Mountain goats (*Oreamnos americanus*) in north-central British Columbia (BC) show significant seasonal use of low-elevation, forested habitats. Forest development has the potential to reduce or eliminate access to mineral licks, cause disturbance to goats on their winter range, and create access for hunters to previously un-hunted and vulnerable goat populations. Current legislation for the protection of mountain goat habitat targets identified habitat (i.e., known mineral licks and natal areas) only and, as such, does not address habitat supply, habitat connectivity, cumulative disturbance impacts, and population viability. With only local-level consideration of habitats used by mountain goats, current management strategies are likely to be ineffective at sustaining goat populations. Here, we present mountain goat habitat supply modeling as a tool to facilitate development and implementation of a broader, ecosystem-based approach to integrated resource planning and wildlife management. Management recommendations are based on the results of a series of consultative workshops with forest industry, government, and First Nations resource planners and managers. The strength of our approach is that it provides an explicit presentation of our understanding about goat ecology, management options and relative impacts, such that planning and management decisions balance ecological and socio-economic concerns, and can be made in a flexible, defensible, and systematic manner.
AUTHOR’S NOTE

This work is based on the results of a series of consultative workshops held with industry, government, and First Nations representatives having a vested interest in supporting sustainable management of mountain goats in north-central British Columbia. These workshops were designed to facilitate the development and application of mountain goat habitat supply modeling and policy development, as components of the Mackenzie Mountain Goat Project.

The Mackenzie Mountain Goat Project is a multi-phase, collaborative effort focused on the development and implementation of effective policy to support integration of goat habitat management in forest management in the Mackenzie Timber Supply Area, in north-central British Columbia. This project was initiated in 2001 by the Peace/Williston Fish and Wildlife Compensation Program and Slocan Forest Products Ltd - Mackenzie Operations (now Canadian Forest Products Ltd.).

Companion documents which describe the mountain goat habitat supply work in detail include:


This document is presented as a discussion paper. The recommendations made herein have no legal status, and are not necessarily official positions of all agencies and individuals who have contributed to this project. However, it is our hope that this work will serve to advance effective and informed mountain goat management in BC.
ACKNOWLEDGMENTS

This project was designed and implemented by:

Scott McNay  Wildlife Infometrics Inc. (Forest Biologist)
Pamela Hengeveld  Synergy Applied Ecology (Wildlife Ecologist)
Rick Ellis  R. Ellis and Associates Inc.

We thank the following individuals for participating in mountain goat habitat supply modeling workshops held in Prince George, BC since January 2003, and making key contributions to this effort:

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<thead>
<tr>
<th>Participant</th>
<th>Affiliation</th>
</tr>
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<tbody>
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<td>Mari Wood</td>
<td>Peace/Williston Fish &amp; Wildlife Compensation Program (Senior Wildlife Biologist)</td>
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<td>Peace/Williston Fish &amp; Wildlife Compensation Program (Wildlife Biologist)</td>
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<td>Canadian Forest Products Ltd. (Wildlife and Biodiversity Manager)</td>
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<td>Glen Watts</td>
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<td>Doug Wilson</td>
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<td>Karl Sturmanis</td>
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<td>Jeremy Greenfield</td>
<td>Kwadacha Natural Resources Agency</td>
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<tr>
<td>Zorica Boskovic</td>
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<td>Patrick Russell</td>
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<td>Emile Begin</td>
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<td>Steve Cole</td>
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<td>Lyle Badger</td>
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<td>Laurence Turney</td>
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</tr>
<tr>
<td>Jeremy Ayotte</td>
<td>University of Northern BC (MSc candidate)</td>
</tr>
</tbody>
</table>

Our modeling approach and documentation are based on principles and techniques developed by the CHASE model (McNay et al. 2003b).

Scott McNay, Dale Seip, Doug Ambedian, Maggie Marsland, Lyle Badger and Clint Cubberley are thanked for their comments on drafts of this document.

Funding was provided by the BC Forest Investment Account Forest Science Program, through Canadian Forest Products Ltd. (Mackenzie Operations).
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INTRODUCTION

Mountain goats (*Oreamnos americanus*) in north-central British Columbia (BC) show significant seasonal use of low-elevation, forested habitats (Clare 2001; Poole 1998; Turney *et al.* 2001a; Turney *et al.* 2001b). Successive generations of goats use forested areas to access valley-bottom mineral licks from early spring to late fall, and for forage and cover during winter. Apparent fidelity to specific sites (e.g., mineral licks and lick access trails) may render goats particularly sensitive to disturbance from industrial activities (Chadwick 1983; Cote 1996; Foster and Rahs 1983; Hebert and McTaggart-Cowan 1977; Joslin 1986; Pendergast and Bindernagel 1977; Penner 1988; Shackleton 1999; Singer and Doherty 1985).

Forest development has the potential to reduce or eliminate access to mineral licks, cause disturbance to goats on their winter range, and create access for hunters to previously un-hunted and vulnerable goat populations. With the continued demand for wood supply, forest development is expanding throughout the Mackenzie Timber Supply Area (TSA; Figure 1), into additional tributary watersheds and higher-elevation forests. In recent years, management concerns regarding mountain goats have been raised, as forest harvesting has begun to encroach on low elevation mountain goat mineral licks (Hatler 1988) and winter ranges. These are not isolated concerns. The forest industry is facing similar concerns managing goat habitat in central (McNay *et al.* 2003b; Turney *et al.* 2001a; Turney *et al.* 2001b), coastal (Wayne Wall, Interfor, Vancouver Island, pers. comm.), and south-eastern (Kim Poole, Aurora Wildlife Research, Nelson, pers. comm.) BC.

In BC, mountain goats are considered sensitive enough to warrant special management concern, and existing strategies provide mechanisms for conserving designated habitat features (Appendix A). Current legislation for the protection of mountain goat habitat targets identified ‘critical’ habitat (i.e., known mineral licks and natal areas). While these mechanisms are valuable, their usefulness is limited to areas where such habitats have been identified, their implementation is often hindered by lengthy bureaucratic processes, and they do not foster development of proactive and adaptive resource management plans. This legislation does not address habitat supply, habitat connectivity, cumulative disturbance impacts, and population viability. With only local-level consideration of habitats used by mountain goats, current management strategies are likely to be ineffective at sustaining goat populations.

Evaluating and addressing relationships among habitat components is expected to provide significant advances toward developing management strategies aimed at ensuring the sustainability of mountain goat populations, rather than focusing only on protection for isolated...
components of goat habitat. It is apparent from mineral lick use data (PWFWCP, unpublished data¹), radio-telemetry, and census data (Canadian Forest Products Ltd., unpublished data²), that connectivity among spatially-disparate habitat components (e.g., mineral licks and escape terrain) is an ecosystem characteristic desired by goats. We believe that this connectivity is critical to maintaining the integrity of individual goat populations.

