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BACKCOUNTRY RECREATION AND MOUNTAIN GOATS: A PROPOSED RESEARCH AND ADAPTIVE MANAGEMENT PLAN

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EXECUTIVE SUMMARY

We present a proposed research and adaptive management plan to study the effects of heli-recreation activities on Mountain Goat populations in southeastern B.C. The plan is based on a review of scientific and wildlife management literature, a review of management guidelines in other jurisdictions, discussions with wildlife professionals, three visits to heli-recreation tenure areas (and discussions with staff), and a reconnaissance-level survey of Mountain Goats.

We found few studies that specifically examined the effects of disturbance on Mountain Goats, although many studies have examined the responses of other Caprinae. Drawing general conclusions about the expected responses of Mountain Goats to heli-recreation activities based on the available literature is difficult because of the variety of methodologies used to study disturbance effects, the large number of variables that influence responses, and variation in response among Caprinae species, populations, and individuals. In general, studies have concluded that Mountain Goats respond more strongly to disturbance than do other Caprinae, although no comparative studies have been done. Helicopters generate the disturbance of greatest concern, while fixed-wing aircraft generate less intense responses. Disturbances associated with foot traffic appear to be minimal and can be easily managed.

The issue of disturbance is complex, and we make several suggestions to help deal with this complexity. First, the research should focus on helicopter disturbance because, based on the literature, current guidelines regarding foot traffic appear adequate. Second, individual variation and multiple causation in short-term responses to disturbance should be accommodated in management by defining a "disturbance space", rather than by trying to define a single disturbance-response function. Decisions and guidelines should be based on the responses of the most sensitive animals (excluding outliers, as judged by the researcher). Third, the study design should focus on factors that are under the control of managers, and responses that are directly relevant to the intended outcome of revising management guidelines. Fourth, research should be stratified into phases that correspond to spatial and temporal scales of animal responses to disturbance.

We suggest that the research be conducted in at least four study areas: two paired tenure and non-tenure areas, that are as similar as possible except for the frequency of helicopter overflights. Responses can be measured at three distinct spatio-temporal scales: short term acute, medium-term chronic, and long-term demographic. Immediate responses to helicopters can be quickly and economically assessed during aerial surveys. Collecting additional information on pre- and post-disturbance behaviour is logistically difficult and expensive. Medium-term chronic responses (e.g., range abandonment, movement differences) require studying radio-collared animals; however, results will probably be confounded by traumatic disturbances related to the capture and collaring of animals. Long-term demographic differences can be assessed by detailed annual surveys and analysis of age-class ratios. Much of the information required to refine management guidelines, and to address knowledge gaps identified in our literature review, can be collected during detailed aerial surveys.

Results of the research, and implications for management, should be reviewed annually and guidelines updated as required. Also, the opportunity should be taken to link B.C.'s efforts with federal legislation governing all aircraft activities in wildlife areas.

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1 INTRODUCTION

Heli-skiing and heli-hiking are increasingly popular recreation activities in the East Kootenay region, as elsewhere in the mountains of British Columbia. Increasing traffic in the backcountry has been accompanied by mounting concerns about the effects of these activities on wildlife populations in general, and on Mountain Goats (*Oreamnos americanus*) in particular.

The concern for Mountain Goats is based on anecdotal suggestions by some (*e.g.,* guide-outfitters, environmental groups) that Mountain Goats are in decline in the East Kootenay. It is also based on preliminary survey data that suggests that Mountain Goats might be less abundant in some heli-recreation tenures than in similar areas outside tenures (B.C. Ministry of Environment, Lands and Parks, unpubl. data). In addition, there is a general consensus in the literature that Mountain Goats are particularly susceptible to human-caused disturbance (see next section).

The heli-recreation industry and its allies have responded with anecdotal evidence that Mountain Goats within tenure areas appear to be habituated, and that there has been no obvious decline in populations in areas where they have been operating for many years. They also point to the general lack of rigorous scientific studies to support the contention that commercial recreation activities, as they are currently occurring, have significant impacts on Mountain Goats.

In response to the controversy, the B.C. Ministry of Environment, Lands and Parks (MELP), B.C. Assets and Lands (BCAL), B.C. Ministry of Small Business, Tourism and Culture, and Canadian Mountain Holidays (CMH) established an interagency committee to direct research on Mountain Goat-helicopter interactions that would eventually lead to management guidelines for heli-recreation tenures. The committee approached us to propose a research and adaptive management plan to study the effects of heli-hiking activities on Mountain Goat populations in the East Kootenay region and to refine existing management guidelines. This report presents our proposed plan.

The plan is based on a review of scientific and wildlife management literature, a review of relevant wildlife management guidelines and legislation from western North American jurisdictions, and extensive discussions with wildlife professionals and commercial recreation staff. In addition, we made three field visits to CMH's Bobbie Burns and Bugaboos operating areas: in the ski season to observe winter operations; in the early summer to participate in guide training and to familiarize ourselves with CMH's hiking operations, and in late summer to conduct reconnaissance-level surveys of CMH's Bobbie Burns and Bugaboos tenures and surrounding areas (Appendix A).

The report is organized into several sections. First, we review the relevant scientific and management literature (effects of human-caused disturbance on wild Caprinae), then present management guidelines from other jurisdictions. Next we develop a problem analysis that synthesizes current knowledge, identifies knowledge gaps, and defines the management problem. We then present the proposed research plan, organized into three distinct phases. A brief section follows to place the plan in the context of adaptive management. Our concluding section offers suggestions on establishing research priorities, how the research should be organized and financed, and by whom it should be conducted. The appendices provide data collected on our reconnaissance survey and precautionary notes on statistical power.

2 LITERATURE REVIEW OF DISTURBANCE EFFECTS ON WILD CAPRINAE

Following is a review of literature on disturbance within wild Caprinae. We have not included studies of domestic animals, or of the effects of roads and vehicle traffic, because they are not directly relevant to heli-recreation. The literature is summarized in two sections: acute responses – studies that examined the short-term responses of animals to disturbance stimuli; and habituation – studies that addressed the attenuation of responses with repeated stimuli. We categorized the literature cited into lists of peer-reviewed and peer-edited papers, and included a section of relevant papers not cited in the text.

This is not the first such review. For related bibliographies and reviews, see Shank (1979a), Lindsey (1987 and reviews cited therein), Frid (1996), U.S. National Parks Service (1994), U.S. Department of Agriculture, Forest Service (1995, 1997), and Tera Environmental Consultants Ltd. (1998). All cover much of the same literature but differ slightly in their focus and scope (species described, specific geographic concerns). Of them, Frid's (1996) is the most relevant to the problem discussed here. We have focussed our discussion on topics directly related to the heli-recreation issue.

2.1 Acute Responses

2.1.1 Helicopter disturbance

During 32% of observations (n = 74) of helicopter disturbance events at Caw Ridge, Alberta, Côté (1996) recorded Mountain Goats walking or running >100 m, or being vigilant for >10 minutes post-overflight. Of the remaining observations, 42% of goats were lightly disturbed (moved <10 m or vigilant for <2 min) and 26% were moderately disturbed (moved 10-100 m or vigilant >2 and <10 min). Distance between animals and helicopters was the most important factor affecting goat responses; the behaviours noted above were observed 85% of the time when helicopters approached <500 m. Other variables (height above ground, group size and composition, pre-disturbance behaviour) had no additive effect on reactions. Disturbance also caused the disintegration of social groups during 7% of overflights.

Foster and Rahs (1983) reported that Mountain Goats in the Stikine region of BC responded to aircraft and ground disturbance during >80% of events (n = 667) and recorded a "severe flight response" during 33% of observations. Fifty-five percent of severe flight responses were observed when disturbances occurred at distances <100 m. Response behaviour was correlated with distance to disturbance and the distance at which the disturbance was visible, as well as to available security cover, but was not dependent on time of year, group size, or vertical orientation of disturbance (*i.e.,* approach from above or below). Severe responses were less common when goats were located in rocky terrain than in densely vegetated habitat. Foster and Rahs (1983) also detected temporary range abandonment as a result of disturbance.

Poole and Heard (1998) observed that Mountain Goats (n = 2) monitored for 24 and 49 days with GPS collars in the Robson Valley of BC moved 70% further in the 24 hours after being surveyed by fixed-wing aircraft, than during the 24 hours before surveys.

Frid (1998, 1999b, 1999c) found that the intensity of response to helicopters by Dall's sheep (*Ovis dalli dalli*) near escape terrain was negatively correlated with approach distance (<3 km) and positively correlated with group size (large groups always had a high escape probability, while small groups were more likely to flee on close helicopter approaches) and the proportion of lambs in a group (n = 42). When sheep were at some distance from escape terrain, there was a high probability of them fleeing. Most sheep became vigilant or walked during approaches, a smaller proportion fled, and activity (*e.g.,* proportion bedded) returned to pre-disturbance levels after 21–45 minutes (Frid 1995, 1999c). The potential costs of disruption of energy assimilation activities appeared to be the principal concern with disturbance-related behaviour changes.

