Northern Wild Sheep and Goat Council
Position Statement
Commercial and Recreational Disturbance of Mountain Goats: Recommendations for Management

PROJECT BACKGROUND:
In 2004, the Northern Wild Sheep and Goat Council (NWSGC) published a position statement on management of helicopter-supported recreation and mountain goats (Hurley 2004). This document was intended to represent the scientific consensus regarding the effects of helicopter-supported recreation on mountain goats, primarily in the context of commercial activities (e.g., summer and winter helicopter-based tourism). The position statement included a summary of the available literature and associated recommendations for management. This document has been widely used and referenced by wildlife and land-management agencies as well as non-government organizations (NGOs) to inform land management decisions in the U.S. and Canada. Since publication of the original NWSGC position statement, new research has been conducted on helicopter and other types of disturbance, resulting in a need for updates. There has been recognition that expanding the scope of the position statement to include management guidance related to helicopter and other disturbance activities in broader industrial and recreational contexts would be useful for wildlife and land managers. During 2019–2020, a NWSGC working group comprised of 18 subject matter experts convened to update and expand the scope of the 2004 NWSGC position statement. The revised position statement was reviewed and unanimously endorsed by the executive committee and membership at the November 2020 NWSGC business meeting.

INTRODUCTION:
Anthropogenic disturbance of wildlife from both commercial and smaller-scale independent recreational activities is an increasingly widespread conservation issue globally (Naugle 2011, Larson et al. 2016, Shannon et al. 2016). Mountain goats are a highly valued and iconic species of western North American mountain landscapes and are particularly sensitive to human disturbance, relative to other ungulates (Côté 1996, Gordon and Reynolds 2000, Festa-Bianchet and Côté 2008, B.C. Ministry of Environment 2010). Mountain goats are habitat specialists that persist under extreme environmental conditions (Festa-Bianchet and Côté 2008). As a consequence, the species has a conservative life history strategy and low potential for population growth across its native range (Bailey 1991, Festa-Bianchet et al. 1994, Hamel et al. 2006, Festa-Bianchet and Côté 2008, Rice and Gay 2010, White et al. 2018). Combined with strict habitat requirements, high fidelity to seasonal home-ranges, and a high degree of fine-scale genetic population structure, the species is particularly vulnerable to negative perturbations; demographic recovery following declines can often be prolonged or uncertain (Fox et al. 1989, Keim 2004, Festa-Bianchet and Côté 2008, Shafer et al, 2011, 2012). As a result, conservation strategies for mitigating negative effects of human disturbance are necessary to ensure mountain goat population productivity and viability, and ultimately, effective stewardship of this iconic wildlife species for future generations (B.C. Ministry of Environment 2010).

Less is known about mountain goats than other North American ungulates due to their relative scarcity and the inaccessible terrain they inhabit (Smith 1982, Festa-Bianchet et al. 1994, Wilson and Shackleton 2001). Nonetheless, important advances have been made in our understanding of disturbance effects on mountain goats with respect to effects of helicopters and other commercial or recreational disturbance. Helicopters are used widely in many industrial activities conducted in remote areas (e.g., mining, logging, hydroelectric development, telecommunications, seismic exploration), and are increasingly used in the context of all manner of summer and winter tourism activities (B.C. Ministry of Environment 2010). For example, the Juneau Icefield is a world-class tourism destination located in Southeast Alaska that receives more than 20,000 summer helicopter landings annually (J. Schalkowski, U.S. Forest Service – Tongass National Forest, personal communication). In British Columbia and Alaska, over 50 different helicopter-based skiing companies are in operation. Other forms of helicopter-supported adventure tourism, involving hiking, mountain biking, glacier exploration, dog mushing and numerous other activities, are locally prevalent and growing in many jurisdictions with some previously inaccessible wilderness areas now experiencing a high intensity of recreational use.

Mountain goats exhibit particular sensitivity to aerial

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disturbance such as helicopters (Foster and Rahs 1983, Côté 1996, Goldstein et al. 2005, Cadsand 2012, Côté et al. 2013) that may have arisen as an adaptation to predation risk occurring from terrestrial carnivores and aerial predators. Indeed, Frid and Dill (2002) described human disturbance as a form of predation risk that can lead to deleterious individual and population-level effects; a useful conceptual framework for understanding disturbance in an ecological context. Mountain goat responses to aerial and other industrial, commercial and recreational disturbances can involve reduction of foraging, increase in movement rates and energetic expenditure, and spatial displacement from important habitats during critical periods (Foster and Rahs 1983, Côté 1996, Goldstein et al. 2005, Cadsand 2012, Côté et al. 2013, Richard and Côté 2016, White and Gregovich 2017). Less visible physiological stress responses can also occur in response to anthropogenic and natural forms of disturbance and result in negative effects on immunological health and reproduction (MacArthur et al. 1982, Stemp 1983, Harlow et al. 1986, Chabot 1991, Downs et al. 2018, Dulude-de Broin et al. 2020). Such responses, if sufficiently intense, can result in negative effects on population demography, such as decreased reproduction and recruitment, as documented by Joslin (1986; also see Figure 1).

