals from 1942 to 1962 (Stelfox and Kerr 1962). Classified counts in recent years show the herd size has varied from 17 animals in 1965 to 7 animals in 1982 (Table 1). During the present study the herd size fluctuated from 7 to 14 animals.

The Pinto Creek herd is considered to be atypical of goat populations and is the longest term example of a goat herd known to reside in a forested area in Alberta. The goats have successfully colonized a restricted river valley habitat that is separated from the main Rocky Mountain goat ranges by 38 kilometers of dense conifer forest.

This paper examines the results of three investigations on the behavioral response and habituation of mountain goats in relation to proposed and completed petroleum exploration activities at Pinto Creek between 1981 and 1987.

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Table 1. Numbers of goats by age and sex cohorts in the Pinto Creek population.

Source	Date	Kid	Yrl.	2-yr old	Adult female	Adult male	Unclass-ified	Total
Stelfox & Kerr(1962)	June'62	1	2	-	3	1	5(Ad)	12
Kerr(1965)	Jul'62	2	3	3	5	4	-	17
Bibaud & Hall(1976)	Jan'76	1	1	-	-	-	7(Ad)	9
Bibaud(1977)	------	2	1	-	-	-	6(Ad)	9
Penner & Jalkotzy (1984)	Mar-Apr'81	1	2	-	3	2	-	9
	May-Dec'81	3	1	2	3	2	-	11
	Jan-Mar'82	3	1	2	3	1	-	10
	Apr'82	2	1	2	3	1	-	9
	May'82	2	2	1	4	2	-	11
	Jun'82	4	2	1	4	2	-	13
	Aug'82	4	1	1	4	2	-	12
	Oct'82	2	1	1	3	1	-	8
	Nov-Apr'83	2	0	1	3	1	-	7
	May-Jul'83	1	2	0	3	2	-	8
Smith(1984)	Jun'84	2	1	2	3	2	-	10
Penner(1986)	Nov'84	1	1	2	3	2	-	9
Taggart(1985)	Aug'85	3	1	1	3	?	1	9
Taggart et. al. (1986)	Jun'86	3	2	-	4	?	-	9
Penner(1988)	Nov'86-Mar'87	3	2	-	4	2	-	11
	May'87	3	3	2	4	2	2[a]	14

[a] Includes 2 goats reported from Hightower Creek (W. Berry, Local Trapper, pers. comm).

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STUDY AREA

The study area, which encompasses the Pinto Creek Mountain Goat Reservation, lies on the eastern slopes of the Rocky Mountain Foothills (Figure 1). The gently rolling forested plateau is dominated by lodgepole pine (Pinus contorta) and white spruce (Picea glauca). Pinto Creek valley is deeply incised through several high, rounded hills, thus exposing the shale and sandstone bedrock. Total relief varies less than 110 m throughout the study area (1112 - 1220 m elevation). Goat habitat is centered on a series of discontinuous bedrock exposures along the slopes of the Pinto Creek valley and along Wroe and Hightower Creeks, near their confluence with Pinto Creek. Thirty-four discrete cliff units have been identified within the 15 kilometers of river valley normally used by the goats. The majority of goat habitat use, however, is centered on three of the largest cliff complexes located in the northern, central and southern portions of the range. The many small bedrock and soil exposures along the valley slopes provide some additional foraging habitat and escape terrain for goats during travels between the larger cliff units. The vegetation of the area is classified as the Upper Foothills Section of the Boreal Forest Region (Rowe 1972). The upland forest is dominated by lodgepole pine and white spruce on well drained sites and black spruce (Picea mariana) and tamarack (Larix laricina) in poorly-drained muskeg areas.

METHODS

Behavioral studies on mountain goats at Pinto Creek were done in response to three petroleum exploration programs:

1. January, 1981 to July, 1983. A natural gas well was proposed and would be located within 400 m of a main goat trail between core cliff complexes. The study included monitoring baseline conditions and experimentally conditioning goats to noise stimuli. The proposed drilling program was not initiated.

