Marmot Basin Ski Area

Site Guide Guidelines for Development and Use

Strategic Environmental Assessment

February 2008

Marmot Basin Ski Area
Site Guidelines for Development and Use

Strategic Environmental Assessment

This strategic environmental assessment has been approved by:

Greg Fenton
Superintendent
Jasper National Park of Canada

February 2008

Table of Contents

1 INTRODUCTION 1

1.1 OVERVIEW 1
1.2 OBJECTIVES OF THIS REPORT 1
1.3 USE OF THIS REPORT 2

2 LEGAL AND POLICY FRAMEWORK 3

2.1 INTRODUCTION 3
2.2 CANADA NATIONAL PARKS ACT 3
2.3 GUIDING PRINCIPLES AND OPERATIONAL POLICIES 3
2.4 PARKS CANADA AGENCY CORPORATE PLAN 4
2.5 JASPER NATIONAL PARK MANAGEMENT PLAN 4
2.6 SKI AREA MANAGEMENT GUIDELINES 5
2.7 SPECIES AT RISK ACT 6
2.8 CABINET DIRECTIVE ON THE ASSESSMENT OF POLICIES, PLANS AND PROGRAM PROPOSALS 6

3 PUBLIC CONSULTATION 8

4 APPROACH 9

4.1 STRATEGIC APPROACH 9
4.2 GEOGRAPHIC AND TEMPORAL SCOPE 9
4.3 ALTERNATIVES 10
4.4 ECOLOGICAL INTEGRITY 11
4.5 CULTURAL RESOURCES 12
4.6 VISITOR EXPERIENCE 12
4.7 REGIONAL INFRASTRUCTURE CAPACITY 13
4.8 APPROACH TO CUMULATIVE EFFECTS ASSESSMENT 14

5 MARMOT BASIN SITE GUIDELINES 15

5.1 LIMITATIONS TO SCOPE OF THE SITE GUIDELINES 15
5.2 SUMMARY OF SITE GUIDELINES 16

6 DESCRIPTION OF ENVIRONMENT 20

6.1 REGIONAL ENVIRONMENT 20
6.2 LOCAL ENVIRONMENT 21
6.3 CLIMATE CHANGE 22

7 VALUED COMPONENTS FOR ENVIRONMENTAL ASSESSMENT 24

7.1 VALUED COMPONENTS OF ECOLOGICAL INTEGRITY 24
7.2 VALUED COMPONENTS OF VISITOR EXPERIENCE 24
7.3 VALUED COMPONENTS – REGIONAL INFRASTRUCTURE CAPACITY 25

8 IMPACT ASSESSMENT - ECOLOGICAL INTEGRITY 26

8.1 NATIVE VEGETATION DIVERSITY 26
8.2 RARE/SENSITIVE SPECIES AND COMMUNITIES 31

8.3 Small Mammal Habitat Structure 35
8.4 Historic Fire Regime 41
8.5 Soils and Terrain - Earth Flow Features, Saturated Glacial Till and Soils 44
8.6 Surface and Subsurface Flow Regimes. 47
8.7 Water Quality 52
8.8 Grizzly Bear 55
8.9 Woodland Caribou 59
8.10 Mountain Goat 66
8.11 Wolverine 71
8.12 Canada Lynx 75
8.13 Residual Cumulative Impacts to Ecological Integrity 77

9 IMPACT ASSESSMENT – VISITOR EXPERIENCE 80

9.1 Visitor Needs and Expectations 80
9.2 Visitor Education and National Park Experience 81
9.3 Viewscapes and Aesthetics 81
9.4 Avoiding visitor use conflicts 82
9.5 Visitor Use Impact Summary 82

10 IMPACT ASSESSMENT – INFRASTRUCTURE CAPACITY 84

10.1 Road and transportation system capacity 84
10.2 Water supply and demand and downstream water quality 84
10.3 Electrical supply and demand 85
10.4 Visitor and staff accommodation capacity. 85
10.5 Environmental management system 86
10.6 Infrastructure Capacity Impact Summary 86

11 FOLLOW-UP 87

12 SUMMARY AND CONCLUSIONS 87

13 LITERATURE CITED 91

13.1 Section 6 - Description of Environment 91
13.2 Section 8.1 – Native Vegetation Diversity 91
13.3 Section 8.2 – Rare/Sensitive Species and Communities 92
13.4 Section 8.3 – Small Mammal Habitat Structure 92
13.5 Section 8.4 – Historic Fire Regime 93
13.6 Section 8.5 – Soils and Terrain Features 94
13.7 Section 8.6 – Surface and Subsurface Flow Regimes 94
13.8 Section 8.7 – Water Quality 95
13.9 Section 8.8 – Grizzly Bear 96
13.10 Section 8.9 – Woodland Caribou 98
13.11 Section 8.10 – Mountain Goat 102
13.12 Section 8.11 - Wolverine 104
13.13 Section 8.12 - Lynx 105

1 Introduction

1.1 Overview

Marmot Basin Ski Area (Marmot Basin) is one of four ski areas in Banff and Jasper national parks and the only one located in Jasper National Park (JNP). Parks Canada is committed to working together with ski areas, the Municipality of Jasper, environmental non-government organizations, and the tourism industry to support a vibrant winter ski experience (Ski Area Management Guidelines, 2006) while fulfilling its responsibilities for protecting heritage resources and ecological integrity, and facilitating opportunities for public education and memorable visitor experiences.

The *National Park Ski Area Management Guidelines (December, 2006*)(the Management Guidelines) provide the policy and planning foundation for new ski area long-range plans for the four ski areas. In accordance with direction in the Management Guidelines, Parks Canada has prepared Ski Area Site Guidelines (Site Guidelines) that represent the site-specific application of the Management Guidelines to Marmot Basin. The primary focus of the Site Guidelines is to establish permanent limits to growth and outline types of projects and use, consistent with the *Management Guidelines*, that can be considered should Marmot advance specific proposals in the future.

Following the establishment of Site Guidelines, Marmot Basin will be responsible for preparing one or more Long Range Plans that details development or redevelopment plans, for a time period chosen by the operator (anticipated to be five to 15 years). The Long Range Plans brought forward by Marmot Basin will be subject to environmental assessment in accordance with the *Canadian Environmental Assessment Act*. Environmental assessments of Long Range Plans will address the project-level environmental effects of specific development proposals consistent with the policy direction established in the Site Guidelines.

1.2 Objectives of this Report

The Marmot Basin Site Guidelines are subject to a strategic environmental assessment (SEA) consistent with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals* (the *Cabinet Directive*). The *Cabinet Directive* indicates that a strategic environmental assessment of a policy plan or program is expected when the following two conditions are met:

- the proposal is submitted to an individual minister of Cabinet for approval; and
- implementation of the proposal may result in important environmental effects, either positive or negative.

The Management Guidelines indicate that the Chief Executive Officer of Parks Canada will approve Site Guidelines and as such the decision to undertake a strategic environmental assessment is not strictly required by the *Cabinet Directive*. However the *Cabinet Directive* also encourages departments and agencies to "conduct strategic environmental assessments for other policy, plan or program proposals when circumstances warrant". Therefore Parks Canada has decided to undertake a strategic

environmental assessment of the Site Guidelines to address the potential environmental implications and public concerns related to ski area development. This approach to strategic environmental assessment is consistent with the Cabinet Directive and other similar Parks Canada planning initiatives including those for park communities and outlying commercial accommodations.

The development of Site Guidelines is nested within a larger policy and planning framework. The strategic environmental assessment of the Site Guidelines is neither the first, nor the last, step in the environmental analysis of ski areas in national parks. Rather, it addresses the transition between considering the ecological implications of ski area development at the broad strategic levels reflected in the *Canada National Parks Act,* the *National Park Ski Area Management Guidelines* and the *Jasper National Park Management Plan*, and project-level assessment of ski area development at Marmot Basin as set out in future Long Range Development Plans.

The objectives of this strategic environmental assessment report are:

- to examine the Site Guidelines and present information about how ski area development and activity carried out within those guidelines would affect the ecological, cultural and visitor experience environments of JNP in a strategic planning context
- to determine if the Site Guidelines are consistent with direction provided in legislation and policy pertinent to the Parks Canada mandate
- to identify and assess potential cumulative environmental effects at regional and local scales to inform future long range planning and comprehensive study environmental assessment requirements
- to document the strategic environmental assessment process in accordance with the guidance in the Cabinet Directive.

The strategic environmental assessment has been conducted so that decision-makers can be informed of the potential consequences of implementing the Site Guidelines and make decisions accordingly.

1.3 Use of this Report

This document reports on the environmental implications of the Marmot Basin Site Guidelines. This report was used to facilitate government, stakeholder and public review and understanding of the Site Guidelines. While certain key information from the Site Guidelines is summarized in this report, readers may wish to refer to the complete Ski Area Management Guidelines and the Marmot Basin Site Guidelines for additional details.

2 Legal and Policy Framework

2.1 Introduction

The Marmot Basin Site Guidelines provide direction for the consideration of potential, future development and operation initiatives that may be advanced by the ski area as part of a Long Range Plan consistent with existing legislation and policy for the management of national parks. The following sections highlight the legislative and policy requirements most relevant to the development and assessment of the Marmot Basin Site Guidelines.

2.2 Canada National Parks Act

The Canada National Parks Act (2000) is the enabling legislation under which Canada's national parks are established and managed. As a commercial operation within Jasper National Park, the development and operation of Marmot Basin Ski Area is governed by that legislation. The general purpose of national parks is stated in Section 4 of the Canada National Parks Act:

> *The National Parks of Canada are hereby dedicated to the people of Canada for their benefit, education and enjoyment, subject to this act and the regulations, and the National Parks shall be maintained and made use of so as to leave them unimpaired for the enjoyment of future generations.*

Section 8 (1.2) provides clarity on what it means to leave national parks "unimpaired" by managing for ecological integrity:

> *8 (1.2) Maintenance or restoration of ecological integrity, through the protection of natural resources and natural processes, shall be the first priority of the Minister when considering all aspects of the management of parks.*

2.3 Guiding Principles and Operational Policies

The Parks Canada Guiding Principles and Operational Policies (1994) provide broad principles that give direction to both present programs and future initiatives of Parks Canada. Specific direction on the management of ski areas is included in Section 5.2.2 in Part II National Parks Policy:

> *5.2.2 Due to the pressures placed on alpine and subalpine environments, the 1988 National Parks Act Amendments prohibited development of new commercial skiing areas inside the national parks. The five existing commercial alpine skiing areas will be managed within their legislated boundaries according to long range development plans approved by the Minister and subject to public consultation.*

Parks Canada is one of the principal cultural resource management organizations in Canada and is responsible for cultural resources in public settings at national parks, national historic sites and other properties.

The Objective of the Cultural Resource Management Policy is:

> *To manage cultural resources administered by Parks Canada in accordance with the principles of value, public benefit, understanding, respect and integrity.*

The Cultural Resource Management Policy requires that the concept of historic value of cultural resources be fully integrated into the planning and delivery of conservation, presentation and operational programs specifically:

> *2.3.2 In all actions that affect cultural resources, Parks Canada will consider the potential consequences of proposed actions and the cumulative effects of those actions on the historic character of those resources and will plan and implement measures that respect that historic character,*

and;

> *2.3.3 When a proposed action on lands or waters administered by Parks Canada requires an environmental assessment, that assessment will include consideration and mitigation of the impacts of the proposed action on cultural resources.*

2.4 Parks Canada Agency Corporate Plan

The *Parks Canada Agency Corporate Plan* (2007) provides direction on achieving the integrated delivery of Parks Canada's mandate of protection, education, and visitor experience. Enhancing visitor experience is one of the primary program activities identified in the Corporate Plan with the planned result of facilitating:

> *Experiences that provide learning opportunities, visitor satisfaction and personal connections.*

The Corporate Plan indicates that the Recreational Activities Assessment Framework will be a primary tool in decision making regarding activities and events that take place in national parks. Also highlighted among the strategies for enhancing visitor experience is integration of the *Code of Ethics and Guidelines for Sustainable Tourism for Canada,* a joint collaboration between Parks Canada and the Tourism Industry Association of Canada, into Parks Canada management practices and accountability framework. The Code of Ethics broadly reflects the visitor experience results contained in the Corporate Plan indicating support for:

> *Tourism activities which foster responsible use and enjoyment of our nature, culture and communities,*

and limiting

> *activities, services and facilities to levels that do not threaten the integrity of heritage resources or systems while continuing to support economic goals and traveler access.*

2.5 Jasper National Park Management Plan

The *Jasper National Park Management Plan* (1999) sets forth a vision for the future of the park and strategic goals and key actions towards achieving the vision. Section 5.10 of the park management plan provides direction for ski area development and operation.

The stated objectives of the management plan in support of the strategic goal are:

- *To recognize the area's importance as a cornerstone of winter tourism and provide opportunities for visitors to appreciate natural and cultural heritage.*
- *To ensure the management of the ski area respects approved long range plans and the national park setting.*
- *To provide a reasonable degree of certainty regarding future planning, project review and approvals.*

The management plan highlights issues that are considered the most serious threats to the ecological integrity of the park. These issues provide a focus for the strategic environmental assessment of the Site Guidelines and include:

- park management practices including waste and wastewater management, flood and fire protection and vegetation management that modify natural processes
- vegetation change largely due to fire suppression activities
- the introduction of exotic organisms
- habitat fragmentation and wildlife displacement in the greater park ecosystem
- continued existence of wide-ranging carnivores such as grizzly bear, wolf, lynx
- wildlife habituation
- degradation of aquatic ecosystems.

Although not mentioned in the current management plan, Species at Risk have become a key issue and focus of resource conservation efforts in Jasper National Park.

2.6 Ski Area Management Guidelines

The *National Park Ski Area Management Guidelines* and the *Jasper National Park Management Plan* together provide the ski area-specific policy and planning foundation for the preparation of the Site Guidelines and the subsequent long range planning process. The Management Guidelines stipulate that Parks Canada's primary goal for the management of ski areas is to achieve long term land use certainty that:

- *ensures ecological integrity will be maintained or restored;*
- *contributes to facilitating memorable national park visitor experiences and educational opportunities; and*
- *provides ski area operators with clear parameters for business planning in support of an economically healthy operation.*

The Management Guidelines distinguish between the existing "Developed Area" within the ski area leasehold and the area of the lease itself. The Management Guidelines stipulate that "*inside the existing Developed Area, new development can be considered where potential ecological impacts can be mitigated. Outside the existing Developed Area, new development can be considered if there is a Substantial Environmental Gain".* Exceptions to the Ski Area Management Guidelines "*may be considered if a Substantial Environmental Gain can be shown by demonstrating a positive change in key ecological conditions*". A leasehold reduction or reconfiguration that results in better protection of sensitive areas in exchange for development in less sensitive areas is an example provided in the Management Guidelines of an exception that can be considered.

The definition of Substantial Environmental Gain in the Management Guidelines includes criteria for determining if an ecological gain is substantial including:

- *magnitude – major as opposed to minor improvement*
- *geographic context – broad scale as opposed to local impact; and*
- *ecological context – improved protection or positive impacts to high value, rare or sensitive species or multiple species.*

The identification of ecological parameters is required by the Management Guidelines as part of developing the *Marmot Basin Site Guidelines*. With respect to new ski area development the Management Guidelines indicate that:

> *"Within the Developed Area, improvements to services and facilities can be considered. Additional infill ski runs, glading, run widening and parking can be considered. However, to ensure ecological integrity and address aesthetic issues, modification of physical terrain and forest cover will be carefully managed. Site Guidelines will identify ecological management parameters to ensure ecosystem functioning is maintained and that sensitive areas are protected. At a minimum, this will include maximum run width, minimum distance between runs, maximum number of new runs and the prohibition of development in sensitive areas. Other parameters will be determined on a ski area by ski area basis."*

The Management Guidelines also provide direction on Memorable Visitor Experiences and Education summarized later in Section 4.6

2.7 Species at Risk Act

Parks Canada is one of three federal departments with responsibility for implementing the *Species at Risk Act* (SARA). *SARA* creates additional obligations for the environmental assessment process under the *Canadian Environmental Assessment Act* primarily involving notification of responsible departments, identification of effects, mitigation, and monitoring. *SARA* has amended the definition of "environmental effect" found in *CEAA* to clarify that environmental assessments must always consider impacts on a listed species, its critical habitat or the residences of individuals of that species. The protection and recovery of species listed under *SARA* is achieved through the development and implementation of regional recovery strategies and action plans. Although *SARA* does not include any specific obligations related to strategic environmental assessment, the consideration of *SARA* at the strategic level is important to ensuring consistency with local *SARA* issues, strategies and plans.

2.8 Cabinet Directive on the Assessment of Policies, Plans and Program Proposals

The conduct of strategic environmental assessment for federal authorities is guided by the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals* (2004). The Guidelines for implementing the Cabinet Directive indicate that federal departments and agencies have "discretion in determining how they conduct strategic environmental assessment" and are "encouraged to apply appropriate frameworks and techniques and to develop approaches tailored to their particular needs

and circumstances". The general guidance provided on the Cabinet Directive recommends that a strategic environmental assessment should address the following considerations:

- the scope and nature of potential positive and adverse effects including cumulative effects
- the need for mitigation or opportunities for enhancement
- the scope and nature of residual effects
- the need for follow-up measures
- public and stakeholder concerns.

Early integration of the strategic environmental assessment process into existing planning, public consultation, and reporting processes is a key feature of the Cabinet Directive.

3 Public Consultation

Parks Canada considered input from a range of people and organizations who have an interest in the future of Marmot Basin as part of the preparation and review of the strategic environmental assessment.

Input and advice from environmental groups and ski areas on a draft contract terms of reference for the strategic environmental assessment of ski area site guidelines and planning support was used to help determine the scope of the strategic environmental assessment for the Marmot Basin Site Guidelines. The strategic environmental assessment process itself relied heavily on the collective expertise and advice of Park science, planning and environmental assessment staff from Jasper, Calgary and Ottawa. The strategic environmental assessment document was subjected to independent peer review and review by the *Canadian Environmental Assessment Agency* at key points in the assessment process; as part of scoping, and prior to completion of the draft for public review.

Public open houses in Jasper and Edmonton attracted more than 100 people and summary documents for the draft Site Guidelines and the draft strategic environmental assessment were provided for comment on the Parks Canada website. Copies of the draft site guidelines and draft strategic environmental assessment were provided to major stakeholders and were available upon request. Views on the draft Marmot Basin Site guidelines were mixed. While there was general support for establishing limits to growth, advancing environmental stewardship and education initiatives, views on other aspects were polarized. Perspectives ranged from those correspondents who fully supported fully supported the draft site guidelines to those who challenged key concepts, in particular initiatives related to achieving substantial environmental gain. Few substantive comments were received with respect to the scope, content or conclusions of the strategic environment assessment though some concern was expressed with respect to levels of scientific certainty.

Parks Canada has carefully considered these views in finalizing the site guidelines to ensure the site guidelines reflect the principles and direction of the *Ski Area Management Guidelines*. Changes were made to the Strategic Environmental Assessment that ensure consistency with changes made to the Site Guidelines. The mitigations of the strategic environmental assessment address acknowledged scientific limitations and uncertainties and provide direction on knowledge deficiencies to be addressed as part of future long range planning processes.
Stakeholder and public consultation will also be undertaken as part of the development of long-range plans and the associated application of the *Canadian Environmental Assessment Act*.

4 Approach

4.1 Strategic Approach

The objective of the SEA is to examine the Site Guidelines and present information about how potential ski area development and activity carried out within the scope of those guidelines would affect the ecological, cultural and visitor experience environments of JNP. Legislation and policy direction as described above is used to focus the SEA on the most important issues to Jasper National Park and to provide a benchmark against which the potential environmental impacts of the Site Guidelines can be assessed.

The Cabinet Directive indicates that the focus of strategic environmental assessment "should be on identifying strategic considerations at a relatively general or conceptual level, rather than evaluating quantitative, detailed environmental impacts as in a project level assessment". Accordingly, the SEA does not attempt to identify or assess all potential environmental impacts arising from ski area development and use. Instead a suite of valued components has been selected for assessment that reflects the key issues arising from legislation and policy direction. The SEA relies on existing information and research to inform the assessment process. Information gaps are identified and future information requirements are noted as appropriate.

Mitigating measures in the SEA take the form of ecological management parameters aimed at achieving expected outcomes pertaining to Parks Canada's integrated mandate. Mitigations also take the form of planning, operational and knowledge requirements to be addressed in future long range plans and project design proposals. The SEA does not address mitigations related to potential ski area project construction and on-going operations. These are addressed separately through a combination of best management practices, the implementation of an environmental management system consistent with an approved long range plan, and the environmental assessment of long range plans pursuant to the requirements of the *Canadian Environmental Assessment Act*.

4.2 Geographic and Temporal Scope

The geographic scope of the assessment encompasses both regional and local ecological scales.

At the regional scale the ski area environment is evaluated within the context of the broad mountain ecoregions of which it is a component. No one predetermined scale is defined that applies to all factors being assessed. Instead, the appropriate regional scale is defined relative to each individual valued component scoped into the assessment. At the regional scale the focus of the assessment is on important regional ecosystem functions.

The local ecosystem includes the area contained within the ski area leasehold as well as ecosystem features immediately adjacent to the leasehold that may be affected by ski

area development and activity. At the local level, the ecosystem shall be evaluated with a particular focus on ecosystem structure and composition. Special emphasis is given to the identification of important or sensitive ecosystem features.

The existing environmental conditions at the ski area represent the cumulative impact of past projects and activities and provide the temporal baseline from which the strategic environmental assessment will proceed. The scope of assessment extends to future projects and activities that may be presented in long range plans consistent with the Site Guidelines.

Although individual project proposals may have limited life spans, overall ski area development is regarded as a permanent change to the environment and the scope of assessment considers potential environmental impacts into the foreseeable future.

4.3 Alternatives

The Cabinet Directive identifies the consideration of alternatives as one of the most important aspects of strategic environmental assessment.

Alternatives were considered in the development of the ski area Management Guidelines. Alternative models to potential ski area development that were considered and rejected in the development of the Management Guidelines included on-hill accommodation, unrestricted year-round use and unrestricted development within the leasehold footprint. Alternatives selected for the Management Guidelines included the continued prohibition of on-hill accommodation, strict criteria for summer use, and a series of development restraints within the leasehold that make up the majority of the Management Guidelines.

The Parks Canada Guide to Compliance With the Canadian Environmental Assessment Act distinguishes between "alternative means" and "alternatives to" a project:

- ***Alternative means*** *are various ways that are technically and economically feasible or methods that are functionally the same and which can be used to achieve a particular purpose*
- ***Alternatives to a project*** *are functionally different ways of achieving the same end.*

For potential ski area development, alternative means might include consideration of different locations, different lift alignments or technologies, or expanding an existing facility rather than building a new one. The need to consider alternative means is identified in proposed mitigation measures throughout the SEA in association with the valued components and proposed elements of the Site Guidelines. Where recommended in the SEA, alternative means will be more fully considered in the development of long range plans and the associated environmental assessment.

The Ski Area Management Guidelines allow for the consideration of alternatives to the standard requirements of the guidelines, stipulating that "exceptions" to the

Management Guidelines may be considered if a "Substantial Environmental Gain" can by shown by demonstrating a positive change in key ecological conditions:

> *"Exceptions to the Guidelines for facilities, parking, terrain modification limits and adjustments to the perimeter of the Developed Area can be considered if there are Substantial Environmental Gains. Exceptions will not be considered for on-hill accommodation, Growth Limits, water permits and infrastructure requirements."*

Substantial Environmental Gain is defined by the Management Guidelines as:

> *"An environmental gain is a positive change in key ecological conditions (wildlife movement and habitat, wildlife mortality, sensitive species/areas and aquatic ecosystems) that leads to the restoration or the long-term certainty of maintaining ecological integrity".*

The "exceptions" outlined in the Site Guidelines represents functionally different ways of approaching potential ski area development from the standards outlined in the Ski Area Management Guidelines. The suite of potential exceptions is considered as an alternative to the standard requirements of the Ski Area Management Guidelines for the purpose of strategic environmental assessment. The potential exceptions are identified and assessed individually throughout this strategic environmental assessment document and also evaluated as a package with a focus on cumulative environmental effects.

The potential exceptions to the Ski Area Management Guidelines are presented throughout the proposed Site Guidelines for Marmot Basin and are summarized in section 5.3.1.

4.4 Ecological Integrity

The *Canada National Parks Act* clarifies the meaning of ecological integrity through the following definition:

> *"ecological integrity" means, with respect to a park, a condition that is determined to be characteristic of its natural region and likely to persist, including abiotic components and the composition and abundance of native species and biological communities, rates of change and supporting processes.*

The key threats to the ecological integrity of JNP (see section 2.4) are consistent with the definition and include the modification of natural processes, vegetation modification, the introduction of exotic organisms, wildlife displacement, habituation and habitat fragmentation, the continued existence of wide ranging carnivores and degradation of aquatic ecosystems. SARA listed species reflect specific threats to ecological integrity in addition to those from the management plan. To address these threats the SEA focuses on expected ecological outcomes that reflect the wildlife, vegetation, terrain and aquatic concerns of importance to JNP. With respect to the potential impacts of the Site Guidelines ecological integrity will be maintained when the following expected ecological outcomes are realized:

- vegetation composition and structure are characteristic of the natural region
- vegetation composition and structure function as habitat for a range of native species
- locally sensitive or valued vegetation communities and terrain features continue to persist
- invasive, non-native species are not introduced or allowed to persist
- sensitive or valued wildlife is not displaced from habitat essential to regional population sustainability
- sensitive or valued wildlife is not habituated through human contact and activity
- wildlife mortality does not increase, directly or indirectly, as a result of human contact and activity.
- terrestrial and aquatic ecosystem processes function within the natural range of variation
- species are protected in accordance with SARA.

Building on these expected ecological outcomes, the suite of valued components selected for assessment in Section 7 represent ecological integrity issues consistent with the requirements of the *Canada National Parks Act* and the *Jasper National Park Management Plan*.

4.5 Cultural Resources

There are no known archaeological, paleontological or other cultural resources within or adjacent to the Marmot Basin Ski Area leasehold (Francis pers com). Potential impacts to currently unknown cultural resources will be addressed as part of the development of best management practices and as part of the environmental assessment of long range plans. As a result, cultural resources are not considered further in this strategic environmental assessment.

4.6 Visitor Experience

The operation of existing downhill ski areas including Marmot Basin is appropriate in accordance with overarching direction in Parks Canada legislation, policy and plans as outlined in Section 2. Accordingly, the issue of ski area development as an appropriate park use is not considered further as part of the SEA.

As reviewed in Section 2.4 the *Parks Canada Agency Corporate Plan* promotes visitor experiences that facilitate learning opportunities, visitor satisfaction and personal connections to nature and history. The *Code of Ethics and Guidelines for Sustainable Tourism for Canada* emphasizes the responsible use and enjoyment of nature, culture and communities and supports activities, services and facilities at levels that do not threaten the integrity of heritage resources or systems while continuing to support economic goals and traveler access.

The Management Guidelines provide specific direction on memorable visitor experience and education indicating that "the nature of ski area operations and visitor experiences will reflect and reinforce its location in a national park and world heritage site". Ski areas are encouraged to "provide winter educational opportunities that focus on the heritage

values of the park and world heritage site as a component of the skiing/snowboarding experience".

To consider the policy direction on visitor experience the SEA focuses on expected visitor experience outcomes that may be affected by changes to the environment as a result of ski area development. Impacts to both on-hill and off-hill park visitors are considered. With respect to the potential impacts of the Site Guidelines visitor experience objectives will be maintained when the following expected visitor experience outcomes are realized:

- potential development considered under the Site Guidelines meets visitor needs and expectations and contributes to quality visitor experience within the parameters of resort balance and public safety
- the range of visitor experience includes opportunities to learn about and connect with natural and cultural heritage consistent with Marmot Basin's location in Jasper National Park and a World Heritage Site
- potential ski area development maintains a natural look and feel with respect to viewscapes and aesthetics for both on-hill and off-hill visitors
- visitor use conflicts, both on-hill and off-hill, are not created or maintained.

4.7 Regional Infrastructure Capacity

Regional infrastructure capacity warrants consideration at a strategic level because of the implications for overall management of cumulative environmental effects. Consideration of the capacity of renewable resources is a requirement of a comprehensive study pursuant to the *Canadian Environmental Assessment Act* and consideration of these factors at a strategic level is consistent with the objectives of the strategic environmental assessment report outlined in Section 1.2.

The Site Guidelines establish growth limits that define the limits of potential build-out and require balancing of ski area components. These limits can be used to identify and evaluate the potential change in natural resource and infrastructure demand pertaining to transportation, water, power and accommodation. The Management Guidelines indicate that infrastructure increase can be considered but that there must be sufficient capacity and environmental standards must be met before related growth can take place. With this expected outcome from the Management Guidelines in mind, the strategic environmental assessment will consider the implications of:

- increasing traffic levels and potential impacts to wildlife mortality, wildlife travel corridors, and public safety;
- increasing water demand and potential impacts to downstream availability and water quality;
- increasing demand on electrical power consumption and potential impacts or upgrades to current systems and infrastructure; and
- increasing demands on visitor accommodation and staff housing capacity and potential impacts to townsite systems and infrastructure.

The focus of the strategic environmental assessment is on avoiding potential impacts first, and secondly, on identifying mitigations that address planning, operational and

knowledge requirements for inclusion in the long range plan and comprehensive study process.

4.8 Approach to Cumulative Effects Assessment

"Cumulative effects are the residual adverse effects of the project being assessed, in combination with the adverse effects from other activities which have affected, are currently affecting, or are likely in the future to affect the same ecosystem components or cultural resources" (Parks Canada 2007). Consideration of cumulative effects is an important aspect of strategic environmental assessment and is inherent throughout the strategic environmental assessment of the Site Guidelines. A three-pronged approach to cumulative effects assessment has been integrated into the strategic environmental assessment.