Although the short-term behavioral responses of mountain goats to helicopter activity have been documented, longer-term habitat use and demographic consequences of disturbance remain only partially understood. These recommendations are intended to minimize short-term behavioral disruptions that are correlated with long-term individual and population-level impacts. Existing research indicates a broad consensus on the pathways leading to detrimental effects, but additional research is required to better characterize effect sizes and interactions. While this work continues, we provide specific mitigation measures as precautionary recommendations, based upon the current body of available science. The following is a synopsis of the identified impacts addressed by research, to date. Each impact is summarized and includes relevant science-based recommendations (also see Appendix Table 1) intended to provide guidance regarding mitigating potential impacts to ensure effective conservation of mountain goats.

MANAGEMENT RECOMMENDATIONS:

Habitat exclusion zones:

Mountain goats live in highly seasonal environments and utilize their landscapes in spatially- and temporally-specific ways to optimize reproduction and survival. In this context, the parturition (kidding) and winter seasons are particularly important for reproduction and survival; excluding disturbance of habitats used during these periods is essential to sustain population viability and productivity.

Mountain goats are habitat specialists and rely on specific

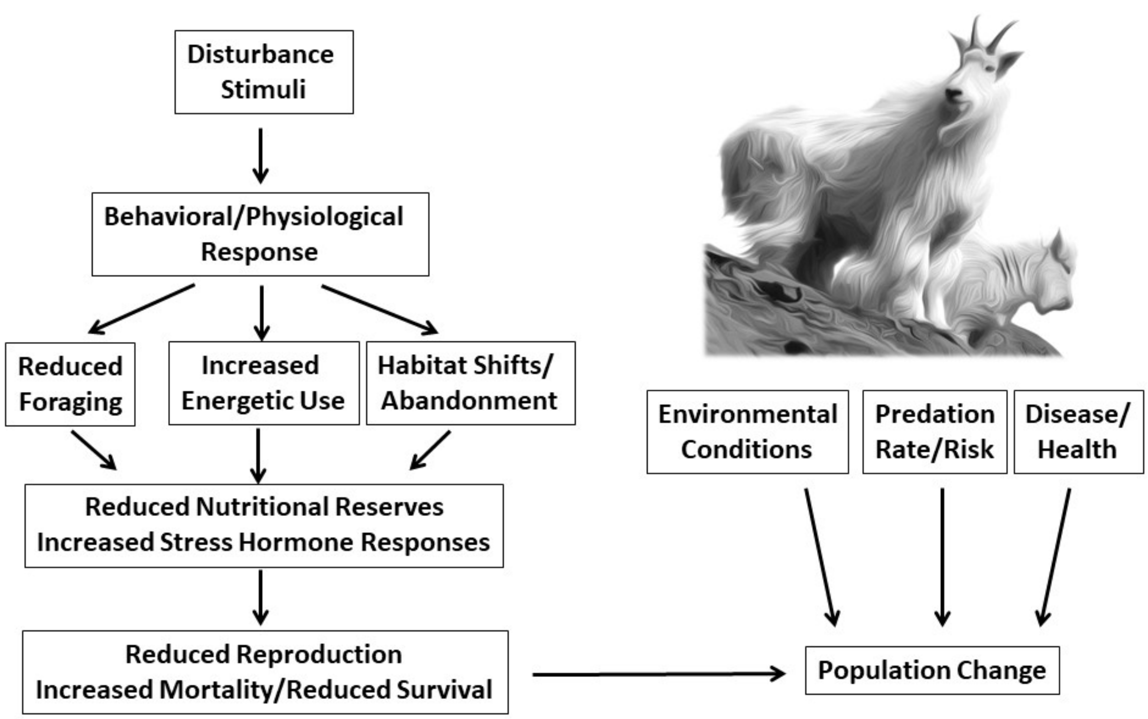

Figure 1. Conceptual framework for characterizing disturbance effects on mountain goats, in the context of other drivers of population demography (adapted from Frid and Dill 2002, Wilson 2011). Expected impacts of disturbance can be exacerbated, or buffered, depending on demographic conditions, environmental conditions, predation, and disease.

habitat features with narrow topographic and vegetative attributes. Studies have consistently documented mountain goat selection of steep, rugged terrain in close proximity to cliffs (Fox et al. 1989, Gross et al. 2002, Festa-Bianchet and Côté 2008, Poole et al. 2009, Shafer et al. 2012, White and Gregovich 2017). Given these preconditions, mountain goat habitat selection can vary with respect to elevation, slope, and aspect, depending on season and region (Hebert and Turnbull 1977). In coastal ecosystems, mountain goats typically migrate from alpine summer ranges to low-elevation, forested winter ranges to avoid deep, wet maritime snowpacks (Hebert and Turnbull 1977, Fox et al. 1989). In forested winter ranges, a strong association to mature, old growth forest stand structure is evident (Fox 1983, Fox et al. 1989, Jex 2004). Conversely, in interior climates mountain goats commonly inhabit windblown subalpine and alpine habitats during the winter season with localized variation in wintering strategies often occurring in coastal-interior transitional climates (Hebert and Turnbull 1977, Jex 2004, Festa-Bianchet and Côté 2008, Poole et al. 2009, White and Gregovich 2018). During the kidding season, mountain goats typically utilize subalpine and alpine habitats in close association to escape terrain regardless of climatic regime or region.