Horejsi (1976) said that Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) in Alberta reacted "explosively" to the sight and sound of a helicopter, often fleeing when the helicopter was 1.6 km away. In contrast, Stockwell *et al.* (1991) found that Desert bighorn sheep (*O. c. nelsoni*) subjected to intense disturbance (15000–42000 flights per year) in Grand Canyon National Park became more vigilant but did not flee when helicopters approached within 250 m. However, the escape options of the sheep were not described in this paper. Frid (1996) considered the situation studied by Stockwell *et al.* (1991) to represent an extreme case because of the exceptional frequency of close helicopter approaches. Although sheep in the study by Stockwell *et al.* (1991) did not flee, their foraging activities decreased when helicopters were nearby (43% reduction in spring). Differences in fleeing behaviour observed by Horejsi (1976) and by Stockwell *et al.* (1991) might have been related to the ruggedness of their respective study areas. Horejsi (1976) observed sheep fleeing towards escape terrain, while sheep in the Grand Canyon were observed in escape terrain.

Bleich *et al.* (1990, 1994) studied movements and habitat changes by bighorn sheep in California as a result of intense helicopter disturbance (100 m altitude) and found that sheep responded "dramatically" to helicopter surveys. Although their sample sizes were small, Bleich *et al.* (1990) also found that sheep in escape terrain responded no less strongly than did sheep in less precipitous terrain.

MacArthur *et al.*(1982) reported that helicopter and fixed-wing aircraft overflights at >400 m did not produce heart rate responses in Rocky Mountain bighorn sheep at Sheep River Sanctuary, Alberta. However, helicopters flying 90–250 m above ground did result in fleeing behaviour and elevated heart rates that lasted for 20–65 seconds. In a different study area in Alberta (Ram Mountain), Stemp (1983) found that both behavioural and cardiac responses of sheep to helicopters were markedly greater than those reported by MacArthur *et al.* (1982). Overflights at 400 m above ground at Ram Mountain, resulted in elevated heart rates lasting for up to one hour post disturbance. Both

MacArthur *et al.* (1982) and Stemp (1983) noted the poor correlation between cardiac and observable behavioural responses. Significant cardiac responses persisted even when sheep appeared to exhibit behaviour consistent with habituation, and there was a strong positive relationship between responses to disturbance and the distance sheep were from escape cover (Stemp 1983).

Scotton and Pletscher (1998) studied bighorn ewe-lamb disruptions during capture operations and found that larger, turbine-powered helicopters (Hughes 500) caused ewes to move farther from lambs than did smaller, piston-powered helicopters (Robinson R-22). However, their results were confounded by capture duration: captures that used the Hughes 500 took longer than captures that used the smaller, more manoeuvrable Robinson R-22. Price and Lent (1971) provided anecdotal evidence that Dall's sheep were disturbed more by helicopters than by fixed wing aircraft. They attributed the differences to the fact that fixed-wing aircraft are generally quieter and fly at higher altitudes and at higher speeds than helicopters.

2.1.2 Fixed-wing aircraft disturbance

Krausman and Hervert (1983) considered the effects of light, fixed-wing aircraft disturbance on Desert bighorn sheep in Arizona and found little effect when overflights were >100 m above ground. All flights <50 m above ground resulted in long movements and interruptions in activity. Only minor behavioural and heart rate responses were observed among bighorn sheep exposed to low-flying military jet aircraft (Krausman *et al.* 1998) and to simulated jet aircraft noise (Weisenberger *et al.* 1996).

2.1.3 Foot traffic disturbance

Foot traffic at distances of 25–50 m resulted in short-term (several minutes) heart rate increases among Rocky Mountain bighorn sheep in Alberta (MacArthur *et al.* 1982). Responses were stronger when hikers approached with dogs. Hicks and Elder (1979) studied interactions between humans and California bighorn sheep (*O. c. californiana*) interactions anecdotally in the Sierra Nevada Mountains. They found that the reactions of sheep to humans were related to distance to humans and to group size and composition. Tracy (1977) reported than Dall's sheep in Alaska could be approached by people on foot to within 100 m without causing overt behavioural responses.

Pyrenean chamois (*Rupicapra pyrenaica pyrenaica*) avoided areas <100 m from an established trail in a protected area in France (Pépin *et al.* 1996). People leaving established trails and walking straight towards Abruzzo chamois (*R. p. ornata*) caused the majority of human-caused disturbances (Cederna and Lovari 1985). Similarly, Alpine chamois (*Rupicapra rupicapra rupicapra*) were alert to foot and bicycle traffic at 62–331 m and fled when humans approached to 43–250 m (Gander and Ingold 1997).

2.2 Habituation

Penner (1988) experimentally habituated a small population of Mountain Goats to noises and human presence associated with oil and gas development. Although goats exhibited habituation to a consistent, predictable noise that was introduced gradually, they continued to be disturbed by "initial, novel, or sudden noise and visual stimuli" (Penner 1988:147). The strongest responses were elicited by helicopters.

Bleich et al. (1994) found no evidence of habituation among the sheep of their study population. Results from the study by Stockwell *et al.* (1991) suggest that long-term habituation might occur, because responses appeared to be less severe than those reported elsewhere and because there was no indication that the helicopter activity was a recent phenomenon.

The disturbance history of Côté's (1996) study population was not outlined in his paper; however, KcKechnie and Gladwin (1995) provide reports of frequent overflights by helicopters in the area and considerable anecdotal evidence of disturbance over the previous six years of the study. In addition, there has been undocumented (at least in the scientific and management literature) helicopter activity in the Caw Ridge area related to oil and gas exploration since the 1960s, and annual aerial surveys since 1973 (M. Festa-Bianchet, *pers. comm.*). Although KcKechnie and Gladwin (1995) reported that Mountain Goats in the Banff/Wind Valley region appeared to have habituated to helicopter activities, they provided no supporting evidence, basing their statement only on reports from Alpine Helicopters staff.

Both Frid (1999b, 1999d) and Côté (1996) studied medium-term responses, and neither found any habituation in the response to helicopters by Dall's sheep or Mountain Goats, respectively, over the seasons of their studies. Regarding short-term habituation, Frid (1999a) found that escape behaviour of Dall's sheep did not differ between the first and second flights of the day, whereas, Côté (1996) could detect no difference in responses by goats between the first and subsequent flights within the same day. Frid (1999a) suggested that responses declined but did not disappear during additional exposure to helicopters; however, his data were inadequate to test the relationship statistically. Following the first flight of the day, animals might alter their behaviour or location, such that their subsequent responses are affected. For example, they might move closer to escape terrain where they feel more secure (Frid 1999a). However, food is often less available in such habitat (Shank 1979b, 1982; Festa-Bianchet 1988).

Foster and Rahs' (1983) observations suggested that Mountain Goats did not habituate to disturbances but became sensitized; that is, disturbance effects were additive. They found that goats in an area disturbed by hydroelectric exploration activity reacted strongly to even natural, non-threatening stimuli such as thunder; although they did not make pre-disturbance observations for comparison. Stemp (1983) also found that bighorn sheep became sensitized to disturbance, with the mildest reaction occurring during the first overflight of the day. In contrast, Mexican bighorn sheep (*O. c. mexicana*) quickly habituated to simulated jet aircraft noise, although even naïve animals displayed only minor and short-term cardiac responses (Weisenberger *et al.* 1996).

Horejsi (1976) argued that animals subjected to stimuli from which they cannot escape quickly learn to control their motor reactions, although any number of chronic conditions can result. Therefore, the absence of an overt reaction does not necessarily mean that animals are not experiencing long-term consequences from disturbance events. The studies cited by Horejsi (1976) involved domestic sheep and goats that were subjected to painful stimuli in confined conditions. The applicability of these results to disturbance scenarios is uncertain.

With respect to human foot traffic, all research to date attributed the minor responses observed to long disturbance histories and resulting habituation (Tracy 1977, Hicks and Elder 1979, MacArthur *et al.* 1982). While Gander and Ingold (1997) provided no data, they did suggest that Alpine chamois were habituating to the presence of foot and bicycle traffic, but the animals had also abandoned habitat near trails. None of the researchers speculated on the reactions of naïve animals to this type of disturbance.

2.3 Conclusions

There is a general consensus in the literature, supported by data, that Mountain Goats are more sensitive to disturbance than are mountain sheep, and that helicopter traffic is more disruptive than fixed-wing overflights. Disturbances due to human foot traffic appear generally minor (but in some species it might also depend on whether a population is hunted or not; D. Shackleton, *pers. obs.*) and should be easily managed in situations where people are guided and/or keep to established trails. In the context of a heli-hiking operation, it is the transportation of hikers by helicopters that is the main concern, rather than the hiking activity itself.

Of the available literature, Côté's (1996) and Foster and Rahs's (1983) studies are clearly the most relevant to this project. They are the only studies that have examined the effect of helicopters on Mountain Goats, and both were published in peer-reviewed journals. However, the studies were purely observational (no manipulation of disturbance events), and the disturbance histories of the animals were unknown or not described. Both studies independently suggested a 2-km buffer around Mountain Goats to completely avoid harassment. The 2 km recommendation was not based on an obvious threshold in observed behaviour, but rather was based on both empirical observations and expert opinion. Poole and Heard's (1998) study provided evidence that Mountain Goats increased movements in response to fixed-wing overflights, although their sample size was small and they were working with individuals that had been captured by helicopter. Other pertinent studies include Frid's work on Dall's sheep, although it is not yet published and did not examine Mountain Goats. Also, Bleich's *et al.* (1990, 1994) studies were well designed and peer reviewed.

Scotton and Pletscher (1998) provide some evidence that helicopter size influences disturbance of Dall's sheep. Most other studies used only one type of helicopter, and most often it was a Bell 206 or a similar model (such small aircraft are not typically used by heli-recreation operators except in the case of sight-seeing). Also, flight speed, duration of exposure, noise level, and time of year are other probable contributory factors that have been examined only rarely or anecdotally.

