AVOIDING DISTURBANCE TO YUKON'S ALPINE UNGULATES AND RAPTORS: A SUMMARY OF SCIENTIFIC KNOWLEDGE ON SPATIAL BUFFERS AND TIMING WINDOWS

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SUMMARY

Many wildlife species can be disturbed from their normal behaviours by human activities, including aircraft flights and foot or vehicle traffic close to key habitats. This has been recognized as a management issue in Yukon for some time, but recent helicopter-based mineral exploration activities have highlighted it as an ongoing problem especially for mountain sheep. Backcountry recreation can result in similar disturbance problems.

Some species use particular habitats in particular seasons, year after year. In these situations, human disturbance can be managed by the application of spatial buffers and timing windows to human activity in and near those habitats. Species in question include alpine ungulates (thinhorn sheep, mountain goat and caribou) and some nesting raptors.

In this Report we summarize the nature of disturbance, and findings of scientific studies addressing this management problem in alpine ungulates and raptors. Based on a review of the literature we recommend timing windows and distance buffers to reduce disturbance, and provide recommendations on ways that buffers and timing windows can be integrated into land management decisions. Finally we explore some of the knowledge gaps in the science of wildlife disturbance.

Three Tables toward the end of the Report summarize our recommendations on the sizes of spatial buffers and the dates for timing windows to be applied to the habitats in question. Successful application of buffers and timing windows will depend on: (i) clear definitions of the habitats in question; (ii) more accurate and precise mapping of these habitats; (iii) clear inclusion of buffers and windows as standard operating conditions applied to permitting under existing land management procedures. We recommend that the Department of Environment within the Yukon Territorial Government take the lead in developing clear definitions of the habitats, and in formalizing a database where these habitats are mapped and adequately documented (the existing Key Wildlife Areas database is a good start). We recommend that the Department of Energy, Mines and Resources and the Yukon Environmental and Socio-economic Assessment Board require the mapping of these habitats in environmental impact assessments, and implement spatial buffers and timing windows in a variety of land use permitting processes.

1. BACKGROUND

It has long been known that numerous wildlife species can be disturbed from their normal behaviours by human activities that the animals perceive as a risk. These activities include aircraft flights and noise, vehicle passage and noise, fixed infrastructure, and on-the-ground movements close to well-used habitats. Although management guidelines are in place to minimize some of these disturbances in the Yukon (e.g., Government of Yukon 2006, 2008), the issue has become more prominent in recent years in association with increasing levels of mineral exploration and backcountry recreation. For example, in 2012, the Yukon Territorial Government (YTG) received letters of concern from the Yukon Fish and Wildlife Management Board (2013), the Dan Keyi Renewable Resources Council, and two outfitters about helicopter disturbance to Dall sheep (*Ovis dalli dalli*) caused by mineral exploration (Hayes 2013). The letters complained that sheep had abandoned traditional summer ranges, and that regional populations had declined due to repeated helicopter traffic over summer ranges.

In the same time period, the Yukon Court of Appeal ruled in the case of *Ross River Dena Council vs. Government of Yukon (2012)*, stating that the YTG has a duty to consult with Ross River Dena Council (RRDC) before allowing any exploration activities to proceed on Crown lands in the RRDC's traditional territory. The ruling is landmark because, until then, mining companies were not required to consult with First Nations before prospecting for minerals.

In partial response to, and compliance with, the Yukon Court of Appeal ruling, YTG has since passed legislation (Bill 66, Amendments to the *Quartz* and *Placer Mining Acts*) that (i) puts in place a consultation process for early stage mineral exploration (Yukon Class 1) after claims are staked, and (ii) provides the opportunity for designation of Special Operating Areas (SOAs). When originally introduced by the Yukon Government (Yukon Energy, Mines and Resources 2013), SOAs (then termed "Identified Areas") were viewed as an opportunity to protect specific critical or key wildlife habitats by establishing spatial and temporal conditions on human disturbance within the SOAs. SOAs could conceivably be established through the mechanisms in Bill 66, and also by designation in land use plans. Whether or not they are established, there is a need to address the disturbance issue across the entire region.

Wildlife occupies habitats across virtually the entire Yukon land base. It is not possible to remove or mitigate human disturbances in all habitats, and some habitats will be completely lost to wildlife. However, there are real opportunities for improved co-existence of wildlife and humans if humans modify some of their behaviours to reduce disturbance and accommodate use of habitats by wildlife. A considerable number of habitats used by individual species are spatially limited and relatively easy to map, and are often of high value to population viability. These habitats deserve priority attention. Wildlife Conservation Society Canada (WCS Canada) is particularly concerned that aircraft and ground disturbances associated with mineral exploration and backcountry recreation are negatively affecting the viability of some populations of ungulates and raptors. This risk is high in alpine and subalpine habitats because these areas lack vegetative cover for ungulates and they are especially attractive for mineral prospecting and backcountry recreation. In addition, WCS Canada notes that nesting sites of some birds of prey (raptors) are repeatedly used over long periods, as are mineral licks. Consequently these site-based habitats need to be protected. In this document we summarize the latest science regarding two site-specific management approaches to reducing disturbance to animals in these habitats: spatial buffers and timing windows.

2. GOAL AND OBJECTIVES

The goal of this report is to summarize the best available science about the nature and management of human disturbance as it affects:

(a) alpine ungulates - specifically thinhorn sheep (Dall's and Stone's sheep; *Ovis dalli*), mountain goat (*Oreamnos americanus*), and woodland caribou (*Rangifer tarandus*), and also bighorn sheep (*Ovis canadensis*) because of their ecological similarities to Yukon sheep;

(b) raptors with high nest fidelity – specifically golden eagle (*Aquila chrysaetos*), bald eagle (*Haliaeetus leucocephalus)*, gyrfalcon (*Falco rusticolus*), peregrine falcon (*Falco peregrinus*), and northern goshawk (*Accipiter gentilis*);

(c) mineral licks.

Our specific Objectives are to:

1. Summarize the nature of disturbance, and findings of scientific studies addressing this management problem with regard to the focal species.
2. Recommend timing windows and distance buffers to reduce disturbance to the alpine ungulates, raptors, and species using mineral licks.
3. Explore knowledge gaps in the science of wildlife disturbance.

3. METHODS

This report is a summary of literature and published information. We searched peer-reviewed science journals and books, government publications, and "grey" literature for disturbance studies on alpine ungulates and raptors. We also examined management prescriptions regarding distance buffers and timing windows, focusing on alpine ungulates. Finally, we reviewed the research recommending distance buffers to protect mineral licks and raptor nesting sites.

4. THE NATURE OF DISTURBANCE

There is a growing body of science showing that wildlife responses to human disturbances are similar to their responses to perceived predation risks (Walther 1969, Berger et al. 1983, Frid and Dill 2002, Blumenstein 2003). Both disturbance and predator avoidance deprive an animal of time and energy by displacing it from preferred activities or habitats. Frid and Dill (2002) provided a conceptual model showing how behavioral responses to increasing disturbance and predator encounters can eventually cause an animal population to decline. Both disturbance and predation risk act by increasing predator avoidance behaviour (fleeing, vigilance), thereby reducing energy intake, resting, and rumination time. Body condition of individuals further declines, in turn reducing the ability of individuals to escape from predators. As body condition declines, so does reproductive success, limiting the replacement of predator-killed individuals. Predation rate increases. The outcome is a declining population.

Aircraft and ground disturbances can affect ungulates in several ways. Disturbed animals may abandon range, or shift their use of habitats (Wilson and Hamilton 2003, Gordon and Wilson 2004, Seip et al. 2007). Predation may increase (Calef et al. 1976, Nette et al. 1984, Harrington 2001), foraging efficiency may decline (Berger et al. 1983), and animals may spend less time ruminating and resting following disturbance (Stockwell et al. 1991, Schoenecker and Krausman 2002, Frid 2003). Disturbed animals lose body mass (Maier 1996). Their reproductive success may fall, with populations declining after repeated disturbance (Joslin 1986, Harrington and Veitch 1992). Social structure and group size can change (Berger et al. 1983), and disturbed animals often increase vigilance (Powell 2004) and movement rates (Powell 2004, Støen et al. 2010). The scale (size of disturbed area), frequency and duration of disturbance affect whether the impact is at the individual, group, or population level (Frid 2003, Cadsand 2012).

