June 25, 2002

Effects of Motorized Recreation on Grizzly Bears and Rocky Mountain Ungulates

An Annotated Bibliography

Submitted to:
Southern Rocky Mountain Management Plan Project Team,
Ministry of Sustainable Resource Management
Cranbrook, B.C.

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Purpose

This Annotated Bibliography summarizes the effects of motorized recreation on grizzly bears and Rocky Mountain ungulates based on seventeen reports provided by the Ministry of Sustainable Resource Management. The Summary attached as appendix 1, is a brief overview of the definitive effect statements in the Annotated Bibliography. The Summary statements are cross referenced with the Annotated Bibliography using reference # and author.

The quotations extracted from the literature describe the effects associated mainly with the following types of disturbance:

- snowmobile use impacts on wintering ungulates;
- helicopter use impacts on mountain goats and bighorn sheep;
- the impacts of road density, traffic, access, and spring snowmobile use on grizzly bears.

Note that for the Reference columns of the Annotated Bibliography, the first citation in each block is the document which was reviewed. The additional citations in that block listed below the 'parent' document are citations occurring within the text of the parent document.

Documented Impacts

Many statements in the Annotated Bibliography are taken from Greater Yellowstone Area reporting on winter recreation effects on wildlife (Olliff et al. 1999)*. For Yellowstone National Park, Dr. Caslick considers the balance between visitor use and resource conservation, and provides conclusions and recommendations which point to the importance of controlling recreation in or near winter ranges. Dr. Caslick states:

> "…in regard to wildlife in Yellowstone, the most pressing Visitor Use Management issue is snowmobiling … in or near thermally–affected wildlife habitats that are known to be unique and of critical value to wildlife in winter. …there is now ample documentation to administratively close these thermally-influenced winter habitats, prohibiting winter use by private and commercial snow machines, skiers, snowshoers, and hikers (page A-10)".

Dr. Caslick developed two summaries of published research which support the above statement. The summaries: the Matrix of Winter Recreation Effects on Wildlife (24 pp), and Selected Literature Citations from Bennett, 1995, and New Citations from Caslick on Winter Recreation Effects on Wildlife (74 pp) are included in Olliff et al. 1999, Appendix 1.

Olliff, T., K. Legg, and B. Kaeding, editors. 1999. Effects of winter recreation on wildlife of the Greater Yellowstone Area: a literature review and assessment. Report to the Greater Yellowstone Coordinating Committee. Yellowstone National Park, Wyoming. 315 pp.

In this Annotated Bibliography, established impacts that are cited repeatedly in the reviewed literature include the following:

- **Animals depend on minimizing energy expenditure during the winter period, so any disturbance resulting in energetically demanding flight, habitat displacement, or physiological stress responses have negative long term survival and reproduction implications** (Gates and Hudson 1979, Geist 1978, Marchand 1996, Thorne 1976, Geist 1982, B.C. Wildlife Branch 2001). Nelson and Leege (1982) demonstrated in experimental feeding trials mimicking elk winter diets, that up to 87% of the daily forage consumed by elk in winter is used for standard metabolic function. Thus less than 15% is left for growth, reproduction, temperature regulation, and activity. The importance of energy conservation by ungulates in winter is clearly established.

- **Disturbances that are most detrimental to wildlife are those that are unanticipated** (Aasheim 1980, Parker et al 1984). Disturbances which are predictable and localized, and without negative associations, may be tolerated over time (Penner 1988, Singer and Doherty 1985). **However, unpredictable activities exact high costs and include in particular, helicopter overflights, and over-land uses which are not confined to established trails** (Segerstrom 1982, Stemp 1983, Penner 1988, Ward 1973, Olliff 1999, Busnel 1978, Geist 1971, Pedevillano and Wright 1987, Cote 1996, Idaho Dept of Fish and Game 1990, McArthur et al 1979, Calef et al 1976, Joslin 1986, Harrington and Veitch 1991).

- Parker et al (1984) and Freddy et al (1986) observed that **greater flight distances occur in response to skiers or individuals on foot than to snowmobiles**. However, since snowmobiles can cover much greater distances in the course of a day, encountering many more animals, the effects of snowmobile use are considered to be significantly more far reaching.

- **Grizzly bear use of suitable habitat declines as road density and road traffic increase** (Mace et al).

- **Vehicular traffic along open roads can displace grizzly bears from 100-900m** (Aune and Kasworm 1989, Kasworm and Manley 1990, Matson et al 1987, McLellan 1990, McLellan and Shackleton 1988).

- **As road access into grizzly bear habitat increases, bear mortalities increase. This results from legal and illegal hunting, and removal and kills of habituated bears** (McLellan 1990, Tietje and Ruff 1983, Brannon 1988, McLellan and Mace 1985, Noss 1995). "Of the collared grizzly bear mortalities reported in the literature for six study areas in Alberta, B.C., Montana and Idaho, 68% of known mortalities were the result of illegal kills and hunting (McLellan 1990)."

Annotated Bibliography on the Effects of Motorized Recreation on Grizzly Bears and Rocky Mountain Ungulates

Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
1	Beckett, J.	Making Tracks - Motorized Use in the Backcountry. A Fact Sheet from Canadian Parks and Wilderness Society. Funded by Forest Renewal BC: Terrestrial Ecosystem Restoration Program. 2002. Page 1, 2.	Bighorn sheep	Helicopters	• Bighorn sheep respond dramatically to helicopter disturbance and may abandon important winter feeding grounds in an effort to flee the aircraft (Bleich, 1994). • Helicopters flying at 400m above ground have produced elevated heart rates that may last up to one hour (Stemp, 1983). This can have a greater impact in the spring when females may have young with them.	Helicopter use impacts on bighorn sheep may include displacement from important winter feeding grounds; and elevated heart rates lasting up to one hour.
	Bleich, V.C., R.T. Bowyer, A.M. Pauli, M.C. Nicholson and R.W. Anthes	Mountain sheep Ovis canadensis and helicopter surveys: ramifications for the conservation of large mammals. Biological Conservations 70:1-7. 1994.				
	Stemp, R.E.	Heart rate responses of bighorn sheep to environmental factors and harassment. M.Sc. thesis, Univ. of Calgary, AB. 1983.				

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2	Beckett, J. U.S. EPA, 1991 California Air Resources Board Scott, D. and R. Suffling (editors)	Making Tracks - Motorized Use in the Backcountry. A Fact Sheet from Canadian Parks and Wilderness Society. Funded by Forest Renewal BC: Terrestrial Ecosystem Restoration Program. 2002. Page 2. Non-road engine and vehicle emission study-report. EPA 21A-2001. US EPA, Office of Air and Radiation. Washington, D.C. 1991. www.arb.ca.gov. 1999. Climate Change and Canada's National Park System. Environment Canada and Parks Canada.	Grizzly bears, ungulates and other wildlife species	Snowmobile and ATV	Pollution and climate change: • Two-stroke engines discharge roughly one third of their fuel unburned, directly into the environment (U.S. EPA, 1991). • Pollutants then travel through the ecosystem by seeping into the soil and end up in streams and lakes. • One hour of two-stroke engine use emits as much hydrocarbon pollution as driving a modern car for one year (California Air Resources Board, 1999). • Climate change is identified as a significant stress in parks and protected areas according to a recent Parks Canada report (Scott and Suffling, 2000).	Snowmobile and ATV use effect wildlife habitat through the substantial contribution they make to pollution and climate change. The two-stroke engine discharges roughly one third of its fuel unburned directly into the environment; and one hour of two-stroke engine use emits as much hydrocarbon pollution as driving a modern car for one year.

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#	Author	Report				
	Canfield, Jodie; Jack Lyon; Michael Hillis and Michael Thompson	Effects of Recreation on Rocky Mountain Wildlife: A Review for Montana. 1999. Chapter 6, page 6.6.	Ungulate Winter Range	Human activity	• Gates and Hudson (1979), found that activity by elk in cold temperatures results in a thermoregulatory penalty, that is, it takes more energy to move in winter than in the fall. Thus, while inactivity provides an energetic advantage for animals exposed to cold, forced activity caused by human disturbance exacts an energetic disadvantage. • Overt expression of energetic cost can take a number of forms, ranging from an increase in general alertness to a slow retreating movement to outright flight, depending on the ungulate species and the type of disturbance. • Geist (1978) defined effects of human disturbance in terms of increased metabolism, which could result in illness, decreased reproduction, and even death.	Human disturbance exacts an energetic disadvantage on wintering animals. Overt behavioural responses are highly variable, and range from an increase in general alertness to outright flight. Physiological responses include increased metabolism, which could result in illness, decreased reproduction and death.
	Gates, C.C. and R.J. Hudson	Effects of posture and activity on metabolic responses of wapiti to cold. Journal of Wildlife Management 43(2):564-567. 1979.				
	Geist, V.	Behaviour. Pages 283-296 in J.L Schmidt and D.L. Gilbert, editors. Big game of North America: ecology and management. Stackpole Books, Harrisburg, P.A.. 494pp. 1978.				

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Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
2	Canfield, Jodie; Jack Lyon; Michael Hillis and Michael Thompson Berwick, S.H. Geist, V. Dunaway, D.J. Stemp, R.E.	Effects of Recreation on Rocky Mountain Wildlife: A Review for Montana. 1999. Chapter 6, page 6.6. Observations on the decline of the Rock Creek, Montana, population of bighorn sheep. Thesis, University of Montana, Missoula, Montana. 245pp. 1968. Bighorn sheep ecology. Wildl. Soc. News 136:61. 1971. Human disturbance as a limiting factor of Sierra Nevada bighorn sheep. Transactions of the N.A. Wild Sheep Conf. 1:165-173. 1971. Heart rate responses of bighorn sheep to environmental factors and harassment. Thesis, Univ. of Calgary, AB, Cda. 314pp+appendices. 1983.	Bighorn sheep	Recreation	• Of the ungulate species for which relationships with humans and disturbance have been reported, the bighorn sheep appears to be most susceptible to detrimental effects. • Berwick (1968) suggested that harassment may be debilitating to winter stressed animals, and several other authors have agreed. Geist (1971) speculated that harassment by recreationists may be fatal to sheep, and Dunaway (1971) considered disturbance caused by human recreation to be a factor limiting populations of bighorn sheep in California. • Stemp (1983), who used observations as well as heart rate data to monitor response to harassment, reported that overt behaviour was a poor indicator of the stress response of bighorn sheep to human intruders.	Bighorn sheep are highly susceptible to human disturbance, however their overt behavioural response is a poor indicator of the stress incurred by disturbance. Disturbance caused by recreation is considered to be a factor limiting populations of bighorn sheep in California.

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#	Author	Report				
3	Canfield, Jodie; Jack Lyon; Michael Hillis and Michael Thompson	Effects of Recreation on Rocky Mountain Wildlife: A Review for Montana. 1999. Chapter 6, page 6.7.	Ungulate Winter Range	Snowmobile	• Mahler (1967) complained that snow machines were illegally used for hunting. • Neuman and Merriam (1972) reported the loss of insulating quality in snow packed by snowmobiles as well as damage to vegetation. Fancy and White (1985) found that the energy cost for caribou of cratering through snow compacted by a snowmobile was 2-4 times as great as for uncrusted snow. • Huff and Savage (1972) reported that the size of home ranges for whitetails was reduced in high use areas, and snowmobile use appeared to force deer into less preferred habitats. • Aasheim (1980) observed that animals accustomed to humans are less affected by snowmobiles than animals in more remote areas.	Effects of snowmobile activity on wintering ungulates include: reduced forage availability as the result of snow compaction; reduced home range size; and displacement to less preferred habitats.
	Malaher, G.W.	Improper use of snow vehicles for hunting. Transactions of the N.A. Wildl. and Natural Resources Conference 32:429-433. 1967.				
	Neuman, P.W. and H.G. Merriam	Ecological effects of snowmobiles. The Cdn Field-Naturalist 86:207-12. 1972.				
	Fancy, S.G. and R.G. White	Energy expenditures by caribou while cratering in snow. Journal of Wildl. Manage.49(4):987-993. 1985.				
	Huff, D.E. and P.J. Savage	A correlation of deer movements with snowmobile activity in Minnesota during winter. Proc. of the Midwest Fish and Wildl. Conf. 34:42-49. 1972.				
	Aasheim, R.	Snowmobile impacts on the natural resource environment. Pages 191-200 in R.N.L. Andrews and P.F. Nowak, ed. Off-road vehicle use: a management challenge. U.S. Dept. of Agric., Office of Environ. Quality. Washington, D.C. 1980.				