2. November and December, 1984. Mountain goats were habituated to noise disturbance prior to a seismic program that would pass about 600 m from the herd's traditional winter range.

3. October, 1986 through May 1987. An exploratory natural gas well was drilled about 2100 m from the winter range. The goat's response to the potential disturbance was monitored.

Monitoring Procedures

Field trips during the three study programs were mostly on a monthly basis, each lasting for about 5 to 10 days. On each trip the goats were

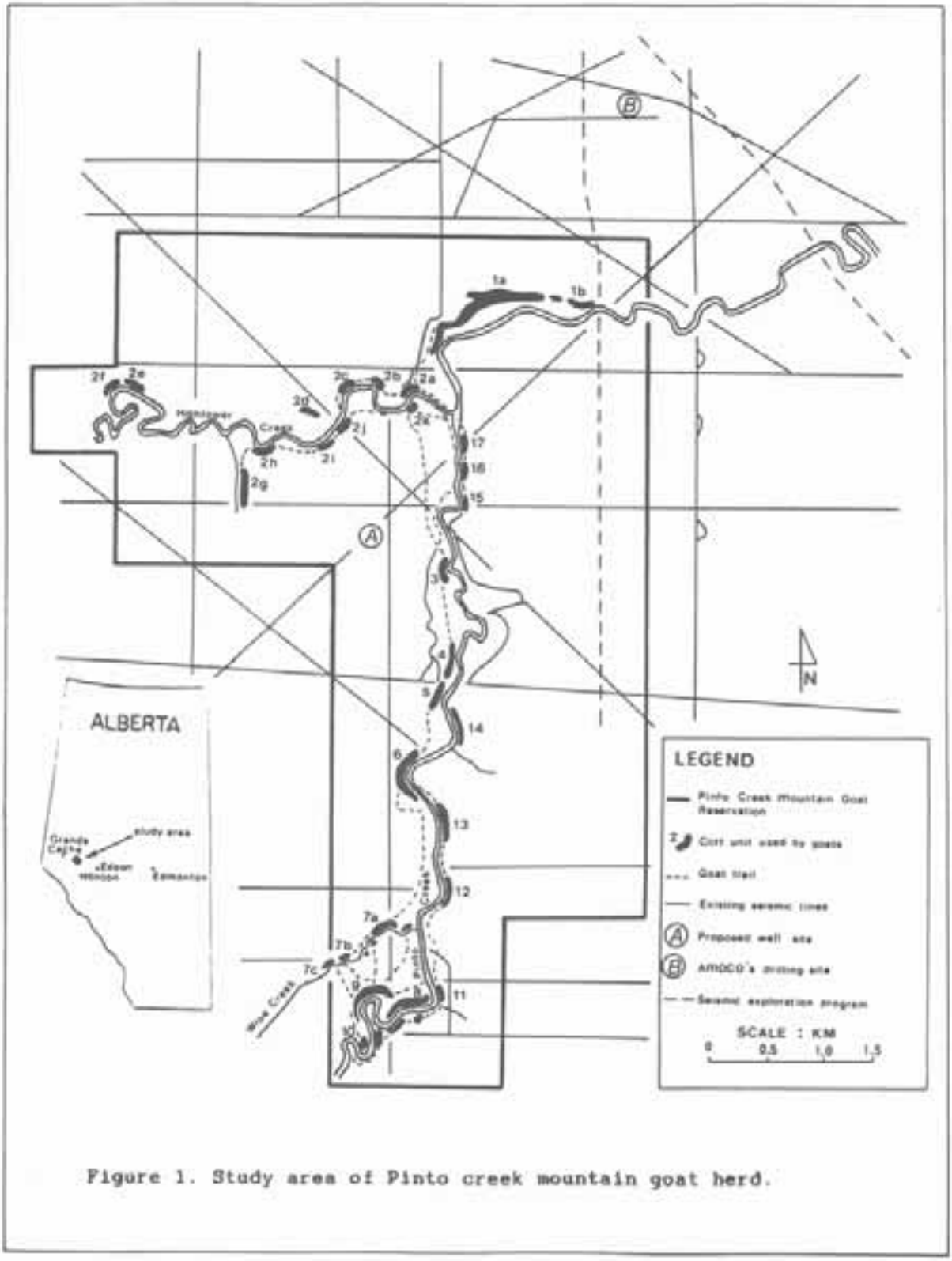

Figure 1. Study area of Pinto creek mountain goat herd.