First, the potential cumulative effects of past and current activities are incorporated into the selection, and description of the current status, of each of the valued components of ecological integrity included in the scope of the strategic environmental assessment. The cumulative effects of all proposed projects and activities envisioned by the Site Guidelines are identified and assessed in relation to each valued component and in relation to the expected outcomes supporting ecological integrity and visitor experience.

Second, the evaluation of alternatives or exceptions to the Ski Area Management Guidelines is focused on cumulative effects. As outlined in section 4.3 the proposed exceptions are identified and assessed individually in relation to each valued component. The exceptions are also evaluated as a package with a focus on cumulative environmental effects and interactions with valued components at the local and regional ecosystem scales.

Third the assessment of regional infrastructure capacity as outlined in Section 4.7 directly addresses cumulative effects and interactions between potential ski area development activity and regional resource capacity and infrastructure.

The cumulative effects of potential ski area development are best reflected in the ability of the Site Guidelines to satisfy the expected outcomes for ecological integrity, visitor experience and infrastructure capacity as outlined in the previous subsections. The expected outcomes as a group reflect Parks Canada's integrated mandate and serve as the benchmark for assessing the potential implications of any residual cumulative effects.

5 Marmot Basin Site Guidelines

The development of the Marmot Basin Site Guidelines is one stage in a tiered planning and environmental assessment process. The process proceeds from broad strategic direction provided in the *Canada National Parks Act,* the *Ski Area Management Guidelines* and the *Jasper National Park Management Plan*, to the development of Site Guidelines, to project-specific plans, environmental assessment and decision points as part of the long range planning process, and finally to project permitting and implementation of approved projects. The reader should refer to the Ski Area Management Guidelines and the Marmot Basin Site Guidelines (Section 1.2 and Appendix 2) for further information on the ski area planning process.

5.1 Limitations to Scope of the Site Guidelines

Two aspects of potential future development are not fully addressed by the site guidelines. Consideration of potential development in Whistlers Creek and potential summer use proposals will be addressed in future planning and assessment initiatives as discussed below.

5.1.1 Whistlers Creek

Marmot has identified lift access in the Outer Limits and Tres Hombres areas as initiatives they may wish to advance as proposals in the future. At this time, Parks Canada is unable to objectively determine, in scientific terms, whether or not potential future development in these areas should be considered because the potential impact of lift development on caribou is not well understood. For this reason, a multi-year, independently led caribou risk assessment will be undertaken. The assessment will examine the impact of potential future development in the Whistlers Creek area on caribou and the effectiveness of potential mitigations to manage human use in the area. Once the risk assessment is complete, a decision on whether to consider potential future lift access in the Outer Limits and Tres Hombres areas will be made.

Accordingly, potential development in Whistlers Creek is not considered further in this strategic environmental assessment. The strategic environmental assessment will however, consider the purpose, scope, and approach to the caribou risk assessment with the intent of ensuring scientifically sound and effective information for future decision making.

5.1.2 Summer Use

The Ski Area Management Guidelines indicate that summer use changes will be addressed in the long range planning process. The Management Guidelines outline criteria that control the consideration of potential summers use including parameters that address wildlife habituation, displacement, disturbance, movement and mortality, wildlife-human conflicts and visitor use and education.

Marmot Basin is not pursuing initiatives related to summer use. As summer use changes are not contemplated in the Marmot Basin Site Guidelines, summer use is not addressed further in the SEA.

5.2 Summary of Site Guidelines

This section summarizes the key components of the Site Guidelines to be considered in the strategic environmental assessment. The reader should refer to the Site Guidelines themselves for more detailed information.

5.2.1 Permanent Growth Limits

The Site Guidelines identify permanent, negotiated, growth limits for the developed area, ski terrain and commercial space at Marmot Basin in accordance with the Management Guidelines. Although expansion and other development may take place the capacity of the ski area will be permanently capped through the growth limits. Capacity will be established as follows:

- the current developed area of 361 hectares will be capped at 437 hectares
- the current ski terrain of 218 hectares will be capped at 275 hectares
- commercial space will be capped at 6270 m^2 providing balanced services for a maximum of 5500 skiers or 85% of ski area design capacity
- a design capacity of 6500 skiers a day will be applied to the balancing of other resort elements including lifts, parking, power, water, and wastewater capacity.

These figures define the limits of maximum potential build-out for the ski area.

5.2.2 Leasehold Reduction

Marmot Basin has proposed a substantial leasehold reduction with the long-term intent of improving winter visitor opportunities while providing long-term protection of important caribou and mountain goat habitat in Whistlers Creek. The leasehold reduction would result in the removal of the Whistler Creek bed area and surrounding up slopes from the ski area leasehold.

Consistent with direction in the Management Guidelines concerning environmental gain, the potential leasehold reduction is an example of a reduction or reconfiguration that results in better protection of sensitive areas in exchange for development in less sensitive areas. The Site Guidelines considered criteria of magnitude, geographic and ecological context in order to determine whether the environmental gain associated with the proposed leasehold reduction is substantial, as outlined in the Ski Area Management Guidelines. The removal of the Whistlers Creek bed and surrounding up slopes is considered a Substantial Environmental Gain because the reconfiguration:

- *represents removal of an area from the leasehold that will result in providing a greater degree of protection and certainty that the area will not be developed in the future and that uses will be carefully managed in the future. This is considered a positive change from the existing situation.*
- *represents a major reduction in the size of the leasehold (approximately18%).*
- *creates long-term certainty and improved protection for sensitive and important caribou and goat habitat features including food sources and the mineral lick*

- *contributes to current and future broad scale ecosystem management initiatives to better protect caribou habitat, which are linked through of the park management plan, federal-provincial collaboration, and SARA recovery strategies*
- *protects broad ecological values for multiple species associated with the Whistlers Creek valley, including habitat security for valued and sensitive species such as grizzly bear, wolverine, and lynx.*

Based on the benefits of removing this ecologically important area from the leasehold and ensuring no future development, Parks Canada will consider several exceptions (see section 5.0) to the *Ski Area Management Guidelines,* subject to final decisions on a long-range plan and the application of the *Canadian Environmental Assessment Act*. In order to consider proposed exceptions a new lease, including the removal of the Whistlers Creek bed area and surrounding up-slopes, must be in place as outlined in Section 7.0 of the Site Guidelines.

Development exceptions that can be considered as part of future long range planning processes are identified and discussed as appropriate throughout the SEA document.

5.2.3 Developed area

Outside of some potential glading, there is minimal physical opportunity for Marmot Basin to propose ski run expansion or re-development within the existing Developed Area as parameters for run width, distance between runs and the ratio of developed to undeveloped terrain have already been reached. To address this limitation Marmot Basin has proposed a number of exceptions to development as provided for under the Ski Area Management Guidelines that would provide opportunities for expansion. These exceptions can be considered in the Site Guidelines as a result of the substantial environmental gain established by the Whistlers Creek leasehold reduction. Potential exceptions related to the Developed Area that may be considered include:

- potential expansion of the developed area
- potential extension of the Knob chairlift towards the summit of Marmot Mountain
- potential development of the forested area below the rock gardens outside current lease into a new beginners area, childrens play area and cross country ski trail network
- potential development of an egress trail from Tres Hombres to lower Keifers subject to the results of the caribou risk assessment.

5.2.4 Ski terrain, ski lifts, terrain modification

Elements of the Site Guidelines pertaining to ski terrain, ski lifts and terrain modification have been summarized together as they involve similar types of development activities and have similar types of environmental effects. The Site Guidelines allow for the consideration of a variety of development and redevelopment related to ski terrain, ski lifts and terrain modification including:

- potential development or modification of new runs and existing runs and glades within the existing developed area
- potential terrain modification to enhance skier safety, environmental protection and visitor experience

- potential development of subalpine or alpine terrain parks involving minimal terrain modification
- potential new lifts or the replacement, upgrade, and realignment of existing lifts within the current developed area.

Potential development exceptions proposed by Marmot Basin related to ski terrain, lifts and terrain modification include:

- potential Knob chairlift extension (see also section 5.2.3)
- potential development of the 'rockgardens' beginner, tubing and cross country ski areas (see also section 5.2.3)
- potential development of a terrain park including significant terrain modification on the lower section of "Lift Line".

5.2.5 Snowmaking and water system

The Site Guidelines allow for the potential expansion and modification of the existing interim snowmaking system at Marmot Basin. Use of the overflow capacity of the existing wastewater lagoons as a snowmaking reservoir can continue. The use of nucleating additives can also be considered subject to fully addressing the environmental benefits and potential impacts in the long range plan.

Potential development exceptions proposed by Marmot Basin related to snowmaking that can be considered include:

- potential development of a mid-mountain water reservoir for snowmaking supply.

5.2.6 Buildings and parking lots

The Site Guidelines allow for the potential expansion and modification of existing lodges to address resort-balancing requirements including the mid-mountain and base area lodges. Construction of new non-commercial warming and patrol huts, or the expansion and modification of existing huts can be considered, and the construction of a washroom for the beginner's area can be considered.

Modifications to parking lots and operational space are allowed for in the Site Guidelines including:

- potential consolidation of vehicle and maintenance facilities into current parking lot 2
- potential expansion of current parking lots 1,3, and 4 into "Home Run"
- potential parking structures related to any existing parking area
- potential development of a bus parking lot in the current vehicle maintenance area.

Potential development exceptions proposed by Marmot Basin related to buildings and parking lots that can be considered include:

- potential development of a group lift ticket group sales facility in the bus parking lot that may be established in the current vehicle maintenance area.

5.2.7 Visitor use – winter and summer

The Site Guidelines allow for the continued use of the ski area in winter consistent with the park management plan. The following existing activities and services are included in the Site Guidelines: downhill skiing, snow boarding, regional ski races and ski related sporting events, cross-country skiing, snowshoeing, food services, ski school, day care,

retail in direct support of skiing activities and rental equipment. The Ski Area Management Guidelines provide some flexibility in winter use indicating that activities inside commercial buildings and non-motorized activities that take place on ski runs and that involve sliding downhill similar to skiing and snowboarding can be considered outside of a long range plan subject to Superintendent approval.

Unserviced "off-piste skiing" is currently allowable in the Tres Hombres, Outer Limits and Caribou Knoll areas of the Whistlers Creek valley. The Tres Hombres area has been closed in the past to off-piste skiing by Marmot Basin for public safety. At a minimum the Site Guidelines provide for the zoning and management of continued off-piste skiing access in the Outer Limits, Caribou Knoll and Tres Hombres areas. Continued off-piste skiing will be subject to any ecological management thresholds and mitigations that may be identified as a result of the caribou risk assessment.

As outlined in section 5.1.2, the Ski Area Management Guidelines indicate that potential summer use changes will be addressed through the long-range planning process. Accordingly no summer use changes are contemplated in the Site Guidelines.

5.2.8 Ski Area Operations and Resource Use

The Site Guidelines require that long range plans include the development of a series of environmental management strategies in order to manage the on-going impacts of ski area development and operation. These include:

- run improvement and vegetation management strategy
- water management strategy including withdrawal, management and conservation
- integrated mass transit strategy
- staff housing strategy
- environmental Management System including, but not limited to, electrical power, water and wastewater management, solid waste and hazardous materials management
- Best Management Practices for routine construction and operations activities.

5.2.9 National Park Experience and Education

The Site Guidelines require that long range plans include the development of strategies to ensure that ski area development and use contributes to a unique and memorable national park experience. These strategies include:

- Best Management Practices for managing viewscapes, noise and external lighting will be components of the Long-Range Plan.
- mountain park wide direction for signage, advertisement and special events will be applied at the ski area where applicable.
- a heritage tourism strategy will be outlined in the Long-Range Plan including approaches for winter education
- a winter Marmot staff and visitor education program to help protect sensitive areas and species, promote environmental stewardship, and facilitate public safety
- development of an architectural theme for new buildings and exterior building improvements in the Long-Range Plan in order to facilitate development review of projects.

6 Description of Environment

The description of environment for the purpose of the strategic environmental assessment is summarized in large part from previous work completed by Leeson (1986) and IRIS (1999). Key information is summarized and presented from these documents; the Marmot Basin Ski Area Initial Environmental Evaluation (Leeson 1986) and; the Comprehensive Environmental Study for the Eagle Ridge development (IRIS 1999).

6.1 Regional Environment

Marmot Basin Ski Area is located in an alpine bowl on Marmot Mountain perched high on the west side of the Athabasca River valley just southwest of the Town of Jasper. Three creeks, Portal, Basin and Whistlers, drain Marmot Mountain and surrounding watersheds into the Athabasca River. A trip to the summit of Marmot Mountain from the access road along the Icefields Parkway spans all major ecoregions of the park from the montane in the valley bottom, through lower and upper subalpine forests and finally on to alpine, rock and ice environments well above treeline.

The variation in ecoregions over a short distance supports a wide range of wildlife species. Marmot Basin provides habitat for forest dwelling subalpine species that live and range through the Athabasca valley including black bear, elk, moose, mule deer, lynx, and wolf. Marmot is also situated on the edge of the Trident Range and is part of a complex of upper subalpine and alpine habitat that supports grizzly bear, mountain goat and woodland caribou populations.

Marmot Basin lies just southwest of the Town of Jasper and the Three Valley Confluence – a hub of human activity including the townsite, two major campgrounds, outlying commercial accommodations, and major railroads, highways and pipelines. Recreational use of the area is highly varied ranging from frontcountry picnic and day use areas to backcountry activities including horseback riding, hiking, mountain biking, rafting, fishing, skiing and snowshoeing.

At the regional scale key threats to ecosystem integrity consistent with the park management plan include habitat fragmentation and wildlife displacement, security of large ranging carnivores, and the viability of woodland caribou populations (a species listed as threatened under SARA). Wildfire is a key vegetation process affected by park management activities. Fire suppression activities and forest fuels management are key strategies to ensuring the protection of the many recreational, commercial and industrial facilities in the valley.

6.2 Local Environment

Marmot Basin Ski Area is situated on the east face of Marmot Mountain. The upper portion of the ski area is located in a large alpine cirque while the lower portion of the ski area is located on the lower flanks of Marmot Mountain below the mouth of the cirque. Marmot Mountain rises 2608 m above sea level; the lower chalet is situated at 1720 m.

Marmot Mountain is bordered on the north by Whistlers creek, to the south by the V-shaped Portal Creek valley, and to the west by Marmot Pass, which connects the Whistlers Creek and Portal Creek drainages. Marmot Basin itself is drained by Basin Creek, which flows to the east joining Whistlers Creek just before its confluence with the Athabasca River. Both surface and subsurface water flows are characteristic of the Marmot Basin hydrologic regime. Groundwater flows are recharged by snowmelt and precipitation in the spring and early summer and are evidenced by many seeps and rills and flat areas and depressions that act as water catchments. A prominent sedge fen located to the north of the parking lots is perhaps the most visible evidence of the groundwater regime that acts to capture, retain and slowly release water to surface water creeks and rivers. Basin Creek is not considered to be fish habitat. Portal Creek and Whistlers Creek both support small fish populations in their lower reaches well below the ski area leasehold.

The groundwater characteristics of Marmot Basin are due to the presence of glacial till deposits that hold and slowly transmit significant amounts of water. This capture and slow release of water contributes to natural flood control, drought suppression and the prevention of large scale erosion and mass wasting. Saturated glacial tills are unstable and prone to slumping and erosion when anchoring vegetation is removed and when excavation and construction designs fail to consider proper drainage and anchoring. A number of naturally occurring terrain flow features are also found in the upper basin.

Marmot Basin Ski Area spans two principle biophysical zones; the alpine and subalpine. Alpine portions of the ski area occur largely above 2,000 m while the subalpine occurs below the base of the cirque under 2,000 m. Stunted Engelmann spruce and subalpine fir mark the transition from the subalpine to alpine. Common vegetation species include yellow heather, western mountain-heather, woolly everlasting, arctic willow, mountain cinquefoil, white mountain avens, snow willow, moss campion, black alpine sedge and various species of saxicolous lichens. Predominant tree species in the upper subalpine are Englemann spruce, subalpine fir, lodgepole pine and whitebark pine. Dominant shrub species include rock willow, bog birch, Barrett's willow and arctic willow. At lower elevations the dominant spruce-fir forest changes to a lodgepole pine-buffalo berry association that marks the transition from upper to lower subalpine.

Wildlife species that have been observed at Marmot Basin Ski Area include elk, mule deer, mountain goat, caribou, grizzly and black bear, wolverine, pine marten, wolf, lynx, red fox, coyote and moose. During winter months, habitat potential for ungulates such as elk and deer is low as a result of deep snow conditions that restrict movement and feeding patterns. Caribou, having a somewhat greater tolerance to deeper snow

conditions, have been observed using habitat in the Whistlers Creek valley portion of the Marmot Basin leasehold throughout the year (for more information refer to Section 8.9). Marmot Mountain is situated on the eastern edge of the Trident Range and is part of a complex of caribou and goat habitat that centres on Marmot Pass as a movement corridor linking seasonal habitats. A mineral goat lick is located in Whistlers Creek near the rockslide below the Tres Hombres area. An extensive colony of pika inhabit the boulder flow above Eagle Chalet and other rock rubble sites around the upper cirque. A variety of other small mammals and birds have been observed or would be expected to occur within the Marmot Basin environment. None of these species are considered to be unique or rare and would be expected to occur in similar habitats throughout JNP.

Marmot Basin Ski Area currently provides skiing services over 361 hectares of terrain including 8 lifts, 3 lodges, a terrain park and 84 named ski runs. An interim snowmaking system has been in place since 2005 servicing limited terrain on the lower mountain. Machine grooming takes place across the mountain on most novice and intermediate runs. Service roads wind their way up the mountain and into Marmot Basin to provide service vehicle access in winter and summer to the upper lodges and lifts. Summer use at Marmot is limited to the occasional use of the Caribou Day lodge for private functions such as weddings and summer maintenance activities.

The water source for potable water and ski area operations including snowmaking is collected by a belowground infiltration system situated along the Basin Creek channel immediately above the Eagle Chalet. Water is piped downhill to the Caribou Chalet. Excess water flows to an emergency overflow wastewater treatment cell that is used as a snowmaking reservoir.

Access to Marmot Basin ski area is by a paved road that branches from Highway 93A. Current recreational activity includes in-bounds skiing and snowboarding. Some skiers and boarders climb to the top of Marmot Mountain to gain access to the upper bowls of the cirque. This climb also provides access to out-of-bounds skiing on the west side of Marmot Mountain into Marmot Pass and on the North Chutes area above Outer Limits. Other local recreational activity includes hiking in Portal Creek and Whistlers Creek and backcountry skiing up Whistlers Creek to Indian and Marmot passes.

6.3 Climate Change

The potential impacts of climate change on winter recreation, national parks and the ski industry in western Canada have been studied and summarized by Scott and others (Scott and Suffling 2000, Scott and Jones 2005, Scott and Jones 2006) and this summary draws upon these papers. In summary the papers referenced above are based on climate change scenarios developed from the application of General Circulation Models - three-dimensional mathematical models simulating the large-scale physical processes governing the global climate system. These highly complex models represent the scientific community's most sophisticated understanding of the global climate system.

Based on climate scenarios developed for years 2050 and 2090, levels of winter precipitation in JNP are expected to increase by between 2% and 25%. The projected increase in precipitation is anticipated to result in a corresponding increase in the depth of the winter snowpack throughout JNP. Deeper snowpacks will be of benefit to small plants and mammals in winter but may restrict the winter ranges of larger wildlife species. A prediction of increased avalanche activity is a key factor in public safety and broad scale vegetation modification that may result in an overall increase in avalanche path subalpine meadow habitat types.

While increased winter precipitation may enhance snow conditions at higher elevations, overall warmer temperatures in the spring and fall and more frequent rainfall, especially at lower elevations, may over the same time period effectively shorten the ski season. An increasing reliance on snowmaking for ensuring a pre-Christmas start to the ski season is anticipated for ski areas across North America. Spring runoff is anticipated to occur earlier in the season and with increased probability of flood events.

These predictions are of a coarse scale and specific climate and weather conditions for Marmot Basin may not reflect the regional predictions. Predictions for Jasper however are consistent with similar predictions for ski areas in Banff.

The potential interaction of climate change factors with elements of the Site Guidelines are identified and discussed as appropriate throughout the assessment document.

7 Valued Components for Environmental Assessment

The valued components (VCs) selected for assessment represent the expected outcomes associated with maintaining ecological integrity, visitor experience and infrastructure capacity outlined in Section 4. Consistent with the approach to the assessment outlined in section 4.1, the VCs selected for evaluating ecological integrity function as indicators of known threats and are associated with maintaining ecological integrity. Expected outcomes for visitor experience and infrastructure capacity can be evaluated directly and do not require an indicator approach for the purposes of this SEA.

7.1 Valued Components of Ecological Integrity

VCs for evaluating ecological integrity were chosen based on known ecological issues related to past ski area development and in consultation with JNP science staff. The following criteria were applied to identify the VCs used to evaluate potential impacts to ecological integrity. As a group the VCs:

- reflect known threats to ecological integrity and the expected ecological outcomes for maintaining ecological integrity
- serve an "umbrella" role where protecting the valued component will inherently protect other ecological values
- are sensitive to ski area development and activity
- reflect local and regional ecosystem scales
- represent a broad spectrum of biodiversity concerns including vegetation, soils and terrain, aquatic ecosystems, and wildlife.

The VCs selected to evaluate the potential implications to ecological integrity are:

- native vegetation diversity
- rare and sensitive species and communities
- small mammal habitat structure
- historic fire regime
- soils and terrain - earth flow features, saturated glacial till and soils
- water quality
- surface and subsurface flow regimes
- grizzly bear
- woodland caribou
- mountain goat
- wolverine
- lynx.

Additional detail on the individual ecological integrity VCs are discussed in following sections.

7.2 Valued Components of Visitor Experience

VCs for the evaluation of potential impacts to visitor experience directly reflect the visitor experience quality objectives outlined earlier in section 4.6. The potential impacts to visitor experience will be evaluated with respect to the following VCs:

- visitor needs and expectations that contributes to quality visitor experience, resort balance and/or public safety
- visitor education and national park experience

- viewscapes and aesthetics
- avoiding visitor use conflicts.

7.3 Valued Components – Regional Infrastructure Capacity

VCs for the evaluation of potential impacts to regional infrastructure capacity directly reflect the expected outcomes of the Management Guidelines outlined earlier in Section 4.7. The potential impacts to regional infrastructure capacity will be evaluated with respect to the following VCs:

- road and transportation system capacity
- water supply and demand and downstream water quality
- electrical supply and demand
- visitor and staff accommodation capacity.

8 Impact Assessment - Ecological Integrity

Each valued component of ecological integrity is discussed below with respect to:

- the current status and ecology of the VC in relation to the local and regional ecosystems
- existing and potential interactions between ski area development activity and the VC, and the resulting potential impacts
- knowledge deficiencies that are important to current and future management decisions.

Mitigations are presented as ecological management parameters, future planning and/or operational requirements, or future knowledge requirements that contribute to the realization of expected ecological outcomes. Ecological management parameters developed through the Strategic Environmental Assessment were incorporated directly into the Site Guidelines.

Residual environmental effects – those remaining after the successful implementation of mitigation – are identified and evaluated in terms of the potential cumulative effects on the VC as a result of all ski area development activities. The impact assessment of each VC concludes with a discussion on the cumulative potential to realize expected ecological outcomes associated with the VC as a result of implementing the Site Guidelines.

8.1 Native Vegetation Diversity

8.1.1 Current status and Ecology

The Marmot Basin Ski Area lies within the upper reaches of the Athabasca watershed, adjacent to the continental divide. These lands include a wide range of elevational and ecological gradients representative of lower subalpine, upper subalpine, and alpine ecoregions of the rocky mountain natural region, and Jasper National Park.

Marmot Basin is represented by a diversity of species, vegetation types, and range of plant community structures. Vegetation is dominated by closed coniferous forests in the lower subalpine (1350 – 1900m), by open coniferous forest in the upper subalpine (1900 – 2200 m), and by a dwarf shrub, herb, and lichen communities in the treeless alpine zone above 2200m (Holland and Coen 1983). Vegetation is adapted to biophysical and climatic conditions within each of these ecoregions. Plant species and phenotypes are increasingly selected by climatic severity as elevation increases from about 1625m to over 2200m within the ski area.

Vegetation at higher elevations characteristically occurs in a complex, fine-scaled mosaic reflecting soil and moisture conditions that varies significantly over distances of even a few centimetres (Billings and Mooney 1968). Vegetation growing at upper elevations is subject to extreme environmental conditions such as wind, low soil temperature, desiccation, low nutrient availability, snow depth, and the shortened growing season (Bliss 1962). These conditions lead to highly variable configurations of species composition and community structure that provide myriad terrestrial and riparian wildlife

habitats, but are highly susceptible to damage and easily disrupted or altered. Hamilton (1981) classified alpine vegetation at Marmot Basin into Heath, Rock, Shrub, Meadow and Snowbed tundra communities characterized by differences in vegetation, soils and terrain, moisture regimes and snow-free periods.

Native vegetation plays a number of important roles in local ecosystem function. Vegetation anchors soils and terrain against wind and water erosion and mass wasting, and function to capture and release water as part of the hydrologic system. The natural diversity of native plant communities provides year-round foraging opportunities for wildlife at Marmot Basin including goats and caribou. Native plant communities contribute to structural habitat diversity that supports local and regional food webs and wildlife life cycle requirements. Grizzly bear for example rely on seasonal diversity in grass, berry and root foods, on open habitat types that support ground squirrels as a food source, and on forest cover and structure that provide security for denning and hibernation.

Maintaining or restoring native species composition, the structure of plant communities, and the pattern of vegetation on the landscape within the range of natural variability as reflected at local and regional scales may be expected to, in turn, maintain or restore the ecological functions facilitated by native vegetation diversity. (Fiedler and Groom 2006, Polster 1999, Parminter 1998).

8.1.2 Existing and Potential Interactions and Impacts

Potential ski area development activities contemplated in the Site Guidelines that were considered to have potential strategic implications for native vegetation diversity include:

- potential expanded development and modification of ski terrain and facilities inside the current leasehold including the potential construction and operation of the mid-mountain water reservoir, the potential Knob Chairlift extension (including associated terrain development, visitor use and operations) and the lower liftline terrain park
- potential development outside the current leasehold; in particular the Rockgardens area
- potential expansion and operation of snowmaking and water systems
- potential parking lot and building expansion
- potential snowmaking and grooming operations.

Potential ski area construction associated with parking lots, lifts, buildings and terrain modification results in the direct destruction and permanent loss of habitat for native vegetation. Potential construction may also have negative secondary implications for soil and terrain stability, surface/sub-surface water flow, and wildlife habitat requirements; all discussed further in subsequent subsections.

The clearing of vegetation for potential ski terrain development has direct impacts to existing vegetation cover. Existing forest cover may be removed as part of glading or run development. Understory and ground cover vegetation may also be removed or modified to facilitate skiing. Potential ski terrain development that alters supporting terrain, micro-topography, soil conditions, water availability, or patterns of solar insolation, wind, and snow deposition may create indirect stress to vegetation (Billings

and Mooney 1968). Stress can be expressed as physical damage or as a reduction in plant productivity, reduced root growth, or declining reproductive ability.

Invasion by non-native species is considered a potentially significant threat to native biodiversity (Groom 2006, Wonham, 2006). Ground disturbance associated with potential terrain development, construction, and operational activities creates potential for the establishment of invasive species that displace native species and reduce native vegetation diversity. Although the current extent and variety of invasive alien plant species has not been comprehensively documented within the ski area, several species do occur and others of concern are found in the area.

Snow grooming and skiing itself can cause direct on-going physical damage to plant life, compounding current environmental stressors (Fahey and Wardle 1998, Rixen et al. 2003). A species shift away from fragile plant forms such as tall, leafy and succulent herbs or low-growing plants with brittle, woody stems towards shorter plants with flexible stems growing in mats or tuft (e.g. grasses) can be anticipated as a result of repeated physical damage (Cole 1985). Hamilton (1981) found that rock tundra communities on raised convex sites were the vegetation communities most susceptible to physical damage at Marmot Basin.

Snow depth is a key factor in the mechanical protection of vegetation and can be enhanced through snowmaking (Fahey and Wardle 1998, Rixen et al. 2003). The use of snowmaking additives may enhance the effectiveness of snowmaking systems, result in a less dense snowpack and optimize the use of water minimizing impacts on aquatic and riparian vegetation (see also section 8.6)(Walker and Wilkinson 1999). Artificial snow however also delays spring snowmelt and can effectively shorten the growing season. This may result in a species shift in some areas from "wind edge" species that favor low snow cover and low temperature environments towards "snowbed" species that favor long lasting snow cover and a short snow free period (Rixen et al. 2003).

Impacts to native vegetation occur as a result of development, and long term operational activity and visitor use (Hamilton 1981). The one-time impacts of physical development are followed by impacts to vegetation that result from on-going operational activities such as snowmaking and grooming and skier activity. Impacts of operational activity may be especially relevant during early season and low snow years when snow cover may not provide adequate protection to underlying vegetation.

Climate change may cause shifts in native vegetation over time. Plants that occupy ecological transition zones or specific climatically controlled niches may be subject to additional stress due to changing climate conditions, or conditions may be potentially enhanced. In combination with the interacting effects of snowmaking and grooming it is difficult to speculate on the potential impacts of climate change on native vegetation.

8.1.3 Knowledge deficiencies

Detailed knowledge describing the location and characteristics of populations of non-native plant species, particularly aggressive species, within the ski area boundary is not available to guide environmental management, operational and development activities.

An evaluation of naturally occurring patterns of vegetation at a scale relevant to ski area management is needed to guide the design and development of ski runs and glades.