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#	Author	Report				
4	Canfield, Jodie; Jack Lyon; Michael Hillis and Michael Thompson	Effects of Recreation on Rocky Mountain Wildlife: A Review for Montana. 1999. Chapter 6, page 6.6.	Ungulate Winter Range	Winter recreation	• Parker et al (1984) observed, "Flight distances decline from early to late winter as the animals become habituated and as body energy reserves are depleted. Greater flight distances occur in response to skiers or individuals on foot than to snowmobiles, suggesting that the most detrimental disturbances to wintering animals is that which is unanticipated." • This greater response to unpredictable or erratic disturbance was also noted for pronghorn (Segerstrom 1982) and bighorn sheep (Stemp 1983).	Observations indicate that the most detrimental disturbances to wintering animals are those that are unanticipated.
	Parker, K.L, C.T Robbins, T.A. Hanley	Energy expenditures for locomotion by mule deer and elk. Journ. of Wildl. Manage. 48(2): 474-488. 1984.				
	Segerstrom, T.	Effects of an operational coal strip mine on pronghorn antelope. Pages 174-208 in J.V. McKenzie, chair. Proc. of the tenth pronghorn antelope conference. 1982.				
	Stemp, R.E.	Heart rate responses of bighorn sheep to environmental factors and harassment. Thesis, Univ. of Calg., AB. 314pp+ appendices. 1983.				

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Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
5	Canfield, Jodie; Jack Lyon; Michael Hillis and Michael Thompson Bleich, V.C., R.T. Bowyer, A.W. Pauli, M.C. Nicholson, and R.W. Anthes Joslin, G. Cote, S.D.	Effects of Recreation on Rocky Mountain Wildlife: A Review for Montana. 1999. Chapter 6, page 6.7. Mountain Sheep and Helicopter Surveys: ramifications for the conservation of large mammals. Biol. Cons. 70(1): 1-7. 1994 Mountain goat population changes in relation to energy exploration along Montana's Rocky Mountain Front. Pages 253-271 in Proceedings of the Fifth Northern Wild Sheep and Goat Council. 1986. Mountain goat responses to helicopter disturbance. Wildl. Soc. Bull. 24(4): 681-685. 1996.	Mtn Goat, Bighorn Sheep	Helicopter	• Bleich et al. (1994) recorded negative responses of bighorn sheep to helicopter over flights. • Joslin (1986b) reported a decline in mountain goat reproduction and/or recruitment of kids in response to disturbance by helicopters in Montana. • Cote (1996) reported that mountain goats were disturbed by 85% of all flights within 500m. • Luz and Smith (1976) found that pronghorn responses to helicopters varied from mild to strong in relation to decibel levels.	Bighorn sheep and mountain goats respond negatively to helicopter over flights; for mountain goats a decline in reproduction rate is reported.
6	Canfield, Jodie; Jack Lyon; Michael Hillis and Michael Thompson Chabot, D.	Effects of Recreation on Rocky Mountain Wildlife: A Review for Montana. 1999. Chapter 6, page 6.7, 6.8. The use of heart rate telemetry in assessing the metabolic cost of disturbances. Transactions of the N.A. Wildlife and Natural Resources Conf. 56:256-263. 1991.	Ungulate Winter Range	Snowmobile and helicopter	The degree of disturbance caused by skiers, snowmobiles, and helicopters has mostly been reported in terms of flight response, or in some other observed change in animal behaviour. Based on elk heart rate data, Chabot (1991) showed that even when disturbances do not induce an overt behavioural response, the increased heart rates can result in relatively high energy expenditures. These results have been confirmed and expanded for a variety of ungulates including mule deer, white tailed deer, elk, bighorn sheep and other ungulates.	Relatively high energy expenditure can result from human disturbance which does not elicit an overt behavioural response, but rather is only expressed through heart rate response. These results are confirmed and expanded for virtually every ungulate species.

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#	Author	Report				
7	Canfield, Jodie; Jack Lyon; Michael Hillis and Michael Thompson	Effects of Recreation on Rocky Mountain Wildlife: A Review for Montana. 1999. Chapter 6, page 6.2.	Ungulate Winter Range	Winter recreation	Impacts of human disturbance to wintering animals include: • increased energy costs at a time when it is critical for the animals to minimize energy expenditure; • possible displacement to less desirable habitats; • possible tolerance of urban developments. Tendencies to habituation vary by species, but habituated ungulates are almost always undesirable.	Winter recreation impacts to ungulates include increased energy expenditure; habitat displacement; and potential habituation.
1	Cote, S.D. McArthur, R.A., R.H. Johnston and V.Geist Calef, G.W., E.A. DeBock and G.M. Lortie Joslin, G. Harrington, F.H. and A.M. Veitch	Mountain goat response to helicopter disturbance. Wildl. Soc. Bull 24(4): 681-685. 1996. Page 684. Factors influencing heart rate in free-ranging bighorn sheep: a physiological approach to the study of wildlife harassment. Can. J. Zool. 57:2010-2021. 1979. The reaction of barren ground caribou to aircraft. Arctic 29:201-212. 1976. Mountain goat population changes in relation to energy exploration along Montana's Rocky Mountain Front. Proc. Bienn. Symp. North. Wild Sheep and Goat Counc. 5: 253-269. 1986. Short term impacts of low-level jet fighter training on caribou in Labrador. Arctic 44: 318-327. 1991.	Mtn Goat	Helicopter	• Reaction to helicopters can increase energy expenditure, reduce fat accumulation, or change animal physiological condition (McArthur et al 1979), factors that may affect survival or reproduction (Calef et al. 1976, Joslin 1986, Harrington and Veitch 1991). • Prolonged helicopter disturbance could have severe consequences on daily energy intake of goats, especially for kids and nursing females.	Impacts of helicopter over flights on mountain goats may include: increased energy expenditure; reduced fat accumulation; and changed physiological condition. These factors affect overall reproduction and survival.

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#	Author	Report				
2	Cote, S.D. Foster, B.R. and E.Y. Rahs Stockwell, C.A., G.C. Bateman and J. Berger	Mountain goat response to helicopter disturbance. Wildl. Soc. Bull 24(4): 681-685. 1996. Page 684. Mountain goat response to hydroelectric exploration in Northwestern British Columbia. Environ. Manage. 7:189-197. 1983. Conflicts in National Parks: a case study of helicopters and bighorn sheep time budgets at the Grand Canyon. Biol. Conserv. 56: 317-328. 1991	Mtn Goat	Helicopter	• In the Alberta Caw Ridge study, the distance between the mountain goat groups and the helicopter was the most important factor affecting their behaviour. Goats appeared to be more sensitive to helicopter traffic than other open terrain ungulates; 37% of flights at > 1500m caused at least a moderate reaction. • Foster and Rahs (1983) found mountain goats were affected by flights within 1 km, the recommended flight distance from caribou and muskox, and responded beyond the disturbance distance threshold of 250-450 m observed for desert bighorn sheep (Stockwell et al 1991). • Observed goat herd splintering supports this conclusion.	Goats reacted to flights which were greater than 1.5 km in distance, indicating a higher sensitivity to helicopter traffic than other open terrain ungulates.
1	Graham, P.J. Moen, A., S. Whittemore, B.Buxton Parker, K.L., C.T. Robbins and T.A. Hanley Ward, L.A and J.C. Cupal	Snowmobile Grant Program. Montana Department of Fish, Wildlife and Parks. Final Programmatic Environmental Impact Statement. 1993. Page 84. Effects of disturbance by snowmobiles on heart rate of captive white-tailed deer. NY Fish & Game Journal. 1982. Energy expenditures for locomotion by mule deer and elk. 1984. Telemetered heart rate of three elk as affected by activity and human disturbance, Rocky Mount. For. Range Exp. Sta. 1980.	Ungulate Winter Range	Snowmobile	Physiological and overt behavioural responses: • Moen et al (1982) reported increased heart rate from 2.5 to 2.9 times in white-tailed deer, depending on the directed course of the snowmobile. They found no evidence of habituation to the disturbance, either in magnitude of the heart rate response or to the time for a return to normal. • Parker et al (1984) pointed out the additional drain on wintering mule deer or elk by artificially induced locomotion, a drain which could be important to their survival on poor winter range. • Ward and Cupal (1980) reported that based on heart rate, security cover was very important in dictating the distances of effective response by elk to human disturbance. Proximity to cover should be an important consideration in laying out snowmobile routes.	Effects of snowmobile disturbance on wintering ungulates include: • increased heart rate; and • flight response representing energy expenditure with potential survival impacts, depending on winter range quality. Effects appear to be directly related to availability of security cover.

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Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
	Graham, P.J.	Snowmobile Grant Program. Montana Department of Fish, Wildlife and Parks. Final Programmatic Environmental Impact Statement. 1993. Page 85.	Grizzly Bear	Snowmobile	Recent studies of radio-collared grizzlies have shown that females and females with cubs were generally found in high elevation habitats covered by snow from mid-October through mid-May. During post-denning periods, females with cubs are less mobile than other bears and remain near the den site from early April through mid-May. Thus high elevation snowmobiling during mid to late-spring could increase the potential for encounters with post-denning bears (Mace and Manley, Pers. Commun.).	Grizzly bears are most susceptible to snowmobile disturbance in mid to late spring when females with cubs emerge from dens and have limited mobility.
	Jamieson, Bob.	Tools for Achieving Compliance with Recreation Management Regulations in B.C. 2002. Page 18.	Grizzly Bear	Open roads – traffic and road density	General consensus in the wildlife literature is that road density and road use have a major impact on habitat availability and therefore long term population status for grizzly bears. Note that it is the human use of the road (not the road itself), that is an issue for bears.	Road density and use have a major impact on habitat availability and therefore long-term population status for grizzly bears.
	Jamieson, Bob.	Tools for Achieving Compliance with Recreation Management Regulations in B.C. 2002. Page 18.	Ungulate Winter Range	Winter recreation	Heavy recreational use can affect both habitat availability for wintering ungulates, and can result in stress in individual animals as measured by stress hormone levels.	Heavy recreational use can affect both habitat availability for wintering ungulates, and can result in stress in individual animals as measured by stress hormone levels.
	Jamieson, Bob	Tools for Achieving Compliance with Recreation Management Regulations in B.C. 2002. Page 18.	Ungulate Winter Range	Snowmobile	Snowmobile use is a major issue in relation to wintering moose and caribou in B.C. since they winter in the deeper snow areas where most winter recreation occurs.	Moose and caribou are particularly susceptible to snowmobile use since they winter in deeper snow areas.
	Jamieson, Bob	Tools for Achieving Compliance with Recreation Management Regulations in B.C. 2002. Page 18.	Ungulate Winter Range	Snowmobile	Anecdotal evidence indicates that predation by wolf and cougar have a major impact on mountain goat populations, and these predators may be accessing high elevation wintering areas via roads and snowmobile tracks (T. Kinley, pers. comm.)	Mountain goat predation pressure in winter ranges is observed to be increasing as the result of wolf use of snowmobile tracks and roads.