located (or at least the nursery herd) and main cliff units and trails were examined to document recent habitat use. The main aggregation of goats were monitored from dawn to dusk whenever possible and most consistently for the times between 0800 and 1800 hours. Goats were observed from across the valley at a distance of 400 to 600 m. Observations were made with the aid of a 20 - 60X spotting scope and 8 X 40 binoculars. Individual goats were identified on the basis of body size (kid, juvenile or adult), sex, and horn size and configuration.

Goat activity and habitat use was documented using the observation-interval technique, adapted from the instantaneous scan method (Altmann 1974). At each 15 minute interval, goats were observed intently for about 3 minutes and the dominant activity, the habitat zone in which it occurred and the behavior of each individual determined and recorded. The activities recorded were: feeding, bedding, standing, moving, playing and intraspecific interactions. The behavior of goats to their surroundings was recorded as an index of increasing levels of awareness, alertness and alarm responses based on overt behavior (adapted from Hicks and Elder 1979) (Table 2). Within the 15 minute interval, the goat herd was monitored to note changes in their distribution on the cliff unit, major changes in activity patterns and especially to document any directional or alarmed behavioral response (i.e. R3-or-greater) to environmental stimuli. Goat behavioral responses were related to all sources of stimuli (e.g. aircraft overflights, rock falls, other wildlife, the observer's location and activity, broadcast noise and petroleum exploration activities).

Habituation

Behavioral conditioning of goats to accept or tolerate noise and human presence was based on the conceptual model of the ruminants "Umwelt" described by Geist (1971) and Thompson and Spencer's (1966, in Leaton and Tighe 1976) characteristics of habituation. The following criteria were central to the habituation procedures:

1. Repeated application of stimuli;

2. A gradual increase in the magnitude and duration of stimuli;

3. Consistency in the location of the stimuli source;

4. Indirect stimulation to foster learning by goats that acoustic, olfactory and visual stimuli emanating from a distance are harmless;

5. The use of noise stimuli that could be controlled by the observers and withdrawn or reduced in intensity if adverse behavioral responses by goats were observed; and

6. The overt behavioral response of goats was monitored to determine whether the magnitude of stimuli was sufficient to facilitate habituation, avoid adverse responses (that would develop negative associations and thus dishabituation), and to document the process of behavioral change.

Table 2. Index of mountain goat behavioral response to environmental stimuli.

R1. NO OVERT RESPONSE

Overt behavior did not indicate awareness of a stimulus. Goats were resting, often with their heads down and eyelids closed, or foraging intently.

R2. UNCONCERNED RESPONSE

Goats raised their heads at irregular intervals (Chadwick, 1977), or appeared to be aware of a potential stimulus as shown by the position of ears and occasional directional glance but continued feeding, bedding or other activities.

R3. CURIOUS RESPONSE

Goats exhibited a directional alertness to a stimulus and periodically watched or listened intently for short periods but continued the normal maintenance activities.

R4. CONCERNED RESPONSE

Goats appeared very alert but did not exhibit directional movement. Goats stood if bedded or stopped feeding to watch and listen intently in the direction of a stimulus. Tail posture was partially erect. Some feeding movements occurred, possibly as displacement behaviour.

R5. ALARMED RESPONSE

Directional movement or flight by walking and/or trotting, usually to more secure escape terrain, where goats stood, watched and listened intently. The goats moved into adjacent forest cover and along trails leading to nearby escape terrain. Flight was immediate or followed a period of concerned response. The tail was held erect, indicating fear and alarm (Singer, 1978).

