Critical Grizzly Bear Habitat Mapping
MacKay Landscape Unit, British Columbia

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Prepared for:
Ministry of Water, Land and Air Protection
Williams Lake, British Columbia

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1 INTRODUCTION

In British Columbia, grizzly bears (*Ursus arctos*) are currently on the provincial Blue List as a species of special concern and are assigned a provincial conservation status ranking of S3 (British Columbia Species and Ecosystems Explorer 2003). Grizzly bears are also an Identified Wildlife Species in the provincial Identified Wildlife Management Strategy (British Columbia Ministry of Environment, Lands and Parks 1999) and are to be considered for establishment of Wildlife Habitat Areas (WHA) (Forest Practices Code 1997).

In the MacKay Landscape Unit (LU), the *Cariboo-Chilcotin Land Use Plan* identifies grizzly bear habitat inventory as a priority for the Quesnel Highlands (Province of British Columbia 1995). The MacKay LU is located in the Quesnel Highlands east of Horsefly British Columbia and is included in the Wells Gray Grizzly Bear Population Unit. Although the MacKay LU is known to support significant areas of high value/ prime grizzly bear habitat there has been no grizzly bear ecology or habitat research completed in this area to date.

Inventory of grizzly bear habitat within the MacKay LU is required to ensure that areas of prime habitat are identified and preserved, and also to identify candidate areas for habitat enhancement and restoration. Logging is the dominant land use in the MacKay LU. Other human uses include hunting, angling, All Terrain Vehicle (ATV) use, hiking, skiing and other non-consumptive uses. These types of human activities are known to cause displacement of grizzly bears from high value habitat and thereby reducing grizzly bear habitat effectiveness. Therefore, to develop a grizzly bear habitat management plan there is a need for scientific information regarding the distribution of seasonal grizzly bear habitat, habitat-use patterns and habitat effectiveness.

Wildlands Ecological Consulting Ltd. was contracted by the British Columbia Ministry of Water, Land, and Air Protection (MWLAP) to identify and map critical seasonal habitats at a 1:20,000 scale for grizzly bears in the MacKay LU. Methodology followed that developed by Applied Ecosystem Management for other landscape units in the Quesnel Highlands and Cariboo Mountains Ecosections (AEM 2002).

1.1 Objectives

The following objectives were identified:

1) Identify critical spring, summer and fall grizzly bear habitat in the study area and map these habitats at a 1:20,000 scale by updating the 1:50,000 TEM map and database for the MacKay LU;
2) Develop an updated habitat rating table for grizzly bears in spring, summer and fall for the study area, including all TEM habitat units, using the provincial six-class habitat rating scheme (Resources Inventory Committee 1999);
3) Create a habitat effectiveness map for the MacKay LU which reflects current impacts of human activity on grizzly bear habitat use;
4) Discuss the relative seasonal importance of individual polygons containing critical or limited habitat as it relates to other habitats within the MacKay LU;

5) Identify mitigative measures that have potential to improve the MacKay LU's habitat effectiveness for the purpose of reducing grizzly bear mortality; and
6) Identify and discuss ecosystem units and/or mapped polygons that have good potential for restorative forestry treatment.

1.2 Study Area

The MacKay LU is situated in the Quesnel Highland Ecosection (QUH) within the Cariboo Forest Region. Horsefly Lake borders the project area on the north, Crooked Lake on the south, and Wells Gray Provincial Park on the east. The project area comprises approximately 35,022 ha and includes 1:20,000 TRIM map sheets 93A series 036, 037, 038, 027, 028, 046, 047, and 048. The MacKay LU includes the MacKay River drainage and upper portions of the Horsefly River drainage. Elevations above mean sea level (asl) range from approximately 914 m (3000') along the Horsefly River on the west to 2443m (8015') at McCallum Peak.

Biogeoclimatic (BEC) Zones with in the MacKay LU include the Interior Cedar Hemlock (ICH), Engelmann Spruce Subalpine Fir (ESSF) and Alpine Tundra (AT). A summary table of Ecosystem, BEC classification, and TEM ecosystem unit classifications for the MacKay study area are provided in Table 1.

The ICHwk2 occupies the lower valley bottom of the MacKay and Horsefly Rivers and extending up the slopes to approximately 1250 m (4101') asl. This zone has a wet cool climate and is dominated by forests consisting of western redcedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), white spruce (*Picea glauca*), Engelmann spruce (*Picea engelmannii*), spruce hybrids, subalpine fir (*Abies lasiocarpa*) and lodgepole pine (*Pinus contorta*). Upslope of the ICHwk2 lies the ESSFwk1 (1250 - 1500m asl) characterized by Engelmann spruce and subalpine fir forests with wet cool climatic conditions. Further upslope is the wet and snowy ESSFwc3 (1500 m - 1800 m asl) and then the ESSFwcp3 (1800 - 1960 m) that is typically parkland like with an interspersion of heath meadows, grasslands and patches of trees.

Above the ESSFwcp3 lies the AT zone which has a more severe climate that is cold, windy and snowy. The AT zone is non-forested, although tree growth may occur as patches of krumholtz. Vegetation in the AT largely consists of alpine heath tundra, windswept grasslands, meadows, and areas of lichen growth. A considerable portion of the AT is non-vegetated and is characterized by glaciers, rock outcrops, talus slopes, moraines and block fields. Detailed bio-physical descriptions of the BEC zones in the MacKay LU are provided by Geowest (1999, 2000), Demarchi (1995, 1996), and (Meidinger and Pojar 1991).

Figure 1. Location of the MacKay Landscape Unit showing Biogeoclimatic Subzones.