Sexual segregation is typical of many ungulate species (Main et al. 1996), including mountain goats. During the non-breeding season, adult male mountain goats are often spatially segregated from nursery groups, composed of adult females, subadults and neonates (Geist 1964, Foster 1982, Risenhoover and Bailey 1982). Habitat selection does not differ strongly between the sexes. Females with offspring, however, display a stronger affinity to escape terrain as compared to other individuals (Hamel and Côté 2007) and show heightened sensitivity to disturbance (Penner 1988). The vitality of mountain goat nursery groups provides obvious contributions to the productivity and viability of mountain goat populations. Due to the sensitivity of adult female mountain goats to disturbance, and the importance of this age/sex class to the persistence of local mountain goat populations, restrictions on late spring and early summer helicopter activities should focus on areas used by parturient females and nursery groups.

During spring and summer, mineral licks represent an important resource for mountain goats, especially females with kids (Singer 1978, Ayotte et al. 2008, Corbould et al. 2010, Poole et al. 2010, Rice 2010, Jokinen et al. 2014). Mineral licks are rare features on the landscape and deserve special management consideration due to the important role they play in providing key nutritional resources during a critical time of year. In some instances, mineral licks occur near human access or commercial activities (i.e. logging), and can increase mountain goat vulnerability to disturbance (including nanny-kid separation) or, in the case of roadside mineral licks, direct mortality (Singer 1978, Corbould et al. 2010).

Mapping mountain goat habitat is an important step for identifying and managing exclusion zones. Advances in radio-tracking technology (e.g. GPS radio-collars; Cagnacci et al. 2010) and analytical methods (e.g. resource selection function modeling; Boyce et al. 2002) have enabled greater understanding of mountain goat habitat relationships and enhanced our ability to delineate (and validate) important seasonal habitats for mountain goats (Lele and Keim 2006, Shafer et al. 2012, Wells et al. 2014, Richard and Côté 2016, Lowrey et al. 2017, White and Gregovich 2017). Such tools are important for developing scientifically-defensible strategies for protecting important mountain goat habitats. Implementation of such methods can aid in clearly articulating trade-offs and development mitigation strategies to reduce disturbance effects to mountain goats (Figure 2).

Recommendation - Habitat exclusion zones:
•Commercial and recreational disturbance activities, including helicopter overflights and landings, should not occur in important seasonal habitats (e.g. winter, kidding, mineral licks).

•The distribution and abundance of mountain goats and their habitats should be determined before commercial permits are issued to inform operating requirements and provide a baseline for monitoring. Permits should allow for changes to operating requirements as new information becomes available.

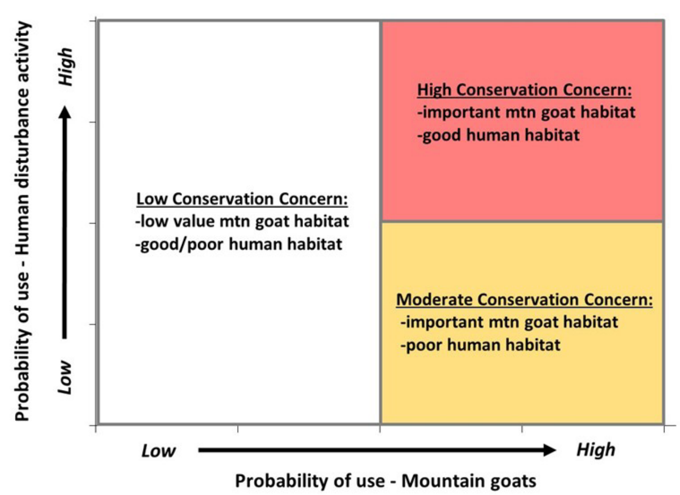

Figure 2. Conceptual framework for evaluating habitat conservation concerns associated with commercial and recreational disturbance in mountain goat habitat (adapted from Nielsen et al. 2006, White and Gregovich 2018).

Timing of disturbance activities:

The winter and parturition (kidding) seasons are of particular concern for management of disturbance stimuli. Winter is a period of severe nutritional deprivation for mountain goats (Chadwick 1974, Fox et al. 1989, Shackleton 1999). Periods of deep snow can reduce food availability and dramatically increase locomotory costs (Fox 1983, Dailey and Hobbs 1989). In winter, mountain goats are relatively immobile (i.e., movements not exceeding 50 m/hour; Poole and Heard 2003, Keim 2004, Richard et al. 2014), occupy small home ranges (<4 km^2; Keim 2004, Poole et al. 2009, White 2006, Shakeri and White 2018), and exhibit a high degree of site fidelity to seasonal ranges (Schoen and Kirchhoff 1982, Keim 2004, Shakeri and White 2018). Selection and use of important winter and kidding habitats may be reduced or abandoned if disturbance is not effectively managed to consider mountain goat habitats and the needs of parturient and/or wintering goats. Evidence suggests more conservative approaches are merited in winter as compared to summer even though growth and nutrition attained during summer can be important for subsequent winter survival (i.e., Mautz 1978, White et al. 2011).