However, relatively little is known about how individual responses to disturbance transform into population-level impacts. Demographic effects may result from physiological and reproductive stress, energy loss, accidental injury, or mortality. Other factors influencing the degree of disturbance impact include the age and sex of disturbed individuals, seasonal sensitivity, the short-term intensity and frequency of disturbance, and the longer-term history of disturbance. Regarding the history of disturbance, ungulates can become sensitized (i.e. repeated exposure to the disturbance increases the avoidance behaviour) (Berger et al. 1983), habituated (i.e. repeated exposure to the disturbance gradually decreases the avoidance behaviour) (Goldstein et al. 2005; Valkenburg and Davis 1985), or remain unaffected by repeated disturbance over many years (Côté et al. 2012, Cadsand 2012; Bleich et al. 1994).

There is evidence that prolonged disturbance has reduced ungulate population size (Stockwell et al. 1991). For example, stress caused by intense helicopter activities reduced reproductive success of female mountain goats in Montana, causing the population to decline while an undisturbed herd was stable (Joslin 1986). Repeated low-level jet overflights caused body mass of caribou to decline, and reduced reproduction in two herds (Maier 1996, Harrington and Veitch 1992). Long-term urban disturbances over many decades caused bighorn sheep to decline in Arizona (Schoenecker and Krausman 2002). These studies do not deal with ungulates in northern alpine habitats, but do indicate a strong potential risk of population level effects in goats, sheep and caribou in Yukon. Ideally such studies would be done in Yukon.

To avoid or mitigate aircraft and ground disturbance, the best approach is to first address the short-term risks of behavioural changes, then determine when wildlife are most sensitive to disturbance. To develop sensitive operating standards for potentially disturbing activities, we need to answer the following questions:

1) Where are the important seasonal habitats, and when do animals use them?
2) On which habitats are ungulates least tolerant of disturbance (e.g. calving, migration, or summer ranges)?
3) What are the flight initiation distances the 3 alpine ungulate species can tolerate before they move away from, or clearly react to, disturbance stimuli?

The next section summarizes results of disturbance studies where some of these questions were examined.

5. ALPINE UNGULATE-DISTURBANCE STUDIES

Human-caused disturbances can conceivably have effects over various periods, ranging from short-term shifts in behaviour to longer term behaviour changes and population effects. Most published studies have examined the short-term effects on the animals' behaviour patterns as a result of aerial and ground disturbances. In this section, we summarize relevant studies on the 3 alpine ungulates. Frid (1999, 2003) and Loehr et al. (2005) studied thinhorn sheep. Stockwell et al. (1991), Bleich et al. (1994), and Schoenecker and Krausman (2002) researched disturbance responses of bighorn. Côté (1996), Cadsand (2012), Goldenstein et al. (2005), Joslin (1986), St. Louis et al. (2012), and Côté et al. (2012) studied mountain goat responses. Calef et al. (1976), Gunn et al. (1983), Harrington and Veitch (1999), Mahoney et al. (2001), Wilson and Hamilton (2003), Powell (2004), Seip et al. (2007), and Valkenburg and Davis (1985) studied caribou responses. These and other disturbance studies helped us recommend timing windows and distance buffers for Yukon alpine ungulates.

Thinhorn sheep

HELICOPTER DISTURBANCE STUDY

Kluane Game Sanctuary

Frid (2003) studied the response of thinhorn sheep (Dall's sheep subspecies) to 25 helicopter and 32 fixed-wing approaches at 3 study sites in the Kluane Game Sanctuary: Hoge Pass, Nines Creek and Vulcan Mountain. Most observations (79%) were made at Hoge Pass in 1997, after the lambing season. Frid (2003) controlled the timing, speed and direction of flights with pilots, recording responses of sheep groups to changing distance, angle of approach, and terrain. Observers recorded the proportion of groups that fled, the distance fled, the flight initiation distance (FID), and time it took for sheep to resume feeding and resting. Independent variables of interest to Frid (2003) included:

minimum distance from aircraft, whether aircraft were above or below sheep, the distance to cliffs (escape terrain), sheep group size, and distance to nearest ridge blocking sheep line of sight to helicopter. Here are the key results of the helicopter trials:

1) The proportion of groups fleeing did not differ between females with young and males, either across the ranges of minimum distances from aircraft, or distances to escape terrain.

2) Sheep groups moved (ran or walked) in 77% of the trials, with 86% of movements being running.

3) Whether aircraft were above or below sheep did not affect their responses.

4) The probability of fleeing declined as distance away from aircraft increased.

5) Sheep farther than 20 m from escape terrain always fled.

6) The flight initiation distance (FID) ranged from 100 to 3000 m, increasing as distance to escape terrain was greater.

Responses to fixed wing aircraft trials were less obvious than for helicopters:

1) For fixed-wing trials, fleeing response was the same for adult females with young and females without young. In addition, there was no difference between the 2 female classes in proportion of sheep interrupting rest when planes approached.

2) 84% of sheep groups that were feeding before disturbance (n=51) reacted by running away.

3) No animals fled when the trajectory of the fixed-wing aircraft was more than 700 m away.

4) 47% of sheep groups that were resting before the disturbance (n=30) interrupted their rest; 57% of those groups fled.

5) Distance to escape terrain had no effect on sheep response to fixed-wing airplanes.

Direct approaches affected sheep response more strongly than oblique passes for both aircraft types. Sheep that had been resting before disturbance tended to feed after the aircraft left. Sheep that had been feeding resumed foraging after the aircraft left. Frid (2003) believed lost rumination time was the most important cost of disturbance to

Dall's sheep.

Management recommendations:

1. Distance buffers should be set on the likelihood of interrupting rest and rumination, rather than on the FID.

2. Elevation limits should be based on reducing direct approaches.

3. Set a speed limit for helicopters directly approaching sheep (no speed suggested).

GROUND DISTURBANCE STUDY

Faro, Yukon Territory

Loehr et al. (2005) studied behavioral responses of different age and sex classes of thinhorn sheep (Dall's x Stone's sheep hybrids) to approaching pedestrians near Faro, Yukon Territory. They tested for sex-age differences in vigilance, bedding, and foraging responses. The researchers differentiated responses among 35 recognizable individuals, including 12 rams (5 adults) and 23 ewes (15 adults). There was no difference in vigilance response between sexes, but ewes decreased bedding and increased foraging after disturbance. Males showed no change in those behaviors. Adults increased vigilance, but juveniles did not. Regardless of sex or age, sheep that increased vigilance were clearly those that felt most threatened. Loehr et al. (2005) raised the concern that increased vigilance may decrease foraging efficiency (see also Stockwell et al. 1991, Frid and Dill 2002, Frid 2003). The authors warned that strong differences in age and sex classes could be masked in studies that lump all animals in the analyses.

Bighorn sheep

HELICOPTER DISTURBANCE STUDIES

a. Mojave Desert

Bleich et al. (1994) studied responses of bighorn sheep to helicopter surveys in the Mojave Desert, California. The study design compared locations and movements of 36 radio-tagged animals (20 males, 16 females) during the day before (control) and day after a helicopter disturbance event. Thirty percent of males and 38% of females shifted to different blocks (sample units of habitat) following disturbance. The proportion of individual sheep that changed blocks after a disturbance event was significantly higher than before the disturbance event, in all seasons. Females moved farther on the day of helicopter disturbance compared to undisturbed days in spring, summer, and fall. Males showed the same response as females in all seasons including winter. The largest movements were in spring, followed by autumn. When disturbed by helicopters, sheep changed their use of vegetation type in spring only. The researchers argued that the downdraft from the helicopter blades and intense noise acutely affected sheep so that they continued to move during the day, long after helicopters had left the area. They cautioned that helicopter disturbances might have most detrimental effects in desert sheep where critical resources are limited and widely separated. We think the same caution also applies to Dall's sheep in the Yukon sub-arctic where range and alpine forage are limited and less productive compared to more temperate mountain areas.

b. Grand Canyon National Park

Stockwell et al. (1991) examined the effects of intense helicopter overflights on the foraging efficiency (proportion of time spent feeding to the sum of time feeding plus time in vigilant scanning) of 35 bighorn sheep in winter and spring in Grand Canyon National Park, Arizona. The researchers compared time budgets of sheep when helicopters were flying overhead with those when the aircraft were absent. All disturbed sheep foraged 43% less efficiently in winter when bighorns used the upper stratum of the canyon closest to helicopter flight paths. Helicopters had no effect on foraging efficiency during spring when sheep used the lower canyon furthest away from helicopters. There were no significant differences in foraging efficiencies between males, females and 6-month old lambs, or among group sizes. Undisturbed sheep were active 70% of the day, so a 43% reduction in foraging may result in lower reproduction.