Government and the forest industry recognize a need for developing mountain goat management strategies that consider the full range of habitat types used by mountain goats (Hengeveld et al. 2004). We propose moving from the current approach, to a more holistic and dynamic ecosystem-based approach, rather than element-based management strategies. Ecosystem-based approaches to resource planning and management necessitate integration of ecological, social, and economic considerations, and inevitably require trade-offs among competing resource values and management interests. Slocombe (1993) suggests that:

“Ecosystem-based management should be transdisciplinary, use a systems approach, and incorporate monitoring and evaluation to support participatory, cooperative, goal-oriented and institutionally integrated regional planning and management of environment and development.”

and further notes that:

"Ecosystem-based management requires not only the greater ecosystem concept, it also requires a new interdisciplinary framework to integrate research, planning, and management and to facilitate an appropriate process. With broad theoretical and rigorous empirical grounding, an ecosystem approach can provide a framework for organizing and integrating research, planning, and management for protected and other areas” (Francis 1988 in Slocombe 1993)

Recent developments in habitat supply modeling (HSM) are providing an innovative approach to meeting ecosystem-based planning and resource management goals. Application of HSM in this way is a relatively novel concept (Jones et al. 2002), but is emerging as a valuable habitat management tool (e.g., Marcot et al. 2001). Development and application of the Caribou Habitat Assessment and Supply Estimator (CHASE, McNay et al. 2003b) in northern BC has contributed to: 1) northern caribou recovery planning (McNay 2004a; McNay et al. 2003a), 2) designation of ungulate winter range under FRPA (McNay 2004b; Schmidt and McNay 2002), and 3) has potential to play a role in Timber Supply Reviews, and 4) is being promoted as a tool in forest certification. Useful lessons from building CHASE can advance analysis of habitat across the province and for many species generally.

Founded on the successes of CHASE, mountain goat habitat supply modeling (Goat HSM) was initiated for the Mackenzie TSA in January 2003, as a component of the Mackenzie Mountain Goat Project (Hengeveld 2002a, b, 2003, 2004; Hengeveld et al. 2003; Hengeveld et al. 2004; McNay and Hengeveld 2004). The ultimate goal was to develop Goat HSM as a tool that can be used by the forest industry at a local, regional, and provincial level to plan the provision of mountain goat habitat in the context of sustainable forest management. Here, we present Goat HSM as a tool to facilitate development and implementation of a broader, ecosystem-based approach to integrated resource planning and wildlife management.

¹ Peace/Williston Fish and Wildlife Compensation Program (PWFWCP), 1011 Fourth Avenue, 3rd Flr., Prince George, BC V2L 3H9
² Canadian Forest Products Ltd., PO Box 310, Mackenzie, BC V0J 2C0
Goat HSM was developed through a series of consultative, habitat supply modeling workshops with forest industry, government, and First Nations resource planners and managers (see Acknowledgements). This document presents mountain goat management recommendations and modeling applications developed during these workshops. Specifically, this document provides information to guide planning and implementation of proposed development activities for site-specific planning requirements, and proposes an approach for larger-scale planning and management applications. Our overall objective in providing these management recommendations is to clearly identify methods and options for minimizing or mitigating disturbance impacts to mountain goats, within the context of integrated resource management plans. The conservation objective is to maintain the current distribution and abundance of goats in the Mackenzie TSA. In this report, ‘management recommendation’ follows the definition presented in the Wildlife Habitat Features Summary of Management Guidelines, Northern Interior Forest Region (2004a): “Generally accepted non-mandatory guidance and management recommendations based on the best available data and expert opinion”. The models and management recommendations were designed to be compatible with applicable legislation, regulations, policies, and management plans (e.g., Harper and Eastman 2000; MWLAP 2004c), and meet provincial standards of performance.

This document is intended as a resource for industry planners, government resource managers, policy developers, regulatory agencies, auditors, public interest groups and ad hoc interagency committees charged with developing or reviewing land use management plans. Our hope is that this work will serve as a platform for discussion, and will provide measurable progress toward developing innovative policies and improved standards for establishing comprehensive management strategies that balance timber supply and mountain goat habitat needs.

METHODS

Mountain Goat Habitat Supply Modeling

Our approach to modeling is based on: 1) maintaining excellent collaboration amongst stakeholders; 2) using tools and processes that are readily available, non-proprietary, and adaptable; and 3) ensuring that the products are operationally relevant and can be readily implemented as planning / management tools to predict the ecological value of habitat types used by mountain goats in the Mackenzie TSA (for supporting documentation refer to Hengeveld et al. 2004).

Goat HSM was developed during a series of professionally-facilitated workshops attended by mountain goat ecologists, foresters, and resource managers. We used Netica® software to formulate a Bayesian Belief Network (BBN) (Norsys 1999) concerning the likely state or condition of mountain goat habitats given observed states or conditions of key ecological factors. Our aim was to develop a comprehensive set of models that describe the suite of mountain goat life requisites, and incorporates relevant influential factors that may impact habitat value.

The key ecological input factors, the influence diagrams, and the choice of conditional probabilities fundamental to each node in the models were all based on a consensus of opinion taken from a variety of professionals experienced in the ecology of mountain goats (see Acknowledgments).

Throughout these models, reference is often made to “habitat”. Habitat is defined herein to include three commonly stated requisites for survival of an individual: procurement of food, avoidance of predators, and the ability to undertake those activities without being displaced or excessively interrupted by human activity or management. Common resultants from each model are estimates of “habitat capability”, “habitat preference”, and “habitat value”.

Habitat capability refers to the landscape’s ability to provide the required physical conditions for optimal habitat. The influence of disturbance impacts on habitat capability is expressed as habitat preference (or effectiveness); preference is deemed to occur any time an animal is located in a habitat type more frequently than would be expected from random locations (Chesson 1983). Mortality factors that are in the realm of management action (e.g. predation risk) further influence goat use of the habitat; the resultant is expressed as an estimate of overall habitat value. Generally, the resultants from each model are determined by factors and relationships depending on a variety of primary ecological inputs or ecological correlates (Marcot et al. 2001) that can be measured or estimated in land-based inventories. Collectively, these models are testable hypotheses that represent the way we think the ecological system functions.

Aspects of Goat Ecology and Management Factors Considered

In developing a conceptual representation (i.e. a model) of an ecological and management system it is impossible to include all known factors and relationships. Goat HSM currently includes only the ecological relationships and influential management factors that the modeling team considered relevant (based on literature reviews and best professional judgment) to determining the ecological value of habitat types used by mountain goats in the Mackenzie TSA (Appendix B; Hengeveld et al. 2004). The management factors that were incorporated into the models were chosen because they were thought to have the most impact, are of key interest, have data available, and are currently within the realm of management action. In future model refinements additional detail can be included, and other factors and relationships incorporated, as needed.

Mountain Goat Habitat Needs

The habitat element models that have been developed address mineral licks, mineral lick access trails, summer escape terrain (including natal areas, alpine summer ranges, and staging areas en route to mineral licks), and winter escape terrain (Table 1, for supporting documentation refer to Hengeveld et al. 2004). In the Mackenzie TSA, summer use by mountain goats occurs between April 15 and November 15 annually.

Key elements of goat habitat are specific geographic features (escape terrain areas and mineral licks). Consequently, unlike other types of habitat for other species, there is little opportunity to manage or “rotate” the supply of habitat. Instead, the specific features must be managed spatially as static features that are continuously available.