R6. VERY ALARMED RESPONSE

Rapid flight to escape terrain, movements on the cliff units to more inaccessible rock outcrops and huddling under ledges or against a rock face. Alternatively, goats abandoned the escape terrain and ran to adjacent forest cover and moved rapidly along ridges and trails to secure terrain of nearby cliff units.

Noise came from a 1750 watt gas-powered generator and pre-recorded noise of an operating drilling rig, amplified by 50 watt speakers. Additional noise stimuli during part of the programs were from the periodicuse of chain saw, all-terrain vehicles and the striking of a suspended steel pipe with an axe to resemble noise of the tripping operations (i.e. the replacement of pipe-string sections) on a drilling rig.

During the initial habituation program, temporal comparisons for the evaluation of goat responses were obtained from preceding baseline studies and by systematic observations several days prior to, and following stimulation procedures. The intensity and duration of stimuli were gradually increased in the months preceding the planned start-up of drilling operations.

The program to condition goats prior to the seismic program consisted of three 7 day sessions of gradually increased noise stimulation within a 30 day period. In addition, a 12 gauge shotgun was used to simulate the sudden explosions generated for seismic recordings. Gun shots were repeated in a series of 3 and spaced at intervals of 1 to 4 minutes. Gun shot stimuli were generated between the 15 minute observation intervals. Up to 5 series of gun shots were fired each day, depending on goat activity and visibility to the observer to allow for the assessment of behavioral response.

In the recent field program when the drilling site was located near the goat's traditional winter range, efforts were concentrated on documenting the distribution of goats during the rutting season, the time of movement to the winter range and observations of the goat's behavioral response to noise from the drilling activities.

RESULTS AND DISCUSSION

Program 1: Experimental Habituation

Mountain goats appeared to develop a tolerance of indirect and persistent noise stimuli in their environment, but continued to exhibit elevated behavioral response levels to initial, novel or sudden noise and visual stimuli. Goats recognized and investigated unfamiliar or initial stimulus, such as the daily introduction of noise stimuli and changes in the nature and intensity of sounds, but generally ignored the persistent and low intensity roar of broadcast sounds of a drilling rig. This is evidenced by the absence of significant overt responses (R3-or-greater) during about 98% of the observation-intervals (Table 3). The apparent habituation of the goats to noise was not demonstrated by a decline in the response frequencies recorded during the sequential stimulations. This was a result of the gradual increase in stimuli intensity, which maintained low levels of behavioral response to the noise stimuli throughout the twelve month program and allowed goats to become acclimatized to the noise disturbance.

The number of goat responses R3-and-greater per 100 goat-hours (GH) observation was significantly greater during days of stimulation than for days of non-stimulation (92.7 and 46.0/100 GH: $P>0.05$) (Table 3). This trend was less pronounced during the fall and spring when the general

Table 3. Percent frequency of goat behavioral response and number of responses R3-or-greater per 100 goat-hours observation during experimental habituation and seismic programs at Pinto Creek, Alberta.[a]

Behavioral index	Stimulation phase	Experimental habituation						
		Non-stimulation phase				Seismic program sessions:		
		Basel.	Pre-	Post-	Mean	1	2	3
Percent Frequency of Responses at observation intervals:								
R1	94	97	95	97	96	73	87	82
R2	4	2	3	2	2	17	11	9
R3	1	1	1	<1	1	10	2	8
R4	<1	<1	<1	<1	<1	0	<1	<1
R5	<1	<1	0	0	<1	0	0	0
R6	0	0	0	0	0	0	0	0
Number of observations	6408	2228	3920	2868	9016	808	942	1744
Number of Responses R3-or-greater per 100 GH:								
R3	74.9	24.2	36.4	32.0	30.9	130.1	70.4	92.7
R4	11.7	5.4	13.0	9.0	9.1	10.4	5.9	8.9
R5	6.1	7.4	3.4	7.3	2.4	2.0	0	2.1
R6	0	0	0	0	0	0	0	0
Total	92.7	37.0	52.8	48.3	46.0	142.5	76.3	103.7
Hours of observation	427	149	261	191	601	202	236	436

[a] Combined data from total observation times during the experimental habituation study: June, 1982 to July, 1983, and seismic program: November-December, 1984.

increased alertness of goats coincided with the rutting, kidding, and post-kidding periods. Noise stimuli was the documented source of 48% (spring) to 78% (winter) of elevated goat responses (R3-or-greater) (Table 4).