Management recommendations:

1. Flight altitudes to be greater than 500 m above bighorn sheep habitat.

2. To minimize effects on sheep foraging efficiency, the number of daily flights should be minimal, and aircraft should avoid flying in morning and late afternoon when sheep are actively foraging.

GROUND DISTURBANCE STUDY

Putsch Ridge, Arizona

Schoenecker and Krausman (2002) studied the effects of hiking and nearby loud urban disturbances on a declining bighorn sheep herd in the Putsch Ridge Wilderness, a small, "protected" habitat near Tucson, Arizona. Sheep had declined from 220 animals in 1927 to fewer than 20 in 1993. Researchers found that off-trail hiking was common, representing 18% (n = 280 people in 126 groups) of hikes into the sheep range. Hikers spent an average of 1.5 hours in occupied bighorn habitat. Noise disturbance averaged 45 decibels (dB) including such diverse sources as loud cheering, gunshots, sirens, dogs barking, vehicle traffic and construction. Building construction noise was persistent during the daylight hours, lasting an average of nearly 3 hours out of 4-hour study periods, changing the watering behavior of sheep, increasing their energy cost, and reducing lamb survival rate. Researchers believed that hiking disturbance caused sheep to lose foraging and resting opportunities, increasing energy expenditure. They also proposed that the combination of many human-created disturbances may explain why bighorn sheep near Tucson abandoned this once prime sheep habitat.

Mountain Goat

HELICOPTER DISTURBANCE STUDIES

Rocky Mountain Front, Montana

Joslin (1986) followed 23-45 marked mountain goats from 1981 through 1986 to document population responses to increasing helicopter-seismic activity along Montana's Rocky Mountain Front. The disturbed group experienced a 37-fold increase in helicopter activities, in an area already stressed by other human developments. The control group experienced only minor disturbances before and during the study. Females declined by more than 50% in the disturbed area, while the number of females in the control area did not change. Therefore, the number of kids also declined in the disturbed area, but kid numbers also fell sharply in the control area in one year, then recovered by the end of the study. Joslin (1986) found a lag effect of seismic activity on reproduction, with the intensity of seismic activities up to two years before birth explaining 82% of variation in productivity during the birth year. Changes in weather, snow pack, summer conditions, hunting loss, and forest removal were not associated with the declines, but broncho-pneumonia could have acted in concert with helicopter disturbance to reduce the population. Joslin (1986) suggested that stress induced by seismic exploration was cumulative over time and additive to other human activities in disturbing the goats.

Management recommendation:

> The author proposed the concepts of seasonal timing windows and restrictions on the frequency of helicopter flights in order to reduce disturbance.

Coastal Mountains, British Columbia

Gordon and Wilson (2004) studied the effect of helicopter logging on the behavior of coastal female mountain goats in British Columbia from spring through autumn. These goats occupy non-alpine habitats: granite cliffs and interspersed meadows within a matrix of mature coastal rain forest. Using a treatment/control herd comparison, the researchers tested two predictions:

1) Helicopter activity increases the tendency of goats to hide, bed or use forest cover to avoid disturbance.

2) Helicopter activity affects the time goats spend bedding, feeding, and walking.

Researchers divided helicopter disturbance into 5 logging activities: pre-falling (no activity), falling, post-falling (no activity), yarding (using heavy lift helicopters), and post-yarding (no activity). Using spotting scopes, they conducted 144 scans that yielded goat sightings. In 50% of the observations, goats were bedded, and in 35%, they were feeding. In the group experiencing intense logging, sightability of goats declined with each disturbance phase, indicating that goats hid from helicopters, or left the logging area. In one year, females and kids increased walking and reduced bedding-time when the helicopter was operating. Gordon and Wilson (2004) did not see an increase in use of cliffs (generally thought of as escape terrain) when goats were disturbed. They speculated that goats do not perceive helicopters as a predator risk, contrary to other research (see below). (*However, our interpretation is that coastal mountain goats use the steep forest stands adjacent to the open rock and meadow habitats as escape terrain rather than the cliffs. This is because (i) the smooth, un-layered, structure of these granite cliffs offers relatively little in the way of escape routes, (ii) the primary predation risk during spring and summer is the golden eagle which would attack in open habitats, and (iii) these valley-side coastal habitats support lower densities of mammalian predators than interior and alpine habitats*). Results from behaviour and sightability analysis indicated that goats were increasingly sensitized to the helicopter disturbance.

Management recommendation:

1. Between May 15 and June 15, helicopter activity should be no closer than 1500 m from mountain goat nursery bands.

Caw Ridge, Alberta

Côté (1996) studied behavioral responses of mountain goats to helicopter disturbances at Caw Ridge, Alberta, a relatively dry alpine and subalpine site on the east side of the Rocky Mountains. The research evaluated responses of 98 marked goats to the following: their distance to helicopter, whether they could see aircraft or not, height of helicopter above animals, group size and composition (males, females, females with young), and the pre-disturbance activity. Researchers recorded responses of 84 groups of mountain goats. There was no difference in responses between the first helicopter flight of day, and later flights the same day. Overall, 42% of groups were lightly disturbed, and 58% were moderately or greatly affected by helicopters. Distance to helicopter was the most important factor affecting behavior. Goats were greatly affected during 85% of flights that were less than 500 m away. Only 9% of flights 1500 m away caused strong reactions. All flights less than 500 m caused a moderate or stronger reaction, and 3% of flights less than 1,500 m were not disturbing, or only lightly disturbing. Goats tended to remain in nearby cliffs for some time after the helicopter passed, indicating that cliffs were used as terrain in which to escape from the perceived risk of the helicopter (contrary to Gordon and Wilson (2004) above).

Fifteen years later, Côté et al. (2012) duplicated the study of Côté (1996) in the same area, testing for evidence of habituation to continuous helicopter disturbance in the intervening time period. Most goats were marked, and their age and sexes were known.

Disturbances responses were similar between periods, averaging 39% of animals showing light disturbance response, and 61% showing stronger response. As in the early study, the horizontal distance between helicopter and animals was the strongest influence on goat behavior. Goats were only slightly habituated to 15 years of helicopter disturbance, and they remained highly disturbed when the machines approached closer than 500 m away. Contrary to Côté (1996), group composition and size, and behaviour before disturbance did not affect responses during this later study.

Management recommendations:

1) Helicopters should remain 2000 m (Côté 1996) away from goats.

2) Helicopters should remain 1500 m (Côté et al. 2012) away from goats.

3) Seismic lines should not be created in alpine areas and in open forests close to timberline (Côté 1996).

4) Establish a buffer zone of 2000 m around alpine areas and cliffs (Côté 1996 and Côté et al. 2012).

5) If helicopters cannot avoid goat areas, stay more than 300 meters above the ground, and do not land on open alpine ridges (Côté 1996).

Coastal Alaska

Goldstein et al. (2005) conducted a well-designed study of mountain goat responses to helicopter disturbances in winter, spring and summer in 4 areas in the coast mountains of Alaska, where goats occupied alpine habitats. They quantified behavioral responses under regular and sustained helicopter activity, and compared those responses to goats unaccustomed to helicopters. The researchers controlled helicopter direction, timing, angle of approach, and distance. Onboard GPS data loggers, and laser rangefinders on the ground, provided accurate distance and time measurements between goats and approaching helicopters. Using spotting scopes, ground observers classified 3 groups of mountain goats: female-kid, female-subadult, and adult. They summarized the proportion of time disturbed goats spent fleeing, hiding, alert, feeding, nursing, walking, standing, lying, or out of sight during the disturbance. They used 4 general responses: maintenance (no change in behavior), alert, vigilance, or fleeing. If a group of goats changed from maintenance to a disturbed category, then researchers recorded the elapsed time until goats returned to the pre-disturbed activity. They analyzed responses to 347 helicopter flights for 122 groups in 4 study areas.