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Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
1	Knight, R.L. and K.J. Gutzwiller	Wildlife and Recreationists: Coexistence through Management and Research	Wildlife species generally	Human-made noise	• Wild animals can abandon favored habitat in response to disturbances or incur energetic expenses after reacting repeatedly when they cannot escape (p 116). • Aversive levels of noise might cause wild animals to become irritable, affecting feed intake, social interactions, or parenting. All these effects might eventually result in population declines (p 116). • If a noisy sound source arouses an animal, it has the potential to affect its metabolic rage by making it more active. Increased activity can, in turn, deplete energetic reserves (p 123).	Human made noise can cause the following responses in wild animals: 1.) preferred habitat abandonment; 2.) increased activity and depletion of energetic reserves; 3.) irritation, reduced feeding, altered social interactions or parenting. These effects have the potential to cause population declines.

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#	Author	Report				
2	Knight, R.L. and K.J. Gutzwiller Harrington, F.H. and A.M. Veitch Murphy, S.M., R.G. White, B.A. Kugler, J.A. Kitchens, M.D. Smith &D.S. Barber Malme, C.I., P.R. Miles, C.W. Clark, Pl Tyack and J.E. Bird Davis, R.W., T.M. Williams and F. Awbrey Gese, E.M., O.J. Rongstad, and W.R. Mytton Klein, D.R.	Wildlife and Recreationists: Coexistence through Management and Research Short term impacts of low-level jet fighter training on caribou in Labrador. Arctic 44 (4): 318-327. 1991. Behavioral effects of jet aircraft on caribou in Alaska. Proc, of the 6th International Congress on Noise as a Public Health Problem. Actes INRETS 34 (3):471-478. 1993. Investigations of the potential effects of underwater noise from petroleum industry activies on migrating gray whale behaviour Phase II: January 1984 Migration. Report by Bolt Beranek and Newman Inc. for U.S. Departments of the Interior. Technical Report No. 5586. 245 pp. 1984. Sea otter oil spill avoidance study. OCS Study. Report by Sea World Research Institute, Hubbs Marine Research Center for U.S. Dep. Of Interior, Minerals Management Services, Pacific Outer Continental Shelf Region. Technical Report No. MMS 88-0051. 65pp. 1988. Changes in coyote movements due to military activity. Journal of Wildlife Management 53(2): 334-339. 1989. Reactions of reindeer to obstructions and disturbances. Science 173: 393-398. 1983.	Grizzly bears, ungulates and other wildlife species	Human-made noise	• Studies have documented increases in activity after aircraft approaches. The overt behavioural component of these responses was fairly mild, such as starting a few steps or walking away slowly from the site of the disturbance (Harrington and Veitch 1991, Murphy et al 1993). However individuals tracked remotely moved greater distances in the 24 hours after exposure, on the order of 1-2 km (p 124). • Large mammals alter their movements for periods of up to one to two days after exposure to noisy disturbances (Harrington and Veitch 1991; Malme et al 1984; Davis et al 1988; Gese et al 1989; Klein 1973; Miller and Gunn 1979). Sometimes this results in short term changes in habitat use (Krausman et al 1986) (p 132). • If noisy sources enter the habitat on a schedule (e.g. snowmobiles on weekends), deer, sheep and elk avoid areas when the noisy sources are present and return when they are not (Van Dyke et al. 1986; Dorrance et al 1975; Edge and Marcum 1985; Leslie and Douglas 1980). If exposure is brief or if mammals have good cover, differences in home-range size are not detectable (Eckstein et al 1979; Edge et al 1985) (p 132). • If mammals are exposed repeatedly to the same noisy stimulus without harassment, responses decline rapidly (Krausman et al 1986; Valkenburg and Davis 1985). On the other hand, harassment amplifies responses (King and Workman 1986) (p 132).	Noisy disturbance causes large mammals to alter their movements for up to two days following exposure. Short term changes to habitat use may result, however in the case that noisy disturbance is predictable and is not associated with harassment, ungulates in particular are capable of developing an adaptive, avoidance or habituation, behavioural response.

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#	Author	Report				
	Continued… Knight, R.L. and K.J. Gutzwiller Miller, F.L. and A. Gunn Krausman, P.R., B.D. Leopold, and D.L. Scarborough.	Continued…. Wildlife and Recreationists: Coexistence through Management and Research Responses of Peary caribou and muskoxen to turbo-helicopter harassment, Prince of Wales Island, NWT, 1976-1977. Canadian Wildlife Service Occasional Paper 40. 88pp. 1979. Desert mule deer response to aircraft. Wildl. Soc. Bull. 14 (1):68-70. 1986.	Cont'd Grizzly bears, ungulates and other wildlife species	Continued… Human-made noise		
	Mace, Richard; John S. Waller; Timothy Manley; Jack Lyon; Hans Zuuring	Relationships among grizzly bears, roads and habitat in the Swan Mountains, Montana. Page 1402, 1403.	Grizzly Bear	Open roads-traffic, and road density	• Female grizzly bears occupied ranges having lower total road densities than unused areas. Female home range selection was high for sub alpine habitats that were unroaded and low for low temperate zone habitats with roads. • Selection was greatest for unroaded cover types, and declined as road densities increased. A total road density on multiple use lands of 6km/sq.km differentiated the used from unused areas.	Grizzly bear use of suitable habitat in Montana declined as road density and road traffic increased.

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#	Author	Report				
	McLellan, Bruce and David Shackleton	Impact of roads on Grizzly Bears. Page 25, 26	Grizzly Bear	Open roads – traffic, and adjacent cover	• Habitats within 250m of open road were used significantly less than habitats greater than 250m from roads. Use pattern represents a habitat loss equivalence of 58% in 0-100m distance from road; and 7% in the 101-250m distance from road. In the Flathead study area, this results in a total habitat loss equivalence of 8.7% (p25). • The amount of traffic on the road did not appear to influence bears' use of the habitat adjacent to it (p1). • The amount of cover offered adjacent to the road did not influence bear use of road side habitat (p1). • Flathead study population behaviours which are potentially reducing habitat loss impacts are: use of areas in close proximity to roads during hours of darkness; bear use of roads for travel; and age/sex class differences in bears that tend to use areas near roads (p25-26). In this case, the study population has somewhat adapted to the long standing presence of roads, however the adaptive behaviours do not compensate for habitat loss impacts resulting from road proximity avoidance (p25-26).	In the Flathead grizzly bear study area, open road represents total habitat loss of 8.7% due to decreased use of areas within 250m of the road (p25).
	McLellan, Bruce and David Shackleton	Impact of roads on Grizzly Bears, Page 29	Grizzly Bears	Open roads-traffic and adjacent cover	Behavioural response to road traffic: Bears immediate responses to vehicles indicates that when they are in open habitats they flee to cover, but when in cover, no reactions were detected. Weaned yearlings demonstrated the least response to vehicles (p2).	Roads in the Flathead study area, at their current density and levels of use, do cause behavioural changes in the bear population, but do not have a significant impact on the grizzly bear population density (p29).
	McLellan, B.N. and D.M. Shackleton	Impact of roads on Grizzly Bears. Page 30, 31	Grizzly Bear	Open roads – direct human caused mortality	Access, and legal and illegal hunting: Roads in the Flathead study area have a very high potential of being a significant factor in future population declines due to the fact that most bears are killed from roads, and a slight increase in the number of adult female bears in the harvest will cause the population to decrease (p30, 31).	Once an area is roaded, its grizzly bear population is put in a precarious position and must be managed carefully (p31).

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Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
	Noss, Reed	Ecological Effects of Roads. 1995. Page 12, 13.	Grizzly Bear	Open roads – traffic, and direct human caused mortality	Habituation response to road traffic: In any area where animals are exposed to frequent human activity, habituation can be expected which is not desirable because: some habituated animals will become aggressive toward humans resulting in their eventual demise (p12); and habituated animals are more vulnerable to legal and illegal shooting (p13).	Grizzly bear studies in Montana and B.C. have found that bears habituated to human activity, especially moving vehicles, are more vulnerable to legal and illegal shooting (p13).
	Noss, Reed Dood Knick & Kasworm	Ecological Effects of Roads. 1995. Page 17. No bibliography provided in the Noss report	Grizzly Bear	Open roads – direct human caused mortality	Access, and legal and illegal hunting: • Dood and coworkers found that 32% of all hunting mortality and 48% of all non-hunting mortality of grizzlies in Montana occurred within one mile of a road. • Knick and Kasworm recently found that illegal shooting was the primary cause of death for grizzlies in the Selkirk and Cabinet-Yaak ecosystems.	The majority of grizzly mortalities occur in close proximity to roads. Consequently, the ability of regions to maintain viable populations of grizzly bears is directly related to road density and human access (p17).

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Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
1	**Olliff, T., K. Legg, and B. Kaeding, editors.** Marchand, P.J. Nelson, J.R. and T.A. Leege Thorne, E.T., R.E. Dean, and W.G. Hepworth Geist, V.	Effects of winter recreation on wildlife of the Greater Yellowstone Area: a literature review and assessment. Report to the Greater Yellowstone Coordinating Committee. Yellowstone National Park, Wyoming. 315 pages. 1999. Page 21. Life in the cold: an introduction to winter ecology. Third edition. University Press of New England, Hanover, New Hampshire, USA. 1996. Nutritional requirements and food habits. Pages 232-368 in J.W. Thomas and D.E. Toweill, editors. Elk of North America: ecology and management. Stackpole Books, Harrisburg, PA, USA. 1982. Nutrition during gestation in relation to successful reproduction in elk. Journal of Wildlife Management 40: 330-335. 1976. Adaptive behavioural strategies. Pages 219-278 in J.W. Thomas and D.E. Toweill, editors. Elk of North America: ecology and management. Stackpole Books, Harrisburg, PA, USA. 1982.	Ungulate Winter Range - Elk	Winter recreation	• Marchand (1996) reports that because of the low quality of winter forage, elk often rely on reducing energy expenditure to increase their chances of surviving and successfully reproducing. • Nelson and Leege (1982) report that in experimental feeding trials most elk lost weight on diets that mimicked winter diets. Up to approx. 87% of the daily forage consumed by an elk in winter is used for standard metabolic function, leaving less than 15% for growth, reproduction, temperature regulation, and activity. • Thorne et al (1976) correlated high winter weight loss in pregnant females with prenatal calf loss, low calf birth weight, and low survival of newborns. • Adult males usually enter the winter in relatively poor condition and often injured as a result of rutting activity in the fall. Geist (1982) reports that quality of winter habitat alone may determine whether some males survive the winter.	Elk rely on fairly restricted winter ranges in which food and cover may be limited or of marginal quality, and consequently, any activity preventing them from using all or part of that range could reduce their ability to survive or to successfully reproduce (p21).

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Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
2	**Olliff, T., K. Legg, and B. Kaeding, editors.** Anderson, E.W. and R.J. Scherzinger Aune, K.E.	Effects of winter recreation on wildlife of the Greater Yellowstone Area: a literature review and assessment. Report to the Greater Yellowstone Coordinating Committee. Yellowstone National Park, Wyoming. 315 pages. 1999. Page 21. Improving quality of forage for elk by cattle grazing. Journal of Range Management 28:120-125. 1975. Impacts of winter recreationists on wildlife in a portion of Yellowstone National Park, Wyoming. Thesis, Montana State University, Bozeman, Montana, USA. 1981.	Ungulate Winter Range - Elk	Snowmobile	• Anderson and Scherzinger (1975) reported that when recreational snowmobile activity increased in the Bridge Creek Game Management Area in northeastern Oregon, winter elk counts decreased by 50%. After the area was closed to snowmobiling, the population returned to its previous numbers. • Aune (1981) reported that snowmobile activity in Yellowstone Nat. Park occasionally inhibited free movement of wildlife, temporarily displacing them from certain areas. The most significant impact on wildlife distribution appeared to be within 60m of groomed snowmobile trails.	Temporary displacement of elk from winter range as the result of snowmobile activity is documented in northeastern Oregon and Yellowstone National Park.