Defining periods of residency on winter range, kidding areas, and mineral licks is important to inform recommendations needed to mitigate disturbance impacts to mountain goats. Residency on winter range is correlated with snowfall in alpine habitats, and for migratory animals, timing windows and important habitat can be quantified using analysis of seasonal migration events (i.e., Spitz et al. 2017, 2018). Variability in weather and climate can alter timing of migratory events and residency time from year to year. For example, in some areas of coastal British Columbia, newborn kids have been observed in late-April, three weeks earlier than normally documented (B. Jex, British Columbia Ministry of Environment, personal communication). While most births normally occur between May 12–June 5, vulnerable neonates are especially dependent on mothers until mid-July (Côté and Festa-Bianchet 2001, Festa-Bianchet and Côté 2008). During a long-term study at Caw Ridge, Alberta (1989–2018), the earliest date a kid survived after losing or being permanently separated from its mother was July 16 (Festa-Bianchet and Côté 2008). Consequently, it is not only important to avoid disturbance of nursery groups during parturition, but during the post-parturition weaning period as well.

Figure 3a. Photograph of mountain goats in forested winter range habitat in coastal Alaska (Photo: K. White)

Recommendation - Timing of disturbance:

•Disturbance activity should not occur on or near important mountain goat winter range habitats between November 1–April 30. (i.e. Figure 3a, 3b).

•Disturbance activity should not occur on or near important mountain goat kidding habitats between May 1–July 15 (i.e. Figure 4).

•Disturbance activity should not occur at mineral licks used by mountain goats during peak use periods generally occurring between May 1–August 31, recognizing that local variation in periods of use can span a different period of time (Figure 5, Table 1).

•Timing windows could be adjusted, as appropriate, based on the best available data for a given area and while recognizing that specific conditions may vary from year-to-year.

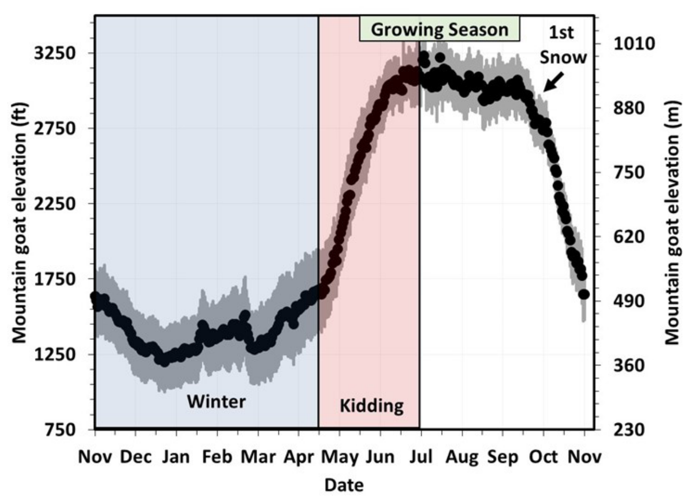

Figure 3b. An example illustrating how elevational migration patterns can define timing and duration of winter range use in coastal Alaska. Data were collected from GPS radio-collared mountain goats (n = 172) 2005–2019 (White et al. 2012, unpublished data). Timing or occurrence of elevational shifts may vary by year or locality.

Table 1. Timing of mineral lick use by mountain goats summarized across six study sites in North America. Data are summarized in relation to first and last months, as well as the peak month during which mountain goats were documented at mineral licks. Data were pooled for male and female mountain goats in this summary, however, timing differences between female vs. male mountain goat use of mineral licks were reported.

Area	Start	Peak	End	Source
Glacier National Park, Montana	April	June/July	September	Singer 1978
Muskwa-Kechika, British Columbia	May	July	August	Ayotte et al. 2008
Caw Ridge, Alberta	May/June	June	August	Festa-Bianchet and Cote 2008
Rocky & Purcell Mtns, British Columbia	February	June/July	August	Poole et al. 2010
Cascade Mtns., Washington	January	July	December	Rice 2010
Southwest Alberta	May	July	Oct	Jokinen et al. 2014