---

### Table 1. Factors and criteria that define mountain goat habitat elements modeled for the Mackenzie Timber Supply Area. For supporting documentation refer to Hengeveld et al. (2004).

<table>
<thead>
<tr>
<th>Habitat Elements and Predictive Factors</th>
<th>Criteria for High Capability Habitats</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mineral Licks</strong></td>
<td>April 15 - November 15</td>
</tr>
<tr>
<td>Terrain instability (failed slopes)¹</td>
<td>Slope &gt;20 degrees</td>
</tr>
<tr>
<td></td>
<td>Poor drainage</td>
</tr>
<tr>
<td></td>
<td>Non-forested sites (excluding glaciers and water bodies)</td>
</tr>
<tr>
<td>Soil texture</td>
<td>Fine / fluvial soil types</td>
</tr>
<tr>
<td><strong>Lick Access Trails²</strong></td>
<td>April 15 - November 15</td>
</tr>
<tr>
<td>Proximity to licks and escape terrain (staging areas and alpine ranges)</td>
<td>Trail corridors follow patches of escape terrain separated by ≤500m</td>
</tr>
<tr>
<td>Forest cover (to low-elevation licks)</td>
<td>Stand age &lt;15 or &gt;80 years of age</td>
</tr>
<tr>
<td><strong>Summer Escape Terrain (incl. natal areas)</strong></td>
<td>April 15 - November 15</td>
</tr>
<tr>
<td>Slope</td>
<td>35-60 degrees</td>
</tr>
<tr>
<td>Forest cover</td>
<td>Non-forested sites (excluding glaciers and water bodies)</td>
</tr>
<tr>
<td>Roughness</td>
<td>Greater than 10% change in slope over 50m</td>
</tr>
<tr>
<td><strong>Winter Escape Terrain</strong></td>
<td>November 16 - April 14</td>
</tr>
<tr>
<td>Aspect</td>
<td>135-270 degrees</td>
</tr>
<tr>
<td>Slope</td>
<td>35-60 degrees</td>
</tr>
<tr>
<td>Forest cover</td>
<td>Non-forested sites (excluding glaciers and water bodies)</td>
</tr>
<tr>
<td>Roughness</td>
<td>Greater than 10% change in slope over 50m</td>
</tr>
</tbody>
</table>

¹ These criteria are used where terrain stability mapping data is not available
² For management purposes, the effective width of trails is considered to be 50m

### Influential Management Factors

Four management lever sub-models have been developed to describe the influential factors that are thought to have the largest potential impact on mountain goats and goat habitat values (for supporting documentation refer to Hengeveld et al. 2004)⁵. While many factors affect the survival of mountain goats, including forage availability, predation, disease, weather, and human impacts, the models include only those factors that are of current management concern and that can be managed or manipulated, specifically:

1. Ground disturbance
2. Aerial disturbance
3. Concentrated harvest of goats (referring to an expected increase in site-specific goat harvest by hunters, due to increased road access to the site)
4. Predation risk to goats

---

MANAGEMENT RECOMMENDATIONS

Ecosystem-based Resource Planning and Management

*Element-Level (Habitat-Specific) Management Recommendations*

Practices which can reduce disturbance to goats range from managing aircraft flight paths to managing habitat seral stages (e.g., cutblock rotations near licks; Table 2). Seasonal timing of activities which may cause disturbance can also be managed to minimize impacts to goats: summer activities (April 15 – November 15) will affect goats on mineral licks, trails, and summer escape terrain; winter activities (November 16 – April 14) will affect goats on winter escape terrain only. The disturbance factor considered most influential is related to road development and management (e.g., deactivation), especially as this relates to hunter access. These recommendations are provided as a guideline for site-specific planning, and are designed to be consistent with the BC Identified Wildlife Management Strategy (MWLAP 2004b, c) recommendations for designated habitats and features.

*Operational Planning (e.g., Forest Stewardship Plans)*

Management Recommendations

1. **Maintain critical habitat features** (i.e., mineral licks, lick access trails, escape terrain).
   - Identify and map mountain goat habitats.
   - For significant or sensitive mineral lick and trail sites that can not be adequately managed by local mitigation measures, consider Wildlife Habitat Area or Wildlife Habitat Feature designations.
   - Apply ungulate winter range guidelines where appropriate to manage winter escape terrain and adjacent habitats.

2. **Minimize hunter access** to sites where goats are concentrated (i.e., mineral licks).
   - Avoid construction (or ensure deactivation) of roads within 2000m of mineral licks, to prevent motorized vehicle access to the licks.

3. **Minimize aerial disturbance to goats.**
   - Maintain seasonal no-fly zones for helicopters and fixed-wing aircraft within 2000m of goat escape terrain.
   - Minimize flight frequency and duration in cases where flight proximity can not be maintained at distances greater than 2000m.

4. **Minimize ground-based disturbance to goats.**
   - Plan winter (November 16 – April 14) harvest for cut blocks within 1000m of mineral licks, trails, or summer escape terrain.
   - Plan the location of main roads to be more than 400m from goat habitats.
   - Avoid non-motorized travel (e.g., hiking, mountain biking) within 100m of goat habitats (including lick access trails).

5. **Minimize predation risk to goats.**
   - Reduce the effect of predation through forest management that minimizes the amount of early seral stage habitats around goat habitat features (early seral stages provide favourable conditions for bears and alternate prey species - e.g., moose and small mammals - which support wolves and cougars).
Table 2. Element-level management recommendations for minimizing or mitigating disturbance impacts to mountain goats in the Mackenzie Timber Supply Area. Habitat elements are mineral licks (ML), lick access trails (TRL), summer escape terrain (SE), and winter escape terrain (WE).

