

**DALL'S SHEEP* AND HUMAN-CAUSED DISTURBANCES:
AN ANNOTATED BIBLIOGRAPHY INCLUDING SUMMARIES OF
IMPACTS AND MITIGATION MEASURES**

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for

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* Ovis dalli: Thinhorn sheep; Dall's sheep; Dall sheep;
Alaskan White sheep; Stone's sheep.

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1.0 INTRODUCTION

1.1 PURPOSE

The primary purpose of this report is to assist environmental assessment agencies and wildlife managers in the identification and mitigation of land use impacts on Dall's sheep in Yukon Territory. Assessment agencies are often required to identify and qualify the effects of proposed land use activities and disturbances on wild sheep populations. However, rarely do these agencies have the manpower, time and expertise to research the possible impacts. Therefore, a literature review was conducted to identify reports containing documented impacts of various human-caused disturbances on wild sheep populations. The literature was then referenced and briefly annotated. An index to the impacts and mitigation was also prepared.

The index and the annotated bibliography are not intended to replace the thorough review process generally necessary for major land use developments. Also, they are not a substitute for the careful field reviews and specific recommendations needed for each unique activity. Instead, the specific intent of this document is to aid in the development of guidelines, to help in the recognition of possible impacts and to assist in the recommendation of mitigative measures. Used in this manner, this document should help legitimize mitigation recommendations and reduce the amount of time and energy directed to the land use review process.

1.2 SCOPE

The review of the literature used for this report was not exhaustive. Many reports could not be obtained in the project's time frame. Also, a number of articles were not included as they contained only casual or unsubstantiated comments regarding impacts and mitigation.

Disturbances associated with specific activities were reviewed for their potential impacts on wild sheep and for any mitigation recommendations. These specific activity groups, which also form the keywords used in the report, are as follows:

- Agriculture
- Aircraft
- Dams-Canals
- Harassment
- Linear Facilities (roads, railways, pipelines)
- Mineral-Petroleum Exploration and Development
- Off-Highway Vehicles (OHV)
- Recreation
- Timber Harvesting

In addition, indices were created for references which documented range abandonments and under-utilization of mineral licks.

The report does not attempt to address off-site mitigation, habitat enhancement and revegetation. These topics are very complex and usually site specific. Also, the mitigation measures are not ranked in any order of importance.

1.3 HOW TO USE THIS REPORT

The report is basically composed of two parts. The first part (Sections 2.0, 3.0 and 4.0), contains indices of references citing impacts and/or mitigation measures. These references are grouped under specific activities headings (eg: aircraft, recreation).

The second part (Section 5.0) contains annotations to those references cited in part one. Each annotation contains information on where the entire document can be acquired and what the text contains. In addition, those references which are more beneficial and contain more concise and valid information are designated by an exclamation mark (!). These designations, however, are purely qualitative and of the author's own personal assessment.

When recommending the implementation of various mitigation measures, it is advisable to include the documentation of the impacts associated with the measures. For example, if a compressor station is to be constructed in Dall's sheep habitat, it is best to document the impact this station and its associated construction activities have previously had on other areas. Once the references have been made, the mitigation measures can then be presented. The system offers reliability and validity to the required mitigation efforts and primarily acts as an authoritative third party. This "impact documentation-mitigation" approach is widely used in impact assessment and mitigation recommendations throughout Alaska and portions of United States with considerable success¹.

The following are hypothetical examples of the "impact documentation-mitigation" approach:

Example 1:

Activity: Domestic sheep grazing near Dall's sheep habitat (no fences involved).

Impact: Domestic sheep grazing on occupied wild sheep range has conclusively resulted in the transmission of diseases and competition for forage and space. These impacts have ultimately caused reductions in wild sheep populations and, in some cases, die-offs (Foreyt and Jessup 1982: Goodson 1982: Packard 1946: Preston 1983).

Mitigation: a) Maintain a minimum buffer distance of 2 miles between occupied wild sheep range and domestic sheep range (Goodson 1982). Utilize fencing

¹Personal Communication: Gary L. Stackhouse. United States Department of the Interior, Fish and Wildlife Service, Anchorage Fish and Wildlife Enhancement, Anchorage, Alaska. March 1987.

which prohibits the intermingling of the two different sheep herds.

- b) Under no circumstances allow domestic sheep on occupied wild sheep range (Andryk 1983: Goodson 1982: Preston 1983).

Note: In this example, prohibiting the activity on Dall's sheep range altogether is primarily the only solution.

Example 2:

Activity: Mineral exploration camp in Dall's sheep habitat (no alternatives; no major aircraft activity or road access).

Impact: Increased human activity on occupied wild sheep range has been responsible for the abandonment of sheep range (Bear and Jones 1973: DeForge 1972: Horejsi 1976) and loss of sheep through increased hunting and poaching pressures (Bromley 1985: Sopuck et al., 1979). In addition, significant noise levels (eg: electric generator noise) that are often associated with camps have resulted in range abandonment (McCourt et al. 1972).

- Mitigation:**
- a) The campsite should not be located in open meadows used by sheep. Instead, it should be placed in a heavily forested area or where visual contact with sheep is virtually non-existent (Stubbs and Markham 1979).
 - b) Prohibit personnel from possessing firearms and ATV's (Andryk 1983: Stubbs and Markham 1979)
 - c) Prohibit dogs during work periods (Interagency

1984).

- d) Muffle or provide sound attenuation measures for generators, compressors and other noise-producing items (Interagency 1984). Maximum _____ decibells at _____ metres must be adhered to.

These are hypothetical examples specific only to sheep. Obviously, most activities are more complex. They may include access developments and aircraft disturbances, all of which have specific mitigation requirements.

2.0 INDEX TO IMPACT AND MITIGATION REFERENCES

2.1 AGRICULTURE

Agricultural impacts on sheep populations are well documented. The majority of the impacts can be categorized into 1) disease transmission; 2) competition; 3) barriers to movement (fencing); and 4) vegetation alteration/damage. In addition, there has been recent concern over genetic contamination in wild sheep from interbreeding with domestic sheep.

Buechner 1960. Major wild sheep die-offs are attributed to fencing, competition, disease transmission and vegetation damage relating to domestic livestock grazing.

Demarchi 1970. Cattle grazing was believed to be responsible for a 35% population decline in bighorn sheep.

Dieterich et al. 1981. Transmission of contagious ecthyma.

Foreyt and Jessup 1982. Transmission of pathogenic pneumonia bacteria (causing pneumonia).

Goodson 1982. Domestic sheep grazing resulted in disease

transmission, competition for forage and space and, ultimately, die-offs.

Graham 1980. General discussion of agricultural impacts on desert bighorn sheep, including fencing and competition.

Hansen 1971. General discussion of fencing and livestock competition on bighorn sheep.

Harrison 1982. Not specific to agriculture but discusses fencing designs.

Helvie 1971. Impacts of fencing on bighorn sheep with specific measures and guidelines to reduce entanglement and barriers to movement.

Hoefs and Brink 1978. Effects of horse grazing on Dall's sheep winter range is discussed. Competition for forage documented.

McCullough et al. 1980. Thorough report on effects of cattle grazing on a specific bighorn sheep range.

Packard 1946. Competition, disease transmission and fencing are implicated as causes to the major die-offs at the turn of the century.

Post 1971. Same as above. Emphasis on bacterial pneumonia.

Preston, 1983. Excellent review of agricultural impacts on wildlife, with reference to Dall's sheep.

2.1.1 General Mitigation

1. Livestock grazing should not occur within or near sheep range (Preston 1983).
2. Protect bighorn winter-spring ranges from domestic sheep and cattle grazing (Andryk 1983).
3. Prevent contact between domestic and wild sheep (Goodson 1982).
4. Do not introduce domestic sheep onto occupied wild sheep range (Goodson 1982).
5. Maintain a minimum buffer distance of 2 miles between occupied wild sheep range and domestic sheep range (Goodson 1982).
6. Restrict cattle grazing to the period of July 1 to October 15 (Andryk 1983: Interagency 1984). Note: only

on those areas which do not severely impact on sheep.
Dates may be different in Yukon.

2.1.2 Fence Mitigation

Guidelines from Helvie (1971) to prevent entanglement and barriers to movements.

1. Barbed wire fences

- wires should be spaced 20", 35" and 39" above the ground (a fourth wire at 43" can be installed).
- the bottom wire should be smooth, not barbed (sheep often crawl under fences).
- the space between the top two (or three) wires should not exceed 4".
- the spacing between the lower two wires should not be less than 15".
- posts should not be more than 10' apart.

2. Woven wire fences

- use of mesh size of 2" x 4" or smaller.

3. Rail Fence

- rails should be made of at least 4" diameter poles, as smaller diameters can be broken by sheep.
- the lower edges of the rails should be 20", 38" and 44" above the ground.

2.2 AIRCRAFT

Aircraft activity, both fixed-wing and rotor, has resulted in a number of impacts ranging from minor disruptions in feeding to range abandonment. Helicopters appear to have the greatest impact as a result of their high noise levels and slow flying ability. However, there is considerable variability among sheep populations. A subjective ranking (minimal, moderate and severe) of the impact is provided with each citation.

- Andryk 1983. Visual contact of the helicopter resulted in flight of sheep - moderate
- Aquatic Environments Ltd 1975. Panic flight when helicopter approached within 1/2 mile - severe
- Feist et al. 1974. Helicopter impacts on Dall's sheep at flights of up to 1500' - moderate.
- Heimer 1978. Seasonal fixed wing and helicopter impacts on Dall's sheep - minimal
- Jakimchuk et al. 1974. General impacts of aircraft on Dall's sheep - severe
- Jakimchuk et al. 1984. Dall's sheep appeared habituated to aircraft traffic along the Trans-Alaskan pipeline - minimal
- Krausman and Hervert 1983. Impacts of aerial sheep surveys using small fixed wing aircraft - moderate
- Lenarz 1974. Impacts of an FH-1100 helicopter on Dall's sheep - moderate/severe
- Linderman 1972. Aircraft activity (helicopter and fixed wing) caused behavioral responses in Dall's sheep, including panic running - moderate
- MacArthur et al. 1979. Impacts of helicopter on bighorn sheep heart rates in a sanctuary - moderate
- MacArthur et al. 1982. same as above
- McCourt et al. 1972. General impacts of helicopters on Dall's sheep - severe
- Pitzman 1970. Effects of small fixed wing aircraft on Dall's sheep - severe
- Price and Lent 1972. Considerable discussion of effects of aircraft on Dall's sheep - variable
- Singer and Mullen 1981. Effects of helicopters on Dall's sheep - moderate/severe
- Stemp, 1982. Heart rate response of bighorn sheep to helicopter activity - moderate
- USDI 1976. Impacts of aircraft on Dall's sheep - severe

2.2.1 General Mitigation

1. Establish helicopter flight patterns of not more than a 1/2 mile in width between designated landing zones and activity areas (Andryk 1983: Interagency 1984).
2. Establish helicopter flight patterns at least one mile away from known mineral licks and seasonal use areas (Interagency 1984).
3. Landing zones should be designated in areas where helicopter traffic and associated activities will have minimal impact on sheep populations (Interagency 1984).
4. Aircraft must maintain a minimum altitude of 1300' between landing zones and activity areas (Interagency 1984).
5. Minimize the number of helicopter trips by consolidating activities (Andryk 1983).
6. Helicopter flights should be predictable (Summerfield 1974).
7. When conducting aerial sheep surveys in small fixed wing aircraft, the minimum flight level should be no less than 100 m (Krausman and Hervert 1983).

2.3 DAMS-CANALS

Water reservoirs and canals can create barriers to movement as well as removing important habitat. The majority of these impacts are contained in major environmental impact statements, primarily in the United States. Unfortunately, most of these were unavailable.

Graham 1980. Aqueducts with steep sides greater than 0.2 km wide often drown those sheep attempting to cross.

Olson and Horak 1979. Briefly discusses impacts of water canals on big game.

Woods and Bradley 1979. Loss of important deer wintering habitat as a result of a B.C. hydro project.