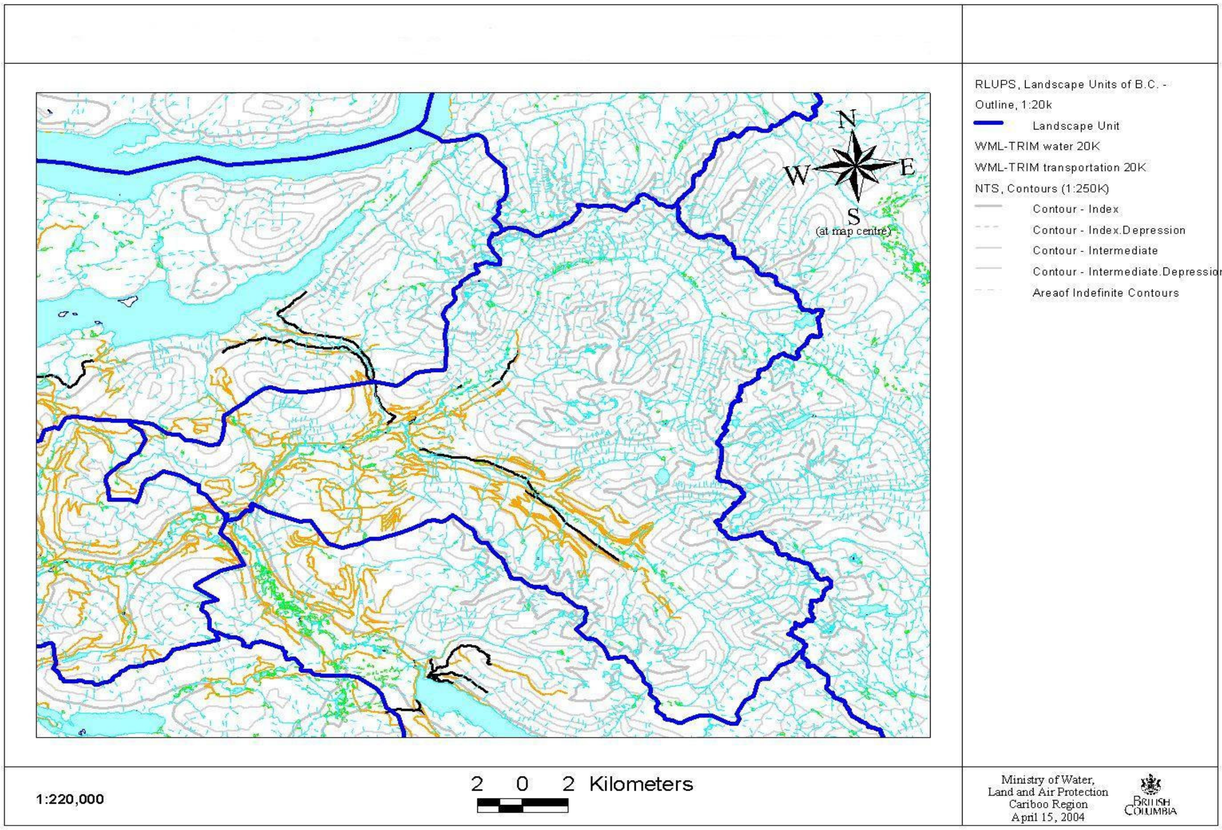

Table 1. Biogeoclimatic and Ecological Classification schemes for the MacKay Landscape Unit.

Ecological Classification					**Biogeoclimatic Classification**						
Ecodomain	**Ecodivision**	**Ecoprovince**	**Ecoregion**	**Ecosection**	**BEC Zone**	**Climate**	**Map Symbol**	**Subzone/ Variant**	**Elevation(m)**	**Dominant Tree spp.**	**Site Series/TEM Ecosystem Unit**
Humid Temperate	Humid Continental Highlands	Southern Interior Mountains	Columbia Highland	Quesnel Highland (QUH)	Interior Cedar Hemlock (ICH)	Cool, moist	ICHwk2	Wet Cool ICH Subzone Quesnel Variant	S: to 1500 N: to 1250	**Hw,Cw** Fa, Sx (Fd, Pl,At)	00/AF,00/AL,OO/PF,00/SS,00/TS,00/WD, 00/WG,00/WW,01/HO,02/HC,03/RJ,04/HM, 05/SO,06/ST,07/RD,08/RC
					Engelmann Spruce-Subalpine Fir (ESSF)	Cool, Snowy, Moist	ESSFwk1	Wet Cool ESSF Subzone Cariboo Variant	S:1500-1800 N:1250-1500	**Se, Bl** Pa, Pl, La, At, (Fd[f], Lw[f])	00/AF,00/AL,00/BV,00/CS,00/PF,00/SM, 00/WC,00/WF,00/WS,01/FB,02/FF,03/FO,04 /FT,05/FD,06/FH
							ESSFwc3	Wet Cold ESSF Subzone Cariboo Variant	S:1800-1960 N:1500-1800	Bl,Se Pa, Pl, La, At	00/AF,OO/AS,00/BV,00/CS,00/FA,00/FD, 00/FH,00/FJ,00/FL,00/FW,00/HP,00/JK, 00/SD,00/SM,00/SS,00/VD,00/VG,00/VM, 00/WS,00/WV,01/FR,02/FQ,03/FG
							ESSFwcp3	Wet Cold ESSF Subzone Upper subalpine Parkland Cariboo Variant	S:1960-1980 N:1800-1960	Bl **Se,**Pa, Pl, La	00/BV,00/FA,00/FB,00/FH,00/FJ,00/FL, 00/FV,00/HL,00/HV,00/JK,00/MC,00/SD, 00/SG,00/TF,00/VD,00/VG,00/VM
					Alpine Tundra (AT)	Cold, Snowy, Windy, Damp	AT Undifferen tiated	AT Undifferentiated	S:1980- crest N:1960-crest	**Bl,Pa,Se** Lw	00/AD,00/AW,00/FL,00/HL,00/MC,00/SL

Elevation: Typical elevation bands on warm (south: S) and cool (north: N) slopes are indicated. Tree Species: BC Ministry of Forestry codes. Ecosystems based on Steen and Coupe' (1997) and Geowest (1999).

1.3 Background

The approach used on the current study follows methodology developed by AEM (2002) for grizzly bear habitat mapping in the Penfold, Eastside and Wasko-Lynx Landscape Units. In that study as well as the current MacKay LU study, a TEM mapping base (*circa* 1996 airphoto) was used to create the final habitat maps (Geowest 1999). AEM (2002) determined grizzly bear habitat suitability ratings for Living (i.e., food and cover values) and then adjusted these values to increase habitat values for units adjacent to salmon streams, or within travel corridors and linkage zones. In units affected by roads habitat suitability values were uniformly decreased to produce a habitat effectiveness map.

The proximity of the MacKay LU to the Penfold, Eastside and Wasko-Lynx Landscape Units study area, along with commonality in BEC subzones and ecosystem units, allows for direct comparison with the current MacKay LU study. However, a significant difference between project areas is the lack of salmon spawning streams in the MacKay LU (pers. comm. Rob Dolighan). This is due to a falls on the Horsefly River downstream of the study area, which forms an impassable natural barrier to migrating salmon.

1.4 Habitat Use Patterns

While no telemetry relocation data are available for grizzly bears in the MacKay LU, grizzly bear ecology studies indicate fairly predictable food habits and habitat use patterns from year-to-year and season-to-season throughout most of their interior British Columbia range. Table 2 presents a summary of seasonally important habitats for the study area based on available information from similar BEC zones (Table 1).

Typically, grizzly bears emerge from dens from early April to May, depending on snow accumulations and spring weather conditions. Males typically emerge in early April and females in late April through to mid-May (LeFranc *et al*. 1987). Den sites are generally located in high elevation forests. Emerging bears tend to seek out early spring vegetation in valley bottoms and avalanche chutes on warm aspects where snow packs melt earliest. Upon den emergence grizzly bears will also actively seek out carrion and winter weakened ungulates on their wintering grounds in valley bottom willow thickets (LeFranc *et al*. 1987, Riddell 2002, AEM 2002).

Other important early season sites include lower elevation non-forested seepage sites, clearcuts and meadows. As the spring green-up continues it advances upslope and to cooler and north aspects eventually reaching upper chutes, and alpine and upper subalpine meadows in late spring to early summer. Grizzly bears will also concentrate feeding on the roots of hedysarum (*Astragalus* spp., *Osmorhiza* spp.) and other root crops where they are available. Although hedysarum is commonly reported as an important early spring food it does not appear to be common in the MacKay LU and is likely an insignificant food resource for local grizzly bears. Beaudry *et al*. (2001) reported that in spring grizzly bears in the Parsnip River area fed heavily on hedysarum (*Hedysarum boreale*) roots and glacier lily (*Erythronium grandiflorum*) corms in the ESSFwk1 and ESSFwk2 BEC units. Glacier lilies were most commonly fed on at sites with well-developed soils on warm aspects and in areas where the snow pack had recently melted. Glacier lilies are locally abundant in the MacKay LU and the corms are expected to be an important early spring and summer food resource. Spring beauty (*Claytonia lanceolata*) corms may also be an important spring food resource where it occurs in the MacKay LU. As the green-up progresses succulent vegetation consisting of grasses, sedges, horsetails (*Equisetum* spp.), and forbs will form the largest portion of the diet. Important forbs include cow parsnip (*Heracleum* *lanatum*), fireweed (*Epilobium angustifolium*), bracted lousewort (*Pedicularis bracteosa*), nettle (*Urtica dioica*), arrow-leaved groundsel (*Senecio triangularis*), Sitka valerian (*Valerian sitchensis*) and others.