<table>
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<tr>
<th>Management Levers and Disturbance Factors</th>
<th>Disturbance Level</th>
<th>Relative Impact $^1$</th>
<th>Management Recommendations</th>
<th>Habitat Element</th>
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<td></td>
<td></td>
<td></td>
<td>ML  TRL  SE  WE</td>
</tr>
<tr>
<td>Flight proximity</td>
<td>Low</td>
<td>1</td>
<td>&gt;2000m distance</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>2</td>
<td>1000-2000m distance</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Mod-High</td>
<td>4</td>
<td>500-1000m distance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>8</td>
<td>&lt;500m distance</td>
<td></td>
</tr>
<tr>
<td>Flight duration</td>
<td>Low</td>
<td>4</td>
<td>&lt;1 minute overhead</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>8</td>
<td>≥1 minute overhead</td>
<td></td>
</tr>
<tr>
<td>Flight frequency</td>
<td>Low</td>
<td>1</td>
<td>&gt;30 days between flights</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>2</td>
<td>7-30 days between flights</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>4</td>
<td>2-7 days between flights</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Extreme</td>
<td>8</td>
<td>&lt;2 days between flights</td>
<td></td>
</tr>
<tr>
<td>Ground Disturbance</td>
<td></td>
<td></td>
<td></td>
<td>X  X  X  X  X</td>
</tr>
<tr>
<td>Noise from industrial machinery</td>
<td>Low</td>
<td>1</td>
<td>&gt;1000m distance</td>
<td></td>
</tr>
<tr>
<td>(timber harvest, oil and gas activity,</td>
<td>Moderate</td>
<td>2</td>
<td>400-1000m distance</td>
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</tr>
<tr>
<td>road construction)</td>
<td>High</td>
<td>4</td>
<td>&lt;400m distance</td>
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<tr>
<td>Road traffic frequency</td>
<td>Low</td>
<td>1</td>
<td>&lt;1 vehicle per hour</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>2</td>
<td>1-2 vehicles per hour</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>4</td>
<td>&gt;2 vehicles per hour</td>
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</tr>
<tr>
<td>Road noise proximity</td>
<td>Low</td>
<td>1</td>
<td>&gt;400m distance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>3</td>
<td>50-400m distance</td>
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</tr>
<tr>
<td></td>
<td>High</td>
<td>6</td>
<td>&lt;50m distance (road crosses or meets lick or trail)</td>
<td></td>
</tr>
<tr>
<td>Frequency of human presence</td>
<td>Low</td>
<td>1</td>
<td>&gt;2d between visits</td>
<td></td>
</tr>
<tr>
<td>(forestry crews, non-motorized</td>
<td>Moderate</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>recreationalists)</td>
<td>High</td>
<td>4</td>
<td>&lt;2d between visits</td>
<td></td>
</tr>
<tr>
<td>Proximity of human presence</td>
<td>Low</td>
<td>1</td>
<td>&gt;100m distance</td>
<td></td>
</tr>
<tr>
<td>(forestry crews, non-motorized</td>
<td>Moderate</td>
<td>3</td>
<td>50-100m distance</td>
<td></td>
</tr>
<tr>
<td>recreationalists)</td>
<td>High</td>
<td>6</td>
<td>&lt;50m (people cross or meet trail or lick)</td>
<td></td>
</tr>
<tr>
<td>Concentrated Goat Harvest</td>
<td></td>
<td></td>
<td></td>
<td>X   X  X</td>
</tr>
<tr>
<td>Hunter access to sites where goats are</td>
<td>Low</td>
<td>1</td>
<td>Vehicle access &gt;2000m away; no increase in goat harvest</td>
<td></td>
</tr>
<tr>
<td>concentrated</td>
<td>Moderate</td>
<td>5</td>
<td>Vehicle access 500-2000m away; goat harvest increases 0-3%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>10</td>
<td>Vehicle access &lt;500m away; goat harvest increases &gt;3%</td>
<td></td>
</tr>
<tr>
<td>Predation by Bears and Wolves</td>
<td></td>
<td></td>
<td></td>
<td>X   X  X</td>
</tr>
<tr>
<td>Proximity to predator-preferred habitat $^2$</td>
<td>Low</td>
<td>1</td>
<td>≤10% early seral, mesic habitat in 2km (7800ha) radial buffer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>5</td>
<td>10-30% early seral, mesic habitat in 2km (7800ha) radial buffer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>10</td>
<td>≥30% early seral, mesic habitat in 2km (7800ha) radial buffer</td>
<td></td>
</tr>
</tbody>
</table>

$^1$ Relative impact (assuming single occurrence per activity): '1' = nil effect, '10' = local extirpation of goats

$^2$ Predator-preferred habitat can be generalized as 'early seral, mesic habitats', or can be mapped using grizzly bear habitat models (e.g., McCann 2004) and wolf density models (e.g., McNay et al. 2003).
Applying Goat HSM to a Management Area to Inform Forest Stewardship Plan Development

Foresters and engineers are faced with numerous challenges at the operational (site-specific) planning level, such as:

- Locating roads and cut-blocks in a design that meets management objectives for wildlife;
- Managing costs of development and logging through equipment choice, seasonal timing, amount of road construction, and silvicultural treatment options;
- Providing the mills with the volume, species and size of timber they desire; and
- Proving due diligence and accountability in Forest Stewardship Plan (FSP) submissions.

Goat HSM facilitates pro-active and informed operational decision-making and government approvals relative to these challenges by providing a mechanism to:

1. **Predict goat habitat distribution and quality.** Rather than focusing on absolute predictions, Goat HSM was designed to predict zones of probability of habitat occurrence (e.g., likely trail corridors), as well as expected habitat values. This facilitates pro-active management by improving forest planner awareness of habitat potential prior to the commencement of development planning activities, and can also promote efficiencies in field inventory.

2. **Assess and visualize cumulative effects of various management activities on the value of goat habitats at the site-specific level.** This is useful in evaluating the cost of various management actions and also helps to identify trade-offs and mitigation options in proposed development plans. Evaluating the effects of isolated or simultaneous application of various management strategies is also useful for prioritizing and selecting management actions.

3. **Quantitatively evaluate temporally-cumulative impacts.** Goat HSM enables habitat supply to be forecasted spatially and temporally, thereby facilitating evaluations of cumulative effects and the sustainability of forest resources. Model results for various forest planning scenarios can be compared with a natural disturbance scenario to assess the impact of cumulative effects relative to natural variation in habitat supply over time.

4. **Conduct scenario evaluations to compare alternative development options of interest to managers and planners.** Goat HSM can be used to quantitatively evaluate the outcomes of alternate forest planning scenarios relative to a base case (e.g., current development plan or actual landscape conditions).

5. **Demonstrate that relevant habitat considerations and management factors were considered in development plans.** Goat HSM and the results obtained for various planning scenarios evaluated during FSP development provide transparent, defensible documentation for the rationale upon which FSP results and strategies are built.

Modeled mineral lick, trails, and escape terrain results can be graphically presented (Figure 2), enabling model users to visualize the predicted spatial distribution and quality of goat habitats in the planning area. Operationally, these results can help to identify priorities for wildlife assessments. If goat habitat is confirmed a priori, cutblock and access road configurations can consider key habitat features at the “proposed” stage of forest development (i.e. the presence of goat habitat would be made known to government during consideration of FSP approval). It would reduce situations of reactive management, where government and industry work to reach agreement on appropriate management under more onerous time pressures (harvest schedule), and typically after significant operational investments have already been made (layout activities, cutting permit approval, etc.). The use of Goat HSM to facilitate pro-active planning that
considers goat habitat values is expected to provide industry and government with cost and time-efficiencies in meeting regulatory (and certification) requirements.

When spatial data for a planning scenario (e.g., new and existing road and cutblock layouts; Figure 3) are input to the models, Goat HSM calculates the amount and spatial distribution of impact to modeled mineral licks, trails, and escape terrain. Multiple planning scenarios can be input to evaluate the effects of alternate development plans. In order to have the model behave as realistically as possible, the starting point for all scenarios might be the current landscape situation (e.g., roads and cut-blocks). The planned roads and cut-blocks are input, and model results determined for each year over the life of the forest development plan of interest. This ultimately helps to guide optimal road and cutblock placement, and to evaluate the location and season of use of roads and cutblocks with respect to their effects on the various components of goat habitat modeled. If measures of timber supply (e.g., volume per species) are incorporated into the model, then model outputs could also provide a basis for cost-benefit analysis among proposed planning scenarios. Model results from scenario evaluations can be used as supporting rationale for results and strategies proposed in FSP submissions; the model and resultant maps with tabular data summaries can be submitted as an evidentiary basis for demonstrating due diligence in the development of FSPs. The explicit and transparent nature of the models also facilitates objective reviews and approvals of FSPs by statutory decision-makers.