8.1.4 Mitigating Measures

The mitigations for impacts on native vegetation identify ecological management parameters, future planning and/or operational requirements, or future knowledge requirements that are needed to realize expected ecological outcomes as outlined in Section 4.4. The expected ecological outcomes that apply to mitigating potential impacts to native vegetation diversity include:

- vegetation composition and structure are characteristic of the natural region
- vegetation composition and structure function as habitat for a range of native species
- locally sensitive or valued vegetation communities and terrain features continue to persist
- invasive, non-native species are not introduced or allowed to persist.

In order to realize expected ecological outcomes important to native vegetation diversity the following ecological management parameters have been incorporated into the Site Guidelines:

- native species and communities dominate vegetation throughout the ski area
- plant communities reflect regional and local vegetation diversity
- glading and thinning simulate native vegetation succession and support the role of fire (see also Section 8.4)
- native vegetation serves as an anchor against soil and terrain erosion.

Additional planning and operational requirements are identified to ensure that expected ecological outcomes are realized. These should be included as part of future planning proposals or management initiatives as indicated:

- long range plans and environmental assessments are to consider the need for alternative tree removal practices such as cable or helicopter logging that protect anchoring vegetation, retain existing ground cover vegetation, and minimize the need for ground disturbance and reclamation
- long range plans and environmental assessments are to consider alternate run and terrain park design and location that minimize the need for the removal of existing ground cover and terrain modification
- best management practices are to address vegetation and soils salvage, reclamation, and invasive species control measures consistent with Park objectives for maintaining or restoring native biodiversity
- best management practices are to develop specific criteria for glading and thinning
- best management practices are to address operational requirements related to snow cover protection during skiing and grooming activities.
- specific glading and thinning proposals are to be included as part of the run improvement and vegetation management strategy and submitted as part of a long range plan.

Additional knowledge requirements to provide future development and environmental protection decisions with objective information and sound science include:

- run improvement and vegetation management strategy to include identification of known invasive plant species locations; if necessary eradication strategies are to be included as part of the ski area environmental management system
- a spatial analysis of other diverse, fragmented, naturally occurring areas such as subalpine slopes subject to frequent avalanche disturbance should be used to inform design criteria for glade and ski run development and be included in the run improvement and vegetation management strategy.

8.1.5 Residual and Cumulative Effects

The modification of vegetation cover is an inherent part of ski area development and residual impacts to native vegetation diversity are unavoidable. The suite of mitigation measures however, is intended to ensure that native vegetation diversity persists within a range of variability that continues to support local flora and fauna while mimicking structural patterns that may be found in the natural environment. While vegetation composition and structure will change, it is anticipated that expected ecological outcomes will be realized.

The overall footprint and pattern of vegetation modification will change across and beyond the current ski area leasehold into areas managed under a License of Occupation. Overall the site guidelines allow for an increase in the developed area of approximately 76 hectares and an increase in ski terrain of approximately 57 ha. On a regional scale, impacts to native vegetation diversity are minimal. Less than .01% of the alpine and subalpine ecoregions in the Park is affected by the increase in the developed area.

The Site Guidelines allow for an overall increase in the intensity of ski area use from the current capacity of 4600 skiers to a potential design capacity of 6500, a potential increase of approximately 30%. However there is no certainty that increased skier, grooming and snowmaking activity will result in increased impacts to vegetation in already developed areas. Mitigations, including the development of best management practices that focus on minimizing original development disturbance and maintaining adequate snow cover in sensitive areas, are expected to minimize the potential for long term impairment of vegetation communities or terrain features.

The Site Guidelines include the potential for new and enhanced glading. By simulating the patterns of successional change, mitigations addressing glading promote vegetation structure that is characteristic of the natural region and serves as habitat for a variety of native species. To some degree glading may simulate the effects of natural processes such as fire and avalanche that must be controlled in a ski area setting.

The potential Knob chairlift extension and the potential development of the Rockgardens area, proposals identified as exceptions in the Site Guidelines, extend potential impacts to native vegetation diversity into areas that have for the most part remained undisturbed. The potential Rockgardens development involves vegetation clearing over approximately 13 hectares including the beginner's area and the cross country ski trail system. Direct impacts to vegetation related to potential construction of the Knob chairlift extension are minimal, associated primarily with the footprint of ski lift construction. In both cases potential on-going impacts to vegetation will occur as a

result on on-going compaction and direct impacts of skiing and grooming as discussed above. The mitigations address potential issues related to ski run construction and reclamation, and are expected to result in a pattern of vegetation structure and composition characteristic of other naturally diverse and fragmented areas in the region.

The potential development of a lower lift line terrain park and a mid-mountain snowmaking reservoir proposed as exceptions in the Site Guidelines occur within areas that have been previously modified. Potential impacts related to the potential terrain park are expected to correspond to that described above. The potential development of a snowmaking reservoir will result in the permanent loss of a minimal amount of subalpine forest and riparian vegetation. These potential initiatives have little potential to affect the expected ecological outcomes related to native vegetation diversity. The site-specific implications of these potential initiatives on native vegetation diversity will be addressed further through the long range planning process.

In summary, it is recognized that potential ski area development, if advanced, will result in changes to vegetation structure and composition at the local scale. With the implementation of the suite of mitigations however, it is expected that ecological outcomes pertaining to native vegetation diversity will be realized.

8.2 Rare/Sensitive Species and Communities

8.2.1 Current status

Several vegetation types or species are considered particularly sensitive or rare within bounds of the Marmot Basin ski development as discussed below.

High elevation dwarf shrub (L4, L5 and L7) and mountain avens (H1) plant communities as described by Achuff (Holland and Coen 1983) are significant, closely related vegetation types of upper subalpine and alpine ecoregions. Dwarf shrub sites are dominated by brittle, low-growing (0.1 – 0.5m) shrubs such as mountain heathers and arctic willow, and herbaceous plants. Mountain avens sites are dominated by Dryas octopetala, snow willow, and various herbs and grasses or sedges. These plant communities grow on and stabilize mesic erosion-prone soils on sloping moraine or fluvial landforms (Holland and Coen 1983). Dwarf shrub communities provide important habitat for many species of birds and small mammals, including prey species for grizzly bears, while mountain avens sites are a key forage resources for goats.

Seepage and riparian plant communities are an important component of the subalpine and alpine vegetation mosaic. They include H16, H9, and H2 (Holland and Coen 1983), are found along the channels of permanent or intermittent streams and seasonal or permanent seepages, and are dominated by herbaceous plants and bryoids. Specially adapted to moist sites, they stabilize erosion-prone soils and anchor surrounding vegetation/habitats.

A large sedge fen with two ponds is located north of the upper parking lots outside of the ski area lease boundary. The fen is sustained by subsurface flows from a small

drainage immediately above the site (Leeson 1986). Development activities within this drainage between the Caribou Chairlift and the slopes draining into Whistlers Creek may have implications for aquifer sustainability and consequences to the fen habitat.

Saxicolous Lichen Communities (H12) are a unique alpine vegetation type dominated by low-growing herbs and lichens (e.g. Cetraria, Cladonia, Rhizocarpon). This community is generally found on dryer alpine areas with poorly developed soils or non-soil.

Rare plants, plant communities and ecosites are features that may have regional or provincial significance. The Eagle Ridge Comprehensive Study Report identified a total of eight, and possibly nine, vascular plant species classified as provincially rare and three species on the ANHIC watch list in this portion of the Marmot ski development. These included one-headed everlasting, Lapland reed grass, lens-fruited sedge, tiny-flowered fescue, alpine gentian, alpine sweet grass, alpine fir-moss and whitebark pine. Their presence in the larger ski area development has not been investigated. Other rare plants are also found, but SARA listed species are not known to occur within the Marmot Basin leasehold.

Some rare or sensitive species may not readily re-grow or recolonize when growing sites are disturbed. Because of their inherent sensitivity to localized microclimatic and abiotic characteristics rare species may not be readily transplanted with confidence of success. Reclamation or restoration of an entire community would involve complex ecological interactions and relationships that may not be studied or well understood.

Because of this potential sensitivity and complexity, actual site protection may be important to ensuring the long-term survival of particular species and communities. Considerations for site protection should be extended to include important ecosystem structure and functional characteristics such as water sources, shade trees or sun exposure, snow cover insulation, and soil types.

8.2.2 Existing and Potential Interactions and Impacts

Potential ski area development activities contemplated in the Site Guidelines that were considered to have potential strategic implications for rare/sensitive species and communities include:

- the potential development and modification of ski terrain
- the potential development and operation of snowmaking and water systems including the construction and operation of the mid-mountain water reservoir
- potential expansion of snowmaking and grooming operations.

The sensitive communities and species described above may occur in isolated, discrete locations where structural and functional ecological characteristics are suited to the establishment and sustainability of the community or population. Ski area development activities related to construction or terrain development may directly damage or destroy sensitive site locations. Alternatively, ski area development, use and operations may indirectly affect sensitive sites through the alteration, disruption or destruction of supporting ecosystem structural or functional characteristics such as water sources, shade trees or sun exposure, or snow cover insulation.

Rare plant surveys have been typically conducted for most past ski area development activities at Marmot Basin and direct impacts to known locations have been avoided or mitigated. Potential on-going operational impacts could include damage to sensitive sites in low snow cover conditions by skiers and grooming equipment.

The potential construction and design of the mid-mountain reservoir has implications for the sustainability of downstream water flow and dependent riparian communities. Reservoir design or water use patterns that disrupt seasonal variation in flow may adversely affect riparian plant communities and associated wildlife (see also Section 8.7). Potential development activities in the shallow bowl above the fen may adversely affect water flow or quality of water supporting fen vegetation and wildlife.

8.2.3 Knowledge deficiencies

Surveys for rare plants and sensitive communities carried out in the past have been related to specific proposed projects and have focused on potential development sites. There is no survey information or locations of rare or sensitive species for the complete ski area leasehold.

8.2.4 Mitigating Measures

The mitigations for rare/sensitive species and communities identify ecological management parameters, future planning and/or operational requirements, or future knowledge requirements that are needed to realize expected ecological outcomes as outlined in Section 4.4. The expected ecological outcomes that apply to mitigating potential impacts to rare/sensitive species and communities include:

- vegetation composition and structure are characteristic of the natural region
- vegetation composition and structure function as habitat for a range of native species
- locally sensitive or valued vegetation communities and terrain features continue to persist
- terrestrial and aquatic ecosystem processes function within the natural range of variation.

In order to realize expected ecological outcomes important to rare/sensitive species and communities the following ecological management parameters have been incorporated into the Site Guidelines:

- rare and sensitive vegetation communities and terrain features persist
- habitat for rare or sensitive species is maintained
- flooding and seasonal flow patterns maintain riparian vegetation.

Additional planning and operational requirements are identified to ensure that expected ecological outcomes are realized. These should be included as part of future planning proposals or management initiatives as indicated:

- riparian community water requirements are to be addressed in the water management strategy and environmental management systems developed for long range plans

- locations of rare/sensitive species are to be mapped and managed so that potential impacts can be avoided and monitored as part of the vegetation management strategy and environmental management systems.

Additional knowledge requirements are also identified to ensure that future development and environmental protection decisions are based on objective information and sound science. These include:

- survey of sensitive plant species and communities should be required background information prior to the consideration of any construction, terrain, or vegetation modification proposals – information collected should be added to the rare/sensitive species map database.

8.2.5 Residual and Cumulative Effects

The mitigations for rare and sensitive species and communities are focused on avoiding direct impacts to sensitive sites including their supporting ecosystem structural and functional characteristics. Direct impacts to sensitive sites as a result of potential construction or modification will be controlled through mitigations that apply to the location and design of ski area developments.

Operational impacts to sensitive sites will be addressed through consideration in the run improvement and vegetation management strategy, water management strategy, environmental management systems and best management practices. It may be reasonable to expect however that operational impacts may be imperfectly controlled. Sensitive sites may be difficult to mark or to control in the winter and some vegetation damage may occur. Identification and monitoring of sites that are most likely exposed to operational impacts will allow for operational adjustments to be made in the event that environmental protection practices are not effective.

By effectively protecting sensitive species and communities from construction, terrain and vegetation modification as outlined in the mitigations, vegetation composition and structure characteristic of the natural region is maintained at local and regional scales. The protection of supporting structural and functional characteristic associated with sensitive sites ensures that ecosystem processes at small scales relevant to rare and sensitive species and associated wildlife continue to function within the natural range of variation.

Should it be advanced, the design of the mid mountain reservoir to account for seasonal flows and consideration of flow regime management in the water management strategy and environmental management system ensures that the riparian system continues to function within the natural range of variation.

The limitations and parameters imposed on potential development combined with the successful implementation of mitigations are expected to address potential cumulative effects and realize the expected ecological outcomes that pertain to rare/sensitive species and communities.

8.3 Small Mammal Habitat Structure

8.3.1 Current Status

Many small mammal species are found throughout the park. Table 1 summarizes a list of species that are likely to occur within the Marmot Basin area. Each of these species is considered common and widespread throughout the park. No species were identified that were considered to be at risk or vulnerable to ski area development activities.

As summarized in the table, some species select closed canopy forests while others select for open canopy. Some species are niche specialists selecting habitats with particular characteristics while others are generalists and use a wide variety of habitat types. Particular sites such as locations of pika and ground squirrel colonies can be important for some specialist species. The golden mantled ground squirrel selects for rocky outcrops within forests while others may select wet meadows or rockslides.

At the regional scale vegetation cover in the subalpine has historically been characterized by more open canopy and early successional stages of forest development (see also sections 8.1 and 8.4). The current state of subalpine forest in the park has been promoted by fire suppression strategies and the resulting habitat characteristics generally favor species that select for contiguous closed canopy forest cover.

At the local scale vegetation cover and habitat within the ski area leasehold has been fragmented by the development of ski runs and altered through glading and vegetation control on developed ski runs. The resulting vegetation and habitat characteristics are not representative of the current mature state of the subalpine forest. Neither is forest fragmentation at the ski area scale characteristic of the historic fire-maintained landscape which would have resulted in large scale, stand-replacing fires. Although there are differences, the pattern of vegetation and resulting habitat structure at the ski area is most similar to subalpine areas that are naturally fragmented and frequently disturbed by avalanche activity. Reference sites can be found on nearby Whistlers and Lectern peaks.

Table 1: Small Mammal Habitat Preference

Common name	Latin name	Maximum Elevation	Canopy Preference	Niche Breadth	Habitat
Red backed vole	Clethrionomys gapperi	2300	Closed	Specialist	Mature forests of all kinds
Porcupine	Erithizon dorsatum	2100	Closed	Generalist	Forests and sometimes alpine
Least chipmunk	Eutamias minimus	2100	Both	Generalist	
Northern flying squirrel	Glaucomys sabrinus	2100	Closed	Specialist	Closed to semi-open forest
Hoary Marmot	Marmota caligata	2600	Open	Specialist	Rock slides, meadows
Long tailed vole	Microtus longicaudus	2300	Open	Specialist	Wet meadows
Meadow vole	Microtus pennsylvanicus	2300	Open	Specialist	Wet meadows
Water Vole	Microtus richardsoni	2400	Open	Specialist	Wet Meadows
Bushy tailed woodrat	Neotoma cinerea	2200	Both	?	Rock slides, cliffs
Pika	Ochotona princeps	2300	Open	Specialist	Alpine meadows, grass
Deer mouse	Peromyscus maniculatus	2100	Both	Generalist	Almost anything, but mostly low shrubby forests
Heather vole	Phenacomys intermedius	2300	Both	Generalist	Almost anything
Masked shrew	Sorex cinereus	2100	Closed	Generalist	Near water, most forest types
Water Shrew	Sorex palustris	2100			Near water, most forest types
Vagrant Shrew	Sorex vagrans	2100	Closed	Generalist	In or near creeks
Columbian ground squirrel	Spermophilus columbianus	2300	Open	Generalist	Mostly treeless patches
Golden mantled ground squirrel	Spermophilus lateralis	2300	Open	Specialist	Rocky outcrops in forests
Northern bog lemming	Synaptomys borealis	2300	Open	Specialist	Wet meadows
Red squirrel	Tamiasciurus hudsonicus	2300	Closed	Specialist	Mature conifer forests
Western jumping mouse	Zapus princeps	2300	Both	Generalist	Almost anything

8.3.2 Existing and Potential Interactions and Impacts

Potential ski area development activities contemplated in the Site Guidelines that have strategic implications for small mammal habitat structure include:

- potential expansion and modification of ski terrain
- potential facility construction including lifts, buildings, trails, roads and parking lots
- potential development and operation of snowmaking and water systems including the construction and operation of the mid-mountain water reservoir
- potential expansion of snowmaking and grooming operations.

The development of ski terrain generally involves the removal and modification of vegetation and may involve physical terrain modification with implications for soil, underlying parent material and water. Along with direct impacts to valued resources, ski area development may contribute to habitat fragmentation, widely recognized as a leading cause in the loss of biological diversity (Wilcox and Murphy 1985; Saunders et al. 1991; Davies et al. 2001, in Percy 2006). Habitat fragmentation may result in a reduction in habitat effectiveness, destruction of daily movement and long-distance dispersal routes, a disturbance of predator/prey relationships, direct mortality and shifts in habitat-use patterns (Percy 2006). The width of ski runs, the patch size in between runs and the overall footprint and pattern of development are key considerations with respect to the level of fragmentation imposed by ski area development.

It is expected that forest patch size suitable for small mammal predators such as lynx and pine marten will serve as effective habitat for small mammals themselves. Canada lynx and pine marten are small mammal predators both of which may be sensitive to fragmentation in forest cover (see also section 8.12). Pine marten are acknowledged to be among the most habitat-specific forest carnivore species in North America and may be an excellent forest carnivore indicator species due to its sensitivity to habitat fragmentation (Kirk 2006).

Openings in forest cover greater than 90-100 metres are generally avoided by lynx but openings less than this are crossed (Koehler 1990, Brittell et al 1989). Similarly, Pine marten typically avoid openings in forest cover greater than 100metres (Hargis et al. 1999). Ski area development that results in openings greater than 100m may result in disruption of predator/prey relationships, daily movement patterns and long distance dispersal of small mammals and prey species.

In general lynx require a mosaic of successional forest stages to meet foraging and denning requirements (see also section 8.12). Forest units managed for lynx in the Pacific Northwest are recommended to be 8-16 hectares in size and contiguous with respect to the maximum 90-100m crossing distance (Kohler and Brittell 1990, Brittell et al 1989). Pine marten have been shown to respond negatively to overall forest habitat fragmentation. Pine marten habitat use decreases in landscapes with > 25% of non-forest cover, with the increasing proximity of open areas, and the increasing extent of high-contrast edges (Hargis et al. 1999).

Most of the forest patches within the lower developed area are currently smaller than the 8-16 hectares recommended above. Many of the forested patches are also long and narrow with little interior habitat. The vegetation cover mosaic on the lower part of the ski area (below Eagle Chalet) is currently 65.5% cleared (including ski runs, parking lots and operational areas) while 34.5% remains in natural forest cover. As a result, the current pattern of ski area development favors edge species over interior forest species. Ski area development along the same pattern can be expected to further degrade habitat for interior forest species.

Ski terrain development and vegetation management practices may result in on-going impacts to remaining small mammal habitat structure. Coarse woody debris, snags and legacy trees that provide habitat may be removed as part of ski terrain development and management. Disposal practices for cleared forest debris could enhance or reduce habitat suitability for small mammals and insects. Mowing or brushing of vegetation on ungroomed ski terrain impacts the vertical structure of native vegetation with the potential of reducing movement and hiding cover for some species. Glading practices can result in the creation of an artificial forest structure with little vegetation understory or habitat structure. Windthrow of desired residual trees can be an effect of forest clearing and run development practices (see also section 9.0).

Facilities development can result in direct impacts to small mammal habitat if construction takes place in areas that are important to specialist species such as pika or ground squirrel colonies, rocky outcrops, wet meadows, riparian areas and seeps.

The potential impacts of snowmaking and grooming activities are also discussed in sections 8.1, 8.5 and 8.6. Snow grooming and compaction by skiers and snow vehicles have negative impacts on vegetation and soils that may in turn influence small mammals. Briefly reviewed, snow compaction may result in direct damage to vegetation and soils, a decrease in soils temperatures, increased frost and ice formation, gradual changes in plant composition, and delayed spring melt and runoff (Fahey and Wardle 1998, Rixen et al. 2004). These changes could have impacts to small mammal habitat including:

- shortened growing season for foraging and gathering
- increase or decrease in herbaceous forage and cover for selected species
- restriction of sub-nivean movement by small mammals and carnivores as a result of increased ice formation and snow density
- changing abiotic conditions including temperature, oxygen levels, water content, and frost penetration.

It is generally accepted that disturbance to soils and vegetation by snow compaction is reduced as snowpack depths increase and that snow compaction has the greatest impacts when snow cover is low such as early or late in the ski season or in the vicinity of hummocks or convex slopes where soils and vegetation are more exposed by wind erosion (Fahey and Wardle 1998). Snowmaking may mitigate some, but not all, of these impacts by contributing to adequate protective snow depth (Rixen et al. 2003, Walker and Wilkinson 1999) early and late in the season and on exposed hummocks or ridge crests. The use of snowmaking additives may further contribute to protection by

decreasing the overall density of the snowpack. Snow additives have not been shown to have adverse animal or human health impacts (see also section 8.6).

Snowmaking and grooming typically take place after opening hours. Noise and light from snow-making and grooming operations may deter activity by nocturnal species.

8.3.3 Knowledge deficiencies

Specific studies on the impacts on snowmaking and grooming on sub-nivean wildlife in the Rocky mountain natural region are lacking and impacts can only be inferred from potential effects to vegetation.

8.3.4 Mitigating Measures

The mitigations for small mammal habitat structure identify ecological management parameters, future planning and/or operational requirements, or future knowledge requirements that are needed to realize expected ecological outcomes as outlined in Section 4.4. The expected ecological outcomes that apply to mitigating potential impacts to small mammal habitat structure include:

- vegetation composition and structure are characteristic of the natural region
- vegetation composition and structure function as habitat for a range of native species.
- locally sensitive or valued vegetation communities and terrain features continue to persist.

Design parameters for ski run width, distance between runs and ratio of developed/undeveloped area that are important to the skier visitor experience are discussed in section 9.2. The design parameters that address visitor experience are less than, or similar to, parameters that would be required to maintain small mammal habitat structure. As a precautionary approach the more conservative ski industry parameters have been applied as the parameters for conserving small mammal habitat.

It is anticipated that parameters that address the requirements of lynx and pine marten will also address the needs of other small mammals. In order to realize expected ecological outcomes important to small mammal habitat structure the following ecological management parameters, to be applied to new runs, or run modification proposals, have been incorporated into the Site Guidelines:

- the maximum run width is 50 metres
- the existing "base" area clearing is limited to the current 6 hectares.
- additional clearings for specialized sites does not exceed 75 metres in width or 3 hectares in area.
- on either side of runs, a strip of contiguous forest at least as wide as the run remains.
- forest areas between runs are irregular in shape and cover a minimum of 8 hectares
- additional vegetation clearing below Eagle Chalet will ensure that a minimum of 65% of natural forest cover is retained.

The following ecological management parameters are to apply to all ski terrain and facility development proposals:

- construction and modification of vegetation and terrain does not impair habitat important to small mammals.

Additional planning and operational requirements are identified to ensure that expected ecological outcomes are realized. These should be included as part of future planning proposals or management initiatives as indicated:

- vegetation management strategy and best practices to address minimum snow depth targets before grooming or skiing can take place (see also section 8.1).

Additional knowledge requirements are also identified to ensure that future development and environmental protection decisions are based on objective information and sound science. These include:

- the results of monitoring for the interim snowmaking project are to be included in the water management strategy and environmental management system included as part of the long range plan (see also section 8.7) addressing potential implications to vegetation and wildlife health
- identification of specific sites important to small mammals should be required background information prior to the consideration of any construction, terrain, or vegetation modification proposals

8.3.5 Residual and Cumulative Effects

The suite of mitigations for small mammal habitat structure are intended to maintain structural characteristics that support a range of wildlife species as consistent as possible with naturally fragmented and frequently disturbed subalpine sites. The mitigations here do not stand alone, but must be viewed in concert with the mitigations for native vegetation diversity, rare and sensitive vegetation, historic fire regime and other valued components of ecological integrity.

Potential ski area development as contemplated in the Site Guidelines can be expected to result in additional impacts to forest interior wildlife species at the local scale should proposals be advanced. In contrast, species that favor open habitats mature forest and edge environments will benefit from vegetation management practices that create habitat diversity and maintain a mosaic of successional stages. While ski area development may be carried out in a fashion that is consistent with park management objectives for restoring historic successional diversity, it should be noted that ski area development will always be only a partial approximation of natural conditions.

Snow compaction and grooming, snow vehicle and skiing activities will continue to impact underlying vegetation and subnivean habitat. These impacts are only partially mitigated by snowmaking. Snow compaction is not expected to result in the complete displacement of small mammal species at the local scale but could be reasonably expected to affect species abundance and distribution.

Small mammal habitat structure is not affected at a regional scale by potential ski area development as contemplated in the Site Guidelines. Species found at the ski area are not sensitive or threatened in a regional ecosystem. The ski area leasehold represents a small proportion of subalpine ecosites found throughout the park. Parameters for run width, patch size and the pattern of developed to undeveloped terrain are conservative and intended to prevent the absolute exclusion of interior forest species from the ski area leasehold.

The limitations and parameters imposed on potential development combined with the successful implementation of mitigations are expected to address potential cumulative effects and realize the expected ecological outcomes that pertain to small mammal habitat structure. Sensitive sites will be identified and protected and a range of species and habitats will be maintained that is consistent with natural patterns of structural and successional diversity.

8.4 Historic Fire Regime

8.4.1 Current status

Natural disturbance processes act over time and space to define the pattern of vegetation types, forest ages, and wildlife habitat across regional and local landscapes. The most important of these disturbances is the historical regime of fire, as defined by the frequency, size, intensity, severity, pattern, and ignition source of fires.

Many studies (e.g. Tande 1977, Cornelson 1988, Van Wagner 1995, Andison 2000) contribute to the knowledge of fire history in the landscape that includes and surrounds Marmot Basin ski area. Regionally, the long-term fire regime is characterized by frequent low intensity (stand maintaining) surface fires in adjacent, lower elevation Montane areas, and by less frequent high intensity (stand replacing) crown fires in more expansive sub-alpine ecoregions. Humans and lightning have contributed ignitions to this ecosystem for over 10,000 years. A compilation of fire history studies in the Alberta Rocky Mountains (Achuff et al. 2001) calculated a long term average annual burn area of nearly 42 square kilometers (4,163 hectares) for Jasper National Park, and fire cycles that ranged from 10 to 350 years in various vegetation types.

Early park policies (1930 – 1988+) promoting fire suppression were effective. They resulted in a theoretical fire cycle of almost 3000 years (Westhaver 2002) which represents a low rate of burning that is historically unprecedented. The impacts of the recent fire "free" period on vegetation are dramatic. Investigations by Andison (2000) show that the amount of Montane forest older than 100 years has nearly quadrupled from 21% to 78% over the past 65 years. Lack of disturbance by fire has resulted in changes to vegetation structure and loss of vegetation (habitat) diversity through processes known as forest "in-growth" (i.e., when the density of young trees greatly increases in the understory of open forest stands), and "forest encroachment" (i.e., when trees colonize open areas or take over grasslands) (Risbrudt 1995). Rhemtulla (1999) and Mitchell (2005) documented losses of 60 percent of grasslands and conversion of more than 70 percent of open forest to closed forest during the fire suppression era. Studies in other American locations support these observations, for example Covington and Moore (1994).

From a fire protection perspective, these conditions result in increased fuel loads, increased horizontal and vertical continuity of fuel (e.g., significant increases in mid-level "ladder" fuels that help lift fire into the crowns), and enhanced probability of uncontrollable crown fires due to increased canopy volume and continuity (Mutch (1994, Daigle 1996, Graham et al. 2004, Scott and Reinhardt 2001).

Given the above, Parks Canada has concluded that the current fire regime and subsequently, the condition of forest vegetation, are significantly outside the historical ranges of variation (Westhaver and Achuff 2000). Parks Canada has also recognized that fire must be actively restored to park lands, but that risks to developed areas must be ameliorated (Parks Canada 2000).

Concentrations of park amenities, including Marmot Basin, affect decisions on the management of ecological (fire) restoration in Park ecosystems. In order to protect facilities such as the ski area from wildfire, park managers continue to exclude fire from a large area surrounding these "values at risk" (Fenton and Wallace 1978, Kubian 1999). Wildfire risk to the ski area currently results in a fire suppression strategy within a radius of more than 10km beyond the ski area boundary.

8.4.2 Existing and Potential Interactions and Impacts

Potential ski area development activities contemplated in the Site Guidelines that have strategic implications for the historic fire regime include:

- potential development and modification of ski terrain including the Rockgardens development
- potential construction of ski area infrastructure including buildings, lifts and other facilities.

The potential threat to facilities and the lack of alternate risk reduction strategies, particularly at Marmot Basin, perpetuate the requirement for continued fire exclusion in the upper and middle Athabasca drainage resulting in adverse impacts to the regional fire regime and to regional ecosystems. It is expected that full suppression of fire within the ski area will continue. However, planning ski area development to minimize the risk of wildfire losses with respect to vegetation, infra-structure and facilities may provide an opportunity to help restore the regional fire regime.

Disturbance rates by fire, forest age, and activity levels of various forest insects and disease are inseparably tied. That is, lowered disturbance rates due to lack of wildfire result in increasing levels of insect and disease activity. Of particular concern to long-term ecological and aesthetic conditions within the ski area, is the mountain pine beetle. Although the time or extent of impacts by this species cannot be forecast specifically, it can be reasonably predicted that impacts will be worsened if regional fire regimes are not restored. These concerns are compounded by the effects of global climate warming.

8.4.3 Knowledge deficiencies

A comprehensive wildfire hazard assessment and risk management strategy to outline appropriate fuel management, infrastructure, building designs, and wildfire preparedness activities has not been prepared for the Marmot Basin ski development.