Few studies made explicit reference to the long-term (*i.e.,* several years) disturbance history of their study populations. Stockwell *et al.* (1991) did not describe the history of helicopter traffic in their study area, while Foster and Rahs (1983) characterized their study population as "relatively inaccessible and unhunted." Consequently, few conclusions can be drawn from the literature regarding long-term habituation, and we cannot assume that researchers who measured strong disturbance reactions were necessarily studying naïve populations. Most references to habituation in the literature refer to human foot traffic.

No studies have linked disturbance events to long-term demographic consequences. This is not because studies have failed to find significant effects, but rather because it has not yet been studied in free-ranging Caprinae subjected to human-caused disturbances. There is literature (not reviewed here) to suggest that behavioural disruption in response to disturbing stimuli can indirectly affect mortality and natality (*e.g.*, see references in Horejsi 1976). However, we do not know whether the disturbance reactions observed by researchers, or other reactions that are undetectable, are severe enough to disrupt foraging, social organization, or other life-history activities to a point that threatens the long-term viability of populations (Shank 1979a). Again, the uncertainty is due to a lack of studies.

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3 REVIEW OF REGULATIONS GOVERNING HELICOPTERS, OVERFLIGHTS AND WILDLIFE IN WESTERN NORTH AMERICA

This section reviews current operating guidelines in jurisdictions other than BC. We contacted representatives of 13 western jurisdictions and three US Federal agencies by e-mail, by phone, or in face-to-face meetings. Of these 16 organisations, only four currently have regulations or guidelines specifying minimum distances that aircraft must keep away from wildlife (Table 1). Most others have regulations governing the use of aircraft for hunting (*e.g.,* Colorado, see right).

The limited number of regulations might reflect a combination of two factors: history and information. Commercial backcountry recreation activities in BC that rely on helicopters began only about 30 years ago with small aircraft in restricted areas. Helicopter activity grew quickly in intensity (as more and larger helicopters were acquired in response to demand) and spatial extent (with expanding operations and new companies). Significant operations are currently restricted to only a few jurisdictions in North America (Alaska, Alberta, British Columbia). Aircraft have been heavily used for many years for surveys (*e.g.,* oil and gas industry), especially in the north (*e.g.,* NWT, Yukon). The second factor is probably the scarcity of information and the lack of relevant studies on potential long-term effects of such activities on wildlife (see Literature Review).

While recreational activities involving helicopters are relatively new, they are increasing rapidly in some areas (see following), and agencies responsible for wildlife management are voicing concerns about

Table 1. Regulations on use of aircraft, including the minimum distances aircraft are required to keep from wildlife according to state, provincial, and federal authorities in western North America.

Jurisdiction	Minimum distance (m)	Other regulations
Alaska	(450)[a]	No fly zone
Alberta	2000[b]	(2000)[c]
California	–	H[d]
Colorado	–	H
Idaho	–	H
Montana	–	H
New Mexico	–	H
Northwest Territories	300	–
Utah	–	H
Washington	–	H
Wyoming	–	H
Yukon	1500	No fly zones
Federal Aviation Authority	610	
U.S. Forest Service	450	

a – U.S. Forest Service regulation for helicopter flight-seeing in southeastern Alaska, involving landing on glaciers.

b – Applies to specific areas of western Alberta.

c – Proposed distance for mountain goats (and bighorn in Alberta).

d – Regulations on use of aircraft for hunting (H = hunting restrictions)

potential impacts and the concomitant need for operating rules. The calls for regulations and enforcement are due to the high mobility of helicopters, their ability to fly or hover close to wildlife, and the noise they produce, all of which are believed by some to create significant disturbance to wildlife. However, such wildlife concerns are not restricted to helicopters; the same are being expressed about snowmobiles (e.g. in high-elevation mountain caribou winter ranges in British Columbia, and in the Northwest Territories for Dall's sheep).

3.1 Summary of Operating Regulations/Guidelines and Activities

3.1.1 Alaska

In Alaska, cruise ships are creating a rapidly increasing demand for sightseeing ("flight-seeing"), and there is also some spring heli-skiing developing. In 1999, 42,000 flights in a 150-day season were reported from ports in southeast Alaska. Most flights were flight-seeing and glacier landings from cruise ships (J. Denton, Bureau of Land Management, *pers. comm.*). Heli-recreation operators working in this state advertise wildlife viewing opportunities on their flights.

Currently in Alaska, there is very little access control on state and federal lands, and helicopters are landing immediately below known kidding cliffs. The state has established a "no-fly" zone where traffic is especially high. In a comparison of control (no helicopters) and test (with helicopters) areas, a significant decrease in kid production was found in the test area, following a severe winter (J. Denton, *op. cit.*). A similar decline has been reported for caribou calf production in Labrador in response to military aircraft (Harrington and Veitch 1992).

There are no state regulations setting overflight restrictions. The only applicable state law regarding aircraft relates to "taking" game without a permit. "Taking" is defined to include "pursuing or attempting to pursue or in any manner disturbing...," but successful prosecution of a helicopter company/operator has been problematic (P. Bente and P. Koehl, Alaska Fish and Game, *pers. comm.*). Other overflight restrictions are considered a Federal Aviation Authority (FAA) matter. However, for permitted helicopter activities, there is a 450 m (1500 ft) above ground level (agl) flight restriction imposed by the U.S. Forest Service. In southeast Alaska, this applies to helicopter flight-seeing excursions that land on the glacier, and are thus required to have a Forest Service permit.

The Alaska Game Department does impose altitude restrictions on aircraft involved in activities permitted by the department (*e.g.,* scientific research, aerial censuses). These restrictions vary depending on the program, type of aircraft, wildlife species, duration of activity, and observed response of an animal (P. Koehl, *op. cit.*).

3.1.2 Alberta

Heli-tourism has been developing rapidly in the last 12 years and is currently focussed around Canmore, adjacent to Banff National Park. In 1999, there were 6000 flights between May and September, mostly for sight-seeing, but heli-hiking is becoming more popular (J. Jorgenson, Alberta Natural Resources, *pers. comm.*). Operators have voluntary minimum distance guidelines of 2000 m for goats and 1300 m for bighorn sheep, around identified ranges. Mountain goat populations have declined in affected areas, but cause and effect has not been established (J. Jorgenson, *op. cit.*).

As a result of observations on Caw Ridge, Alberta (Côté 1996), conditions for aerial operations over bighorn sheep and Mountain Goat habitat have changed (T. Sorensen, Alberta Natural Resources, *pers. comm.*). On the "Fisheries and Wildlife Land Use Referral Map for the Northern East Slopes Region" these areas are zoned as Class H along the Rocky Mountain East Slopes. The conditions applied to aerial operations in these zones are as follows:

1. No low level aerial operations to be conducted within 1.5 km of treeline. The 1700 m (5500 ft) contour can be used as a rough guide for planning.

2. Aircraft flying over sheep and goat habitat must be ≥300 m agl (above ground level).

Alberta Fish and Wildlife Service is also asking for a 2000 m buffer for "intensive" helicopter activity and to keep overflights to >400 m except in emergencies (K. Smith, Alberta Natural Resources, *pers. comm.*).

3.1.3 California

This state presently experiences little or no recreational activity involving helicopters (S. Torres, California Department of Fish and Game, *pers. comm.*). Regulations governing use of aircraft near wildlife pertain only to hunting. Hunters sometimes request permission to "survey" areas for bighorn sheep; such surveys would require flying under 60 m (200 ft). While California State law is not specific to this issue, the State (in both the Fish and Game Code, and the State law) does not allow harassment of wildlife, and an approach to within 60 m (200 ft) would constitute harassment (S. Torres, *op. cit.*).

3.1.4 Colorado

The only current law regulates the use of aircraft for hunting (B. Frano, Colorado Division of Wildlife, *pers. comm.*):
Title 33 – Colorado Revised Statutes – Wildlife Article 6 Section 33-6-124 (subsection 2) 33-6-124. Use of a motor vehicle or aircraft.

(1) Unless otherwise permitted by commission rule or regulation, it is unlawful for a person to hunt, take, or harass any wildlife from or with a motor vehicle.

(2) It is unlawful for any person airborne in an aircraft to spot or locate any wildlife and communicate the location thereof to any person on the ground as an aid to hunting or pursuing said wildlife; and it is unlawful for such airborne person or person on the ground receiving such communication to pursue, hunt, or take game on the same day or the day following such flight.

(3) Any person who violates this section is guilty of a misdemeanour and, upon conviction thereof, shall be punished by a fine of two hundred dollars and an assessment of fifteen license suspension points.

3.1.5 Idaho

There are no regulations (F. Cassirer, Idaho Department of Fish and Game, *pers. comm.*), except for those limiting the use of aircraft for hunting (see 3.1.4 Colorado).

3.1.6 Oregon

The 2000 Big Game Regulations (page 10), states under Vehicles, Boats, Aircrafts:
No person shall: (in regard to aircraft)

- Communicate information on the location of game mammals from an aircraft.
- Hunt within 8 hours after having been transported by helicopter or fixed-wing aircraft to any point other than an established airport adequate for fixed-wing aircraft.
- Shoot at pronghorn antelope from a point within 50 yards of a motor-propelled vehicle, including aircraft.

3.1.7 New Mexico

The department's regulations govern aircraft directly related to hunting. They are 19 NMAC 31.1.17, and the *Airborne Hunting Act* 17-3-43.