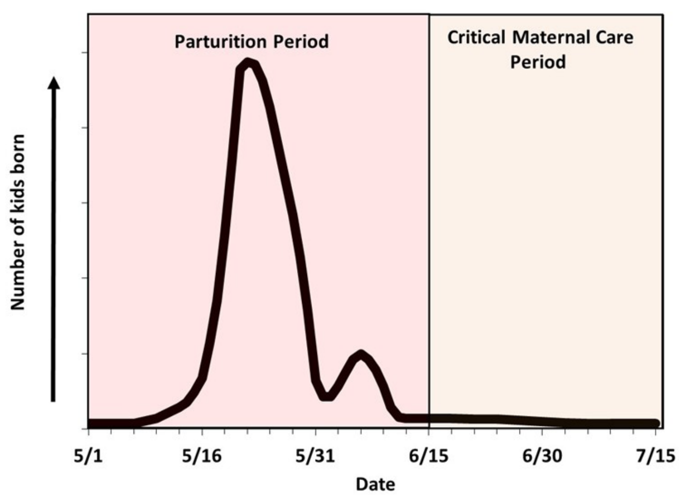

Figure 4. Generalized pattern of mountain goat parturition and the critical post-birth maternal care period (based on Côté and Festa-Bianchet 2001, Festa-Bianchet and Côté 2008). Timing may vary across years and by locality.

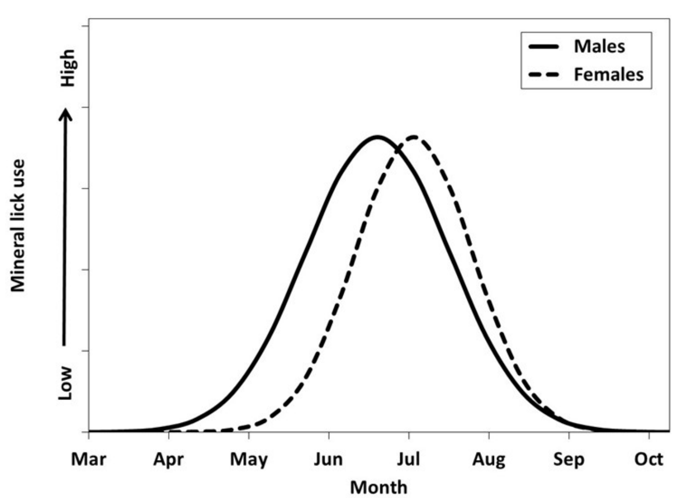

Figure 5. Generalized pattern of mineral lick use by male and female mountain goats (based on sources in Table 1). Timing may vary across years and by locality.

Distance from important seasonal habitats

Acute, short-term behavioral responses to helicopter activity have been consistently documented at distances of 1.5 km, and up to 2 km, for mountain goats (Côté 1996, Frid 2003, Gordon 2003, Cadsand 2012, Goldstein et al. 2005, Côté et al. 2013). Mountain goats within 2 km of winter helicopter skiing exhibited medium-term behavioral responses, involving alteration of movement patterns and habitat selection up to 48 hours following disturbance events (Cadsand 2012). Helicopters used for tourism are typically lighter and quieter than those used for larger, industrial-scale commercial activities such as mining and logging. Thus, response distances from these studies, primarily conducted in lighter-duty helicopter recreation/tourism contexts, may underestimate responses both in terms of distance and overtness to industrial-sized helicopters. Examination of mining-related disturbance, including helicopter activity, blasting, heavy machinery operation and other operations, indicate mountain goat avoidance of suitable winter habitat within 1.8 km of point-source disturbances (White and Gregovich 2017). Similar responses were observed during behavioral spot-monitoring assessments focused on mountain goat responses to helicopters and horn signaling during logging activities adjacent to known winter range habitat, showing temporary habitat abandonment during active operations (Jex 2007). It is important to consider the surrounding terrain or relative position of mountain goats to helicopters/machinery may amplify noise or visual disturbance stimuli, and increased buffers may be required in confined geographies such as canyons or for direct and overhead approach vectors (i.e., Andrus 2005).

Recommendation - Distance from important seasonal habitats:

•Commercial or recreational disturbance activity that includes the use of light helicopters[1], should not occur within 1.5 – 2.0 km of winter and kidding habitats or mineral licks, depending on the local context or human safety considerations[2].

•Additional setbacks should be considered where the use of medium and heavy helicopters are proposed.

•Industrial scale mining activity should not occur within 1.8 km of mountain goat winter habitat.

Habituation and sensitization to disturbance:

Factors influencing whether an animal moves away from a site of human disturbance, either temporarily in the case of a fleeing response, or more permanently in the case of habitat displacement, are complex and can be influenced by a wide range of factors (Bejder et al. 2009). These factors are related to the nature of the disturbance stimuli and the quality of the site, availability of alternative suitable habitat, the perceived risk of predation and competition by individuals (Gill et al. 2001, Bejder et al. 2009). For example, wildlife may remain in an area and tolerate a high level of disturbance if the benefit (e.g., access to a critical resource or habitat) is perceived to outweigh the immediate risk (e.g., use of road-side mineral licks by mountain goats in National Parks) and the level of tolerance displayed can vary by individual, age and sex. In some instances, animals choosing to be tolerant to a known disturbance may be incorrectly described as being habituated to it (Penner 1988, Côté 2013). Similarly, an animal may not immediately flee following disturbance if the energetic costs of moving are exceedingly high, or if the animal is already occupying the safest or most suitable terrain accessible. In instances where an animal does not demonstrate an overt disturbance response, the individual may still experience a negative impact, either due to physiological stress response (often only detectable via laboratory analyses; sensu Dulude-de Broin et al. 2019, 2020), or a behavioral response that does not involve fleeing (i.e. increased vigilance and less foraging). An animal is considered habituated if its response to disturbance (both behaviorally and physiologically) decreases with increasing exposure to the disturbance stimuli. Conversely, an animal becomes sensitized to disturbance when its stress response increases with repeated exposure; the opposite of a habituation or tolerance response (Frid and Dill 2002). In practice, true habituation of wildlife to disturbance stimuli is uncommon and may not occur if stimuli are sufficiently strong (Bleich et al. 1994, Steidl and Anthony 2000, Frid 2003). Further, animals are less likely to habituate to irregular and/or unpredictable disturbances (Bergerud 1978, Risenhoover and Bailey 1982, Penner 1988).

Recent analyses of long-term data collected at Caw Ridge, Alberta, demonstrated limited evidence of habituation of mountain goats to helicopter disturbance over a 15-year period of regular overflights (Côté 1996, Côté et al. 2013). Similarly, Cadsand (2012) found that the likelihood of a mountain goat fleeing in response to helicopter activity was not affected by that individual's cumulative disturbance history. Frid (2003) found that the proportion of Dall's sheep fleeing did not decrease with the number of cumulative weeks of disturbance. In contrast, Goldstein et al. (2005) reported that mountain goats in the study site with greatest prior exposure to helicopters seemed to have the most tolerance to helicopters, relative to less impacted sites; yet the authors indicated that disturbance responses were potentially confounded by terrain characteristics. For example, abundant steep terrain and proximity to escape terrain may have influenced responses by limiting the distance mountain goats could, or needed to, run following disturbance (Goldstein et al. 2005). Thus, comparison between areas, as a means of assessing habituation, resulted in limited inference due to presumed differences in landscape composition among sites. Existing literature suggests that mountain goat responses to commercial activities and helicopter disturbances are complex and likely alter risk/reward trade-offs associated with fitness-linked behavioral decisions thereby reducing benefits; apparent tolerance of disturbance does not mean that negative effects are absent.

Recommendation - Habituation and sensitization:

•Habituation of mountain goats to helicopter or other disturbance should not be assumed to occur over time. Existing scientific evidence, including data from a long-term study indicates that mountain goats do not habituate to helicopter overflights.

•Recognize that disturbance alters risk: reward trade-offs associated with fitness-linked behavioral decisions and may have negative effects. In some instances, effects may not be overtly visible.

•Recognize the possibility that exposure to disturbance stimuli may result in heightened sensitivity to disturbance and that the degree of sensitivity can increase with the frequency of exposure to the disturbance.

[1] 'Light' helicopters include, but are not limited to: Hughes 500, Bell 206, A-Star AS350. 'Medium' helicopters include Bell 212 and Kamov Ka-32A. 'Heavy' helicopters include Sikorsky Sky Crane CH-54, Boeing Vertol, Boeing 234 Chinook.

[2] In some jurisdictions, a 400-600 m vertical buffer is considered in cases where avoidance of habitat is not possible due to weather or other human safety considerations (i.e. British Columba Ministry of the Environment 2010).

Other motorized and non-motorized recreational activities:

Projected increases in both motorized and non-motorized recreational disturbance creates concerns about the effect on wildlife and their habitats (Wisdom et al. 2004, Ciuti et al. 2012, Harris et al. 2012, Courtemanch 2014, Crisfield et al. 2018, Wisdom et al. 2018). Off-highway vehicles, including single operator all-terrain vehicles and over-snow vehicles (e.g., snowmobiles, snowcats, snowbikes) are increasingly popular for recreational access into backcountry areas, with numbers of recreational users in the US projected to increase to 62–75 million participants by 2060 (Bowker et al. 2012). Mechanical innovations, such as tracked modifications to stock vehicles and greater engine horsepower have expanded the capability of off-road machines and their use into mountain goat habitats (BVORS 2011, St-Louis et al. 2013). Recreational activity is largely unregulated and management/mitigation strategies are often limited or lacking (Flood 2005). Research has documented adverse effects of off-highway use on movement and/or habitat use across a range of ungulate species including moose (Colescott and Gillingham 1998), elk/red deer (Wisdom et al. 2018, Ciuti et al. 2012), caribou (Seip et al. 2007) and thinhorn sheep (Freeman 2018). Physiological stress responses to all-terrain vehicles has also been documented in elk (Creel et al. 2002). Specific to mountain goats, research documented all-terrain vehicle use resulted in moderate-significant spatial displacement and reduction in foraging of mountain goats 44% of the time (St-Louis et al. 2013). Negative responses were greater when vehicles approached at higher speeds and directly towards animals (St-Louis et al. 2013). Similar to helicopter-disturbance studies, approach trajectories and distance-specific responses of mountain goats to all-terrain vehicle disturbance also occur, but more research is needed to identify appropriate buffer distance guidelines.