8.4.4 Mitigating Measures

The mitigations for historic fire regime identify ecological management parameters, future planning and/or operational requirements, or future knowledge requirements that are needed to realize expected ecological outcomes as outlined in Section 4.4. The

expected ecological outcomes that apply to mitigating potential impacts to the historic fire regime include:

- vegetation composition and structure are characteristic of the natural region
- vegetation composition and structure function as habitat for a range of native species
- terrestrial and aquatic ecosystem processes function within the natural range of variation.

In order to realize expected ecological outcomes important to restoring the historic fire regime the following ecological management parameter has been incorporated into the Site Guidelines:

- vegetation management and facility design support the restoration of fire as a natural process.

Additional planning and operational requirements are identified to ensure that expected ecological outcomes are realized. These should be included as part of future planning proposals or management initiatives as indicated:

- long range plans are to include the application of "FireSmart" principles and consideration of fire suppression planning into ski area development proposals for vegetation management, infrastructure and facility design
- run development, glading and vegetation management strategies are to consider maintaining a mosaic of forest class structure reflective of conditions supported by the historic fire regime (see also Section 8.1).

No additional knowledge requirements have been identified as part of the SEA.

8.4.5 Residual and Cumulative Effects

The mitigations for the historic fire regime focus on restoration of the regional fire regime and reducing wildfire risk to the ski area itself. Implementation of Firesmart principles will potentially reduce the need for fire suppression strategies in the surrounding region and allow for the potential restoration of the historic fire regime. Consideration for simulating the historic mosaic of forest age classes within the ski area will contribute to local ecosystem structure and habitat conditions that are more characteristic of the natural region. Coordination of fuel management and fire suppression planning with run clearing, glading, and snowmaking/water storage development may address multiple ecological objectives.

The natural disturbance process of fire is not fully restored by the mitigating measures and fire suppression strategies will still be necessary to protect ski area and other local facilities. The cumulative effect of the mitigations is however a positive improvement over the current situation moving towards the restoration of natural processes, cost effectiveness and public safety. Expected ecological outcomes related to the historic fire regime at both local and regional scales are realized in part by creating the necessary conditions for fire restoration in the regional landscape, and by simulating some effects of fire disturbance within the bounds of the ski area itself.

8.5 Soils and Terrain - Earth Flow Features, Saturated Glacial Till and Soils

8.5.1 Current status

A number of unstable earth flow features are found in the Marmot basin proper as documented by Leeson (1986) including:

- a number of whale-shaped earthflows along Basin creek above timberline
- an unstable slate deposit off the east face of Eagle Ridge
- a rock glacier that originates on Caribou Ridge and extends into Whistlers Creek valley.

These features may be considered to be inherently unstable for construction purposes and may have value as examples and evidence of glacial and geologic mass wasting processes.

Soils at Marmot Basin were initially mapped and described by Holland and Coen (1981) and further described by Leeson (1986). Leeson indicated that saturated soils at Marmot Basin were of particular concern with respect to ski area development. Gleysolic soils are found in ecosystems that are frequently flooded or permanently waterlogged (Agriculture and Agri-Foods Canada, 1996). Gleysols are not the only saturated soils at Marmot Basin but are highlighted here as being indicative of areas where soils may often be saturated and therefore more prone to erosion. Gleysolic soils are found at Marmot Basin associated with:

- CA 1 ecosites encompassing the lower portion of the ski area lease from parking lot 4 to just below Caribou Lodge
- EG 3 and CA1 ecosites in the lower elevations of Whistlers Creek
- PR 3 ecosites below the main ski area and to the south of the current lease boundary.

Marmot Basin ski area is also characterized by glacial till surficial deposits on the lower flanks of Marmot Mountain (Leeson 1986, IRIS 1999). Both soils and unconsolidated glacial tills may be considered to be very unstable when on even moderately sloping terrain, exposed by vegetation removal, and when saturated with water, which in some areas at Marmot Basin can be for much of the year.

8.5.2 Existing and Potential Interactions and Impacts

Potential ski area development activities considered under the Site Guidelines that have strategic implications for soils and terrain include:

- potential development and modification of ski terrain including terrain modification associated with development of the Rockgardens area and the lower liftline terrain park.
- potential construction of buildings, ski lifts and other facilities
- potential expansion and operation of snowmaking and water systems including the potential development of a mid-mountain water reservoir

Construction and modification of earth flow features has been avoided in past developments at Marmot and these features remain intact.

Past construction at Marmot Basin has resulted in the exposure and subsequent erosion of unstable soils and/or underlying surficial materials. Examples of this have been

observed in association with the upper day lodges, the service road to the upper day lodges, on the cuts between parking lots and on the main access road to Marmot Basin from Highway 93A.

Removal of vegetation for the development of ski runs and other facility development has implications for further disturbance of unstable soils and surficial materials. Excavation activities may involve direct disturbance of unstable materials and release groundwater to surface flow, exacerbating potential erosion issues.

The natural flow rates and the physical form of earth flow features are essential to maintaining the value of earth flow features from a scientific and education standpoint. Development that affects the water content, internal friction or loading characteristic of earth flow features may increase the natural flow rates and instability of these features (Leeson, 1986).

The potential proposal for a mid-mountain water reservoir and the lower liftline terrain park both have potential implications for loading of unstable terrain including earthflow features and saturated soils or surficial materials. Maintaining drainage and surface anchoring of unstable surficial materials and soils in areas of vegetation or terrain modification, and excavation is essential to ensuring terrain stability and protection of these and other built facilities.

Potential construction of the Knob Chairlift summit terminus may require leveling that spans the summit ridge and may require a license of occupation for the modification and use of terrain outside of the current leasehold boundary. Other minor terrain modification in the alpine zone is addressed in the Site guidelines including the development of terrain parks. Terrain modification and developments can be considered as a permanent change to the environment due to the difficulty of reclamation. Terrain modification also has implications for aesthetics and visitor experience addressed more fully in Section 9.

8.5.3 Knowledge deficiencies

Detailed maps and evaluations of soils and surficial materials sufficient for the assessment of geotechnical stability at any given development site are not available.

8.5.4 Mitigating Measures

The mitigations for soils and terrain identify ecological management parameters, future planning and/or operational requirements, or future knowledge requirements that are needed to realize expected ecological outcomes as outlined in Section 4.4. The expected ecological outcomes that apply to mitigating potential impacts to soils and terrain include:

- locally sensitive or valued vegetation communities and terrain features continue to persist
- terrestrial and aquatic ecosystem processes function within the natural range of variation.

The Site Guidelines already address parameters for the development of terrain parks or features in the alpine – these are not repeated here. In order to realize expected ecological outcomes important to soils and terrain the following additional ecological management parameters have been incorporated into the Site Guidelines:

- construction and modification to vegetation and terrain do not alter natural flow rates or earth and rock flow features.
- construction, terrain modification and vegetation removal avoid saturated soils or surficial deposits where mitigation measures are unlikely to be successful.

Additional planning and operational requirements are identified to ensure that expected ecological outcomes are realized. These should be included as part of future planning proposals or management initiatives as indicated:

- routine construction and operational impacts to soils and terrain to be addressed in best management practices
- long range plans should consider the need for alternative tree removal practices such as cable or helicopter logging that protect anchoring vegetation in areas of wet or sensitive soils
- stabilization of current erosion sites to be included as part of run improvement and vegetation management strategy and environmental management systems

Additional knowledge requirements are also identified to ensure that future development and environmental protection decisions are based on objective information and sound science. These include:

- geotechnical stability assessments shall be required background information prior to the consideration of any significant construction, terrain, or vegetation modification proposals.

8.5.5 Residual and Cumulative Effects

Construction, terrain modification, or vegetation modification on naturally occurring earth or rock flow features is to be avoided. No residual or cumulative environmental impacts to these features are identified.

The mitigations for saturated glacial tills and soils are intended to avoid the potential impacts of inherently unstable sites on ski area infrastructure, and to prevent mass wasting and persistent erosion. The mitigations address issues of erosion control, drainage, and terrain stability that will be used to inform project planning and design and ski area operations. Some disturbance of soils and surficial materials will occur as a result of project development. However with proper implementation of mitigation, this disturbance is expected to be limited in spatial scope to the immediate vicinity of project sites.

Potential ski area development activities are not expected to result in persistent erosion or mass wasting at local or regional ecological scales or to affect natural drainage, terrain flow or erosion processes. For the most part disturbances are expected to be site-specific, limited in spatial extent, and reversible with proper reclamation efforts.

The impacts of a potential Knob Chairlift extension, in particular a proposed summit terminus, are less likely to be reversible. The need for relatively significant terrain modification combined with snow grooming and skiing activity will inhibit vegetation reclamation. However since the summit area terrain is composed primarily of scree and talus, soil erosion is not expected to be an issue. Earthflow features and saturated soils or tills are not generally suitable sites for lift towers and impacts to these features are not anticipated.

The limitations and parameters imposed on development combined with the successful implementation of mitigations are expected to address the potential cumulative effects to earth flow features, and saturated soils and till and realize the expected ecological outcomes that pertain to soils and terrain.

8.6 Surface and Subsurface Flow Regimes.

8.6.1 Current Status

Within Marmot Basin two intermittent streams lead from the upper alpine basin and converge near the base of the Yellow T-bar. The resulting stream (known locally as "Basin Creek") converges with Whistlers Creek outside of the ski area leasehold. Whistlers Creek drains the slopes extending up to Caribou Ridge and runs for approximately 1.7 km along the northern edge of the lease before leaving the leasehold and draining into the Athabasca River. Besides these primary flows, several diffuse unnamed and unmapped streams form from collecting seeps throughout the sub-alpine. Additionally, some surface runoff, primarily from the east face of Eagle Ridge, drains into Portal Creek. Peak surface flows on the leasehold occur as a result of meltwater runoff during the months of May and June. A large sedge fen containing a shallow pond is located just north of the upper parking lot outside of the ski area leasehold (see also Section 8.2).

Generally, streams are characterized by a diversity of physical habitat types determined by such factors as stream discharge, slope and substrate. This results in alternating patterns of rapids, riffles, runs and pools. Many organisms are only able to exist in the stream in one or more of these habitats types. Maintaining structural diversity is generally considered to be an essential element of a healthy stream course. Streams are also characterized by seasonally variable flow patterns. Both aquatic life and vegetation may be reliant on these flows patterns and volume for completion of life cycles (Richards et al 1993, Tockner and Ward 1999, Arscott et al 2000, Lipori et al 2005). No studies have been completed with respect to the wildlife or aquatic and riparian habitat of Basin creek.

Streams generally also support unique water influenced (riparian) vegetation communities extending out from the water's edge. The magnitude of a stream's riparian zone is regulated by the availability of water. Riparian vegetation helps to provide food and travel corridors for terrestrial wildlife, habitats for aquatic insects and shade for the stream course (Naiman et al 1993, Kondolf et al 1996).

Soils in the Marmot Basin ski area play an important role in capturing, releasing and transporting water from alpine and sub-alpine areas to the valley bottom (Leeson 1986, IRIS, 1998). Though not visible, subsurface flows play a critical role in shaping vegetation communities within and down slope of the leasehold. Subsurface flows also have potential implications for soils and terrain stability (see also Section 8.5).

A large sedge fen with two ponds is located north of the upper parking lots outside of the ski area lease boundary. The fen is sustained by subsurface flows from a small drainage immediately above the site (Leeson 1986). Should they be considered, development activities within the drainage between the Caribou Chair and the slopes draining into Whistlers Creek have implications for aquifer and fen sustainability (see also sections 8.2 and 8.5).

8.6.2 Existing and Potential Interactions and Impacts

Potential ski area development activities contemplated in the Site Guidelines that have strategic implications for surface and subsurface flow regimes include:

- potential development and modification of ski terrain including vegetation
- potential expansion and operation of snowmaking and water systems
- potential construction and operation of a mid-mountain water reservoir.

Excavation of soils for construction or terrain modification may release subsurface flows to the ground surface resulting in increased surface erosion and sediment transport, decreased slope stability, creation of unnatural wet areas on the slope and decreased subsurface flows down-slope of the incursion. Downstream or downslope vegetation communities and associated wildlife may also be directly or indirectly affected (Newcombe and Macdonald 1991) (see also Sections 8.1 and 8.5).

In general ski area development and operational activities have the potential to affect the patterns of storm and meltwater runoff. Removal of vegetation, especially over large areas may result in less water retention on slopes and increased runoff peak flows. Ditching or other surface drainage works have the effect of moving water more quickly out of an area thereby decreasing availability of water to vegetation communities and increasing the intensity of storm and meltwater runoff. Increased sedimentation was identified as a factor in the composition and diversity of stream invertebrates downstream of ski areas in New Mexico (Molles and Gosz 1980).

A portion of Basin Creek's flow is diverted for domestic water use for the ski area as well as for snowmaking operations. These withdrawals decrease downstream flows potentially affecting available habitat for aquatic and riparian vegetation, invertebrates and small mammals although the current magnitude of this potential impact is unknown.

During the winter operational season flows in Basin Creek are lowest while water withdrawals are highest. It is therefore expected that most significant effects on water quantity will occur during ski hill winter operations. Effects can include loss of habitat for aquatic organisms, loss of stream connectivity, deterioration of water quality, alteration of food resources, and changes in the strength and structure of interspecific interactions (Lake 2003).

Once Basin Creek converges with Whistlers Creek outside the ski area leasehold the effect of withdrawals is likely not to have discernable effects as Basin Creek flow represents a relatively small percentage of the total Whistler Creek flow. A portion of the water removed from Basin Creek, which would naturally drain into Whistler Creek, is diverted into the Portal Creek drainage after being released from the wastewater treatment process. The significance of this diversion on flows in Portal Creek is likely minimal however the diversion of water from the Basin Creek drainage for visitor services is never returned to the creek. Some surface drainage on the lower mountain that would normally flow into Basin Creek is captured and diverted by a manmade channel that drains into the wastewater lagoons again reducing volume in the Basin Creek system.

Snow compaction through skiing, grooming and vehicle use may affect seasonal flows in terms of the seasonal timing and rate of release. Snow compaction decreases snow permeability allowing meltwater to pass through more quickly and delays snowmelt in the spring (Fahey and Wardle 1998, Rixen et al. 2004). Aquatic wildlife and vegetation that are reliant on seasonal flow patterns and volume for completion of life cycle requirements may be adversely affected by seemingly minor changes to flow regimes. While the fen site is located off the leasehold, dependent vegetation and wildlife could be impacted if surface drainage patterns are altered upslope on the lease.

The potential expansion of the snow making operation and potential construction of a mid-mountain water reservoir have potential implications for surface and subsurface flows associated with Basin Creek. More water will be intercepted from Basin Creek surface flow to serve the expanded snowmaking system. The Site Guidelines allow for a potential increase in terrain serviced by snowmaking. An increase in the snow pack over a greater area as a result of snowmaking may exacerbate the potential intensity of meltwater runoff, sedimentation and delay spring melt as outlined above. It should be noted that snowmaking has other beneficial impacts to vegetation and subnivean habitats (see sections 8.1 And 8.3) that may offset adverse impacts to stream flow patterns.

Snowmaking additives, such as Snomax, have the potential to significantly increase snow making equipment efficiency and could be employed to reduce the volume of water required to provide adequate snow cover. Use of snowmaking additives may also result in a snowpack with lower density (Walker and Wilkinson 1999) potentially offsetting to some degree the impacts of snow compaction outlined above.

The potential construction of a mid-mountain reservoir or the installation of culverts or other structures covering streams may have potential to disrupt aquatic connectivity and decrease available aquatic habitats throughout the leasehold. Unaltered stream courses provide for both up and downstream movement for aquatic life (Pringle 2001). Although particular species of concern have not been identified for Basin Creek, disrupting stream connectivity has potential to degrade aquatic ecosystem integrity.

8.6.3 Knowledge deficiencies

No information is available on the percentage of water withdrawn from Basin Creek relative to the total water available in the stream. Without this information the determination of how much water could safely be removed from Basin Creek without having deleterious affects on the stream environment is not possible.

No information is currently available on specific species that inhabit aquatic or riparian habitats of Basin Creek or their habitat needs and sensitivities.

Uncertainty with respect to localized climate change effects exist as existing climate model predictions may not be reflected at the scale of the ski area. If early winter season flows were to generally increase, withdrawal affects would be lessened. If early season flows were to generally decrease the effects of any water withdrawals on stream environments would be compounded.

8.6.4 Mitigating Measures

The mitigations for surface and subsurface flow regimes identify ecological management parameters, future planning and/or operational requirements, or future knowledge requirements that are needed to realize expected ecological outcomes as outlined in Section 4.4. The expected ecological outcomes that apply to mitigating potential impacts to surface and subsurface flow regimes include:

- locally sensitive or valued vegetation communities and terrain features continue to persist
- sensitive or valued wildlife is not displaced from habitat essential to regional population sustainability
- terrestrial and aquatic ecosystem processes function within the natural range of variation.

In order to realize expected ecological outcomes important to restoring surface and subsurface flow regimes the following ecological management parameters have been incorporated into the Site Guidelines:

- development does not compromise natural surface and subsurface connectivity and drainage
- minimum in-stream flows support aquatic wildlife taking seasonal variability into account
- flooding and seasonal flow patterns maintain riparian vegetation.

Additional planning and operational requirements are identified to ensure that expected ecological outcomes are realized. These should be included as part of future planning proposals or management initiatives as indicated:

- design of a potential mid-mountain reservoir allows for seasonal variations in downstream water flow that correspond to the needs of riparian communities
- water management strategy, best management practices and environmental management systems to collectively address the potential impacts related to needs analysis, in-stream flow volumes, seasonal flow patterns, natural drainage patterns and erosion/sedimentation

- on-hill drainage channels that divert water from the Basin Creek system should be identified and modified to restore natural downstream flows to Basin Creek as part of the water management strategy
- the use of snowmaking additives may be considered as part of the water management strategies and environmental management system
- long range plans to address the potential impacts of climate change on water availability and hydrologic regimes specific to Marmot Basin.

Visitor education is an important component of gaining visitor cooperation and contribution towards achieving ecological management parameters pertaining to water flows. The following educational goals should be addressed in a visitor education program to be brought forward as part of the long range planning process:
Visitors are informed of the potential impacts associated with water use and are encouraged to support water conservation measures.

Additional knowledge requirements are also identified to ensure that future development and environmental protection decisions are based on objective information and sound science. These include:

- hydrological studies to determine flow volumes of stream and groundwater sources is required as background to the water management strategy
- investigation into aquatic and riparian wildlife biota to determine habitat needs and limitations is required as background to the water management strategy.

8.6.5 Residual and Cumulative Effects

The mitigations for surface/subsurface water flows are intended to maintain and restore the natural variability in flow and to maintain minimum in-stream flows that support aquatic and riparian flora and fauna.

Some water of course is withdrawn, used and returned to the hydrological system. The design of water collection systems including the potential mid-mountain reservoir is to focus on designs allowing for seasonal levels and variation in surface flows in Basin Creek. Potential alternatives such as the use of snowmaking additives may be considered to maximize the efficiency of water use. An objective needs analysis and hydrological assessment will provide the necessary background to determining minimal flows and identifying additional water source alternatives. As a result the actual withdrawal of water is not expected to impair the structure or process of aquatic or riparian systems.

The timing of water release back into the hydrologic system and alterations to drainage patterns are residual effects of ski area operations. The compaction of snow by grooming and skiing activity will result in the delay, and increase the intensity of, spring runoff. However climate change predictions are for an earlier spring runoff and these two factors may well cancel each other out. Snow making additives if used by the ski area may partially mitigate the intensity of runoff by increasing the porosity of the snowpack. The interplay of these factors will be more fully explored as part of the long range plan.

The diversion of water from the Basin Creek system is perhaps the most important residual impact of ski area operations to consider. All water used for visitor services operations is withdrawn from Basin Creek and released to Portal Creek through the wastewater treatment system. Surface runoff on the lower mountain is also captured and diverted to the Portal Creek watershed. This is unlikely to affect Portal Creek as mentioned previously and is not a regional factor for the Athabasca River flows. However these diversions do potentially result in a downstream flow deficit for the Basin Creek system itself.

To a large degree the potential impacts of water diversion may be mitigated by the design of water collection systems that are designed to allow for natural variations in flow to continue. The identification and restoration of artificial drainage channels that currently divert water from the Basin Creek system will contribute to the restoration of seasonal and in-stream flow regimes and can be expected to mitigate current impacts.

The limitations and parameters imposed on potential ski area development to maintain and restore natural flow and drainage patterns are expected to address potential cumulative effects to surface and subsurface flows at a local scale and realize the expected ecological outcomes that pertain to surface/subsurface flow regimes.

8.7 Water Quality

8.7.1 Current status

The quality of water can be interpreted from its physical, chemical and biological characteristics. Water quality related to the Marmot Ski Area can be viewed as three separate yet connected elements. These are, water quality in the area's natural stream courses and standing waters, water quality related to potable (drinking) water and water quality related to wastewater management practices.

No specific information on the water quality of streams on the Marmot Ski Area is currently available. Waters in the area are generally cold, highly oxygenated and nutrient poor. These conditions persist throughout the year. High-altitude and high-latitude rivers and streams tend to have fewer species, be less productive and are controlled by nutrient concentrations.

Potable water is currently collected from Basin Creek just above the Upper Chalet. There is on-hill water treatment and an underground potable water distribution system to other facilities on the hill. Excess water is released from the stave tank just above the lower chalet either into a drainage ditch or to the wastewater lagoon. Drinking water quality is monitored and reported to the Aspen Regional Health Authority.

The present wastewater treatment process uses holding tanks at the Caribou, Paradise and Eagle chalets to remove solids from the wastewater. The sludge from the holding tanks is transported off-site for treatment and the clarified wastewater is stored in cell #1. Wastewater from the cell is treated using the Hydroxyl system and treated effluent is released to a dry drainage channel once it meets water quality standards. The skim

collected in the Hydroxyl system is disposed of at the Jasper Municipal Wastewater Treatment Plant.

8.7.2 Existing and Potential Interactions and Impacts

Potential ski area development activities contemplated in the Site Guidelines that have strategic implications for water quality include:

- potential expansion of ski area commercial facilities and accompanying wastewater production
- potential development and modification of ski terrain
- ski area operational activities including snowmaking, grooming, vegetation management and commercial operations.

Increased nutrients downslope of the ski area may result from the release of increased wastewater effluent. In nutrient poor rivers the growth of benthic algae is limited by phosphorus concentrations. Slight increases in nutrient concentrations can cause proliferation of benthic algae and an associated reduction in biodiversity. In theory, eutrophication should increase the amount of biomass being produced at all trophic levels. However, less edible algal species often replace more edible species and the realized result of eutrophication (usually caused by additional phosphorus) is frequently lower biodiversity. The elimination of a few key species in northern or alpine aquatic systems could have significant impacts on the functioning of the ecosystem because there is little redundancy in high latitude and high altitude communities (Bowman, 2004).

The potential development and modification of ski terrain may have impacts on water quality related to increased sediment in water due as a result of soil erosion, vegetation removal or damage, ground disturbance or increased seasonal flows as a result of snowmaking. Increased sedimentation can lead to increases in water temperature as well as loss of interstitial habitats. Removal of shading and water withdrawal itself may impact water temperatures affecting aquatic and riparian flora and fauna. These impacts are also addressed in Sections 8.1, 8.5 and 8.6 and will not be addressed further here.

Ski area operations make use of a variety of hazardous and polluting materials. Potential exists for spills or releases of hydrocarbons or other hazardous materials from equipment, storage tanks, operational and commercial areas. Two types of materials with specific ski area applications are worth mentioning due to expressed public interest and concern; Perfluorooctanoic Acid (PFOA) and Fluorinated Telomers and, snowmaking nucleating agents such as Snowmax. Although discussed here, it should be noted that the use of these materials for Marmot Basin operations has not been proposed and the discussion that follows is based on hypothetical use only.

Perfluorooctanoic Acid (PFOA) and Fluorinated Telomers are present in some ski waxes and are also found in non-stick coatings, carpets, Gortex, and thousands of other commercial products. These compounds are persistent in the environment. Their potential for toxicity is unclear (Swedish Chemicals Agency 2006, Betts 2006, Bergfald and Co. 2005) and is currently being reviewed by American and Canadian government authorities including Environment Canada and Health Canada (Environment Canada

2006). Despite uncertainty as to the potential for serious environmental or health effects, these chemicals are voluntarily being phased out by many industrial manufacturers. Non-fluorinated ski waxes alternative are available (Bioglide 2007, Ethica Enviro Wax 2007, Enviro Mountain Sports Inc 2007).

Snow making additives or nucleating agents, such as Snowmax, have been suggested to have potential effects on human and animal health and on vegetation. Research efforts have failed to substantiate these concerns and have demonstrated environmental benefits of reduced water and energy consumption (Walker and Wilkenson 1999, Wallis et al. 1988, Rixen et al. 2003).

8.7.3 Knowledge deficiencies

No information is currently available regarding the physical, chemical and biological baseline characteristics of surface or subsurface water on the ski hill.

No information is available that gauges the affects (if any) of the release of treated effluent into Portal Creek drainage.

8.7.4 Mitigating Measures

The mitigations for water quality identify ecological management parameters, future planning and/or operational requirements, or future knowledge requirements that are needed to realize expected ecological outcomes as outlined in Section 4.4. The expected ecological outcomes that apply to mitigating potential impacts to water quality include:

- terrestrial and aquatic ecosystem processes function within the natural range of variation.

In order to realize expected ecological outcomes important to maintaining or restoring water quality the following ecological management parameter has been incorporated into the Site Guidelines:

- water quality in Portal Creek and the Athabasca River is maintained.

Additional planning and operational requirements are identified to ensure that expected ecological outcomes are realized. These should be included as part of future planning proposals or management initiatives as indicated:

- ecologically "friendly" product alternatives should be selected where available and operationally feasible as a best practice
- long range plan water management strategy to establish appropriate effluent standards taking into consideration the existing treatment system, and the area and timing of wastewater release
- water withdrawal and wastewater management should be managed and monitored under a permit pursuant to the National Park General Regulations and addressed as part of the ski area water management strategy and environmental management system
- Best Management Practices to include the handling and storage of hazardous materials.
- environmental management systems are to address on-going monitoring of polluting substances and emergency spill response.

Additional knowledge requirements are also identified to ensure that future development and environmental protection decisions are based on objective information and sound science. These include:

- baseline water quality information for Basin and Portal Creeks is to be gathered as background for the water management strategy and long range planning process.

8.7.5 Residual and Cumulative Effects

The mitigations for water quality are intended to maintain water and wastewater quality within accepted established guidelines, to maintain or restore natural nutrient levels downstream of the ski area and to minimize the potential operational/accidental impacts of hazardous and polluting substances.

Compliance with established guidelines sets a reasonable and attainable standard that addresses potential ecological and health issues. Managing and monitoring water and wastewater quality through the environmental management system and water permitting process assures on-going water quality standards and compliance with National Park Regulations. The preferential use of eco-friendly product alternatives minimizes the potential for cumulative or accidental releases of toxic materials to water courses.

Expected ecological outcomes pertaining to water quality can be realized through the planning, product selection and monitoring mitigations as outlined.

8.8 Grizzly Bear

8.8.1 Current status

Grizzly bears are generally characterized as being highly sensitive to habitat and population disturbances (Weaver et al. 1996). They are commonly considered an umbrella species for wildlife management considerations because of their large land-area requirements, use of a broad array of habitats, and complexity of relationships with other species (Noss et al., 1996; Ross, 2002). Grizzly bears in Jasper National Park are considered part of Canada's Northwestern Population which is listed in Schedule 2 of the Canada Species at Risk Act as a species of special concern (Ross, 2002). The Jasper National Park Management Plan identifies the state of the grizzly bear population and habitat in Jasper National Park as an indicator of the park's ecological integrity (Parks Canada, 2000).

At a bioregional level, grizzly bears in Alberta are experiencing an increase in human access to previously remote areas because of the expansion of industrial resource extraction activities (Schneider et al., 2003). This access has the potential to amplify human-caused mortality, which is the primary source of death for grizzly bears (Benn and Herrero, 2002; Mace and Waller, 1998; Nielsen et al., 2004). Despite high human-caused mortality rates in the Central Rockies Ecosystem (CRE) in and around Banff National Park, Garshelis et al. (2005) estimated a slight positive growth rate for the area's population from 1994 to 2002. No population growth rate estimate is available for the grizzly bear population in Jasper National Park. However, Boulanger (2006)

estimated survival rates for bears in the Foothills Model Forest Grizzly Bear Research Program study area, which encompasses the east portion of Jasper National Park and the adjacent Alberta provincial land. Although quite different from the Marmot area, comparison of these estimates with the CRE study suggests that adult male, sub-adult-male, sub-adult female, and cub survival rates were lower for the Foothills Model Forest study area. Estimates of adult female survival and reproductive rates for the Foothills Model Forest study area were similar to the CRE study area (Boulanger, 2006).

Grizzly bears are wide-ranging, opportunistic omnivores that use a variety of habitats that change throughout the seasons. The food habits of grizzly bears change as the availability of foods of high nutritional value change with the season (Munroe and Stenhouse, 2005). In mountainous regions, this typically results in seasonal migrations along an elevational gradient (Ross, 2002).

Maps of seasonal female grizzly bear habitat selection within the southern portion of Jasper National Park have been derived using resource selection function (RSF)(multiple logistic regression) models developed through the Foothills Model Forest Grizzly Bear Research Project (Nielson, 2005). The Marmot Basin ski area is predicted to have a high relative probability of bear occurrence. This is supported by past and present direct observations identifying single grizzly bears and female grizzly bears with offspring using the ski area and adjacent environs (Mamo and Kunelius, 1998; Bradford, personal communication, Leeson 1986 and pers com).

