Do mountain goats habituate to helicopter disturbance?

Article *in* Journal of Wildlife Management · August 2013

DOI: 10.2307/23470662

Steeve D Côté
Laval University

Antoine St-Louis
Ministère des Forêts, de la Faune et des Parcs, Québec, Canada

Julien Mainguy
Ministère des Forêts, de la Faune et des Parcs

The Journal of Wildlife Management 77(6):1244–1248; 2013; DOI: 10.1002/jwmg.565

Management and Conservation

Do Mountain Goats Habituate to Helicopter Disturbance?

STEEVE D. CÔTÉ,[1] *Département de Biologie and Centre D'études Nordiques, Université Laval, Québec, QC G1V 0A6, Canada*

SANDRA HAMEL, *Département de Biologie and Centre D'études Nordiques, Université Laval, Québec, QC G1V 0A6, Canada and Faculty of Biosciences, Department of Arctic and Marine Biology, Fisheries and Economics, University of Tromsø, 9037, Tromsø, Norway*

ANTOINE ST-LOUIS, *Département de Biologie and Centre D'études Nordiques, Université Laval, Québec, QC G1V 0A6, Canada*

JULIEN MAINGUY, *Département de Biologie and Centre D'études Nordiques, Université Laval, Québec, QC G1V 0A6, Canada*

ABSTRACT Helicopter flights may affect wildlife, but habituation to disturbance is possible. We tested the hypothesis that mountain goats in a population exposed to helicopter flights for over 40 years have habituated to helicopter traffic. We contrasted behavioral responses of marked mountain goats to helicopter flights during 2 time periods (1995 vs. 2005–2009). The proportions of helicopter flights resulting in no/light, moderate, or strong disturbance were similar in 1995 and 2005–2009. Horizontal distance was the main factor determining mountain goat responses to helicopter flights; goats had a very high probability (>0.8) of being moderately and strongly disturbed (moderate: moved 10–100 m, alert for 2–10 min; strong: ran >100 m, alert for >10 min) when they were approached within 500 m by helicopters. We found that mountain goats only very slightly habituated to helicopter flights during a period of 10–15 years of repeated helicopter traffic. Because disturbance from helicopter flights has remained high, and in view of the continuous increase of helicopter traffic in mountainous habitat, we recommend helicopter flights do not approach closer than 1,500 m from mountain goat groups.

KEY WORDS Alberta, behavior, conservation, disturbance, habituation, helicopter, mountain goat, *Oreamnos americanus*.

Concerns about the potential detrimental effects of anthropogenic activities on wildlife are increasing, particularly those associated with noise (Stankowich 2008, Barber et al. 2009). Helicopter traffic for industrial activities, transportation, wildlife surveys, and tourism is noisy and widespread in most developed countries, and often affects wildlife negatively (Côté 1996, Harris 2005, Tracey and Fleming 2007). Helicopter disturbance has been reported in a variety of taxa such as birds (Harris 2005, Hughes et al. 2008), sea mammals (Born et al. 1999, Southwell 2005), and ungulates (Miller and Gunn 1979, Bleich et al. 1994, Côté 1996). Helicopter traffic may affect the foraging behavior and vigilance levels of animals, and it may even displace animals from safe habitats to areas where they might be more vulnerable to predation (Lima and Dill 1990, Frid 2003). Long-term consequences of repeated disturbance involving home range shifts from preferred habitats may also reduce body condition, survival rates, and reproductive success (Joslin 1986, Knight and Cole 1995, Phillips and Alldredge 2000).

