Michelle Webb

From: Julie Cozzi
Sent: Thursday, March 06, 2014 5:58 PM
To: Michelle Webb
Subject: FW: mountain goats and disturbance
Attachments: Mountain goats and ATVs.pdf; Mountain goats and helicopters.pdf

Categories: Purple Category

From: George Campbell [mailto:outback@alaska.net]
Sent: Thursday, March 06, 2014 5:46 PM
To: Ryan (DFG) Scott; Stephanie Scott; Debra Schnabel; Diana Lapham; Dave Berry; Julie Cozzi; Jerry Lapp; Joanne Waterman
Cc: S Diggity; Sunny Sundberg; Nic Trimble
Subject: Fwd: mountain goats and disturbance

Here is a couple of studies sent to me by a friend. Please notice that he is an Associate Professor at Oregon State University. The Journal of Wildlife Management is supposed to be a highly credible publication, so this study rates well in the science vs. opinion category.

In reading this there are some pieces that make it less similar to Haines situation. These studies were done in concert with each other.

In the conclusions a notable declaration is that during the study the goat heard increased in numbers.

I was left with more questions than answers, but the study(s) tells me the following: If you approach a goat at a high rate of speed on a direct path it will most likely spook, no mater what method of travel; goats and motorized can coexist in close proximity; goat populations can exist and increase with motorized activity around them.

Please feel free to read for yourselves.

George

Begin forwarded message:

From: "Bruce & Katie Dugger" <tinamou@comcast.net>
Date: August 13, 2013 6:31:28 AM AKDT
To: "'George Campbell'" <outback@alaska.net>
Subject: FW: mountain goats and disturbance

Hey George,

The new JWM had a paper on mountain goats and helicopter disturbance. Rather timely given our discussions. There was another paper this year on ATVs and goats, same authors. The literature cited section would be a good reference, if you wanted to read on the topic.

B

Bruce D. Dugger
Associate Professor
Dept. of Fisheries and Wildlife
104 Nash Hall
Oregon State University
Corvallis, OR 97331
ph: 541-737-2465
fax: 541-737-3590
http://fwl.oregonstate.edu/labs/dugger/

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Management and Conservation

Factors Influencing the Reaction of Mountain Goats Towards All-Terrain Vehicles

ANTOINE ST-LOUIS,[1,2] *Département de biologie and Centre d'études nordiques, Université Laval, Québec, Québec, Canada G1V 0A6*
SANDRA HAMEL, *Faculty of Biosciences, Fisheries and Economics, Department of Arctic and Marine Biology, University of Tromsø, 9037 Tromsø, Norway*
JULIEN MAINGUY, *Département de biologie and Centre d'études nordiques, Université Laval, Québec, Québec, Canada G1V 0A6*
STEEVE D. CÔTÉ, *Département de biologie and Centre d'études nordiques, Université Laval, Québec, Québec, Canada G1V 0A6*

ABSTRACT The increasing popularity of recreational activities in the wild has led to concerns about their potential impacts on wildlife. All-terrain vehicles (ATVs) often bring people into wildlife habitats, where they may disturb animal populations. We assessed the influence of ATVs on the behavior of mountain goats (*Oreamnos americanus*) in a long-term study population at Caw Ridge, Alberta, Canada. We used multinomial models containing environment-, disturbance-, and group-related factors, to evaluate the response of mountain goats to the approach of ATVs. Goats were moderately to strongly disturbed by ATVs 44% of the time, and disturbance levels were mainly influenced by the direction and speed of the approaching vehicles. Environment- or group-related factors (e.g., time of year, distance to escape terrain, group size or type) did not affect mountain goat responses to ATVs. Because goat reactions were influenced by disturbance-level factors, we propose mitigating measures regarding the use of ATVs in the wild to minimize the disturbance to mountain goats, and potentially other alpine ungulates. © 2012 The Wildlife Society.

KEY WORDS Alberta, all-terrain vehicles, human-induced disturbance, mountain goats, *Oreamnos americanus*, recreational activities.