Daily introduction of acoustical stimulation, sound surges (due to changing wind patterns) and sudden noises resulted in more frequent responses by goats than from the more consistent, predictable drilling rig sounds. The periodic noise from pipe clanging and the use of a chain saw at the generator site was also effective in capturing the goat's attention, and evoked curious responses (R3).

Goats responded to human presence (observers) in a manner similar to their acceptance of introduced noise stimuli. Our cautious approach during the program allowed the goats to learn that our presence across the valley was predictable and harmless. Goats exhibited curious responses to the observer's arrival at an observation site but mostly ignored our presence thereafter. Goat's awareness of observer presence, changes in observer position, or sudden movements was evidenced by their unconcerned (R2) and curious (R3) responses. Goat response to observer presence was similar between stimulation and non-stimulation periods in fall, winter and summer (Table 4). Nannies, during the kidding and post-kidding season, exhibited a greater awareness of observers and alertness to other environmental stimuli than in other seasons (Table 4).

Daily activity patterns were characterized by alterations in feeding and resting periods. The proportion of time spent feeding on stimulation days was not consistently greater or less than control comparisons for various months or seasons. The average duration of feeding bouts during stimulation days (1.9 hours) was similar to the preceding days (2.0 hours) but less than post-stimulation days (2.4 hours) (Table 5). Increased frequency of feeding bouts were accompanied by a reduced duration of feeding bouts so that the total foraging time per day (annual mean of 4.8 hours) remained the same between stimulation and non-stimulation periods.

Goats exhibited their greatest sensitivity to unusual or sudden stimuli such as rock falls, aircraft overflights and predators (Table 4). Stimuli that could be seen or seen and heard by goats elicited a stronger response than most types of noise alone. The goat's response to fixed-wing aircraft overflights was usually unconcerned (R3) while the sounds of a helicopter frequently elicited concerned (R4) or alarm (R5) responses. Previous experience with helicopters may have been a sensitization factor influencing the goat's behavioral response.

In conclusion, goats accepted or tolerated indirect and persistent noise disturbance based on insignificant changes in behavior, activity and habitat use.

Program 2: Seismic Exploration

Nine goats were monitored between November and December, 1984 (Table 1). Location of goats on the southern cliff complexes during the rut was similar to seasonal distribution patterns observed in previous years. Movements of the herd (with the exception of an injured male) to the

Table 4. Number of behavioral responses per 100 goat-hours at levels R3-and-greater to different environmental and introduced stimuli during 4 seasons of the habituation program and the seismic program.

	Responses per 100 goat-hours: stimulation days						
	Habituation program				Seismic program		
Stimuli source	Winter	Spring	Summer	Fall	1	2	3
Introduced Stimuli							
general broadcast	20	37	19	24	11	28	20
initial start-up	21	27	21	34	4	14	12
sound surges	4	0	7	5	-	-	-
horn	2	10	2	11	-	-	-
pipe clanging	9	13	0	0	-	-	-
chain saw	3	10	-	-	9	1	0
snowmobile/ATV	3	-	-	-	0	8	3
subtotal	62	97	49	74	24	51	35
Other Stimuli							
observer	5	17	14	21	25	7	10
predators	1	-	-	-	-	-	-
birds	4	0	0	1	17	1	1
rock falls	1	-	3	-	-	-	-
aircraft	-	3	3	-	9	-	4
intraspecific	2	3	5	6	42	7	5
seismic program	-	-	-	-	-	-	24
other/unknown	4	80	6	2	20	11	24
subtotal	17	103	31	30	113	26	68
Total	79	200	80	104	137	77	103