The negative effects of helicopter traffic may be attenuated if animals habituate to this disturbance. Habituation is the decrease of a response to a stimulus and requires a frequent repeated stimulus usually occurring at low intensity (Hill et al. 1997). The role of repeated disturbance on potential habituation in wildlife species is poorly known (Hughes et al. 2008). In a previous study, we reported negative effects of helicopter flights on mountain goat (*Oreamnos americanus*) groups, which showed a strong behavioral response to most flights closer than 500 m (Côté 1996). Because our study was based on a single year when helicopter traffic had increased as a result of oil and gas exploration in the area, a common critique of our work—and of other studies based on only 1 year of data—was that mountain goats would eventually habituate to helicopter traffic. However, previous research has not provided convincing evidence that ungulates habituate to helicopter flights (Miller and Gunn 1980; Bleich et al. 1990, 1994; Frid 2003). Therefore, we tested the hypothesis that mountain goats in our study population habituated to helicopter traffic because they had been exposed to helicopter flights for over 40 years. Mountain goats are a good taxon to test for habituation because they are sensitive to human disturbance and their reaction to helicopter flights can be easily monitored in alpine environments (Pendergast and Bindernagel 1977, Joslin 1986, Hamel et al. 2006, Festa-Bianchet and Côté 2008, St-Louis et al. 2013). We specifically tested for the effects of habituation by contrasting behavioral responses of mountain goats to helicopter flights during 2 time periods separated by a decade (1995 vs. 2005–2009).

Received: 22 November 2012; Accepted: 25 March 2013
Published: 16 June 2013

[1]*E-mail: steeve.cote@bio.ulaval.ca*

STUDY AREA

We studied a marked population of mountain goats located at Caw Ridge (54°N, 119°W), west-central Alberta, Canada, in the front range of the Rocky Mountains. The climate at Caw Ridge is subarctic-arctic and snowfalls can occur during any month of the year (Festa-Bianchet and Côté 2008). Goats use 28 km^2 of alpine tundra and subalpine open forest of Engelmann spruce (*Picea engelmanii*) and subalpine fir (*Abies lasiocarpa*) at 1,750–2,170 m elevation. The landscape includes gently rolling hills and steep grassy slopes, as well as rockslides and a few cliff faces that function as crucial escape terrain for mountain goats (Festa-Bianchet and Côté 2008).

METHODS

Behavioral Observations

We marked goats aged 1 year and older with plastic ear tags and canvas collars. Since 1993, 98% of goats 1 year and older have been marked; thus, the age and sex of all individuals in the population were known (Côté et al. 1998). We used binoculars (10×) and spotting scopes (15–45×) to monitor the reaction of mountain goat groups to the approach of helicopters from May to September 1995 and 2005–2009. We observed animals at distances ranging from 300 m to 1,500 m. Total population size was 109 animals in 1995 and varied between 139 and 149 in 2005–2009. Goats were observed daily (weather permitting) by at least 2 observers. Because the study area is an open landscape of gently rolling hills above tree line, we could easily observe the movements of all goat groups.

We observed goat reactions to helicopter flights opportunistically. Goats were exposed to approximately 1–10 overflights daily during the summer. Most flights occurred along the ridge and were from helicopters carrying equipment and staff to and from industrial sites. During each helicopter approach, we recorded the date, time, group size, group type (adult [≥3 years old] male alone, bachelor [>1 adult males], adult [≥3 years old] female alone, nursery [adult females, juveniles, and kids], mixed [nursery with ≥1 adult male], and unknown [when not all individuals were identified prior to the disturbance]), behavior of animals prior to the approach (active or resting/lying), height of the helicopter above ground (altitude <100 m or >100 m), and shortest estimated horizontal distance to goats from helicopters. We estimated all distances using topographic maps. For comparisons, we visually estimated the horizontal distance of approaching helicopters from goats according to the 3 categories used by Côté (1996): <500 m, 500–1,500 m, and >1,500 m. To measure the level of disturbance, we recorded time spent alert and distance moved for each documented helicopter approach. Alert goats stood, raised their ears, and looked towards the approaching helicopter. To allow comparisons with our previous study, we classified goat responses to the approach using the same 3 categories as in Côté (1996): not/lightly, moderately, and strongly disturbed. We classified goats as not or lightly disturbed if they either continued their pre-approach activity during or after the disturbance or were alert for <2 minutes or moved <10 m. We classified goats that moved 10–100 m or were alert 2–10 minutes as moderately disturbed. We considered goats that walked or ran >100 m or were alert for >10 minutes to be strongly disturbed. We did not distinguish individual responses of marked goats, but rather recorded group responses because events happened too quickly to observe animals individually, and because individual responses would not be independent. We considered that a group changed its behavior when at least half of the individuals did so.