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Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
3	**Olliff, T., K. Legg, and B. Kaeding, editors.** **Ward, A.L.** **Aune, K.E.**	Effects of winter recreation on wildlife of the Greater Yellowstone Area: a literature review and assessment. Report to the Greater Yellowstone Coordinating Committee. Yellowstone National Park, Wyoming. 315 pages. 1999. Page 23. Elk behaviour in relation to multiple uses on the Medicine Bow National Forest. Proceedings of Western Association State Game and Fish Commission 53: 125-141. 1973. Impacts of winter recreationists on wildlife in a portion of Yellowstone National Park, Wyoming. Thesis, Montana State University, Bozeman, Montana, USA. 1981.	Ungulate Winter Range - Elk	Snowmobile	• Ward (1973) reported that elk are easily conditioned to repeated patterns of human activity, but tend to be disturbed by deviations from normal patterns (p23). • In Yellowstone Nat. Park, Aune (1981) found that wildlife species, including elk, were more likely to be displaced by, or exhibit flight responses to snowmobile traffic during the pre-season than during the recreational season. This may have resulted from habituation by elk to the presence of snowmobile traffic and to establishment of a more constant traffic pattern during the recreational season. This change in response may also have resulted from decreasing physical condition of elk later in the winter, and increasing snow depth and crusting that inhibited flight (p23). • Elk also demonstrated a shift to a more crepuscular activity pattern when recreational snowmobile activity increased (Aune, 1981) (p23).	Elk are less likely to be displaced by or exhibit flight responses, when disturbance is predictable and limited to established trails.
4	**Olliff, T., K. Legg, and B. Kaeding, editors.**	Effects of winter recreation on wildlife of the Greater Yellowstone Area: a literature review and assessment. Report to the Greater Yellowstone Coordinating Committee. Yellowstone National Park, Wyoming. 315 pages. 1999. Page 25.	Ungulate Winter Range - Elk	Snowmobile	• Disturbance in areas where motorized activity is overland, is less predictable than on established motorized routes, and therefore has more potential to create flight response in individual elk or groups of elk. • Overland motorized use is likely to occur over a less confined area than transportation routes, potentially increasing the area of disturbance or displacement of elk. • This type of recreation usually occurs in higher elevation, deep snow areas and so may impact only scattered groups of adult males.	Overland motorized activity has more potential for causing elk flight response, since disturbance in these areas is unpredictable.

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Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
5	**Olliff, T., K. Legg, and B. Kaeding, editors.** Shank, C.C.	Effects of winter recreation on wildlife of the Greater Yellowstone Area: a literature review and assessment. Report to the Greater Yellowstone Coordinating Committee. Yellowstone National Park, Wyoming. 315 pages. 1999. Page 78. Human related behavioural disturbance to northern large mammals: a bibliography and review. Report prepared for Foothills Pipe Lines (South Yukon) Limited, Calgary, Alberta. 1979.	Ungulate Winter Range - Moose	Human activity	• Flight behaviour of moose is unusual and often misinterpreted. Their reputation of being tolerant to humans may in part be because their stress response is more subtle than that of other ungulates. Shank (1979) reported a common response of moose to a disturbance was that they rarely reacted immediately and overtly to disturbing stimuli unless that stimulus was very intense. Often, they continued feeding and might even increase the intensity of feeding. While this is occurring, they moved without obvious sign of stress toward cover. Once cover was reached, they usually looked directly at the source of disturbance, often for the first time, and then ran. Until the moose bolts, stress may not be obvious because it is expressed in less noticeable physiological responses, such as increased breathing and elimination rates (p78).	Immediate response to disturbance by moose is physiological stress, which, because it is not physically obvious, has often been misinterpreted as a high degree of tolerance to human activity.
6	**Olliff, T., K. Legg, and B. Kaeding, editors.** Geist, V. Busnel, R.G.	Effects of winter recreation on wildlife of the Greater Yellowstone Area: a literature review and assessment. Report to the Greater Yellowstone Coordinating Committee. Yellowstone National Park, Wyoming. 315 pages. 1999. Page 77, 80, 81. A behavioural approach to the management of wild ungulates. Pages 413-424 in E. Duffey and A.S. Watt, editors. The scientific management of animal and plant communities for conservation. Eleventh Symposium of the British Ecological Society. 1971. Introduction in J.L Fletcher and R.G. Busnell, editors. Effects of noise on wildlife. Academic Press. NY, NY, USA. 1978.	Ungulate Winter Range - Moose	Human activity	• Moose are negatively impacted if disturbance causes increased energy expenditure (p80). • Increased energy expenditure through flight and stress, are most likely when disturbance is unpredictable, is severe to sensory perception, and is in close proximity (p80, 81). • Moose are often in an environment where snow is deep, so flight response to disturbance is energetically costly (p80). • Geist (1971) stated that if visual and acoustical stimuli are predictable in space and time, the process of habituation by wildlife is enhanced (p77). • Busnel (1978) reported that panic responses may occur as a result of any kind of abrupt unexpected intrusion (p77).	The most severe impacts to wintering animals are the energetically costly flight and stress responses, resulting from unpredictable disturbance.

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Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
7	**Olliff, T., K. Legg, and B. Kaeding, editors.** **Rudd, L.T. and** **L.L. Irwin**	Effects of winter recreation on wildlife of the Greater Yellowstone Area: a literature review and assessment. Report to the Greater Yellowstone Coordinating Committee. Yellowstone National Park, Wyoming. 315 pages. 1999. Page 78, 81. Wintering moose vs oil/gas activity in western Wyoming. Alces 21:279-298. 1985.	Ungulate Winter Range - Moose	Snowmobile	• Rudd and Irwin (1985) reported that 50% of encounters between moose and snowmobiles resulted in displacement, while 94% resulted in some form of disturbance (p78). • Disturbance in areas where motorized activity is overland (not limited to established trails), is not predictable to moose. Routes, time of day, and numbers of people will be highly variable. As a result, there is a high probability of initiating a flight response and a low probability of habituation occurring. In addition, there is a chance snowmobilers will approach moose because snowmobile movements are unrestricted. This could be energetically very expensive for moose (p81).	Snowmobile activity causes displacement and disturbance responses in moose. The most severe impacts are in areas where overland motorized activity is permitted, since disturbance is these areas is unpredictable.
8	**Olliff, T., K. Legg, and B. Kaeding, editors.**	Effects of winter recreation on wildlife of the Greater Yellowstone Area: a literature review and assessment. Report to the Greater Yellowstone Coordinating Committee. Yellowstone National Park, Wyoming. 315 pages. 1999. Page 81.	Ungulate Winter Range - Moose	Roads and groomed trails	Moose are uniquely vulnerable to mortality by collisions with vehicles. This is because of the relationship between moose, browse availability, and snow conditions. Plowed roads and groomed trails in moose winter range offer moose relief from snow conditions as well as travel corridors to sources of browse. This, combined with their instinctive response of standing their ground in the face of a perceived threat help explain why this is such a serious problem in many areas (p81).	Moose tend to use plowed roads and groomed trails as travel routes, which combined with their delayed flight response, invites collisions with vehicles.

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Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
9	**Olliff, T., K. Legg, and B. Kaeding, editors.** Penner, D.F. Chadwick, D.H. Foster, B.R. Hebert, D.H. and W.G. Turnbull,	Effects of winter recreation on wildlife of the Greater Yellowstone Area: a literature review and assessment. Report to the Greater Yellowstone Coordinating Committee. Yellowstone National Park, Wyoming. 315 pages. 1999. Page 90. Behavioural response and habituation of mountain goats in relation to petroleum exploration at Pinto Creek, Alberta. Biennial Symposium of the Northern Wild Sheep and Goat Council 6:141-158. 1988. Mountain goat ecology-logging relationships in the Bunker Creek Drainage of Western Montana. Thesis, University of Montana, Missoula, Montana, USA. 1973. Historical patterns of mountain goat harvest in British Columbia. Pages 147-159 in W. Samuel and W.G. Macgregor, editors. Proceedings of First International Mountain Goat Symposium, Kalispell, Montana. British Columbia Ministry of Recreation and Conservation, Canada. 1977. A description of southern interior and coastal mountain goat ecotypes in B.C.. Pages 126-146 in W. Samuel and W.G. Macgregor, editors. Proceedings of First International Mountain Goat Symposium, Kalispell, Montana. British Columbia Ministry of Recreation and Conservation, Canada. 1977.	Mtn Goat	Human activity Continued…	• Human disturbance can affect goat physiology, distribution, habitat use, fecundity, and ultimately, population health (Penner, 1988). • Decline in goat population levels occurred when development in or near goat habitats took place. The mechanisms causing population declines seem to be related to improved access for hunting or poaching (Chadwick, 1973; Foster, 1977; Hebert and Turnbull, 1977; Smith and Raedeke, 1982; Smith, 1984), abandonment of habitat due to alterations or disturbance (Chadwick, 1973; Hebert and Turnbull, 1977; Pendergast and Bindernagel, 1977), or continual stress as a result of human presence (Joslin, 1986). • Controlling human access has been continually suggested as the management tool that will have the greatest effects on the long-term health of goat populations (Chadwick, 1973, 1983; Eastman, 1977; Hebert and Turnbull, 1977; McFetridge, 1977; Wigal and Coggins, 1982; Joslin, 1986; Haynes, 1992). Joslin (1986) states, "Motorized access in or near mountain goat habitat is probably the single biggest threat to goat herds throughout North America."	Goat populations have declined in response to human disturbance. Population declines appear to be related to improved access for hunting and poaching, abandonment of habitat due to alteration or disturbance, or continual stress as the result of human presence. Of these mechanisms, motorized access is considered the biggest threat.

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Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
9	Olliff et al cont'd			human disturbance continued…		
	Smith, C.A. and K.J. Raedeke	Group size and movements of a dispersed, low density goat population with comments on inbreeding and human impact. Biennial Symposium of the Northern Wild Sheep and Goat Council 3: 54-67. 1982.				
	Smith, C.A.	Evaluation and management implications of long-term trends in coastal mountain goat populations in southeast Alaska. Biennial Symposium of the Northern Wild Sheep and Goat Council 4: 395-424. 1984.				
	Pendergast, B. and J. Bindernagel	The impact of exploration of coal on mountain goats in northeastern B.C.. Pages 64-68 in W. Samuel and W.G. Macgregor, editors. Proceedings of First International Mountain Goat Symposium, Kalispell, Montana. British Columbia Ministry of Recreation and Conservation, Canada. 1977.				
	Chadwick, D.H.	A beast the color of winter. Sierral Club Books, San Francisco, California, USA. 1983.				
	Eastman, D.S.	Research needs for mountain goat management. Pages 160-168 in W. Samuel and W.G. Macgregor, editors. Proceedings of First International Mountain Goat Symposium, Kalispell, Montana. British Columbia Ministry of Recreation and Conservation, Canada. 1977.				
				Continued…		

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Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
9	Olliff et al cont'd			human disturbance continued		
	McFetridge, R.J.	Strategy of resource use by mountain goat nursery groups. Pages 169-173 in W. Samuel and W.G. Macgregor, editors. Proceedings of First International Mountain Goat Symposium, Kalispell, Montana. British Columbia Ministry of Recreation and Conservation, Canada. 1977.				
	Wigal, R.A. and V.L. Coggins	Mountain goat. Pages 1008-1020 in J.A. Chapman and G.A. Feldhamer, editors. Wild mammals of North America: biology, management and economics. John Hopkins University Press, Baltimore, Maryland, USA. 1982.				
	Joslin, G.	Mountain goat population changes in relation to energy exploration along Montana's Rocky Mountain Front. Biennial Symposium of the Northern Wild Sheep and Goat Council 5: 253-271. 1986.				
	Haynes, L.A.	Mountain goat habitat of Wyoming's Beartooth Plateau: Implications for management. Biennial Symposium of the Northern Wild Sheep and Goat Council 8: 325-339. 1992.				