Based on food habits modelling, Riddell (2002) reported important spring habitat in the Cariboo Mountains Provincial Park area (CMPP) to include bottomland wetlands, riparian zones, seepage sites, toe slopes, and lower slopes in the ICHwk2. In the ESSFwk1 and ESSFwc3, the value of openings supporting horsetail and sedges, avalanche tracts and openings on mesic deep, medium textured soils were rated highest.

In summer, grizzly bears shift their food habits from foraging on succulent forbs and graminoids to berry crops. Berries and other soft mast crops will include soopolallie (*Shepherdia canadensis*), black huckleberry (*Vaccinium membranaceum*), other blueberries (*Vaccinium* spp.), saskatoon (*Amelanchier alnifolia*), currants and gooseberries (*Ribes* spp.), raspberries (*Rubus idaeus*) and thimbleberries (*Rubus parviflorus),* highbush-cranberry (V*iburnum edule*), Devil's club (*Oplopanax horridus*), black twinberry (*Lonicera involucrata*), and mountain-ash (*Sorbus* spp.). At this time of year, grizzly bears enter a hyperphagic state and rapidly accumulate fat reserves for winter hibernation. Over most of grizzly bear range berry crops are essential to successful over-wintering and reproductive success (LeFranc *et al.* 1987). Also during this season, they feed on remaining pockets of succulent vegetation and supplement their diet with rodents such as microtines, ground squirrels (*Spermophilus columbianus*) and marmots (*Marmota caligata*). Ants and wasps (*Hymenoptera*) are fed on opportunistically and may become an important alternative food resource during years when berry crops fail (Beaudry *et al*. 2001). In late summer and fall, grizzly bears frequently select open shrubfields and especially open burns with huckleberries, blue berries and other berry crops.

In other areas of the Quesnel Highlands, grizzly bears actively seek out salmon spawning streams and utilise this resource from August through to November depending on the year's salmon run (Riddell 2002, AEM 2002). However, as indicated natural barriers located downstream on the Horsefly River prevent salmon from migrating upstream into the MacKay LU and therefore this resource was not considered during the present study. As indicated, no telemetry relocation data are available for grizzly bears in the MacKay LU, however, bears in the study area may annually move outside the project area to exploit this resource in nearby streams.

In the CMPP area, important summer habitat included high elevation forested ecosystem units often in moist areas associated with high snow packs and seepage sites on north aspects (Riddell 2002). Other important sites at this time of year included avalanche tracts, mesic sites on deep soils in the ESSFwc3 and ESSFwk1, and drier crest positions in the ESSFwc3. The ICHwk2 was also important in summer with 16 habitat types rated high including seepage zones, toe and lower slope positions, a wetland type, and mesic sites with deep soils.

After the first heavy frost cures most herbaceous plants and cause remaining berries to drop, grizzly bears will seek out pockets of higher moisture levels with lush vegetation. These areas include seepage sites, riparian zones, moist avalanche chutes, and residual patches of berry crops including blueberry, crowberry (*Empetrum nigrum*), bearberry (*Arctostaphylos uva-ursi*), red-osier dogwood (*Cornus sericea*), wild rose (*Rosa acicularis*), highbush-cranberry, black huckleberry, devil's club, currant, mountain ash, soopolallie, and other late season or enduring berry crops. During the fall season grizzly bears will also expend more effort hunting rodents such as marmots, ground squirrels and microtines (Riddell 2002, AEM 2002). Marmots are most commonly associated with in upper elevation talus slopes and ground squirrels are most abundant in upper elevation meadows and herbaceous avalanche slopes. In the MacKay study area mountain goats may also be actively hunted at this time of year.

Table 2. Summary of grizzly bear seasons with a description dominant food items and habitat use patterns.

Season	Description	Elevation Band	Months	Dominant Food Items	Veg. Stage*	Dominant Habitat/Actvity Important Habitat Types
Spring	Pre-green up	≤ 1500 m	Den emergence to late April	Glacier lily corms, spring beauty, *Osmorhiza* spp. roots, *Astragalus* spp. roots, bearberries, over-wintered berries	PV 0	warm avalanches slopes, lower elevation meadows, wetlands, seepage sites, riparian areas, open moist forest, patches of glacier lilies and over-wintered berries
				Winter killed or weakened ungulates, and other carrion	PV 0	willow and *Cornus sericea* dominated lower elevation valley bottoms; traditional ungulate over-wintering grounds; carrion on avalanche tracts
	Green-up/ Pre berry	≤ 1500 m	Early May to mid July	emerging forbs, horsetails, grasses and sedges; patches of cow parsnip and glacier lilies	PV 1-5 PV 5-6	warm avalanches slopes, lower elevation meadows, wetlands, seepage sites, riparian areas, open moist forest, moist cutblocks with adjacent security cover, patches of glacier lilies and over-wintered berries
		1500 to 1800 m	Mid May to late July	emerging forbs, horsetails, grasses and sedges; patches of cow parsnip and glacier lilies	PV 5-6	mid elevation avalanches slopes, meadows, wetlands, seepage sites, riparian areas, open moist forest, and moist cutblocks with adjacent security cover; mid elevation patches of glacier lilies and over-wintered berries
		≥ 1800 m	Late May to late August	emerging forbs, horsetails, grasses and sedges; patches of cow parsnip and glacier lilies	PV 5-6	Upper elevation avalanches slopes, meadows, wetlands, seepage sites, patches of glacier lilies
Summer	Berry/ Post green-up	≤ 1500 m	Mid July to late August	Various berries, remaining patches of succulent forbs	PV 6 PG 11-12	Shrubfields, clearcuts, open forests, riparian zones, floodplains, open canopy receiving sites
		1500 to 1800 m	Early August to early October	Various berries, remaining patches of succulent forbs graminoids	PV 6 PG 11-12	Shrubfields, clearcuts, open forests, riparian zones, floodplains, open canopy receiving sites
		≥ 1800 m	Late August to late October	Various berries, remaining patches of succulent forbs	PV 6 PG 11-12	Shrubfields, clearcuts, open forests, riparian zones, floodplains, open canopy receiving sites
Fall	Post Berry	≤ 1500 m	Late August to mid November	remaining patches of berries, bearberry, crow berry, root crops, remaining patches of succulents, ground squirrel, marmots	PV 6 PG 12-13	Shrubfields, clearcuts, open forests, riparian zones, floodplains, open canopy receiving sites, herbaceous meadows with ground squirrel
		1500 to 1800 m	Early Sept. to early November	remaining patches of berries, bearberry, crow berry, root crops, remaining patches of succulents, ground squirrel, marmots	PG 12-13	Moist shrubfields, clearcuts, open forests, riparian zones, floodplains, seepage sites, moist chutes, upper elevation meadows for ground squirrel, talus slopes for marmot
		≥ 1800 m	August to November	remaining patches of berries, bearberry, crow berry, root crops, remaining patches of succulents, ground squirrel, marmots	PG 12-13	Moist shrubfields, clearcuts, open forests, riparian zones, floodplains, seepage sites, moist chutes, upper elevation meadows for ground squirrel, talus slopes for marmot
Winter	Denning	≥ 2100 m	Oct./Nov. to April/May	None	PV 0 PG 0	high elevation forests for denning sites

* (B.C. ministry of Environment, Lands and Parks 1998)

2 METHODS

2.1 Field Planning

A literature review was conducted for the MacKay LU study area and pre-typing was completed to provide an approximation of important grizzly bear habitats. These included avalanche chutes, non-forested wetlands (e.g. bogs, shallow water ecosystems, fens, marshes), berry producing areas, forested wetlands, alpine and subalpine meadows, river corridors, and travel routes. Polygons were selected for in field evaluation by reviewing the TEM maps, airphoto mosaic, and individual airphotos.