Statistical Analyses

We modeled the probability of mountain goats being disturbed by the approach of helicopters using a multinomial logistic regression with a logit link fitted with the R function mlogit (multinomial logit model; R package version 0.2-2, http://CRAN.R-project.org/package=mlogit, accessed 21 June 2012; R Development Core Team 2012), considering goat reactions to helicopters as ordinal responses. A multinomial logistic regression analyzes the probability of moving from the reference level of disturbance to another level. Our reference level was the probability of being not/lightly disturbed. Therefore, the multinomial logistic regression provided 2 estimates for each predictor: 1 describing the probability of goats being moderately disturbed versus not/lightly disturbed and the other describing the probability of goats being strongly disturbed versus not/lightly disturbed.

Analyses in Côté (1996), which were based on data collected in 1995, showed that the closest horizontal distance of approaching helicopters to goats was the only variable (among date, time, group size, group type, behavior of animals prior to the approach, height of the helicopter above ground, and closest estimated horizontal distance) influencing the probability of being disturbed. To verify whether the other variables measured still had no influence in 2005–2009, we performed a preliminary analysis that assessed the relationship between each variable and interaction and the probability of being disturbed, following the method proposed by Hosmer and Lemeshow (2000). Preliminary results confirmed that the horizontal distance was still the only variable influencing the probability of disturbance (for all other variables, $P > 0.2$). Because our goal was to evaluate whether goats had habituated to helicopters, we simply assessed the influence of the horizontal distance, period (1995 vs. 2005–2009), and their interaction on the probability of being disturbed. We grouped recent years because sample sizes were small in some years, and because we were interested in contrasting long-term changes rather than annual variation. We evaluated 5 a priori models using Akaike's Information Criterion, adjusted for small sample sizes (AIC_c) because the ratio of sample size to the number of parameters estimated (n/k) was <40 for some of our models (Burnham and Anderson 2002). We ranked models according to their AIC_c scores and considered models with a $\Delta AIC_c \leq 2$ as competitive (Burnham and Anderson 2002). We performed model averaging to obtain final parameter estimates and their 95% confidence intervals.

Table 1. Percentage of helicopter events resulting in no/light, moderate, or strong disturbance in mountain goats at Caw Ridge, Alberta, Canada, according to 2 time periods.

	Intensity of disturbance			
Period	**No/light**	**Moderate**	**Strong**	***n***
1995	42.0	25.9	32.1	81
2005–2009	38.1	27.6	34.3	134
All years	39.5	27.0	33.5	215

RESULTS

The percentage of helicopter events resulting in no/light, moderate, or strong disturbance were similar in 1995 and in 2005–2009 (Pearson $\chi^2_2 = 0.3$, $P = 0.9$; Table 1). As in 1995, mountain goats were still strongly disturbed in about 30% of events when approached by a helicopter in recent years. Model selection resulted in 2 models being competitive (Table 2). Both models included the closest horizontal distance; the best-supported model also included the contrast between the 2 periods (Table 2). The influence of distance and period was similar for both the probability of being moderately and strongly disturbed (Table 3, Fig. 1). Mountain goats had a very high probability of being moderately or strongly disturbed when they were approached within 500 m by helicopters in both periods (Fig. 1). These probabilities were 2–5 times lesser when the approach distance was 500 m–1,500 m (odds ratio [95% CI] using 500–1,500 m as the reference level versus <500 m for the probability of being moderately disturbed = 2.4 [0.5; 10.1], and strongly disturbed = 5.4 [1.3; 21.8]). Nevertheless, we only observed a major decrease when approach distance was >1,500 m (Table 3, Fig. 1); at this distance, the probability of being moderately disturbed was 5 times lesser and that of being strongly disturbed was 129 times lesser (odds ratio [95% CI] using >1,500 m as the reference level versus <500 m for the probability of being moderately disturbed = 5.4 [1.3; 21.8], and strongly disturbed = 129.0 [30.0; 561.2]). The probability of goats being moderately or strongly disturbed decreased slightly between the periods, mostly when the approach distance was 500–1,500 m (Table 3, Fig. 1). The differences between the periods, however, were small compared with the differences among distance classes (range of differences in predicted probabilities between periods was 0.02–0.19 and among distances was 0.02–0.73; Table 3, Fig. 1).