2.3.1 General Mitigation

1. Seek financial compensation and use the award to set up an interest-bearing fund which can then be used for habitat development and intensive management (Woods and Bradley 1979).
2. Reduce drowning mortalities along canals by fencing and constructing wildlife crossings and drinking bays (Olson and Horak 1979).
3. Provide escape ramps in canals (additional details provided in Olson and Horak 1979).

2.4 HARASSMENT

A considerable number of reports do not distinguish between the type of activity. Instead, all activities that directly impact on sheep causing excitement, stress and/or flight are considered harassing agents. These agents can ultimately lead to range abandonment and mortality in some cases. Many of the following citations discuss the effects of harassment on the viability of the population. Hunting is included in this section.

Cornish et al. 1980. (on order)

DeForge 1976. Harassment "triggers" the deployment of an evolved physiological/behavioral mechanism which controls overpopulation.

Donihee and Gray 1982. Hunting: in northern Alberta, 80% of the hunting effort is within 1.6 km of a road.

- Franzman 1972. Discusses physiological changes in sheep resulting from excitation.
- Geist 1970. Disturbances cause stress which lead to physiological malfunction. Hunting alone can cause range abandonment.
- Geist 1971. The process of excitation is discussed as well as its effects.
- Geist 1975. Considerable discussion of harassment and what it may lead to (eg: avoidance, range abandonment).
- Graf 1980. (on order)
- Hansen 1971. Social mechanisms triggered by disturbances are a limiting factor in the survival of wild sheep.
- Horejsi 1976. Discussion of active and passive harassment, both having major impacts (eg: range abandonment, growth reduction).
- King and Workman 1984. Previously disturbed sheep populations (those that were hunted, etc.) react more severely to human disturbances.
- MacArthur et al. 1979. A discussion of heart rate responses to various disturbances in a sanctuary.
- MacArthur et al. 1982. Basically, same as above.
- Neil et al. 1975. (on order)
- Sopuck et al. 1979. Discusses the effects of harassment on big game species encountered in north-central Alberta, excluding wild sheep.
- Stemp 1982. Heart rate responses as a function of distance from escape terrain are discussed.
- Thorne et al. 1979. Degree of harassment varies with factors such as sex, age, juxtaposition and type of disturbance.
- Tracey 1977. Discusses the effects of a road on wildlife, including Dall's sheep, in Mt. McKinley National Park.
- Wishart et al. 1980. Discussion of increased susceptibility of sanctuary sheep to lungworm (sheep congregating in sanctuary to escape harassment).

2.4.1. General Mitigation

There is rarely any specific mitigation mentioned to reduce the impacts associated with harassment. However, any reduction in harassment and excitation must be accompanied by the limitation or removal of the disturbances, or the acceptance of the disturbance by the sheep. This acceptance can only occur if there are no negative attributes associated with the disturbance.

2.5 LINEAR FACILITIES

Linear facilities include roads, railways, pipelines and their accompanying right-of-ways. The impacts from these facilities are often numerous and range from pre-construction (eg: aircraft and blasting disturbances), construction (eg: elevated levels of hunting, poaching and harassment) and post-construction activities (barriers to movement, collisions, increased recreation and hunting). Probably the greatest impacts result from improved access and the subsequent increase in human activity.

Cornish et al. 1980. General impacts of roads and trails on wildlife, including bighorn sheep, in Kananaskis Country, Alberta (on order)

Cowan 1972. General impacts of roads on northern wildlife and guidelines to minimize wildlife disturbances.

Damas and Smith 1982. (on order)

DeForge 1972. Activities along a road resulted in range abandonment. A road closure enabled sheep to reoccupy the area.

Donihee and Gray 1982. Good review of wildlife/road problems in northern Canada.

Environment Canada 1979. Very good review of linear facility impacts in northern Canada (resulting in range abandonments).

Flygare 1979. Effects of Trans-Canada highway on wildlife (and sheep) mortality (on order).

- Geist 1971. Documentation of collisions with vehicles and barriers to movement as a result of roads.
- Geist 1975. Good discussion of the impacts of roads on wildlife.
- Graf 1980. General discussion of the impacts of roads on sheep (on order)
- Graham 1980. Unfenced multi-lane highways act as partial barriers to movement and result in some collision mortalities.
- Hansen 1971. High speed highways result in some barriers to movement and collision deaths: also, poaching increases.
- Harrison et al. 1982. Documents vehicle collision mortalities of ungulates in Banff National Park (concise mitigation) (on order).
- Hoefs 1979. New roads in the Yukon almost always result in population declines and range abandonment.
- Holroyd 1980. Discusses impacts of highways and railroads in Banff National Park on ungulate populations.
- Horejsi 1976. Documented impacts of road disturbances causing barriers to movement.
- Jakimchuk et al. 1984. Suggests that linear facilities (pipeline, road) had marginal effect on Dall's sheep in Northern Brooks Range, Alaska.
- Kovach 1979. Vehicle traffic on a road did not appear to disturb bighorn sheep unless people left their vehicles.
- MacArthur et al. 1979. Vehicles passing within 200 m of sheep elicited increases in heart rates (habituated).
- MacArthur et al. 1982. Basically, same as above (study conducted in a sanctuary).
- McCrorry 1975. A revegetated pipeline right-of-way was used extensively by bighorn sheep for foraging.
- Murie 1944. Roads provided greater mobility and advantages to wolves preying on Dall's sheep in Mt. McKinley area.
- Packard 1946. Some important bighorn winter ranges and mineral licks in the continental United States have become inaccessible as a result of roads.
- Pendergast and Birdernagel 1977. New access is highly correlated to declines in goat population in northeast B.C.

Sanderson 1983. Discusses road kills of big game in Alberta and presents mitigation measures.

Stewart 1980. Dall's sheep along the Dempster Highway are very susceptible to disturbances during May and June (recommendations to reduce impacts are mentioned).

Sopuck et al. 1979. Reviews literature regarding transportation corridor impacts on big game species common to north-central Alberta (general).

Thomas 1979. Effects of roads and timber harvest on habitat use, including mitigation (not specific to sheep).

Tracey 1977. Impacts of Mt. McKinley Park road are discussed. The road may have resulted in displacement and range under-utilization.

Van Tighem 1981. Discusses mortality of sheep in relation to railroads and highways in Jasper National Park (on order).

2.5.1. General Mitigation

1. Base road construction proposals on a completed transportation plan which considers wildlife habitat components and seasonal use areas in relation to road location, construction period, road standards, seasons of heavy vehicle use, road management requirements, etc. (Interagency 1984).
2. Use minimum road and site construction specifications based on projected transportation needs. Schedule construction times to avoid seasonal wildlife use areas (Interagency 1984).
3. Use aircraft instead of roads if possible (Andryk 1983).
4. Roads should not pass through open areas where visual contact with sheep can occur. Visual barriers reduce disturbances and road hunting activities (Stubb and Markham 1979).

5. Roads should not be constructed to allow long lines of site. Curves should be included as should vegetation buffers along the right-of-way (Stubbs and Markham 1979; Thomas 1979). Straight stretches should not exceed a distance of 0.4 km (Thomas 1979).
6. At known wildlife crossings, the cleared right-of-way should be minimal so wildlife remain in cover until actual crossing (Thomas 1979).
7. Roads which are not compatible with area management objectives and are no longer needed for the purpose for which they were built should be closed and revegetated (Interagency 1984).
8. Establish a no-hunting zone of at least 2 miles on each side of the road (Geist 1975).
9. Design roads to facilitate road closures at major junctions (Thomas 1979).
10. Keep roads which are in use during exploration and development activity closed to unauthorized use (prohibit public use). Place gates and/or road guards at strategic locations (Interagency 1984; Stubbs and Markham 1979).
11. Impose seasonal closures and/or vehicle restrictions based on wildlife use on those roads which remain open (Interagency 1984).
12. Bus crews to and from work sites to reduce activity levels on roads (Geist 1975).
13. Vehicles should travel in convoys to reduce disturbances and vehicle/wildlife collisions (Geist 1975).

14. At important sheep and wildlife crossings mitigate the barrier of snow caused by plowing (Geist 1975).
15. Screen forage areas from the highway by leaving treed strips (Thomas 1979).
16. Cuts and fills near roads should not block wildlife travel routes (Thomas 1979).

2.5.2 Primary Highway Mitigation

(in addition to general mitigation)

1. Plant unpalatable vegetation on road right-of-ways which are permanent (Sanderson 1983).
2. Provide services only at a few designated areas along the corridor (Geist 1975).
3. Enhance habitat away from the highway or in those areas where wildlife should cross (Damas and Smith 1982; Geist 1975).
4. Restrict or replace the use of salt for de-icing highways: calcium chloride may be a substitute (Damas and Smith 1982; Sanderson 1983).
5. Advise drivers of high risk areas through such means as road signs and speed restrictions (Damas and Smith 1982; Sanderson 1983).
6. Chemical wildlife repellents can be used along road right-of-ways to deter foraging activities (Damas and Smith 1982; Sanderson 1983).
7. Fence and provide underpasses/overpasses in high use areas (Damas and Smith 1982). Use hog wire instead of barbed wire (Graham 1980). Precise design criteria for

underpasses/overpasses are provided in Harrison et al. (1982).

8. Numerous techniques to reduce wildlife-vehicle collisions are discussed in Damas and Smith (1982) and Harrison et al. (1982) and include deer guards, one way gates, speed restrictions, etc.

2.6 MINERAL-PETROLEUM EXPLORATION AND DEVELOPMENT

Numerous activities are associated with mineral and petroleum disturbances such as linear facility and aircraft impacts. Included under this heading are seismic, drilling and camp activities as well as the impacts of noise.

Andryk 1983. Sheep were displaced as a result of seismographic activity. Noise from blasting 2 km away had little effect.

Cowan 1975. Sheep can adapt to noise as long as it is not associated with any threat.

Etter 1973. (on order)

Fletcher and Busnel 1978. Transient loud noises generally provoke alarm. Detailed discussion of noise effects on all wildlife.

* Heimer 1978. Moderate human activity had no discernable effect on a specific Dall's sheep herd in Alaska.

Hoefs 1979. Dall's sheep along the Dempster Highway corridor are much more susceptible to pipeline construction activities than other wildlife in the area.

McCourt et al. 1972. Effects of simulated compressor noise on Dall's sheep (caused range abandonment).

* Reynolds 1974. Simulated compressor noise caused no significant change in mineral lick use.

Sopuck et at. 1979. Discusses the possible effects petroleum exploration and development will have on wildlife common to northeast Alberta, excluding sheep.

* Stuart 1974. The primary impact of mining exploration and development is new access (note linear facilities).

Stubbs and Markham 1979. Concise review of oil and gas impacts on wildlife, including mitigation.

USDI 1976. Dall's sheep are affected by gas compressor noises and may abandon the nearby area.

2.6.1 Seismic Mitigation

1. Restrict seismic activity to the period July 1 - November 1 (Andryk 1983).

Note: Dates may differ in Yukon. Similar recommendation in Stubbs and Markham (1979).

2. Space concurrently active seismographic lines at least 9 miles apart to allow an undisturbed corridor in between. One survey crew may be allowed to work between active lines if it contributes to a reduction in total activity time in the area (Interagency 1984).
3. Seismographic and exploration companies should keep a daily log of activities including locations and shift changes (Interagency 1984). In the event of major impacts on sheep, the log can be checked for any correlation to the disturbance.
4. Schedule activities to avoid seasonal sheep use areas (Andryk 1983).
5. Conventional seismic lines (approximately 6m wide) within 10° variance should not be closer than 1/2 km of each other or existing lines Existing lines are defined as lines where regeneration does not exceed 2m (Stubbs and Markham 1979).
6. Portable lines (1-3m wide) within 10° variance should not be closer than one-quarter km to each other (Stubbs and Markham 1979).

7. Where a conventional seismic line intersects a point of access (eg: road, trail) the line is to be dog-legged and the dog-leg is to be closed by piling debris along its length (Stubbs and Markham 1979).

2.6.2 Drilling/Wells Mitigation

1. Timing constraints and seasonal use habitat restrictions apply as in previous activities.
2. The drill site location should not be on or near key habitats (wintering slopes, mineral licks, etc). The drill site should be buffered by vegetation that eliminates visual contact (100 m buffer is recommended) (Andryk 1983: Stubbs and Markham 1979).