For the past few decades, the popularity of recreational activities in the wild has increased substantially in North America (Boyle and Samson 1985, Knight and Gutzwiller 1995, Buckley 2004, Naylor et al. 2009). Activities such as wildlife watching, hiking, skiing, mountain biking, and riding all-terrain vehicles (ATVs) bring people into wildlife habitats, often in close proximity with wild animals. Although visiting wild places may help raise awareness about environmental conservation (Buckley 2004), recreational activities in the wild also have detrimental effects on wildlife at several levels, from individuals to populations (Boyle and Samson 1985, Knight and Cole 1995, Duchesne et al. 2000, Naylor et al. 2009). Recreational activities may have short-term impacts on individuals, such as diverting animals from fitness-related behaviors (e.g., feeding, parental care) and displacing them from safe habitats to areas where they might be more vulnerable to predation (Lima and Dill 1990, Knight and Cole 1995, Papouchis et al. 2001). These immediate reactions can also have long-term consequences, potentially causing animals to shift their home ranges from preferred habitats, disrupting social bonds among group members, or decreasing reproductive success and population size (Boyle and Samson 1985, Knight and Cole 1995). Understanding factors influencing the reaction to disturbance is crucial to mitigate the potential impacts of recreational activities on wildlife.

Several authors have suggested that animals perceive human-induced disturbances similarly to predation risk (e.g., Gill et al. 1996, Frid and Dill 2002, Gavin and Komers 2006, Stankowich 2008). Factors similar to those influencing reactions to predation risk, such as the proximity to an escape habitat, the direction of approach of the potential threat, the speed and distance at which it approaches, and the age–sex classes of individuals submitted to an approaching threat, may influence the reaction to disturbance (Frid and Dill 2002, Loehr et al. 2005, Stankowich and Blumstein 2005, Stankowich 2008). Environmental factors such as time of year and day, as well as wind direction and strength, may also influence the reaction of animals to disturbance (Stankowich and Blumstein 2005, Stankowich 2008). For example, females could be more sensitive to disturbance at times of the year when they are accompanied by young vulnerable offspring than when they are alone or with older offspring (Stankowich 2008). Animals could also be more vulnerable at dawn and dusk, periods when predators are usually more active.

In Alberta, Canada, mountain goats form small populations that are sensitive to human disturbances (Côté 1996, Hamel et al. 2006). The population of individually marked mountain goats at Caw Ridge offers useful conditions to

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[1]*E-mail: antoinestlouis@yahoo.ca*
[2]*Present address: Direction générale de l'expertise sur la faune et ses habitats, Ministère des Ressources naturelles et de la Faune, 880 Chemin Sainte-Foy, Québec, Québec, Canada G1S 4X4.*

assess the impacts of ATVs, an increasingly popular activity in the area. This population, which has ranged from about 80 to 160 animals in the past, has been the focus of a long-term study since 1989 (Festa-Bianchet and Côté 2008). The easy access and the open landscape at Caw Ridge were 2 reasons for the initiation of the long-term study in this area. Furthermore, the area is accessible to ATVs, and has seen an increase from about 50 ATVs visiting the area annually in 1994 to >300 vehicles/summer in recent years. The influence of ATVs on mountain goat behavior at Caw Ridge, however, has not been studied. We assessed the short-term behavioral reaction of mountain goats to disturbances induced by ATVs by assessing the influence of factors related to the environment, the attributes of goat groups, and the characteristics of the disturbance on the occurrence of 3 gradually increasing levels of behavioral reaction: none or light, moderate, and severe. We hypothesized that goats would react to the approach of ATVs and expected that 1) goat reactions would be stronger at close distances from approaching vehicles, and strongest when vehicles approach rapidly and directly towards them, 2) goats located far from escape habitat should have stronger reactions than those located close to a safe refuge, 3) nursery groups (females, juveniles, and kids) would be more sensitive to disturbance by ATVs than bachelor groups (males only), and 4) goat reactions would be stronger at dusk than during daytime, at the beginning of the summer, when kids are more vulnerable, and when the wind is strong and directly towards the animals.