DISCUSSION

We found that mountain goats exhibited minimal habituation to helicopter flights during a period of 10–15 years of repeated helicopter traffic. Although the probability of being disturbed slightly decreased in the recent decade, goats were still highly disturbed at distances <500 m for about a third of the flights, similarly to 1995, and their cumulative probability of being moderately or strongly disturbed remained very high (approx. 95%). The main factor determining goat responses was the minimal horizontal distance of the approaching helicopter during both periods. Group type, group size, and the behavior of animals prior to disturbance did not influence goat responses to helicopter flights, as reported earlier (Côté 1996). Research on mountain goats and feral goats (*Capra hircus*) elsewhere has also shown that the distance from the helicopter was among the most influential factors affecting alert behavior and distance moved in response to flights (Goldstein et al. 2005, Tracey and Fleming 2007). Other studies of mountain goats also reported that goats were generally disturbed by flights within 1 km (Foster and Rahs 1983, Gordon and Wilson 2004, Goldstein et al. 2005).

Based on our results on time spent disturbed and distance moved, we concluded that repeated helicopter flights at close distance can affect the behavior of mountain goats. Time devoted to vigilance and escape behavior reduce time spent foraging (Duchesne et al. 2000, Frid 2003) and eventually may affect fitness. The costs related to vigilance and escape to cliffs could be high for a species living in a harsh environment such as mountain goats do, as this may compromise foraging time in the best habitats (Lima and Dill 1990, Frid 2003, Hamel and Côté 2007, Naylor et al. 2009). Additionally, recent work on mountain goats has shown delayed effects of helicopter flights, such as individuals performing extended movements for up to 2 days following the disturbance (Cadsand 2012), suggesting that helicopter disturbance can have longer-term influences on behavior. Behavioral responses to helicopter disturbance, thus, may not fully reflect the stress levels of animals because longer-term movements and increased vigilance levels in the hours and

Table 2. Summary of the results of the model selection evaluating the influence of horizontal helicopter flight distance and time period on the probability of mountain goats being moderately and strongly disturbed at Caw Ridge (Alberta, Canada).

Model	K[a]	Dev[b]	AIC_c[c]	ΔAIC_c[d]	w_i[e]
Distance + time period	8	360.3	377.0	0.0	0.60
Distance	6	366.6	379.0	2.0	0.22
Distance × time period	12	353.8	379.4	2.4	0.18
Null	2	467.3	471.3	94.3	0.00
Time period	4	466.9	475.1	98.1	0.00

[a] Number of parameters estimated by the model. Because this is a multinomial analysis with 3 response categories, 2 estimates are always calculated for each parameter included in the models. Therefore, adding 1 parameter to a model automatically adds 2 to *K*.
[b] Model deviance.
[c] Akaike's Information Criterion adjusted for small sample sizes.
[d] Differences in the scores of AIC_c for the different models.
[e] Weights of the different models based on AIC_c scores.

Table 3. Summary of the multinomial regression estimates (model-averaged estimates) describing the influence of helicopter horizontal flight distance and time period on the probability of mountain goats being moderately and strongly disturbed at Caw Ridge (Alberta, Canada).