2.6.3 Camp Mitigation

1. Campsites should not be located on open meadow used by ungulates. They are to be placed in heavy coniferous cover and buffered from utilized natural openings (Stubbs and Markham 1979).
2. Personnel should be prohibited from possessing firearms and ATV's (Andryk 1983: Stubbs and Markham 1979).
3. Personnel should be prohibited from hunting (Stubbs and Markham 1979).
4. Prohibit dogs during work periods (Interagency 1984).
5. Consider alternates to camps (eg: air transportation to and from work site)(Andryk 1983).

2.6.4 Noise Mitigation

1. Keep noise levels at a minimum by muffling such things as engines, compressors and energy production facilities (Interagency 1984).
2. Provide sound attenuation measures to compressor stations within 2 miles of Dall's sheep range (McCourt et al. 1972).

2.7 OFF-HIGHWAY VEHICLES (OHV)

Off-highway vehicle use often results in impacts similar to those cited in "Recreation". The disturbances elevate sheep energy costs and may cause the avoidance of an area.

Bear and Jones 1973. ATV use in association with other recreation activities has resulted in sub-optimal range utilization and avoidance.

Cornish et al. 1980. ATV use in association with other activities resulted in the abandonment of seasonal bighorn habitat.

DeForge 1972. OHV activity contributed to the abandonment of a preferred desert bighorn sheep range.

Heath 1974. OHV's are altering sheep distribution.

Penny 1971. (on order)

2.7.1 General Mitigation

1. Prohibit OHV's on sheep range (Wishart 1975).

2.8 RECREATION

Recreational activities include hiking, camping, picnicing, mountaineering and photography. The degree of the recreational disturbance is variable in many cases and often depends on such factors as the intensity, duration, timing, juxtaposition and

previous disturbance history (eg: hunting). Many of the citations concern desert bighorn sheep populations whose habitat is most preferred by the numerous mountain recreationists, especially in California and Arizona.

- Bear and Jones 1973. Hiking and picnicing resulting in the abandonment of a key water hole.
- Blong 1967. Hiking and picnicing resulted in the abandonment of a key water hole.
- Cornish et al. 1980. (on order)
- DeForge 1972. Hiking, in combination with other activities, caused the abandonment of seasonal bighorn sheep habitat.
- Dunaway 1971. Recreation activities are attributed to a 50% population decline in Sierra Nevada bighorn sheep.
- Graf 1980. (on order)
- Hicks and Elder 1979. Hiking and camping appeared to have no major impacts on sanctuary sheep, given present use patterns.
- Jakimchuck et al. 1984. Hikers within 200 m to 500 m elicited a response from 90% of a Dall's sheep herd.
- King 1984. Behavioral responses of desert bighorn sheep to encounters with humans was more "energy costly" when the sheep were historically exposed to human disturbance.
- Kovach 1979. Sheep left the area when approached by humans on foot within 300' to 500'.
- Light 1971. Heavy human recreation (500 visitor days/year) resulted in range abandonment.
- MacArthur et al. 1979. Hikers with dogs caused greater disturbances than when unaccompanied.
- MacArthur et al. 1982. Heart rate response of bighorn sheep to hikers: author recommends hikers should be restricted to designated trails and roads.
- Sopuck et al. 1979. General literature review of recreation impacts on ungulates (primarily elk and deer).
- Thorne et al. 1979. General discussion of effects of mountain recreationists on bighorn sheep.
- Weaver and Hall 1971. Sheep have avoided key water holes as a result of recreational disturbances.

Wilson 1975. (on order)

Wishart 1975. Human disturbances, primarily from recreationists, have resulted in major behavioral changes in bighorn sheep.

Wishart et al. 1980. Sanctuaries may be detrimental to some sheep populations due to a greater susceptibility to lungworm.

2.8.1 General Mitigation

1. Prohibit recreational activities in key sheep habitat such as mineral licks and lambing areas (Wishart 1975).
2. Off-trail hiking in occupied sheep range should be restricted (Hicks and Elder 1979).
3. Close trails passing through or leading to mineral licks (Stevens 1982).
4. Prohibit camping within sight of any high use areas such as mineral licks and lambing areas (Wilson 1975).
5. Trails should be routed away from intensive sheep use areas (Hicks and Elder 1979).
6. Restrict human activity to specified trails and roads (MacArthur et al. 1982).
7. Discourage the presence of dogs on sheep range (MacArthur et al. 1982).
8. Managing for consumptive and non-consumptive use of wildlife is largely incompatible (Geist 1975).

2.9 TIMBER HARVESTING

The majority of Dall's sheep habitat does not contain significant quantities of merchantable timber. Therefore, this activity is generally not in conflict with sheep populations. However, some citations are presented in the event timber activities are initiated in sheep habitat.

Sopuck et al. 1979. General literature review of logging impacts on wildlife (sheep not mentioned).

Thomas 1979. Specific discussion on managing timber harvest to optimize wildlife use (sheep not mentioned).

2.9.1 General Mitigation

1. Timing and habitat use restrictions similar to other activities should apply.
2. Allow no timber or firewood cutting on winter-spring ranges and rutting, lambing and mineral lick areas during bighorn seasonal use periods (Andryk 1983).
3. Do not replant burn sites with low timber production potential (eg: less than 50 board/feet/acre/year) on existing or potential sheep range (Andryk 1983).
4. Concentrate management activities to the shortest time period possible and within the smallest area (Thomas 1979).
5. Maintain non-activity areas near zones of concentrated disturbances (Thomas 1979).
6. Confine timber operations to a single drainage at a time (Thomas 1979).
7. Slash can be piled in windrows if it provides a break in long site distances (Thomas 1979).

8. Heavy slash (2' in depth) significantly reduces the use of both clear cuts and timber stands (Thomas 1979).
9. Cover within known travel routes should be maintained (Thomas 1979).

3.0 INDEX TO REFERENCES ON RANGE ABANDONMENT

The following citations contain the documentation of temporary or permanent range abandonments, excluding those associated with mineral licks or watering holes.

Bear and Jones 1983. Recreational activities resulted in range abandonment for some herds in Colorado.

Buechner 1960. Fencing, livestock grazing and human disturbances were attributed to many of the range abandonments which occurred during 1850-1900.

DeForge 1972. Human activity associated with a road resulted in temporary range abandonment.

Donihee and Gray 1982. Range abandonment along some highway corridors (Northwest Territories).

Dunaway 1971. Under-utilization and abandonment of sheep range were correlated to high recreational activity.

Environment Canada 1979. Range abandonment resulted from linear facilities in Yukon and other northern areas.

Geist 1970. Hunting activities resulted in seasonal range abandonment and some permanent range abandonments - general

Geist 1971. Same as above.

Goodson 1982. Die-offs and/or range abandonment resulting from livestock grazing (including B.C).

Graham 1980. Elevated disturbance near lambing cliffs will result in abandonment.

Heath 1974. Off-highway vehicle use has resulted in the abandonment of some optimal sheep ranges.

Hoefs 1979. Mineral exploration and related subsequent access has resulted, in many cases, in range abandonment (Yukon).

Light 1971. Heavy recreational use caused sheep to abandon an area.

McCourt et al. 1972. Simulated compressor noise caused sheep to abandon areas within 1 mile.

USDI 1976. Aircraft activity can result in temporary range abandonment.

4.0 INDEX OF IMPACTS SPECIFIC TO MINERAL LICKS (and water sources)

In Yukon environments, mineral licks are a key habitat component for Dall's sheep. Because these licks are highly susceptible to human-caused disturbances, land use activities must be closely monitored. Most of the following articles discuss water sources for desert bighorn sheep. Water sources are similar to mineral licks as they are both "point" habitat components essential to the well being of the population.

Blong 1967. Recreation activities were attributed to the abandonment of a key water hole.

Campbell and Remington 1981. Bighorn sheep activity was disrupted and frequency of visits decreased following disturbances at a water source.

Jorgensen 1974. Vehicle traffic along a road resulted in a decrease in water-hole use.

Leslie et al. 1980. Construction activities near a key water source was likely responsible for changes in sheep movement and behavior.

Packard 1946. Some mineral licks have become inaccessible as a result of fencing, livestock grazing and roads.

Price and Lent 1972. Sheep were more wary, and abandoned a mineral lick, as a result of helicopter activity at 500' agl.

Reynolds 1974. Simulated compressor station noise appeared to have no effect on mineral lick use by Dall's sheep.

Stevens 1982. Human activity (primarily recreationists) caused sheep to abandon two mineral licks.

Weaver and Hall 1971. Camping and OHV activity are causing sheep to avoid water sources.

Wilson 1975. (on order)

**5.0 ANNOTATED BIBLIOGRAPHY OF
SELECTED REFERENCES**

Key to Symbols

!	- Very good report
*	- Location where report can be acquired
ADFG	- Alaska Department of Fish & Game
AFWB	- Alberta Fish & Wildlife Branch
CWSL	- Canadian Wildlife Service Library, Edmonton
RRL	- Renewable Resources Library, Yukon
RRL - Hab	- Renewable Resource's Habitat Library, Yukon
RRL - Sheep	- Renewable Resources' Sheep/Goat Library, Yukon
RRL - Caribou	- Renewable Resources' Caribou Library, Yukon
RRL - Wolves	- Renewable Resources' Wolf Library, Yukon
U of C	- University of Calgary
partial	- An incomplete copy

Other symbols and names are self explanatory.

Andryk, Timothy A. 1983. Ecology of bighorn sheep in relation to oil and gas development along the east slope of the Rocky Mountains, northcentral Montana. M.Sc. Thesis, Montana State University. Bozeman, Mt. 100 pp.
*RRL - Hab (Mycashiw)

This paper discusses the response of bighorn sheep to oil and gas exploration and development with particular reference to habitat use. The study indicated that sheep were displaced from a lambing area during seismographic activity. Also, during helicopter surveys, sheep were flushed at a mean distance of 364 m agl. The flushing distance was often related to the sheep's visual contact with the helicopter. Sheep showed little response to the detonation of explosive charges approximately 2 km away.

The paper also presents brief mitigation guidelines for seismic exploration, oil and gas wells, roads, livestock grazing and timber harvest.

Keywords: Mineral-petroleum / linear facilities (roads) / Aircraft/
Mitigation (agriculture, aircraft, mineral-petroleum,
timber harvesting)

Aquatic Environments Ltd. 1975. Baseline studies of the biology of streams and wildlife populations in the Sheep Creek drainage, Alberta. Crossfield, Alberta.
* A.F.W.B. - Calgary

Included in this report is a discussion of the effects of a helicopter on wildlife (and sheep) near Grande Cache, Alberta. The helicopter activity almost always resulted in bighorn sheep running. The helicopter observer noted that in most cases sheep were running when they were first observed and they rarely allowed approaches closer than 1/2 mile. Ewes and yearlings exhibited the greatest response and their flight distances were extensive (no distance stated).

The author indicates that bighorn sheep showed the greatest sensitivity to helicopter disturbances of all the large mammals surveyed.

Keywords: Aircraft

Bear, G.D. and G.W. Jones. 1973. History and distribution of bighorn sheep in Colorado. Colorado Div. Wild, Denver. 232 pp.
* ADFG - Juneau

The authors present qualitative data that implies recreational activities (hiking, camping, ATV activities and horseback riding) significantly affect bighorn sheep distribution and behavior. Although it is a general report discussing the major sheep herds in Colorado, some specific instances of range abandonments or under-utilization attributed to recreation are presented.

The combination of the various recreation activities has resulted, in some cases, of sheep avoiding "recreation" areas.

Keywords: Recreation / OHV / Range abandonment

Blong, B. 1967. Desert bighorn and people in the Santa Rosa Mountains. Pages 66-70 in J. Yoakum, B. Browning, R. Miller and A. Leopold, eds. California-Nevada Section, The Wildlife Society, 1967 Transactions. 14th Annual Meeting. January 1967, Disneyland California, The Wildlife Society, Reno, Nevada.
* U. of Alaska - Fairbanks

Recreational activities (hiking and picnicing) were primarily responsible for the abandonment of a key water hole in California. The author suggests that recreational activities pose the most serious threat to desert bighorn sheep, which already live on the "limits" of the habitat.