STUDY AREA

We studied goats at Caw Ridge (54°N, 119°W), west-central Alberta, Canada, in the front range of the Rocky Mountains (Festa-Bianchet and Côté 2008). The climate is subarctic-arctic and snowfalls can occur during any month of the year. The study area covers 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 boundaries of the study area are defined by the tree line (see Fig. 1), which acts as a dispersal barrier because mountain goats avoid dense forested areas (Festa-Bianchet and Côté 2008). Goats use the open alpine habitat where all individuals of the population can be easily observed. Within the alpine habitat, the landscape is characterized by gently rolling hills and steep grassy slopes, as well as rockslides and a few cliff faces that provide escape terrain (Festa-Bianchet and Côté 2008). Apart from a few cliffs and rockslides, most of the Caw Ridge area can be easily reached and is accessible to ATVs (Fig. 1; Festa-Bianchet and Côté 2008). Because of the open alpine habitat, ATVs are easily detected by observers. Goats use the whole study area, including the human-created trails, which often pass close to some foraging habitats and to small cliffs that are used as escape terrain and resting sites by goats. The main trail used by ATVs is located on the North ridge (Fig. 1), from which all areas used by goats are visible. Although the trail generally runs in 1 direction at a large landscape-scale, a close approach by ATV towards a goat group can occur from all directions (see Fig. 1). The study area has no specific regulation on the use of ATVs. In 2004, 2 trail signs were placed by the Alberta government at the entrance of the study area to increase awareness of the impacts of ATVs in alpine areas. These signs also list recommendations on how to use the trails and to approach wildlife. Although most ATV users usually follow the trail, the absence of trees and steep cliffs facilitates off-trail ATV use.

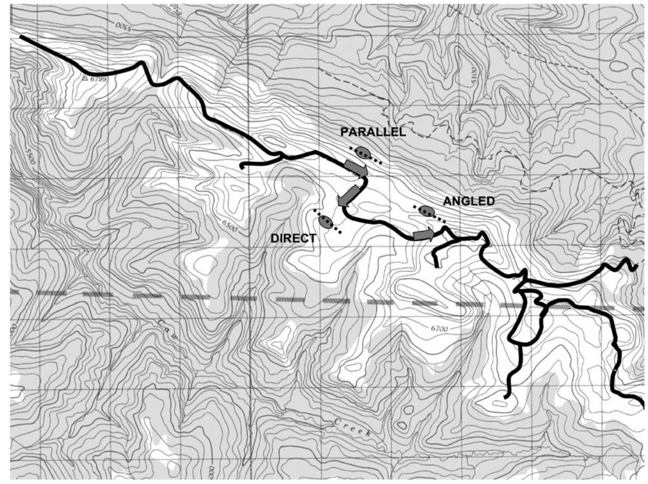

Figure 1. Orientation and aspect of the trail (thick line) used by all-terrain vehicles (ATVs) at Caw Ridge, Alberta, Canada, in 2006–2009, in relation to mountain goat groups and habitat. The gray arrows illustrate the direction of approaching ATVs (direct, angled, or parallel) in relation to mountain goat groups (gray circles). Rows of black dots indicate the general orientation of goat groups. We recorded the direction of approach between the center of the group and the approach of the ATV(s) at the time when it was closest to the group. The white area represents the open alpine habitat used by mountain goats, whereas the gray areas represent dense forested habitats that were not part of the study area. Thus, the tree line is the boundary of the study area.

METHODS

Behavioral Observations

We recorded behavioral observations on marked mountain goats. 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, and their age and sex is known (see Festa-Bianchet and Côté 2008 for more details). We used binoculars (10×) and spotting scopes (15–45×) to monitor the reaction of mountain goat groups to the approach of ATVs from May to September 2006–2009. At least 2 observers monitored goats daily (weather permitting). Goats were widely distributed throughout the range, but both goats and ATVs were almost always visible to the observers from several observation locations that have been used for decades. Because the study area is an open landscape of gently rolling hills above the tree line, we could easily observe the movements of all goat groups within the study area. The re-sighting probability for males and females is respectively 0.98 and 0.99 (Festa-Bianchet et al. 2003).

During each ATV approach, we recorded factors that were included in 3 broad categories. The first category included time and environmental attributes: date (number of days since 1 Jun), time of day (morning, from 0600 to 1159 hours; afternoon, from 1200 to 1759 hours; evening, from 1800 to

2200 hours), wind strength (none or light, moderate, or strong), and wind direction (none, parallel, opposite, or towards the goats according to the approaching vehicle). The second category included disturbance-related attributes: the number of vehicles approaching, average vehicles' speed (measured in m/s by dividing the distance covered by the vehicle with the time taken to cover the distance and later converted into km/hr), the direction from which the vehicles approached the group when it was at its closest distance to the goats (parallel, angled, or direct; see Fig. 1 for an explanation of the categories), and the closest distance vehicles got to the group. The third category included group-related attributes: group size, group type (nursery: adult females $\geq$3 years, juveniles, and kids; bachelor: lone or groups of adult $\geq$3 years males; mixed: nursery groups with $\geq$1 adult male; or unknown: not all individuals could be identified prior to the disturbance), distance of the group to the nearest escape terrain, and behavior of animals prior to the approach (active [e.g., foraging, moving] vs. inactive [i.e., lying]).