Variables	Estimates [95% CI]
Moderate vs. no/light	
Intercept[a]	2.14 [0.66, 3.62]
Distance (500–1,500 m)	−0.86 [−2.31, 0.60]
Distance (1,500 m)	−3.11 [−4.49, −1.72]
Time period (2005–2009)	−0.81 [−1.68, 0.06]
Distance (500–1,500 m) × time period (2005–2009)	−6.60 [−8.23, −4.97]
Distance (1,500 m) × time period (2005–2009)	7.31 [−144.60, 159.22]
Strong vs. no/light	
Intercept[a]	3.23 [1.67, 4.80]
Distance (500–1,500 m)	−1.68 [−3.08, −0.27]
Distance (1,500 m)	−4.86 [−6.33, −3.40]
Time period (2005–2009)	−1.18 [−2.17, −0.19]
Distance (500–1,500 m) × time period (2005–2009)	−5.72 [−7.33, −4.11]
Distance (1,500 m) × time period (2005–2009)	9.39 [−142.52, 161.30]

[a] The reference level for the intercept is distance <500 m and time period 1995. Nagelkerke $R^2 = 0.59$.

days following disturbance can occur. Thus, long-term movements and physiological indicators such as heart rate and body temperature should be measured in future research to better understand the stress response associated with helicopter disturbance (MacArthur et al. 1979, Regel and Ptz 1997). In addition, long-term impacts of repeated helicopter flights on vital rates, such as reproduction and survival, should be evaluated.

MANAGEMENT IMPLICATIONS

Because we detected minimal habituation to helicopter flights, and in view of the continuous increase of helicopter traffic in mountainous habitat, we maintain our recommendation to avoid helicopter flights closer than 1,500 m from mountain goat groups (Côté 1996, Hurley 2004, Cadsand 2012). A practical approach would be to recommend buffer zones of 2 km around alpine habitats known to support populations of mountain goats as prescribed in the British Columbia mountain goat management plan (Mountain Goat Management Team 2010).

ACKNOWLEDGMENTS

The Caw Ridge research project is mainly funded by the Natural Sciences and Engineering Research Council of Canada and the Alberta Conservation Association. We are grateful to the many biologists who assisted with fieldwork and to Alberta Fish and Wildlife for logistical help.