Keywords: Recreation / Mineral licks

Blood, D.A. 1971. Contagious ecthymia in Rocky Mountain bighorn sheep. J. Wildl. Manage. 35(2):270-275.
* RRL

Bighorn sheep were monitored in B.C. and Alberta since 1953 in this study for symptoms of contagious ecthyma (CE). This disease is normally associated with domestic sheep and, in some cases, domestic goats. CE was identified in bighorn sheep of all age groups. Domestic sheep previously grazed in those areas where CE was detected. Although the domestic sheep were no longer present on the range during the research, CE transmission most likely continued through salt blocks. The blocks were present throughout the range, and sheep did utilize them.

Keywords: Agriculture (disease transmission)

Campbell, Bruce and R. Remington. 1981. Influence of construction activities on water-use patterns of desert bighorn sheep. Wildl. Soc. Bull. 9(1):63-65.
* RRL

The study which was conducted in Arizona during 1978 and 1979, indicated that desert bighorn sheep modified their activity to human-caused disturbances. They disrupted their visits to the water-hole during construction activities, and their number of water-hole visitations decreased.

The brief infrequent use of the spring resulted in the long term effect of higher energy costs which likely affected the viability of the population. This was probably exemplified by the unusually low ewe-lamb ratio during the construction period.

Note: Water-holes are key "point" habitat requirements for desert bighorn sheep and are very similar to the relationship between mineral licks and Dall's sheep.

Keywords: Mineral licks

! Cornish, B., J. Van Camp and M. McNicholl. 1980. The impacts of recreation on fish and wildlife with emphasis on Kananaskis Country: a literature review and partial bibliography. Planning Doc. No. 4. Kananaskis Planning Team, Calgary, Alberta. 113+ pp.

(on order)

! Cowan, I. McT. 1971. Some environmental considerations in
northern road planning, construction and maintenance.
Unpublished M.Sc. Thesis, Env. Prot. Serv., Canada. 63 pp.

(on order)

Cowan, I. MCT. 1975. Testimony in Proceeding at inquiry. Mackenzie Valley pipeline inquiry before the Hon. Mr. Justice Berger, Commissioner. Allwest Reporting Ltd. Burnaby, B.C. Vol 107:16290-16291.
* U of C

The author implies that activities (ie: construction) producing noise may eventually be ignored by sheep if the noise is not associated with any threat. He states, in his testimony that "Dall sheep adapt to noise providing there is no harassment due to hunting."

Keywords: Mineral-petroleum (noise)

Damas and Smith, Ltd. 1982. Wildlife mortality in transportation corridors in Canada's national parks - impact and mitigation. Parks Canada. Ottawa. 2 vol.
* Parks Canada - Winnipeg (RRL - Hab:partial)

The report documents various animal/vehicle collisions in the national parks of Canada, and discusses mitigation measures to alleviate these collisions. The measures discussed in detail concern highway design (location, design speed, signing, lighting and ROW clearing), fencing, associated structures (overpasses, underpasses, deer guards and gates), alternatives to road salt and deterrents (light, sound and scent).

General mitigation recommendations include physically keeping the animal off the roadway either by both active restraint (ie: fencing) and/or passive restraint, and providing drivers with an increased awareness of the "problem." In combination, these measures could be very effective and cost-efficient.

Keywords: Linear facilities (roads, railways) / Mitigation (linear facilities)

! DeForge, J.R. 1972. Man's invasion into the bighorn's habitat.
Desert Bighorn Council Transactions 16:112-115.
* RRL - Hab

The author conducted a field research study in California during 1972 to determine the effects on bighorn sheep of various human activities along a road. These activities (logging, hiking and ATV use) resulted in the abandonment of seasonal bighorn habitat. Between April and June, a nearby logging operation (no distance given) near the lambing area, and subsequent heavy weekend use of ATV's (primarily motorbikes) caused sheep to leave the valley.

During the fire season, the road was closed to all vehicles, and sheep began to reoccupy the valley. Observations of sheep bedding on the road were noted. However, during the hunting season, the road was reactivated when deer hunters cut through the gate. Sheep again abandoned the area.

Keywords: Linear facilities (roads) / OHV / Recreation / Timber
harvesting / Range abandonment

DeForge, J.R. 1976. Stress: is it limiting bighorn? Page 30-31 in
Desert Bighorn Council. Transactions - 1976. Bahia Hino,
Mexico. Las Vegas, Nevada. Vol. 20.
* U of C

This report indicates harassment and human intrusion in bighorn sheep habitat can result in range abandonment or marginal use of preferred areas. A loss of habitat can lead to displacement, local overpopulation and elevated stress levels.

The author suggests that the overcrowding and elevated stress causes the "deployment" of an evolved physiological/behavioral mechanism in sheep which controls over-population. The mechanism results in greater susceptibility to disease and parasites, inhibition of reproductive functions and ultimately a decline in the viability of the population. Therefore, mortality resulting from such causes as pneumonia may be an actual result of human disturbances.

Keywords: Harassment / Range abandonment

Demarchi, D.A. 1970. Bighorn sheep and overgrazing in the lower Chilcotin River Region, British Columbia. Pages 39-45 in Transactions of the northern wild sheep council, Williams Lake, 1970. Wildl. Manage. B.C. Fish Wildl. Branch.
* U of C

During a field study conducted in the summer of 1968 and 1969, cattle grazing on bighorn sheep range was directly responsible for vegetation damage and composition changes. Overgrazing of the dominant and most nutritious grasses resulted in the invasion of weedy forbs. These changes, and others associated with livestock grazing were most likely responsible for a 50% mortality in lambs and a total population decline of 35% during the study period.

Keywords: Agriculture (competition, vegetation damage)

! Dieterich, R.A., G.R. Spencer, D. Berger, A.M. Gallina and J. Vander Schalie. 1981. Contagious ecthyma in Alaska musk-ox and Dall sheep. J. Am. Vet. Med. Assoc. 179 (11): 1140-1143.
* U of C

Domestic livestock grazing was attributed to the transmission of contagious ecthyma (CE) to Dall's sheep. These sheep were confined near Fairbanks, Alaska during 1976 to 1977 in close association with domestic livestock. Almost all of the sheep contracted CE and some lambs and yearlings perished as a result.

Keywords: Agriculture (disease transmission)

! Donihee, John and Paul A. Gray. 1982. A review of road related wildlife problems and the environmental management process in the north. Department of Renewable Resources, Yellowknife, NWT. Info. Rep. NO. 2 20 pp.
* RRL - Hab

The authors indicated that quantitative documentation of long term effects from linear facilities on wildlife in Canada is virtually non-existent. The primary reason for this is the lack of pre-development information on population abundance and distribution. Avoidance of habitat adjacent to highways and, in some cases, range abandonment have resulted from the synergistic effects of ancillary development, road construction and human activity. The highest proportion of hunting effort is associated with roads (80% of hunting effort in northern Alberta is within 1.6 km of a road). Other reports are summarized by the authors as well.

The report stresses the need for lead time prior to a commitment made for the construction of a road. Sometimes, lead time of up to 2-3 years may be necessary. In addition, the environmental assessment process should be ongoing, even after the pre-construction phase.

Keywords: Linear facilities (roads) / Harassment (hunting) / Range Abandonment / Mitigation (linear facilities)

Dunaway, D.J. 1971. Human disturbance as a limiting factor of Sierra Nevada bighorn sheep. Pages 165-173 in E. Decker, ed. Transactions of the First North American Wild Sheep Conference. Colorado State Univ. April 14-15 Fort Collins, Colorado. 187 pp.
* U of C

The author reviews the population decline (50%) of the Sierra Nevada bighorn sheep in California between 1949 and 1970, and he indicates that human recreational activity (hiking and camping) was the causative agent. Other limiting factors such as hunting, predation, livestock competition, diseases and range quality were either absent or constant throughout the period. Areas showing the greatest decline in sheep correlated with the highest activity in human recreation. Although no statistical evidence is presented, this high degree of correlation is indicative of the major impact outdoor recreation (hiking and camping) has on bighorn sheep populations.

Keywords: Recreation / Range abandonment

! **Environment Canada. 1979. Impact of linear facilities in Northern Canada: A review of environmental literature. Env. Prot. Serv. Tech. Rep. (EPS 3-NW-79-3A 157 pp.**
* RRL - Hab

Although this report is not specific to sheep or large mammals, it does discuss concerns and effects of pipelines, railways and roads on northern terrain, vegetation, hydrology, aquatic systems and wildlife. General comments are included on the impacts of linear facilities on sheep as a result of clearing of right-of-ways and construction and operation. Subsequent human activities created by access (eg: hunting) can cause range abandonment, change in habitat utilization and roadway mortality. The report also documents range abandonments and population reductions as a result of linear facilities in the Yukon.

Keywords: Linear facilities / Range abandonment

Etter, H.M. 1973. Mineral land reclamation studies on bighorn sheep range in Alberta, Canada. Biol. Cons. 5(3):191-195.

(on order)

Feist, J.D., W.P. McCrory and H.J. Russell. 1974. Distribution of Dall sheep in the Mount Goodenough area, Northwest Territories, Chapt. II in K.A. McCourt and L.P. Horstman, eds. Studies of large mammal populations in northern Alaska, Yukon and Northwest Territories, 1973. Renewable Resources Consulting Services Ltd. Can. Arctic Gas Study Ltd. Biol. Rep. No. 22.
* U of C

This report references helicopter disturbances to Dall's sheep during 1973. Very strong reactions were evident in sheep when helicopter flights at elevations up to 1500' occurred. Horizontal distances of one mile also elicited response and in one case sheep ran 1 1/2 miles.

Keywords: Aircraft

Fletcher, J.L. and R.G. Busnel (eds). 1978. Effects of noise on
wildlife . Academic Press, New York, pg 7-22.
* U of C

Although not specific to sheep or any wildlife species, this book primarily discusses physiological and behavioral attributes of noise on wildlife in general. Reactions vary between species as well as depending on factors such as population status, season, conditioning and juxtaposition. Transient loud noises generally provoked alarm especially if the noise is associated with some kind of visual stimulus. Common noises not associated with negative experiences may eventually be ignored by animals.

Keywords: Mineral-petroleum (noise)

! Flygare, H. 1979. Ungulate mortality and mitigated measures.
Trans-Canada highway; Banff National Park - east gate to
Sunshine turnoff. Western Regional Office, Parks Canada 168
pp.

(on order)

! Foreyt, W.S. and D.A. Jessup. 1982. Fatal pneumonia of bighorn sheep following association with domestic sheep. J. Wildl. Dis. 18(2):163-168.
* U of C.

This report indicates that confined wild sheep in excellent condition subjected to close association with domestic sheep contracted acute bacterial pneumonia. Nearly all sheep perished. Domestic sheep, apparently healthy, were enclosed with wild sheep in one trial, and in the second trial, the two groups were separated by a fence (Note: stress may have been a factor as a result of confinement and the association with sheep). There was strong evidence that supports the transmission of pathogenic bacteria from the domestic sheep to the wild sheep.

The author also reviews various literature discussing disease transmission and suggests that the decline in North American bighorn sheep was largely due to introduced diseases.

Keywords: Agriculture (disease transmission)

Franzman, A.W. 1972. Environmental sources of variation in physiological values of bighorn sheep. J. Wildl. Manage. 36:924-932.
* RRL

This report discusses the physiological changes when wild bighorn sheep are excited. Rectal temperature, blood glucose, blood cholesterol, hemoglobin, blood calcium, blood protein and packed cell volume all were influenced by excitability.

The author indicated that management procedures should be implemented to ensure that excitement of bighorn sheep is minimized.

Keywords: Harassment

Geist, V. 1970. Sheep management dilemmas. Pages 46-49 in Trans.
North Wild Sheep Council. 1970.
* U of C

The author indicates that sheep are highly susceptible to disturbances, which results in elevated stress levels. This stress, in turn, causes physiological malfunction which ultimately leads to lower population viability. Also, hunting has resulted in rams occupying sub-optimal areas which are more remote and rugged. Seasonal and, in some cases, permanent range abandonment resulted.