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Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
10	**Olliff, T., K. Legg, and B. Kaeding, editors.** Smith, K.G. Chadwick,D.H. Smith, C.A. Wigal, R.A. and V.L. Coggins Hamilton, S., J. Carlisle, and R. Garwood USFS (U.S. Forest Service)	Effects of winter recreation on wildlife of the Greater Yellowstone Area: a literature review and assessment. Report to the Greater Yellowstone Coordinating Committee. Yellowstone National Park, Wyoming. 315 pages. 1999. Page 91. Winter studies of forest dwelling mountain goats of Pinto Creek, Alberta. Biennial Symposium of Wild Sheep and Goat Council 3:374-390. 1982. A beast the color of winter. Sierral Club Books, San Francisco, California, USA. 1983. Evaluation and management implications of long-term trends in coastal mountain goat populations in southeast Alaska. Biennial Symposium of the Northern Wild Sheep and Goat Council 4: 395-424. 1984. Mountain goat. Pages 1008-1020 in J.A. Chapman and G.A. Feldhamer, editors. Wild mammals of North America: biology, management and economics. John Hopkins University Press, Baltimore, Maryland, USA. 1982. Human effects on mountain goats in the Sawtooth National Forest. Sawtooth National Recreation Area. Headquarters, Star Route, Ketchum, Idaho, USA. Environmental assessment for outfitted and guided backcountry helicopter skiing on the Sawtooth National Forest. U.S. Forest Service, Sawtooth National Forest, Ketchum, Idaho, USA. 1977.	Mtn Goat	Winter Recreation	• Because of low productivity and narrow habitat requirements, goats can be considered a fragile wildlife resource, particularly while on winter ranges (Smith, 1982; Chadwick, 1983; Smith, 1984; Wigal and Coggins, 1988). • Because of the remote, rugged nature of goat wintering habitats, recreational use of such areas is unlikely. However, any use could potentially be detrimental. Abandonment of habitats or increased stress related to frequent encounters could be elicited through recreational activities including snowmobiling, skiing accessed by helicopter or from the ground, and ice climbing. • On the Sawtooth National Forest and Sawtooth National Recreation Area in Idaho, special management restrictions on winter recreation, including foot, snow machine and helicopter travel, have been established. Mitigation measures, including area restrictions, closures and other regulations, were enacted to minimize the potential for disturbances to wintering goat populations (Hamilton et al., 1996; USFS, 1997).	Goats are considered a fragile wilderness resource, and although recreational use of their remote, rugged wintering range is unlikely, any use could be detrimental due to potential habitat abandonment or increased stress in response to disturbance.

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Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
11	**Olliff, T., K. Legg, and B. Kaeding, editors.** Singer,F.J. and J.L. Doherty Pedevillano, C. and R.G. Wright Cote, S.D. Penner, D.F. Idaho Department of Fish and Game	Effects of winter recreation on wildlife of the Greater Yellowstone Area: a literature review and assessment. Report to the Greater Yellowstone Coordinating Committee. Yellowstone National Park, Wyoming. 315 pages. 1999. Page 90. Managing mountain goats at a highway crossing. Wildl. Soc. Bull. 13:469-477. 1985. The influence of visitors on mountain goat activities in Glacier National Park, Montana. Biological Conservation 39: 1-11. 1987. Mountain goat responses to helicopter disturbance. Wildl. Soc. Bull. 24(4): 681-685. 1996. Behavioural response and habituation of mountain goats in relation to petroleum exploration at Pinto Creek, Alberta. Biennial Symposium of the Northern Wild Sheep and Goat Council 6:141-158. 1988. Mountain goat management plan, 1991-1995. Boise, Idaho, USA. 1990.	Mtn Goat	Helicopter	• Goats are sensitive to loud noises, so snowmobiles and helicopters could affect their behaviour depending upon the proximity and duration of the disturbance (Singer and Doherty, 1985; Pedevillano and Wright, 1987, Cote, 1996). • Goats are capable of habituation if they are gradually acclimatized and negative associations are avoided (Penner, 1988). This possibility is best achieved when stimuli sources are localized and highly predictable (Penner, 1988; Singer and Doherty, 1985). • Sudden loud noises from helicopters elicited alarm responses from goats that have been habituated to human activity (Penner, 1998; Cote, 1996). • In the Greater Yellowstone Area, most occupied goat winter range occurs within established national wilderness areas where motorized travel is strictly prohibited. • Idaho Department of Fish and Game identified use of helicopters for skiing as an activity potentially detrimental to goats. Where the two are in conflict, goats require protection (Idaho Department of Fish and Game, 1990).	Goats are capable of habituation under certain circumstances when disturbance is localized and predictable, however they do not habituate to the unpredictable, loud disturbance created by helicopters.
1	**Pojar, Rosamund**	Human Disturbance and Mountain Ungulates. Page 2.	Mtn Goat, Bighorn Sheep	Recreation	Human disturbance from snowmobiles, helicopters, hunting, hikers, skiers all add up and make the animals increasingly less able to cope with cold, starvation and natural predation (p2).	The overall impacts of sustained disturbance to ungulates are decreased immunity to disease, increased wear on the body, reduced fertility rates and eventually, population decline (p2).

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Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
	Pojar, Rosamund	Human Disturbance and Mountain Ungulates. Page 2.	Mtn Goat, Bighorn Sheep	Snowmobile	Evidence shows that tracks made by snowmobiles are used by predators (wolves) for easier travel and may contribute to greater levels of predation (p2).	Snowmobile tracks are used by wolves and may be contributing to greater levels of predation.
	Pojar, Rosamund	Human Disturbance and Mountain Ungulates. Page 3.	Mtn Goat	Recreation	Since the 1970's population numbers are recovering as the result of changes to hunting practices from open season goat hunting to limited entry. An overall net increase in numbers could mask declines in the rate of reproduction that may occur as the result of increased recreational disturbance (p3).	Reproduction rates are likely declining in response to recreational disturbance, however demographic impacts are masked by population recovery since the reduction in harvest levels in the 1970's.
2	**Pojar, Rosamund** Foster, B.R. and E.Y. Rahs Foster, B.R. and E.Y. Rahs	Human Disturbance and Mountain Ungulates. Page 1. Relationships between mountain goat ecology and proposed hydro electric development on the Stikine River, B.C.. Report prepared for BC Hydro by Marr-Terr Enviro Research Ltd,, Vancouver (Report no. MT-1). 1981. Mountain goat response to hydroelectric exploration in Northwestern British Columbia. Environ. Manage. 7:189-197. 1983.	Mtn Goat	Recreation	When disturbance displaces animals from preferred habitat: • Sub-optimal habitat is used where forage is poorer resulting in greater expenditure of time and energy to take in the same amount of food. Foster and Rahs (1981, 1983) found that mountain goats disturbed by helicopter and drilling in the Stikine moved away from preferred habitat to rocky, sparsely vegetated areas containing less preferred forage species for the duration of the disturbance. • Fleeing response represents lost opportunity to rest and conserve food reserves. Rest and conservation of food reserves is especially critical in late winter or early spring when food reserves are already low. • Panic runs to avoid disturbance, especially if unexpected, can result in direct injury or abortion in females. • Animals are in new, unfamiliar surroundings where they are more susceptible to predation.	When mountain goats flee preferred habitats in response to disturbance, potential results include: • use of sub-optimal habitat requiring greater energy expenditure for foraging; • lost opportunity to rest and conserve food resources; • injury, or abortion in females; • increased predation.

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Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
1	Sheppard, Kathleen McLellan, B.N. Tietje, W.D. and R.L. Ruff Brannon, R.D., R.D. Mace and A.R. Dood McLellan, B.N. and R.D. Mace	Impacts of Off-Road Vehicles on Wildlands: A Review. Special Publication No. 7 of the Castle-Crown Wilderness Coalition. Page 6-7. Relationships between human industrial activity and grizzly bears. Int. Conf. Bear Research and Management 8:57-64. 1990. Responses of black bears to oil development in Alberta. Wildl. Soc. Bull. 11(2):99-112. 1983. Grizzly bear mortality in the Northern Continental Divide Ecosystem, Montana. Wildl. Soc. Bull. 16:262-269. 1988. Behaviour of grizzly bears in response to roads, seismic activity, and people. Preliminary Report, Canadian Border Grizzly Project, Cranbrook, B.C. 53pp. 1985.	Grizzly Bear	Open roads – direct human caused mortality	• McLellan (1990) notes that road access into an area leads to increased human use of all kinds which places grizzly bears at greater risk to human caused mortality, including hunting, poaching, and management removals and kills. Of the collared grizzly bear mortalities reported in the literature for six study areas in Alberta, B.C., Montana and Idaho, 68% of known mortalities were the result of illegal kills and hunting. • Tietje and Ruff (1983) state that "As new roads are opened and access is provided to previously inaccessible tracts, human bear interactions will increase. Legal and illegal taking of bears will rise and without appropriate management provisions, the consequences on local bear populations could be severe." • Brannon et al (1988) implicates road access to legal and illegal grizzly bear hunting mortality in the southwestern Alberta, Continental Divide ecosystem. • McLellan and Mace (1985) found hunting and poaching to be problems when new roads open, and recommend that roads be closed whenever possible to reduce grizzly bear habituation and death.	Road access facilitates increased human activity, inevitably increasing human caused grizzly mortality due to hunting, poaching and management removals and kills. Without appropriate access management, consequences on bear populations could be severe.
2	Sheppard, Kathleen McLellan, B.N. and D.M. Shackleton McLellan, B.N.	Impacts of Off-Road Vehicles on Wildlands: A Review. Special Publication No. 7 of the Castle-Crown Wilderness Coalition. Page 7. Grizzly bears and resource extraction industries: habitat displacement in response to seismic exploration, timber harvesting and road maintenance. J. Appl. Ecol. 26:371-380. 1989. Relationships between human industrial activity and grizzly bears. Int. Conf. Bear Research and Management 8:57-64. 1990.	Grizzly Bear	Open roads – traffic	Bears reacted more strongly to approaching vehicles when the vehicle was in the open. Grizzlies fled from an approaching vehicle over 50% of the time when the vehicle was in forest and came closer than 150 m, but over 60% of the time when the bear was in an open area (McLellan and Shackleton 1989b).	McLellan (1990) concludes, "Vehicles on roads can harass bears, displace them from quality habitats, and cause reduced bear use of altered habitats…"