3.1.8 Northwest Territories

In the Northwest Territories, Dall's sheep are the biggest concern because Bell 206s and 212s are operating in the immediate vicinity of lambing cliffs. Snow machine disturbance of Dall's sheep in the Richardson mountains is also becoming an issue (A. Gunn, Government of the NWT, *pers. comm.*).

There are no current regulations in the Northwest Territories, although the Northwest Territories *Wildlife Act* permits no harassment of wildlife. In its 1984 Caribou Protection Measures (which apply only to Land Use Permits issued for the Qamanirjuaq and Beverly herd calving grounds in June and early July), the Department of Indian Affairs and Northern Development (DIAND) has restrictions on aircraft overflight altitudes. The minimum altitude is 300 m agl. When the Northwest Territories Department of Natural Resources reviews environmental assessment reports and land use permits, it recommends the 300 m minimum distance for Dall's sheep as well as for caribou, and 100 m for wildlife survey work.

3.1.9 Washington

It is not permitted to fly over and survey an area that you plan to hunt the same day (H. Calkins, Washington Department of Fish and Wildlife, *pers. comm.*).

3.1.10 Yukon

Lambing areas are closed to disturbance, and the Department of Renewable Resources has asked pilots to avoid approaching within 3.5 km of Dall's sheep herds. The department is also proposing a minimum distance of 1500 m, and contracted a consultant (A. Frid) to study the issue (see Literature Review; J. Carey, Yukon Department of Renewable Resources, *pers. comm.*).

3.1.11 U.S. Fish and Wildlife Service

The service does not issue regulations regarding aircraft overflights/ceilings – it considers this to be the purview of the FAA (K. Johnson, U.S. Fish and Wildlife Service, *pers. comm.*).

3.1.12 Federal Aviation Authority (USA)

Section 4 of the FAA's Aeronautical Information Manual (AIM) deals with "Bird Hazards and Flight Over National Refuges, Parks, and Forests," within which Section 7-4-6 addresses "Flights Over Charted U.S. Wildlife Refuges, Parks, and Forest Service Areas." Subsection b. states "Pilots are requested to maintain a minimum altitude of 2000 feet *[600 m]* above the surface of the following: National Parks, Monuments, Seashores, Lakeshores, Recreation Areas, and Scenic Riverways administered by the National Park Service, National Wildlife Refuges, Big Game Refuges, Game Ranges and Wildlife Ranges administered by the U.S. Fish and Wildlife Service, and Wilderness and Primitive areas administered by the U.S. Forest Service." Subsection c. states "Federal statutes prohibit certain types of flight activity and/or provide altitude restrictions over designated U.S. Wildlife Refuges, Parks, and Forest Service areas... These designated areas...are charted on Sectional Charts." This information is taken directly from the FAA's online Aeronautical Information Manual: http://www.faa.gov/atpubs/aim/Chap7/aim 0704.html

3.2 Conclusions

Not surprisingly, jurisdictions with little or no aircraft traffic in the immediate vicinity of wildlife have no approach regulations, other than those pertaining to hunting. Conversely, in those where aircraft traffic is frequent and increasing, recommendations or guidelines are either in place or being proposed. The range of minimum approach distances varies from 300 to 2000 m, with the greater distances almost always based on Côté's (1996) research, although the 2000 m distance was first suggested by Foster and Rahs (1983).

Despite the limited activity in the western states south of the 49th parallel, their wildlife managers are concerned because heli-recreation and/or other helicopter activity (e.g., surveying, mining, movies, research) are beginning to increase. As a result, the Northern Wild Sheep and Goat Council formed a working group at its May 2000 Symposium to assemble available literature and propose guidelines. Steve Wilson will be involved and will work with the group. This group should be encouraged to consider co-operative complementary research projects by different agencies that will maximize research returns across broad geographic areas and habitat types and thus increase confidence in, and the applicability of, research results.

We wish to stress that the potential impacts of helicopters on wildlife are not restricted to commercial recreation activities. The opportunity should be taken to link BC's efforts with federal legislation governing all aircraft activities in wildlife areas.

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Bureau of Land Management
U.S. Dep. Inter., Alaska

Phil Koehl
Alaska Fish and Game Dep.

Jon Jorgenson, Troy Sorensen and Kirby Smith
Alberta Nat. Resour. Serv.

Bob Forbes and Steve Gordon
B.C. Wildl. Branch

Mari Woods
Peace/Williston Fish and Wildl. Compensation Program

Steve Torres
California Fish and Game Dep.

Brad Frano
Colorado Divi. Wildl.

Frances Cassirer and Dale Toweil
Idaho Dep. Fish and Game

Dan Brooks
New Mexico State Fish and Game Dep.

Anne Gunn and Alistair Veitch
Resour., Wildl. and Econ. Dev.
Government of the NWT

Lori Hansen
Oregon Dep. Fish and Wildl.

Michelle Bourassa
Badlands National Park
South Dakota

Mike Ray and Jim Karpowitz
Utah Divi. Wildl. Resour.

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4 PROBLEM ANALYSIS AND SYNTHESIS

Previous research on Mountain Goats and other wild Caprinae has measured how behaviour is affected by human-caused disturbance. Four broad conclusions can be drawn from the literature. First, helicopters are the disturbance of greatest concern. Second, all studies examining acute responses (*i.e.,* immediate, obvious, but of short duration) to human-caused disturbance have reported behavioural disruption, although the intensity of responses has varied among studies. Third, few published studies of wild Caprinae have addressed chronic responses (*i.e.,* slow to develop and dissipate) to helicopter disturbance, such as temporary or permanent range abandonment. Fourth, no studies of wild Caprinae have attempted to document the long-term effects of behavioural disruption on demography. These conclusions provide foci for our research and adaptive management plan.

4.1 Short-term Acute Behaviour

Acute responses are obvious, immediate changes in behaviour that occur when Mountain Goats are disturbed. These can include: increased vigilance, fleeing, group dissolution and nanny-kid separations (temporary or permanent), and injury. There is enough variation reported anecdotally and in helicopter disturbance studies of Caprinae to lend support for calls for both minimal setback distances and more conservative guidelines. This is because the responses of Mountain Goats and mountain sheep to disturbance are variable and are related to a number of factors (*i.e.,* disturbance intensity and duration, terrain, disturbance history, group size, age/sex, reproductive status, wind direction, loudness, distance between animals and helicopter, distance to security cover, relative elevation, season, etc.). These factors vary among studies, as do methods to account or to control for them. In addition, variation in observed behaviour suggests that the importance of these factors (and how they interact) varies among species and among populations within species. In fact, there can be considerable variation among individuals in a group. As a result, the ability of any single disturbance-behaviour function to define and/or to predict the behaviour of Mountain Goats subjected to helicopter disturbance is limited. This limitation is not due to lack of research or observations, but is due to the complex interaction of factors that influence the behavioural decisions of individual animals.

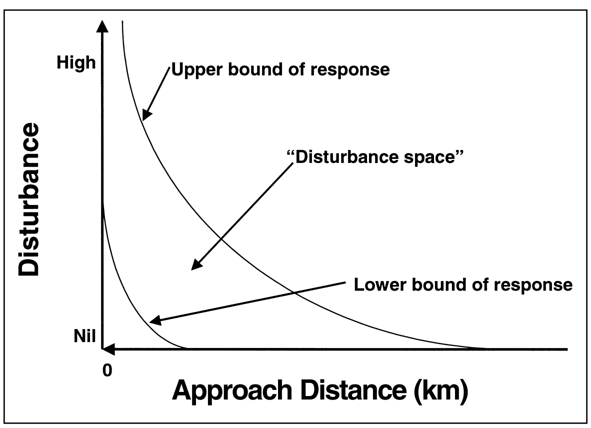

Figure 1. Theoretical relationship between the distance from a disturbance and the behavioural reaction of animals.

Individual behaviour is variable, is influenced by many factors, and ultimately is very difficult to predict; however, individual disturbance-behaviour fuctions will all fall within a more easily defined disturbance space. The upper and lower functions represent the responses of the most and least sensitive animals, respectively.

One way to conceptualize the problem is to consider a "disturbance space" (Figure 1), where animal behaviour in relation to disturbance is bounded by upper and lower functions representing the behaviours of the most and least sensitive animals, respectively. The functions can also represent percentiles of responses (*e.g.,* 5% and 95%) to exclude outliers. For clarity, the independent variable in Figure 1 is approach distance, although the stressor is better represented by a multivariate vector that includes several variables (speed, noise, angles of approach, etc.). Individual animals have unique disturbance-behaviour functions within this space, but neither the exact shapes of the functions, nor their distribution, can be accurately predicted.

The disturbance space defines the management problem and focuses attention on the expected range of animal behaviours, rather than on the multiple factors that result in variable behaviour among individuals.

Identifying important factors that influence the behavioural decisions of Mountain Goats faced with human-caused disturbances is certainly of biological interest and should be part of any research program; however, the central problem remains that individual animal behaviour is difficult to predict and is likely influenced by many factors. Therefore, broad management guidelines need to be based on the range of behaviours that can be expected under different disturbance scenarios (Figure 2). Management guidelines should be precautionary; therefore, guidelines should be based generally on the most sensitive animals in a population (excluding outliers). This ensures that managers can be confident that the behavioural responses of goats, under most disturbance scenarios, will be less severe than responses that are judged unacceptable. The priority in research aimed at defining management guidelines should be in defining the disturbance space, rather than in attempting to understand the multiple factors that influence behaviour. Clearly, most of the factors will not be under the control of management and, therefore, cannot be considered in management guidelines.