In 65% of the trials, goats did not change their behaviors. For 35% of the trials , goats changed to being alert or vigilant, or they fled. Of the 773 goats seen, 194 (35%) reacted to helicopters. Of these, 66% became alert or vigilant, and 34% fled. There were strong differences in the sensitivity of goats to helicopters. At a distance of 1000 m, 65 to 90% of the animals were apparently undisturbed. Compared to other studies, Goldstein et al. (2005) found goats were less reactive to helicopters, with 33% of overflights causing disturbed responses. They suggested the lower reaction was because goats were usually close to escape cliffs. Goats showed most tolerance in areas where experience with helicopters was highest, indicating some habituation.

Management recommendations:

1) Using a validated habitat model, develop no fly zones surrounding occupied mountain goat range.

2) Monitor backcountry operators by requiring company to submit flights recorded by on-board GPS units.

3) Helicopters should stay 2000 m from goats.

4) Future research should study population productivity and activity budgets under different levels of helicopter disturbance.

Coastal-Interior British Columbia

Cadsand (2012) studied helicopter disturbance to mountain goats occupying subalpine and alpine habitats in the British Columbia Coast Mountains during 4 winters She analysed the movement responses of 11 GPS-collared female mountain goats to heli-ski disturbance. The ski company was already regulated to stay 1500 m from goats, and had excluded most of the known goat winter range from their ski runs. Overall, goats occupied high elevation, precipitous terrain, within which heli-skiing runs were restricted to open slopes with deep, consolidated snow. Otherwise ski runs were in valleys and low passes, away from mountain goat range. Using remote GPS techniques, Cadsand (2012) found that the probability of female goats moving during and after the disturbance increased the closer the animals were to the helicopter, and the further they were from escape terrain. Overall helicopter disturbance was light (less than 1 hour/month), and did not cause an increase in movement rates of females between the early winter and the heli-ski season. Researchers documented 214 encounters in which the helicopter was less than 2000 m away from a collared goat. Disturbed goats began unusually long distance movements (1000 to 3400 m) up to 48 hours after helicopters had approached. Goats reacted similarly when helicopters were in-sight and out-of-sight behind ridges. Cadsand (2012) did not find evidence for sensitization or habituation to helicopters. Animals did not avoid areas disturbed by helicopters, but the selection and use of escape terrain increased with greater helicopter activity.

Management recommendations:

1. Maintain 2000 m distances to goats for in-sight and out-of-sight helicopter approaches.
2. If maximum disturbance is less than 1 hour/month, separation distance should be reduced to 1500 m.

3. Heli-skiing flights should be monitored using on-board GPS to assess compliance to distance buffers around goat winter range.

GROUND DISTURBANCE STUDY

Caw Ridge, Alberta

St-Louis et al. (2012) studied responses of mountain goats to All-Terrain-Vehicles (ATV) at Caw Ridge, Alberta; the same animals with which Côté (1996) and Côté et al. (2012) studied responses to helicopters. The ground study used the same behavioral criteria as Côté (1996) for lightly disturbed, moderately disturbed, or greatly disturbed responses. Researchers documented 201 reactions of mountain goats to approaching ATVs. Overall, goats were undisturbed or lightly disturbed 56% of the time, moderately disturbed 21%, and greatly disturbed 23% of the time. The angle of approach (direct, parallel, oblique), vehicle speed, goat group size, and goat behavior before the approach, all influenced responses. A direct, rapid approach had the strongest negative effect. Compared to parallel ATV travel, direct approaches were 31 times more likely to cause a strong goat response, and 17 times more likely to cause a moderate response. When ATVs approached at 40 km/hour, goats were 8 times more likely to be moderately than lightly disturbed compared to lower speeds. Goats showed little or no response during half of the encounters, suggesting goats did not perceive ATVs as a major threat. However, the strong response to fast and direct approaches showed ATVs can negatively affect goat behavior, with the potential to reduce fitness if ATV traffic is long-term. St-Louis et al. (2012) found that various factors did not affect behavioural responses including: sex-age class, season, time of day, wind speed, wind direction, group size, and distance to escape terrain.
Management recommendations:

1. ATV riders should be discouraged from approaching goats directly.

2. Riders should be encouraged to reduce speed when they approach goats.

3. Government should establish regulations on ATV use in the wild.

4. Government should restrict access in certain areas frequented by goats.

Caribou (barren-ground and woodland)

HELICOPTER AND FIXED-WING DISTURBANCE STUDIES

Northern Yukon

Calef et al. (1976) were among various researchers in the 1970s documenting response of barren-ground caribou to aircraft disturbance. During two years, they recorded the reactions of 736 caribou groups (ranging from singles to many thousands of animals) to approaching fixed wing aircraft and helicopters. Their objective was to determine minimum aircraft distances that caused panic responses in caribou that might lead to injury or death. They used a gradient of 5 reactions, ranging from no visible response to panic (animal running out of control, endangering itself).

Caribou were sensitive during calving, post-calving and during fall migration (rut). Caribou were most sensitive during calving, showing panic and strong escape responses up to 150 m from aircraft. Calves were most sensitive compared to other caribou. During the rut, aircraft flying less than 60 m above the ground caused most caribou to panic, and 30-65% of groups fled when aircraft were lower than 150 m above the ground. In spring migration, 40-60% of groups fled when aircraft were 60-90 m away, but panic response was lower than during the rut. Animals responded less to helicopter (Bell 206) than fixed-wing aircraft. Caribou group size had no effect on responses. The researchers concluded that panic responses happened when aircraft were less than 150 m away, and most caribou ran when aircraft were 300 m or closer.

Management recommendations:

1. To avoid caribou injuries or death, aircraft should maintain an elevation of 300 m above ground on caribou range at all times of the year.

Beverly Caribou Herd Calving Range, Northwest Territories

Gunn et al. (1983) studied responses of caribou to 16 helicopter approaches and landings on the calving range of the Beverly herd, Northwest Territories. Ground observers monitored for change in 6 activities (bedded, foraging, standing, walking, trotting, and galloping) at 2-minute intervals over the disturbance phase. When a helicopter approached and landed, observers recorded the direction the cow-calf groups moved, if the cow and calf trotted or galloped away, the direction they moved, and the period each animal ran. Researchers recorded 307, 2-minute scans. In 9 of 16 approaches, caribou started to move before the helicopter descended from 300 m above the ground. The rate of nursing declined during the disturbance phase. Overall, cows and calves were readily displaced and their activity patterns interrupted by landing 300 to 2000 m away.

Management recommendation:

1. Aircraft should maintain 600 m elevation above ground during calving and post-calving.

Delta and Western Arctic Herds, Alaska

Valkenburg and Davis (1985) compared the responses of caribou to small aircraft overflights during winter in the Delta caribou range - a herd that had been habituated to military overflights – with responses in the non-habituated Western Arctic herd. Delta caribou ran from 36% of flights compared to 85% in the Western Arctic herd. Western Arctic caribou also ran for longer periods when disturbed by aircraft. Both herds were more disturbed by low-level helicopter flights below 100 m compared to fixed-wing over flights. The intensity of caribou disturbance response diminished when both aircraft types were more than 300 m above the ground.

Central Selkirk Mountains, British Columbia

Wilson and Hamilton (2003) assessed the combined, long-term effects of logging, heliskiing and snowmobile activities on winter range use by caribou in the Central Selkirk Mountains, British Columbia. They followed 36 VHF radio-tagged caribou, collecting 449 early winter and 519 late winter locations. They ran an analysis of cumulative effects analysis with the following factors: frequency of heli-skiing run use; high, low or no snowmobile use; elevation, aspect and slope; forest habitat type; and snow depth during early and late winter. Terrain and structural stages of the forest best explained where caribou were distributed in early and late winter. Heli-skiing had a minor effect on caribou use of habitats in late winter. Snowmobile use did not affect caribou at the scale of the study, contrary to Seip et al. (2007, see below).