Recommendation - Other recreational activities:

•Recreational activity should be regulated near important seasonal wintering and kidding habitats, and near mineral licks.

•Regulation of off-highway vehicles and recreational activity should include seasonal timing of use, proximity to important habitat, speed and approach vectors.

Monitoring and regulatory enforcement of disturbance activities:

Monitoring the spatial distribution, intensity, and frequency of disturbance is critical for assessing effects of activities on mountain goats and for ensuring regulations are effective and followed (B.C. Ministry of Environment 2010). Comprehensive, long-term land use, resource management and project-specific activity plans, are important policy tools ensuring proposed management actions characterize impacts to mountain goats and include adaptive management mitigations. Planning incorporates strategies and mitigation measures to protect important mountain goat habitats yet still allow commercial and recreational activities to occur, where appropriate. Effective plans address disturbance effects on wildlife, both short and long-term. Enforcement of terms and conditions of permitted commercial activities is important to ensure operating plans are effective. Monitoring and enforcement policies should be data-based and consistent across jurisdictions to ensure social acceptance and provide a predictable economic and regulatory environment for commercial and recreational entities.

Recommendation - Monitoring and regulatory enforcement of disturbance activities:

•Permitting policy should be based on scientific data and analysis, and consistent with other jurisdictions/agencies, to the extent possible. Consistent regulatory frameworks aid in acceptance among diverse stakeholders.

•Monitoring should include compliance monitoring and evaluation of the effectiveness of mitigation strategies. Baseline environmental reviews should be conducted to inform local mitigation approaches as part of permitting processes. Use of permitting fees to fund monitoring and review activities can be an effective and appropriate mechanism for ensuring data collection and analyses occur over the long-term.

•Commercial use permits should include provisions to address cases of non-compliance. Provisions should be included to modify permitted areas or conditions, based on new information.

•Disturbance activities (i.e., helicopter flight activity/landings, ski run boundaries/use, commercial development activity/infrastructure) should be spatially referenced (recommended resolution = 100 m) and quantified. Monitoring and data collection is most effective when occurring at the scale of mountain goat management (i.e., population or sub-population scale).

•Establishment of management control areas, in which commercial and recreational activity is not permitted, is important to enable interpretation of changes in populations, trends and assign changes to the activity vs. other factors.

Monitoring mountain goat populations:

Monitoring mountain goat population dynamics and distribution is important for understanding how populations respond to anthropogenic changes. This knowledge is critical for informing land-management decisions and devising conservation strategies which can, at times, involve significant trade-offs in economic return. Despite the inherent difficulty of collecting field data on mountain goats, rigorous techniques have been developed for gathering scientifically defensible population data needed for monitoring populations. Collection of data in a rigorous sampling design framework, including control-treatment designs when possible, that directly feeds into decision-making frameworks, including adaptive management systems, can help ensure scientific understanding and social acceptance of outcomes. Programs may be technical to implement but are considered critical preconditions when anthropogenic manipulations of mountain landscapes are proposed.

Recommendation - Monitoring mountain goat populations:

•Monitoring and assessment of mountain goat demography, including population abundance, composition and distribution, at appropriate spatial and temporal scales is critical and represents an important pre-condition for all permitted disturbance-related activities.

•Rigorous sampling designs, including monitoring areas pre- and post-activity with spatial control areas when possible, should be implemented. Monitoring programs should also include collecting relevant ecological covariate data to improve inference and ensure assessment of disturbance effects are not confounded by other factors.

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Appendix: Information Needs and Research Gaps

Management/Monitoring:

Currently, there is little information available to track the location and intensity of human activities in or near mountain goat habitats. Helicopter activity in particular is poorly monitored because it does not leave physical evidence. The following management and monitoring approaches are recommended:

•Spatially-referenced GPS flight track, landing site and area use information associated with commercial helicopter activities is needed to ensure compliance with permit requirements (as applicable) and quantify disturbance activities (i.e. necessary for monitoring disturbance effects on mountain goat populations).

•Geographical Information System (GIS) analyses (currently in development; S. Gordon, pers. comm.) are needed to enable analysis of incursions into pre-identified exclusion zones (where these have been defined) and assessment of relative differences in disturbance activity among areas. Such analyses would aid an understanding of flight safety-necessitated incursions, localized compliance and determination of mountain goat disturbance response thresholds.

•Compilation of a database detailing management strategies and responses across jurisdictions would provide a basis for ensuring range-wide policy is science-based and consistent, to the extent possible.

•Development of policy that fosters data sharing between operators and local biologists to aid in development of effective mitigation strategies needed to reduce risk of potential disturbance to mountain goats (sensu Wilson et al. 2011).

•Development of decision-making frameworks, or risk matrices, that are explicitly parameterized using ecological and socioeconomic data is needed to provide an improved means for implementing policy decisions that are scientifically defensible and socially acceptable.