Table 2 presents grizzly bear seasons that were largely defined by AEM (2002) and RIC Wildlife Habitat Rating Standards (RIC 1999). Appendix I lists 75 plant food items and 4 animal food items that are expected to be important to grizzly bears in the MacKay LU. These were determined from this study and a review of other relevant grizzly bear ecology studies (Table 3) completed in the ICH, ESSF and AT Biogeoclimatic Zones. Food habits data from the Quesnel Highlands comes from habitat use data based on telemetry relocations and scat analysis from the current study, and the recent studies completed by AEM (2002) and Riddell (2002). Each food item in Appendix I is rated High (H), Moderate (M) or Low (L) for seasonal food importance.

2.2 Field Sampling

Field sampling methodology closely adhered to AEM (2002), MOF (1996), Luttmerding *et al*. (1990) and RIC standards (RIC 1998) (if all these references used same methods, cite only earliest one). Vegetation and ecological site data were recorded on Ground Inspection Forms (RIC), and Vegetation Ecosystem Field Forms (FS882 (3) HRE 98/5). Classification of ecosystem units was based on Geowest (1999) and Cariboo Forest Region site series descriptions provided by Steen and Coupé (1997). Sufficient information was collected to confirm the site series type and the percent ground cover of all grizzly bear plant foods (Appendix I). Other data collected included ant activity and habitat availability, rodent presence/not present, and presence of any microhabitat inclusions (e.g., seepage sites). All micro-site habitat inclusions were recorded according to location, surrounding site series type, and site position. Grizzly bear feeding sites were plotted on air-photos and maps and full detailed plots were completed including details regarding nature of activity and estimated date of use. Ant foraging opportunities were evaluated by inspecting up to 10 rocks, logs and stumps at each plot and recording presence/ absence of ants. Security cover levels were estimated ocularily based on the distance to obscure 90% of an adult grizzly bear.

Observations regarding grizzly bear activity and habitat suitability were recorded on a Grizzly Bear Site Evaluation Form. Detailed vegetation plots were completed at all grizzly bear activity sites encountered. Human use data was collected based on Wildlife Habitat Assessment Forms (FS 882 (5) HRE 98/5) and standards outlined in the Land Management Handbook #25 (Province of British Columbia 1998). These data included type and intensity of activity, distance to disturbance or human activity, management requirements including season of use, capability, management technique, feasibility and intensity. UTM co-ordinates obtained by GPS were recorded at all plots and site photographs were taken at many of these plots to document representative habitat types. Plots were accessed by helicopter and from logging roads.

A minimum of 10% of the polygons within the Landscape Unit were field sampled to verify the pre-typing and to record detailed habitat data. Polygons were assessed during detailed sampling and additional polygons were visually assessed from the helicopter or from prominent vantage points.

Table 3. List of studies consulted for grizzly bear food habits and habitat use data.

Information Available	Location	BEC Zones	Reference
Habitat Mapping Food Habits (Incidental)	Penfold, Eastside and Wasko-Lynx LU's	ICHwk2 ESSFwk1 ESSFwc3 ESSFwcp3 AT	AEM (2002)
Habitat Mapping Food Habits (Incidental)	Cariboo Mountain Provincial Park and Lower Mitchell River area	ICHwk2 ESSFwk1 ESSFwc3 ESSFwcp3 AT	Riddell (2002)
Habitat Use Food Habits	Parsnip River/Hart Range northeast of Prince George	ESSFwk2 AT	Ciarniello *et al*. (2002) Ciarniello *et al*. (2003)
Habitat Use	Wet Columbia Mountains/Revelstoke area (Glacier to Yoho National Park)	ICH ESSF AT	Ramcharita (2000) Munro (1999) Simpson *et al*. (1985)
Habitat Use Food Habits	Banff National Park	ESSF AT	Jalkotzy *et al*. (1999)
Habitat Use Food Habit	Yoho and Kootenay National Parks	ESSF AT	Raine and Riddell (1991)
Habitat Use Food Habits	Jasper National Park	ESSF AT	Russell *et al*. (1979)
Habitat Use Food Habits	Banff, Jasper, Yoho and Kootenay National Parks	ESSF AT	Kansas and Riddell (1995)

2.3 Data Analysis

2.3.1 Field Data

Field data were analysed with an EXCEL™ spreadsheet. Assessment of habitat quality was based on evidence of grizzly bear habitat use, grizzly bear plant food abundance and distribution, security and thermal cover availability, terrain features, and documented grizzly bear habitat use in similar ecosystems.

2.3.2 Ecosystem Unit Ratings

Seasonal habitat selection by grizzly bears is largely a function of a land units food resource abundance, quality and availability with respect to security needs and thermal cover. Security cover becomes increasingly important in areas with significant human activity. Intraspecific competition can also influence habitat use patterns by females and subadult grizzly bears (LeFranc *et al*. 1987). Other important habitat includes travel corridors, linkage zones, mating areas, bedding sites, and denning sites.

Linkage zones are identified at the landscape level, and based on the current scale of mapping are identified as grizzly bear habitat that provides foraging opportunities, connectivity within home ranges, and avenues of dispersal (AEM 2000, Ruediger 2000). Travel corridors are areas within a bear's home range that provide an adequate level of security cover to allow uninhibited daily movements between patches of habitat.

For the current study, ecosystem units were rated for "Living" by 1) reviewing grizzly bear food habits in the MacKay LU and similar ecosystems, 2) accessing the seasonal abundance of grizzly bear food items within ecosystem units, and 3) by reviewing documented habitat use patterns. Initially ecosystem ratings from the three recent studies completed in the Quesnel Highlands were compared and integrated (Geowest 1999, Geowest 2000, AEM 2002, Riddell 2002). These ratings were then revised based on a review of the species composition of each ecosystem unit and reference to the revised grizzly bear food items list (Appendix I). Field data from the current study were also reviewed to identify seasonally important ecosystem units within the MacKay LU. The final six-class rating scheme was based on RIC (1999) Standards that ranks each ecosystem unit for life requisites, including food and security/thermal cover (i.e., Living). Six Class Ratings for habitat suitability included:

1. High (Class 1);
2. Moderately High (Class 2);
3. Moderate (Class 3);
4. Low (Class 4);
5. Very Low (Class 5); and
6. Nil (Class 6).

The following section provides a brief review of grizzly bear habitat types that have High (Class 1) or Moderately High (Class 2) seasonal habitat suitability values for Living. The corresponding ecosystem units and season of use are identified for each habitat type.