GROUND DISTURBANCE STUDIES

Hart Range, British Columbia

Snowmobile disturbance caused woodland caribou to abandon preferred winter habitat in the Hart Ranges, British Columbia (Seip et al. 2007). The study used a resource selection function (RSF) to quantify winter habitat values in different survey areas, including one area that was heavily used by recreational snowmobilers. Researchers used caribou counts and a habitat-based estimator of population size to predict the number of caribou expected to occur on survey blocks. Then they compared the number of caribou seen on the blocks to the expected number based on habitat conditions. During 4 winters, caribou were found on the 4 blocks that had little or no snowmobile use. No caribou were seen in 3 of the 4 winters in the snowmobile-disturbed block. RSF analysis showed the habitat in the snowmobile-disturbed block could support 75 caribou, and the habitat was of similar quality to the other blocks. Seip et al. (2007) concluded snowmobile disturbance displaced caribou from high quality habitat. They cautioned that disturbed caribou could be forced into terrain with inferior habitat quality where there is a greater risk of mortality from avalanches, predation, or nutritional stress.

Management recommendations:

1. Snowmobiling should be restricted from high quality woodland caribou winter habitat, or limited to a small proportion of the high quality habitat available for each herd in British Columbia.

Gros Morne National Park, Newfoundland

Mahoney et al. (2001) studied responses of 162 caribou groups to controlled snowmobile approaches during 4 winters in Gros Morne National Park, Newfoundland. They drove snowmobiles to provoke caribou, noting the angle of approach and recording median distances to the first visible reaction (205 m), alarm (172 m), and fleeing response (100 m). Responses varied by year, with caribou groups in the initial year reacting sooner to snowmobiles and moving greater distances, than in other years. Angle of approach had no effect on caribou response. In all years, groups with calves allowed snowmobiles to approach closer before reacting compared to adult-only groups. Compared to other caribou groupings, cow/calf groups showed the shortest disturbance periods before resuming their pre-disturbance behavior. The results of this study were therefore contrary to some other studies (e.g. Powell 2004) that found cow-calf groups were most sensitive to disturbance. Gros Morne caribou have been exposed to high snowmobile activity for a long time, and might be somewhat habituated to the disturbance. Caribou showed lower movement rates and shorter displacement distances when snow was deep, suggesting they adjusted their responses to minimize spent energy. The researchers concluded that approaching snowmobiles were displacing caribou from resting and feeding, and forcing increased movement rates, potentially affecting energy intake.

Ibex Caribou Herd Winter Range, Yukon Territory

Powell (2004) studied the effects of snowmobiles on winter range of the Ibex caribou herd near Whitehorse, Yukon Territory. The area had high snowmobile use, and caribou were at risk of being displaced by increasing recreational activities. Using treatment/control area comparisons, Powell (2004) tested predictions that snowmobile disturbance would increase caribou vigilance and movement, compared to undisturbed caribou. Results showed that snowmobile speed and approach angle did not affect reaction. Compared to males, maternal cow/calf groups reacted when snowmobiles were further away, they were twice as likely to run from approaching machines, and they spent more time moving and being vigilant after the disturbance passed. Flight initiation distance declined as the size of male groups increased, but it did not change for cow/calf groups. Powell (2004) estimated that a single disturbance response increased daily energy expenditure by 1%; less than the 5% estimated for Svalbard reindeer (Tyler 1991). When snowmobiles were absent, caribou in the disturbed area spent similar amounts of time feeding, resting, being vigilant, and moving, as caribou in undisturbed areas. Generally, Ibex caribou reacted when snowmobiles were further away compared to caribou and reindeer in other studies.

Management recommendations:

1. Maintain a distance of 500 m or more between snowmobiles and caribou.

2. Educate snowmobile users of the risk of approaching caribou at close distance.

6. GUIDELINES TO AVOID DISTURBANCE TO ALPINE UNGULATES AND RAPTORS

Mountain Goat and Thinhorn Sheep

a. Aircraft

Our review of disturbance studies found that mountain goats and wild sheep react strongly to helicopters (Frid 2003, British Columbia Mountain Goat Management Team 2010). Both species are especially sensitive during birth, neonatal rearing, and winter periods (mountain goats: Hurley 2004, Goldstein et al. 2005, Cadsand 2012; sheep: Stockwell et al. 1981, Bleitch et al. 1994, Frid 2003). Consequently, we grouped both species in our recommended operating standards (Section 7).

Frid (2003) argued that lost ruminating time is the most critical effect of disturbance, and that the point at which the animals stop ruminating is a better indicator of negative effects of disturbance than is flight initiation distance (FID). He recommended a minimum horizontal buffer of 3000 m for Dall's sheep based on the distance that they stopped resting (and ruminating) when aircraft approached (Frid 2003). Most other studies have recommended buffers based on FID, because fast movement (i.e. flight) away from the current site is easily recognizable as a disturbance-induced behavioural shift. Côté (1996), Cadsand (2012) and Goldstein et al. (2005) recommended a 2000 m buffer for mountain goat, based on FID. The Government of British Columbia (2008) and the British Columbia Mountain Goat Management Team (2010) recommended a 2000 m horizontal buffer for both mountain goats and wild sheep. Côté et al. (2012) reduced the buffer to 1500 m based on some evidence of habituation by goats at the study site, and Cadsand (2012) recommended 1500 m if helicopter exposure is less than 1 hour/month. Gordon and Wilson (2004) recommended helicopters stay 1500 m from mountain goat nursery bands between May 15 and June 15. Government of British Columbia (2006) recommended 1500 m, unless an alternate strategy is proposed and some sort of monitoring is carried out. The Northern Wild Sheep and Goat Council (Hurley 2004) recommended helicopters approach no closer than 1500 m to mountain goat kidding areas from May 1 to July 15, and winter range from November 1 to April 30.

Côté (1996) recommended helicopters should stay more than 300 m above the ground and not land on open alpine ridges. On U.S. federal lands in Alaska, aircraft must not land closer than 800 m and fly less than 500 m above goats (see Goldstein *et al.* 2005). Stockwell et al. (1991) recommended a ceiling of 500 m above occupied bighorn sheep range.

Recent guidelines for Alberta (Government of Alberta 2010) and British Columbia (Government of British Columbia 2008, British Columbia Mountain Goat Management Team 2010) recommend aircraft fly more than 400 m above goat and sheep range. Alberta also limits industrial activities in alpine areas from July 1 to August 22 (to avoid disturbing hunters). Guidelines also restrict only 1 geophysical exploration activity at one time, and no more than 1/3 of a contiguous block of range may be available for mineral exploration at any time. Flight paths to and from approved activity area should avoid steep cliffs, mineral licks, and other high use sheep/goat areas.

In Alberta, exploration companies are encouraged to hire qualified biologists to monitor activity of goats and bighorn sheep during exploration to mitigate disturbances. In B.C., biologists are required to monitor activities of heli-ski operations in goat range using on-board GPS tracking devices (Government of British Columbia 2006, AECOM 2009). Evaluation of one operation in northern B.C. shows the company has successfully avoided goat wintering habitats using these methods (Cadsand 2012).

Based on research by Frid (2003), the Government of Yukon (2006) guidelines include maintaining a distance of 3500 m away from known Dall's sheep range, avoiding lambing cliffs and mineral licks from May 1 to June 15, placing a ridge between helicopter and sheep, flying below the elevation of known sheep, and concentrating flying time over the shortest period. Stockwell et al. (1991) recommended restricting the number of helicopter flights, and avoiding flying in morning and late evening when alpine ungulates are most actively feeding and ruminating (Frid 2003). Any closer flights should use topographic features to block goats from seeing the helicopter, avoid flying below and directly towards known goats, avoid hovering or landing nearby, and minimize the number of flights and duration spent inside the disturbance zone.

The Gitanyow Huwilp Recognition and Reconciliation Agreement (2013) does not allow helicopter logging within 2000 meters line of sight of goat winter range, and no industrial activities are allowed within 1000 m of canyon winter range, and within 500 m of occupied goat range between November 1 and June 15.

b. Ground

There are no formalized distance buffers or timing windows for ATVs, snowmobiles, or pedestrian disturbances in any jurisdiction. Government of Alberta (2010) and the Yukon Chamber of Mines (2010) recommend ATV drivers restrict travel to existing alpine trails, but there is no definition of such trails. B.C. Ministry of Forest and Range (2008) recommend ATVs avoid alpine areas and stay off undefined, 'sensitive' areas.