Research:

•Long-term population monitoring in an experimental framework focused on assessing impacts of disturbance intensity on population dynamics would enable greater understanding of population-level responses to disturbance activities.

•Collection of broad-scale population and demographic monitoring data (i.e. province/state-wide) is important for establishing regional baseline population conditions, and aid in detection of whether disturbance related effects are occurring in affected mountain goat populations.

•Additional studies on movement responses to disturbance under different intensities of disturbance and temporal scales (sensu Cadsand 2012) would provide a more comprehensive understanding of how disturbance influences movement behavior.

•Study of the effect of different helicopter types (light, medium, heavy) on mountain goat disturbance responses, including how orientation (above, level, below) and local topography (terrain masking/amplification) influence responses.

•Studies on the effects of snowmobiles, all-terrain vehicles and non-motorized backcountry recreational activities such as mountain biking, hiking and skiing (sensu Courtemanch 2014) on mountain goats would fill existing knowledge gaps and provide effective guidance for managing these activities in mountain goat habitat.

•Future studies focused on relationships among disturbance and endocrinology, immune function, gut microbiome, and the extent to which they are ultimately linked to population performance (sensu Downs et al. 2018), would improve our understanding of disturbance responses that are not easily detected through direct observation.

•Research on climate effects to assess shifting baselines (i.e. plant phenology, thermal stress, etc.) and possible interactive effects on disturbance. Such studies would advance our understanding of bottom-up effects on mountain goats and provide important ecological context for observed population-level changes, particularly as they relate to disturbance responses in the context of cumulative effects.

Appendix, Table 1. Summary of recommendations and additional standards and guidance for effective management of commercial and recreational disturbance in mountain goat habitat.

Mitigation Guideline	Recommendation	Additional Standards/Guidance
Habitat exclusion	-Avoid important seasonal habitats, especially during winter and kidding seasons, and mineral licks. -Delineate important habitat using best available data and analytical techniques.	-Habitats used by nursery groups are key for population persistence and should be prioritized in management/mitigation strategies. -Include provisions to support inclusion of new habitat and use information as well as adaptive management approaches. -Most effective to delineate habitat prior to permitting/management of disturbance activities
Distance from important seasonal habitats	-Commercial or recreational disturbance activity, including use of light helicopters, should not occur within 1.5–2.0 km of winter and kidding habitats, or mineral licks, depending on the local context. -Industrial-scale mining activity should not occur within 1.8 km of important winter range	-Greater separation distances should be considered when medium and heavy helicopters are used[1]. -Approach vectors and surrounding topography should be considered.
Timing of disturbance activities	-Avoid critical periods during the mountain goat life cycle: winter (Nov 1–Apr 30), kidding (May 1–July 15), mineral licks (May 1–Aug 31).	-Critical periods can vary geographically, and timing windows should be adjusted based on local data.
Habituation/sensitization	-Recognize that habituation of mountain goats to helicopter or other disturbance should not be assumed.	-Disturbance alters fitness. If apparent tolerance of disturbance occurs, it does not infer effects are absent (physiological stress responses are often not visible). -Exposure to disturbance, especially if intense or chronic, may result in heightened sensitivity to disturbance.

Appendix, Table 1 (continued). Summary of recommendations and additional standards and guidance for effective management of commercial and recreational disturbance in mountain goat habitat.

Mitigation Guideline	Recommendation	Additional Standards/Guidance
Other motorized and non-motorized recreational activities	-Recreational activity should be regulated near important seasonal wintering and kidding habitats, and near mineral licks.	-Regulation of off-highway vehicles and recreational activity should include seasonal timing of use, proximity to important habitat, speed and approach vectors.
Monitoring: Policy	-Permitting policy should be based on scientific data and analysis, and consistent with other jurisdictions, to the extent possible.	-Consistent regulatory frameworks aid in acceptance among diverse stakeholders.
	-Monitoring should include compliance and evaluation of the effectiveness of mitigation strategies.	-Investment into pre-permitting baseline environmental reviews should directly inform local permitting mitigation.
	-Commercial use permits should include enforceable provisions to address cases of non-compliance.	-Provisions should be included to modify permitted areas or conditions based on new information.
	-Disturbance activities should be spatially referenced and quantified (i.e. number of landings, flight paths, area use boundaries, etc.)	-Monitoring should occur at the scale of management (i.e., population or sub-population scale).
Monitoring: Mountain goat populations	-Long-term monitoring of mountain goat population abundance, composition and distribution at the appropriate scale should be a precondition of all permitted disturbance-related activities.	-Rigorous sampling designs, including treatment-control areas and collection of relevant ecological covariate data, should be used to appropriately interpret factors driving population changes.

[1] ‘Light’ helicopters include, but are not limited to: Hughes 500, Bell 206, A-Star AS350. ‘Medium’ helicopters include Bell 212 and Kamov Ka-32A. ‘Heavy’ helicopters include Sikorsky Sky Crane CH-54, Boeing Vertol, Boeing 234 Chinook.