Figure 2. Modeled summer escape terrain (gradient of preferred in deep blue, to avoided in grey), modeled high capability mineral licks (red), and 4 known mountain goat trails (yellow) in the lower Ospika River valley of the Mackenzie Timber Supply Area (inset), north-central British Columbia.

![Figure 2](image_url)
Figure 3. Demonstration of a planning scenario layout for the lower Ospika River valley: modeled summer escape terrain (gradient of preferred in deep blue, to avoided in grey), modeled high capability mineral licks (red), 4 known mountain goat trails (yellow), roads (pink), existing cutblocks (purple), and machinery noise disturbance radii at new blocks harvested in the summer of the current year (orange). Model results will show reductions in goat habitat values based on proximity and intensity of disturbance factors.

Strategic and Landscape-Level Planning

Management Recommendations

1. Conduct conservation assessments (including risk analysis) for mountain goat populations in the Mackenzie TSA, to determine management priorities.
   - Determine priorities for goat conservation (e.g., in high biodiversity emphasis landscape units).
   - Determine population and habitat goals.

2. Develop and implement an access management plan for roads, to manage hunter access to sites where goats are concentrated (i.e., mineral licks).
   - Plan new roads to be more than 2000m from mineral licks.
   - Deactivate roads located within these distance boundaries as soon as possible.

3. Develop and implement an aircraft flight path management plan, to minimize disturbance impacts to goat populations.
   - Establish no-fly zones, where appropriate.

4. Develop and implement a ground-based disturbance management plan.
   - Schedule seasonal timing of industrial activities within 1000m of goat habitats to minimize disturbance during the season of habitat use.
   - Avoid non-motorized recreational activities within 100m of goat habitats.
   - Avoid motorized recreational activities within 400m of goat habitats.
5. **Minimize predation risk to goats.**
   - Recommend harvest schedules that minimize the amount of early seral stage habitats in close proximity to goat habitats.

**Goat HSM Applications**

As part of strategic and landscape-level planning, Goat HSM can be used to:

1. **Assess macro-level strategies to manage disturbance and access.** Goat HSM would also permit an evaluation of the overall risk/outlook for various groups or populations of goats, and the types of habitat that are limiting for each group or population.
2. **Evaluate habitat connectivity and identify limiting habitats.** Goat HSM can be used to help identify priorities relative to managing goat habitats, such that government can develop pro-active management plans for important habitat features (e.g., directing the establishment of WHAs, WHFs, GWMs, and UWRs in areas where these mechanisms may be deemed the most appropriate habitat management technique). Goat HSM can also help to focus research and monitoring plans.
3. **Prioritize IWMS and UWR designations.** Goat HSM can be used to help identify priorities relative to managing goat habitats, such that government can develop pro-active management plans for important habitat features (e.g., directing the establishment of WHAs, WHFs, GWMs, and UWRs in areas where these mechanisms may be deemed the most appropriate habitat management technique). Goat HSM can also help to focus research and monitoring plans.
4. **Provide a platform for regional integration of management efforts.** Goat HSM enables comparisons among alternate management plans, and can help identify priorities and efficiencies (e.g., implementing alternative goat hunting regulations and / or closures to compliment habitat management efforts).
5. **Develop management guidelines and policy.** In addition to the application of the model tools to the Mackenzie TSA, more generalized products such as guidebooks could be developed to transfer general landscape management guidelines derived locally from the Goat HSM results to a broader geographic area.
6. **Contribute to recovery planning.** Goat HSM could assist in goat recovery (if necessary), by identifying areas where establishment, or re-establishment, of goat populations are likely to be successful.

Strategic land use plans developed at the regional or sub-regional scale (e.g., objectives set for resource management zones) consider biodiversity conservation measures and socio-economic factors. Such considerations might be evaluated through trade-off analyses among competing resource values (e.g., habitat needs for multiple species, recreational interests, timber supply, etc.), and could be informed by habitat supply models for multiple species.

HSM expresses habitat relationships in measurable and testable parameters, incorporate spatial (i.e., proximity) relationships among life requisites, consider modifying influences on habitat values as a result of predation risk and displacement, and forecast the supply of habitat values under alternate disturbance scenarios. When combined with forecasts of predicted future conditions of the forest based on assumed levels of natural disturbance, habitat supply represents estimates of thresholds to enable risk assessments and base-case analyses. When combined with forecasts of predicted future conditions of the forest based on simulated management, estimates of habitat supply and timber supply can be interpreted together to enable decisions about trade-offs among resource values (Jones *et al.* 2002). These are the ultimate goals relative to implementation of Goat HSM as a forest stewardship planning tool.
**Effectiveness Monitoring (Criteria and Indicators) and Adaptive Management**

Model results for forest planning scenarios can be compared to natural disturbance scenarios to assess the impact of cumulative effects relative to natural variation in habitat supply over time. As such, use of Goat HSM as a planning tool is compatible with the development of monitoring criteria, indicators, and thresholds under Sustainable Forest Management Plans (Hengeveld 2003a). Ultimately, targets and/or limits regarding the amount of impact that is considered acceptable regarding each type of goat habitat will be developed. These targets will be based on the determination of what is a significant impact to the various types of goat habitat. Currently, the model assists in promoting this discussion and focusing efforts to acquire additional field information. Once developed, these targets or limits could be used to guide decisions regarding when change is required in an operational plan.

Adaptive management is defined to mean a systematic process for continually improving forestry policies and practices by learning from the outcomes of operational activities (Taylor and Nyberg 1999). Adaptive management may be thought of as a continuous cycle of policy development, implementation, monitoring, evaluation, and refinement (adaptation) in response to a management concern. Goat HSM can be a useful tool in each of these steps toward development of model-motivated adaptive management strategies that support a sustainable balance of goat habitat and timber supply. The habitat models themselves are inherently testable hypotheses relative to our understanding of mountain goat ecology, and provide a transparent framework for continuous improvement of goat habitat management policy. Despite the potential dangers of using complex, forest-level modeling to assess real-world policy options (Nelson 2003), BBN-based habitat supply modeling allows us to move forward cautiously within a framework of continuous improvement, that is consistent with the goals of adaptive management.

Sensitivity analyses can be conducted for key factors in the model to provide a framework for interim policy development and implementation. Evaluating the effectiveness of implemented policy is accomplished through routine, extensive, intensive, and/or validation monitoring programs. Model-motivated monitoring can be used to develop indicators of mountain goat sustainability over time (i.e., which factors are sensitive to disturbance; which factors are limiting to goats?). The proposed approach to determining important or critical changes in habitat is via development of a set of “red flags” – a set of criteria that would indicate significant events in the predicted future supply of habitat (e.g., a change in the amount of the preferred habitat value class for any habitat element).

Evaluating the result of policy implementation is important to determine if the outcomes match forecasts made at the outset of policy development and implementation. Measuring the results against the intended goal provides the basis for recommendations toward adapting future management decisions, and also provides data that can be used to test and refine relationships identified in Goat HSM.