To measure disturbance, we recorded time spent in alert and distance moved for each documented ATV approach. Alert goats stood, raised their ears, and looked towards the approaching vehicle. We classified goat responses to the approach in 3 categories following Côté (1996): not or 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 classed goats that moved 10–100 m or were alert between 2 minutes and 10 minutes as moderately disturbed. We classed goats that walked or ran >100 m or were alert for >10 minutes as 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 were not independent. We considered that a group changed its behavior when at least half of the individuals did so. We noted all distances on a continuous scale ($\pm$10 m) using topographic maps. Our observations were not random, as they were dependent on the presence of an ATV on the ridge. The observations recorded, however, were relatively well balanced and encompassed a large range of time and environmental conditions, as well as characteristics of goat groups and disturbances (e.g., 95% range of some continuous variables: distance to escape terrain = 0–400 m, day = 19 May–17 August, time of day = 0930–2030 hours, and closest distance between ATV and goats = 50–1,500 m).

Statistical Analyses

We modeled the probability of mountain goats being disturbed by the approach of ATVs using a multinomial logistic regression with a general logit link function with SAS version 9.1 (SAS Institute Inc., Cary, NC), considering goat reaction to ATVs as an ordinal response. A multinomial logistic regression analyzes the probability of moving from the reference level of disturbance to another level. In our specific case, the reference level was the probability of being not or lightly disturbed. Therefore, the multinomial logistic regression provided 2 estimates for each predictor: 1 describing the probability of goats being moderately disturbed versus not or lightly disturbed and the other describing the probability of goats being strongly disturbed versus not or lightly disturbed.

We used Akaike's Information Criterion adjusted for sample size (AIC_c; Burnham and Anderson 2002) to select the predictors having the greatest influence on disturbance by ATVs. Because we had numerous potential explanatory variables, we built candidate models in 2 steps (see Table 1 for the detailed list of all models that were considered). First, we built 3 sets of candidate models based on 1) time and environmental variables (year, date, period of the day, wind direction, and wind speed), 2) disturbance variables (distance of approaching vehicles, their speed, the number of ATVs, and their direction of approach), and 3) characteristics of mountain goat groups (group type, group size, behavior of goats before the disturbance, and distance to an escape terrain). Each model set contained a model with all variables without interactions (full), a model without any predictors except the intercept (null), and several models containing each variable separately or a combination of variables. We implemented interactions and squared terms when we judged that they constituted relevant models (see Table 1). We then ranked models according to their AIC_c score (lowest to highest); we considered models with a ΔAIC_c value <2 to be equivalent and supported (Burnham and Anderson 2002). Second, we combined the results from the 3 sets of candidate models to build a final set of candidate models. We built the final set based on the variables included in the supported models obtained at step 1, unless the null model was a supported model (i.e., demonstrating very little support for other equivalent models). We ranked models similarly to the ones analyzed in step 1. We considered all variables included in the supported models of the final step as having an influence on goat disturbance. We then described the contribution of these predictors by presenting their odds ratio (with 95% CI), a measure of effect size in logistic regressions (Littell et al. 2006).

RESULTS

Between 2006 and 2009, we documented 201 behavioral reactions following ATV approaches in the mountain goat population. Overall, goats were not or lightly disturbed by 55.7%, moderately disturbed by 21.4%, and strongly disturbed by 22.9% of all vehicle-approach events we recorded.

The influence of environmental attributes on the probability of being disturbed by ATVs in mountain goats was not prominent, because the null model was as equally supported as models with environmental attributes (Table 1, model 1). Among disturbance attributes, only the direction of approach, and to a lesser extent the vehicle speed, influenced the probability of being disturbed (Table 1, model 2). For group attributes, the strongest support was for 2 models including both group size and behavior of goats before the disturbance as predictors (Table 1, model 3). Therefore, the direction of approach, vehicle speed, group size, and behavior

Table 1. Multinomial models considered to assess the influence of factors linked to 1) time and environmental conditions, 2) all-terrain vehicles, and 3) group characteristics on the behavioral reaction of mountain goat groups to the approach of all-terrain vehicles at Caw Ridge, Alberta, Canada, 2006–2009. Within each set (1–3), we considered models with Akaike's Information Criterion corrected for small sample sizes (ΔAIC_c) <2 supported, and thus we used predictors in these models in the final step (4) under a similar AIC approach.