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Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
3	Sheppard, Kathleen US Interagency Grizzly Bear Committee	Impacts of Off-Road Vehicles on Wildlands: A Review. Special Publication No. 7 of the Castle-Crown Wilderness Coalition. Page 5. Grizzly Bear Compendium. Nat. Wildl. Fed., Washington, D.C. 540pp. 1987.	Grizzly Bear	Open roads – direct human caused mortality; and traffic and road density	US Interagency Grizzly Bear Committee (1987) identifies the major impacts of roads on grizzlies as follows: • Access into grizzly habitat and consequent escalation of human activities in both frontcountry and backcountry areas; • Human activity causing displacement or disruption of normal behaviour patterns; • Physiological stress; • Habitat loss to road construction and industrial activities.	The major impacts of roads on grizzlies are: increased human access and activity in grizzly habitat (leading to increased mortality due to hunting, poaching and management); normal behaviour pattern disruption; physiological stress; and habitat loss.
4	Sheppard, Kathleen Freddy, D.J., W.M. Bronaugh, and M.C. Fowler	Impacts of Off-Road Vehicles on Wildlands: A Review. Special Publication No. 7 of the Castle-Crown Wilderness Coalition. Page 5. Responses of mule deer to disturbance by persons afoot and snowmobiles. 1986.	Ungulate Winter Range - Mule deer	Winter recreation	A study by Freddy et al (1986) indicates that mule deer react less strongly to snowmobiles than to people on foot. However, snowmobiles travel further in the course of a day and are capable of encountering many more animals. The reaction of mule deer to human intrusion represents an additional energy cost at a time when food is of poor quality and in short supply. To keep the disturbance of wintering mule deer to minimum would require that persons on foot and on snowmobiles avoid deer by distances of more than 334 and 470meters, respectively.	The reaction of mule deer to human intrusion represents an additional energy cost at a time when food is of poor quality and in short supply.
5	Sheppard, Kathleen Horejsi, B.L.	Impacts of Off-Road Vehicles on Wildlands: A Review. Special Publication No. 7 of the Castle-Crown Wilderness Coalition. Page 5. Some thoughts and observations on harassment and bighorn sheep. Biennial Meeting Northern Wild Sheep Council. Jackson, Wyoming. 14pp. 1976.	Bighorn sheep	Snowmobile	Human intrusions into sheep habitat in the Sheep River region of Alberta, resulted in increased energy expenditure by the animals, altered activity patterns, changes in distribution and possibly increased predation. "Causing sheep to abandon preferred parts of their range forces them to spend more time in peripheral areas… The animals will be less sure of themselves, more excitable, and burn more energy. They may be more susceptible to predation, accidents and hunters." The observed abandonment of preferred range was largely caused by snowmobiles, as well as improvement in the quality of roads (Horejsi 1976).	Impacts of snowmobile use on wintering bighorn sheep include increased energy expenditure; altered activity patterns; changes in distribution, and possibly increased predation.

Annotated Bibliography on the Effects of Motorized Recreation on Grizzly Bears and Rocky Mountain Ungulates

Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
1	Wakkinen, W. and W. Kasworm	Grizzly Bear and Road Density Relationships in the Selkirk and Cabinet-Yahk Recovery Zones. Page 22.	Grizzly bear	Open roads-traffic and human caused mortality	Roads can affect populations in at least 2 ways; by displacing animals from otherwise suitable habitat because of high levels of disturbance and by increased human access resulting in higher mortality from hunting, illegal killing, and removal due to habituation.	Roads can affect populations in at least 2 ways; by displacing animals from otherwise suitable habitat because of high levels of disturbance, and by increased human access resulting in higher mortality from hunting, illegal killing, and removal due to habituation.
2	Wakkinen, W. and W. Kasworm	Grizzly Bear and Road Density Relationships in the Selkirk and Cabinet-Yahk Recovery Zones. Page 22, 23.	Grizzly bear	Open roads-density	• In the Selkirk and Cabinet-Yahk Recovery Zones, areas where total road density exceeded 2mi/sq.mile and open road density exceeded 1mi/sq. mile, were used less than expected (avoided). Unroaded areas were used more than expected (preferred) (page 1, 22). • Wakkenin and Kasworm suggest that the proportion of the home ranges with >2mi/sq.mi total road density; >1 mi/sq.mi open road density; and the amount of core area, i.e. no open or gated roads, are appropriate access management standard categories (page 1). • Use/availability results regarding vegetated, barriered, and gated roads were not statistically significant, but appeared to indicate greater use of vegetated and barriered roads which lacked any motorized use (page 22, 23). Total road density use calculations include vegetated, barriered, gated and open roads. • Consideration should be given to habitat quality in the proximity of road closures. Certain types of habitat may not be sufficiently represented in all Bear Management Units and require additional protection (e.g. spring range or high quality foraging sites) (page 1).	Grizzly bears in the Selkirk and Cabinet-Yahk Recovery Zones avoided areas where total road density exceeded 2mi/sq.mile and open road density exceeded 1mi/sq. mile, and used unroaded areas more than expected.

Annotated Bibliography on the Effects of Motorized Recreation on Grizzly Bears and Rocky Mountain Ungulates

Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
1	Weaver, J.L.	The Transboundary Flathead: A Critical Landscape for Carnivores in the Rocky Mountains. Wildlife Conservation Society. 2001. Page 22.	Grizzly bear	Open roads-direct human caused mortality and traffic.	Overall, resilience is low in grizzly bears because "in many interior areas of North America grizzly bears rely on berries in late summer for weight gain and fat deposition necessary for successful hibernation and reproduction. During years of poor berry production, bears move widely in search of alternative foods that can bring them into contact with humans and increased risk of mortality. Grizzly bears have a low reproductive rate (0.5-0.8 cubs/adult female/year) and cannot compensate with higher reproduction for increased mortality. Hence, low mortality of adult females is critical to the persistence of grizzly bear populations …. Increased vehicle access can displace some grizzly bears by up to 1 km and lead to greater mortality by poaching. Sub-adult females do not disperse far, often establishing a range within or adjacent to their mother's home range."	Low mortality of adult females grizzly bears is critical to the persistence of grizzly bear populations because grizzly bear reproductive capacity is inherently low. Increased vehicle access can displace some grizzly bears by up to 1 km and lead to greater mortality by poaching.
2	Weaver, J.L.	The Transboundary Flathead: A Critical Landscape for Carnivores in the Rocky Mountains. Wildlife Conservation Society. 2001. Page 23.	Grizzly bear	Open roads-direct human caused mortality, traffic and density.	"Due to the vulnerability of grizzly bear populations (especially adult females) to excessive killing by humans, security areas (areas > 500m from high use roads/trails and > 9 sq. km in size: sensu Mattson 1993) can be considered vital 'habitats'. Recent studies have determined that security areas comprised an average of 68% of the home range of adult females (Mace and Waller 1997, Gibeau et al In Press)."	"Due to the vulnerability of grizzly bear populations (especially adult females) to excessive killing by humans, security areas (areas > 500m from high use roads/trails and > 9 sq. km in size: sensu Mattson 1993) can be considered vital 'habitats' (Weaver, page 23)."
3	Weaver, J.L.	The Transboundary Flathead: A Critical Landscape for Carnivores in the Rocky Mountains. Wildlife Conservation Society. 2001. Page 42, 43.	Grizzly bear	Open roads-direct human caused mortality, traffic and density.	Grizzly bears "lack resiliency and thus are vulnerable to excessive mortality that may not be easily detected nor reduced…hence there is uncertainty and risk….. Wildlife scientists throughout the world are recognizing that carnivores need some network of core reserves where security from human impacts takes precedence, and ecological integrity is restored or maintained with natural processes (Weaver et al 1996, Noss et al. 1999). Core reserves can benefit many wildlife in several ways by: (1) allowing undisturbed access to important habitats where energetic needs can be fulfilled, (2) minimizing potential for illegal or incidental killing by humans, and (3) retaining wary behaviour rather than habituation to humans."	Networks of core reserves where wildlife are protected from human impacts are needed particularly by carnivores. Core reserves benefit wildlife by: "(1) allowing undisturbed access to important habitats where energetic needs can be fulfilled, (2) minimizing potential for illegal or incidental killing by humans, and (3) retaining wary behaviour rather than habituation to humans (Weaver, page 42, 43)."

Annotated Bibliography on the Effects of Motorized Recreation on Grizzly Bears and Rocky Mountain Ungulates

Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
1	Wildlife Branch (B.C.)	Draft Guidelines for Mitigating Impacts of Commercial Recreation on Wildlife in B.C. 2001. Page 17.	Ungulate Winter Range	Winter recreation	In ungulate winter range it is the cumulative incremental effects of seemingly innocuous human disturbance that are of greatest concern. Consequences of disturbance are often subtle, sub-clinical and delayed. Chronic stress can impair immune responses, animals lose weight and die of malnutrition, others are less able to escape predators or withstand disease, females abort fetuses, newborns fail to thrive because of inadequate milk supplies or interrupted maternal care.	The cumulative incremental effects of human disturbance cause the most profound long-term impacts on the wintering ungulate population.
	Wildlife Branch (B.C.) Joslin, G.	Draft Guidelines for Mitigating Impacts of Commercial Recreation on Wildlife in B.C. 2001. Page 23. Mountain goat population changes in relation to energy exploration along Montana's Rocky Mountain Front. Biennial Symposium of the Northern Wild Sheep and Goat Council 5:253-271. 1986.	Mtn Goat	Helicopter	Of all the ungulate species, mountain goats appear the most sensitive to disturbance, especially by helicopters. In Montana, increased disturbance by helicopters reduced productivity of mountain goats (Joslin 1986).	Increased disturbance by helicopters reduced productivity of mountain goats.
3	Wildlife Branch (B.C.) Cote, S.D. Cote, S.D. and M. Festa-Bianchet Foster, B.R. and E.Y. Rahs	Draft Guidelines for Mitigating Impacts of Commercial Recreation on Wildlife in B.C. 2001. Page 24. Mountain goat responses to helicopter disturbance. Wildlife Society Bulletin 24: 681-685. 1996. XX. 1997 A study of canyon dwelling mountain goats in relation to proposed hydroelectric development in NW B.C.. Biological Conservation 33: 209-228. 1983	Mtn Goat	Helicopter	• In the Alberta Rockies, mountain goats moved in response to helicopters which were greater than 1.5 km distant (Cote 1996, Cote and Festa-Bianchet 1997). • Foster and Rahs (1983) reported that goats required a buffer area of 2 km to completely avoid harassment.	Mountain goats moved in response to helicopter over flights greater than 1.5km in distance, indicating at minimum, a physiological stress response by the animal to flights at that distance.

Annotated Bibliography on the Effects of Motorized Recreation on Grizzly Bears and Rocky Mountain Ungulates

Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
4	Wildlife Branch (B.C.) Penner, D.F.	**Draft Guidelines for Mitigating Impacts of Commercial Recreation on Wildlife in B.C. 2001. Page 24.** Behavioural response and habituation of Mountain Goats in relation to petroleum exploration at Pinto Creek, Alberta. Biennial Symposium of the Northern Wild Sheep and Goat Council 6: 141-158. 1988.	Mtn Goat	Helicopter	In summer goats can tolerate foot and vehicular traffic, "if they are gradually acclimatized and negative associations are avoided" (Penner 1998), especially if activity is localized and highly predictable, but do not appear to habituate to sudden, unpredictable stimuli such as aircraft overflights or predators. Penner (1998) reported that mountain goats accepted indirect, persistent noise (i.e. generator noise) but showed alarm response to aircraft.	Goats do not appear to habituate to sudden unpredictable stimuli such as over flights.
	Wildlife Branch (B.C.)	Draft Guidelines for Mitigating Impacts of Commercial Recreation on Wildlife in B.C. 2001. Page 19.	Mtn Goat	Helicopter	In the Todagin Mountain area, there appears to be a noticeable displacement of thinhorn sheep and mountain goats within 4 to 5 km of the main flight path related to frequent aircraft/helicopter use associated with mine development (S. Sharpe, pers. comm.).	Mountain goats are displaced from habitat within 4 to 5 km of a frequently used aircraft/helicopter flight path.
	Wildlife Branch (B.C.) Olliff, T., K. Legg and B. Kaeding (eds.) Paquet, M.M., and R.A. Demarchi	Draft Guidelines for Mitigating Impacts of Commercial Recreation on Wildlife in B.C. 2001. Page 19. Effects of winter recreation on wildlife of the Greater Yellowstone Area: a literature review and assessment. Report to the Greater Yellowstone Coordinating Committee. Yellowstone National Park, WY. 315 pp. 1999. Stone's Sheep of the northern Rockies: the effects of access. Prepared for the Foundation of North American Wild Sheep and Guide Outfitters Association of British Columbia. 1999.	Bighorn Sheep	Snowmobile and helicopter	In addition to habitat needs generally described for hoofed mammals, wild sheep require steep cliffs for escape terrain and lambing (Olliff et al.; Paquet and Demarchi). Recreational activities that prevent wild sheep from accessing escape terrain, or increases time spent in these areas, probably increases stress, and may lower foraging efficiency.	If bighorn sheep access to or from steep cliffs is disrupted, impacts may include increased stress levels and decreased foraging efficiency.