2.3.2.1 Avalanche Chutes

Avalanche chutes offer important foraging opportunities and have been widely recognised as valuable spring and early summer grizzly bear habitat (LeFranc *et al*. 1987, Beaudry *et al*. 2001, Mowat 2000, Ramcharita 2000, Munro 1999, Simpson *et al*. 1985). The most productive avalanche chutes will have well-developed soils, with mesic to subhygric moisture levels, and occur primarily on warm aspects (i.e. southeast to southwest). These habitats support lush forb and graminoid growth, and may support root and berry crops.

Avalanche chutes are most frequently used in spring and early summer when young succulent plants are available. However, lower intensity use will extend into late summer where favourable mircosites occur. In the MacKay LU, glacier lilies are expected to be an important food resource found within certain avalanche chute types. Typically, patches of glacier lilies are heavily fed on as they emerge from receding snow and this food resource will be sought after well into summer (Beaudry *et al*. 2001). In the MacKay LU study area avalanche chutes often have thick alder cover or adjacent forests which provide security and thermal cover to foraging bears.

Ramcharita (2000) reported that in the Columbia Mountains near Revelstoke, grizzly bear use of avalanche chutes in spring and early summer (1 May to 31 July) accounted for approximately 54% of grizzly bears' radio-relocations. Grizzly bears used chutes at all elevations, but selected open east and south facing herbaceous chutes and generally avoided very steep terrain.

Season of Use:

- ICHwk2 and ESSFwk1 in spring and summer;
- ESSFwc3 and ESSFwcp3 on warm aspects (w) in spring; and
- ESSFwc3 and ESSFwcp3 in summer and early fall.

Important Ecosystem Units:

- ICHwk2 - AF2, 3; PF2.
- ESSFwk1 - AF2, 3; BV2, 3; PF2.
- ESSFwc3 - AF2, 3; BV2, 3; VG2; VM2.
- ESSFwcp3 - BV2, 3; VG2; VM2.

2.3.2.2 Wetlands and Moist Meadows

During spring when other food resources are in limited supply, grizzly bears select lower elevation moist meadows for succulent grasses, sedges and forbs (Ross *et al*. 2000, Beaudry *et al*. 2001). In the MacKay LU, grizzly bears are expected to use lower elevation valley bottom sites in the ICHwk2 and ESSFwk1 from den emergence and continuing well into May. As the season progresses from spring through summer to fall there will be an elevation shift upslope to foraging in subalpine parkland meadows and alpine meadows through to approximately August (Beaudry *et al*. 2001).

Season of Use:

- ICHwk2 and ESSFwk1 from early spring to early summer;
- ESSFwc3 and ESSFwcp3 from late spring to early summer;
- ESSFwc3 and ESSFwcp3 in early to late summer; and
- AT mid summer.

Important Ecosystem Units:

- ICHwk2 - AS3; SR2; WG2, 3; WW2, 3.
- ESSFwk1 - AH2, 3; SM2; WS2, 3.
- ESSFwc3 - SM2; VD2; WS2, 3; WV2, 3.
- ESSFwcp3 - FA2, 3; FV2; HV2; HL2; VD2; SG2.
- AT - AD2.

2.3.2.3 Riparian Zones

Riparian zones typically have deep rich soils with mesic to subhygric moisture levels. They produce nutritious succulent vegetation including grasses, sedges, horsetails, cow parsnip, and other forbs that are sought after by bears in spring and summer (Saxena and Gazey 2000, Beaudry *et al*. 2001). Upon den emergence grizzly bears traditionally move to low elevation riparian sites in search of early emerging green vegetation and to search for winter-killed or weakened ungulates in willow and red-osier dominated shrublands (Riddell 2002, AEM 2002). As the season progresses, higher elevation riparian zones become available to foraging grizzly bears. In summer and fall, riparian zones support a diversity of berry plants such as huckleberry, highbush-cranberry, currant, gooseberry, twisted stalk (*Streptopus* spp.), raspberry, thimbleberry, black twinberry, crowberry, red-osier dogwood, rose hips, devil's club, and mountain ash. Black twinberry cover can be substantial in the MacKay LU and berries from this shrub may be very important to resident grizzly bears. Beaudry *et al*. (2001) reported that in the Parsnip River study area, grizzly bears fed intensely on black twinberry for short periods during summer.

AEM (2002) identified active flood plains as an important modified habitat type based on other studies completed in the Quesnel Highlands (Bruhjell *et al*. 1998) and in the coastal Kutzeymateen Valley (MacHutchon *et al*. 1993). Units affected by active flooding were rated higher because of the positive influence on grizzly bears food resources. However, Beaudry *et al*. (2001) reported limited use of flood plains in the Parsnip River area other than during short feeding periods when grizzly bears fed on black twinberry. For consistency with the AEM (2002) study area, active flood plains were rated higher in summer on the current study. In addition, riparian zones are also recognised as important travel corridors, marking sites, and bedding site habitat.

Season of Use:

- ICHwk2 and ESSFwk1 green forage from early spring to late summer and berries through until late fall;
- ESSFwc3 and ESSFwcp3 green forage from late spring to early summer; and
- ESSFwc3 and ESSFwcp3 green forage in summer and early fall.

Important Ecosystem Units:

- ICHwk2 - WD2, 3; AS3; RC2-7; ST2, 3; WWa2, 3.
- ESSFwk1 - FH2, 3, 6, 7; WCa2, 3; WS2, 3
- ESSFwc3 - FG2, 3, 6, 7; WV2, 3.
- ESSFwcp3 - FV2-7 (along small streamlets)
- AT - n/a.

2.3.2.4 Seepage Sites

Seepage sites are important microhabitat inclusions located in moisture-receiving areas typically with deep rich soils. Typically they occur in toe-slope positions and at discharge sites on slopes. Soils are generally moist throughout the growing season and sites produce a diversity and abundance of succulent graminoids and forbs. These habitats are also important berry producing sites and often support high cover of thimbleberry, black twinberry, black huckleberry, currant, gooseberry, and other berry producing shrubs.

Season of Use:

- ICHwk2 and ESSFwk1 from early spring to late summer;
- ESSFwc3 and ESSFwcp3 from late spring to late summer; and
- ESSFwc3 and ESSFwcp3 early summer to early fall.

Important Ecosystem Units:

- ICHwk2 - AL2, 3; RC2-7; RD2, 3, 6, 7; SO2, 3, 7; ST2, 3, 7.
- ESSFwk1 - FD2, 3, 6, 7; AL2, 3; FH2, 3, 6, 7; FT2, 3, 6, 7; SM2.

- ESSFwc3 - FG2, 3, 7; FH2, 3, 7; FW2, 3, 7; SM2; WV2, 3.
- ESSFwcp3 - FV2-7; SG2.
- AT - n/a.

2.3.2.5 Clearcuts

Clearcuts in Structural Stages 2 (Herbaceous) and 3 (Shrub) often provide good forage and berry shrubs depending on aspect, soil nutrient regime, moisture regime, and other environmental factors. Similar to avalanche slopes, forage and berry production will generally be higher on warm south facing aspects. If coarse woody debris and stumps are retained in these blocks they will also provide opportunities to forage for ants. Ant abundance will also be highest in cutblocks on warm aspects (Riddell 2002). Beaudry *et al*. (2001) suggest that in the Parsnip study area ants may be an important alternative food resource during poor berry production years. Although cutblocks can provide significant food values, their use in areas with significant human activity will depend on the amount and proximity of security cover. Displacement of bears either spatially or temporally can significantly reduce habitat effectiveness in this habitat type (Zager *et al*.1983, Ramcharita 2000, Herrero *et al*. 2000, Hamilton and Wilson 2001).