4.2 Medium-term Chronic Behaviour

The medium-term, chronic reaction of Mountain Goats to helicopters has not been rigorously studied. Regardless of their short-term behavioural responses, goats might alter their behaviour over the medium term (days-months) to minimize the probability of future disturbance. In addition, there is the possibility that rare but severe responses of goats to infrequent flybys might be less important than less severe but more frequent responses. These effects might manifest themselves in chronic changes in behaviour. The most obvious change would be to abandon previously used range for areas that are less subject to disturbance. Because goats will normally occupy preferred areas, when disturbed they might move to sub-optimal habitats where, most likely, forage is less available and security cover is of lower value. This can have significant consequences at critical times of the year (*e.g.,* spring and summer). Such habitat shifts might not be obvious in studies of acute, short-term behaviour.

4.3 Long-term Demographic Consequences

Arguably the most important aspect of the Mountain Goat disturbance issue is whether the behavioural disruptions that occur as a result of human-caused disturbances have long-term consequences for the viability of populations (Shank 1979). Effects at this spatio-temporal scale are not independent of some medium-term effects. For example, range abandonment can have long-term demographic consequences. Most researchers assume that disturbances result in demographic consequences (*e.g.,* Côté 1996, Frid 1996), although the consequences have not been documented in studies of wild Caprinae. Detecting demographic change and relating it to behavioural disruption is difficult because of the time lags involved, and because there are many possible confounding factors that are difficult to measure and control experimentally (*e.g.,* severe weather, disease, predation, hunting vulnerability, etc.). Designing a manipulative study to establish cause and effect is equally difficult because of the ecology of Mountain Goats; they occur at low densities in very rugged and usually remote terrain. A manipulative approach also raises ethical issues about the appropriateness of deliberately harassing Mountain Goats to the point of demographic decline.

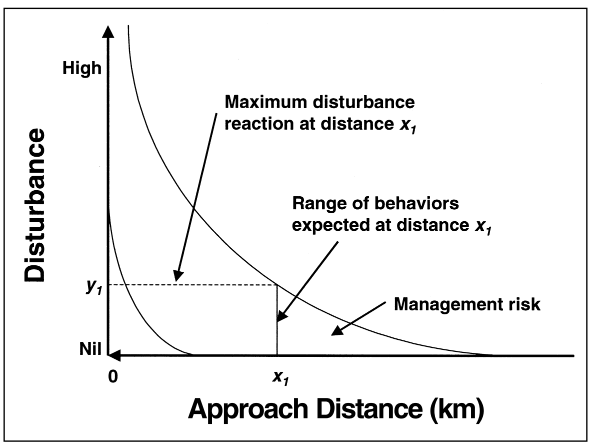

Figure 2. The disturbance space defines the range of expected behaviours at a given approach distance (*e.g.,* x_1).

The behaviour of individual animals is difficult to predict, but the bounds of their behaviour can be established by research and observations. In this example, an approach distance of x_1 predicts a precautionary upper limit in animal response of y_1. The area under the curve to the right of x_1 bounds the reactions of animals in the population expected at approach distances of x_1 and greater. The area represents the risk that managers accept by allowing approaches to x_1.

As a result, we are left with observational studies, measuring the characteristics of Mountain Goat populations in areas subjected to helicopter activity (treatments), and comparing them with characteristics of populations in similar areas with little or no helicopter activity (controls). If designed properly, this is a valid method to test for a link between helicopter disturbance and demographic consequences, although statistical power is low (Appendix B). For management purposes, the underlying assumption is that the long-term demographic differences between treatment and control areas are related to observed short- and/or medium-term differences in goat behaviour, and that managing populations to minimize these behavioural differences will minimize demographic differences.

In summary, the Mountain Goat disturbance issue can be considered at three spatio-temporal scales of interest: short-term acute behaviour, medium-term chronic behaviour, and long-term demographic consequences. Study at each of these scales provides separate lines of evidence for disturbance effects on Mountain Goats, although in the absence of manipulative studies, relationships between the scales can only be assumed.

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5 PROPOSED RESEARCH PROGRAM

This chapter presents our proposal for a research program to determine the effects of helicopter disturbance on Mountain Goats.

Our review of relevant literature and operating guidelines in other jurisdictions, and our analysis of the Mountain Goat-heli-recreation issue has led to three conclusions: 1) disturbances caused by heli-hiking operations are likely to be the result of helicopters rather than hiking, and the effects of helicopters, regardless of season, should be the focus of the research; 2) the proposed study should be organized according to three distinct spatio-temporal scales; and 3) research priorities should be assigned according to utility in generating management guidelines. Depending on time and funding limitations, an additional long-term study is also proposed.

5.1 Study Areas

All three phases of the proposed research project require a **minimum** of four separate study areas: two treatment (tenure) areas and two control (non-tenure) areas. Replicates of treatment and control areas are required to control for "area effects" in statistical tests. Activities related to tenure operations should be as similar as possible in the treatment areas. Otherwise, all study areas should be as similar as possible, differing only in frequency of helicopter traffic between treatment and control areas. Treatment areas should be similar not only in the frequency of helicopter traffic, but also in the nature of the traffic. That is, helicopter activity should be capable of generating similar disturbances in the different treatment areas. Unregulated helicopter traffic is a serious design concern and must be addressed before proceeding with the study. Some other factors to consider in choosing study areas are: biogeoclimatic zones, prevailing aspects, human activity (hunting, recreation, forestry), predator populations, elevational range, abundance of alpine meadow and escape cover, latitude, and geology.

An important consideration in selecting the study areas is that some activities not currently taking place might begin during the study. For example, wildlife viewing from helicopters is not subject to regulation by the Provincial Government. Therefore, study area selection must attempt to account for this uncontrolled variable by predicting where it will most likely occur. Also note that potential study areas should be assessed for future planned activities such as forestry and mining. Local staff of the B.C. Assets and Lands Corporation might be able to help in this regard.

Control and treatment areas should be paired within mountain ranges, but pairs could occur in different ranges (except for the Coast ranges where habitat use by Mountain Goats is very different than in the interior), leading to results with more general applicability. The size of study areas should be similar to the size of tenure areas: 800–1000 km^2. Goat populations (from total counts, not corrected for sightability) should be at least >50 for each study area, and ideally >100. Small populations result in greater year-to-year variation in important population indices and increase the effects of random sampling error, making differences between control and treatment areas more difficult to detect (Appendix B).

Clearly, there are no perfect study areas. Choosing treatment and control areas will require the researcher to weigh factors we have listed here against a number of practical constraints: historical land-use patterns, feasibility of conducting research, etc. The researcher will have to exercise his/her professional judgement, based on existing and preliminary data.

5.2 Short-term Acute Behaviour

Objective: to determine the short-term behavioural reactions of Mountain Goats to helicopter approaches

Secondary objective: to determine whether Mountain Goat reactions suggest habituation or sensitization to helicopter disturbance

The short-term behavioural response to disturbance is an important measure of impacts. Previous studies have shown that Mountain Goats do respond to helicopter approaches; however, sample sizes were small and observations were not independent. Also, the commercial recreation community contends that goats in tenure areas respond differently than those in other areas because they have become habituated to helicopters.

5.2.1 Methodology

Because goats in the northern Purcell Mountains occur at low densities and occupy very rugged and remote terrain, repeating Côté's (1996) methods is impractical. However, similar (although less complete) data can be collected during annual aerial surveys of goat populations (see methodology in third phase section). Doing so has the advantage of ensuring that observations are independent and sample sizes are limited only by the number of goats observed on flights. In addition, with the possible exception of intense observations (explained later in this section), helicopter activity associated with research activities will be restricted to a single flight in treatment and control areas, to reduce the risk of sensitization or habituation to research-related overflights.

The general protocol involves recording the following data when Mountain Goats are encountered on aerial surveys: closest approach distance (measured by rangefinder or GPS), altitude asl and altitude relative to goats (*i.e.,* approach from below or above), helicopter speed, group composition, responses of individuals (classified according to Côté's 1996 response categories), and location relative to two-three broad habitat features (*e.g.,* security cover, timber). All encounters should be recorded with a digital camcorder with sufficient optical zoom to resolve behavioural responses. To minimize variation among approaches, other variables should be controlled: helicopter type (as large as is affordable), approach angle, disturbance duration, and season.

Behavioural responses of goats to helicopters will be categorized; therefore, response data in statistical tests will be frequencies. Log-linear analysis is the most flexible statistical technique for analyzing frequencies. It is a model-fitting technique that tests for interactions between response frequencies and one or more factors. The number of factors that can be tested simultaneously is practically limited by the complexity of the candidate models. As in ANOVA, interpretation becomes difficult when ≥3 factors are included in models. As a result, to test for all of the factors listed above will require the partitioning of data into separate analyses based on logical groups: for example, testing the responses of animals near different habitat features in separate analyses. Decisions about partitioning data into separate analyses or pooling across other factors will have to be *post hoc* decisions based on sample sizes and the researcher's opinions, after flying surveys, about the importance of different factors.

The log-linear analysis accommodates individual variation in responses and multiple factors although, as discussed in a previous section, many of these factors are beyond the control of managers. Collectively, the observations define the "disturbance space" on which management guidelines should be based. The key relationship is that of the helicopter approach vector (*i.e.,* distance of closest approach, speed, angle in both the horizontal and vertical planes) and the aggregate responses of goats under all conditions (the "disturbance space"). Management guidelines should focus on the responses of the most sensitive animals observed.