Annotated Bibliography on the Effects of Motorized Recreation on Grizzly Bears and Rocky Mountain Ungulates

Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
5	Wildlife Branch (B.C.) Stockwell, C.A. G.C. Bateman and J. Berger Bleich, V.C., R.T. Bowyer, A.M. Pauli, M.C. Nicholson and R.W. Anthes Geist, V.	Draft Guidelines for Mitigating Impacts of Commercial Recreation on Wildlife in B.C. 2001. Page 19. Conflicts in national parks: a case study of helicopters and bighorn sheep time budgets at the Grand Canyon. Biol. Cons. 56: 317-328. 1991. Mountain sheep helicopter surveys: ramifications for the conservation of large mammals. Biological Conservation 70: 1-7. 1994. Behaviour – Chapter 19. Pages 283-296 in JL Schmidt and D.L Gilbert, eds. Big game of North America- Ecology and management. Stackpole Books, Harrisburg, Pa. 1978.	Bighorn Sheep	Snowmobile and helicopter	Chronic exposure to disturbance potentially reduces forage efficiency (Stockwell et al. 1991, Beich et al. 1994) that, in turn, impacts growth and survival (Geist 1978). Chronic stress can also compromise the immune system in wild sheep, increasing their vulnerability to diseases.	Chronic exposure to disturbance potentially reduces forage efficiency that, in turn, impacts growth and survival. Chronic stress can also compromise the immune system in wild sheep, increasing their vulnerability to diseases.
	Wildlife Branch (B.C.)	Draft Guidelines for Mitigating Impacts of Commercial Recreation on Wildlife in B.C. 2001. Page 19.	Bighorn Sheep	Helicopter	A five year research program in the Churn Creek area suggests bighorn sheep may be as sensitive to helicopter disturbance as mountain goats. Bighorns have been observed to flee from helicopters that are 1 to 2 km away (J. Youds, pers. comm.).	Bighorn sheep may be as sensitive to helicopter disturbance as mountain goats.

Annotated Bibliography on the Effects of Motorized Recreation on Grizzly Bears and Rocky Mountain Ungulates

Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
6	Wildlife Branch (B.C.) Aune, K.E. and W.F. Kasworm Kasworm, W.F. and T.M. Manley Mattson, D.J., R.R. Knight, and B. M. Blanchard McLellan, B.N. and D.M. Shackleton	Draft Guidelines for Mitigating Impacts of Commercial Recreation on Wildlife in B.C. 2001. Page 28. Final report on East Front grizzly bear study. Montana Department of Fish, Wildlife and Parks. Helena, Montana. 1989. Road and trail influences on grizzly bears and black bears in NW Montana. International Conference on Bear Research and Management 8: 79-85. 1990. The effects of development and primary roads on grizzly bear habitat use in Yellowstone National Park. 1987. Grizzly bears and resource extraction industries: effects of roads on behaviour, habitat use and demography. Journal of Applied Ecology 25: 451-460. 1988.	Grizzly Bear	Open roads-traffic	Vehicular traffic along open roads can displace grizzly bears from 100-900m (Aune & Kasworm 1989; Kasworm & Manley 1990; Mattson et al. 1987; McLellan & Shackleton 1988.)	Vehicular traffic along open roads can displace grizzly bears from 100-900m.

Annotated Bibliography on the Effects of Motorized Recreation on Grizzly Bears and Rocky Mountain Ungulates

Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
1	Wilson, S.F. and D.M. Shackleton Foster, B.R. and E.Y. Rahs Cote, S.D.	Backcountry Recreation and Mountain Goats: A Proposed Research and Adaptive Management Plan. Wildl. Bulletin No. B-103. March, 2001. Page 2, 12. Mountain goat response to hydroelectric exploration in Northwestern British Columbia. Environ. Manage. 7:189-197. 1983. Mountain goat responses to helicopter disturbance. Wildl Soc Bull 24(4): 681-685. 1996	Mtn Goat	Helicopter	Acute responses to helicopter disturbance are well studied, highly variable and include fleeing, temporary range abandonment; group dissolution; injury; increased vigilance and nanny-kid separations (temporary and permanent) (page 12). Medium term chronic behaviour response to helicopter disturbance would be abandonment of preferred (disturbed) habitat for sub optimal habitat where forage and escape terrain are less available. This behavioural response may have significant consequences at critical times of the year (e.g. spring and summer) (page 12, 13). Foster and Rahs (1983) reported that: • Mountain goats in the Stikine responded to aircraft and ground disturbance during > 80% of events (n=667) and recorded "severe flight responses" during 33% of observations. 55% of severe flight responses were observed when disturbances occurred at distances <100m. • Response behaviour was correlated with distance to disturbance and the distance at which the disturbance was visible, as well as to available security cover, but was not dependent on the time of year, group size, or vertical orientation of disturbance (i.e. approach from above or below). Severe responses were less common when goats were located in rocky terrain than in densely vegetated habitat. • Disturbance caused temporary range abandonment. Cote (1996) reports that: • distance between animals and helicopters is the most important factor affecting goat responses; and • 7% of helicopter disturbance caused the disintegration of social groups.	Acute responses to helicopter disturbance are include: • fleeing; • temporary range abandonment; • group dissolution; • injury; • increased vigilance; • nanny-kid separations (temporary and permanent). Goat response is determined by distance to disturbance and distance to escape terrain.

Annotated Bibliography on the Effects of Motorized Recreation on Grizzly Bears and Rocky Mountain Ungulates

Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
2	Wilson, S.F. and D.M. Shackleton	Backcountry Recreation and Mountain Goats: A Proposed Research and Adaptive Management Plan. Wildl. Bulletin No. B-103. March, 2001. Page 2, 3.	Bighorn Sheep	Helicopter	Intense helicopter disturbance (100m in altitude) caused dramatic reaction in sheep (Bleich et al., 1994). Bighorn sheep in Alberta reacted "explosively" to the sight and sound of a helicopter, often fleeing when the helicopter was 1.6km away (Horejsi, 1976). Overflights at 400m above the ground at Ram Mtn, Alberta resulted in elevated heart rates lasting for up to one hour post disturbance (Stemp, 1983). Both Stemp (1983) and MacArthur et al. (1982) noted the poor correlation between cardiac and observable behavioural responses. Significant cardiac and observable responses persisted even when sheep appeared to exhibit behaviour consistent with habituation, and there was a strong positive relationship between responses to disturbance and the distance sheep were from escape terrain (Stemp, 1983).	**Helicopter disturbance is shown to cause dramatic reaction in bighorn sheep in terms of observable behavioural response and cardiac response.** Lack of overt behavioural response does not indicate lack of physiological response.
	Bleich, V.C., R.T. Bowyer, A.M. Pauli, M.C. Nicholson, and R.W. Anthes	Mountain sheep (Ovis canadensis and helicopter surveys: ramifications for the conservation of large mammals. Biol.Conserv. 70:1-7. 1994.				
	Horejsi, B.	Some thoughts on harassment and bighorn sheep. Biennial Symposium of the North. Wild Sheep and Goat Counc. 1:149-155. 1976.				
	Stemp, R.E.	Heart rate responses of bighorn sheep to environmental factors and harassment. M.Sc. thesis, Univ. Calgary, AB. 1983.				
	MacArthur, R.A., V. Geist and R.H. Johnston	Cardiac and behavioural responses of mountain sheep to human disturbance. J. Wildl. Manage. 46:351-358. 1982.				

Annotated Bibliography on the Effects of Motorized Recreation on Grizzly Bears and Rocky Mountain Ungulates

Reference			Species	Activity	Effect	Conclusion
#	Author	Report				
1	Wittinger, Tom	Effects of Recreation on Rocky Mountain Wildlife: A Review for Montana. 1999. Chapter 7, page 7.25.	Grizzly Bear	Snowmobile and helicopter	• Vehicles operating within 3300 feet of denned bears, caused heart rates to increase (Reynolds et al. 1986). • The greatest potential for disturbance from snowmobile activity occurs when females with cubs are still confined to the den vicinity during spring, and when emerging bears descend to lower elevations, and more gentle terrain which is more suitable for snowmobiling (Mace and Waller 1997). • Over flights by small aircraft near the time of den emergence caused denned bears' heart rates to increase (Reynolds et al. 1986). • Numerous studies have indicated that physiological stresses can result in serious consequences to bears (Reynolds and Hechtel 1980; Watts and Jonkel 1989; Mace and Waller 1997).	Physiological stress has serious consequences for grizzlies, and physiological stress in terms of increased heart rate, is documented as the result of motor vehicle use within 3300 ft of denned bears. Near the time of den emergence however, is when grizzlies are most seriously physiologically impacted by snow related motorized activity.
	Reynolds, P.E., H.V.Reynolds and E.H. Follmann	Responses of grizzly bears to seismic surveys in northern Alaska. Int. Conf. on Bear Res. And Manage. 6:169-175. 1986.				
	Reynolds, D.G. and J. Hechtel	Big game investigation. Structure, status, reproductive biology, movements, distribution and habitat utilization of a grizzly bear population. Fed. Aid. Wildl. RestProj. W17-11, Job 4.1R. Job Prog. Rpt, July 1, 1978-June 30, 1979. Alaska Dept. Fish and Game, Juneau. 66pp.				
	Watts, P.D. and C. Jonkel	Energetic cost of winter dormancy in grizzly bears. J. Wildl. Manage. 54(4): 654-656. 1989.				
	Mace, R. and J. Waller	Final Report: grizzly bear ecology in the Swan Mountains, Montana, Montana Fish, Wildlife and Parks, Helena, MT. 191 pp. 1997.				