Fine scale grizzly bear habitat selection within the Marmot Basin ski area has not been studied. Food habits of grizzly bears have been evaluated within the Foothills Model Forest Grizzly Bear Research Project study area from 2001 to 2003 (Munro et al., 2005). Grizzly bears were found to select sweet vetch root (*Hedysarum* spp.) and ungulate matter in early spring, green vegetation including graminoids and forbs during late spring, fruit including Buffalo berry (*Shepherdia canadensis)* and mountain huckleberry (*Vaccinium membranceum*) during summer, and sweet vetch root again in the fall. Forbs detected in the diet included horsetails (*Equisetum* spp.), cow parsnip (*Heracleum lanatum*), clover (*Trifolium* spp.), dandelions (*Taraxacum offincinale*), and willow (*Salix* spp.). Rodents were selected to a low degree throughout the seasons (Munro et al., 2005).

This research corresponds well with grizzly bear observations within the Marmot Basin ski area. Grizzly bears have been observed on the lower ski runs, access road (Marmot Basin road), sewage lagoon area, and lower Whistlers creek during the spring vegetation green-up period from May to mid-June. During this time, they have appeared to forage on and follow green vegetation at the edge of the snow melt from lower to upper elevations before turning their attention to hunting ground squirrels (Bradford, personal communication). From mid June to mid August, grizzly bears have been observed to return to the lower elevation ski runs, access road, sewage lagoon area and Whistlers creek, which have been found to contain relatively high concentrations of buffalo berry bushes. From mid to late August through to the fall, bears have been more often seen in the higher elevations from mid-mountain up to the alpine, and along the upper sections of Whistler creek. They have been observed to use alternate berry crops,

sweet vetch root, and ground squirrels in these areas (Bradford, personal communication).

8.8.2 Existing and Potential Interactions and Impacts

Ski area development activities allowed for under the Site Guidelines that have strategic implications for Grizzly bear include:

- potential expansion and modification of ski terrain including the development of the Rockgardens area
- potential facility construction and on-going maintenance of lifts, buildings, trails, roads and parking lots

Several studies have identified that grizzly bears avoid areas with high levels of human activity (Mace et al., 1996;1999; McLellan and Shackleton, 1989; Gibeau et al. 2002). Other studies have shown that bears may become habituated to human activity and will make use of habitats near humans, but suffer a significantly elevated mortality risk (Mattson et al., 1992; Benn et al., 2005). Habituated animals are also more likely to be involved in a human-wildlife interaction resulting in human injury or death (Herrero and Higgins, 2003; Herrero, 1985). Ski area construction, summer season maintenance activities, and operational practices have the potential to result in grizzly bear displacement and bear/human conflicts. In order to reduce human caused Grizzly bear mortality, bear/human conflicts and bear habituation to humans and facilities must be minimized.

Grizzly bear denning in the Jasper National Park region typically occurs from October-November to April-May (Hobson, 2005). A study of 35 den locations in the front mountain ranges of Jasper National Park found them located at an average elevation of 2017m (range 1500 to 2300m), on an average slope of 25 degrees (range 14 to 46 degrees), and tending to face a northerly to easterly aspect (Hobson, 2005). The Marmot Basin ski area contains habitat of the appropriate elevation, slope angle, and aspect to be used as den sites although no actual den sites have been identified within the ski area.

No research has been completed that identifies the importance of the Marmot Basin ski area and road to grizzly bear movement at a local and regional scale. At a local scale, grizzly bears studied within the Foothills Model Forest study area and other mountainous environments were shown to travel widely throughout their home ranges in search of seasonally important foods (Munro and Stenhouse, 2005; Mattson et al., 1992). Although not generally known as good dispersers, grizzly bears have been shown to disperse over large distances from their natal home ranges to establish new home ranges (Weaver et al. 1996). Grizzly bears have been shown to avoid roads with increasing levels of use (Mace et al, 1996).

Access and connectivity to quality habitat allow the Marmot Basin area to function as an integral component of regional Grizzly bear habitat. Access to quality habitat with minimal disturbance by facilities or people is an important characteristic of quality, secure Grizzly bear habitat.

8.8.3 Knowledge deficiencies

Jasper National Park currently has a resource selection function model for grizzly bears that provides a broad scale habitat value assessment and probability of grizzly occurrence for the park. However, a detailed site-specific Grizzly bear habitat assessment including bear movement, food sources, or den sites for the Marmot Basin ski area does not exist.

8.8.4 Mitigating Measures

The mitigations for Grizzly bear identify ecological management parameters, future planning and/or operational requirements, or future knowledge requirements that are needed to realize expected ecological outcomes as outlined in Section 4.4. The expected ecological outcomes that apply to mitigating potential impacts to Grizzly bear include:

- sensitive or valued wildlife is not displaced from habitat essential to regional population sustainability
- sensitive or valued wildlife is not habituated through human contact and activity
- wildlife mortality does not increase, directly or indirectly, as a result of human contact and activity.

In order to realize expected ecological outcomes important to Grizzly Bears the following ecological management parameters have been incorporated into the Site Guidelines:

- summer activities such as construction and maintenance do not displace or habituate grizzly bears
- development preserves natural food sources for grizzly bears and does not create non-native sources of food that would attract them.

Additional planning and operational requirements are identified to ensure that expected ecological outcomes are realized. These should be included as part of future planning proposals or management initiatives as indicated:

- long range plans are to investigate and address the potential to impact Grizzly bear den sites or den habitat associated with the potential Rockgardens development;
- Best Management Practices to address construction and operational practices including the management of food and food wastes that prevent attraction and habituation of bears.

Ecological management parameters for summer use are included in the Ski Area Management Guidelines and apply to Grizzly bear and other wildlife. Additional planning and knowledge and requirements are identified to ensure that potential summer use and environmental protection decisions that affect Grizzly bears are based on objective information and sound science. These include:

- long range plans are to address potential impacts of off-lease vehicle traffic on the Marmot Basin access road on Grizzly bear collision and mortality.

8.8.5 Residual and Cumulative Effects

The mitigating measures for grizzly bears focus on eliminating potential human/bear interactions that would lead to increased displacement, habituation, conflict and subsequent mortality. In order to realize the ecological management parameters it is expected that potential ski area development plans will have to consider grizzly bear food sources, movement patterns and the possibility of den sites. With these

considerations in mind, potential ski area development activities and summer maintenance are expected to result in minor residual impacts and incremental contributions to regional cumulative effects impacts to grizzly bears. The impacts of these minor changes on the regional grizzly bear population is not known.

Although the potential impacts of summer use are not addressed in this assessment the parameters for potential summer use outlined in the Management Guidelines are strengthened by the inclusion of specific information requirements and considerations that must be addressed through the long range planning process.

Expected ecological outcomes pertaining to Grizzly bears can be realized through the development limitations, operating and planning requirements outline above.

8.9 Woodland Caribou

8.9.1 Current status

Woodland caribou (*Rangifer tarandus caribou*) in Jasper National Park comprise part of the Southern Mountain population, which is listed as Threatened in Canada and occur on Schedule 1 of the Species at Risk Act (Thomas and Gray 2002).

Jasper National Park has 3 distinct sub-populations of woodland caribou: the Tonquin, Maligne/Brazeau, and A la Peche. There is little to no evidence of recent exchange between these groups (Whittington et al. 2005), although historically the subpopulations were thought to be more contiguous. Declines in South Jasper's sub-populations have been documented over several years: in 1961-1973, there were approximately 425 – 711 caribou (Stelfox 1974) based on ground and aerial observational counts. By 1988, the population was estimated at 175 to 200 (Brown et al. 1994). Today, South Jasper's caribou combined sub-populations are estimated at approximately 150 individuals (Neufeld and Bradley 2007). The North Jasper sub-population (the A la Peche) has been stable or increasing slightly since the late 1990s, however migratory behavior has changed substantially resulting in range retraction; the majority of the ALP herd has not returned to the industrialized portion of their range for the last 10 years (Smith 2004).

Caribou in the Marmot Basin ski-hill area comprise part of the Tonquin subpopulation, which has increased in recent years. Other subpopulations in Jasper have declined to varying degrees, most drastically in the Maligne range. Bioregionally, caribou populations throughout the Rocky Mountains and foothills are in decline (Hebblewhite et al. 2007, Wittmer et al. 2005). Habitat loss and fragmentation, increasing primary prey for wolves and subsequent increases in predator populations have spelled serious population declines, range retraction, and increased isolation and vulnerability of small sub-populations throughout the Southern Mountain range (Dzus 2001, Smith 2004, Smith et al. 2000, Alberta Caribou Recovery Team 2005, Wittmer et al. 2005). Provincial recovery plans have been developed for Alberta and BC, while national recovery plans are in development.

Caribou currently use areas around Marmot Basin, as they have also done historically (Mamo and Kunelius 1998). Specific to Marmot Basin, caribou were recorded in the Upper Basin prior to lift development, they have been observed around the Caribou chair lift and Caribou Knoll, and caribou have been seen in the Whistlers Creek drainage (including several observations during winter 2006/07) (Mamo and Kunelius 1998, Neufeld and Bradley 2007). Knowledge of caribou ecology indicates that caribou occur at low densities, range over large areas, and avoid areas with high human use (Bergerud 1992, Dyer et al. 2001, Nellemann et al. 2001, Frid and Dill 2002, Nellemann et al. 2003), therefore, while caribou are seen only occasionally at Marmot, caribou are not commonly seen in general. While observational recordings may be informative for long-term trends, they are considered incomplete, biased, and unreliable for defining caribou habitat requirements. To address this, biologists have developed rigorous range-level models of caribou habitat selection patterns (Whittington et al. 2005). Resource selection function (RSF) models developed from several thousand radio-collar location points are statistically defendable, have been shown to effectively predict important caribou habitat, and should be used in preference to individual GPS caribou locations (Boyce et al. 2002, Manly et al. 2002, Johnson et al. 2004).

RSF models indicate selection by caribou for a variety of habitat characteristics within the Park (details in Whittington et al. 2005), and coupled with knowledge of caribou ecology, they allow interpretation of large-scale habitat requirements for caribou. Caribou require contiguous tracts of old forest that contain lichens, a food source not used by other ungulates, but used as a primary winter food source by caribou (Bjorge 1984, Stevenson 1990, Thomas et al. 1996). In mountainous environments, caribou select high elevations and old forest (depending on snow conditions) not only for forage, but to separate from other ungulate species and their predators (Bergerud 1974, Edmonds and Bloomfield 1984, Bergerud and Elliot 1986, Bergerud and Page 1987, Seip 1992, James et al. 2004). The RSF model for caribou indicates that the ski-hill and Whistlers Creek areas are regions that caribou are likely to use. RSF models are reliable at the scale of the Park for identifying broad areas where caribou are more likely to be found or for identifying resources important to caribou at a coarse scale. However current RSF models cannot accurately detect differences in the likelihood of caribou use at smaller scales, within the ski hill/Whistlers Creek area for instance, or be used to assess impacts to caribou use of habitat at such scales.

8.9.2 Existing and Potential Interactions and Impacts

Ski area development activities that can be considered under the Site Guidelines that have strategic implications for woodland caribou include:

- potential changes to the developed area and leasehold
- potential for a Knob Chairlift extension and other lift relocations
- off-piste skiing and potential out-of- bounds visitor use
- potential development and modification of ski terrain.

As outlined in section 5.2.2 Marmot Basin has proposed a leasehold reconfiguration that would result in the removal of the Whistlers Creek bed area and surrounding up slopes from the ski area leasehold in exchange for exceptions that would be otherwise inconsistent with the Ski Area Management Guidelines. Potential proposals for the

Rockgardens, lower liftline terrain park and a mid-mountain water reservoir exceptions are in locations no longer used by caribou and are not expected to affect other unique or important environmental values. The potential Knob Chairlift extension also does not directly impact valued caribou habitat, though it may have implications for caribou conservation because of associated effects (see below).

The potential lease reduction will provide greater certainty that the Whistlers Creek bed area and surrounding upslopes will remain undeveloped. The potential Knob chairlift extension and other potential lift realignments envisioned by the Site Guidelines have the potential to increase access and attract skiers to off-piste and out-of-bounds skiing opportunities (such as Marmot Pass and the upper Whistlers creek valley), which may potentially result in the displacement of caribou from important habitat. Evidence from caribou herds in JNP and elsewhere suggests this type of activity can displace caribou from important habitat (see below). While any potential for consideration of future potential development proposals (including potential lifts and snow management) of the Tres Hombres and Outer Limits areas is deferred until completion of the caribou risk assessment, the site guidelines allow for the zoning and management of continued, existing off-piste skiing in these areas.

Potential Impacts of Disturbance

Caribou, throughout their circumpolar distribution, have been shown to be sensitive to disturbance (Klein 1971, Bradshaw et al. 1998, Wolfe et al. 2000, Dyer 2001). Several studies have identified effects of disturbance on displacement and interruption of daily activities, such as foraging and resting (Bradshaw et al. 1998, Webster 1997, Duchesne et al. 2000, Wolfe et al. 2000). In highly-impacted areas, full avoidance of infrastructure has been documented (Dyer et al. 2001, Nellemann et al. 2001, Frid and Dill 2002, Nellemann et al. 2003).

A number of studies have been conducted on the effects of winter activities on disturbance of caribou. Recent research shows that free-riding snow sports can elevate stress in alpine animals, which represents potential consequences to fitness and survival costs (Arlettaz et al. 2007). Also, in the winter months, when food availability and quality are more limited, a large number of skiers may negatively influence animal condition due to repeated displacement and disturbance (Reimers et al. 2006). Duchesne et al. (2000), in a study of the effects of ski or snowshoe winter activity on caribou behavior observed that caribou spent less time foraging and more time alert when encountering people. Pruitt (1979) concluded that caribou leave their wintering range when approximately 70% of the snow cover in the area has been disturbed during a current winter. Bergerud (1974b) found that, in early winter, caribou left preferred habitats in situations of intense and persistent harassment. In the Selkirk mountains, caribou use was lower in ski zones within heli-ski tenures during months and years when ski activity was high (Wilson and Hamilton 2003). Vistnes and Nellemann (2001) noted significant avoidance by semi-domesticated reindeer during calving of areas within 4 km of resort areas used for snowmobiling and skiing. In a related study, Vistnes et al. (2001) reported that densities of reindeer were significantly lower in developed quadrats (with power lines, roads, and ski trails) compared to undeveloped quadrats in south-central Norway. Development and the degree of development affected distribution, and

therefore the availability of habitat, of wild reindeer (Vistnes et al. 2001). Nellemann et al. (2000) reported similar results for wild reindeer in winter near a cross-country skiing resort, despite the lack of forage available in areas to which they were apparently displaced. Caribou were displaced significantly farther when approached by a skier (on average 970 m) than when approached by snowmobile, although overall provocations by skiers or snowmobiles revealed similar behavioral responses (Reimers et al. 2003). However, Simpson and Terry (2000) reasoned that, compared to helicopter or snowcat skiing, the non-motorized nature of backcountry skiing as well as the slow pace at which skiers travel suggest this activity likely has relatively low impacts on B.C. mountain caribou populations, although no data were provided within this assessment. Reimers et al. (2006) concluded that approaches by hikers/skiers would not represent significant energy expenditure or serious negative consequences, although reindeer were still displaced during all seasons and the farthest during summer (median 525m). Although research into responses of caribou to specific human-use activities is not comprehensive, it is a key focus in recent work. For example, Seip et al. (2007) are the first to publish conclusive results showing displacement of caribou from an area of suitable habitat as a result of snowmobiling.

Similar disturbance studies exist for the summer season; in Jasper National Park, caribou spent significantly more time active and less time foraging/bedding in response to hiker encounters (McKay 2007). 44% of hiker encounters resulted in displacement of caribou to distances ranging from 200 to 2400 m and caribou reacted to hikers at an average distance of just over 200m (McKay 2007). Similarly, Colman et al. (2001) found that approach by a person on foot elicited flight responses in wild reindeer. Tourist activities in the spring and early summer, forced woodland caribou to move from the alpine tundra to the forest zone, increasing their risk to predation (Dumont 1993).

Inferring from the literature, potential increases in current, existing off-piste and out-of-bounds skiing that may be facilitated by new lift alignments may result in increased potential for displacement of caribou from important habitat; the caribou risk assessment will examine specific scenarios more relevant to the Whistlers Creek area (see 8.9.4).

Potential Impacts of Terrain

The potential development and modification of ski terrain may potentially affect caribou on and adjacent to the leasehold by increasing the risk of predation. As described above, caribou anti-predator strategies include avoidance of areas with high densities of other ungulates (Bergerud 1974, Bergerud and Elliot 1986, Bergerud and Page 1987, Seip 1992, James et al. 2004). Because space, and therefore the ability to spatially separate from other ungulates and their predators, is a critical environmental variable enabling caribou to find refuge from predation (Bergerud et al. 1984, Bergerud 1988), increasing ease of access for predators into caribou habitat, or increasing ungulate abundance in the region, may have implications for caribou survival. Increasing or enhancing the developed ski area has the potential to increase early seral stage vegetation, consequently ameliorating available forage for other ungulates, and ultimately compromising caribou anti-predator strategies. With attraction of other ungulates and their predators, the potential exists for greater numbers of wolves to

exploit caribou predator refuges, causing increased predation rates on caribou (e.g. Seip 1992, James et al. 2004, James and Stuart-Smith 2000).

In addition to potential increases in prey abundance, linear features may reduce energetic demands of movement, creating attractive travel corridors for wide-ranging predators (Musiani et al. 1998). Wolves throughout the world, as well as within JNP, have been shown to select linear disturbances (e.g. trails/roads) as travel routes, which allow facilitated and efficient travel during hunting (James 1999, Whittington et al. 2004). Generally, wolves select roads and trails as travel routes, so long as levels of human use remain relatively low (Thurber et al. 1994, Musiani et al. 1998, James and Stuart-Smith 2000, Callaghan 2002, Ciucci et al. 2003, Whittington et al. 2004). Selection of secondary roads/trails by wolves in winter, when snow depths off-trail may preclude their movements (Mech 1970, Thurber et al. 1994, Singleton 1995, Paquet et al. 1996), is particularly relevant to trail creation around Marmot Basin. Coupled with evidence that predation risk for caribou is greater near linear disturbances (James and Stuart-Smith 2000), risk to caribou is exacerbated with packed trails into caribou habitat. In Jasper National Park, models of caribou and wolf habitat selection indicate that caribou avoid trails while wolves select trails (Whittington et al. 2005). Specific to Marmot, Parks Canada is in the process of collecting specific data related to the Whistlers Creek access trail; unpublished wolf telemetry data and remote camera photos have shown that wolves use this trail.

The existing snowmobile trail on the lease, coupled with backcountry skiers continuing up Marmot Pass through to Portal Creek currently facilitates access for wolves to caribou habitat in Whistlers Creek, Marmot Pass, and the greater Tonquin area. It is possible that new egress trails in the Whistlers Creek valley may increase access to caribou habitat by wolves and this potential will be considered in the caribou risk assessment.

8.9.3 Knowledge deficiencies:

Current limitations to knowledge regarding how caribou are affected on a regional scale by human use and development affect the ability to assess the degree to which caribou will be affected by ski area development proposals. During the caribou risk assessment process, specific knowledge gaps related to potential development in Whistlers creek will be identified. This process may be informed and guided by the following general knowledge gaps identified for the greater South Jasper Woodland Caribou project:

- thresholds for recreational use of caribou habitat – especially related to winter recreational use and development; values from previously published studies may be the best way to estimate thresholds
- habitat quality (food availability) locally and regionally; a coarse lichen occurrence model for the Park (could be validated at the local ski-hill level to objectively assess habitat quality locally)
- predation risk model; predation risk plus food availability will provide a much better idea of caribou habitat *quality* across the Park
- information on the distribution, abundance, and habitat selection patterns of alternate prey in the Park; the role that habitat change in JNP could play in changing alternate prey densities, and ultimately caribou survival, is unknown. Initial steps toward this are underway.

- continued monitoring of predator access to caribou habitat; this will allow predator risk models to be verified through field-level observation
- the nature, season, and frequency of caribou movement and the importance of specific travel routes are unknown, affecting the ability to determine the potential magnitude of impacts of backcountry and out-of-bounds use on caribou.

As a listed species under SARA, national and regional caribou recovery strategies, in part as a follow-up to the already present Alberta Woodland Caribou Recovery Plan, are being developed. Recommendations for caribou recovery from these processes are anticipated by early 2008.

8.9.4 Mitigating Measures

The mitigations for Woodland caribou identify ecological management parameters, future planning and/or operational requirements, or future knowledge requirements that are needed to realize expected ecological outcomes as outlined in Section 4.4. The expected ecological outcomes that apply to mitigating potential impacts to caribou include:

- sensitive or valued wildlife is not displaced from habitat essential to regional population sustainability
- wildlife mortality does not increase, directly or indirectly, as a result of human contact and activity
- species are protected in accordance with SARA.

In order to realize expected ecological outcomes important to woodland caribou the following ecological management parameters have been incorporated into the Site Guidelines:

- off-piste and out-of-bounds skiing do not displace caribou from habitat important to the regional population
- development does not increase access for predators or the density of prey in important caribou habitat in and near the leasehold.
- modifications to vegetation and terrain do not affect the availability of caribou lichen outside of the existing Developed Area.

Additional planning and operational requirements are identified to ensure that expected ecological outcomes are realized. These should be included as part of future planning or management initiatives as indicated:

- long Range Plans are to address alternatives to the Knob chairlift terminating at the summit of Marmot Peak
- long Range Plans and vegetation management strategies to use best available caribou data and published findings to identify areas of habitat concern
- long range plans to identify and address potential impacts to caribou calving and rutting seasons
- Best management practices should address alternatives to salt on roads/parking lots and wherever salt is applied up from Portal Creek to prevent traffic mortality.

Visitor education is an important component of gaining visitor cooperation and contribution towards achieving ecological management parameters pertaining to caribou. The following educational goals should be addressed in the visitor education program brought forward as part of the long range planning process:

- visitors are informed of the potential impacts to caribou associated with off-piste and out-of bounds skiing and encouraged to follow protective guidelines.

Additional knowledge requirements are identified in association with the current use and potential future consideration of development in the Tres Hombres, Outer limits, Caribou Knoll, Whistlers Creek and Marmot Pass areas. A conceptual approach to the caribou risk assessment required by the Site Guidelines is outlined below to assist with developing objective, scientifically sound information to guide decisions that affect caribou.

The overall purpose of the caribou risk assessment will be to determine whether development in the Tres Hombres and Outer Limits areas can be considered. The general objectives of the caribou risk assessment, which will be led by an independent researcher, are anticipated to be:

- determine, or infer from a literature review, the potential influence of skier and other visitor use on caribou use of habitat in and around Whistlers Creek valley
- determine the potential influence of ski area development proposals, including egress routes, on predation risk to caribou in Whistlers Creek
- identify ecological management thresholds and determine the nature of mitigations, if any that should be considered to address potential development impacts identified in the research.

Notwithstanding the above initial considerations, the overall objectives, approach and terms of reference for the caribou risk assessment will be developed with the advice of internal and external experts.

Ideally the risk assessment and scenario modeling would be developed prior to, and included as part of the Long Range Plan; the predictions of the assessment would be verified by a follow-up monitoring program.

8.9.5 Residual and Cumulative Effects

The mitigating measures for woodland caribou focus on: 1) avoiding the displacement of caribou, and 2) minimizing additional predator access to key caribou habitat.
There is some uncertainty as to how the mitigating measures will be achieved in future Long Range Plan proposals. The caribou risk assessment will provide information to reduce this uncertainty and to provide objective, scientifically sound information for decision making.

The proposed lease reduction will provide greater certainty that the Whistlers Creek bed area and surrounding upslopes will remain undeveloped. As such, it will provide greater long-term protection of ecological integrity in the area than would be the case if the area remained in the lease, including enhanced protection of valuable caribou habitat This improved level of long-term certainty and protection is considered a substantial environmental gain that will contribute meaningfully to Parks Canada's objective of maintaining or improving ecological integrity in Jasper National Park.

The risk of potential disturbance impacts to caribou as a result of accidental encounters or unsanctioned backcountry use will continue to exist. Similarly, caribou populations will continue to be affected by natural stressors such as the presence of alternate prey and

risk of predation. Mitigations associated with Marmot Basin will focus on preventing the potential for development to increase these risks. The national Recovery Strategy for the Woodland Caribou, Southern Mountain population (Rangifer tarandus caribou) in Canada, as the overarching strategy for caribou recovery and management, and the recommendations from the West-Central Caribou Landscape Planning Team will aid in addressing cumulative impacts at a regional scale. Successful caribou management at the regional and local scales is dependent on cooperative actions and decisions by provincial and federal authorities, including Parks Canada. To the extent that ski area planning and management can mitigate local impacts, the Site Guidelines are expected to support caribou recovery.

The expected ecological outcomes for woodland caribou are expected to be achieved through the Site Guidelines. Successful realization and implementation of ecological outcomes related to potential consideration of future development in the Whistlers Creek valley will be further assessed through the caribou risk assessment. Ecological outcomes for caribou will also be realized in combination with the Recovery Strategy for the Woodland Caribou, Southern Mountain population (Rangifer tarandus caribou), the Alberta Caribou Recovery Strategy (2005), the West-Central Caribou Landscape Plan (in prep), the British Columbia Recovery Strategy (2007) and supporting local strategies and actions by Jasper National Park.

8.10 Mountain Goat

8.10.1 Current status

Mountain goats occupy alpine and subalpine areas throughout northwestern North America. They occur primarily in the Rocky Mountains and associated foothills, as well as along the main coastal mountain ranges in British Columbia and southern Alaska (Cote and Festa-Bianchet, 2003). Mountain goat populations in Alberta are believed to have drastically declined in the 1960's and have been slow to recover despite more stringent management programs adopted in the 1980's (ASRD, 2003). The ability to monitor goat population abundance, however, is limited by the remote characteristics of goat habitat and the high variability of goat sight-ability during aerial surveys (Poole, 2007; Gonzalez-Voyer et al., 2001).

No recent research has been completed in Jasper National Park to assess the abundance of mountain goats in the Marmot Basin area. In 1982-83, Carnell conducted monthly aerial surveys in the regional mountain complex that surrounds Marmot Mountain (Carnell, 1982; Parks Canada 1984). The minimum goat population estimate for the mountain complex was reported to be 100 individuals. The counted population was distributed along Marmot Mountain, Pevril Peak, upper Whistler's creek, Indian Ridge, upper Muhigan Creek, and Whistler's peak (Carnell, 1982; Parks Canada 1984).

No research has been completed in Jasper National Park to assess the habitat requirements of mountain goats in the Marmot Basin area. Generally, mountain goats occur from treeline to the highest alpine meadows in areas close to cliffs or rocky ledges (Chadwick, 1983). In the northern Rocky Mountains, typical goat habitat was found to

range in elevation from 1500 to 2700 meters (Smith, 1977). The reliance of mountain goats on access to escape terrain restricts their movement resulting in relatively small, fixed home ranges (McFetteridge, 1977; Chadwick, 1983). In the Caw Ridge area of Alberta, Cote calculated the summer home range of adult male goats to be 5 km^2, and the yearly home range of adult females to be 25 km^2 (Cote and Festa-Bianchet, 2003). In Montana, yearly home ranges of adult males and females in Montana were calculated to be 24.0 km^2 and 21.5 km^2 respectively (Rideout, 1977). In winter, ranges have been found to be restricted to wind-swept, south and west-facing exposures at and just below treeline near escape terrain (Smith 1977; Rideout 1977).

Mountain goats are not believed to have specific rutting ranges (Cote and Festa-Bianchet, 2003). Mating season is from late October to early December, normally peaking in mid-November (Chadwick, 1983). Mountain goats give birth from mid-May to early June with females isolating themselves by selecting rocky outcrops or cliffs that are safe from predators (Cote and Festa-Bianchet, 2001).

A series of pellet group transects were completed in 1997 to estimate the relative goat distribution in and around the Marmot Basin leasehold (Mamo and Kunelius, 1998). The highest pellet group counts were recorded on the south, west, and north sides of Marmot Mountain including the "backside", Caribou Ridge, North Chutes, and Tres Hombres (Mamo and Kunelius, 1998). In 1980, Van Tighem completed targeted pellet count transects along Caribou ridge and recorded high numbers of both summer and winter mountain goat pellet groups relative to randomly sampled locations elsewhere in the mountain parks (Van Tighem, 1980).

The pellet transect data is supported by aerial and ground observations in the vicinity of the leasehold. The goats observed on Marmot Mountain during the aerial surveys completed in 1982-83 were primarily located along the south, west, and north-west ridges and slopes during all seasons (Carnell, 1982). Winter aerial and ground surveys of the leasehold conducted in 1998 also located goats and goat sign on the "backside", Tres Hombres, Caribou ridge, and the North Chutes (Mamo and Kunelius, 1998).

The fine-scale distribution of mountain goat food resources is unknown in and around the Marmot Basin ski area. Mountain goats are generalist herbivores and have the capacity to eat a wide variety of plant materials (Cote and Festa-Bianchet, 2003). They also appear to restrict their diets to vegetation in close proximity to their escape terrain (McFetteridge, 1977). Diets are similar in summer and winter and are generally dominated by grasses (Laundre, 1994). A summary of 10 studies on the feeding habits of mountain goats found that summer diet included 52% grass, 30% forb, and 16% browse (Laundre, 1994). In the winter, Laundre reported a shift in the average diet to 60% grasses, 8% forbs, and 32% browse. In Jasper National Park, a study of the summer rumen contents of five mountain goats found 63% grasses and sedges, 14% forbs, and 23% browse (Cowan, 1944).

Minerals are limited in alpine vegetation (Hebert and Cowan 1971). Mountain goats, therefore, use traditional salt licks regularly during the summer (Singer and Doherty 1985). Goats in Jasper National Park were found to start use of licks in May, reach a

peak in June and July, then taper off until early fall (McCrory, 1965). The Whistlers Creek valley features a mineral lick that receives extensive visitation by goats in the Marmot Basin region during late spring and summer (Bradford, personal communication).