	Responses per 100 goat-hours: non-stimulation days			
	Habituation program			
Stimuli source	Winter	Spring	Summer	Fall
observer	6	46	17	15
nowmobile/ATV	7	0	0	3
predators	10	-	-	-
birds	6	7	1	0
rock falls	2	-	3	-
aircraft	2	5	1	4
intraspecific	3	34	2	2
other/unknown	0	90	12	5
Total	46	182	36	29

Table 5. Number and duration of daily feeding bouts by adult female mountain goats during baseline and habituation studies.[a]

	Number (duration in hours) of daily feeding bouts				
	Winter	Spring	Summer	Fall	Mean
Study phase	No.(dur)	No.(dur)	No.(dur)	No.(dur)	No.(dur)
Baseline	2.2(2.3)	3.8(1.8)	4.0(1.1)	2.7(1.7)	2.9(1.7)
Experimental Habituation					
Pre-stimuli	1.7(2.7)	5.0(1.3)	2.5(0.8)	2.5(1.2)	2.6(2.0)
Stimulation	2.5(2.2)	3.0(1.7)	2.3(1.2)	2.6(2.0)	2.6(1.9)
Post-stimuli	1.8(3.0)	6.0(1.1)	-	1.7(1.6)	2.5(2.4)
Habituation and Seismic Program					
Stimuli	2.3(2.1)	-	-	-	-

[a] Data are means of the most complete days of goat observations.

traditional winter range was earlier than in previous years and may have been influenced by severe weather and 30 cm of snow. This program required rapid acclimatization of the goats to noise during 3 habituation sessions.

Goats exhibited an unconcerned behavior (R1 and R2) to noise and other stimuli in their environment during the majority of observation intervals (90%, 98% and 91% during sessions 1 to 3, respectively) (Table 3). Overt responses of R3-and-greater during and between observation intervals were greatest during the first habituation session (142.5/100 GH), least during the second session (76.3/100 GH) and intermediate in frequency during the last session (103.7/100 GH) (not including the gun shot stimuli) (Table 3).

The heightened level of goat alertness during the first session was attributed to intraspecific responses related to rutting behavior, observer presence, and the introduction of noise (Table 4). Rutting activities appeared to increase the alert behavior of adult goats, particularly the dominant billy. Goats were more responsive to the noise stimuli on the first day of each session (mean of 46/100 GH) than on subsequent days (mean of 16/100 GH). The goats were more responsive to infrequent and novel sounds created by the use of a chain saw, distant vehicles and aircraft overflights than the constant generated noise.

During the second session, goats were located mostly on cliff 11 (Figure 1) across from the sound generation site. Broadcast sounds were responsible for an average of 55% of the responses R3 or greater. Goats exhibited overt behavioral responses to the initial introduction of noise each day, sound surges or unusual sounds such as the horn blast on the tape, and appeared to ignore the more constant noise stimuli. The directional alertness associated with curious (R3) responses to acoustic stimuli were normally of short duration (i.e. less than 60 seconds) before the goats resumed maintenance activities.

The third habituation session overlapped a 5 day period when seismic lines were being cleared near the traditional winter range at cliff unit 1 (Figure 1). A drilling rig, about 5 km west of the winter range, was also audible periodically. The noises from the line-clearing activities were discontinuous and varied in nature, intensity and location over several days. Goat responses to these stimuli were mainly curious (R3), with directional alertness. On 3 days during the peak of seismic line clearing activities, the goat herd exhibited an increased nervousness and several prolonged periods (up to 2 hours) of concerned (R4) response to noise stimuli. Several goats exhibited alarm responses (R5). After the periods of elevated alertness, goats would begin foraging, often in the upland forest zone, 50 to 100 m from escape terrain. We interpreted the goat's behavior as nearing the threshold of tolerance before abandonment of the cliff unit for other secure locations. The dozer, drilling rig and broadcast noises appeared to have a cumulative effect with a resulting higher frequency, intensity and duration of behavioral responses by goats. Stopping the broadcast noise was later followed by a more relaxed behavior by the goats. On the following days the noise from the line clearing operation were infrequent and less intense and the goats exhibited a tolerance of noise disturbances.