Overall, Goat HSM provides the necessary functional links among inventory, policy, and management to provide a useful, flexible framework for the development of adaptive management strategies. The Goat HSM was constructed in a way that ensured both the model inputs and the model results could be measured and monitored. This helps to identify appropriate indicators that are measurable through monitoring protocols. Furthermore, Goat HSM is adaptable, and easy to update with new information about basic resources or relationships as knowledge is gained through resource inventory and adaptive management trials.
DISCUSSION AND CONCLUSIONS

With increasing emphasis on results-based management, utility of developing innovative tools that enable forecasts of habitat supply, evaluations of disturbance impacts and cumulative effects, and trade-off analyses among competing resource values is self-evident. In addition to facilitating defensible decision-making at the operational level, developing and applying such tools provides a baseline for developing management strategies that are flexible and innovative. Goat HSM provides a foundation for strategic planning, and a process for identifying and evaluating indicators of sustainable management and adaptive management plans as a basis for forest certification.

The strength of our Goat HSM approach is that our (limited) understanding of mountain goat ecology can be expressed in an explicit and transparent manner, such that everyone charged with making management decisions (no matter what scale) understands the system in the same way. This common understanding is useful for assessing management concerns in a way that is consistent across jurisdictional boundaries, and also, among resource managers. In addition, the framework that the model provides for informed decision-making ensures that decisions are made both systematically and defensibly, in a way that can be easily communicated to others. Goat HSM is a flexible tool that enables quantitative evaluation of impacts on habitat values, facilitates trade-offs analyses, and identifies mitigation measures.

As continued research provides more information about mountain goat ecology, and resource management needs evolve, the models (and therefore the management recommendations) can be further refined. The modeling tools, management strategies, and policy frameworks arising from this work are relevant and readily-adaptable to other species and geographic areas. In addition, despite being developed within a forestry context, this approach can be applied to the management of oil and gas industry activities, backcountry recreation concerns (e.g., wildlife viewing, hiking, snowmobile and all-terrain-vehicle tours, heli-tourism operations, hunting), and other interests.

A measure of both the need for more comprehensive management strategies, and of our success over the course of this project, is the level of commitment that stakeholders have shown to this process to date. Collaboration is a critical component of developing effective management plans, given the controversial nature of managing wildlife populations and the existence of polarized views on social and economic objectives concerning management of timber. In principle, consultation and awareness are paramount to successful implementation. Using a highly integrated approach from the onset is the best way to ensure that the results are relevant and well-supported. It also provides opportunity for on-going discussion and peer review. Continued development of Goat HSM and goat management recommendations through collaborative workshops with stakeholders and peers in the scientific and resource management community is recommended. These workshops could be convened biennially, perhaps as a provincial initiative or in conjunction with other relevant meetings and conferences (e.g., biennial Northern Wild Sheep and Goat conferences).
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APPENDIX A. Existing management strategies for mountain goats in the Mackenzie TSA

Common Name: Mountain goat
Scientific Name: Oreamnos americanus

Status:
- Global rank G5 (species is demonstrably widespread, abundant, and secure)
- Canada COSEWIC not listed
- BC Provincial Yellow List (species is not at risk of extinction)
- BC Provincial Identified Wildlife Species not listed (note: goats were included in IWMS Volume I but are not currently in IWMS Version 2004; because they are yellow-listed in BC they are not expected to be added to the IWMS Species At Risk list but may be added to the Regionally Important Wildlife list at a later date)
- BC Category of Ungulate Species requiring winter range protection Yes
- Mackenzie LRMP Regionally important species

IWMS Species Listings

The BC Identified Wildlife Management Strategy (IWMS) is a strategy for protecting species identified as requiring special management attention under the BC Forest and Range Practices Act (FRPA). IWMS Version 2004, which replaces the earlier IWMS Volume 1, provides species accounts as well as performance measures and procedures for managing identified wildlife. The strategy is focused on maintaining limiting habitats that may be impacted by forest and range practices on Crown land. To balance socio-economic and conservation interests, the allowable impact to short-term forest harvest levels is limited to 1%.

Species included in the IWMS Version 2004
- Two categories of species are defined by FRPA as Identified Wildlife: 1) species at risk (SAR); and 2) regionally important wildlife (RIW).
- May 2004, MWLAP established a category of SAR by order made under section 11(1) of the Government Actions Regulation of FRPA. This order designated SAR as:
  1) species that may be affected by forest or range management on Crown Land, or
  2) federally-listed species at risk designated by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).
- Additional non-COSEWIC listed species that are red- or blue-listed in BC will be added to the BC IWMS SAR list soon.
- Regionally Important Wildlife (i.e., species that are important to a region of BC and may be adversely impacted by forest or range practices) will be added to the IWMS list at a later date.

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Mechanisms available to protect Identified Wildlife (SAR)

- Identified Wildlife are managed by: establishing wildlife habitat areas (WHAs); general wildlife measures (GWMs) associated with WHAs; WHA objectives; wildlife habitat features (WHF); or through other management practices specified in strategic or landscape level plans.
- Mountain goats were included in IWMS Volume 1, therefore some WHA planning objectives and GWM management objectives have been identified. A few goat WHAs were proposed and approved in BC.

Mechanisms available to protect Regionally Important Wildlife

- Areas set aside for RIW species are called RIW WHAs.
- In RIW WHAs, Best Management Practices (BMPs) or Wildlife Habitat Features (WHFs) management are applicable. E.g., MWLAP has drafted management objectives and guidelines for mineral licks, as an identified Wildlife Habitat Feature.

UWR Management Strategy

The Ungulate Winter Range (UWR) strategy establishes UWRs for categories of ungulate species for which an ungulate winter range may be required for winter survival of the species.

Species included in the category ‘Ungulate Species’

- Category of ungulate species established for which an ungulate winter range may be required for winter survival of the species.
- An order (given under the authority of section 11(3) of the Government Actions Regulation) issued in May 2004 identifies the following as ungulate species for which an ungulate winter range may be required for the winter survival of the species: mule and black-tailed deer; white-tailed deer; elk; mountain goat; caribou; bighorn sheep; thinhorn sheep; and moose.

Mechanisms available to protect Ungulate Species

- Ungulate Winter Ranges (UWRs) are defined as areas that contain habitat necessary to meet the winter habitat requirements of an ungulate species.
- Formal legal establishment of UWRs and associated objectives began under the Forest Practices Code, and will continue under FRPA.
- UWR establishment and related objectives are guided by a Memorandum of Understanding between MWLAP, MSRM, and MoF (each agency has a distinct role in the process).
- One UWR for goats has already been approved in the Mackenzie Forest District (at Mt Brewster / Nabesche River) [plus others elsewhere in BC].

Managing For Wildlife Under FRPA

The BC Forest and Range Practices Act (FRPA), effective January 31st 2004, is a results-based forest, range, and woodlot management regime. Under FRPA, forest licensees are required to develop operational Forest Stewardship Plans (FSP) that identify results and strategies to address...
government objectives for designated sensitive species. Further, licensees must implement proposed strategies in accordance with practice requirements identified in the Forest Planning and Practices Regulation (FPPR; B.C. Reg. 14/04) under FRPA. The FPPR contains requirements (i.e., ‘default’ results and strategies) to ensure that minimum targets are met for higher-risk objectives or those objectives with complex management issues (e.g., soils).