The importance of the Marmot Basin ski area to mountain goat movement at a local or regional scale has not been studied. Carnell hypothesized from goat and track observations that an established movement pattern existed between goats on Marmot Mountain and those at Muhigan creek (Carnell, 1982; Parks Canada 1984). Goat tracks were also observed during ground surveys in 1998 crossing from Marmot Mountain over to Terminal Mountain and the main Trident Range mountain complex (Mamo and Kunelius, 1998). Goats in the Marmot Basin region also appear to travel from tree-line habitat to the salt lick located in the Whistlers Creek valley (Bradford, personal communication).

Information on the effects of development and recreational activity on the behavior and ecology of mountain goats is scarce. Hutchins and Geist (1987) identified the concern that human encroachment into goat habitat might elevate energetic costs to the animals by increasing the frequency of flight responses, by requiring movement to alternate feeding sites, or by causing the abandonment of the home range permanently. Penner (1988) documented a change in habitat use by goats in Alberta when an exploratory gas well was placed two kilometers from their traditional winter range. During the drilling program, the nursery band failed to move to its traditional winter range. In northern British Columbia, another mountain goat population moved 1 to 3 kilometers away from its traditional summer range in apparent response to a drilling program (Foster and Rahs, 1983). Singer (1978) suggested that goats may respond to human and vehicle activity at a salt lick in Montana by primarily visiting the lick at night. In contrast, a study that simulated recreational approaches to mountain goats were reported to have a negligible effect on goat activities (Thompson, 1980). The impact of more intensive recreational activities on mountain goat behavior and ecology have not been investigated.

Cote and Festa-Bianchet (2003) recommend that important areas such as winter range, parturition areas, and salt licks must be identified and protected from development and recreational activities.

8.10.2 Existing and Potential Interactions and Impacts

Potential ski area development activities contemplated in the Site Guidelines that have strategic implications for mountain goats include:

- potential development and modification of ski terrain
- potential extension of the Knob Chairlift
- potential visitor use including off-piste and potential out-of-bounds skiing.

Mountain goats may be temporarily displaced from important habitat or travel routes as a result of construction and operational activities (Penner, 1988; Foster and Rahs,1983). New facilities may result in the permanent abandonment of goat habitat or create

permanent barriers to goat movement, especially during the winter time period when goats seek wind-exposed west and south-facing ridges (Smith, 1977; Rideout, 1977). This sensitivity is potentially relevant to the potential extension of the Knob Chairlift towards the summit of Marmot Peak.

Goats appear to use the wind swept ridges of Marmot Mountain areas for access to forage and winter travel. Physical barriers or human disturbance may effectively restrict goat movement during a sensitive time period. The majority of mountain goat mortality is reported in the winter season due to energetic shortfalls (Chatwick, 1983). Visitor and operational use may displace goats from quality habitat or cause undue stress and disturbance during sensitive winter and kidding periods.

Construction activities, facilities and human use have potential to alter the use and access to the mineral lick in Whistlers creek (Singer, 1978). The mineral lick itself falls within the lower Whistlers Creek drainage that will be potentially removed from the leasehold as part of the exceptions package and will benefit from long-term protection from development. Disturbance of essential travel routes for goats to and from the mineral lick may prevent access to and use of this important resource.

8.10.3 Knowledge Deficiencies

No habitat selection models exist for mountain goats. The relative importance of potential goat habitat in the Marmot Basin area to the regional population is unknown and local Mountain goat home ranges, kidding ranges, and winter ranges have not been identified. Movement routes between important habitat features including the Whistlers Creek mineral lick have not been identified.

There is little knowledge of what thresholds of human development and activity might cause displacement of mountain goats from important areas such as winter range, kidding areas, and salt licks.

A current population estimate cannot be obtained due to a lack of long-term aerial survey data.

8.10.4 Mitigating Measures

The following ecological protection objectives identified in section 4.3 are applicable to the management of ski area development activities as related to mountain goats:

- sensitive or valued wildlife is not displaced from habitat essential to regional population sustainability
- sensitive or valued wildlife is not habituated through human contact and activity
- wildlife mortality does not increase, directly or indirectly, as a result of human contact and activity.

In order to satisfy EI protection objectives important to Mountain goats the following Ecological Management Parameters have been incorporated into the Site Guidelines:

- construction, modification of vegetation and terrain, visitor use and operational activities do not displace goats from local habitat essential to the regional population or from travel routes essential to the regional population

- goat travel routes to and from the Whistlers Creek mineral lick are identified and protected.

Additional planning and operational requirements are also identified to ensure that EI Protection objectives are satisfied. These should be included as part of future planning proposals or management initiatives as indicated :

- long range plans and environmental assessments are to consider alternative designs and/or locations for the potential Knob chairlift upper terminal that would not adversely nor significantly impact goat migration routes
- goat management protocols that address criteria for visitor and operational use that minimize disturbance to goat habitat and movement will be developed (similar to the grizzly bear management protocols for Lake Louise – see also section 8.8.4).

Visitor education is an important component of gaining visitor cooperation and contribution towards achieving ecological management parameters pertaining to mountain goats. The following educational goals should be addressed in the visitor education program brought forward as part of the long range planning process:

- visitors are informed of the potential impacts to mountain goats associated with off-piste and out-of bounds skiing and encouraged to follow protective guidelines

Additional knowledge requirements are also identified to ensure that future development and environmental protection decisions are based on objective information and sound science. These include:

- local goat population assessment and identification of important habitat features including local feeding areas, bedding down areas, escape terrain, summer and winter movement routes, rutting and kidding areas and sensitive seasons, and the Whistlers Creek mineral lick should be considered as part of the long range planning and environmental assessment process.

8.10.5 Residual and Cumulative Effects

Temporary and infrequent disturbance or displacement of Mountain goats will likely still occur as a result of construction, operation and visitor activities. The suite of mitigation measures are intended to prevent permanent displacement of Mountain goats from habitat features essential to the regional population as a result of individual and cumulative development activity. The focus in the mitigation of separating human activity from important goat habitat will also address EI protection objectives of minimizing potential habituation. Except as noted below, and with mitigations to prevent permanent displacement and habituation, no increase in Mountain goat mortality is expected as a result of implementing ski area development activities as contemplated in the Site Guidelines.

The potential extension of the Knob Chairlift presents particular challenges to ensuring that Mountain goats are not displaced by ski area activity. The summit ridge is fairly broad and a goat trail traverses the west slopes of the ridge somewhat below the summit indicating a summer travel route for goats. In the winter however the west slopes are loaded with snow and the only feasible travel route for goats may be along the exposed windswept ridge-top itself. The installation of a detachable chair lift terminal on the summit would span the ridge-top potentially impacting winter travel

routes. Having a clear understanding of the importance of the ridge-top to regional winter goat movement is necessary for determining potential impacts to ecological integrity and the assessment of proposed lift options in future long range plans.

It is anticipated that expected ecological outcomes pertaining to Mountain goats can be realized if it can be shown that potential use and development along the summit ridge will not significantly impact goat movement patterns essential to the regional population. Impacts to Mountain goat populations at the regional scale of the Trident Range are considered unlikely if important movement patterns can be maintained.

8.11 Wolverine

8.11.1 Current Status and Ecology

Wolverines are wide-ranging, opportunistic scavengers that occupy large home-ranges encompassing a diversity of habitat types (Weaver et al., 1996; COSEWIC, 2003). They are a holoarctic species that has been delineated into two geographically separated populations in Canada. Wolverines in Jasper National Park belong to the western population which has been designated as a species of special concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC, 2003).

Wolverines have been observed within and around the Marmot Basin ski area (Parks Canada, 2007). However, little is known about wolverine distribution and abundance within Jasper National Park, or within the park region (COSEWIC, 2003). An opinion survey of trappers in Alberta in 1994 suggested decreasing wolverine trapping success and a potentially declining provincial population (Peterson, 1997). Low reproductive rates (Hornocker and Hash, 1981; Krebs and Lewis, 2000), litter size, and age of reproductive senescence contribute to a high sensitivity of the species to human disturbance of habitat and populations (Weaver, 1996; Carrol et al., 2001).

Wolverines consume a variety of foods. A large component of their diet is carrion from ungulates such as moose, elk, caribou, deer, and mountain goats. Wolverines have also been reported to prey on showshoe hares, porcupines, ground squirrels, marmots, small rodents, birds, and fish (Banci, 1994). They appear to actively hunt smaller prey during the non-winter periods when carrion supplies might be more limited (Krebs and Lewis, 2000).

Wolverines maintain large home ranges due to their dependency on a variety of different food items in diverse structural habitat. Male home ranges have been typically found to be three times the size of female home ranges. Krebs and Lewis (2000) estimated home range sizes of males and females in the Columbia Mountains to be 1005 km^2 and 311 km^2 respectively.

No research has been completed in Jasper National Park to assess the habitat requirements of wolverines that use the Marmot Basin ski area landscape. In general, studies of the attributes of wolverine telemetry locations (Copeland, 1996; Krebs and Lewis, 2000; Lofroth, 2001) suggest little selection for wolverine habitat at a stand

scale. It is hypothesized that wolverine habitat is better defined by the distribution and abundance of food, including carrion, as well as suitable habitat/structures for denning (COSEWIC, 2003). At a landscape level, adult female wolverines in the Columbia mountains appeared to use higher elevation subalpine areas during winter, and alpine areas during the summer. Adult males, and subadult males and females appeared to use lower elevation montane and subalpine areas in the winter, and higher elevation subalpine areas during the summer (Krebs and Lewis, 2000). Hornocker & Hash (1981) found that cover may be important to wolverines and that observed individuals were reluctant to cross openings such as clearcuts. Wolverine telemetry data from north-central British Columbia showed a high proportion of use of mature and old forest (Lofroth, 2001). However, Lofroth (2001) also found that females used high elevation open areas during the rearing season while provisioning for their young. Copeland (1996) did not find a reluctance of wolverines to cross natural openings. Wolverines also appear to avoid human settlements (Banci, 1994).

Natal and maternal dens are believed to be the only small-scale structures for which wolverines exhibit selection. Female wolverines typically situate dens in snow tunnels leading to masses of fallen trees (coarse woody debris), or rocky colluvium in areas with little or no human disturbance (Krebs and Lewis 2000; Copeland, 1996). Natal and maternal dens are generally associated with small-scale forest openings (e.g., <100 m across) at high-elevations below treeline (Krebs and Lewis 2000; Lofroth 2001). The placement of dens within the landscape is believed to be important because these structures provide security for kits (i.e., snow cover) with proximity to food resources (i.e., late-winter carrion or prey) (COSEWIC, 2003). Human disturbance at natal den sites has been found to cause den abandonment (Copeland, 1996). Females occupied dens as early as February and used them as late as mid-May in the Columbia Mountains study (Krebs and Lewis, 2000).

No research has been completed in Jasper National Park that identifies the importance of the Marmot Basin ski area to wolverine movement at a local or regional scale. Wolverines have been shown to travel widely within their home ranges to search for variable food resources (Krebs and Lewis, 2000; Copeland, 1996). They have also been shown to undergo extensive movements when dispersing from their natal home ranges to establish new home ranges. Dispersing subadult wolverines were observed to travel distances greater than 200 kilometers in western Montana (Copeland, 1996). Highways have been shown to interrupt daily movements of wolverines (Austin, 1998) and can be a source of mortality (Krebs and Lewis, 2000).

8.11.2 Existing and Potential Interactions and Impacts

Potential ski area development activities contemplated in the Site Guidelines that have strategic implications for wolverine include:

- potential expansion and modification of ski terrain
- potential increases in levels of visitor and operational use

Potential expansion of use into Whistlers Creek, through increased off-piste skiing and out-of–bounds skiing activity, non-winter use of the whole area, and increased vehicle traffic on the Marmot road carry the greatest potential to impact wolverine forage,

movement, and mortality. Wolverines require large areas of contiguous subalpine and alpine habitat that provide access to large ungulate carrion, snowshoe hares, porcupines, and other small mammals and birds (Krebs and Lewis, 2000; Banci, 1994). These areas must also contain suitable high elevation denning habitat remote from human disturbance that is characterized by high snow cover, and coarse woody debris or rocky colluvium (Krebs and Lewis, 2000; Copeland, 1996). The contiguous nature of the habitat is important to allow for travel over large distances to search for food resources, and to allow long range dispersal events from natal home ranges (Krebs and Lewis, 2000; Copeland, 1996).

Potential increases in development and activity at the ski area have the potential to displace wolverines (Banci, 1994;Copeland, 1996). Research has suggested that wolverines are reluctant to use open areas the size of clearcuts (Hornocker and Hash, 1981; or may prefer closed forest (Lofroth, 2001), but these findings are refutable (Copeland, 1996). The current level of winter use within the developed area of the Marmot Basin ski area is likely already at a level that displaces wolverines during the daytime. It is unlikely that potential development or increased use of the developed area would have a further impact.

Wolverines den in remote subalpine regions and may be sensitive to disturbance during denning (Krebbs and Lewis, 2000; Copeland, 1996). The current level of use within the developed area of the Marmot Basin ski area would be expected to prohibit any denning activity, so further potential development within this area would not likely cause further impact. Potential increases in human use in the Whistlers Creek drainage have the potential to impact more remote denning habitat.

Wolverines may be temporarily displaced from potential habitat during summer construction and maintenance activities. An overall increase in snowmaking and grooming activities could displace wolverine from nocturnal movements across the ski area. Inadequate garbage and human food management during any season could result in the attraction of wolverines to the Marmot Basin ski area, which could result in increased mortality risk because of proximity to roads and human facilities.

Wolverines have shown avoidance of (Austin, 1998), and mortality on (Krebs and Lewis, 2000) high use highways. Increased traffic on the Marmot Basin road will increase mortality risk for wolverines using the area. Current risk is very low, however. High levels of vehicle traffic have been shown to inhibit movement.

8.11.3 Knowledge Deficiencies

While wolverine use of Marmot Basin ski area has been observed (Parks Canada, 2007), and the ski area sits in potential landscape level habitat zones (Krebs and Lewis, 2000), little is known about stand level habitat attributes that might be important to wolverines:

- no habitat selection models exist for wolverines and wolverine use of cleared areas is poorly understood
- there is no knowledge of the fine scale distribution of wolverine denning habitat attributes on or adjacent to the leasehold

- there is little knowledge of what thresholds of human development and activity might cause displacement of wolverines from an area
- there is little knowledge of what thresholds of vehicle traffic will result in avoidance of roads, barriers to movement, or roadway mortality.

8.11.4 Mitigating Measures

The mitigations for wolverine identify ecological management parameters, future planning and/or operational requirements, or future knowledge requirements that are needed to realize expected ecological outcomes as outlined in Section 4.4. The expected ecological outcomes that apply to mitigating potential impacts to wolverine include:

- sensitive or valued wildlife is not displaced from habitat essential to regional population sustainability
- sensitive or valued wildlife is not habituated through human contact and activity
- wildlife mortality does not increase, directly or indirectly, as a result of human contact and activity.

In order to realize expected ecological outcomes important to wolverine the following ecological management parameters have been incorporated into the Site Guidelines:

- ski area vegetation management to fall within the parameters for small mammal habitat as identified in section 8.3
- ski area vegetation management to result in a mosaic or forest age classes consistent with mitigations in section 8.1 and 8.4.

Additional planning and operational requirements are identified to ensure that expected ecological outcomes are realized. These should be included as part of future planning proposals or management initiatives as indicated :

- long range plans to consider potential impacts of traffic on wolverine mortality
- the importance of Whistlers Creek valley for wolverine and nature of wolverine movement across the ski area, including the potential for nocturnal disturbance, should be addressed appropriately as part of the long range planning environmental assessment process.
- Best management practices are to address protocols for garbage and solid waste management that prevent attracting wildlife including wolverine (see also section 8.8.4).

Additional knowledge requirements have not been identified beyond the long range planning and associated environmental assessment requirements.

8.11.5 Residual and Cumulative Effects

The mitigations for wolverine are focused on maintaining movement across the ski area and preventing further displacement or mortality of wolverine as a result of ski area expansion.

At a local scale, maintaining vegetation composition and structure within the parameters for small mammals is expected to maintain the ability of wolverine to move across the ski area and forage during the ski off-season. Waste management best practices are expected to prevent attracting wolverine to the ski area and resulting subsequent habituation and mortality. Additional information and assessment of wolverine habitat

use gathered as part of the long range planning process will facilitate the consideration and mitigation of site-specific disturbance and movement issues for wolverine.

Wolverines have large home ranges (Krebbs and Lewis, 2000; Copeland, 1996) and at a regional scale are unlikely to be affected by small scale ski-hill development within the developed area. It is anticipated that expected ecological outcomes for wolverine may be realized preventing further displacement of wolverine at the local scale and controlling the potential for habituation and mortality.

8.12 Canada Lynx

8.12.1 Current status

Lynx are linked to their primary prey, snowshoe hare and require a mosaic of habitat types to be successful – young conifer forests for foraging, and older forests for denning and travel (Apps 2005, Ruggierie 1994). The core of good lynx habitat is the boreal forest – the Rocky Mountains contain only small patches of discontinuous lynx habitat. The ecology of lynx in the Rocky Mountains resembles a boreal population during the low phase of the hare cycle – low density, high dispersal rates, and low reproductive success (Apps 2005). Also, Rocky Mountain lynx have shorter and less successful dispersal than boreal lynx (Apps 2005). Lynx in the Rocky Mountains are therefore sensitive to environmental change and care must be taken when considering changes to lynx habitat.

8.12.2 Existing and Potential Interactions and Impacts

Potential ski area development activities contemplated in the Site Guidelines that have strategic implications for Canada lynx include:

- potential changes to the developed area and leasehold
- potential development and modification of ski terrain including the Rockgardens area
- potential visitor use and ski area operations.

Maintaining a suitable mosaic of habitat necessary for foraging, denning and travel is essential for maintaining lynx at the local level, and probably also at the regional level. Specific targets are not available for degree of fragmentation, but lynx are traditionally considered to avoid open areas (Koehler, 1990, Ruggieri 1994). There is no literature on how many ski runs that lynx will cross, but it is documented that lynx typically do not cross areas wider than 100m (Koehler 1990). However in other studies lynx and snowshoe hare have been observed to preferentially use open terrain such as roadsides and pipeline right-of ways as travel corridors (AMEC 2005). In northern environments lynx have been observed to cross open distances up to 1000 metres wide (Jalkotsky et al 1997). Although lynx are generally considered to be fairly tolerant of the presence of humans and human infrastructure (Ruggieri et. al. 1994), the number of skiers during daily ski operations is likely more of a factor inhibiting lynx from using the developed area than run width. Tracking data has demonstrated that lynx cross the Lake Louise ski hill between dawn and dusk, even though the area is used by many skiers during the day (Stevens et al. 1996, Percy 2006).

The ratio of developed to undeveloped land in the current developed area degrades it's suitability as lynx habitat. Open areas are unsuitable for foraging or denning, and present obstacles to daily movement and habitat use (Apps 2005, Koehler 1990, Todd 1983). Lynx need a mosaic of forest ages (older for denning and travel, younger for foraging), (Ruggieri et. al. 1994, Apps et. al. 2000, Todd 1983, Boyd 1978). The addition of new developed areas, or an increase in the number of runs in the current developed area increase the proportion of open areas that are generally unsuitable as lynx habitat.

Increased vehicle traffic may result in increased lynx mortality.

8.12.3 Knowledge deficiencies

Research has provided a general understanding of lynx ecology in the Rocky Mountains, but there has been no specific research on lynx in Jasper National Park. The importance of the Marmot Basin area including the undeveloped Rockgardens areas to park lynx populations is unknown.

8.12.4 Mitigating Measures

The mitigations for Canada lynx identify ecological management parameters, future planning and/or operational requirements, or future knowledge requirements that are needed to realize expected ecological outcomes as outlined in Section 4.4. The expected ecological outcomes that apply to mitigating potential impacts to Canada lynx include:

- sensitive or valued wildlife is not displaced from habitat essential to regional population sustainability
- sensitive or valued wildlife is not habituated through human contact and activity
- wildlife mortality does not increase, directly or indirectly, as a result of human contact and activity.

In order to realize expected ecological outcomes important to Canada lynx the following ecological management parameters have been incorporated into the Site Guidelines:

- ski area vegetation management to fall within the parameters for small mammal habitat as identified in section 8.3
- ski area vegetation management to result in a mosaic or forest age classes consistent with mitigations in section 8.1 and 8.4.

Additional planning and operational requirements are identified to ensure that expected ecological outcomes are realized. These should be included as part of future planning proposals or management initiatives as indicated :

- long range plans to consider potential effects of vegetation management strategies on lynx food sources i.e., snowshoe hare habitat – and denning habitat especially for the currently undeveloped Rockgardens area – existing Lynx habitat models should be used as appropriate
- long range plans to consider potential impacts of traffic on lynx mortality.

Additional knowledge requirements have not been identified beyond the long range planning and associated environmental assessment requirements.

8.12.5 Residual and Cumulative Effects

The mitigations for lynx are focused on maintaining snowshoe hare habitat on the lease and habitat parameters that will allow lynx to use and travel through the ski area leasehold.

The potential conversion of habitat in the Rockgardens area and other vegetation modification may result in the loss and disruption of potential foraging and denning habitat. The actual potential for impact will be determined as part of the long range planning process. Vegetation management strategies and mitigations outlined in other sections of this document may offset potential terrain development activities on lynx by improving the mix of forest age classes across the ski area. Temporary forest clearing (fires, fire smart, glading) could potentially be a benefit for lynx, as snowshoe hare habitats would increase in young conifer forests. The parameters for new terrain development should not result in the creation of forest habitat patches that are too small for lynx use. Run widths should not present a movement obstacle that lynx cannot navigate.

While local lynx habitat may be adversely affected by ski terrain development the physical parameters for development should not result in the absolute exclusion of lynx from the ski area leasehold. Human use may present the greatest obstacle to lynx use of the ski area environment. The magnitude of potential residual effects on lynx at a regional or local scale is likely not large given that the entire leasehold represents less than 1% of an adult lynx's home range. Mortality due to increased vehicle traffic is unlikely to be completely mitigatable.

It is anticipated that expected ecological outcomes for lynx may be realized by maintaining habitat parameters and vegetation structure that supports lynx use of the ski area leasehold.

8.13 Residual Cumulative Impacts to Ecological Integrity

This section summarizes the residual ecological impacts of ski area development as provided for by the site guidelines with an emphasis on the potential cumulative impacts and the potential for environmental gain.

Environmental impacts will be associated with potential ski area development should proposals be advanced. The footprint of the area developed and used as ski terrain and for ski area operations will increase. Environmental impacts will result from new terrain development, expanded ski area operations and increased levels of human use. Native vegetation diversity, especially forest cover, is the VC most directly and spatially impacted by potential ski area development. Changes in forest cover affect all other VCs to varying degrees.

Although potential ski terrain development involves unavoidable environmental impacts, with planning and mitigation measures as outlined in the SEA it is anticipated that expected outcomes for ecological integrity will be realized. It is not expected that

ecological integrity will be compromised at a regional scale by ski area development activities. Although artificially modified and managed, ecosystem composition and structure is intended to approximate naturally fragmented and frequently disturbed landscapes such as bowls and slopes frequently disturbed by avalanche activity. Essential ecological characteristics that define or support sensitive species, communities or features will be protected, maintained, and restored where feasible. Potential ski area development is not expected to result in the local extirpation of any sensitive species, community or wildlife.

The potential development of the Rockgardens area would contribute to the impacts noted above but will have little impact on caribou or caribou habitat. The potential lower liftline terrain park and the potential development of the mid-mountain water reservoir also do not have particular implications for caribou. It is expected that the potential impacts of these exceptions to caribou and other VCs can be addressed through project design and mitigation.

The potential lease reduction will provide greater certainty that the Whistlers Creek bed area and surrounding upslopes will remain undeveloped. As such, it will provide greater long-term protection of ecological integrity in the area than would be the case if the area remained in the lease, including enhanced protection of valuable caribou habitat and enhanced protection of an important goat mineral lick. This improved level of long-term certainty and protection is considered a substantial environmental gain that will contribute meaningfully to Parks Canada's objective of maintaining or improving ecological integrity in Jasper National Park. The environmental gains associated with Whistlers Creek also extend to other wildlife using the area including grizzly bear, wolverine, lynx, and mountain goat.

The security of the Whistlers Creek environmental gain for caribou and other wildlife is dependent in part, on the ability to control skier access from the potential Knob chairlift extension down the backside of Marmot Mountain into Marmot Pass and upper and lower Whistlers Creek valley. Off-piste skiing in the Outer Limits and Tres Hombres area, even within the adjusted ski area boundary, may result in the disturbance of caribou outside the boundary. Parameters and thresholds to manage off-piste skiing and educate ski area visitors provide insurance that environmental gains associated with the return of Whistlers Creek from the leasehold are achieved. The caribou risk assessment is an important step in determining the potential impacts of skier use in Whistlers Creek valley.

The potential Knob Chairlift extension may present a potential barrier and disruption to mountain goat migration routes depending on the upper terminal location and design. Information on mountain goat habitat and regional goat use of the Marmot Basin environment will allow for an objective and scientifically sound assessment of the nature of potential impacts to the regional mountain goat population in a long range plan.

Planning and assessment initiatives pertaining to caribou and mountain goat will take place prior to, and be included as part of, future long range planning processes. This will

ensure that long range plans focus on the most feasible and beneficial development options before entering into the formal planning, assessment and approval process.

Specific measures to mitigate potential impacts to caribou, mountain goats and other wildlife, that use Whistlers Creek valley will be addressed in long-range plans and subsequent environmental assessments. However, potential ski area development that proceeds in accordance with the parameters of the Site Guidelines and that responds to the planning and information requirements of the SEA, can be expected to result in long-term environmental gain.

9 Impact Assessment – Visitor Experience

9.1 Visitor Needs and Expectations

As an overall package the potential development options that can be considered under the Site Guidelines are intended to address needs for:

- new beginner terrain options
- additional expert terrain to respond to identified target markets needs
- upgraded lift systems that meet modern standards
- balanced day lodge facilities and other services that meet industry standards
- resolving parking congestion and facilitating mass transit options.

There are no published standards for ski terrain design (Devlin, pers com) but ski area planners utilize rules of thumb for run and terrain design that are intended to account for visitor comfort, aesthetics, skill levels, safety and general environmental concerns such as windthrow.

Modern designers typically design ski areas so that a 35/65 ratio is maintained between cleared areas for ski runs and natural forest cover to meet the aesthetic expectations of skiers (Devlin, pers com). The vegetation cover mosaic on the lower part of the ski area (below Eagle Chalet) is not optimal with respect to modern design standards being currently 65.5% cleared (including ski runs, parking lots and operational areas) while 34.5% remains in natural forest cover.

Ski area designers typically design ski runs to fall within the 30-50 m width range depending on the desired level of skiing experience and to meet aesthetic expectations and skill level variation of skiers (Devlin, pers com). The potential for windthrow, and snow retention are other considerations that the 30-50 m rule-of-thumb is intended to address.

Designers typically design ski runs so that the distance between runs more than exceeds the typical 30-50 m width of adjoining ski runs to meet aesthetic expectations of skiers (Devlin, pers com) and to prevent wind throw. This rule-of-thumb was reflected in the parameters for the Eagle Ridge Comprehensive Study which indicated that forest strips in between runs should be at least as wide as the run itself (IRIS 1999) to prevent wind throw and to provide adequate shelter for skiers from the wind and weather.

It should be noted that the design parameters for ski run width, distance between runs and developed/undeveloped terrain are less than, or similar to, the parameters required to maintain small mammal habitat structure discussed in section 8.3. As a precautionary approach the more conservative ski industry parameters have been applied as the parameters for conserving small mammal habitat (see section 8.3.4).

Design standards are also incorporated into development calculations for ski lifts, food and commercial services, and parking and transportation.

The rules of thumb and standard calculations used to calculate the growth limits and balancing parameters for Marmot Basin are based on reasonable industry standards that are intended to ensure a comfortable, safe and enjoyable ski experience. They also respect key ecological considerations for wildlife outlined previously in this document.

9.2 Visitor Education and National Park Experience

Site Guidelines include direction on visitor educational and national park experience that supplement the ski experience and reinforce national park messages and management objectives consistent with existing park management direction. Although specific direction is not provided, the Site Guidelines create expectations in the long range plan and in the development of best management practices for managing viewscapes, noise and external lighting, signage, advertisement and special events, developing a heritage tourism and winter education strategy, and encouraging a consistent architectural theme. These expectations are consistent with those required of communities and outlying commercial accommodations and will be fully evaluated as part of the long range planning process.

Visitor education is an important component of gaining visitor cooperation and contribution towards achieving certain ski area ecological management parameters. The following educational goals should be addressed in the visitor education program brought forward as part of the long range planning process:

- visitors are informed of the potential impacts to caribou and mountain goats associated with off-piste and out-of bounds skiing and encouraged to follow protective guidelines
- visitors are informed of the potential impacts associated with water use and are encouraged to support water conservation measures.

9.3 Viewscapes and Aesthetics

Potential ski area development may impact the aesthetic experience of other national park users. Potential ski run development in the Rockgardens area will not be easily visible from the Athabasca River valley bottom or from the town of Jasper. This area may be visible from the south along highway 93 or from popular Cavell Meadows raising the visual profile and aesthetic impact of the ski area to many visitors. The potential Rockgardens development may also be visible from the Skyline trail across the Athabasca valley to the east. Mitigations for the management of vegetation and development of ski terrain (see sections 8.1 and 8.3) will to some degree minimize visual impacts by simulating the parameters of naturally fragmented and frequently disturbed landscapes that could be seen in other areas.

If a summit terminal were proposed for the potential Knob chairlift extension it would also have potential visual impacts. A summit terminal would interrupt the summit ridge profile and could be visible from the locations mentioned above as well as from the Town of Jasper and the summit of Whistlers Mountain. The potential for a summit lift to adversely impact the scenic views from the Whistlers summit trail was previously documented by Leeson (1986).