The disadvantage of the methodology outlined above is that data regarding pre- and post-disturbance behaviours and response duration are not collected. These data are important because goats in different circumstances might have the same response intensities but different response durations. These two response components are equally important, but not equivalent; that is, there is no way to compare animals with low response intensities and long response durations with animals with high response intensities and short response durations. This complicates the drafting of management guidelines.

Collecting pre- and post-disturbance behaviour requires substantial resources and is logistically difficult. The following steps are required: 1) locating goats by helicopter (with extra time required in non-tenure areas) at distances that do not disturb goats (>2.5–3 km); 2) dropping off an observer at a "safe" (*i.e.,* non-disturbing, >2.5–3 km) distance; 3) hiking to a suitable observation point; 4) 30–60 minutes of pre-disturbance observations; 5) calling in the helicopter to approach the goats; 6) >1 hour of post-disturbance observations; 7) observer pick-up at a distance not causing disturbance. Ideally, intense observations would be conducted over a relatively short time span but over a large area to minimize the chance of exposing the same groups of goats to multiple fly-bys. Failing to do so would result in statistical pseudo replication and could result in either behavioural habituation or sensitization to the helicopter treatments.

Clearly, under even the most optimistic funding scenario, these intense observations would be limited in scope and the power of resulting statistical tests would be low. Therefore, variables that could be modelled in aerial survey observations would have to be controlled in the intense observations. Most likely, only one approach distance and one relative altitude could be tested, and though partially opportunistic, variation in group size and habitat would have to be minimized among observations. As a result, the intense observations would allow researchers to relate only a limited range of helicopter disturbance scenarios to the pre- and post-disturbance behaviour of Mountain Goats, unless additional funding were secured. The aerial survey component of the study would generate most of the data relating approach characteristics of helicopters to goat behaviour.

The target time period for the short-term behavioural study is two years.

5.3 Medium-term Chronic Behaviour

Objective: to determine whether disturbance history leads to changes in movement behaviour, or to temporary and/or permanent range abandonment

Helicopter disturbance can have impacts that are not apparent or are difficult to study in short-term behavioural studies. The most obvious effect reported in the literature is changes in range use by goats attempting to minimize future disturbance. These changes can take the form of increases in daily movement distances, and post-disturbance, seasonal, or permanent abandonment of range areas (Poole and Heard 1998).

Beyond changes in range use, there can be physiological changes in animals that indicate medium-term chronic behavioural changes. Unfortunately, available technology to monitor physiological indicators in free-ranging animals is very limited and generally impractical for Mountain Goats.

5.3.1 Methodology

Issues of range use and animal movements are best examined in the context of a traditional habitat-space use study using radio-collared animals. Because Mountain Goats occur at low densities in remote and rugged areas, GPS collars are the most efficient and cost-effective means to collect repeated point location data.

Collaring effort should be restricted to adult females in both tenure and control areas (see preceding section for discussion of control area selection), and at least five animals should be collared in each of the treatment and control areas. We suspect that there might be sex-specific differences in behavioural responses, but males should be collared only if resources allow larger sample sizes. GPS collars should be programmed to acquire locations at least twice a day (one daytime and one night time), or more often if on-board memory and battery capacity allows, or if data can be downloaded remotely. Collars should be retrieved annually, serviced, and reused. The target time period for the medium-term study is five years.

Animals can be collared safely and efficiently by net-gunning from helicopters; however, collared animals will probably alter their responses towards helicopters following capture. As a result, changes in movement or range characteristics of collared animals in tenured areas could be attributed to sensitization to helicopters as a result of capture. The only alternative to accepting this confounding effect is to investigate alternative collaring strategies that do not involve the use of helicopters (for other capture limitations, see also Côté *et al.* 1998). It might be possible to use clover traps set along trails to salt licks to capture goats without the use of either helicopters or tranquillisers (B.N. McLellan, Ministry of Forests, *pers. comm.*). Kid abandonment is a serious concern during any capture operation; therefore, spring and summer captures should be avoided (Côté *et al.* 1998).

In terms of data analysis, effort should be directed towards comparing range and movement characteristics between control and treatment areas. Where appropriate, the design should be an analysis of variance with replication. The sampling unit is each collared goat. This design can be used to test for differences in home range size, mean daily distances moved, and mean elevation. Because the latter two measures are second-order variables (means), parallel tests should be run based on measures of dispersion (*e.g.,* coefficient of variation) to test for differences in variability in movement characteristics between goats in treatment and control areas.

Data collected on goats within tenure areas can be examined more closely for differences between "flying" and "no flying" seasons; however, such comparisons will be confounded by seasonal changes in goat activity and range use. Therefore, results should be interpreted cautiously. "Flying" and "no flying" seasonal comparisons can also be made to detect short-term shifts in range use. Simple plots of sequential animal movements might be adequate to describe any shifts in range behaviour. The opportunity might also exist to investigate changes in habitat use. The details of this aspect of the project will need to be developed by the principal investigator and will depend on the nature of the study areas, the "undisturbed" behaviour of goats (*e.g.,* seasonal range movements), and the characteristics of helicopter activity. A pilot year of data collection might be required before the specific hypotheses, sampling, and statistical designs can be developed or refined.

Acquiring two locations per day with GPS collars will not be adequate to examine immediate post disturbance movement behaviour; however, we recommend that the researcher review results after two years and consider reprogramming GPS collars to increase the frequency of location fixes. This would present the opportunity to examine the effect of helicopter fly-bys on post-disturbance movements and range use by radio-collared goats. Increasing the frequency of radio fixes will affect battery life, and the merits of the trade-off will need to be considered carefully.

Because helicopters have affected the treatment areas for many years, there will be no opportunity to directly collect evidence for permanent range abandonment; however, differences in home range size and use of elevation strata might indicate long-term changes in use of habitats in treatments areas. Interpretation of these data must include a consideration of the scale-dependent nature of space use. Goats might continue to occupy range over broad areas (such as tenures), while abandoning smaller pockets of range that are subject to local disturbance phenomena.

5.4 Long-term Demographic Consequences

Objective: to determine whether there are differences in key population parameters between tenure and non-tenure areas

Ultimately, any study of disturbance effects on Mountain Goats must address the issue of demographic consequences. For management purposes, short- or medium-term responses are a concern only to the extent that they lead to changes in the ability of goat populations to sustain themselves in areas where they are actively disturbed.

5.4.1 Methodology

Population data are relatively easy to collect with annual aerial surveys. The key is to survey areas with an intensity that ensures that a high proportion of goats are seen. Sightability can be estimated from the proportion of collared goats seen on survey flights, and flight speeds and coverage strategies can be adjusted accordingly. Surveys should be flown in late summer for good weather and optimum visibility. The surveyors should be experienced in classified goats surveys and make single passes of all study areas at 2400 m (8000 feet) asl. The surveys should be separated temporally as much as possible from helicopter activity associated with other phases of the study. During surveys, the response of goats to the helicopter should be filmed using a digital video camera (Gordon and Reynolds, *in review*); at the same time the GPS location, altitude, and distance from the goats should be recorded for future analysis.

Table 2. Ratios derived from aerial data and corresponding population productivity indices.

Ratio	Productivity Index
Young-of-year: Adult	Fecundity
Yearlings: Adult	Recruitment
Young-of-year: Yearlings	Early survival

Goat populations are expected to differ between areas for a host of biological reasons unrelated to disturbance impacts caused by heli-recreation activities; therefore, absolute population estimates are poor measures of population productivity. Still, population estimates and, in particular, year-to-year population trends can provide useful information and should not be dismissed. Ideally, counts should be stratified into adult, yearlings, and young-of-year estimates, and analyses of different ratios between tenure and control areas should be used to compare measures of productivity (Table 2). Note that these ratios should be relatively independent of the effects of hunting if hunters select adult males and only occasionally females. These ratios can also be compared with results from other surveys and studies in British Columbia and other areas (*e.g.,* Caw Ridge, Alberta) to provide a more representative picture of Mountain Goat demographics.

Distinguishing yearling Mountain Goats from young-of-year can be difficult from the air, and resulting classified counts might be unreliable (Gonzalez-Voyer *et al.*, *in press*). This leaves two alternatives. First, supplement aerial surveys with ground-based observations to improve the reliability of classified counts. This requires additional helicopter time to drop off and pick up observers near occupied goat ranges (without additional disturbance to goats).

Alternatively, the researcher could abandon any attempts to distinguish among yearlings and young-of-year and simply collect adult and subadult data. Estimates of productivity would be restricted to a single subadult:adult ratio. Year-to-year population trends could still be estimated, as could gross population productivity; however, information about specific demographic sinks would be lost. For example, there would be no way to distinguish demographic declines due to poor young-of-year survival (perhaps due to nanny abandonment or predation) from declines due to poor yearling survival (perhaps due to poor overwinter survival for nutritional reasons).

Again, the choice between these alternatives depends on funding levels, sample sizes, and the feasibility of making ground observations in specific study areas.

Treatment and control areas should be compared with a repeated measures analysis of variance with replication. The ratios are binomially distributed; therefore, they should be arcsine transformed to normalize distributions before analysis. The repeated measure in the analysis is year. Because statistical power for this test will likely be low (see Appendix B) due to natural variation in goat numbers, the time horizon for monitoring long-term impacts will be five or more years.

5.5 Longer-term Manipulation

Recognizing that the original terms of reference limited the research phase to five years, it is nevertheless worthwhile to propose an additional experiment. This would involve selecting one or more study areas in which there is no current heli-recreational tenure, but in which commercial recreation activity is planned. Data collection would occur during a pre-tenure period of at least three years, followed by a period of at least five years during the operational phase of the tenure(s). This approach would allow impacts of the heli-recreation operation to be measured directly and provide additional confidence that observed differences are caused by helicopter activity. Such a project would obviously require full co-operation with the tenure holder and assurances that activities would be allowed to run for the full study period.