Woodland Caribou

a. Aircraft

Caribou responses to human disturbances tend to be brief and moderate. Compared to other ungulates, all subspecies of *Rangifer* allow humans to approach much closer before reacting (see Reimers and Colman 2006). This close approach advantage has led to the evolution of many circumpolar caribou-hunting cultures since the end of the ice age (Speiss 1979).

Caribou are most sensitive to disturbance during calving and post-calving, fall rut, and winter (see Porcupine Caribou Technical Committee 1993, Government of Yukon 2008). Harrington (2001) argued woodland caribou are especially vulnerable during calving and post-calving because cows have evolved to 'space away' to isolated, solitary calving sites (i.e., rugged alpine slopes and snow patches) to avoid calves being detected by predators. Any increase in movements in early summer following aircraft disturbance could increase the probability of calves being found and killed by predators, and would increase energetic costs for mother and calf.

Unfortunately, there are no studies on the response of woodland caribou to aircraft during calving, and there are no ground disturbance studies during summer to recommend distance buffers or timing windows for the woodland caribou ecotype.

Calef et al. (1976) and Government of Yukon (2008) recommended aircraft should stay at least 300 m above the ground in occupied caribou range at all times of the year. Gunn et al. (1983) and Government of Yukon (2008) recommended 600 m during calving, post calving and rut. Government of Yukon (2008) suggested aircraft avoid flying near mountain snow patches where caribou aggregate after calving, and stay more than 1000 m from mineral licks used by caribou.

b. Ground

We could find no distance or timing window recommendations for ATVs other than snowmobiles, so we recommend adapting snowmobile buffers until caribou responses to other ATVs are studied. Tyler (1991) found that wild reindeer in Scandinavia first reacted to snowmobiles at 640 m, showed overt disturbance at 400 m, and usually fled at less than 100 m. Intense snowmobile activity can displace caribou from preferred habitats (Seip et al. 2007), and can substantially alter the normal feeding and resting schedule (Mahoney et al. 2001). Maternal groups were more sensitive than males to snowmobiles in the Yukon (Powell 2004), but less sensitive than males in Newfoundland (Mahoney et al. 2001). Powell (2004) recommended a minimum distance of 500 m between snowmobiles and caribou. We recommend a conservative ATV distance buffer of 750 m from woodland caribou during calving and post calving, and 500 m for late summer, fall and winter (see Section 7).

Nesting Raptors

Golden eagle, gyrfalcon and peregrine falcon are the 3 cliff-nesting raptors most vulnerable to disturbance caused by helicopter flights in the Yukon. Bald eagle is also susceptible to disturbance because it nests near water bodies that are attractive as camp sites for industrial and recreational interests. Northern goshawk is of concern because it nests in old growth forest which is often targeted for timber harvest. We address these species collectively because they have high inter-annual fidelity to the same nest sites, or nesting cliffs, and therefore these key habitats can be identified with high spatial accuracy.

Golden eagles are at the greatest risk because they have *low* tolerance disturbance before abandoning young. They nest throughout the Yukon on cliffs situated generally in landscapes with a relative lack of forest cover. These are also landscapes where mineral exploration activities are often concentrated. The northern goshawk also has *low* tolerance, nesting in lower elevation forested areas. Gyrfalcons are at *moderate* risk to disturbance. Their nesting sites are found throughout the Yukon on mountain cliff faces. Peregrine falcons concentrate their nesting along lower elevation riparian cliffs and bluffs. Peregrines are at *moderate* risk of abandoning their nests when disturbed by human activities. A single, direct disturbance from a helicopter may have insignificant effects on nesting success. But repeated flights close to the nest may cause the adults to abandon the site. Establishing a base camp near an active cliff nest may also cause abandonment.

There has been substantial research on the tolerances of various raptors to human activities, based on how far each species tends to flush when disturbed by stimuli. Table 1 summarizes these distance for Yukon nesting raptors based on literature reviews elsewhere (Richardson and Miller 1997, Whittington and Allen 2010, Government of British Columbia 2008 and 2013), and specific guidelines for peregrine falcons in Ontario (Ontario Ministry of Natural Resources 1987), and Alaskan raptors (Pebble Partnership 2010).

Helicopters are a high-risk disturbance during the nesting period because adults often sit tightly on eggs or young nestlings. If a helicopter approaches rapidly, the surprised adults may suddenly flush and eject eggs or young from the nest, ending the breeding attempt. In addition to distance buffers, Richardson and Miller (1997) suggested timing windows should exclude all human activities within the buffered space spanning the early arrival of adult birds, egg laying, hatching, and fledging of young.

The Pebble Partnership (2010) recommended the following operating standards for helicopters in Alaska to avoid disturbing golden and bald eagle, gyrfalcon, peregrine falcon, and northern goshawk; the 5 raptors most at risk in the state.

- When an occupied nest is seen, avoid flying directly over it, and maximize horizontal distance in helicopter as quickly as possible, staying at least 800 m away.
- Avoid landing within 800 m of an occupied nest. This may require exploring for minerals at another site or coming back later, after young birds fledge.
- For all occupied nests, these flight precautions should be exercised from 15 March-31 August (for cliff nesting golden eagles, gyrfalcons and peregrines), and 15 April-31 August (for tree nesting bald eagles and goshawks).
- Helicopter flights may be necessary in this zone from time to time, but routine flights should be as far away as are safe and practical. The goal is to avoid repeated aerial disturbance during nesting.
- Approach nests along a tangential visible path. Do not approach cliff nests from behind, which increases the chances for adults being alarmed and ejecting eggs or nestlings from nest.
- Do not land on top of cliffs or river bluffs.

Table 1. Recommended minimum buffers for nesting raptors: [1]United States Fish and Wildlife Service (Whittington and Allen 2008), [2]British Columbia (Government of British Columbia 2013), [3]Ontario (Ontario Ministry Natural Resources 1987), [4]Alaska helicopter guidelines (Pebble Partnership 2010), [5]Peace River helicopter guidelines (Government of British Columbia 2008), and [6]Richardson and Miller (1997). * Shows Yukon raptor species of highest concern.

Falconiformes

Common name	**Species name**	**Ability to tolerate disturbance**	**Horizontal avoidance distance (m)**	**Aircraft distance (m above ground)**
Golden eagle*	*Aquila chrysaetos*	Low	800[1,4,6],500[2]	400[5],150[4]
Bald eagle*	*Haliaeetus leucocephalus*	Moderate-high	800-1600[1,4],500[6] 200[2]	400[5],150[4]
Gyrfalcon*	*Falco rusticolus*	Moderate	800[4],400[1],500[2]	400[5],150[4]
Peregrine falcon*	*Falco peregrinus*	Moderate	800[4,6],1600[1,3],500[2]	400[5,3],150[4]
Northern goshawk*	*Accipiter gentilis*	Low	800[1,4],500[2],450[6]	400[5],150[4]
Sharp-shinned hawk	*Accipiter striatus*	Moderate	800[4],450[6],400[1],500[2]	400[5],150[4]
Rough-legged hawk	*Buteo lagopus*	Moderate	800[4],400[1],500[2]	400[5],150[4]
Merlin	*Falco columbarius*	Moderate-high	800[4],400[1],200[2]	400[5],150[4]
Kestrel	*Falco sparverius*	Moderate-high	800[4],200[1,2]	400[5],150[4]
Cooper's hawk	*Accipiter cooperii*	Moderate-high	800[4],400[1],200[2]	400[5],150[4]
Swainson's hawk	*Buteo swainsoni*	Moderate-high	800[4],400[1],200[2]	400[5],150[4]
Northern harrier	*Circus cyaneus*	Moderate-high	800[4],400[1],200[2]	400[5],150[4]
Red-tailed hawk	*Buteo jamaciensis*	High	800[4],500[1],450[6],200[2]	400[5],150[4]
Osprey	*Pandion halietus*	High	1000[6],800[4],400[1],200[2]	400[5],150[4]

Strigiformes

Western screech-owl	*Megascops kennicotti*	Moderate	800[4],200[1],500[2]	400[5],150[4]
Northern pygmy owl	*Glaucidium gnoma*	Moderate	800[4],400[1],500[2]	400[5],150[4]
Great gray owl	*Strix nebulosa*	Moderate	800[4],400[1],500[2]	400[5],150[4]
Northern hawk owl	*Surnia ulula*	Moderate	800[4],200[1],500[2]	400[5],150[4]
Boreal owl	*Aegolius funereus*	Moderate	800[4],200[1],500[2]	400[5],150[4]
Snowy owl	*Bubeo scandiacus*	Moderate-high	800[4],200[1,2]	400[5],150[4]
Northern saw-whet owl	*Aegolius acadicus*	Moderate-high	800[4],200[1,2]	400[5],150[4]
Great-horned owl	*Bubeo virginianus*	High	800[4],200[1,2]	400[5],150[4]

The Government of British Columbia (2008) issued guidelines for exploration companies using helicopters, including:

- Prepare a written flight plan to avoid important wildlife habitats, including raptor nest sites.
- Avoid disturbing nesting birds of prey from May 15 through July 15.
- Designate avoidance distance of 500 m above ground and 2000 m horizontal for cliff nesting raptors.
- Plan suitable flight routes to maintain avoidance distances, provide visual screening and reduce flights near occupied nests.
- Identify suitable landing sites, and instruct pilots to use them whenever it is safe.