Models[a]	n	K[b]	AIC_c	ΔAIC_c	w_i[c]
1. Environmental attributes					
Null	156	2	280.11	0.00	0.29
Dayperiod	156	6	280.38	0.27	0.25
Year	156	8	280.73	0.62	0.21
Year + dayperiod	156	12	281.59	1.48	0.14
Date	156	4	283.50	3.39	0.05
Wind	156	4	284.28	4.17	0.04
$Date^2$	156	6	285.99	5.88	0.02
Winddirect	156	8	286.01	5.90	0.01
Full	156	24	301.33	21.22	0
2. Disturbance attributes					
Approach	117	6	194.67	0.00	0.41
Speed + approach	117	8	195.26	0.59	0.31
Speed × approach	117	12	197.78	3.11	0.09
Approach + N	117	8	198.03	3.36	0.08
Speed + approach + distance	117	10	198.81	4.14	0.05
Speed + approach + N	117	10	198.84	4.17	0.05
Full	117	12	202.58	7.91	0.01
Approach × N	117	12	206.58	11.91	0.00
Null	117	2	210.48	15.81	0.00
N	117	4	213.92	19.25	0.00
Distance	117	4	214.90	20.23	0.00
Speed	117	4	218.75	24.08	0.00
Speed × N	117	8	220.74	26.07	0.00
3. Group attributes					
Size + behavbefore	146	6	261.53	0.00	0.59
Size × behavbefore	146	8	263.56	2.03	0.21
Full	146	14	267.23	5.70	0.03
Size	146	4	270.91	9.38	0.01
Behavbefore	146	4	279.83	18.30	0.00
Esc-terrain	146	4	285.05	23.52	0.00
Null	146	2	289.70	28.17	0.00
Type	146	8	296.08	34.55	0.00
4. Final models					
Speed + approach	112	8	184.97	0.00	0.38
Approach	112	6	185.72	0.75	0.26
Speed + approach + behavbefore	112	10	187.83	2.86	0.09
Speed + approach + size	112	10	188.15	3.18	0.08
Approach + behavbefore	112	8	188.23	3.26	0.07
Approach + size	112	8	189.01	4.04	0.05
Approach × speed	112	12	190.47	5.50	0.02
Speed + approach + behavbefore + size	112	12	191.08	6.11	0.02
Approach + behavbefore + size	112	10	191.62	6.65	0.01
Behavbefore	112	4	195.48	10.51	0.00
Null	112	2	195.49	10.52	0.00
Speed + behavbefore	112	6	196.23	11.26	0.00
Speed	112	4	198.12	13.15	0.00
Behavbefore + size	112	6	198.26	13.29	0.00
Speed + behavbefore + size	112	8	199.17	14.20	0.00
Size	112	4	199.71	14.74	0.00
Speed + size	112	6	200.70	15.73	0.00

[a] Dayperiod, period of the day (morning, afternoon, evening); Behavbefore, behavior of the group before the disturbance (active or lying); Type, group type (bachelor group, nursery group, mixed group, unknown); Esc-terrain, distance from escape terrain; Approach, direction of approaching all-terrain vehicle (ATV; parallel, angled, direct); Wind, wind strength (none or light, moderate, strong); Winddirect, wind direction (toward, opposite, parallel, none); N, number of approaching vehicles. Full refers to a model including all the factors considered for a given attribute in set 1, 2, or 3, whereas null considers the intercept of the model only.

[b] Number of parameters.

[c] Akaike weights.

of goats before the disturbance were included in the final step of the model selection procedure (Table 1, model 4). The models having the strongest support in the final step included the speed and direction of approaching ATVs, or only the direction of their approach (Table 1, model 4).