The data collected and analysis methods would be similar to those in both the short- and long-term phases described above.

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6 THE ADAPTIVE MANAGEMENT APPROACH

Adaptive management is a systematic process whereby management practices are periodically updated based on the outcomes of management prescriptions. Nyberg (1998) presented key characteristics, which are listed below in the context of the proposed research plan. Although we provide comments and suggestions, note that adaptive management is designed to be a collaborative process involving relevant stakeholders.

1. "Acknowledgement of uncertainty about what policy or practice is 'best' for the particular management issue"

Operational guidelines for backcountry operators in goat ranges were established with the knowledge that the disturbance literature was incomplete and that further research was required. This proposal represents an important step in the adaptive management process because it reviews the relevant research and identifies knowledge gaps.

2. "Thoughtful selection of the polices or practices to be applied"

Based on our literature and jurisdictional reviews, current operational guidelines are generally in line with current available information.

3. "Careful implementation of a plan of action designed to reveal the critical knowledge"

The proposed research plan is designed to address knowledge gaps identified by our review of the relevant literature.

4. "Monitoring of key response indicators"

The intensity of short-term behavioural responses observed on aerial surveys is the key proximate indicator that is assumed to be correlated with longer-term effects. Population productivity indices on tenure and non-tenure areas are the key, long-term indicators that might signal the need for changes in management guidelines.

5. "Analysis of the outcome in consideration of the original objectives"

The research program is designed to collect data and test relationships that are related directly to management guidelines. The issue of disturbance is very complex, and it is critical that the researcher remain focussed on the intended outcome of establishing appropriate management guidelines.

Behavioural responses during aerial surveys will define the "disturbance space" described in an earlier section. There will be a number of factors that will influence the responses of goats to fly-bys (*e.g.,* group size, distance to escape terrain); however, these variables are beyond the control of managers and cannot reasonably be included in guidelines. Management should focus on the responses of the most sensitive animals (excluding outliers). Variables associated with the approach vector of helicopters are the only factors under the control of managers; therefore, the key issue in interpreting results is the relationship between approach vector variables and the maximum behavioural responses of goats.

6. "Incorporation of the results into future decisions"

Research results should be reviewed annually to determine whether they warrant changes in management guidelines, or whether research efforts should be altered. The results of research at the three spatio-temporal scales represent separate lines of evidence that are assumed to be related to one another.

Management guidelines based on approach vectors should be related to the maximum expected response of goats, as determined by observations made during aerial surveys. Accepting any behavioural response of goats to helicopter disturbance is a management risk. Whether it is an acceptable risk should be determined by evidence for or against any long-term demographic differences between goat populations in tenure and non-tenure areas. The acceptable maximum response of goats can be updated as more demographic data become available.

The proposal phase of the project has led to a number of recommendations regarding interim guidelines. Those recommendations are listed in Appendix C.

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7 CONCLUSIONS AND RECOMMENDATIONS

The relationship between backcountry recreation and Mountain Goats is complex. We suggest several strategies for dealing with this complexity. First, focus on the disturbance of greatest concern (helicopters); second, accommodate individual variation and multiple causation in drafting management guidelines (disturbance space); third, use a study design that focuses on factors that are under the control of managers and responses that are directly relevant to the intended outcome of the research (management guidelines); and fourth, stratify the study into phases that correspond to different spatial and temporal scales of possible responses.

7.1 What are the Research Priorities?

Resources should be allocated such that those research activities that can return the most information for the lowest cost are given priority. In the case of the research and adaptive management plan we have proposed, priority should be given to securing funding for detailed aerial surveys. As discussed, both short-term acute (at least in part) and long-term demographic effects can be assessed by analysis of detailed annual survey data.

Information collected on aerial surveys might help to allocate additional resources more efficiently. For example, if there are significant differences in the acute behavioural responses of goats exposed to survey helicopters in tenure versus non-tenure areas (suggesting either sensitization or habituation), there might be little benefit in further investigating short-term responses, in light of the primary goal of adjusting management guidelines. In contrast, if no significant differences in the intensity of short-term responses are detected, then further work might be required to test for possible differences in the duration of short-term responses. Such additional work is presented under short-term responses.

Investigating medium-term chronic behaviour is expensive because of the capture and hardware requirements of the research. In addition, the collaring procedure is a significant disturbance that might confound any significant results. This phase of the research should be given low priority, unless it is practical to use a capture strategy that does not use helicopters, or if managers are prepared to risk potential confounding effects.

7.2 Who should do the Research?

Ideally, the research should be conducted through a university, preferably by a Caprin specialist (possible funding sources and requirements are outlined in Appendix D). Doing so affirms the independence of the research and the credentials of the researchers and allows the leveraging of university resources (lab space, library, computing, graduate students, etc.). The challenge of conducting the research through a university is ensuring that the project accommodates the principal researcher's need to generate scientifically publishable results while still ensuring that management needs are met.

From a research perspective, it would be valuable if a small technical advisory committee were struck to which the researcher reported and with which the researcher met annually. One function of this technical committee would be to work with the research team to ensure that it continues to work towards meeting the objectives of the research and to provide a preliminary level of peer review. A scientific peer review system could also be established, if necessary, to assess the progress of the work (*e.g.,* that used by the Science Council of B.C. in its FRBC research program).

We also recommend that a larger advisory group be established that includes representatives from MELP, BCAL, the heli-recreation industry, and local representative of each of the following agencies/organizations: B.C. Helicopter and Snowcat Skiing Association, Southern Guide Outfitters of B.C., East Kootenay Backcountry Coalition, East Kootenay Environmental Society, East Kootenay Wildlife Association (B.C. Wildlife Federation), East Kootenay Recreational Snowmobile Association, and Ktunaxa-Kinbasket Tribal Council (First Nations). The advisory group could help with fund acquisition, communications, and general research issues, as well as advising decision-makers of stakeholder concerns.

Appendix A. Results of Reconnaissance Survey for Mountain Goats in the Bobbie Burns and Bugaboos.

A.1 Introduction

Few formal surveys have been conducted in the Bobbie Burns and Bugaboo tenure areas, and the number of Mountain Goats in the area is in dispute. We conducted a reconnaissance-level survey to: 1) collect preliminary information on the number and distribution of Mountain Goats in the area; 2) record basic information on the responses of goats to survey methods; 3) collect information to guide the development of the research plan.

A.2 Methods

We flew a reconnaissance-level survey of CMH's Bobbie Burns and Bugaboos tenure areas, as well as adjacent areas to the east and south, on 7 September 2000. Inside tenure areas, we primarily flew valleys where CMH had sighted Mountain Goats. We made single passes through the valleys at approximately 130 kph and 2440 m asl. When we spotted goats, we often made a second pass by the group to get accurate classified counts. Approach distances were generally 90–150 m and approach angle (below or above) varied.

We recorded group size, group composition (yearlings/subadults/adults and young-of-year), location (GPS), elevation, closest approach distance, and reactions of goats.

Because we made only a single pass through valleys at a relatively a relatively high speed, our numbers represent minimums. We made no attempts to correct for sightability.

Table 3. Summary of behavioural responses of goats observed during a reconnaissance-level survey of the Bobbie Burns and Bugaboos tenure areas and non-tenure areas to the east and south.

Response	Individuals	Groups
Remained bedded/standing	27%	39%
Walked	18%	17%
Ran	55%	44%

Percentages are based on the total number of individuals (n=55) and groups (n=18) seen on the survey.

A.3 Results

During the flight, we observed 18 groups and a total of 55 goats: 39 adults (six suspected lone males), six juveniles (yearlings and/or subadults), and 10 young-of-year (including a possible set of twins). In addition, hikers reported five adults and one yearling that we did not see on the flight. Table 3 lists the responses of goats to helicopter disturbances.

A.4 Discussion

Because we made single passes at high speed and made no attempts to assess sightability, reported goat numbers are considered minimums. The helicopter and flight paths we used during surveys differ from those used in commercial recreation activities; therefore, responses might not be typical.

Both inside and outside tenure areas, goats appeared to occur at relatively low densities, and in our opinion, habitat quality for Mountain Goats was lower in survey areas than in other regions (*i.e.,* Rocky Mountains).

Appendix B. Notes on Statistical Power.

Statistical power (1-β) can be defined as the likelihood of accepting a null hypothesis when it is true (Sokal and Rohlf 1981): that is, the chance of correctly identifying no treatment effect. Statistical power is a concern in most ecological field experiments because sample sizes are usually small and variances high. Both these characteristics can lead to low statistical power and, as a result, incorrect inferences.

The common effect of low statistical power is a "Type II error," or accepting a null hypothesis when it is false. In the context of the proposed research plan, low statistical power could lead to the conclusion that there is no effect of helicopters on goats, even if one exists.

Statistical power depends on sample size, variability in the data, and effect size. Larger samples sizes, less variable data, and larger effect sizes all increase statistical power. Sample size is the only one of these variables that is under the control of the researcher; therefore, increasing the length of the study, collaring more animals, or examining additional sites is the only way to address the issue of low statistical power.