Season of Use:

- ICHwk2 and ESSFwk1 from early spring to late summer;
- ESSFwc3 and ESSFwcp3 from late spring to late summer; and
- ESSFwc3 and ESSFwcp3 early summer to early fall.

Important Ecosystem Units:

- IWHwk2 – HC; RC; RD; SO; RJ; ST (2,3 in all).
- ESSFwk1 – FB; FF; FO; FD; FT (2,3 in all).
- ESSFwc3 – FA; FG; FH; FJ; FL; FQ; FR; FW (2,3 in all).
- ESSFwcp3 – FB; FL; FV (2,3 in all).
- AT – n/a

2.3.2.6 Burns

A number of researchers have identified burns as important late summer and fall habitat for grizzly bears (Zager *et al*.1983, LeFranc *et al*. 1987). AEM (2002) identified burns on warm slopes as an important habitat type in the Penfold study area. However, there were no burns observed in the MacKay LU during the field survey and no polygons were assigned a burn disturbance modifier. Therefore, there were no polygon enhancements applied for this disturbance type.

2.3.2.7 Root Crops

Glacier lilies have been identified as an important food resource for grizzly bears through the spring season (Beaudry *et al*. 2001, AEM 2002, Riddell 2002). Typically, glacier lilies occur on open avalanche chutes extending upward in elevation into open areas in the subalpine. In the Parsnip study, Beaudry *et al*. (2001) reported that grizzly bears dug extensively for glacier lilies throughout the spring and into summer while hedysarum spp. was fed on only in spring and fall. As noted above, hedysarum spp. is not common in the study area and consequently for the purpose of this study it was ignored as an important food item. Patches of spring beauty may also be a critical spring food in the MacKay LU. Other important spring and fall root crops likely include *Osmorhiza* spp., and *Astragalus* spp.

Season of Use:

- ICHwk2 and ESSFwk1 in spring and fall;
- ESSFwc3 and ESSFwcp3 from late spring to summer and again in fall; and
- ESSFwc3 and ESSFwcp3 early summer to late fall.

Important Ecosystem Units:

- ICHwk2 - AF2; PF2.
- ESSFwk1- AF2; BV2, 3; PF2.
- ESSFwc3 - AF2, 3; BV2, 3; VG2; VM2; FA2-7; VD2.
- ESSFwcp3 - BV2, 3;VG2; VM2; HL2; HV2; VD2.

2.3.2.8 Berry Production

Important berry production areas include forested and non-forested moisture receiving sites on lower slopes, valley bottom floodplains, and riparian zones. In the MacKay LU, important berry crops include black huckleberry, soopolallie, saskatoon, thimbleberry, raspberry, black twinberry, currant, gooseberry, highbush-cranberry, bearberry and crowberry. Many other soft mast crops will be utilized as well, including wild cherry (*Prunus* spp.), mountain ash, devil's club, red-osier dogwood, juniper, solomon's-seal (*Smilacina* spp.), twistedstalk (*Streptopus* spp.), and others. In the Parsnip study area, Beaudry *et al.* (2001) reported that fall berry production was higher along the edges of riparian areas. Clearcuts, burns, shrubfields and other open areas on warm aspects are also important berry producing areas for black huckleberry, various blueberries, soopolallie, saskatoon, rasberry, thimbleberry, and currants.

Season of Use:

- ICHwk2 and ESSFwk1 from early summer to fall;
- ESSFwc3 and ESSFwcp3 from mid summer to fall; and
- ESSFwc3 and ESSFwcp3 from summer to late fall and bearberry in spring in the JK type.

Important Ecosystem Units:

- IWHwk2 – HC; RC; RD; SO; RJ; ST (3, 6, 7 in all).
- ESSFwk1 – FB; FF; FO; FD; FT (3, 6, 7 in all).
- ESSFwc3 – FA; FG; FH; FJ; FL; FQ; FR; FW; JK (3, 6, 7 in all); and JK (fall/spring).
- ESSFwcp3 – FB; FL; FV (3, 6, 7 in all); and JK (fall/spring).

2.3.2.9 Structural Stages

Grizzly bears are known to prefer early successional stage vegetation and select habitats dominated by herbs and shrubs. These include non-forested meadows, avalanche chutes, wetlands, seepage sites, clearcuts, shrubfields, and similar sites. In some forest types with Mature (structural stage 6) and Old Forest (structural stage 7) there are numerous canopy openings which permit herbaceous and shrub growth. Based on food habits modelling in the CMPP area, Herbaceous (structural stage 2) and Shrub (structural stage 3) rated highest overall for food value followed by Mature (6) and Old Forest (7) (Riddell 2002). In Riddell (2002), the importance of early structural stages decreased from spring to fall dropping from 80% in spring, to 77% in summer, and 30% in fall. In contrast, mature and old forest structural stages increased in importance through the year from 13 % in both spring and summer to 50% in fall. On the MacKay study area, the importance of younger structural stages for green forage was reflected by generally increasing the values of ecosystem units for Herbaceous (2) and Shrub (3) types by one habitat suitability class over Pole Sapling (4) and Young Forest (5) structural stages.

Season of Use:
- ICHwk2 and ESSFwk1 spring and summer;
- ESSFwc3 and ESSFwcp3 spring and summer; and
- ESSFwc3 and ESSFwcp3 late spring to late summer.

Important Ecosystem Units:
- Most forest types.

2.3.2.10 Warm Aspects

The seasonal productivity and availability of green forage, root crops, and berry crops can be influenced to a large degree by aspect. Succulent graminoids and forbs, and root crops are first available on south-facing aspects in early spring at a time when other food resources are in limited supply. Typically, cool north facing aspects retain snow cover late into the season, often have greater moss cover, less herbaceous cover, fewer root crops, and generally less productive berry crops. In the Parsnip River area, Beaudry *et al*. (2001) reported that 52% of spring grizzly bear locations occurred on southerly aspects. They found that although a variety of aspects were selected for throughout the growing season, warm aspects overall were used more than other aspects. A number of other studies have reported greater use of chutes on warm aspects during the spring (Mowat 2000, Ramcharita 2000, Saxena and Gazey 2000, Apps 2000).

Season of Use:
- ICHwk2 and ESSFwk1 from early spring to early summer;
- ESSFwc3 and ESSFwcp3 from early spring to early summer;
- ESSFwc3 and
- ESSFwcp3 in late spring to mid summer.

Important Ecosystem Units (Forest types include structural Stages 6 and 7):
- ICHwk2 – PF2; AF2, 3; AL 2, 3; and HC; RC; RD; SO; RJ; ST (2,3 in all).
- ESSFwk1 - PF2; and AF; AL; FB; FF; FO; FD; FT (2,3 in all).
- ESSFwc3 – VG2; VM2; VD2; and AF; BV; FA; FG; FH; FJ; FL; FQ; FR; FW (2,3 in all).
- ESSFwcp3 - VG2; VM2; VD2; and FA; FG; FH; FJ; FL; FQ; FR; FW (2,3 in all).
- AT – AD2

2.3.2.11 Ungulates

Upon den emergence grizzly bears are known to actively seek winter-killed or weakened ungulates on their traditional wintering grounds (LeFranc *et al*. 1987). The high protein and fat content of animals make this food item an important component of grizzly bear diets whenever its available (LeFranc *et al*. 1987). Moose (*Alces alces*) and deer (*Odocoileus* spp.) are distributed at low density through most of the growing season but concentrate their activity in winter, generally yarding in more confined areas. Often yarding occurs in willow and red-osier dominated stands in lower valley riparian zones. Riddell (2002) reported that the incidence of moose sign was highest in the ICHwk2 (70%), followed by the ESSFwk1 (12%), ESSFwc3 (9%) and ESSFwcp3 (4%). In the Penfold area, Bruhjell *et al*. (1998) reported that in early spring moose were associated most closely with ICHwk2 WW, ST, WD, WS and ESSFwk1 WS ecosystem units.