Knowing the location of raptor nest sites is essential to managing aircraft and other disturbances associated with mineral exploration. Before timing windows, spatial buffers, and best practices for helicopters can be applied, companies need to know where nesting sites are located in their area of exploration interest or backcountry use. Such information could come principally from (i) existing mapped inventories held by various First Nations and Yukon Territorial government agencies, and (ii) new inventory work done as part of environmental impact assessment work in preparation for exploration and development work by mining, forestry and recreational interests.

The Yukon government surveyed various mountain ranges of the Yukon during the 1970-1980s. The locations of cliff nests of golden eagles and falcons are included in key wildlife area maps available from the Yukon Department of Environment. These sites and other critical wildlife areas should help form the details of flight routes and work scheduling to avoid disturbing raptors during nesting periods. Raptors will sometimes use alternate nesting sites, so exact locations of occupied nests may vary from year to year. Locations of gyrfalcon and peregrine falcon nests are not generally available to the public, due to the high value of young nestlings to falconers. Confidentiality of sites should be discussed with Yukon government as part of company exploration plans.

7. FINDINGS AND RECOMMENDATIONS

Spatial Buffers and Timing Windows

Human disturbance to wildlife is clearly a pervasive and complicated issue for managers of the land base. This review has uncovered some new science on the topic, and has also revealed some management approaches and tools of value. One of our principal conclusions is that flight initiation distance (FID) is not a sufficient indicator of a detrimental effect of a disturbance stimulus in ungulates. These animals frequently curtail other essential behaviours, notably rumination and resting, before they are actually induced to run or flee from the disturbance. Spatial buffers have often been established based on FID. However, these buffers should reflect the distances at which the animals change their ongoing behavior to one of heightened vigilance, which is better measured as a halt in the ongoing behaviour and shift to a posture from which flight could be initiated.

We have summarized our recommendations regarding spatial buffers and timing windows in Tables 2, 3 and 4. These suggested management directions are based on our interpretation of the current science, and an understanding of how other jurisdictions are dealing with the issue of disturbance.

Recommendation: WCS Canada recommends that the management criteria outlined in Tables 2, 3 and 4 be implemented in Yukon.

In the following section we provide some general thoughts on the applicability of the scientific information we have gathered, with our recommendations on how it might be used.

The specific regulatory and management mechanisms for implementing spatial buffers and timing windows are potentially varied. At the strategic scale, the need to apply these management approaches is best accomplished in regional land use plans (such as those mandated by the Umbrella Final Agreement) and strategic forest management plans. These plans may not include inventory and maps of the key habitats in question, but would ideally provide general management direction indicating that the risk of disturbance to these habitats needs to be addressed with buffers and windows.

Such strategic management direction would then feed into tactical scale or derivative planning processes, such as sub-regional plans and Timber Harvest Plans. At these scales, specific inventory information would be required, with direct application of buffers and windows.

Recommendation: WCS Canada recommends that the risk of disturbance to alpine ungulates and raptors in the spatially discrete seasonal habitats outlined in this review, be addressed through general management direction regarding spatial buffers and timing windows. The most effective approach is through strategic land and resource management plans, and any derivative planning processes such as sub-regional plans.

In the mineral exploration context, the regulatory framework is still in a state of flux, given lack of resolution on a new governance regime following the Yukon Court of Appeal decision in RRDC vs. Government of Yukon (December 2012). The most responsible approach to mineral exploration would require that a mining interest provide an Exploration Plan to all concerned governments before any prospecting and exploration takes place. In this context, the potential exploration activities can be reviewed in the context of all resource values, including wildlife habitats. Currently, there is no opportunity for management and stewardship agencies to explicitly address wildlife disturbance through the prospecting and staking stages, prior to Class 1 notifications now enabled through Bill 66 (Amendments to the Quartz and Placer Mining Acts). WCS Canada is concerned that Class 1 notifications may not be applied territory-wide.

Recommendation: WCS Canada recommends that all mineral exploration interests should be required to provide Exploration Plans in all parts of the Yukon. Such Plans should be reviewed by agencies with knowledge of wildlife habitats (Yukon Department of Environment, First Nation governments and regional Renewable Resources Councils). Plans should be open for change wherever there is unnecessary disturbance to wildlife and wildlife habitats.

In this document we have provided the scientific evidence for establishment of spatial buffers around key habitats for alpine ungulates and for raptors with high nest fidelity, along with timing windows for their application. This information is of little value unless it is formalized in policy or regulatory processes whereby the recommended buffers and timing windows have the force of law or at least normative behavior. For example the specific buffers and timing windows (Tables 2, 3 and 4) could become:

- Standard Operating Conditions attached to mineral exploration and commercial backcountry recreation permits (e.g. Special Operating Areas in Class 1 notification and permitting under the *Quartz* and *Placer Mining Acts*).
- Permitting conditions prescribed by Yukon Environmental or Socio-economic Assessment Board (YESAB) or the Inuvialuit Environmental Impact Screening Committee (EISC) in review of an environmental impact assessment.
- General guidelines for ongoing activity on the integrated management land base (e.g. Best Management Guidelines developed by Yukon Environment and Yukon Energy, Mines and Resources).

Recommendation: WCS recommends that Yukon Environmental and Socioeconomic Assessment Board incorporate spatial buffers and timing windows into the conditions imposed on projects through the regular YESAB impact assessment process. WCS also recommends that Yukon Energy, Mines and Resources implements the timing windows and spatial buffers outlined in this document as special operating conditions for Class 1 mineral exploration in the Territory. WCS also recommends that Yukon Environment champion the development of Best Management Guidelines for minimizing aircraft disturbance, incorporating the scientific information brought forward in this document along with future new work.

At the operational scale, aircraft disturbance cannot be reduced without the compliance of the aircraft operators. The information presented in this document, specifically the flight guidelines for B.C. (Government of British Columbia 2008) and Alaska (Pebble Partnership 2010), provide solid direction for aircraft operators. This information needs to be effectively communicated to the operators (managers and pilots), and to the biologists developing mitigation measures for environmental impact assessments and permits. Such communication may have to be an ongoing activity.

The ability to effectively manage disturbance depends on an accurate and complete inventory of wildlife habitats. Although considerable mapping already exists (e.g., Yukon Environment's Key Wildlife Areas database; some First Nations' databases), current inventories are far from complete and there is a lack of resolution on appropriate definitions of habitat boundaries and of scale.

Recommendation: WCS Canada recommends that management agencies take a pro-active approach to dealing with the question of adequate and necessary definitions of, and appropriate scales, for mapping seasonal habitats for focal species, with an initial focus on the alpine ungulates and raptors discussed in this document. Yukon Environment is the agency best positioned to take on this role, because of its existing inventories and its mandate.

Recommendation: WCS Canada recommends that management agencies (in all governments), and interested parties, focus considerable effort on acquiring the inventories of key seasonal habitats for diverse wildlife species, and mapping these digitally so that they can be recognized in future land and resource management actions.