For example, consider the ability to detect long-term demographic differences between treatment and control areas from aerial survey data. If we assume that treatment areas produce 20 ± 10 kids/100 adults and control areas 40 ± 10 kids/100 adults, we can generally expect to detect a helicopter effect at $\alpha = 0.1$, based on five years of data and two treatment and two control sites. However, if control areas produce only 30 ± 10 kids/100 adults, we are unlikely to detect a helicopter effect, even though control areas are producing 50% more kids than treatment areas. The only way to improve the study design to increase the probability of detecting a helicopter effect where one exists is to increase the number of sites included in the design, or lengthen the study.

Error rates α and β are related. The probability of making a type II error (β) increases as a becomes more restrictive. Setting an appropriate α level for statistical tests can control Type II error rates. As in the above example, we suggest setting α = 0.1. Power can be calculated *a priori* for each factor used in a multivariate statistical test. Zar (1984) provides methods for calculating β for paired t-tests, which is appropriate for calculating repeated measure (*i.e.,* year) effects. Power could be calculated for each treatment/control pair to examine the probability of detecting a helicopter effect, if one actually exists.

The important point is that a well-designed study might fail to find a helicopter effect, even if one exists. The natural variability in Mountain Goat reproduction and practical constraints on the researcher's ability to monitor populations might prevent the detection of a helicopter effect. Knowing the probability of actually detecting the effect, if it exists, is critical for the correct interpretation of results. The data presented above suggest that the effect size in at least some of the statistical tests might have to be very large to be detected.

Alternatives to the hypothesis-testing method have been the subject of several recent papers. One or more of these methods might be useful as an alternative to the approach outlined above, or in addition to it. The alternatives fall into three broad categories: avoiding null hypothesis testing, modelling, and Bayesian approaches.

The first approach involves simply reporting means and confidence intervals without calculating P values. The information is adequate to estimate effect size and its uncertainty (Johnson 1999). The second approach involves fitting a number of candidate models to the data and determining which one (or ones) best explain observed patterns, usually by using likelihood estimates or related information criteria (Burnham and Anderson 1998, Johnson 1999, Anderson *et al.* 2000). The third approach relies on Bayesian approaches, which are well suited to adaptive management problems (see papers in Sit and Taylor 1998), although even simple problems can be computationally complex (Ellison 1996, Wade 2000). Advances in data processing power and numerical approaches to integration might soon make Bayesian methods more accessible (Wade 2000).

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Appendix C. Interim Supplementary Recommendations for Helicopter Operation Near Mountain Goats.

The risk that helicopters pose to goat populations is likely a function of several factors. Risk increases as separation distance decreases, as frequency and duration of disturbance increases, and with certain patterns of helicopter operation relative to goats. The literature considered in chapter 3 suggests that 2000 m is the maximum distance at which helicopters begin to affect goat behaviour. The literature offers little evidence that helicopters pose a significant risk to goats at separation distances >2000 m. By allowing flights by existing tenure holders <2000 m, the Provincial Government is assuming a management risk. The magnitude of this risk is difficult to assess based on only existing literature and expert opinion.

At this time, we have insufficient understanding of the long-term sensitivities of Mountain Goats to helicopters to be able to speculate on any thresholds related to acute or chronic behavioural changes. The research program we have recommended in this proposal will help to address this significant gap in knowledge.

The following recommendations are offered as expert opinion to guide the operation of all heli-hiking and heli-ski tenures until we better understand the sensitivity of goats to helicopters. They are meant to supplement, not replace, current provincial guidelines that stipulate a minimum separation distance of 500 m for existing heli-ski and heli-hiking tenures and 2000 m for new tenures.

Heli-skiing and heli-hiking constitute only a portion of helicopter activity in and around goat habitat. Ideally, these guidelines would apply to all helicopter activities (*e.g.,* "flight-seeing," industrial surveying) that are not governed by provincial guidelines. Accordingly, we encourage the Province and the tourism industry to promote these guidelines to all helicopter operators.

C.1 Disturbance Space

The research proposal introduced the concept of disturbance space. While we have no empirical measure of the concept at this time, the 2000 m separation distance provides a reasonable surrogate that should be used as an interim guideline for the outer edge of disturbance space.

C.2 Avoiding Disturbance Space

Provincial guidelines for new tenures require helicopters to remain at least 2000 m from goat habitat. However, regardless of separation distances specified by tenure, care must always be taken to reduce the possibility of surprise encounters with goats or unplanned flights into disturbance space. To achieve this, the following measures should be applied to flight planning and helicopter operation.

- Concentrate flight lines in the centre of valleys.
- As much as possible, operate at elevations below 2100 m (7000 ft). This does not necessarily avoid disturbance space, but it helps to keep helicopters below goats.
- Avoid flying through passes and over ridges near occupied goat range.
- Pilots and guides should inform each other of goat sightings and activity and plan flights to avoid goats.

C.3 Helicopter Operation within Disturbance Space

Provincial guidelines for existing tenures allow helicopters to approach to within 500 m of goat habitat. As stated above, at separation distances <2000 m, factors such as helicopter size, approach angle, and relative elevation appear to influence goat responses to helicopters. Accordingly, at separation distances <2000 m:

- use topographical barriers such as ridges to separate helicopters from goats.
- if possible, keep helicopters below goats.
- avoid flying directly towards goats.
- do not hover or land near goats.
- minimize time spent in disturbance space.
- minimize the number of flights into disturbance space.
- regardless of minimum distances specified in tenures, keep helicopters as far from goats as practically possible.

C.4 Seasonal Considerations

- Guides and pilots should be especially vigilant of goats in winter (November-March)
- Helicopters should not operate within disturbance space (2000 m) during the kidding season (May–June)

C.5 Operational Considerations

- Guides and pilots should be aware of sensitive wildlife and of these guidelines.
- These guidelines and others like them should be routinely promoted to staff at guide training and through the operating season.
- MELP staff should be involved in guide training and should be consulted in the planning of operations.

Appendix D. Funding Sources, Requirements and Timing.

D.1 Funding

The Habitat Conservation Trust Fund has expressed interest in making a significant contribution to the project. Other possible funding sources include: Columbia Basin Trust and Science Council of B.C. (for both student support and general program funding). However, these research funding agencies will probably be unable to provide all the necessary funding and might be reluctant to provide significant funding without firm commitments from the major stakeholders of the project. Some of the costs will have to be borne by direct and in-kind support from the Provincial Government (*e.g.,* use of existing aerial survey budgets and staff time from MELP), and from the heli-recreation industry. There should be some GPS collars and other equipment available from completed studies (e.g., Shackleton (Taylor) – UBC, Doug Heard – MELP, pers. comm.).

Below are the approximate, minimum funding requirements for the projects. A significant unknown is the exact number of hours of helicopter time required, which will depend largely on the choice of study areas.

D.2 Timelines

D.2.1 Pre-study phase – 2001

- By April 2001 the research team should have been determined
- May-September – reconnaissance observations and study area selection by research team in co-operation with Region 4 staff from MELP and BCAL
- September – graduate students begin their M.Sc. programs for short and medium-term projects
- November 1 – deadline for application by research team to HCTF
- Contact Columbia Basin Trust (1-800-505-8998, www.cbt.org) for funding deadlines
- January 31 – deadline for application by research team to Science Council of BC for GREAT scholarships; see http://www.scbc.org/applications/default.asp for other programs and deadlines

D.2.2 Short-term acute behaviour – 2001–04

Based on a minimum two years field work and one year analysis/write up.

- Graduate student – GREAT scholarship rate ($20 000/annum) for three years – **$60,000**
- Helicopter time – $700/hour in four-hour blocks for intense observations, at least 20 observations per year – **$112,000**
- Student/supervisor travel (depending on university) $4000/annum for two years – **$8000**

D.2.3 Medium-term chronic behaviour – 2001–06

Based on minimum five years minimum with two Masters-level graduate students. Both would use GPS collared goats and would overlap on the third year of the study.

- two graduate students – GREAT scholarship rate ($20 000/annum) for three years each – **$120,000**
- 20 GPS collars – minimum @ $6000 each – **$120,000**
- Capture costs – net-gunning @ $1200/goat – **$24,000**
- Annual recovery and refurbishing of collars – $2000 annually per collar in years two–four – **$120,000**
- Additional helicopter fly-bys in years three–five; 60 hours @ $700/hr – **$42,000**

D.2.4 Long-term demographic consequences – 2001-06

Based on 5 years, including analysis.

- Helicopter time – $700/hour, at least 10 hours for each of four study areas annually – **$140,000**
- Equipment – camcorder, tapes, etc. – **$3000**
- Observer time (in addition to in-kind from MELP researchers, if required) 20 days @ $400 – **$8000**

D.3 References Cited

D.M. Shackleton Wildlife Research Group Agroecology, Faculty of Agricultural Science Univ. British Columbia Vancouver BC

Doug Heard B.C. Ministry of Environment, Lands and Parks Prince George BC

Copies of Wildlife Bulletins can be obtained, depending on supply, from the Wildlife Branch, B.C. Ministry of Environment, Lands & Parks, P.O. Box 9374 Stn Prov Gov, Victoria, BC V8W 9M4. Titles of Bulletins 1 to 49 are also available.

No. B-50 Functional relationships between salal understory and forest overstory. D.J. Vales. October 1986. 122pp. (Also printed as IWIFR-32).

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No. B-58 Evaluation of health status of Rocky Mountain sheep (Ovis canadensis canadensis) in southeastern British Columbia. H.M. Schwantje. April 1988. 64pp.

No. B-59 Dispersal and colonization of arboreal forage lichens in young forests. S.K. Stevenson. March 1988. 71pp. (Also printed as IWIFR-38)

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