Appendix 1. Summary of the Annotated Bibliography of the Effects of Motorized Recreation on Grizzly Bear and Rocky Mountain Ungulates

Species	Activity	Conclusion	Reference #
Ungulate Winter Range-Elk	Winter recreation	Elk rely on fairly restricted winter ranges in which food and cover may be limited or of marginal quality, and consequently, any activity preventing the animals from using all or part of that range could reduce their ability to survive or to successfully reproduce.	Olliff 1
Ungulate Winter Range-Elk	Snowmobile	Temporary displacement of elk from winter range as the result of snowmobile activity is documented in northeastern Oregon and Yellowstone National Park.	Olliff 2
Ungulate Winter Range-Elk	Snowmobile	Elk are less likely to be displaced by, or exhibit flight responses, when disturbance is predictable and limited to established trails.	Olliff 3
Ungulate Winter Range-Elk	Snowmobile	Overland motorized activity has more potential for causing elk flight response, since disturbance in these areas is unpredictable.	Olliff 4
Ungulate Winter Range-Moose	Human activity	Immediate response to disturbance by moose is physiological stress, which, because it is not physically obvious, has often been misinterpreted as a high degree of tolerance to human activity.	Olliff 5
Ungulate Winter Range-Moose	Human activity	The most severe impacts to wintering animals are the energetically costly flight and stress responses, resulting from unpredictable disturbance.	Olliff 6
Ungulate Winter Range-Moose	Snowmobile	Snowmobile activity causes displacement and disturbance responses in moose. The most severe impacts are in areas where overland motorized activity is permitted, since disturbance is these areas is unpredictable.	Olliff 7
Ungulate Winter Range-Moose	Roads and groomed trails	Moose tend to use plowed roads and groomed trails as travel routes, which combined with their delayed flight response, invites collisions with vehicles.	Oliff 8
Ungulate Winter Range-Mule deer	Winter recreation	The reaction of mule deer to human intrusion represents an additional energy cost at a time when food is of poor quality and in short supply.	Shepp 4
Ungulate Winter Range	Winter recreation	In ungulate winter range it is the cumulative incremental effects of seemingly innocuous human disturbance that are of greatest concern. Consequences of disturbance are often subtle, sub-clinical and delayed. Chronic stress can impair immune responses, animals lose weight and die of malnutrition, others are less able to escape predators or withstand disease, females abort fetuses, newborns fail to thrive because of inadequate milk supplies or interrupted maternal care.	Wild 1
Ungulate Winter Range	Human activity	Human disturbance exacts an energetic disadvantage on wintering animals. Overt behavioural responses are highly variable, and range from an increase in general alertness to outright flight. Physiological responses include increased metabolism, which could result in illness, decreased reproduction and death.	Canfi 1
Ungulate Winter Range-	Snowmobile	Effects of snowmobile activity on wintering ungulates include: reduction in forage availability as the result of snow compaction; reduction of home range size; and displacement to less preferred habitats.	Canfi 3
Ungulate Winter Range	Winter recreation	Observations indicate that the most detrimental disturbances to wintering animals are those that are unanticipated.	Canfi 4
Ungulate Winter Range-	Snowmobile	Relatively high energy expenditure can result from human disturbance which does not elicit an overt behavioural response, but rather is only expressed through heart rate response. These results are confirmed and expanded for virtually every ungulate species.	Canfi 6
Ungulate Winter Range	Winter recreation	Winter recreation impacts to ungulates include increased energy expenditure; habitat displacement; and potential habituation.	Canfi 7

Appendix 1. Summary of the Annotated Bibliography of the Effects of Motorized Recreation on Grizzly Bear and Rocky Mountain Ungulates

Species	Activity	Conclusion	Reference #
Mountain goat	Helicopter	Impacts of helicopter over flights on mountain goats may include: increased energy expenditure; reduced fat accumulation; and changed physiological condition. These factors affect overall reproduction and survival.	Cote 1
Mountain goat	Helicopter	Goats reacted to flights which were greater than 1.5 km in distance, indicating a higher sensitivity to helicopter traffic than other open terrain ungulates.	Cote 2
Mountain goat	Snowmobile	Effects of snowmobile disturbance on wintering ungulates include: • increased heart rate; and • flight response representing energy expenditure with potential survival impacts, depending on winter range quality. Effects appear to be directly related to availability of security cover.	Graha 1
Mountain goat	Human activity	Goat populations have declined in response to human disturbance. Population declines appear to be related to improved access for hunting and poaching, abandonment of habitat due to alteration or disturbance, or continual stress as the result of human presence. Of these mechanisms, motorized access is considered the biggest threat.	Olliff 9
Mountain goat	Winter Recreation	Goats are considered a fragile wilderness resource, and although recreational use of their remote, rugged wintering range is unlikely, any use could be detrimental due to potential habitat abandonment or increased stress in response to disturbance.	Olliff 10
Mountain goat	Helicopter	Goats are capable of habituation under certain circumstances when disturbance is localized and predictable, however they do not habituate to the unpredictable, loud disturbance created by helicopters.	Olliff 11
Mountain goat and bighorn sheep	Recreation	The overall impacts of sustained disturbance to ungulates are decreased immunity to disease, increased wear on the body, reduced fertility rates and eventually, population decline.	Pojar 1
Mountain goat	Recreation	When mountain goats flee preferred habitats in response to disturbance, potential results include: • use of sub-optimal habitat requiring greater energy expenditure for foraging; • lost opportunity to rest and conserve food resources; • injury, or abortion in females; • increased predation.	Pojar 2
Mountain goat	Helicopter	Of all the ungulate species, mountain goats appear the most sensitive to disturbance, especially by helicopters. In Montana, increased disturbance by helicopters reduced productivity of mountain goats.	Wild 2
Mountain goat	Helicopter	Mountain goats moved in response to helicopter over flights greater than 1.5 km in distance, indicating at minimum, a physiological stress response by the animal to flights at that distance.	Wild 3
Mountain goat	Helicopter	Goats do not appear to habituate to sudden unpredictable stimuli such as over flights.	Wild 4
Mountain goat	Helicopter	Acute responses to helicopter disturbance are include: fleeing; temporary range abandonment; group dissolution; injury; increased vigilance; nanny-kid separations (temporary and permanent). Goat response is determined by distance to disturbance and distance to escape terrain.	Wilso 1
Mountain goat	Helicopter	Bighorn sheep and mountain goats respond negatively to helicopter over flights; for mountain goats a decline in reproduction rate is reported.	Canfi 5

Appendix 1. Summary of the Annotated Bibliography of the Effects of Motorized Recreation on Grizzly Bear and Rocky Mountain Ungulates

Species	Activity	Conclusion	Reference #
Bighorn sheep	Helicopter	Helicopter use impacts on bighorn sheep may include displacement from important winter feeding grounds; and elevated heart rates lasting up to one hour.	Becke 1
Bighorn sheep	Recreation	Bighorn sheep are highly susceptible to human disturbance, however their overt behavioural response is a poor indicator of the stress incurred by disturbance. Disturbance caused by recreation is considered to be a factor limiting populations of bighorn sheep in California.	Canfi 2
Bighorn sheep	Snowmobile	Impacts of snowmobile use on wintering bighorn sheep include increased energy expenditure; altered activity patterns; changes in distribution, and possibly increased predation.	Shepp 5
Bighorn sheep	Snowmobile and helicopter	Chronic exposure to disturbance potentially reduces forage efficiency that, in turn, impacts growth and survival. Chronic stress can also compromise the immune system in wild sheep, increasing their vulnerability to diseases.	Wild 5
Bighorn sheep	Helicopter	**Helicopter disturbance is shown to cause dramatic reaction in bighorn sheep in terms of observable behavioural response and cardiac response.** Lack of overt behavioural response is not indicative of physiological response.	Wilso 2
Grizzly bear	Open roads-traffic and road density	Grizzly bear use of suitable habitat in Montana declined as road density and road traffic increased.	Mace 1
Grizzly bear	Open roads-traffic and adjacent cover	In the Flathead grizzly bear study area, open road represents total habitat loss of 8.7% due to decreased use of areas within 250m of the road (p25).	McLe 1
Grizzly bear	Open roads – direct human caused mortality	Roads in the Flathead study area have a very high potential of being a significant factor in future population declines due to the fact that most bears are killed from roads, and a slight increase in the number of adult female bears in the harvest will cause the population to decrease	McLe 2
Grizzly bear	Open roads – traffic and direct human caused mortality	Grizzly bear studies in Montana and B.C. have found that bears habituated to human activity, especially moving vehicles, are more vulnerable to legal and illegal shooting.	Noss 1
Grizzly bear	Open roads – direct human caused mortality	The majority of grizzly mortalities occur in close proximity to roads. Consequently, the ability of regions to maintain viable populations of grizzly bears is directly related to road density and human access.	Noss 2
Grizzly bear	Open roads – direct human caused mortality	Road access facilitates increased human activity, inevitably increasing human caused grizzly mortality due to hunting, poaching and management removals and kills. Without appropriate access management, consequences on bear populations could be severe.	Shepp 1
Grizzly bear	Open roads – traffic	"Vehicles on roads can harass bears, displace them from quality habitats, and cause reduced bear use of altered habitats…"	Shepp 2

Appendix 1. Summary of the Annotated Bibliography of the Effects of Motorized Recreation on Grizzly Bear and Rocky Mountain Ungulates

Species	Activity	Conclusion	Reference #
Grizzly bear	Open roads - direct human caused mortality, traffic and road density	The major impacts of roads on grizzlies are: increased human access and activity in grizzly habitat (leading to increased mortality due to hunting, poaching and management); normal behaviour pattern disruption; physiological stress; and habitat loss.	Shepp 3
Grizzly bear	Open roads	Vehicular traffic along open roads can displace grizzly bears from 100-900m.	Wild 6
Grizzly bear	Open roads - direct human caused mortality and traffic	Roads can affect populations in at least 2 ways; by displacing animals from otherwise suitable habitat because of high levels of disturbance, and by increased human access resulting in higher mortality from hunting, illegal killing, and removal due to habituation.	Wakk 1
Grizzly bear	Open roads - road density	Grizzly bears in the Selkirk and Cabinet-Yahk Recovery Zones avoided areas where total road density exceeded 2mi/sq.mile and open road density exceeded 1mi/sq. mile, and used unroaded areas more than expected.	Wakk 2
Grizzly bear	Open roads - direct human caused mortality, traffic and road density	Low mortality of adult females grizzly bears is critical to the persistence of grizzly bear populations because grizzly bear reproductive capacity is inherently low. Increased vehicle access can displace some grizzly bears by up to 1 km and lead to greater mortality by poaching.	Weav 1
Grizzly bear	Open roads - direct human caused mortality, traffic and road density	"Due to the vulnerability of grizzly bear populations (especially adult females) to excessive killing by humans, security areas (areas > 500m from high use roads/trails and > 9 sq. km in size: sensu Mattson 1993) can be considered vital 'habitats'."	Weav 2
Grizzly bear	Open roads - direct human caused mortality, traffic and road density	Networks of core reserves where wildlife are protected from human impacts are needed, particularly by carnivores. Core reserves benefit wildlife by: "(1) allowing undisturbed access to important habitats where energetic needs can be fulfilled, (2) minimizing potential for illegal or incidental killing by humans, and (3) retaining wary behaviour rather than habituation to humans (Weaver, page 42, 43)."	Weav 3
Grizzly bear	Snowmobile	Grizzly bears are most susceptible to snowmobile disturbance in mid to late spring when females with cubs emerge from dens and have limited mobility.	Graha 2
Grizzly bear	Snowmobile	Physiological stress has serious consequences for grizzlies, and physiological stress in terms of increased heart rate, is documented as the result of motor vehicle use within 3300 ft of denned bears. Near the time of den emergence however, is when grizzlies are most seriously physiologically impacted by snow related motorized activity.	Witt 1

Appendix 1. Summary of the Annotated Bibliography of the Effects of Motorized Recreation on Grizzly Bear and Rocky Mountain Ungulates

Species	Activity	Conclusion	Reference #
All	ATV and snowmobile	Snowmobile and ATV use effect wildlife habitat through the substantial contribution they make to pollution and climate change. The two-stroke engine discharges roughly one third of its fuel unburned directly into the environment; and one hour of two-stroke engine use emits as much hydrocarbon pollution as driving a modern car for one year.	Beck 2
All	Noise	Human-made noise can cause the following responses in wild animals: 1.) preferred habitat abandonment; 4.) increased activity and depletion of energetic reserves; 5.) irritation, reduced feeding, altered social interactions or parenting. These effects have the potential to cause population declines.	Knigh 1
All	Noise	Noisy disturbance causes large mammals to alter their movements for up to two days following exposure. Short term changes to habitat use may result, however in the case that noisy disturbance is predictable and is not associated with harassment, ungulates in particular are capable of developing an adaptive, avoidance or habituation, behavioural response.	Knigh 2