The intensity of gun shot noise was increased during the habituation program by changing the direction of the shots and reducing the distance between the goats and the gun shots. The initial sequences of gun shots resulted in directional alertness and concern (R3 and R4 responses) by all goats which lasted several minutes. The frequency and intensity of behavioral responses declined with subsequent gun shots in each series and subsequent gun shot series during a particular day (Table 6). The average frequency of response (R3-or-greater) for a sequence of three shots for all observations combined was: 38, 26 and 19% of the goats, respectively. Alert responses to a sequence of 4 gun shot series in one day averaged 40, 23, 17 and 12%, respectively. The overall response frequencies (R3-or-greater) also declined during the three habituation sessions: an average of 40, 22 and 14%, respectively. During the last session, gun shots directed towards the goats from a distance of about 500 m resulted in very few alert responses by goats.

The behavioral responses of mountain goats to the gun shot stimuli are perhaps the best indication that goats can become conditioned to potentially disturbing noise stimuli. Goats did not appear to associate the gun shot noise with the observers and thus a negative association was not formed. Goats exhibited an increased tolerance of both the observers and gun shots during the habituation program. The higher frequencies of goat responses (R3-or-greater) at the initiation of gun shots during each day, each series and monitoring session shows their re-investigation of this stimulus (i.e. spontaneous recovery from conditioning).

Goats maintained typical patterns of daily activity and habitat use throughout the habituation and seismic program in comparison to baseline data. Results suggested that goats tolerated the potentially disturbing noise stimuli that would accompany seismic activities.

Program 3: Drilling of an Exploratory Natural Gas Well

The drilling rig was about 2100 m from (behind) the traditional winter range (cliff 1, Figure 1) and was not visible to the goats. Noise abatement from drilling activities included use of a diesel-electric generator and the piling of clearing slash along the southern perimeter of the well site. Noise levels of the operating rig at the well site averaged about 69 dBA. The highest noise levels (79 to 92 dBA) were from the warning horn and drum brake (i.e. a friction brake that controls the pipe-string and emits a high frequency noise). Drilling rig noises attenuated rapidly within the first 500 m of forest cover and then more slowly with increasing distances up to 2000 m. On goat winter range, noise levels were near ambient sound pressure levels in the A scale, but intermittently audible to the observer as distinct sounds. Under conditions of better sound transmission, drilling rig noise was perceptible to the observer at central and southern cliff complexes (6100 m and 8600 m, respectively). These noise levels were within the range of introduced noise disturbance that goats tolerated or became habituated to in previous investigations.

Eleven goats were monitored (Table 1). The nursery group of goats did not move to the traditional winter range, but remained in the central and southern part of their range and moved frequently between cliff units

Table 6. Frequency of behavioral responses R3-or-greater to sequential gun shots during habituation of mountain goats to seismic activities at Pinto Creek, Alberta.

Series (N)[a]	S[b]	Habituation session			
		1	2	3	Mean[c]
First (75)	1	71	50	48	56
	2	71	22	16	36
	3	67	10	16	30
Second (37)	1	45	23	0	30
	2	25	45	0	24
	3	15	25	0	14
Third (37)	1	32	11	50	22
	2	32	11	0	19
	3	25	0	0	11
Fourth (28)	1	13	33	0	18
	2	0	25	0	11
	3	0	17	0	7
All series (177)	1	47	34	28	38
	2	40	22	8	26
	3	34	10	8	19

[a] N: sample size of goats observed during gun shot sequences; responses from the days of each stimulation session are combined.

[b] S: sequence of gun shots in each series.