Keywords: Harassment (hunting) / Range abandonment

! Geist, V. 1971. A behavioral approach to the management of ungulates in E. Duffey and A.S. Watts, eds. The scientific management of animal and plant communities for conservation. Brit. Ecol. Soc. Symp. 11:413-424.
* U of C

Although this article is not specific to sheep, the concepts concerning the behavior of ungulates can be directly applied. The author suggests that ungulates can get along with humans as long as no negative stimuli (eg: hunting) is associated with them. However, they may initially avoid humans until they learn no harm is associated with contact. If hunted, harassed or chased, sheep will leave the area to avoid humans.

The author describes the stimulus process of excitation in 3 steps: 1) the unpleasant stimulus is sensed and the animal becomes excited (even after the object has left, this excitation will often remain for an extended period of time); 2) the animal avoids the area where the undesirable stimulus was encountered; and 3) the animal associates similar objects to the same stimulus (it generalizes) and avoids all those objects and the areas they frequent or becomes increasingly disturbed.

Excitation and unpredictability can cause neurosis, weight loss, appetite loss, reduced reproduction, susceptibility to disease, parasites and predation, and in some cases, death.

In all cases there is an increased cost of living. The report also documents collision with vehicles as a result of the attraction to artificial food sources along highway right-of-ways. In addition, snow plowing on roads may cause an impassable barrier. The author suggests that sheep, a non-nomadic social species, are the most vulnerable to disturbance.

Keywords: Harassment / Linear facilities (roads) / Range abandonment

! Geist, V. 1975. Harrassment of large mammals and birds with a critique of the research submitted by Arctic Gas Studies Ltd. on this subject. Report to the Berger Commission. University of Calgary, 63 pp.
* RRL - Hab

The author defines in general the effects of harrassment:

1. Harassment, by greatly elevating the metabolism of the body, elevates the cost of living to the animal at the expense of its body growth, development and reproduction.
2. Harassment can lead to death, illness or reduced reproduction due to secondary effects of physical excitation and temporary confusion.
3. Harassment can lead to avoidance or abandonment of areas leading to a reduction of the population, due to loss of access to resources, increased predation or increased cost of existence.

The report discusses some effects of roads on wildlife, especially caribou, and provides good documentation on the response by some wildlife to various road-related factors (vehicles, hunting parties, snowbanks, services, etc) such as:

- roads increase contact between hunters and animals.
resulting in increased kills.

- roads may block normal migratory routes, leading to higher rates of collision between wildlife and vehicles.
- hard road surfaces and low snow depth may attract big game, increasing collision rates.
- winter plowing may create an impossible snow barrier.
- salting to reduce ice may attract wildlife, resulting in higher collision rates.
- naive animals may not cross used roads well, shying back from highway traffic, leading to delayed migrations and possible range abandonment.

Various mitigation measures for primary roads are given.

The author also critiques the report by McCourt et al. (1972) on disturbance studies of Dall's sheep (and other mammals). In general he suggests the findings of the author are unacceptable.

Keywords: Harassment / Linear facilities (roads) / Mitigation
(linear facilities, recreation)

! Goodson, Mike J. 1982. Effects of domestic sheep grazing on bighorn sheep populations: a review. Pages 287-323 in J.A. Bailey and G.G. Schoonveld. Northern Wild Sheep and Goat Council. Proceedings of the Third Biennial Symp. Fort Collins, Colorado.

* RRL

Domestic sheep grazing can effect bighorn sheep in 3 different ways: 1) competition for forage; 2) competition for space; and 3) transmission of diseases. Generally, in areas where domestic sheep ranges overlap, bighorn sheep often socially avoid these zones thereby utilizing only part of the available habitat.

Bighorn sheep lack resistance to pneumophilic bacteria (often transmitted by domestic sheep) and many succumb to fatal pneumonia as a result. Chronic sinusitis also introduced by domestic sheep has led to a decrease in population viability. The co-existence of domestic and bighorn sheep has consistently been linked with declines, die-offs and extinctions of bighorn populations. After the removal of domestic sheep and livestock a significant number of bighorn populations have increased.

This report also contains very good documentation of declines and die-offs attributed to the presence of domestic sheep and includes Canadian examples.

Keywords: Agriculture (competition, disease transmission, vegetation damage) / Range Abandonment / Mitigation (agriculture)

! Graf, W. 1980. Habitat protection and improvement. Pages
310-319 in G. Monson and L. Sumner, eds. The desert bighorn:
its life history, ecology and management. University of
Arizona Press, Arizona. 370 pp.

(on order)

Graham, H. 1980. The impact of modern man. Pages 288-309 in G. Monson and L. Summer, eds. The desert bighorn: its life history, ecology and management. University of Arizona Press, Arizona. 370 pp.

The author documents impacts on desert bighorn sheep as a result of a wide range of activities. Some of these impacts include collisions with vehicles, entanglement in wires, livestock competition, barriers to movements and entrapment in excavations and canals. Although many of the impacts are linked to environments having a much higher human population, some of the discussion is directly applicable to conditions presently existing in the Yukon. The author provides documentation which indicates that: 1) bedding and lambing areas which receive frequent disturbances (degree not specified) will be abandoned; 2) high speed highways through sheep range result in fatal collisions; 3) barbed wire fences entangle sheep and can result in mortality; and 4) concrete water canals can result in drowning. General mitigation regarding overpasses, fencing and tunnels is discussed.

Keywords: Agriculture (competioion, fencing) / Linear facilities (roads) / Dams-canals / Range abandonment / Mitigation (linear facilities)

Hansen, C.G. 1971. Over-population as a factor in reducing desert bighorn populations. Desert Bighorn Council. Trans. 15:46-52.
* U of Alaska - Fairbanks

The author incorporates various reports, dating back to the early 1950's, into his review of human impacts on desert bighorn sheep. He documents the following impacts: 1) livestock competition (food and space); 2) barriers to movement resulting from fences and highways; 3) fence entanglement; 4) crowding of sheep into undisturbed areas resulting in increased predation, disease and stress; 5) collision with vehicles; and 6) increased levels of poaching.

Bighorn populations are decreasing as a result of the above-mentioned impacts. The author also states that the social mechanisms in sheep are the primary limiting factors in their survival. Stress, one of the key components of this mechanism, is severely influenced by human disturbance and crowding.

Keywords: Agriculture (competition, fencing) / Harassment (hunting) / Linear facilities (roads)

Harrison, G., R. Hooper and P. Jacobson. 1982. Ungulate populations statistics and habitat analysis. Natural History Research Division. Western Region, Calgary, Parks Canada, 114 pp.

(on order)

This report discusses, in part, the effects the Trans-Canada Highway has on wildlife (including sheep) in Banff National Park. Only the section from the east gate of the park to the Sunshine ski hill turnoff is addressed.

The report presents mitigation techniques to reduce the number of vehicles and ungulates. At present the mortality is excessive. A minimum of 232 ungulates were killed as a result of vehicle collisions between 1917 and 1979. All mitigation measures are reviewed, including the application of noxious chemicals (ie: lithium chloride) on the road right-of-way and psychological barriers (eg: reflectors). However, fences and underpasses/overpasses appeared to offer the most satisfactory results. The report contains very precise design criteria for the fences and artificial passes including the best techniques for placement.

Keywords: Linear facilities (roads) / Mitigation (linear facilities)

! Heath, R. 1974. The environmental consequences of the off-road vehicle: with profiles of the industry and the enthusiast. Defenders of Wildlife and Friends of the Earth. Wash., D.C. 36 pp.
* U of Alaska - Fairbanks

This report reviews various articles concerning the impacts of off-highway vehicles (OHV) on the environment. The author indicates that OHV are altering the distribution of sheep and forcing them to use marginal habitat. Some optimal ranges are being abandoned.

Keywords: OHV / Range abandonment

Heimer, W.E. 1978. Big game investigations: Dall sheep responses to human activity. Alaska Department of Fish and Game Proj. W-110, Job 6.13R.
* U of Alaska - Fairbanks

This report discusses the effects that moderate human activity had on the Dry Creek sheep population (a "low quality" population) in Alaska. The population was subjected to frequent fixed-wing and helicopter activity (no distance or duration stated), moderate hunting and intensive mineral exploration. All the disturbances were generally seasonal and of short duration. In addition, the activities were controlled by some environmental regulations (not stated).

The author indicates that these activities had no identifiable impacts on population trends, lamb production and lamb survival. However, he does suggest that activities in Dall's sheep habitat should be rigidly monitored and conducted in the shortest time possible.

Keywords: Aircraft / Mineral-petroleum

! Helvie, J.B. 1971. Bighorns and fences. Desert Bighorn Counc.
Trans. 15:53-62.
* U of Alaska - Fairbanks

The report documents the direct impacts of fencing on bighorn sheep. Fences have resulted in barriers to movement and entanglement, resulting in death (primarily from barbed and woven wire fences).

The author tests various types of fencing and provides concise guidelines for the design and construction of fencing to allow passage and to limit entanglement (Note Section 2.1.2: Agriculture - mitigation).

Keywords: Agriculture (fencing) / Mitigation (agriculture)

Hicks, L.L. and J.M Elder. 1979. Human disturbances of Sierra Nevada bighorn sheep. J. Wildl. Manage. 43(4):909-915.
* RRL

This study was conducted in California's Bighorn Zoological Area, a game sanctuary where hunting is prohibited. The effects that recreational activities (hiking and camping) have on bighorn sheep were assessed.

Although the report documents some harassment, the author concluded that the current use of the sanctuary by hikers has had no major impact on sheep. The author did indicate that trails should be routed away from intensive sheep use areas and off-trail hiking should be restricted.

Keywords: Recreation / Mitigation (recreation)

Hoefs, M. 1979. Dall sheep distribution, abundance and "critical" areas along the proposed Dempster lateral pipeline route. Prepared for Foothills Pipe Lines (Yukon) Ltd. Calgary, Alta. 42 pp.
* RRL - Sheep

The author indicates that sheep are much more susceptible to activities in the Dempster area because their range is very small and restricted. Also, unlike caribou and raptors, they are present within the area throughout the year.

The author also suggests that exploration activities in the Yukon, especially those made accessible by roads and trails, almost always result in population declines and range abandonments. In addition, there is not one example of sheep recolonizing these abandoned areas in the Yukon.

Keywords: Linear facilities (roads) / Mineral-petroleum / Range abandonment

Holroyd, G.L. 1980. The impact of highway and railroad mortality on the ungulate populations in the Bow Valley, Banff National Park. Canadian Wildlife Service, Edmonton, Alberta. 11 pp.

(on order)

! Horejsi, Brian. 1976. Some thoughts and observations on harassment and bighorn sheep. Pages 149-155 in Proc. Bien. Symp. North. Wild Sheep Counc. Wyoming. 165 pp.
* RRL

The author defines two different types of harassment - active and passive. Active harassment refers to an obvious change in activity which results in flight while effects from passive harassment are more subtle and are not associated with flight. Numerous examples are given of both types including those associated with roads and aircraft.

Although the effects of passive harassment are more subtle, it can lead to physiological stress, which, in turn, can cause a significant reduction in population viability. The author, through various references and discussions, explains that harassment impacts on sheep may: 1) result in death through predation, accidents and increased hunting mortality; 2) affect growth and development of individuals; 3) cause abandonment of some ranges or parts of them; and 4) alters activity patterns and distribution in occupied areas.

The report also briefly discusses differences associated with human disturbances on hunted and unhunted populations. Hunted populations are greatly alarmed by human activity, resulting in significantly higher levels of harassment. Flight response to humans is much higher than that associated with natural predators.

Keywords: Harassment / Linear facilities (roads)

! Interagency Rocky Mountain Front Wildlife Monitoring/Evaluation Program. 1984. Management guidelines for selected species, Rocky Mountain Front Studies, Montana Department Fish, Wildlife and Parks, U.S. Fish and Wildlife Service. Bureau of Land Management. 63 pp.
* RRL - Hab (partial)

The article provides both general and specific guidelines to reduce impacts of various land use activities on wildlife, including bighorn sheep. These mitigation measures are presented under each "Activity" section (beginning in Section 2.0).