Three types of objectives apply to licensees under FRPA:

1. **Land Use Objectives** are intended to guide preparation of results and strategies by enabling objectives developed under regional and sub-regional planning processes to be integrated with FRPA;
2. **Objectives in Regulation** are intended to guide the management and protection of FRPA values\(^\text{10}\); and
3. **Objectives Enabled by Regulation** are intended to guide effective forest management, for specific resource values, at the local level (E.g., IWMS).

FRPA objectives and practice requirements specifically identified for wildlife values in the Mackenzie TSA include:

1. **Land Use Objectives**
   a. Some species (e.g., with large home range sizes, low population densities, widely and sparsely distributed limiting habitats, or sensitivity to landscape-level disturbances; i.e., fisher, bull trout, grizzly bear), have landscape-level habitat requirements that are not adequately addressed by WHAs or coarse filter management provisions. Habitat management for such species is addressed through higher-level plans.
   b. No higher-level plans, sustainable resource management plans, or Cabinet-approved strategic land-use plans exist for the Mackenzie TSA

2. **Objectives in Regulation** require licensees to “without unduly reducing the timber supply”:
   a. Conserve sufficient wildlife habitat to sustain species at risk and regionally important species, and ensure winter survival of selected ungulate species (species designated by government).
   b. Retain wildlife trees at the stand level. (FRPA S. 149, FPPR S. 7, 9(2))

- **Section 7(1) of the FRPA Forest Planning and Practices Regulations (FPPR)** states that
  - The objective set by government for wildlife is, without unduly reducing the supply of timber from BC’s forest, to conserve sufficient wildlife habitat in terms of amount of area, distribution of areas and attributes of those areas, for
    a) The survival of species at risk,
    b) The survival of regionally important wildlife, and
    c) The winter survival of specified ungulate species.
- **Section 7(2) FPPR** states that
  - A person required to prepare a forest stewardship plan must specify a result of strategy in respect of the objective stated under subsection (1) only if the

\(^{10}\) The resource values identified by FRPA include: 1) Soils; 2) Timber including Forest Health; 3) Fish; 4) Wildlife; 5) Biodiversity; 6) Water; 7) Resource Features; 8) Recreation Resources; 9) Visual Quality; 10) Cultural Heritage Resources; and 11) Forage and Associated Plant Communities.
Minister of Water, Land and Air Protection, or a designated official, notifies the person of the applicable
a) Species referred to in subsection (1), and
b) Indicators of the amount, distribution and attributes of wildlife habitat described in subsection (1).

- Section 7(3) FPPR states that
  o If satisfied that the objective set out in subsection (1) is addressed, in whole or in part, by an objective in relation to a wildlife habitat area or an ungulate winter range, a general wildlife measure, or a wildlife habitat feature, the Minister of MWLAP, or a designated official, must exempt a person from the obligation to specify a result or strategy in relation to the objective set out in subsection (1) to the extent that the objective is already addressed.

Note: Through discussion between Rodger Stewart and Scott McNay (pers. comm., October 1st, 2004), it is understood that licensees are under no obligation to address any wildlife value unless:
- An Order is issued listing the SAR, RIW, and Ungulate species to be considered, and
- A legal Notice is issued, providing the amounts, distribution, and attributes of habitat to be protected/managed. The amounts have to be within the expected or allowable timber supply impact; it can only amount to x amount of impact as decided by government, or as might have been indicated in a HLP or some LU objective.
- The background material that comes out with the Notice (e.g., maps including linework, etc.) is not legal material. It is only information available for consideration in developing a strategy. The proponent still has to develop a strategy to meet the section 7 objective.

3. Objectives Enabled by Regulation require licensees to
   a. Adhere to IWMS designations and objectives established under statutory authority of the Minister of WLAP (GAR S 7, 8, 10, 11).
   b. Note that GWM, UWR, WHA designations and objectives established under the FPC will be grandparented into FRPA (FRPA S.180, 181, 182).

4. Practice Requirements require licensees to prepare a FSP that contains results and strategies to address the objective in regulation identified above, plus any land use objectives or objectives enabled by regulation that apply to the area under the FSP. The FPPR do not contain required (default) results or strategies, nor do they list any factors in regulation (FPPR) to consider in developing results and strategies, to meet wildlife objectives. In place of factors, information to be considered will be provided by the Minister of WLAP (e.g., lists of species that should be considered). Practice requirements in FPPR for wildlife include:
   a. compliance with each GWM that applies in the plan area;
   b. a restriction on damaging or rendering ineffective a resource feature or wildlife habitat feature; and
   c. any previously unidentified wildlife habitat features must be reported to the District Manager in the annual report only if it is in or contiguous to the operation and the order establishing the feature requires it to be reported.
   d. Note that a designated WLAP official can exempt a person from practice requirements to comply with general wildlife measures and to avoid damage to a wildlife habitat feature in certain circumstances. (FPPR S 69, 70, 92).
Other Relevant Management Strategies, Guidelines, and Plans

The Mackenzie Land and Resource Management Plan

The Mackenzie Land and Resource Management Plan (LRMP)\(^{11}\) identified the mountain goat as a regionally important species of special management interest. The LRMP further stated the need to identify and appropriately manage mountain goats and their habitats. However, it deferred all management to policies defined at a regional level. Currently, no regional management policies have been developed. The Mackenzie LRMP identified the following objectives for conserving wildlife and wildlife habitat:

- Maintain habitat needs of all naturally occurring wildlife species across the LRMP area;
- Maintain or enhance habitat for threatened and endangered (red-listed), vulnerable (blue-listed), and regionally important wildlife species, not to the detriment of the ecosystem as a whole;
- Manage wildlife populations at sustainable levels to meet both consumptive and non-consumptive uses, consistent with the management direction of each resource management zone (RMZ);

Specific recommendations for individual RMZs include:

- Identify and map distribution and habitats of threatened and endangered, vulnerable, and regionally important wildlife species;
- Identify and map high value habitat features (e.g., mineral licks); maintain these features consistent with the management direction of each RMZ;
- Identify travel and connectivity corridors and, over time, manage them within the context of landscape level planning consistent with RMZ management direction;
- Utilize known and provincially acceptable management strategies for the management of habitat for threatened and endangered, vulnerable, and regionally important wildlife species;
- Manage to maintain or enhance existing population levels;
- Monitor the abundance of species of wildlife at selected sites in the Plan Area over the long term;
- Adjust specific management practices to prevent the further decline of populations at risk and where possible, remove limiting factors for species or populations at risk and take advantage of any opportunities to increase populations; and
- Where desirable, encourage research to determine the habitat requirements of threatened and endangered, vulnerable, and regionally important wildlife species.