The direction of ATV approach had the strongest support among the predictors, and was included in both supported models, as well as in all the highest-ranking models. Goats showed a greater probability of being disturbed when ATVs where approaching directly towards the groups rather than in

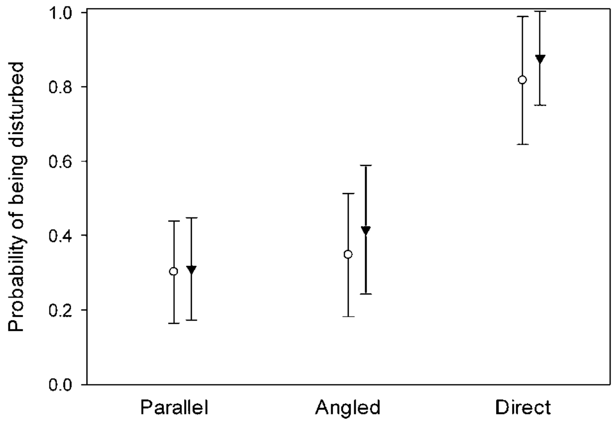

Figure 2. Probability of a mountain goat group being moderately (white dots) or strongly (black triangles) disturbed according to the direction of approaching all-terrain vehicles at Caw Ridge, Alberta, Canada, 2006–2009. The reference level (probability = 0) was the probability of the group being not or lightly disturbed. Error bars represent 95% confidence intervals.

a parallel manner or at an angle to them (Fig. 2). When ATVs were approaching directly rather than running parallel with the groups, goats were about 31 times more likely to be strongly than not or lightly disturbed (direct vs. parallel: odds ratio [CI] = 30.8 [4.8–199.0]), and about 17 times more likely to be moderately than not or lightly disturbed (odds ratio [CI] = 16.8 [2.7–102.8]; Fig. 2). When ATVs were approaching at an angle rather than parallel to the groups, goats had an equal chance of being strongly or moderately disturbed (odds ratio [CI] = 1.7 [0.5–5.6], and an equal chance of being moderately disturbed to being not or lightly disturbed (odds ratio [CI] = 0.7 [0.2–2.3]; Fig. 2).

To a lesser extent, the speed of the ATVs also affected the probability of goats being disturbed; this variable was included in 1 of the 2 most supported models (Table 1, model 4). Goats were about 8 times more likely to be moderately rather than not or lightly disturbed when ATVs were driven at 40 km/hour compared with 10 km/hour (odds ratio [CI] for 1 unit difference [i.e., 1 km/hr] = 1.07 [1.00–1.13]; Fig. 3A). Similarly, goats were about 6 times more likely to be strongly rather than not or lightly disturbed when ATVs were driven at 40 km/hour rather than 10 km/hour (odds ratio [CI] = 1.06 [1.00–1.13]; Fig. 3B).

DISCUSSION

Our results showed that ATVs can cause high levels of disturbance in mountain goats, especially when ATVs approach the animals directly and at high speeds (≥25 km/hr). A disturbance source approaching fast and directly toward animals is more likely to induce a strong behavioral reaction compared to a disturbance source running parallel or away from the animals at a slower speed. Moreover, the magnitude of mountain goats' reactions towards ATVs varied from none to light for about half of the cases recorded. This result suggests that ATVs are not perceived as a major threat by mountain goats, possibly because of their constant presence in the study area over the summer.

In a recent review, Stankowich (2008) showed that humans on foot induced a stronger flight response than motorized vehicles. Similarly, Gander and Ingold (1997) showed a stronger influence of hikers than mountain bikers on alpine chamois (*Rupicaprar rupicapra*). Papouchis et al. (2001) also reported that motorized vehicles and mountain bikes had less impact than hikers on desert bighorn sheep (*Ovis canadensis nelsoni*), presumably because these disturbance sources were more predictable to sheep than hikers. This could also be the case at Caw Ridge because ATVs usually stay on the same trails (Festa-Bianchet and Côté 2008). Although the number of ATVs has increased in our study area, the goats could have also been habituated because trails at Caw Ridge have been used since the early 1970s. Mountain goat sensitivity to ATV disturbance could be greater in other, less-visited areas inhabited by goats. The costs related to vigilance and fleeing to an escape habitat could be high for a species that lives in a harsh environment, as this would likely compromise foraging time in good feeding habitats (Lima and Dill 1990, Fortin et al. 2004, Naylor et al. 2009). Goats may perceive most