The following actions should be considered as part of the long range planning process in order to more accurately gauge and mitigate the potential aesthetic impacts of the potential Rockgardens and Knob chair developments, if advanced:

- design and location alternatives that minimize the disruption of the summit ridge profile and visibility of the potential Knob chair extension should be identified and evaluated.

9.4 Avoiding visitor use conflicts

The potential for increased out-of-bounds skiing has been described in association with potential impacts to caribou in section 8.9. While important to wildlife, the Whistlers Creek valley is also used by backcountry skiers and snowshoe enthusiasts as it is one of the only locations that regularly supports good snow conditions close to the Town of Jasper. Potential conflict between different backcountry user groups such as hikers, mountain bikers and horseback riders or helicopter skiing, snowmobile, and backcountry skiers are well known in other multi-use recreational landscapes. It would not be unreasonable to predict that an increase in out-of-bounds skiing in the Tres Hombre and Outer limits areas, or in Marmot Pass and upper Whistlers Creek might conflict with the snow conditions and solitary experience that backcountry recreationists seek.

However, mitigations that prevent the disruption and displacement of caribou and mountain goats as outlined in sections 8.9 and 8.10 are expected to also effectively mitigate ski area visitor use conflicts with backcountry recreation. No other potential visitor use conflicts or mitigations have been identified.

9.5 Visitor Use Impact Summary

Expected visitor experience outcomes as outlined in section 4.6 can be realized through application of the site guidelines and mitigations in this SEA.

The potential development contemplated in the Site Guidelines is expected to contribute to a quality ski area visitor experience. Ski area resort balance is addressed within the existing guidelines. The identification and assessment of alternatives for the potential Knob Chairlift extension are expected to ensure that the most appropriate development option is brought forward as part of the long range plan.

The Site Guidelines include expectations for visitor education and experience that are consistent with those required of communities and outlying commercial accommodations ensuring that the range of visitor experience includes opportunities to learn about and connect with natural and cultural heritage consistent with Marmot Basin's location in Jasper National Park and a World Heritage Site.

The aesthetic impacts of potential ski area development are addressed for both on-hill and off-hill park users. Ski area design "rules of thumb" are applied to the development of new ski terrain addressing the expectations of skiers. These design parameters are also consistent with naturally fragmented areas in Jasper, contributing towards a natural look and feel with respect to viewscapes and aesthetics for both on-hill and off-hill visitors. The identification and consideration of alternatives for the potential Knob

chairlift is expected to ensure that the most visually appropriate development option is brought forward for consideration as part of a long range plan.

Mitigations that address potential impacts to caribou and mountain goats are also expected to mitigate any potential visitor use conflicts between ski area users and backcountry recreationists.

10 Impact Assessment – Infrastructure Capacity

VCs for the evaluation of potential impacts to regional infrastructure capacity directly reflect the expected outcomes of the Management Guidelines outlined earlier in Section 4.7. The expected outcome related to infrastructure capacity is that sufficient capacity and environmental standards are met before growth can take place.

10.1 Road and transportation system capacity

With respect to transportation capacity issues the objectives of the Site Guidelines focus on the use of buses and other forms of mass transit, improving the efficiency of parking lots, ensuring public safety, consolidating operational roads, and reducing impacts such as erosion.

The site guidelines allow for the potential reconfiguration and expansion of personal vehicle and bus parking lots, the construction of parking structures, and use of the access road within the existing developed area to address parking needs. The site guidelines also indicate that an integrated mass transportation strategy is required before parking lot expansion can occur.

The site guidelines also indicate that there will be no net increase in operational service roads/trails to lifts and facilities. Roads/trails will be consolidated where possible and those no longer required rehabilitated. Impacts of operational road use, such as erosion, will be addressed.

The Site Guidelines largely consist of actions designed to mitigate the potential impacts of increased traffic, road and parking lot use. The following mitigations have also been included in the Site Guidelines:

- parking lot expansion to include rehabilitation and restoration strategies to address erosion, water, and vegetation issues of new and existing parking lots and roads
- long range plans to address the potential impacts of increased road use on wildlife mortality and habituation on the Marmot access road
- long range plans to address potential impacts to public safety as a result of increased traffic on the Marmot access road

Expected outcomes for road and transportation systems can be realized through the application of the site guidelines and the mitigations above. The use of mass transit will minimize the impact and need for new facilities or capacity upgrades. The consideration of wildlife and public safety in the long range plans, and the inclusion of rehabilitation and restoration strategies will address past and future impacts of the road, parking lot and transportation system.

10.2 Water supply and demand and downstream water quality

Water and wastewater issues have been addressed in sections 8.6 and 8.7 of this document. No additional issues or mitigations are identified here.

Expected outcomes related to the regional sustainability and quality of water can be realized through the application of the site guidelines and previously identified mitigations. With effective planning, operation and monitoring no downstream water supply or water quality issues are anticipated to arise.

10.3 Electrical supply and demand

The Ski Area Management Guidelines indicate that electrical capacity increase can be considered but qualifies this by requiring that "infrastructure must have sufficient capacity and meet environmental standards before ski area growth can take place". The principle electrical power is generated locally in Jasper National Park. Jasper is not part of the provincial power grid and there is a limited power supply.

A requirement for additional electrical power at the ski area is not expected unless in the future lift access is extended to the Tres Hombres and Outer limits area. The Site Guidelines indicate that that green alternative energy sources such as micro-hydro, solar or small-scale wind generation can be considered if additional power is required. The following issues are to be considered in the development of best management practices:

- building modifications should incorporate and promote energy efficiency and conservation technologies and design principles
- snowmaking systems should be designed and purchased to utilize the most efficient technology in snow guns reducing the need for on hill power, compressed air and water consumption.

Expected outcomes related to electrical supply and demand can be realized through the application of the site guidelines and mitigations identified above. A focus on energy efficient technologies e.g. snowgun technology, will reduce the need for additional electrical power. If additional power is required on-hill, alternative energy technologies are an option reducing the need to draw on the local power grid. If additional development requires expanded use of the regional power grid, capacity must be in place prior to development.

10.4 Visitor and staff accommodation capacity.

All employee housing and visitor accommodation is currently provided in the Town of Jasper, in outlying commercial accommodations (OCAs) and in the Town of Hinton outside the park east gate. The Ski Area Management Guidelines and the Site Guidelines indicate that this will continue to be the case into the foreseeable future.

The Jasper Community Plan accounts for local infrastructure capacity issues in relation to residential, seasonal and visitor accommodation. The Town of Jasper Community Plan and OCA growth limits allow increased employee or visitor use accommodation. The anticipated need for extra staff at Marmot as a result of development is minimal (Marmot predicts an increase in staff from 225 to 250) at full build-out should it occur.

The Site Guidelines indicate that an Employee Housing Strategy, consistent with community plan direction and the Ski Area Management Guidelines will be required as part of a Long-Range Plan and that staff housing be in place prior to ski area expansion that requires the hiring of additional employees. Long range plans will need to

demonstrate that growth at the ski area respects the existing growth limits established for the community and OCAs.

Expected outcomes related to visitor and staff accommodation capacity can be realized through the application of the site guidelines identified above. Increased accommodation demand related to ski area growth will remain within the established infrastructure and environmental capacity defined in the community and OCA plans.

10.5 Environmental management system

An EMS provides an overall system for the management of an organization's environmental issues. It includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, and reviewing an organization's environmental management goals. An EMS also provides an auditable system for documenting, tracking, managing and improving environmental performance.

The development of Best Management Practices will provide the basic framework for an EMS for the ski area. Action plans and a monitoring program will be developed for key issues as part of a long range plan.

Incorporation of the above EMS components and issues is expected to ensure that the ski area EMS effectively addresses potential on-going operational impacts of ski area development and operation.

10.6 Infrastructure Capacity Impact Summary

Expected infrastructure capacity outcomes as outlined in section 4.7 can be realized through application of the site guidelines and mitigations in this SEA. The strategies and mitigations outlined in the site guidelines and the SEA are intended to ensure that ski area resource use falls within existing infrastructure capacity. Where additional capacity is required the mitigations are intended to ensure that ski areas resource use falls within existing environmental capacity.

The incorporation of sustainable design principles and products into ski area development plans is intended to ensure resource use efficiency and conservation. The implementation of an environmental management system is intended to ensure that ski area operational impacts are within accepted or agreed upon environmental parameters and standards. Ski area growth limits will be incorporated into the updates for the Jasper National Park Management Plan ensuring that ski area growth is further factored into regional plans and assessments.

11 Follow-up

A suite of follow-up actions including parameters for future studies and information requirements are identified throughout the SEA. For the subsequent long range planning process and environmental assessment the most important of these are:

- information on vegetation fragmentation (see section 8.1)
- hydrologic flow and water quality (see section 8.6 and 8.7)
- caribou risk assessment and scenario modeling (see section 8.9)
- goat habitat assessment (see section 8.10)
- visual impact assessment (see section 9)
- analyses of infrastructure capacity and requirements as appropriate (see section 10).

The information from these follow-up actions will be factored into the next stage of planning. Some information will be used to identify and evaluate potential development options to be included in long range plans. The Comprehensive Study environmental assessment will use the information gathered to build on the SEA confirming or altering the conclusions as appropriate. The development of best management practices and the implementation of an environmental management system will also be important elements of the long range planning and environmental assessment processes.

No other follow-up to the SEA is considered necessary.

12 Summary and Conclusions

The objectives of the strategic environmental assessment report as outlined in section 1.2 were to:

- examine the Site Guidelines and present information about how ski area development and activity carried out within those guidelines would affect the ecological, cultural and visitor experience environments of JNP in a strategic planning context
- determine if the Site Guidelines are consistent with direction provided in legislation and policy pertinent to the Parks Canada mandate
- provide an assessment of cumulative environmental effects that informs future long range planning and comprehensive study environmental assessment requirements
- document the strategic environmental assessment process in accordance with the guidance in the Cabinet Directive.

Potential impacts to the ecological, cultural and visitor experience environments of ski area development were identified and assessed in relation to expected outcomes for ecological integrity, visitor use and infrastructure capacity. Expected outcomes were based on established legislation and policy direction for Parks Canada including the *Jasper National Park Management Plan* and the *Ski Area Management Guidelines*. Ski area development that achieves expected outcomes is considered to be consistent with policy and legislated direction.

There are inevitable environmental impacts associated with potential ski area development, should it be advanced. The footprint of ski area development and operations will increase. Native vegetation diversity and small mammal habitat structural

characteristics are the valued ecological components most directly impacted by potential development. However, ski area development that proceeds in accordance with the parameters of the Site Guidelines and that responds to the planning and information requirements of the SEA is expected to achieve the outcomes for ecological integrity consistent with direction in the Park Management Plan.

The cumulative effects associated with potential ski area development as considered in the Site Guidelines are not expected to compromise ecological integrity at a regional scale. Permanent growth limits are established by the Site Guidelines, along with a reduced leasehold size, providing long-term land development and resource use certainty in accordance with the Ski Area Management Guidelines. Ski terrain design and vegetation management practices are expected to reflect natural patterns of fragmentation and support regional fire and vegetation management efforts. While recognizing that additional analysis will take place as part of the caribou risk assessment, it is expected at this point that potentially sensitive regional wildlife populations including grizzly bear, wolverine, lynx, woodland caribou and mountain goat will not be threatened by development that proceeds in accordance with the Site Guidelines.

At the local scale, ecosystem composition and structure and essential ecological characteristics that define or support sensitive species, communities or features will be protected, maintained, and restored where feasible. Although there may be increased water use associated with ski area development, it is expected that aquatic ecosystem processes will continue to function within a natural range of variability and that seasonal flows patterns will continue to support local aquatic and riparian wildlife and vegetation communities. The cumulative effects of ski area development are not expected to result in the extirpation of local sensitive species, communities or wildlife populations.

The proposed lease reduction will provide greater certainty that the Whistlers Creek bed area and surrounding upslopes will remain undeveloped. As such, it will provide greater long-term protection of ecological integrity in the area than would be the case if the area remained in the lease, including enhanced protection of valuable caribou habitat and enhanced protection of an important goat mineral lick. This improved level of long-term certainty and protection is considered a substantial environmental gain that will contribute meaningfully to Parks Canada's objective of maintaining or improving ecological integrity in Jasper National Park. The environmental gains associated with Whistlers Creek also extend to other wildlife using the area including grizzly bear, wolverine, lynx, and mountain goat.

Parks Canada applies the precautionary approach in situations where a decision must be made about a risk of serious or irreversible harm and where there is scientific uncertainty. A precautionary approach is being taken to address potential development issues where uncertainties exist. Precautionary measures have been applied throughout the Site Guidelines and the strategic environmental assessment, in particular with respect to potential adverse effects on the habits and habitats of both mountain goats and woodland caribou.

Consistent with a precautionary approach, the Site Guidelines stipulate the conditions that must be met before Parks Canada will consider potential future projects. In a number of cases there are environmental knowledge deficiencies related to some of the potential future initiatives that Marmot Basin has identified. In these cases, the knowledge gaps must be addressed as part of the preparation of a long-range plan if the ski area wishes to pursue the potential initiative in the future. In the case of potential Whistlers Creek development, the caribou risk assessment will determine if potential development in the area can be considered.

As a specific issue requiring a precautionary approach, there is some uncertainty as to the environmental effects of a potential extension to the Knob Chairlift on mountain goat and caribou habitat and how mitigating measures will be achieved. The precautionary planning and information requirements in the strategic environmental assessment are intended to provide direction that will address these uncertainties as part of future long range planning and environmental assessment exercises, should a proposal for extension to the Knob Chairlift be advanced.

There is also uncertainty as to the potential environmental effects of off-piste skiing in the Tres Hombres and Outer Limits areas on caribou and caribou habitat. These uncertainties will be addressed through management thresholds and mitigations developed in association with the caribou risk assessment.

Overall, the guidance provided on planning and information requirements in the strategic environmental assessment is intended to provide information to reduce uncertainty and to provide objective, scientifically sound information for decision making. It should be emphasized that proposed long range plans and subsequent environmental assessments will have to clearly respond to the ecological management parameters of the Site Guidelines and the planning and information requirements of the SEA in order to demonstrate that expected outcomes for ecological integrity can be achieved.

Potential ski area development proposals that proceed in accordance with the parameters of the Site Guidelines and the planning and information requirements of the SEA are expected to achieve the defined outcomes for visitor experience. Potential development contemplated in the Site Guidelines is expected to contribute to a balanced resort and a quality visitor experience that enables the ski area to remain competitive in the marketplace. The Site Guidelines include expectations for visitor education and experience that are consistent with those required of communities and outlying commercial accommodations ensuring that the range of visitor experience includes opportunities to learn about and connect with natural and cultural heritage consistent with Marmot Basin's location in Jasper National Park and a World Heritage Site. Viewscape impacts and potential visitor use conflicts are addressed with respect to the needs of on-hill and off-hill park visitors.

Expected infrastructure capacity outcomes can be realized through application of the Site Guidelines and the planning and information requirements of the SEA. Ski area resource use related to transportation, accommodation and electrical generation is

expected to remain within the limits of existing infrastructure. If additional infrastructure capacity is required, environmental capacity must be established and infrastructure upgrades must be in place prior to the associated development taking place. Ski area water use may increase but seasonal flow patterns and water levels necessary to maintain aquatic life will be maintained. Wastewater discharge will meet appropriate guidelines. Ski area growth limits will be incorporated into the updates for the Jasper National Park Management Plan ensuring that ski area growth is further factored into regional plans and assessments.

As part of a precautionary approach, additional research and planning needs to take place to ensure that potential ski area development proposals, should they be advanced and approved, will result in intended environmental and visitor experience gains. Planning and information initiatives as outlined in the SEA will allow for an objective and scientifically sound assessment of ski area development opportunities and alternatives leading into the long range planning phase of ski area development. Planning and risk assessment information will be used to identify and evaluate potential development options to be included in long range plans. Subsequent environmental assessment of long range plans in accordance with the *Canadian Environmental Assessment Act* will use the information gathered to build on this SEA, confirming or refining the conclusions as appropriate.

The strategic environmental assessment has been conducted so that decision-makers can understand the potential consequences of implementing the Site Guidelines and make decisions accordingly. Ski area development that proceeds in accordance with the ecological management parameters of the Site Guidelines and that responds to the planning and information requirements of this strategic environmental assessment may be expected to result in the achievement of expected ecological, visitor experience and infrastructure capacity outcomes.

13 Literature Cited

13.1 Section 6 - Description of Environment

IRIS Environmental Systems, 1999. A proposal to develop a chairlift and ski runs on Eagle Ridge Marmot Basin Ski Area, Jasper National Park. IRIS Environmental Systems. Calgary, Alberta.

Leeson, B. 1986. Marmot Basin Ski Area initial environmental evaluation. Environment Canada – Parks. Calgary, Alberta.

Scott, D. and Jones, B. 2005. Climate Change & Banff National Park: Implications for Tourism and Recreation. Report prepared for the Town of Banff. Waterloo, ON: University of Waterloo.

Scott, D. and Jones, B. 2006. Climate Change & Seasonality in Canadian Outdoor Recreation and Tourism. Waterloo, ON: University of Waterloo, Department of Geography.

Scott, D. and Suffling, R. (2000). Climate change and Canada's national park

system. Hull, QC: Environment Canada and Parks Canada.

13.2 Section 8.1 – Native Vegetation Diversity

Billings, W.D. and H.A. Mooney. 1968. The ecology of arctic and alpine plants. Biol. Rev. 43:481-525.

Bliss, L.C. 1962. Adaptations of arctic and alpine plants to environmental conditions. Arctic. 15: 117 – 144.

Cole, D.N., 1985. Recreational trampling effects on six habitat types in Western Montana. Research Paper INT-350. Ogden, UT. U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 43p.

Fahey, B and K Wardle. 1998. Likely impacts of snow grooming and related activities in the West Otago ski fields. Science for Conservation: 85. Department of Conservation. Wellington, New Zealand.

Fiedler and Groom 2006. Restoration of Damaged Ecosystems. Principles of Conservation Biology, Third Edition, Chapter 9. Ed., Groom M, G. Meffe and C.R. Carroll.

Groom, M. 2006. Threats to Biodiversity. Principles of Conservation Biology, Third Edition, Chapter 9. Ed., Groom M, G. Meffe and C.R. Carroll.

Hamilton, E. H. 1981. The Alpine Vegetation of Marmot Basin, Jasper National Park, Alberta And the Impact of Ski Activities Upon It. Masters Thesis. Faculty of Graduate Studies and Research, Department of Botany, University of Alberta.

Holland. E. D. and G.M. Coen. General Editors. Ecological (biophysical) land classification of Banff and Jasper National Parks. Alberta Institute of Pedology. Publ. No. M-83-2.

Rixen, C., V Stoeckli and W. Ammann. 2003. Does artificial snow cover affect soil and vegetation of ski pistes? A review. Perspectives in Plant Ecology, Evolution and Systematics. Vol. 5/4, pp. 219-230.

Parminter, J. 1998. Natural disturbance ecology. Conservation Biology Principles for Forested Landscapes, Chapter 1. Ed., Joan Valler and Scott Harrison.

Polster, D.F. 1999, Successional reclamation: a model for ecological restortation. Proceedings - Helping the Land Heal Conference. University of Victoria.

Walker, D. and K Wilkinson. 1999. An Analysis of Converns Relating to the Use of Snomax Snow Inducer for Snowmaking at the Lake Louise Ski Area. David Walker & Associates Ltd. Calgary Alberta.

Wonham, M. 2006. Species Invasions. Principles of Conservation Biology, Third Edition, Chapter 9. Ed., Groom M, G. Meffe and C.R. Carroll.

13.3 Section 8.2 – Rare/Sensitive Species and Communities

Holland. E. D. and G.M. Coen. General Editors. Ecological (biophysical) land classification of Banff and Jasper National Parks. Alberta Institute of Pedology. Publ. No. M-83-2.

Leeson, B. 1986. Marmot Basin Ski Area initial environmental evaluation. Environment Canada – Parks. Calgary, Alberta.

13.4 Section 8.3 – Small Mammal Habitat Structure

Brittell, J.D., R.J. Poelker, S.J. Sweeny, and G.M Koehler. 1989. Native cats of Washington – Section III: Lynx. Washington State Dept.Wildl. Olympia, Wash.

Fahey, B and K Wardle. 1998. Likely impacts of snow grooming and related activities in the West Otago ski fields. Science for Conservation: 85. Department of Conservation. Wellington, New Zealand.

Hargis, C. et al. 1999. The Influence of forest fragmentation and landscape pattern on American martens. Journal of Applied Ecology. 36 (1), 157-172.

Kirk, T.A. 2006. Building and testing a habitat suitability model for the American marten (Martes Americana) in northeastern California. Environmental and Natural Resource Sciences, Humbolt State University. Arcata, California.

Koehler, G.M. 1990. Population and habitat characteristics of lynx and snowshoe hares in north central Washington. Can. J. Zool. 68:845-851.

Koehler, G.M. and J.D. Brittell. 1990. Managing spruce-fir habitat for lynx and snoeshoe hares. Journal of Forestry 88: 10-14.

Rixen, C., V Stoeckli and W. Ammann. 2003. Does artificial snow cover affect soil and vegetation of ski pistes? A review. Perspectives in Plant Ecology, Evolution and Systematics. Vol. 5/4, pp. 219-230.

Percy, M. 2006. Lake Louise Corridor and Snow Tracking Project 1993-2004. Unpublished. Lake Louise, Yoho and Kootenay Field Unit, Parks Canada.

Walker, D. and K Wilkinson. 1999. An Analysis of Converns Relating to the Use of Snomax Snow Inducer for Snowmaking at the Lake Louise Ski Area. David Walker & Associates Ltd. Calgary Alberta.

13.5 Section 8.4 – Historic Fire Regime

Achuff, P.L., A.L. Westhaver and M. Mitchell. 2001. Fire/vegetation groups, fire cycles, fire behavior prediction fuel types, and annual burn areas in Jasper National Park. Unpublished Parks Canada Report. 20pp.

Andison. D.W. 2000. Landscape level fire activity on foothills and mountain landscapes of Alberta. Bandaloop Landscape-Ecosystem Services. Foothills Model Forest. Ecology Research Series, Report No. 2.

Cornelson, Steve. 1985-88. Unpublished fire history maps of Jasper National Park. Warden Service fire history project.

Daigle, Patrick. 1996. Fire in the dry interior forests of British Columbia. Ministry of Forests Research Program. Extension Note #8. British Columbia Ministry of Forests. Victoria, B.C. 6p.

Fenton, G. and B. Wallace. 1978. Preliminary fire management plan for Jasper National Park. Internal report. Jasper National Park.

Graham, R.T., S. McCaffrey, and T.B. Jain (technical editors). 2004. Science basis for changing forest structure to modify wildfire behavior and severity. Gen. Tech. Report RMRS-GTR-120. Fort Collins, CO. U.S. Department of Agriculture, Forest Service, Rocky Mountain Res. Station. 43p.

Kubian, R. 1999. Fire management zone map, Jasper National Park. Unpublished Warden Service operations aid. Jasper. Alberta.

Mitchell, M.P. 2005. Montane landscape heterogeneity and vegetation change in Jasper National Park (1949-1997). M.Sc. thesis. University of Northern British Columbia, Prince George, British Columbia. 132p.

Mutch, Robert W. 1994. Fighting fire with prescribed fire: a return to ecosystem health. Journal of Forestry. 92(11): 31-33.

Partners in Protection. 1999. FireSmart: Protecting your community from wildfire. Quality Color Press. Edmonton, Alberta, Canada. ISBN 0-662-27920-4.

Parks Canada. 2000. Jasper National Park of Canada management plan. Minister of Public Works and Public Services Canada. Department of Canadian Heritage. Ottawa Catalogue Number R64-105/28-2000E. 78pp.

Rhemtulla, J.M. 1999 Eighty years of change : the montane vegetation of Jasper National Park. University of Alberta. MSc. Thesis.

Risbrudt, C.D. 1995. Ecosystem Management: a framework for management of our national forests. Natural Resources and Environmental Issues. Vol V. pp. 91-96.

Scott, J.H. and E.D. Reinhardt. 2001. Assessing crown fire potential by linking models of surface and crown fire behavior. Res. Paper RMRS-RP-29. Fort Collins, CO. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 59p.

Tande, G. F. 1979. Forest fire history around Jasper townsite, Jasper National Park, Alberta. MSc. Thesis, University of Alberta. 169 pp.

Van Wagner, C.E. 1995. Analysis of fire history for Banff, Jasper, and Kootenay National Parks. Unpublished Parks Canada Report. Ottawa. 28pp.

Westhaver, A.L. 2002. Summary of prescribed burns (completed and planned) in Jasper National Park. Internal working paper. Jasper National Park. 4pp.

Westhaver, A.L. and P.L. Achuff. 2000. Vegetation Management Strategy for Jasper National Park. Unpublished Parks Canada Report. 105 pp.

13.6 Section 8.5 – Soils and Terrain Features

Holland. E. D. and G.M. Coen. General Editors. Ecological (biophysical) land classification of Banff and Jasper National Parks. Alberta Institute of Pedology. Publ. No. M-83-2.

IRIS Environmental Systems, 1999. A proposal to develop a chairlift and ski runs on Eagle Ridge Marmot Basin Ski Area, Jasper National Park. IRIS Environmental Systems. Calgary, Alberta.

Leeson, B. 1986. Marmot Basin Ski Area initial environmental evaluation. Environment Canada – Parks. Calgary, Alberta.

13.7 Section 8.6 – Surface and Subsurface Flow Regimes

ARSCOTT D. B. ; TOCKNER K. ; WARD J. V. (2000) Aquatic habitat diversity along the corridor of an Alpine floodplain river (Fiume Tagliamento, Italy). Department of Limnology, EAWAG/ETH, Ueberlandstrasse 133, 8600 Duebendorf, SUISSE

Fahey, B and K Wardle. 1998. Likely impacts of snow grooming and related activities in the West Otago ski fields. Science for Conservation: 85. Department of Conservation. Wellington, New Zealand.

IRIS Environmental Systems, 1999. A proposal to develop a chairlift and ski runs on Eagle Ridge Marmot Basin Ski Area, Jasper National Park. IRIS Environmental Systems. Calgary, Alberta.

Kondolf, G. Mathias; Kattelmann, Richard; Embury, Michael; Erman, Don C. 1996. Status of riparian habitat. In: Sierra Nevada Ecosystem Project: Final report to Congress, vol. II, Assessments and scientific basis for management options. Wildland Resources Center Report no. 37. Davis, CA: University of California, Centers for Water and Wildland Resources; 1009-1030.

Lake P.S. 2003. Ecological effects of perturbation by drought in flowing waters Freshwater Biology 48 (7), 1161–1172.).

Leeson, B. 1986. Marmot Basin Ski Area initial environmental evaluation. Environment Canada – Parks. Calgary, Alberta.

Lepori F, Palm D, Brännäs E, Malmqvist B (2005) DOES RESTORATION OF STRUCTURAL HETEROGENEITY IN STREAMS ENHANCE FISH AND

MACROINVERTEBRATE DIVERSITY. Ecological Applications: Vol. 15, No. 6 pp. 2060–2071.

Molles, M and J Gosz. 1980. Effects of a Ski Area on the Water Quality and Invertebrates of a Mountain Stream. Water, Air and Soil Pollution 14 (1980) pp 187-205.

Naiman Robert J., Henri Decamps, Michael Pollock The Role of Riparian Corridors in Maintaining Regional Biodiversity *Ecological Applications*, Vol. 3, No. 2 (May, 1993), pp. 209-212.

NEWCOMBE CP, MACDONALD DD (1991) Effects of Suspended Sediments on Aquatic Ecosystems. North American Journal of Fisheries Management: Vol. 11, No. 1 pp. 72–82.

Pringle, Catherine M. (2001) Hydrologic Connectivity and the Management of Biological Reserves: A Global Perspective. *Ecological Applications*, Vol. 11, No. 4 (Aug., 2001), pp. 981-998.

RICHARDS CARL, GEORGE E. HOST, JOHN W. ARTHUR (1993) Identification of predominant environmental factors structuring stream macroinvertebrate communities within a large agricultural catchment. Freshwater Biology 29 (2), 285–294.

Rixen, C., V Stoeckli and W. Ammann. 2003. Does artificial snow cover affect soil and vegetation of ski pistes? A review. Perspectives in Plant Ecology, Evolution and Systematics. Vol. 5/4, pp. 219-230.

Rixen C., W Haeberli and V Stoeckli. 2004. Ground Temperatures Under Ski Pistes with Artificial and Natural Snow. Arctic, Antarctic, and Alpine Research. Vol 36, No. 4 pp. 419-427.

TOCKNER K. ; WARD J. V. (1999) Biodiversity along riparian corridors Department of Limnology, EAWAG/ETH, 8600 Dübendorf, SUISSE.

Walker, D. and K Wilkinson. 1999. An Analysis of Converns Relating to the Use of Snomax Snow Inducer for Snowmaking at the Lake Louise Ski Area. David Walker & Associates Ltd. Calgary, Alberta.

13.8 Section 8.7 – Water Quality

Bergfald & Co. on behalf of the Norwegian Pollution Control Authority. 2005. A study of the priority substances of the Water Framework Directive.

Betts, K. S. 2007. May 2007. Perfluoroalkyl Acids What Is the Evidence Telling Us? Environmental Health Perspectives. Vol. 115 (5).

Bio-Glide. 2007 URL: http://www.welovesoy.com/bioglide.html Accessed June 7, 2007.

Bowman, Michelle, 2004, Effects of Low-Level Eutrophication on Ecological Integrity of Rivers in the Rocky Mountain National Parks of Canada, PhD thesis University of Alberta, Department of Biological Sciences.

Enviro Mountain Sports Inc. 2007. URL: http://www.enviromountain.com/ Accessed May 22, 2007.