Throughout the year other ungulates such as elk (*Cervus elaphus*), mountain goats (*Oreamnos americanus*), and mountain caribou (*Rangier tarandus*) may be hunted or scavenged opportunistically by grizzly. Grizzly bears may also search out spring calving grounds and fall rutting grounds for opportunities to hunt ungulates.

Season of Use:

- ICHwk2;
- ESSFwk1; and
- ESSFwc3 after den emergence.

Important Ecosystem Units:

- ICHwk2 - WD3; AS3; RC3; ST3; WWa3; WGa3.
- ESSFwk1 - FH3; FD3; WCa3; WS3; AH3.
- ESSFwc3 - FG3; WV3;WS3.
- ESSFwcp3 - n/a.
- AT - n/a.

2.3.2.12 Rodents

Ground squirrel, microtines and marmots are often reported as important food items in grizzly bear diets (LeFranc *et al*. 1987, AEM 2002, Riddell 2002). They are hunted opportunistically throughout the year with concentrated hunting for ground squirrels and marmots in the fall. Ground squirrels inhabit open meadows including avalanche slopes and upper elevation meadows in the alpine and subalpine. Marmots are commonly associated with talus slopes and rock outcroppings adjacent to meadows.

In the CMPP study, ground squirrel populations occurred at low density (<3% of 175 evaluation sites) and had patchy distribution (Riddell 2002). All sites were located in herbaceous cover on warm upper slopes in the ESSFwc3 (HL and HV) and ESSFwcp3 (HP and VG). Marmot sign was typically recorded in herbaceous or sparsely vegetated cover on warm aspects in upper slope to crest positions. Most sites were located in the ESSFwc3 and ESSFwcp3. Microtines were found in two grizzly bear scats collected in shrub habitat in the ICHwk2 (ST3) but this food item is likely eaten opportunistically throughout all BEC zones.

Season of Use:

- Microtines – opportunistically spring to fall; and
- Ground squirrel and marmot – mostly in late summer and fall.

Important Ecosystem Units for ground squirrel:

- ICHwk2.
- ESSFwk1 - PF2; AF2; BV2;.
- ESSFwc3 - AF2; BV2; FA2, 3, 7; VD2; VG2; VM2; WV2.
- ESSFwcp3 - HL2; HV2;VD2; Marmots –TA.
- AT - AD2, 3.

Important Ecosystem Units for marmots:

- ICHwk2 - n/a.
- ESSFwk1 - n/a.
- ESSFwc3 - TA associated with AF2; BV2; VG2; VM2.
- ESSFwcp3 - TA associated with BV2; VG2; VM2.
- AT - TA associated with AD2.

2.3.2.13 Ants

Ants are a food item routinely reported in grizzly bear diets from most of their range, however, the importance of this food is not fully known (LeFranc *et al*. 1987). Riddell (2002) reported that in the CMPP study area ant activity was recorded at 10 % of 175 habitat evaluation (?) plots. Plots where ants were recorded were entirely from the ESSFwc3 (59%) and ICHwk2 (41%). Ant presence was associated with mid to crest slope positions (71%), on south aspects (76%) and on sites with less than 60% slopes (100%). Ant presence was greatest in structural stages 2 and 3 (82%), and on sites with less than 10% canopy closure (88%).

Season of Use:

- Warm aspects in the ICHwk2;
- ESSFwk1 and ESSFwc3 that are free of snow in early spring;
- ICHwk2;
- ESSFwk1; and
- ESSFwc3 warm aspects at all elevations through summer and fall.

Important Ecosystem Units:

- ICHwk2 - ALw2; HOw2, 3; SOw2, 3; RDw2, 3.
- ESSFwk1 - AFw2; BVw2, 3; PF2; FBw2, 3; FFw2, 3; FOw2, 3; FTw2, 3
- ESSFwc3-AFw2; BVw2, 3; FAw2, 3; FHw2,3; VGw2, 3; VMw2, 3; FRw2, 3; FQw2, 3.
- ESSFwcp3 - n/a
- AT - n/a.

2.3.2.14 Security cover

Security cover is an important consideration when evaluating habitat suitability for grizzly bears in areas with human activity. Grizzly bears are known to utilise open habitats in remote landscapes that have minimal human activity. In the MacKay LU, open habitats include clearcuts, alpine areas, sedge meadows and open avalanche chutes. These same areas tend to have higher food values and displacement of bears from these habitat types will have impacts on grizzly bear habitat effectiveness. In these habitats the proximity of security cover afforded by tall shrub (Structural Stage 3b) or forest cover (Structural Stages 4-7) to food patches will be an important factor in determining the level of displacement. Zager *et al*. (1983) indicated that grizzly bears used clearcuts providing there was nearby cover (<50m) such as well-developed shrub strata, leave trees, or borders of cutblocks.

Quantitative security cover data for the Quesnel Highlands is available from this study and from the Mitchell River area study (Riddell 2002). For the current study, these data were not used directly in determining habitat suitability ratings for ecosystem units. However, in the course of completing habitat effectiveness mapping most clearcut areas were uniformly reduced by a suitability class because road buffers also affected these areas.

Season of Use:

- All seasons in all BEC zones.

Important Ecosystem Units:

- Applies to all ecosystem units.

2.3.2.15 Bedding Sites

In some cases less productive foraging habitat may be as important as bedding habitat. An example of this would be forest or alder thickets adjacent to an avalanche chute (Ramcharita 2000). Feeding sites in these localized areas are frequented repeatedly over a number of consecutive days and bears will construct and reuse day beds in the immediate vicinity. Ramcharita (2000) found that all bed sites associated with chutes in the Revelstoke area were located either within chutes or in forested habitat located < 25 m from them. Zager *et al*. (1983) reported that timbered areas between cutblocks were often used as bedding sites. Ross *et al*. (2000) reported grizzly bears in the Parsnip study area excavated shallow bedding sites at the edges of wet meadows in summer. Riddell (2002) reported one bedding site in the Lower Mitchell River in streamside willow shrubbery (ICHwk2 WD 3b) adjacent to a salmon spawning stream. Bedding sites are too small to map and can occur in a variety of habitat types. Therefore they were not considered when determining suitability ratings or in the mapping process. However, because they typically are associated with ecosystem units that have high habitat suitability ratings they are taken indirectly into account during the mapping process.

Season of Use:

- All seasons in all BEC zones.

Important Ecosystem Units:

- Applies to all ecosystem units.

2.3.2.16 Mating Sites

Typically grizzly bears mate in May to mid-July and mating habitat appears to vary but is usually associated with prime spring feeding areas (LeFranc *et al*. 1987). In the MacKay LU this will include lower elevation open habitat types and south facing avalanche slopes.