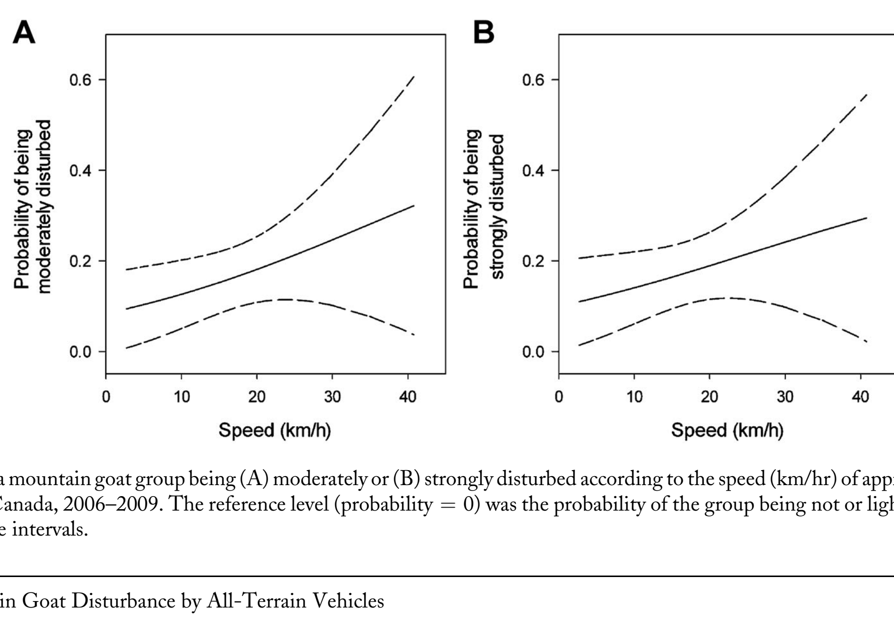

Figure 3. Probability of a mountain goat group being (A) moderately or (B) strongly disturbed according to the speed (km/hr) of approaching all-terrain vehicles at Caw Ridge, Alberta, Canada, 2006–2009. The reference level (probability = 0) was the probability of the group being not or lightly disturbed. Dashed lines represent 95% confidence intervals.

approaching objects as potentially threatening, but would reduce the costs of fleeing or disrupting their activities as much as possible unless the perceived threat is very high. Although quantifying the influence of the behavioral changes triggered by ATV disturbance on individual fitness is difficult, Gill et al. (2001) showed that species that cannot completely avoid disturbance are likely more vulnerable to disturbance than species having evolved an anti-predatory strategy consisting of moving to undisturbed areas. This is likely the case of mountain goats, because they have evolved an anti-predatory strategy consisting of remaining in or close to an escape terrain where they cannot completely avoid potential disturbances (Festa-Bianchet and Côté 2008).

Our results follow those of Frid and Dill (2002), Stankowich and Blumstein (2005), and Stankowich (2008), that the direction of approach is a major determinant of an animal's reaction to an approaching threat. Mountain goats at Caw Ridge had stronger reactions when ATVs were approaching directly towards them rather than when the ATVs were running parallel or at an angle from them. This suggests that, rather than its mere presence, the threat posed by an approaching object is what triggers a strong response in mountain goats. Fleeing only when the threat is perceived as real could be a way to avoid fleeing whenever a predator is seen, thus preventing unnecessary energy expenditures in reaction to the simple presence of a threat (Lima and Dill 1990). When ATVs, and likely other off-road vehicles, are in the vicinity but not moving towards a given individual or group, goats could perceive that the risk to be lower than when approaching directly. However, even if goats seemed only lightly disturbed by ATVs in half of the events recorded, the fact that they reacted strongly towards directly approaching ATVs indicates that recreational vehicles have a large impact on their behavior with potential detrimental effects on fitness.

In general, nursery groups are more vulnerable to predation than bachelor groups, and are more likely to react strongly to a disturbance (Lima and Dill 1990, Frid and Dill 2002, Loehr et al. 2005). In our study, the reaction of goat groups was not influenced by their age–sex class composition. That large groups are generally less vulnerable toward predators and disturbance than small groups, and that nursery groups were generally larger than bachelor groups, may have counter-balanced the effect of disturbance on group types in our study. The lack of relationship between the behavioral response recorded and group size, however, suggests caution in this interpretation. In the light of our results, considering that all group types had the same chances of being disturbed, seems reasonable. The reaction of goats was not influenced by distance to escape terrain, even though the variation in the distance measured was quite large (from 0 m to >500 m). Goats could possibly perceive that when faced with a human-induced disturbance, moving out of view is generally sufficient to avoid the threat regardless of distance to escape terrain.