Environment Canada. 2006. National Office of Pollution Prevention. Perfluorinated Carboxylic Acids (PFCAs) and Precursors: An Action Plan for Assessment and Management. URL: http://www.ec.gc.ca/nopp/DOCS/rpt/PFCA/en/actionPlan.cfm Accessed June 4, 2007.

Ethica Enviro Wax/Hillbilly Wax-Works. 2007. URL: http://www.hillbillywaxworks.com/ Accessed June 11, 2007.

Cory-Slechta, D.Dr., (Chair). 2006. EPA Science Advisory Board. SAB Review of EPA's Draft Risk Assessment of Potential Human Health Effects Associated with PFOA and Its Salts. URL: http://www.epa.gov/sab/pdf/sab_06_006.pdf Accessed June 11, 2007.

Rixen, C., V Stoeckli and W. Ammann. 2003. Does artificial snow cover affect soil and vegetation of ski pistes? A review. Perspectives in Plant Ecology, Evolution and Systematics. Vol. 5/4, pp. 219-230.

Swedish Chemicals Agency. 2006. Perfluorinated substances and their uses in Sweden. URL: http://kemi.se/upload/Trycksaker/Pdf/Rapporter/Report7_06.pdf Accessed June 8, 2007.

Wallis, P., J Buchanan-Mappin and Jcorbin. 1988. Effects of Using Ice Nucleating Bacteria (SNOWMAX) on Vegetation and Soil at Nakiska, Alberta, Canada. Kananaskis Centre for Environmental Research, University of Calgary and Hyperion Research Ltd.

Walker, D. and K Wilkinson. 1999. An Analysis of Converns Relating to the Use of Snomax Snow Inducer for Snowmaking at the Lake Louise Ski Area. David Walker & Associates Ltd. Calgary, Alberta.

13.9 Section 8.8 – Grizzly Bear

Benn, B. and S. Herrero. 2002. Grizzly bear mortality and human access in Banff and Yoho National parks, 1971-98. Ursus 13: 213-221.

Benn, B, S. Jevons, and S. Herrero. 2005. Grizzly bear mortality and human access in the central Rockies ecosystem of Alberta and British Columbia, 1972/1976-2002. Pages 73-94 in S.Herrero, editor. Biology, demography, ecology, and management of grizzly bears in and around Banff National Park and Kananaskis Country: The Final Report of the Eastern Slopes Grizzly Bear Project. Faculty of Environmental Design. University of Calgary, AB,.Canada.

Boulanger, J. 2005. Demography of Foothills Model Forest Grizzly Bears: 1999-2003. Pages 38-58 in Stenhouse, G.B. and K. Graham, eds. Foothills Model Forest Grizzly Bear Research Program 1993-2003 Final Report. Hinton, AB, Canada.

Bradford, W. Jasper National Park Wildlife Conflict Specialist.

Gibeau, M.L., and Heuer, K. 1996. Effects of Transportation Corridors on Large Carnivores in the Bow River Valley, Alberta. In: Evink GL, Garrett P, Zeigler D, Berry J, editors. Trends in Addressing Transportation Related Wildlife Mortality: Proceedings of the Transportation Related Wildlife Mortality Seminar. Tallahassee, Florida: State of Florida, Department of Transportation, Environmental Management Office.

Gibeau, M., S. Herrero, J. Kansas, and B. Benn. 1996. Grizzly bear populations and habitat status in Banff National Park: A report to the Banff Bow Valley Task Force. 61pp.

Gibeau, M.L., S. Herrero, B.N. McLellan, and J.G. Woods. 2001. Managing for grizzly bear security areas in Banff National Park and the Central Canadian Rocky Mountains. Ursus 12:121-130.

Gibeau, M.L., A.P. Clevenger, S. Herrero, and J.Wierzchowski. 2002. Grizzly bear response to human development and activities in the Bow River Watershed, AB, Canada. Bological Conservation 103: 227-236.

Gibeau, M.L., H. Purves, and B.Bush. 2007. Grizzly bear habitat security. in The Jasper National Park State of the Park draft report. Unpublished technical report. Jasper, AB. 3pp.

Herrero, S. 1985. Bear Attacks. Their Causes and Avoidances. Winchester Press. Piscataway, N.J. 287 pp.

Herrero, S. and A. Higgens. 2003. Human Injuries Inflicted by Bears in Alberta: 1960-98. Ursus. 14(1).

Hobson, D. 2005. Denning of Grizzly Bears in the Foothills Model Forest. In Pages 32-37 in Stenhouse, G.B. and K. Graham, eds. Foothills Model Forest Grizzly Bear Research Program 1993-2003 Final Report. Hinton, AB, Canada.

Mace, R.D., J.S. Waller, T.L. Manley, L.J.Lyon, and H.Zuuring. 1996. Relationships among grizzly bears, roads, and habitat in the Swan Mountains, Montana. Journal of Applied Ecology 33:1395-1404.

Mace, R.D., J.S. Waller, T.L. Manley, K. Ake, and W.T.Wittinger. 1999. Landscape evaluation of grizzly bear habitat in western Montana. Conservation Biology 13: 367-377.

Mamo, C. and R. Kunelius. 1998. Long Range Plan Wildlife Research Component. Prepared for Parks Canada and Marmot Basin Ski Area by IRIS Environmental Systems, Calgary, Alberta.

Mattson, D.J., B.M.Blanchard, and R.R. Knight. 1992. Yellowstone grizzly bear mortality, human habituation, and whitebark pine seed crops. Journal of Wildlife Management 56:432-442.

Mattson, D.J. 1993. Background and proposed standards for managing grizzly bear habitat security in the Yellowstone ecosystem. Managing Grizzly Bear Habitat Security. 17pp.

McLellan, B.N., and D.M.Shackleton, 1989. Immediate reactions of grizzly bears to human activities. Wildlife Society Bulletin. 17:269-274.

Munro, R.H.M., and G.B.Stenhouse. 2005. The diet of grizzly bears, Ursus arctos, in West-Central Alberta, Canada. Pages 11-28 in Stenhouse, G.B. and K. Graham, eds. Foothills Model Forest Grizzly Bear Research Program 1993-2003 Final Report. Hinton, AB, Canada.

Neilsen, S.E. S. Herrero, M.S. Boyce, R.D. Mace, B.Benn, M.L. Gibeau, and S.Jevons. 2004. Modelling the spatial distribution of human-caused grizzly bear mortalities in the central Rockies ecosystem of Canada. Biological Conservation 120:101-113.

Noss, R.F., Quigley, H.B., Hornocker, M.G., Merrill, T., Paquet P.C., 1996. Conservation biology and carnivore conservation in the Rocky Mountains. Conservation Biology 10, 949-963.

Ross, P.I. 2002. Update COSEWIC stutus report on the grizzly bear Ursus arctos in Canada, in COSEWIC assessment and update status report on the grizzly bear Ursos arctos in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 99 pp.

Stenhouse, G.B. Foothills Model Forest Grizzly Bear Project manager.

US Department of Agriculture Forest Service. 1990. CEM – A model for asssessing effects on grizzly bears. Missoula, MT, USA.

US Fish and Wildlife Service. 2003. Final conservation strategy for the grizzly bear in the Greater Yellowstone Area. Report prepared by the Interagency Conservation Strategy Team, Missoula MT. 160pp.

Weaver, J.L., P.C.Paquet, and L.F. Ruggiero. 1996. Resilience and conservation of large carnivores in the Rocky Mountains. Conservation Biology 10: 964-976.

13.10 Section 8.9 – Woodland Caribou

Alberta Woodland Caribou Recovery Team. 2005. Alberta woodland caribou recovery plan 2004/05-2013/14. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species at Risk Recovery Plan No. 4. Edmonton, AB.

Arlettaz, R., P. Patthey, M. Baltic, T. Leu, M. Schaub, R. Palme, and S. Jenni-Eiermann. 2007. Spreading free-riding snow sports represent a novel serious threat for wildlife. Proceedings of the Royal Society B 274:1219-1224.

Bergerud, A. T. 1974. Decline of caribou in North America following settlement. Journal of Widlife Management 38:757-770.

Bergerud, A.T., 1974b. Rutting behaviour of Newfoundland caribou. In: Geist, V., Walthers, V.F.,Morges, F. (Eds.), The Behaviour of Ungulates and its Relation to Management. Switzerland, pp. 395-435.

Bergerud, A.T. 1988. Caribou, wolves and man. Trends in Ecology & Evolution 3:68-72.

Bergerud, A.T. 1992. Rareness as an antipredator strategy to reduce predation risk for moose and caribou. In Wildlife 2001: populations. Eds. D.R. McCullough and R.H. Barrett. Elsevier Science Publishers, Ltd., London. Pp. 1008–1021.

Bergerud, A.T., R.D. Jakimchuk and D.R. Carruthers. 1984. The buffalo of the North: caribou (Rangifer tarandus) and human developments. Arctic 37:7-22.

Bergerud, A.T. and J.P. Elliott. 1986. Dynamics of caribou and wolves in northern British Columbia. Canadian Journal of Zoology 64: 1515-1529.

Bergerud, A.T. and R.E. Page. 1987. Displacement and dispersion of parturient caribou at calving as an antipredator tactic. Canadian Journal of Zoology 65:1597-1606.

Bjorge, R.R. 1984. Winter habitat use by woodland caribou in west-central Alberta, with implications for management. In Fish and Wildlife Relationships in Oldgrowth Forests, Proceedings of a Symposium held in Juneau, Alaska, 1982. Eds. W. R. Meehan, T. R. Merrel, and T. A. Hanley. American Institute of Fisheries Research Biology, Morehead City, NC. Pp. 335–342.

Boyce, M.S., P.R. Vernier, S.E. Nielsen, and F.K.A. Schmiegelow. 2002. Evaluating resource selection functions. Ecological Modelling 157:281-300.

Bradshaw, C.J.A. S. Boutin, and D.M. Hebert. 1998. Energetic implications of disturbance caused by petroleum exploration to woodland caribou. Canadian Journal of Zoology 76:1319-1324.

Brown, W.K., Kansas, J.L., and Thomas, D.C. 1994. The Greater Jasper Ecosystem caribou research project, final report. Unpublished report prepared for Parks Canada, Alberta Region, and World Wildlife Fund.

Callaghan, C., 2002. The ecology of gray wolf (Canis lupus) habitat use, survival, and persistence in the central rocky mountains, Canada. Ph.D. thesis, University of Guelph.

Cameron, R.D. and J.M. Ver Hoef. 1994. Predicting parturition rate of caribou from autumn body mass. Journal of Wildlife Management 58: 674-678.

Ciucci, P., M. Masi, and L. Boitani. 2003. Winter habitat and travel route selection by wolves in the northern Apennines, Italy. Ecography 26:223-235.

Colman, J., B.W. Jacobsen, and E. Reimers. 2001. Summer response distances of Svalbard reindeer Rangifer tarandus platyrhyncus to provocation by humans on foot. Wildlife Biology 7: 275-283.

Duchesne, M., S.D. Côté, and C. Barrette. 2000. Responses of woodland caribou to winter ecotourism in the Charlevoix Biosphere Reserve, Canada. Biological Conservation, 96: 311-317.

Dumont, A., 1993. Impact des randonneurs sur les caribous Rangifer tarandus caribou du parc de la Gaspesie. MSc thesis, Universite Laval, Quebec.

Dyer, S.J., J.P. O'Neill, S.M. Wasel, and S. Boutin. 2001. Avoidance of industrial development by woodland caribou. Journal of Wildlife Management 65:531-542.

Dzus, E. 2001. Status of the woodland caribou (Rangifer tarandus caribou) in Alberta. Alberta Environment, Fisheries and Management Division, and Alberta Conservation Association, Wildlife Status Report No. 30, Edmonton, AB.

Edmonds, E.J. and M. Bloomfield. 1984. A study of woodland caribou (Rangifer tarandus caribou) in west-central Alberta, 1979-1983. Alberta Energy and Natural Resources Fish and Wildlife Division.

Freddy, D.J., M.B. Whitcomb, and M.C. Fowler. 1986. Responses of mule deer to disturbance by persons afoot and snowmobiles. Wildlife Society Bulletin 14: 63-68.

Frid, A., and L. Dill. 2002. Human-caused disturbance stimuli as a form of predation risk. Conservation Ecology 6: 11-26.

Hebblewhite, M., Whittington, J., Bradley, M., Skinner, G., Dibb, A. & White, C. A. 2007. Conditions for caribou persistence in the wolf-elk-caribou systems of the Canadian Rockies. Rangifer, 17, In Press.

James, A.R.C. 1999. Effects of industrial development on the predator-prey relationship between wolves and caribou in northeastern Alberta. Ph.D. Thesis, University of Alberta, Edmonton, AB.

James, A.R.C. and A.K. Stuart-Smith. 2000. Distribution of caribou and wolves in relation to linear corridors. Journal of Wildlife Management 64:154-159.

James, A.R.C., S. Boutin, D.M. Hebert, and A.B. Rippin. 2004. Spatial separation of caribou from moose and its relation to predation by wolves. Journal of Wildlife Management 68: 799-809.

Johnson, C.J., D.R. Seip, and M.S. Boyce. 2004. A quantitative approach to conservation planning: using resource selection functions to map the distribution of mountain caribou at multiple spatial scales. Journal of Applied Ecology 41:238-251.

Klein, D.R. 1971. Reaction of reindeer to obstructions and disturbances. Science 173:393-398.

Mamo, C. and R. Kunelius. 1998. Long Range Plan Wildlife Research Component. Prepared for Parks Canada and Marmot Basin Ski Area by IRIS Environmental Systems, Calgary, Alberta.

Manly, B.F.J., L.L. McDonald, D.L. Thomas, T.L. McDonald, W.P. Erickson. 2002. Resource selection by animals: statistical design and analysis for field studies. Second edition. Kluwer Academic Publishers, Dordrecht, the Netherlands.

McKay, T.L. 2007. Woodland caribou response to encounters with people in Jasper National Park. M.Sc. Thesis, Royal Roads University, Victoria, BC.

Mech, L.D. 1970. The wolf: the ecology and behavior of an endangered species. The Natural History Press, New York, NY.

Musiani, M., H. Okarma, and W. Jedrezejewski. 1998. Speed and actual distances travelled by radiocollared wolves in Bialowieza Primeval Forest (Poland). Acta Theriologica 43:409-416.

Nellemann, C., I. Vistnes, P. Jordhoy, and O. Strand. 2001. Winter distribution of wild reindeer in relation to power lines, roads and resorts. Biological Conservation 101: 351-360.

Nellemann, C., I. Vistnes, P. Jordhoy, O. Strand, an A. Newton. 2003. Progressive impact of piecemeal infrastructure development on wild reindeer. Biological Conservation 113: 307-317.

Neufeld, L., and M. Bradley. 2007. South Jasper Woodland caribou summary report 2005-2006. Jasper National Park, Jasper, Alberta.

Paquet, P.C., Wierzchowski, J., and Callaghan, C. 1996. Summary report on the effects of human activity on gray wolves in the Bow River Valley, Banff National Park. In Ecological Outlooks Project: a cumulative effects assessment and futures outlook of the Banff Bow Valley. Edited by J.C. Green, C. Pacas, L. Cornwell, and S. Bayley. Prepared for the Banff Bow Valley Study, Department of Canadian Heritage, Ottawa, Ont. p. 74.

Pruitt Jr., W.O., 1979. A numerical ``Snow Index'' for reindeer Rangifer tarandus winter ecology (Mammalia, Cervidae). Annales Zoologici Fennici 16, 271±280.

Reimers, E., S. Eftestol, and J.E. Colman. 2003. Behavior responses of wild reindeer to direct provocation by a snowmobile or skier. Journal of Wildlife Management 67: 747-754.

Reimers, E., F. Miller, S. Eftestol, J.E. Colman, and B. Dahle. 2006. Flight by feral reindeer Rangifer tarandus tarandus in response to a directly approaching human on foot or on skis. Wildlife Biology 12: 403-413.

Rettie, W.J., J.W. Sheard, and F. Messier. 1997. Identification and description of forested vegetation communities available to woodland caribou: relating wildlife habitat to forest cover data. Forest Ecology and Management 93:245-260.

Seip, D.R. 1992. Factors limiting woodland caribou populations and their interrelationships with wolves and moose in southeastern British Columbia. Canadian Journal of Zoology 70:1494-1503.

Seip, D.R., C.J. Johnson, and G.S. Watts. 2007. Displacement of mountain caribou from winter habitat by snowmobiles. The Journal of Wildlife Management 71:1539-1544.

Simpson, K., and E. Terry. 2000. Impacts of Backcountry Recreation Activities on Mountain Caribou – Management Concerns, Interim Management Guidelines and Research Needs. B.C. Minist. Environ., Lands and Parks, Wildl. Branch, Victoria, BC. Wildl.Working Rep. No. WR-99. 11pp

Singleton, P.H. 1995. Winter habitat selection by wolves in the North Fork of the Flathead River Basin, Montana and British Columbia. M.S. thesis. University of Montana, Missoula.

Smith, K.G., E.J Ficht, D. Hobson, T.C. Sorensen, and D. Hervieux. 2000. Winter distribution of woodland caribou in relation to clear-cut logging in west-central Alberta. Canadian Journal of Zoology 78:1433-1440.

Smith, K.G. 2004. Woodland caribou demography and persistence relative to landscape change in west central Alberta. M.Sc. Thesis, University of Alberta. Edmonton, AB.

Stelfox, J.G. and Jasper Warden Service. 1974. The abundance and distribution of caribou and elk in Jasper National Park. 1971-1973. Unpublished report prepared for National and Historic Parks Branch, Environment Canada. Calgary. 84pp.

Stevenson, S. 1990. Managing second growth forestes as caribou habitat. Rangifer. Special Issue 3: 139-144.

Szkorupa, T.D. 2002. Multi-scale habitat selection by mountain caribou in west-central Alberta. M.Sc. Thesis, University of Alberta, Edmonton, AB.

Thomas, D.C., E.J. Edmonds, and W.K. Brown. 1996. The diet of woodland caribou populations in west-central Alberta. Rangifer Special Issue No. 9: 337-342.

Thomas, D.C. and D.R Gray. 2002. Update COSEWIC status report on the woodland caribou Rangifer tarandus caribou in Canada. In COSEWIC assessment and update status report on the Woodland Caribou Rangifer tarandus caribou in Canada. Ottawa, ON.

Thurber, J.M., R.O. Peterson, T.D. Drummer, and S.A. Thomasma. 1994. Gray wolf response to refuge boundaries and roads in Alaska. Wildlife Society Bulletin 22:61-68.

Webster, L. 1997. The effects of human related harassment on caribou (Rangifer tarandus). Williams Lake, B.C.: Ministry of the Environment.

Vistnes, I. and C. Nelleman, 2001. Avoidance of cabins, roads, and power lines by reindeer during calving. Journal of Wildlife Management 65: 915-925.

Vistnes, I., C. Nellemann, P. Jordhoy, O. Strand. 2001. Wild reindeer: impacts of progressive infrastructure development on distribution and range use. Polar Biology 24: 531-537.

Wittmer, H.U., B.N. Mclellan, D.R. Seip, J.A. Young, T.A. Kinley, G.S. Watts, and D. Hamilton. 2005. Population dynamics of the endangered mountain ecotype of

Whittington, J., C.C. St. Clair, and G. Mercer. 2004. Path tortuosity and the permeability of roads and trails to wolf movement. Ecology and Society 9:4.

Whittington, J., M. Bradley, and G. Skinner. 2005. South Jasper Woodland Caribou Research Project Progress Report for 2004-2005. Jasper National Park: Parks Canada.

Wilson, S. F., and Hamilton, D. 2003. Cumulative effects of habitat change and backcountry recreation on mountain caribou in the Central Selkirk Mountains. EcoLogic Report Series No. 10. Prepared for; BC Ministry of Sutainable Resource Management, Nelson, Canadian Mountain Holidays, Banff AB, and Pope & Talbot Ltd., Nakusp BC.

Wolfe, S.A., Griffith, B. & Wolfe, C.A.G. 2000: Response of reindeer and caribou to human activities. Polar Research 19: 63-73.

13.11 Section 8.10 – Mountain Goat

Alberta Sustainable Resource Development (ASRD). 2003. Management Plan for Mountain Goats in Alberta. Wildlife Management Planning Series Number 7. Fish and Wildlife Division. Edmonton, AB. 115 p.

Bradford, W. Jasper National Park Wildlife Conflict Specialist.

Carnell, D. 1982. Marmot Basin goat/caribou study – interim report. Unpublished Technical Report. Jasper National Park, AB. 12 p.

Chadwick, D.H. 1983. A Beast the Color of Winter. Sierra Club Books. San Francisco. 208 p.

Cote, S. D. and M. Festa-Bianchet. 2003. Mountain goat, *Oreamos americanus*. P. 1061-1075 In: Wild mammals of North America (2nd edition). GA Feldhamer and B. Thompson, eds. The John Hopkins University Press, Baltimore, Maryland.

Cote, S. D., and M. Festa-Bianchet. 2001. Birthdate, mass and survival in mountain goat kids: Effects of maternal characteristics and forage quality. Oecologia 127:230–38.

Cowan, I.M. 1944. Wildlife studies in Jasper, Banff and Yoho National Parks in 1944 and parasites, diseases and injuries of game animals in the Rocky Mountain national parks, 1942-1944. Unpublished Report. Jasper National Park, AB. 96 p.

Dailey, T. V., N. T. Hobbs, and T. N.Woodard. 1984. Experimental comparisons of diet selection by mountain goats and mountain sheep in Colorado. Journal of Wildlife Management 48:799–806.

Gonzalez-Voyer, A., M.Festa-Bianchet, K.G.Smith. 2001. Efficiency of aerial surveys of mountain goats. Wildlife Society Bulletin 29(1): 140-144.

Hebert, D. M., and I. M. Cowan. 1971. Natural salt licks as a part of the ecology

of the mountain goat. Canadian Journal of Zoology 49:605–10.

Holroyd, G. and K. Van Tighem. Ecological (Biophysical) Land Classification of Banff and Jasper National Park. Vol III: The Wildlife Inventory. 1983.

Hutchins, M. and V.Geist. 1987. Behavioural consideration in the management of mountain-dwelling ungulates. Mountain Research and Development 7.2: 135-144.

Laundre, J. W. 1994. Resource overlap between mountain goats and bighorn sheep. Great Basin Naturalist 54:114–21.

Mamo, C. and R. Kunelius. 1998. Long range plan - wildlife research component. Marmot Basin ski area. Iris Environmental Systems. Unpublished technical report. 57 p.

McCrory, W. 1965. Preliminary report on study of natural licks used by mountain goats and bighorn sheep in Jasper National Park. Unpublished technical report. Jasper National Park, AB. 55 p.

McFetridge, R.J. 1977. Strategy of resource use by mountain goat nursery groups. Pages 1169-173 *in* W. Samuel and W. G. Macgregor, eds. Proceedings of the first international mountain goat symposium. Kalispell, MT.

Parks Canada. 2007. Jasper National Park wildlife observation database. Unpublished data.

Parks Canada. 1984. Distribution and abundance of goats and caribou within and surrounding Marmot Basin ski development in Jasper National Park *in* B.F. Leeson. Initial environmental evaluation: Marmot Basin ski area long term development. Unpublished technical report. Environment Canada. Calgary. pp.148.

Penner, D.F. 1988. Behavioural response and habituation of mountain goats in relation to petroleum exploration at Pinto Creek, Alberta. *in* W. Samuel ed. Proceedings of the Biennieal Symposium of the Northern Wild Sheep and Goat Council; 11-15 Apr. 1988. Banff, AB. pp141-148.

Poole, K.G. 2007: Does survey effort influence sightability of mountain goats Oreamnos americanus during aerial surveys? - Wildl. Biol. 13: 113-119.

Singer, F.J. 1978. Behavior of mountain goats in relation to U.S. Highway 2, Glacier National Park, Montana. Journal of Wildlife Management 42:591-597.

Singer, F. J., and J. L. Doherty. 1985. Movements and habitat use in an unhunted population of mountain goats, *Oreamnos americanus*. Canadian Field Naturalist 99:205–217.

Smith, B. L. 1977. Influence of snow conditions on winter distribution, habitat use, and group size of mountain goats. Pages 174–89 *in* W. Samuel and W. G. Macgregor, eds. Proceedings of the first international mountain goat symposium. Kalispell, MT.

Rideout, C. 1977. Mountain goat home ranges in the Saphire Mountains of Montana. Pages 201-211 *in* W. Samuel and W. G. Macgregor, eds. Proceedings of the first international mountain goat symposium. Kalispell, MT.

Thompson, R.W. Population dynamic, habitat utilization, recreational impacts, and trapping introduced Rocky Mountain goats in the Eagles Nest Wilderness area, Colorado. *in* W. Samuel ed. Proceedings of the Biennieal Symposium of the Northern Wild Sheep and Goat Council; 23-25 Apr. 1980.

Van Tighem, K. 1980. Memo to Bruce Leeson, Parks Canada re: ungulate studies on Caribou Ridge, Marmot Basin Ski Area, Jasper National Park *in* B.F. Leeson. Initial environmental evaluation: Marmot Basin ski area long term development. Unpublished technical report. Environment Canada. Calgary. pp.148.

13.12 Section 8.11 - Wolverine

Austin, M. 1998. Wolverine winter travel routes and response to transportation corridors in Kicking Horse pass between Yoho and Banff National Parks. MSc. Thesis. Univeristy of Calgary, AB. 40 pp.

Banci, V. 1994. Wolverine. Pages 99-127 in L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, L.F. Lyon, and W.J. Zielinksi, eds. American marten, fisher, lynx, and wolverine in the western United States. U.S. Forest Service Gen. Tech. Rep. RM-254.

Carroll, C., R.F. Noss, and P.C. Paquet. 2001. Carnivores as focal species for conservation planning in the Rocky Mountain region. Ecological Applications 11:961-980.

Copeland, J. 1996. Biology of the wolverine in Central Idaho. M.Sc. Thesis, University of Idaho, Boise, Idaho. l38 pp.

COSEWIC 2003. COSEWIC assessment and update status report on the wolverine Gulo gulo in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 41 pp.

Heinemeyer, K.S., B.C. Aber, and D.F. Doak. 2001. Aerial surveys for wolverine presence and potential winter recreation impacts to predicted wolverine denning habitats in the southwestern Yellowstone ecosystem. GIS/ISC Laboratory, Dept. of Environmental Studies, University of California, Santa Cruz. 21pp.

Hornocker, M.G. and H.S. Hash. 1981. Ecology of the wolverine in northwestern Montana. Canadian Journal of Zoology 59:1286-1301.

Krebs, J.A., and D.Lewis.2000. Wolverine ecology and habitat use in the North Columbia Mountains: Progress Report. Pp. 695-703 in L.M. Darling, (ed.). Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk, Kamloops, B.C., 15-19 Feb., 1999. Volume Two. B.C. Ministry of Environment, Lands and Parks, Victoria, B.C. and University College of the Cariboo, Kamloops, British Columbia.

Lofroth, E. 2001. Wolverine ecology in plateau and foothill landscapes, 1996-2001. 2000/01 Year end report, northern wolverine project. Forest Renewal Activity No. 712260. Ministry of Environment, Lands and Parks, Victoria, B.C. 98 pp.

Parks Canada. 2007. Jasper National Park wildlife observation database. Unpublished data.

Petersen, S. 1997. Status of the wolverine (Gulo gulo) in Alberta. Alberta Environmental Protection, Wildlife Management Division, Wildlife Status Report No. 2, Edmonton, Alberta. l7 pp.

Weaver, J.L., P.C. Paquet, and L.F. Ruggiero. 1996. Resilience and conservation of large carnivores in the Rocky Mountains. Conservation Biology 10:964-976.

Whitman, J.S., W.B. Ballard, and C.L. Gardner. 1986. Home range and habitat use by wolverines in southcentral Alaska. Journal of Wildlife Management 50:460-462.

13.13 Section 8.12 - Lynx

AMEC, 2002. Wildlife Models Used in the Assessment of Potential Effects of the MacKenzie Gas Project. Report prepared for Imperial Oil Resources Ventures Limited by AMEC Americas Limited, February 2005.

Apps, C. 2005. Canada Lynx monitoring program for the mountain parks and southern Canadian Rocky Mountains. Aspen Wildlife Research, report prepared for Parks Canada. 46 pp.

Apps, C., A. Dibb, and A. Fontana. 2000. in L. M. Darling, editor. 2000.Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk, Kamloops, B.C., 15 - 19 Feb.,1999. Volume Two. B.C. Ministry of Environment, Lands and Parks, Victoria, B.C. and University College of the Cariboo, Kamloops, B.C. 520pp.

Boyd, M. 1978. Management of marten, fisher, and lynx in Saskatchewan – with special reference to the effects of forest harvesting in the mixed wood boreal forest. M.Sc. thesis, University of Calgary.

Jalkotzy, M.G., P.I. Ross, and M.D. Nasserden. 1997. The Effects of Linear Developments on Wildlife: A Review of Selected Scientific Literature. Prep. for Canadian Association of Petroleum Producers. Arc Wildlife Services Ltd.,

Calgary. 115pp.

Koehler, G.M. 1990. Population and habitat characteristics of lynx and snowshoe hares in north central Washington. Canadian Journal of Zoology. 68:845-851.

Percy, M. 2006. Lake Louise Corridor and Snow Tracking Project 1993-2004. Unpublished. Lake Louise, Yoho and Kootenay Field Unit, Parks Canada.

Ruggiero, L., K. Aubry, S. Buskirk, L. Lyon, W. Zielinski. 1994. The Scientific Basis for Conserving Forest Carnivores: American Marten, Fisher, Lynx, and Wolverine in the Western United States. USDA Forest Service, General Technical Report RM-254.

Stevens, S., Callaghan, C., Owchar, R. 1996. *A Survey of Wildlife Corridors in the Bow Valley of Banff National Park, Winter 1994/95*. 41pp. Banff National Park, Alberta.

Todd, A.W. 1983. Dynamics and management of lynx populations in Alberta. Alberta Fish and Wildlife Division, Edmonton, Alberta.