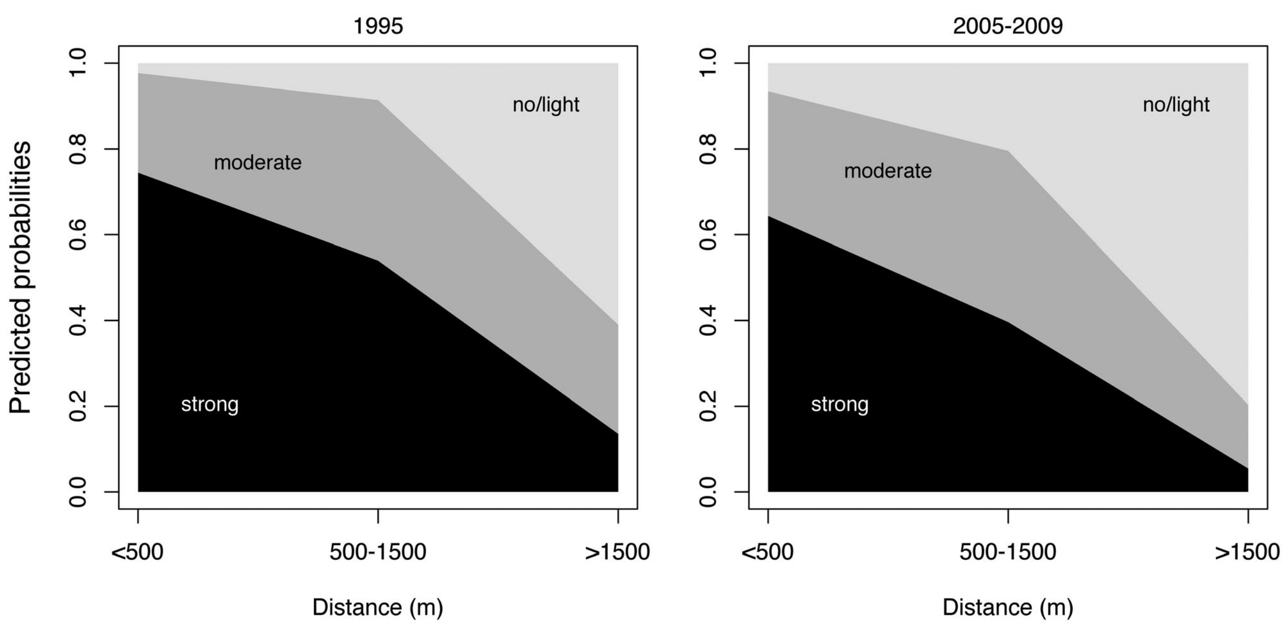

Figure 1. Changes in the predicted probability of being strongly (black), moderately (dark gray), and not/lightly disturbed (light gray) according to horizontal helicopter flight distance, for each time period (1995 vs. 2005–2009), in mountain goats at Caw Ridge, Alberta, Canada. The figure presents cumulative probabilities.

LITERATURE CITED

Barber, J. R., K. R. Crooks, and K. M. Fristrup. 2009. The costs of chronic noise exposure for terrestrial organisms. Trends in Ecology and Evolution 25:180–189.

Bleich, V. C., R. T. Bowyer, A. M. Pauli, M. C. Nicholson, and R. W. Anthes. 1994. Mountain sheep (*Ovis canadensis*) and helicopter surveys: ramifications for the conservation of large mammals. Biological Conservation 70:1–7.

Bleich, V. C., R. T. Bowyer, A. M. Pauli, R. L. Vernoy, and R. W. Anthes. 1990. Responses of mountain sheep to helicopter surveys. California Fish and Game 76:197–204.

Born, E. W., F. F. Riget, R. Dietz, and D. Andriashek. 1999. Escape responses of hauled out ringed seals (*Phoca hispida*) to aircraft disturbance. Polar Biology 21:171–178.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Second edition. Springer, New York, New York, USA.

Cadsand, B. A. 2012. Responses of mountain goats to heliskiing activity: movements and resource selection. Thesis, University of Northern British Columbia Prince George, Canada

Côté, S. D. 1996. Mountain goat responses to helicopter disturbance. Wildlife Society Bulletin 24:681–685.

Côté, S. D., M. Festa-Bianchet, and F. Fournier. 1998. Life-history effects of chemical immobilization and radio collars in mountain goats. Journal of Wildlife Management 62:745–752.

Duchesne, M., S. D. Côté, and C. Barrette. 2000. Responses of woodland caribou to winter ecotourism in the Charlevoix Biosphere Reserve, Canada. Biological Conservation 96:311–317.

Festa-Bianchet, M., and S. D. Côté. 2008. Mountain goats: ecology, behavior and conservation of an alpine ungulate. Island Press, Washington, DC, USA.

Foster, B. R., and E. Y. Rahs. 1983. Mountain goat response to hydroelectric exploration in Northwestern British Columbia. Environmental Management 7:189–197.

Frid, A. 2003. Dall's sheep responses to overflights by helicopter and fixed-wing aircraft. Biological Conservation 110:387–399.

Goldstein, M. I., A. J. Poe, E. Cooper, D. Youkey, B. A. Brown, and T. K. McDonald. 2005. Mountain goat response to helicopter overflights in Alaska. Wildlife Society Bulletin 33:688–699.

Gordon, S. M., and S. F. Wilson. 2004. Effect of helicopter logging on mountain goat behaviour in coastal British Columbia. Biennial Symposium of the Northern Wild Sheep and Goat Council 14:49–63.

Hamel, S., and S. D. Côté. 2007. Habitat use patterns in relation to escape terrain: are alpine ungulate females trading off better foraging sites for safety? Canadian Journal of Zoology 85:933–943.

Hamel, S., S. D. Côté, K. G. Smith, and M. Festa-Bianchet. 2006. Population dynamics and harvest potential of mountain goat herds in Alberta. Journal of Wildlife Management 70:1044–1053.