We expected that goats would have a stronger reaction towards approaching ATVs at dusk, in early summer, and when the wind blew strongly and directly towards the animals. The fact that none of these factors influenced goats' responses suggests that the disturbance levels induced by motorized-vehicles on goats remain constant under different environmental conditions. Considering that group attributes also did not influence goat reactions towards ATVs in a detectable manner, our study shows that factors influencing the reaction of goats were mostly related to the disturbance per se.

MANAGEMENT IMPLICATIONS

Our study shows that the reaction of goats towards ATVs depends mainly on the direction of the ATV approach and its speed. Consequently, ATV riders should be discouraged from approaching goats directly and encouraged to reduce their speed when they do, because these 2 factors have a substantial impact on goat behavior. Although these recommendations are intuitive, limited effort has been directed towards reducing the impacts of recreational vehicles on wildlife in North America. Land managers have placed a few signs beside trails in our study area to increase awareness about mountain goats and other wildlife, but the signs have been there for many years without detectable changes in the behavior of most ATV riders, suggesting that this passive strategy is largely inefficient when used alone. Our study demonstrated that ATV use in areas used by wildlife influenced their behavior with possible detrimental effects. We suggest implementing active management strategies, such as establishing regulations on the use of ATVs in the wild. Because ATVs affected goat behavior, restricting access to certain zones frequented by goats could reduce direct encounters between mountain goats and ATVs.

ACKNOWLEDGMENTS

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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).

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

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

Period	Intensity of disturbance			
	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).

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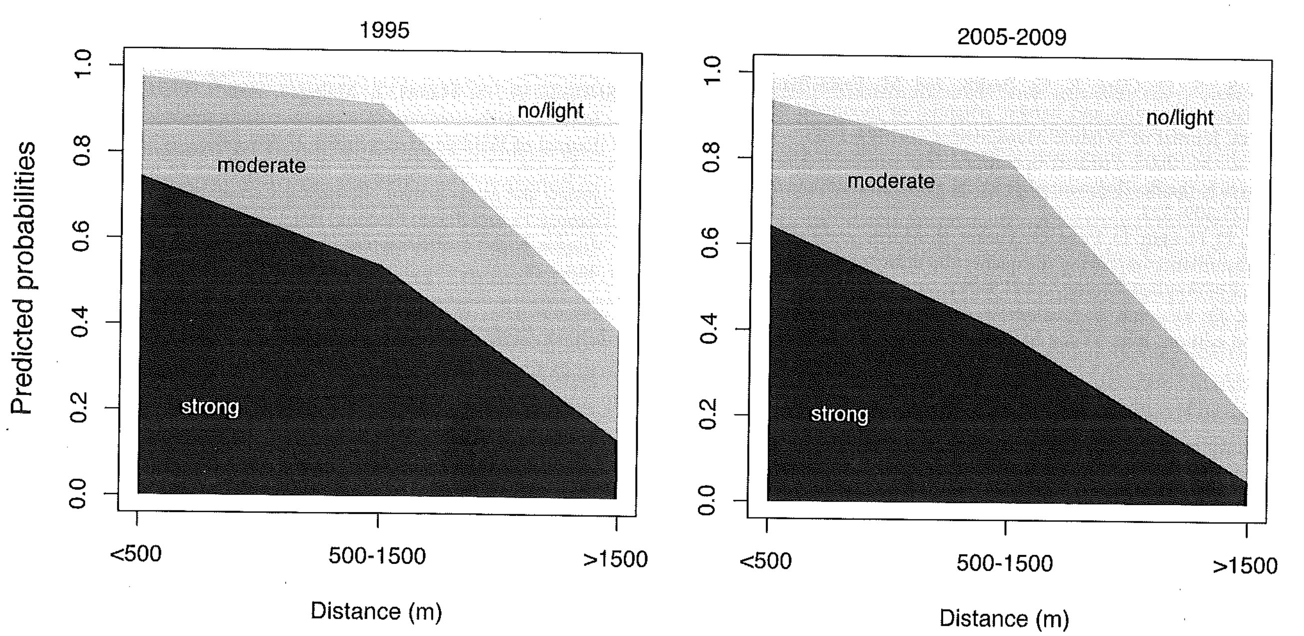

Figure 1. Changes in the predicted probability of being strongly (black), moderately (dark gray), and not/lightly disturbed (light gray) according to horizontal helicopter flight distance, for each time period (1995 vs. 2005–2009), in mountain goats at Caw Ridge, Alberta, Canada. The figure presents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

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