Keywords: Mitigation (agriculture, aircraft, linear facilities, mineral-petroleum)

Jakimchuk, R.D., E.A. De Bock, H.J. Russell and G.P. Semenchuck.
1974. A study of the Porcupine Caribou herd, 1971. Chapt. 1.
in R.D. Jakimchuck, ed. The Porcupine herd - Canada.
Renewable Resources Consulting Services Ltd., Can Arctic Gas
Study Ltd. Biol. Rep. Ser. Vol. 4.
* RRL - Caribou

During this research the authors document various observations concerning Dall's sheep activity. Dall's sheep are more reactive to aircraft disturbances than caribou. Even fixed wing aircraft at high altitude (no distance stated) elicited a major response.

Keywords: Aircraft

Jakimchuk, R.D., D.J Vernam and L.G. Sopuck. 1984. The relationship between Dall sheep and the Trans-Alaska pipeline in the Northern Brooks Range, Prepared for: Alyeska Pipeline Service Company by Renewable Resources Consulting Services, Sidney, B.C. 156 pp.
* RRL - Hab: partial

This report indicates that there was no evidence to suggest that the operation and disturbances associated with the pipeline had adversely affected the Atigun Dall's sheep population. The sheep appeared to have become accustomed to aircraft and vehicle traffic, and were also utilizing man-altered habitats associated with pipeline facilities (eg: mineral licks, revegetated areas). Their activity patterns, habitat use, productivity and social organization were similar to the control group of sheep in the Sagavonisktok Valley.

Hunting was prohibited in the pipeline corridor for approximately 6 years until 1980 when virtually all of the construction activity ceased. The report documents the death of four sheep as a result of vehicle collision. The author suggests these animals were feeding on revegetated grasses along the highway. In addition, 20% of the sheep responded to helicopters at elevations between 200 m to 500 m and trucks at 200 m. Hikers (humans on foot) within 200m to 500 m elicited a response from 90% of the population. The article discusses numerous reports which document sheep habituated to human disturbances.

Keywords: Linear facilities (roads, pipelines) / Recreation / Aircraft

Jorgensen, P. 1974. Vehicle use at a desert bighorn watering area.
Trans. Desert Bighorn Council. 187:18-24.
* U of Alaska - Fairbanks

Vehicle traffic along a road adjacent to a creek resulted in a decrease in use of the water source by sheep. Bighorn sheep use decreased approximately 50% on days when recreational vehicles travelled along the road or stopped near the creek. Rams appeared to be affected the most. When sheep were at the creek as vehicles approached, they ran to escape terrain.

Keywords: Mineral licks

! King, Michael M. and Gar W. Workman. 1984. Response of desert bighorn sheep to human harassment: management implications. Trans. 51st N.A. Wildl. Nat. Res. Conf.
* RRL

This report studied the behavioral response of desert bighorn sheep to human disturbance in Utah from 1981 to 1983. The response was compared between two different areas having contrasting disturbance histories. The results indicate that the population which had been exposed to greater levels of hunting and vehicle pressures had a much greater flight response (83%) to deliberate harassment trials (hikers and vehicles) than the lightly disturbed population (46%). The heavily disturbed population also fled approximately 2.75 times farther than the lightly disturbed population.

"Behavioural response of desert bighorn to encounters with humans were more severe and thus more energy costly for animals that had been historically exposed to relatively high levels of human disturbance."

Keywords: Harassment / Recreation

Kovach, S.D. 1979. An ecological survey of the White Mountain Peak bighorn. Pages 57-61 in Desert Bighorn Coun. Trans. Boulder City, Nevada. April 4-6, 1979.
* U of Alaska - Fairbanks

The author discusses observations of sheep behaviour during approaches by humans on foot. The bighorn sheep would not tolerate direct approaches and approaches from above.

Sheep left the area when aircraft flew within 300' to 500'agl of the herd. Vehicles travelling a nearby road did not appear to disturb the sheep, unless people left the vehicle.

Keywords: Linear facilities (roads) / Recreation

Krausman, Paul R. and J.J. Hervert. 1983. Mountain sheep responses to aerial surveys. Wildl. Soc. Bull. 11(4) 372-375.
* RRL

This study suggests that different sex and age classes of sheep react similarly to low-flying aircraft. The Arizona sheep appeared to be accustomed to wildlife survey aircraft flying greater than 100 m agl although flights less than 50 m agl cause sheep to abandon an area.

The author discusses the implications of aerial sheep surveys and suggests that surveys to determine habitat use or behavior patterns may be misleading if collected from flights less than 100 m agl. It appears that the study utilized a small fixed-wing aircraft instead of a helicopter.

Keywords: Aircraft / Mitigation (aircraft)

Lenarz, M. 1974. The reaction of Dall sheep to an FH-1100 helicopter. Pages 1-12 in R.D. Jakimchuk, ed. The reaction of some mammals to aircraft and compressor station noise disturbance. Arctic Gas Biol. Rept. Ser. Vol. 23. Prepared by Renewable Resources Consulting Services. Ltd. for Canadian Arctic Gas Study Ltd. and Alaskan Arctic Gas Company.
* U of C

This report was based on research conducted in the summer of 1973 on the North Slope of Alaska.

Approximately 36% of surveyed sheep groups ran in panic, 49% walked slowly and 15% became alert when a Fairchild-Hiller 1100 helicopter approached within 300' - 500' agl. These disturbances were not affected by the type of approaches (above or below), group size and the timing of the summer flights.

The sheep had appeared to be previously habituated to heavy fixed-wing aircraft activity.

Keywords: Aircraft

Leslie, David M.jr. and Charles L. Douglas. 1980. Human disturbance at water sources of desert bighorn sheep. Wildl. Soc. Bull. 8(4):284-290.
* RRL

"Abstract: Alterations of behavior and movement of desert bighorn sheep...were coincident with construction activities near the populations primary watering site. The juxtaposition of construction efforts with summer water dependence of bighorn sheep caused a significant shift in use of artificial water sources. Nine of 17 marked ewes altered their watering patterns in response to construction activities. Productivity during construction did not depart from the long-term population mean; however, lamb survival may have been affected. Responses of the River Mountain herd to construction activities were dampened by a high degree of habituation to man."

Keywords: Mineral licks

Light, J.T. 1971. An ecological view of bighorn habitat on Mt. San Antonia. Pages 150-157 in E. Decker, ed. Trans. First N.A. Wild Sheep Conf., Colo. State Univ. April 14-15, 1971. Fort Collins, Co.
* U of C

This report documents the impact of recreation on bighorn sheep in summer range habitat. Disturbances resulted in range abandonment. Heavy recreational activity (500 visitor days/year) excluded bighorn use on the associated summer range.

In observations of humans on foot approaching sheep, ewes with lambs exhibited the greatest degree of response..

Keywords: Recreation / Range abandonment

Linderman, S. 1972. A report on the sheep study at the Dietrich River headwaters. Appendix 2 in L. Nichols and W. Heimer, eds. Sheep report, Vol. 13, Alaska Department of Fish and Game, Juneau app.
* ADFG - Juneau

The report documents impacts associated with aircraft activity in Dall's sheep ranges. Although no altitude is stated, the author notes that 2 fixed wing and 2 helicopter flights per day conclusively resulted in sheep behavioural responses. These responses ranged from panic running to standing about. The author provides general mitigation for timing of construction activities, aircraft ceiling restrictions and a no-hunting corridor on the specific area.

Keywords: Aircraft

! MacArthur, R.A., R.M. Johnston and V. Geist. 1979. Factors influencing heart rate in free-ranging bighorn sheep: a physiological approach to the study of the wildlife harassment. Can. J. Zool. 57: 2010-2021.
* U of C

The report documents the effects of various disturbances on heart rates of bighorn sheep in a wildlife sanctuary in southern Alberta. These sheep have been habituated to disturbances from roads and recreationists.

A helicopter at 150-200 m agl elicited a dramatic response, but virtually no response at 500-1500 m agl. Domestic dogs not leashed caused major increases in heart rates when within 100 m and vehicles passing within 200 m elicited heart rate responses.

The authors suggest that periodic disturbances are not that detrimental but persistent disturbances can cause significant increases in energy costs.

Keywords: Aircraft / Harassment / Linear Facilities (roads) / Recreation

MacArthur, R.A., V. Geist and R.M. Johnston. 1982. Cardiac and behavioural responses of mountain sheep to human disturbances. J. Wildl. Manag. 46(2):351-358. .
* RRL

In a continuation from their previous report (MacArthur et al. 1979), the authors expand on heart rate reactions of bighorn sheep to various disturbances. Their conclusions indicate that in the sanctuary 1) vehicle traffic within 25 m caused no behavioural reactions: 2) aircraft above 400 m elicited no response; and 3) domestic dogs caused significant responses. Humans on foot also elicited some responses especially if they approached from a ridge or were accompanied by a dog.

Recommendations for areas similar to the Sheep River sanctuary include: a) restrict human activity (eg: hiking, photography) to specified trails and roads; and b) discourage the presence of dogs on sheep range.

Keywords: Harassment / Aircraft / Linear facilities (roads) / Recreation / Mitigation (recreation)

Mace, R.A. 1974. Application of vehicle restriction in wildlife management. Proc. Annu. Conf. West. Assoc. State Game Fish Comm. 54:205-210.

(On Order)

! Malcom, J. 1983. Mitigating the impacts of mineral exploration and development on wildlife. Proc. Annual Meeting Montana Chapt. Wild. Soc.

(on order)

! McCollough, S.A., A.Y. Cooperrider and J.A. Bailey. 1980. Impact of cattle grazing on bighorn sheep habitat at Trickle Mountain, Colorado, Pages 42-59 in W.O. Hickey, ed. Proc. Bien. Symp. Northn. Wild Sheep Goat Counc. April 23-24, Salmon, ID
* RRL - Sheep

This well designed research report conducted in Colorado discusses the effects of summer cattle grazing on winter-spring bighorn sheep ranges. Bighorn sheep forage 90% of the time within approximately 240 m of escape terrain. In addition, the average slope in which sheep were observed was 20°. Cattle, on the other hand, rarely used slopes of 5° or more, and they were heavily associated with water sources (50% of cattle were observed within 240 m of water). However, overlap was apparent in some areas, and cattle did consume forage needed by sheep during the winter and spring periods. At one monitored site, cattle consumed 35% of the forage needed by wintering sheep.

The author indicates that the cattle/sheep overlap may be dependent on the local topography and distribution characteristics of individual populations.

Keywords: Agriculture (competition)

McCourt, K.H., J.D. Fiest, D. Doll and J.J. Russell. 1972.

Disturbance studies of caribou and other mammals in the Yukon and Alaska. Environmental Studies. Arctic Gas Biol. Rep. Ser. No. 5. 258 pp.

* RRL - Hab:partial

This report presents a brief analysis of the effects of simulated compressor noises on a small group of ewes and lambs near Mt. Goodenough in the Northern Richardson Mountains. In addition, helicopter disturbances are discussed.

Although the methodology may be questionable (Note Geist, 1975) some interesting information was provided. In this study, there were normally 9 sheep present prior to any disturbances. When a helicopter arrived at the base of the mountain all but one left the area. All but three left the area after the sound simulator was turned on. The most significant affect of the sound simulator was that the majority of sheep within 1 mile abandoned their range. Helicopter disturbances were even more severe.

The author recommends that sound alteration measures be applied to any compressor stations located within 2 miles of Dall sheep range.

Keywords: Aircraft / Mineral-petroleum (noise) / Range Abandonment

McCrorry, W.P. 1975. Study of ungulates along the proposed gas pipeline in British Columbia. Chapter 5, pages 1-49 in R.D. Jakimchuk, ed. Arctic Gas Biol. Rept. Ser. Vol. 32. Studies of large mammals along the proposed MacKenzie Valley gas pipeline route from Alaska to British Columbia. Prepared by Renewable Resources Consulting Services, Ltd. for Canadian Arctic Gas Study Ltd. and Alaskan Arctic Gas Study Co.
* U of C

The research presented in this report primarily documents the use of natural gas pipeline right-of-way (ROW) by bighorn sheep in southeast British Columbia. The graded and revegetated ROW was attractive to nearby bighorn sheep. High quality legumes on the ROW were used extensively by sheep, primarily in late November. Also the ROW exposed clay banks which were used by sheep as mineral licks.