Harris, C. M. 2005. Aircraft operations near concentrations of birds in Antarctica: the development of practical guidelines. Biological Conservation 125:309–322.

Hill, D., D. Hockin, D. Price, G. Tucker, R. Morris, and J. Treweek. 1997. Bird disturbance improving the quality and utility of disturbance research. Journal of Applied Ecology 34:275–288.

Hosmer, D. W., and S. Lemeshow. 2000. Applied logistic regression. Second edition. John Wiley & Sons, New York, New York, USA.

Hughes, K. A., C. M. Waluda, R. E. Stone, M. S. Ridout, and J. R. Shears. 2008. Short-term response of king penguins *Aptenodytes patagonicus* to helicopter disturbance at South Georgia. Polar Biology 31:1521–1530.

Hurley, K. 2004. NWSGC position statement on helicopter-supported recreation and mountain goats. Biennial Symposium of the Northern Wild Sheep and Goat Council 14:131–136.

Joslin, G. 1986. Mountain goat population changes in relation to energy exploration along Montana's Rocky Mountain front. Biennial Symposium of the Northern Wild Sheep and Goat Council 5:253–269.

Knight, R. L., and D. N. Cole. 1995. Wildlife responses to recreationists. Pages 51–69 *in* R. L. Knight, and D. N. Cole, editors. Wildlife and recreationists: coexistence through management and research. Island Press, Washington, DC, USA.

Lima, S. L., and L. M. Dill. 1990. Behavioral decisions made under the risk of predation: a review and prospectus. Canadian Journal of Zoology 68:619–640.

MacArthur, R. A., R. H. Johnston, and V. Geist. 1979. Factors influencing heart rate in free-ranging bighorn sheep: a physiological approach to the study of wildlife harassment. Canadian Journal of Zoology 57:2010–2021.

Miller, F. L., and A. Gunn. 1979. Responses of Peary caribou and muskoxen to helicopter harassment. Canadian Wildlife Service Occasional Paper No. 40, Ottawa, Ontario, Canada.

Miller, F. L., and A. Gunn. 1980. Behavioral responses of muskox herds to simulation of cargo slinging by helicopter, Northwest Territories. Canadian Field-Naturalist 94:52–60.

Mountain Goat Management Team. 2010. Management plan for the mountain goat (*Oreamnos americanus*) in British Columbia. Prepared for the B.C. Ministry of Environment, Victoria, Canada.

Naylor, L. M., M. J. Wisdom, and R. G. Anthony. 2009. Behavioral responses of North American elk to recreational activity. Journal of Wildlife Management 73:328–338.

Pendergast, B., and J. Bindernagel. 1977. The impact of exploration for coal on mountain goats in Northeastern British Columbia. Pages 64–73 *in* Proceedings of the first international 275 mountain goat symposium. W. Samuel, and W. G. Macgregor, editors. Kalispell, Montana, USA.

Phillips, G. E., and A. W. Alldredge. 2000. Reproductive success of elk following disturbance by humans during calving season. Journal of Wildlife Management 64:521–530.

R Development Core Team. 2012. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Regel, J., and K. Pütz. 1997. Effect of human disturbance on body temperature and energy expenditure in penguins. Polar Biology 18:246–253.

Southwell, C. 2005. Response behaviour of seals and penguins to helicopter surveys over the pack ice off East Antarctica. Antarctic Science 17: 328–334.

St-Louis, A., S. Hamel, J. Mainguy, and S. D. Côté. 2013. Factors influencing the reaction of mountain goats towards all-terrain vehicles. Journal of Wildlife Management 77:599–605.

Stankowich, T. 2008. Ungulate flight responses to human disturbance: a review and meta-analysis. Biological Conservation 141:2159–2173.

Tracey, J. P., and P. J. S. Fleming, 2007. Behavioural responses of feral goats (*Capra hircus*) to helicopters. Applied Animal Behaviour Science 108: 114–128.

Associate Editor: Scott McCorquodale.