Knowledge Gaps

In reviewing the literature we have identified the following gaps in scientific knowledge:

1. There is no information on the long-term effects of intense, aerial disturbance on the use of seasonal habitats or the productivity and population composition of the alpine ungulates. Some Yukon observers have reported complete abandonment of summer range by Dall's sheep during and after intensive helicopter activity for a prolonged period. This seems to be a serious concern given that sheep choose the optimum range available to them in any season. However, the duration of range abandonment and possible demographic effects remain unknown.
   Recommendation: WCS recommends that managers attempt to learn about longer-term effects of intensive and prolonged use of helicopters on alpine ungulates by establishing studies in conjunction with a mineral exploration or backcountry recreation operation. The goals would be to (i) test how well the spatial buffers and timing windows work to avoid negative effects of aircraft, and (ii) test how well restrictions on intensity of activity within contiguous mountain blocks work to mitigate disturbance. The focus would be on the extent, if any, of range abandonment, and the productivity of the population or herd. It would be unethical to subject the animals to intensive disturbance by ignoring buffers and timing windows, so the study design should include "control" populations that are subjected to no, or very minimal, helicopter disturbance.

2. There is no information on short-term effects of ground disturbance by all-terrain vehicles (ATVs – principally four-wheelers, but also mountain bikes) during summer on thinhorn sheep or woodland caribou, and also little information, with management recommendations, on short-term effects of ground disturbance on mountain goats. Summer use of all-terrain vehicles for mineral exploration, hunting and recreation is very extensive in Yukon, and potentially a large source of disturbance to these alpine ungulates. Recommendation: WCS recommends that the Yukon government lead a study of the short-term responses of caribou, thinhorn sheep and mountain goats to summer ATV and mountain bike/hiker disturbance. The goal would be to determine effective distance buffers and timing windows within which most disturbance to these ungulates would be avoided, and provide more substance to the recommendations in Tables 2 and 3.

7. SPECIFIC RECOMMENDATIONS FOR UNGULATES AND RAPTORS

Table 2. Recommended operating conditions for aircraft and ground activities near thinhorn sheep and mountain goat ranges.

SOURCE OF DISTURBANCE	SEASON OR TIMING WINDOW	DISTANCE BUFFER	GENERAL CONDITIONS
Aircraft	Spring – May & June (Birthing and Neo-natal)	Horizontal Helicopter: 3000[1] m Fixed-wing: 1000 m Vertical Heli & Fixed: 500 m	Permitting process (mineral exploration or backcountry recreation) must detail measures to avoid disturbance. Compliance monitoring with on-board GPS flight tracking units assessed with respect to prescribed flight paths.
	Summer – July *Nursery or offspring rearing ranges*	Horizontal Helicopter: 3000[1] m Fixed-wing: 1000 m Vertical Heli & Fixed: 500 m	Permitting process (mineral exploration or backcountry recreation) must detail measures to avoid disturbance. Compliance monitoring with on-board GPS flight tracking units assessed with respect to prescribed flight paths.
	Summer – July *Other ranges*	Horizontal None Vertical None	No more than 1/3 of contiguous block of range available for access at any one time Maximum one geophysical exploration program or one commercial backcountry recreation program at one time, *OR* Maximum of 1 hour per month of cumulative helicopter disturbance permitted on a block of range
	Fall - Aug through Oct *Non-hunting ranges*	Horizontal None Vertical None	No more than 1/3 of contiguous block of range available for access at any one time Maximum one geophysical exploration program or one commercial backcountry recreation program at one time, *OR* Maximum of 1 hour per month of cumulative helicopter disturbance permitted on a block of range
	Fall - Aug through Oct *Hunting ranges*	Horizontal Helicopter: 3000[1] m Fixed-wing: 1000 m Vertical Heli & Fixed: 500 m	Permitting process (mineral exploration or backcountry recreation) must detail measures to avoid disturbance. Compliance monitoring with on-board GPS flight tracking units assessed with respect to prescribed flight paths.
	Winter - Nov through April *Rut & winter*	Horizontal Helicopter: 3000[1] m Fixed-wing: 1000 m Vertical	Permitting process (mineral exploration or backcountry recreation) must detail measures to avoid disturbance.

		Heli & Fixed: 500 m	Compliance monitoring with on-board GPS flight tracking units assessed with respect to prescribed flight paths.
	Mineral Licks	<u>Horizontal</u> Helicopter: 3000[1] m Fixed-wing: 1000 m <u>Vertical</u> Heli & Fixed: 500 m	Permitting process (mineral exploration or backcountry recreation) must detail measures to avoid disturbance. Compliance monitoring with on-board GPS flight tracking units assessed with respect to prescribed flight paths.
Ground (Camps, ATV route, snowmobile route, walking)	Winter through early summer - Nov through June & Mineral licks *All ranges*	<u>Horizontal</u> 1000 m	
	Summer through fall – July through October *All ranges*	<u>Horizontal</u> None	No more than 1/3 of contiguous block of range available for access at any one time Maximum one geophysical exploration program or one commercial backcountry recreation program at one time, *OR* Maximum of 1 hour per month of cumulative disturbance permitted on a block of range

[1] based on maximum distance that resting sheep stop ruminating in response to helicopter presence (Frid 2003).

Table 3. Recommended operating conditions for aircraft and ground activities near woodland caribou ranges.

SOURCE OF DISTURBANCE	SEASON OR TIMING WINDOW	DISTANCE BUFFER	GENERAL CONDITIONS
Aircraft	Spring – May through June *Calving and Post-calving ranges*	<u>Horizontal</u> Helicopter: 2000 m Fixed-wing: 1000 m <u>Vertical</u> Heli & Fixed: 600 m	Permitting process (mineral exploration or backcountry recreation) must detail measures to avoid disturbance. Compliance monitoring with on-board GPS flight tracking units assessed with respect to prescribed flight paths.
	Summer – July through 15 Sept *All ranges*	<u>Horizontal</u> None <u>Vertical</u> None	
	Fall & Winter – 16 Sept through April *Rut and winter ranges*	<u>Horizontal</u> Helicopter: 2000 m Fixed-wing: 1000 m <u>Vertical</u> Heli & Fixed: 600 m	Permitting process (mineral exploration or backcountry recreation) must detail measures to avoid disturbance. Compliance monitoring with on-board GPS flight tracking units assessed with respect to prescribed flight paths.
	Mineral Licks	<u>Horizontal</u> Helicopter: 2000 m Fixed-wing: 1000 m <u>Vertical</u> Heli & Fixed: 600 m	Permitting process (mineral exploration or backcountry recreation) must detail measures to avoid disturbance. Compliance monitoring with on-board GPS flight tracking units assessed with respect to prescribed flight paths.
Ground (ATV & snowmobile routes, walking, camps)	Spring & Summer – May through June *Calving and post-calving ranges*	<u>Horizontal</u> ATV & walking: 1000 m	
	Winter – Nov through April *Winter ranges*	<u>Horizontal</u> Snowmobile: 500 m	
	Mineral Licks- All year	<u>Horizontal</u> All activity: 1000 m	

Table 4. Recommended operating conditions for aircraft and ground activities near golden eagle, bald eagle, gyrfalcon, peregrine falcon, and northern goshawk nesting sites.

SOURCE OF DISTURBANCE	SEASON OR TIMING WINDOW	DISTANCE BUFFER	GENERAL CONDITIONS
Aircraft	Spring & Summer *Nesting* Gyrfalcon (15 Mar to 15 June); Golden eagle (15 Mar to 15 Aug); Other species (15 April to 1 August)	Horizontal Helicopter: 2000 m Fixed-wing: 1000 m Vertical Heli & Fixed: 500 m	Applies to all known nest sites or high frequency nesting areas Permitting process (mineral exploration or backcountry recreation) must detail measures to avoid disturbance, including prescribed flight paths using distance buffers. Biologist monitors raptor nests and aircraft flights for compliance with flight paths and levels of disturbance
	Other Seasons *Non-nesting*	Horizontal None Vertical None	
Ground (ATV & snowmobile routes, camps)	Spring & Summer *Nesting* Gyrfalcon (15 Mar to 15 June); Golden eagle (15 Mar to 15 Aug); Other species (15 April to 1 August)	Horizontal ATV, snowmobile, camps: 1000 m	Applies to all known nest sites or high frequency nesting areas Permitting process (mineral exploration or backcountry recreation) must detail measures to avoid disturbance, including prescribed travel routes using distance buffers. Biologist monitors raptor nests and travel routes for compliance with buffers and levels of disturbance
	Other Seasons *Non-nesting*	Horizontal None Vertical None	

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