Keywords: Linear facilities (pipelines)

Murie, Adolph. 1944. The wolves of Mount McKinley. Fauna of the National Parks of the United States. Fauna Series No. 5. U.S. Gov't Printing Office. 238 pp.
RRL - wolves

The highways in Mt. McKinley National Park, Alaska provided an advantage to wolves hunting Dall's sheep in 3 ways: 1) wolves could travel very easily from place to place; 2) the roads provided access directly into cliffs frequented by sheep; and 3) blind corners on the road allowed the wolves to surprise sheep quite easily, especially if the sheep were bedded down on the road. The author also documents sheep kills along the roads resulting from wolf predation.

Keywords: Linear facilities (roads)

! Neil, P.H., R.W. Hoffman, and R.B. Gill. 1975. Effects of harassment on wild animals - an annotated bibliography of selected references. Colo. Div. Wildl., Spec. Rep. No. 32. 21pp.

(on order)

Olson, J.E. and G.C. Horak. 1979. Successful and potentially successful measures to protect and improve fish and wildlife habitats. Pages 429-433 in The Mitigation Symposium. Rocky Mountain Forest and Range Experiment Station. Gen. Tech. Rep. No. RM-65, Fort Collins, Colo. 684 pp.
* RRL - Hab

This paper discusses information available from a handbook on habitat improvement measures concerning water reservoirs and canals. Although the majority of the article discusses measures relating to fish, some of the information addresses barriers to movement for big game. Animal losses (big game) normally number one or more per mile of canal per year. The high water velocities and slick, steep walls of the canal make escape very difficult. Escape ramps are discussed and documented, and reference is made to fencing, wildlife crossings and drinking bays.

The more thorough handbook is called " Western reservoir and stream improvements handbook" by W.R. Nelson, G.C. Horak and J.C. Olson. 1978. FWS/OBS/-78/56.

Keywords: Dams-canals / Mitigation (dams-canals)

Packard, F.M. 1946. An ecological study of the bighorn sheep in Rocky Mountain National Park, Colorado. J. Mammal. 27:3-28.
* U of C

The author suggests that various human caused disturbances in the late 1800's and early 1900's are responsible for a severe reduction in regional bighorn sheep populations in the Rocky Mountain National Park area. Bighorn sheep winter ranges and some mineral licks have become inaccessible as a result of fencing, livestock grazing and roads. This appeared to be the greatest factor responsible for the population decline. Also, the transmission of scabies from domestic to bighorn sheep was considered as a factor in the reductions. Domestic sheep were responsible for vegetation damage and alteration, and they utilized the majority of available forage. The poor quality range conditions and lack of access to mineral licks reduced the viability of the population through starvation and increased susceptibility to parasites and diseases.

Keywords: Agriculture (competition, disease transmissions, fencing) / Linear facilities (roads) / Mineral licks

! Pendergast, B. and J. Bindernagel. 1977. The impacts of exploration for coal on mountain goats in northeastern British Columbia. Pages 64-68 in W. Samuel and W.G. MacGregor, eds. First International Mountain Goat Symposium, Montana. 243 pp.
* RRL - Sheep

Although not associated with sheep, this article provides a good indication of the effects of new access on big game. The report indicates that coal mining and related activities have been correlated to a decline in mountain goat populations. There is a clear relationship between access resulting from coal mining activities and goat numbers. Nowhere in the coal block is there a healthy goat population with nearby road access. This observation seems to be supported by the study of Phelps et al. (1976) in the East Kootenay's of B.C. which singled out increased access as the cause of drastic declines of mountain goats in that area.

(Phelps, D.G., B. Jamieson and R.A. Demarchi. 1975. Mountain goat management in the Kootenays. I. The history of goat management. Fish and Wildlife Branch, Cranbrook, B.C.)

Keywords: Linear facilities (roads)

Penny, J.R. 1971. Off-road vehicles on the public lands in California. Pages 95-110 in M. Chubb, ed. Proceedings of the 1971 Snowmobile and off the road vehicle research symposium. June 14-15, 1971. East Lansing, Mich. Dep. Park Recr. Res. Tech. Rep. No. 8.

(on order)

Pitzman, M.S. 1970. Birth behavior and lamb survival in mountain sheep in Alaska. M.Sc. Thesis, Univ. of Alaska, Fairbanks, 116 pp.
* U of Alaska - Fairbanks

This article indicates that fixed wing aircraft (Supercub) flying at low elevations (no distance stated) caused Dall's sheep to panic run. The sheep were all ewes and lambs. The flights also appeared to be directly responsible for the death of one ewe which died from a fall. Flights had been conducted in the area shortly before.

Keywords: Aircraft

Post, G. 1971. The pneumonia complex in bighorn sheep. Pages 98-106 in E. Desker, ed. Transactions of the first North American Wild Sheep Conference. Colo. State Univ. April 14-15, Fort Collins, 187 pp.
* U of C

This report generally discusses the effects that livestock competition, vegetation damage and disease transmission had on historical bighorn sheep populations. The severe die-off of sheep during the 1900's was probably a result of all these impacts but the author suggests the direct cause could be attributed to bacterial pneumonia. The bacteria was believed to be transmitted from domestic sheep.

Keywords: Agriculture (competition, disease transmission, vegetation damage)

! Preston, D.J. 1983. The impacts of agriculture on wildlife.
Alaska Dep. Fish Game, Fed. Aid in Wild. Rest. Final Rep.
(Research). W-22-2 and W-22-1, Job 18.6R Juneau. 143 pp.
* U of Alaska - Fairbanks

This publication provides a very good review of existing literature regarding agricultural impacts on wildlife. Three lethal diseases have been transmitted from domestic to wild sheep. These include parainfluenza-3 virus (causes pneumonia), blue tongue virus and scabies mites. In addition, livestock in general can severely compete with sheep for the available forage.

The author recommends that no livestock grazing occur within or near sheep range.

Keywords: Agriculture (competition, disease transmission) /
Mitigation (agriculture)

! Price, R. and P.C. Lent. 1972. Effect of human disturbance on Dall sheep (final report). Alaska Coop. Wildl. Res. Unit, Univ. of Alaska, Fairbanks. Quarterly Rep. 23(3):23-28.
* U of Alaska - Fairbanks

The authors studied a Dall's sheep population in the Brooks Range of Alaska during the summer of 1970 and 1971. Aircraft disturbance resulting from the Trans-Alaska pipeline pre-construction activities conclusively caused harassment of Dall's sheep. Both helicopter and fixed wing (twin engine) aircraft activity caused sheep to run, although helicopters created significantly greater disturbances. These disturbances were quite variable, however. Helicopters flying 200' agl caused some movement in sheep (running less than 30'), although sheep abandoned a mineral lick when a helicopter at 500' agl approached. Sheep were greatly disturbed (running for 1/2 - 2/3 miles) when helicopters flew below 200' agl. The author suggests that sheep at mineral licks and lambing areas are particularly susceptible to aircraft disturbances. Specific mitigation measures for the area are made, including flight restrictions and operational windows.

Keywords: Aircraft / Mineral licks / Mitigation (aircraft)

! **Public Works Canada. 1981.** Principles and details of animal fencing and crossing structures proposed for Trans-Canada highway twinning, Banff National Park. Prepared as part of the Environmental Assessment Review Process on twinning of the first 13 kilometers of the Trans-Canada Highway in Banff National Park. Western Region, Public Works Canada. 20 pp.

(on order)

Reynolds, P.C. 1974. The effects of simulated compressor station sounds on Dall sheep using mineral licks in the Brooks Range, Alaska. Chapter 2 in R.D. Jakimchuck, ed. The reaction of some mammals to aircraft and compressor station noise disturbance. Arctic Gas Biol. Rep. Ser., Vol. 23. August. 82 pp.
* U of C

The research for this report was conducted near the Canning River of the Brooks Range during the summer of 1972. The author indicates that simulated compressor station noises caused no significant change in mineral lick used by Dall's sheep. The two mineral licks under observation were located 1 1/4 and 3/4 miles away from the simulator. These findings conflict with those of McCourt et al. (1974). The author suggests that the differences may be, in part, due to some habituation to aircraft disturbances (Note: The weather for the control period which determined lick use was significantly different than the noise simulator period).

The research also considered aircraft disturbances. Sheep were significantly disturbed (eg: running) by helicopters flying under 450'.

Keywords: Aircraft / Mineral-petroleum (noise) / Mineral licks

! Sanderson, Kim. 1983. Wildlife roadkills and potential mitigation in Alberta. ECA83-ST/1 Edmonton. Environment Council of Alberta. 10 pp.
* RRL - Hab

The report, which deals with large mammals common to Alberta, discusses factors affecting the number of road kills and mitigation measures to reduce these kills. In Alberta, 81% of vehicle collisions with wildlife take place during periods of dawn, dusk or dark usually between the hours of 0600 to 0800 and 1800 to 2400. (Note: These times may not be applicable in the Yukon). Approximately 41% of the collisions recorded in Alberta during 1980 occurred in October, November and December. This period coincided with the greatest amount of movement and was associated with migratory and rutting behaviour as well as hunting. Spring also contained a relatively high proportion of collisions which may partially be explained by animals feeding on the right-of-way.

Various highway conditions and locations are also crucial in the degree of vehicle/animal accidents. Mitigation measures which include physical barriers such as fences are discussed in detail. In addition, psychological barriers (eg: reflectors), habitat manipulation and improved drivers awareness are discussed.

Keywords: Linear facilities (roads)

Singer, F.J. and K. Mullen. 1981. Summer distribution and numbers of Dall sheep and mountain goats in Wrangell - St. Elias National Park and Preserve. Prog. Rep. USDI:NPS, Anchorage. 15 pp.
* ADFG - Juneau

In this report the author documents Dall's sheep disturbance resulting from helicopter activity. Dall's sheep became extremely excited (running) when helicopters approaching within 270' to 390'. However, not all sheep (and goats) ran. Those sheep located on escape terrain generally remained stationary while sheep distant from escape terrain generally ran. Also, ewes appeared much more sensitive to disturbances than rams.

Keywords: Aircraft

! Sopuck, L.G., C. Eric Tull, J.E. Green and R.E. Salter. 1979.
Impacts of development on wildlife: a review from the
perspective of the Cold Lake project. LGL Limited for Esso
Resources Canada Ltd. Calgary. 383 pp.
*RRL - Hab (Hoefs)

Although this review of various literature contains virtually no specific data on sheep, it does discuss the effects of numerous types of disturbances on ungulates. Disturbance activities discussed include those associated with transportation corridors, logging, mining, seismic trials, noise, aircraft, recreation, harassment (from hunting) and other types of human activity. The authors summarize the findings of various studies and reports of these impacts and present them in a concise format.

Keywords: Aircraft / Mineral-petroleum (Noise) / Harassment /
Linear facilities / Recreation / Timber Harvesting

Stemp, Raymond. 1982. Heart rate responses of bighorn sheep to some environmental factors. Pages 314-319 in North. Wild Sheep Goat Counc. Proc. Third Bien. Symp., Fort Collins, Colo. 409 pp.
* RRL

(Note: only an abstract and questions/answers are presented.)

An experimental increase in heart rate was directly associated with an increase in distance from escape terrain. For example, a change in location from cliffs into shrubs 300 m away resulted in 11.8% increase in heart rate.

There appeared to be very minimal predation. The author suggests that elevated levels of predation would likely contribute to greater changes in heart rate.

Sheep were observed to remain within 300 m of escape terrain even though good forage existed at distances greater than this. Also, sheep which visibly appear to be undisturbed may have very high heart rates. Therefore, the energy costs are very significant.

Helicopters passing overhead (one at 1400' agl) resulted in increased heart rates.