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APPENDIX B. Limiting factors for mountain goats in the Mackenzie TSA

The modeling team considered limiting factors for mountain goats in the Mackenzie TSA to include (excerpted from Hengeveld et al. 2004):

- Accidents – goats stay close to steep escape terrain; accidental fatal falls may occur;
- Avalanches – goats use on steep, snow-covered terrain and are known to die in avalanches;
- Disease – goats are susceptible to disease (as are all wild ungulates);
- Predation – goats are effective anti-predator strategists, but are not immune to predation; as an alternate prey species, changes in predator-prey relationships and abundance may impact goats (Geist 1971, Fox and Streveler 1986, Smith 1986, Festa-Bianchet et al. 1994);
- Starvation – goats have a generalist diet; they are not restricted by food requirements but predator avoidance takes precedence over forage availability; persistent heavy snowfall well into spring can prevent access to forage and result in starvation;
- Hunting – goats live in small populations; significant hunting has the potential to impact population viability, particularly if harvest is concentrated at mineral licks (Hebert and Turnbull 1977, Kuck 1977, Pendergast and Bindemagel 1977, Chadwick 1983, Phelps et al. 1983, Smith 1986); and
- Disturbance / Harassment – aircraft disturbance, industrial disturbance, and road/traffic disturbance can impact the whole goat population (direct impact, short-term); recreational activities may have long-term impacts (Foster and Rahs 1981, 1983; Horejsi 1976; Penner 1988; Bleich et al. 1994; Cote 1996; Frid 1999).

Disease transfer from domestic animals to mountain goats is not currently an issue of concern because there is no evidence to suggest that Pasteurella is transmitted between domestic sheep and mountain goats (B. Foreyt, University of Washington, pers. comm.), nor are domestic sheep grazing tenures common in the Mackenzie TSA.

Goats typically exist at low population densities. When combined with their effective anti-predator strategy of remaining within or near escape terrain, this reduces their importance to predators as a major prey source (Geist 1971, Fox and Streveler 1986). However, changes in abundance of alternate prey species and consequently predators, can significantly affect goat populations. Primary mountain goat predators in our study area include wolves, grizzly bears, wolverines, eagles, and to a lesser degree, black bears. Although wolves are generally thought to prey on goats opportunistically (Smith 1986, Festa-Bianchet et al. 1994), they can be a significant predator in areas of higher goat densities and/or few alternate large ungulates (Fox and Streveler 1986), and individual packs may even specialize on specific goat populations (Cote et al. 1997).

The presence of roads and cutblocks greatly influences the numbers and distribution of predators in an area. Bears use roads for travel and roadside feeding, and early seral cutblocks for summer foraging. Wolves use roads as year-round travel corridors, and they are attracted to the higher densities of ungulates (primarily moose) using early seral cutblocks for year-round forage. Bears may pose a higher risk to goats due to a greater chance of a random encounter at licks and along trails. Mineral lick access trails themselves might be more attractive to predators as travel corridors. Early seral habitats also favour a variety of prey species that support other potential goat predators, e.g., rabbits (lynx) and deer (cougars).
It is thought that predator avoidance (rather than forage availability) is a dominant factor in goat habitat use, and that goats may seldom venture more than 500m from escape terrain to obtain forage. Thus, proximity to escape terrain is considered to be important in all aspects of mountain goat habitat. The presence of steep, rough terrain is an important habitat feature common to natal areas, alpine summer range, alpine winter range, and forested habitats. Two models for escape terrain (summer and winter) can generally represent all four habitat types; each specific type can be distinguished as a sub-set of the general models by simple addition of 1 or 2 parameters unique to each (e.g., restricted to south aspects in winter).

Hunting affects mountain goat populations both directly through the removal of goats, and indirectly through reducing the population’s productivity (Smith 1986). Several factors render goat populations particularly sensitive to over-hunting (Eastman 1977, Hebert and Turnbull 1977, Adams and Bailey 1982, Swenson 1985, Smith 1986, Festa-Bianchet et al. 1994):

- Late sexual maturity of adults;
- Low kid production and survival;
- High female harvest due to the difficulties inexperienced hunters have in differentiating between the sexes; and
- Importance of social structure – survival of yearlings and kids may be reduced if dominant nanny in family group killed; also, breeding success of dominant nannies is often higher.

Hunting mortality is considered additive to other types of mortality, and is blamed for goat population declines in many areas (Hebert and Turnbull 1977, Kuck 1977, Pendergast and Bindernagel 1977, Chadwick 1983, Phelps et al. 1983, Smith 1986). When human access is facilitated, goat populations previously in balance with other mortality factors can be rapidly depleted (Foster 1977, Kuck 1977, MacGregor 1977, Hoefs et al. 1977, Pendergast and Bindernagel 1977, Adams and Bailey 1982, Chadwick 1973, Child and King 1991). The 1988 Regional Wildlife Plan for the Omineca sub-region (Child and King 1991) acknowledged that hunter access in the Williston watershed in the late 80’s was generally poor, and that most goat populations were still healthy and largely an “untapped resource”. A potentially large degree of change was anticipated as logging roads extended northwards and into side drainages, particularly an increase in resident harvest of goats. The management objective for goats was to sustain a conservative level of annual harvest of 4 - 6% (Child and King 1991).

Many mountain goat populations show high fidelity to low-elevation mineral licks (Fox and Smith 1988). These licks and their associated access trails are used seasonally (April through October; Hebert and McTaggart-Cowan 1971, McCrory et al. 1977, Hebert and Turnbull 1977, Clare 2001, Demarchi et al. 2000) by successive generations of goats (Fox and Smith 1988). The licks themselves are thought to provide minerals that satisfy important physiological requirements of mountain goats (Fox and Smith 1988), possibly to replenish sodium reserves that are flushed from the body due to the intake of potassium-rich green spring forage.

As such, low elevation licks and their access trails are considered to be important components of mountain goat habitat. Valley bottom mineral licks can be as far as 10 km from typical alpine summer habitat (though most are probably within 5 km), and well-used trails worn down to mineral soil have resulted from traditional use of the same routes by successive generations of goats (Fox and Smith 1988). Trails seldom lead directly from summer habitat to low elevation licks but appear to be influenced by topography (following creek draws and ridges) and the presence of small areas of escape terrain referred to as “staging areas” (small rock outcrops, bluffs, cliffs).
Goats are known to show strong fidelity to specific forested access trails. This fidelity to low-elevation licks and forested access can render goats sensitive to disturbance from and displacement by various industrial activities (Hebert and McTaggart-Cowan 1971, Chadwick 1973, Pendergast and Bindernagel 1977, Foster and Rahs 1983, Singer and Doherty 1985, Cote 1996, Shackleton 1999). Concerns have been raised regarding the potential impacts of forest harvesting activities on mountain goat populations using low elevation mineral licks in forested habitats.

Industrial development (e.g., forestry, oil and gas) has the potential to reduce or eliminate goat access to mineral licks, cause avoidance of licks by goats due to noise or traffic disturbance, create habitat conditions favourable for other prey species and consequently predators, and create access to licks for hunters. Removal of forested cover immediately adjacent to mineral licks is not thought to be of significant concern compared to the previously listed factors.

Key components of goat habitat are specific geographic features (escape terrain areas and mineral licks). Consequently, unlike other types of habitat for other species, there is little opportunity to “rotate” habitat or habitat use. Rather, the specific features must be managed and the impact of management activities assessed. This requires a modeling approach that can assess the impact of any specific management activity and also assess the cumulative impacts of activities occurring over time.