[c] Weighted means are total responses divided by all possible responses for the period represented.

during winter. Observations of the nursery herd provided few indications that these goats perceived the noise from the drilling program. Observations of the goat herd's behavior in December were interpreted as a possible attempt to move from the central cliffs to the winter range. The goats engaged in several excursions to the northern limits of the cliff complex but returned as a cohesive group to the security of the main cliff unit. The goats did not exhibit notable overt behavioral responses to indicate concern or alarm. Several nannies exhibited curious responses (R3), with directional alertness to the drilling noises. Although there was no behavioral evidence to indicate that noise disturbance was a factor, the failure of the nursery herd to move to the traditional winter range coincided with the occurrence of the drilling program.

In contrast to the nursery herd, both adult males utilized the winter range during the drilling program. One adult male, first located on the winter range in October, was alert (R3) to low intensity drilling noise, but did not exhibit concerned responses. This animal soon travelled to the southern cliff units where he tended 2 nannies for the duration of the rut. The other billy moved to the winter range following the rut and remained there for four months in the presence of noise from the drilling program. This billy appeared to be constantly aware of, and alert to, the variations in sound stimuli from the drilling rig (primarily R3 responses). The goat's responses were interpreted as investigative behavior to sudden or novel sounds and a tolerance of the persistent noise stimuli.

The winter drilling program did not appear to have an impact on the health and survival of the goat herd. The 11 goats were still present in March. The birth of 3 kids in May and the expectation of another kid from a pregnant nanny indicated that the unusual winter distribution did not have significant adverse effects on the nutritional status and health of the adult females, as evidenced by reproductive success. It may have been fortuitous that this winter was relatively mild and had low snow accumulations. These conditions facilitated goat movements between cliff units and made forage readily available during much of the winter.

Wildlife managers believe mountain goats are particularly vulnerable to disturbance (or harassment as defined by Geist 1978) and that this high sensitivity should be reflected in management strategies when goat populations are subjected to industrial activities (Pendergast and Bindernagel 1977, Smith 1982, Joslin 1986). Joslin (1986) reported that seismic activities for energy exploration did not result in abandonment of home ranges by mountain goats in Montana, but did coincide with a decline in adult female numbers, kid numbers and productivity in one population segment. Joslin (1986) suggested that stress induced by the seismic activities was cumulative over several years, resulting in reduced mountain goat productivity.

Geist (1978) noted that, in contrast to bighorn sheep (Ovis canadensis) which are easily habituated to humans provided there is no hunting, mountain goats tend to remain flighty and are far less readily approached. Singer (1975) examined the influence of a highway, passing traffic and visitors on mountain goat movements and use of a mineral lick. While he demonstrated a negative association of highway crossings by goats

with vehicle passage and visitor presence he also showed goats at the lick became habituated to sounds of visitors on the exhibit and passing trains across the river, but continued to perceive the sounds and presence of passing vehicles as a hazard. Foster and Rahs (1980) found that goats in the Stikine Canyon, that were subject to drilling disturbances in full view of normally used cliffs, shifted their distribution one to three kilometers for the duration of the drilling program and returned to their normal distribution soon after rig removal. McFetridge (1977) suggested that the absolute amount of forage available to any herd of mountain goats is a function of the distance that they will travel from core area of high security and that the total area used by goats or the frequency of excursions might be reduced by disturbance.

Large mammals can habituate to potentially adverse stimuli (Kelsall 1968, Geist 1971, Erickson 1972, Bergerud 1974, MacArthur et al. 1982). Big game animals can become conditioned to, and tolerate or accept, noisy highways and airports, crowds of tourists, and the presence of loud, dusty and smelly industrial activities, all of which tend to be localized and therefore highly predictable (Geist 1978).

From the Pinto Creek investigations, we concluded that goats are adaptable and can habituate to potentially adverse stimuli if they are gradually acclimatized and negative associations are avoided. The conditioning of mountain goats to potentially disturbing stimuli prior to the initiation of development activities is a positive mitigation measure that can reduce potentially adverse impacts. This approach may also be applicable for other big game species in situations where industrial activity impinges on critical habitat.

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