Keywords: Harassment / Aircraft

Stevens, D.R. 1982. Bighorn sheep management in Rocky Mountain National Park. Proc. North. Wild Sheep Goat Council. 3:244-253.
* RRL - Sheep

Human activity along a road resulted in the avoidance of a mineral lick. Most sheep would not cross the highway and those that did manage to reach it, left shortly thereafter when people left their vehicles. Another nearby lick was abandoned as a result of harassment from photographers and hikers. The park agency eventually provided some specific area mitigation measures which included the closure of trails near the second mineral lick and the deployment of a park officer to enforce sheep "proximity" prohibitions.

Keywords: Mineral licks

Stewart, Donna L. 1980. Critical areas for Dall's sheep (Ovis dalli dalli) in the Ogilvie Mountains: with recommendations for Dempster corridor management. A report in partial fulfillment for M.Sc., U. of Calgary, Alberta. 53+ pp.
*RRL - Hab

Dall's sheep are most susceptible to disturbance from May 5 to June 20 during the lambing period. Lambing areas are located between km 85 and 94 on the east side of the highways. The author provides the following recommendations:

- no spot developments on the east side of the highway between km 85 and 94 (Dempster Highway)
- restrict construction activities in the North Fork pass during May and June
- air traffic should avoid the area
- continue the present ban on firearms in the Dempster Highway corridor
- ongoing studies are necessary to determine movement patterns of these sheep

Keywords: Linear facilities (roads)

Stuart, R.W. 1974. Surface mining and wildlife. North Dakota
Outdoors 37(5):27.
* U of C

This report briefly discusses the exploration and development of surface mines and the impacts of these activities on wildlife. The primary impact appears to be the development of new access into previously inaccessible areas. Legal and illegal hunting pressures increase dramatically and have resulted in population declines.

Keywords: Mineral-petroleum / Linear facilities (roads)

! Stubbs, B. and B.J. Markham. 1979. Wildlife mitigative measures for oil and gas activity in Alberta. Pages 264-269 in The Mitigation Symposium. Rocky Mtn. For. Range Exp. Stn. Fort Collins, Colo. Gen. Tech. Rep. RM-65.
* RRL - Hab

Although not specific to any particular wildlife species, the paper discusses various approaches to minimize impacts on key wildlife habitat resulting from oil and gas activities in Alberta. Specifically, the activities associated with seismic work, roads, exploratory drilling and field development are discussed.

The author presents concise mitigation measures for the above activities and discusses the process of how these are implemented.

Keywords: Mineral-petroleum / Linear facilities (roads, pipelines) / Mitigation (linear facilities, mineral-petroleum)

Summerfield, B.L. 1974. Population dynamics and seasonal movement patterns of Dall sheep in the Atigun Canyon area, Brooks Range, Alaska. M.Sc. Thesis, Univ. of Alaska, Fairbanks.
* U of Alaska - Fairbanks

Through observations and experience, the author suggests that Dall's sheep can adapt to aircraft activity as long as it is regular and not too low (no distance stated). In addition he notes that in Alaska, hunting prohibitions or restrictions must be imposed along new roads in almost every case.

Keywords: Aircraft / Linear facilities (roads)

Thomas, Jack W. (editor). 1979. Wildlife habitats in managed forests: the blue mountains of Oregon and Washington. Agric. Handbook No. 553. USDA 512 pp.
* RRL - Hab (Lindsey)

The handbook discusses the manipulation and changes of wildlife habitat in managed forests. Although very little discussion is presented on sheep, the report does provide detailed information on other ungulates (deer and elk, primarily). Silvicultural options are presented that optimize wildlife habitat while accomplishing timber harvesting objectives.

The booklet mentions that the presence of roads adversely effects the use of deer and elk habitat. Roads were classified into 3 categories: 1) main road; 2) secondary roads; and 3) primitive roads. Figures are presented which provides an estimated loss of the effectiveness of habitat for varying degrees or road distances (ie. ___ kilometers of open travelled road per km² of habitat results in ___% loss of habitat).

The report also summarizes ways to minimize adverse impacts of timber management on deer and elk habitat (which may be applicable to some sheep habitat). Some of these recommendations are as follows:

1. Concentrate management activities in the shortest time period possible and within the smallest area.

2. Maintain non-activity areas near zones of concentrated disturbances.
3. Confine timber operations to a single drainage at a time.
4. Slash can be piled and left in windrows if it provides a break in long sight distances.
5. Heavy slash (2' in depth) significantly reduces the use of both clear cuts and timber stands.
6. Fire breaks should be constructed in a manner so as to keep sight distances under 0.4 km.

Roads

- a. Avoid the placement of roads in riparian zones.
- b. Screen forage areas (eg: meadows, clearcuts) from the road to ensure usability.
- c. Cuts and fills near roads should not block travel routes for deer and elk.
- d. Where roads cut across travel routes, the right-of-way should be as narrow as possible.
- e. Roads should be designed to facilitate road closures.
- f. Avoid locating straight stretches longer than 0.4 km.
- g. Maintain roadside vegetation as hiding cover, not foraging areas.
- h. Close as many roads as possible.

Keywords: Linear facilities (roads) / Timber harvesting / Mitigation (linear facilities, timber harvesting)

Thorne, T., G. Butler, T. Varcalli, K. Becker and S. Hayden-Wing.
1979. The status, mortality and response to management of the
bighorn sheep of Whiskey Mountain. Wyo. Game Fish Dept. Game
Fish Res. Wildl. Tech. Rep. No. 7 213 pp.
* U of Alaska - Fairbanks

This report discusses the effects of mountain recreationists on
bighorn sheep. The degree of harassment varied and depended on
environmental condition, type of activity, sex, age, and
juxtaposition of the sheep. The greatest impact is likely stress,
which can cause other related complications.

Keywords: Harassment / Recreation

! Trefethen, J.B. (ed). 1974. The wild sheep in modern North America. Procedural workshop on the management biology of North American wild sheep. U. of Montana, Missoula. July 18-20, 1974. Boone and Crocket Club. The Winchester Press, N.Y.

(on order)

Tracey, D.M. 1977. Reactions of wildlife to human activity along Mount McKinley National Park Road. M.Sc. Thesis, Univ. of Alaska, Fairbanks. 260+ pp.
* U of Alaska - Fairbanks

This report documents of human activity along a road and its effects on park wildlife. The author suggests that use of the sheep range prior to the road was much greater and the road may have resulted in displacement and/or under-utilization. However, those sheep that are present have habituated fairly well to human activity. Sheep did show strong responses to humans within 200 m. Also, movement of sheep between winter and summer ranges (and across the road) may be inhibited by vehicles and human activities.

Keywords: Harassment / Linear facilities (roads)

USDI. 1976. Alaska natural gas transportation system - final environmental impact statement. Washington, D.C.
* U of C: U of Alaska - Fairbanks

The report summarizes anticipated environmental impacts resulting from a natural gas pipeline in Alaska. The authors indicate that Dall's sheep are affected by gas compressor noise and they may abandon or reduce their use of the area (no distance specified). Aircraft disturbances could result in temporary range abandonment, panic running and under-utilization of habitat along flight zones. In addition, blasting (noise) conducted approximately 3.5 miles away would interrupt normal sheep activity.

Keywords: Mineral-petroleum (noise) / Aircraft

Van Tighem, KJ. 1981. Mortality of bighorn sheep (Ovis canadensis)
on a railroad and highway in Jasper National Park, Canada.
Can. Wildl. Serv., Edmonton, Alberta.

(on order)

Weaver, R. A. and J. Hall. 1971. Big game investigations: bighorn sheep in Joshua Tree National Monument and adjacent areas. Calif. Dept. Fish Game. Project W-051-R-16/SP 56 pp.
* ADFG - Juneau

This report documents the effects that human activity, particularly camping and off-highway vehicles have had on bighorn sheep in a specific area. Water sources (similar to Dall's sheep mineral licks) are becoming inaccessible as a result of the above mentioned activities. Sheep avoid areas where significant human activities occur. Unfortunately, recreationists enjoy the benefits of water sources as well. The avoidance of these water holes by sheep has ultimately reduced the population levels.

Keywords: Recreation / Mineral licks / Range abandonment

Woods, G.P. and R.M. Bradley. 1979. Mitigation of impacts affecting white-tailed deer at the seven mile project, British Columbia. Pages 639-641 in The Mitigation Symposium: Rocky Mtn. For. Range Exp. Stn. Gen. Tech. Rep. RM-65. Fort Collins, Colo.
* RRL - Hab

Although this article discusses impacts on white-tailed deer, the basic strategy can be extended to sheep. As a result of the construction of a dam in southeast B.C., the Fish and Wildlife Branch was awarded 1.8 million dollars as compensation for the loss of deer habitat. A permanent, interest-bearing fund was established that enabled land purchases as well as the implementation of mitigation measures identified in the early planning stages. The arrangement allowed the Fish and Wildlife Branch to own and manage land on a long term basis, to put into effect an intensive habitat management plan, to operate the plan, to conduct required research, and to monitor the results of management efforts without affecting normal Branch budgeting.

The authors noted that compensation only allowed the opportunity to optimize productivity from the remaining land base. It did not replace lost habitat.

Keywords: Dams-canals / Mitigation (dams-canals)

Wishart, W.D., J. Jorgenson and M. Hilton. 1980. A minor die-off of bighorns from pneumonia in southern Alberta (1978). Pages 229-247 in W.O. Hickey, chairman. Proc. Bien. Symp. North. Wild Sheep Goat Counc., Salmon, ID. April 23-24, 1980.
* RRL - Sheep

This report analyzes the causative factors responsible for a high incidence of lungworm in bighorn sheep near Calgary, Alberta (1978-1980). A newly declared sheep sanctuary (1973) resulted in an increased concentration of sheep during normally low concentration periods (ie: late summer and early fall). This increased concentration was largely due to hunting and hiking activities outside the sanctuary.

Lungworm larvae can be easily transmitted through snails during the mild conditions associated with late summer and early fall. Excessively high numbers of larvae are transmitted, resulting in approximately a 10% mortality in sanctuary sheep by late October.

Keywords: Recreation / Harassment

Wishart, W. 1975. Report and recommendations of the Rocky Mountain bighorn workshop group. Pages 165-207 in J.B. Trefethen, ed. The wild sheep in modern North American. Boone and Crocket Club. The Winchester Press, New York, NY.

(On Order)

Management objectives and guidelines for Rocky Mountain bighorn are presented. Human disturbances, primarily from recreation activities, have resulted in activity changes and harassment of sheep populations. Recommendations to decrease the impacts include the prohibition of off-highway vehicles on or near bighorn sheep habitat and the prohibition of recreational use of key habitat (eg: mineral licks, lambing areas).

Keywords: OHV / Recreation

Wilson, L.O. 1975. Report and recommendations of the desert and mexican bighorn sheep workshop group. Pages 110-143 in J.B. Trefethen, ed. The wild sheep in modern North America. Boone and Crocket Club. The Winchester Press, New York, NY.

(on order)

6.0 APPENDIX A

Other Important Annotated Bibliographies

Boyle, Stephan A and Fred B. Swanson 1983. Nonconsumptive outdoor recreation: an annotated bibliography of human-wildlife interactions. United States Department of the Interior, Fish and Wildlife Service. Special Scientific Report - Wildlife No. 252. 97 pp.

Bromley, Marianne. 1985. Wildlife managements of petroleum exploration and development in wild land environments. General Technical Report INT-191. Ogden, UT: US Dept. Agric, Forest Service intermountain Research Station. 42 pp.

Poll, David M. and John G. Stelfox, eds. 1985. Annotated bibliography of Rocky Mountain bighorn sheep specific to the management of bighorn sheep in Kootenay National Park. Canadian Wildlife Service, Edmonton. 241+ pp.

Shank, C.C. 1979. Human-related behavioral disturbance to northern large mammals: a bibliography and review. Report prepared for Foothills Pipeline (South Yukon) Ltd, Calgary. 253 pp.

State of Alaska. 1986. Alaska habitat management guide. Impacts of canals and water use on wildlife and their habitat and on human use of fish and wildlife. Department of Fish and Game, Divison of Habitat, Juneau, Alaska. Tech. Rep. No. 86-2: 86-3, 10986.

NOTE: This document is very beneficial for determining impacts of most land use activities on northern big game species.