Season of Use:
- ICHwk2;
- ESSFwk1; and
- ESSFwc3 in spring and early summer.

Important Ecosystem Units: Various units but likely will include the following.
- ICHwk2 - AF2,3; PF2.
- ESSFwk1 - AF2, 3; BV2, 3; PF2.
- ESSFwc3 - AF2, 3; BV2, 3; VG2; VM2.

2.3.2.17 Den Sites

The habitat maps included with this report indicate "Living" habitat and so denning habitat was not mapped. Typically den sites are located in upper elevation forests on north and north easterly aspects, often adjacent to avalanche slopes or in subalpine krumholtz stands (LeFranc *et al*. 1987, Beaudry *et al*. 2001).

2.3.3 Polygon Habitat Ratings

2.3.3.1 Mapping Procedures

The mapping procedure involved obtaining a series of 1:20,000 orthophoto mosaics of the MacKay LU and overlaying these with hydrography and roads from the most current TRIM data. This product was then overlayed with the ecosystem polygons from the available TEM data (Geowest 1999). The maps created by this process were then merged to form three 1:20,000 working maps of the MacKay LU.

Mapping of important grizzly bear habitats proceeded by subdividing and delineating new polygons of prime habitat within the existing TEM polygons. The newly created polygons were digitised into ArcInfo GIS, assigned unique numbers and revised ecosystem unit labels in the TEM database. A review of the original TEM mapping indicated that most wetlands and avalanche chutes were mapped as distinct polygons and so mapping concentrated on separating out smaller units of prime habitat using the standard 2 ha minimum size based on 1:20,000 scale mapping (RIC 1998). Sliver polygons created when the study area boundary was superimposed were merged with adjacent polygons that shared the longest common border or had the most similar ecosystem composition. When a polygon was split into two sub-units, one of the offspring polygons retained the parent tag number while a number 9 prefix was attached to the same tag number to create a unique label for the second polygon. All corrections and updates of the original TEM map and database were documented.

Due to the scale of mapping, microhabitat inclusions are often inadequately represented. As discussed above these inclusions in the MacKay study area may include seepage sites, small high-gradient streams, small wetlands, narrow avalanche chutes, patches of glacier lily, patches of soft mast crops, rodent colonies, patches of root crops, and other small productive sites. In cases where mapped units had a high incidence of important microhabitat inclusions that were too small to map the ecosystem label was modified to include it as a secondary or tertiary component providing it made up at least 10% of the polygon. In cases where avalanche chutes were mapped, and polygons were split, a number 5 prefix was used to label one of the new polygons.

2.3.3.2 Habitat Suitability

For consistency, the methodology used to calculate habitat suitability ratings adhered to that used by AEM (2002) in the Penfold, Eastside and Wasko-Lynx Landscape Units. Thus only ecosystem units with High (1) or Moderately High (2) ratings were used in the calculations to determine final polygon values. Using the ecosystem unit suitability ratings from Appendix IV (i.e. Ratings Table 1), habitat suitability ratings were calculated for each updated TEM polygon based on their respective composition of ecosystem units. Thus the habitat suitability values of each component ecosystem unit were added together to produce a final rating for the polygon. Calculations were completed for each grizzly bear season.

In review, Habitat Suitability ratings for each polygon were determined by eliminating lower value ecosystem units ($\geq$3) from the calculations and using only ecosystem units rated High (1) or Moderately High (2). Habitat Suitability was then calculated by multiplying the ecosystem rank by the decile (i.e. in tenths) proportion of each ecosystem unit within the polygon. For calculation purposes the ecosystem units rated High were assigned a value of 2 and those rated Moderately High a value of 1. For example the formula for a polygon composed of 5 deciles (50%) of Moderately High, 3 deciles (30%) of High, and 2 deciles (20%) of Low rated ecosystem units would be (5x1)+(3x2)+(2x0) = 11. The final ratings ranged from 0 to 20 and these were then bracketed to create six classes of Habitat Suitability Ratings.

2.3.3.3 Habitat Enhancements

Two habitat enhancements were used on the MacKay study and these included riparian travel corridors and linkage zones. This assessment is based on a review of the unique features of the landscape within the study area and is independent of the ecosystem ratings and TEM mapping process. As discussed above, there are no salmon spawning streams within the MacKay LU and therefore no corresponding enhancement was applied. Habitat suitability values were increased uniformly by one class across all polygons affected by the delineated habitat enhancement area (e.g., riparian travel corridor). For example a polygon with a ecosystem unit suitability rating of Low (4) would then be changed to Moderate (3) (Table 4). To qualify as a habitat enhancement area sites must provide a contiguous food supply and accessible security cover (AEM 2002). The following section provides a discussion of each habitat enhancement type.

2.3.3.3.1 Riparian Travel Corridors

Grizzly bears are known to use riparian corridors as an efficient and secure means of travel through their home ranges (Saxena and Gazey 2000). While they form a conduit between patches of high value habitat, riparian corridors generally also provide a contiguous supply of food items, water, and both security and thermal cover. Riparian areas often are also preferred habitat for deer and moose, especially in winter, and these corridors areas can provide grizzly bears with increased hunting and scavenging opportunities. Frequent use of these corridors by ungulates creates a network of game trails that will also be preferentially used by grizzly bears as they travel between habitat patches. Riparian corridors are frequently traveled by grizzly bears with overlapping home ranges and these travel routes may also act as important areas to establish marking sites (LeFranc *et al*. 1987).

For the current habitat model riparian travel corridor were delineated to include all habitat within 150 m of either side of a Class I streams (MacHutchon *et al*.1993, AEM 2002). In the MacKay study area this included the entire length of the Horsefly and MacKay Rivers. The boundaries of this enhancement zone were adjusted to fit adjacent TEM lines and new polygons were created whenever the minimum polygon size was attained to justify a polygon split. New polygons created when riparian buffers split existing units were generally identified by the number 6 prefix.

2.3.3.3.2 Linkage Zones

As discussed, linkage zones are habitat that provide foraging opportunities, connectivity within home ranges, and avenues of dispersal. Effective linkage zones become crucial in heavily fragmented habitats by maintaining connectivity between patches of important habitat. This habitat attribute is critical for the maintaining intact individual grizzly bear home ranges and to maintain genetic flow between sub-populations in order to prevent isolation of habitat and sub-populations (Ruediger 2000).

To be effective, linkage zones must have adequate vegetation cover with short distances to security cover, low road density, and low human use levels (AEM 2002, Ruediger 2000). The MacKay landscape is mountainous with significant portions of steep terrain that form physical barriers to movement. These are barriers that are punctuated by low mountain passes allowing unrestricted movement of grizzly bears from one area to another. Linkage zones in the MacKay LU were delineated in passes, which link major drainages and riparian corridors. In other more open areas, a lack of security cover forms barriers to travel especially in areas of human development and frequent use. These landscapes are most evident in clearcut areas and in one case a linkage zone was delineated through a series of retained forest cover that provided security cover.

In the Mackay LU, linkage zones were identified during fieldwork, and by reviewing maps and airphotos. Linkages zones between drainages were confined to the pass itself and extended out to the next 20 m contour above the pass contour level (AEM 2002). The one linkage zone delineated in forest cover was approximately 300 m wide and extended from one large tract of contiguous forest to another. New polygons created when linkage zones split existing units were generally identified by the number 7 prefix.

Table 4. Buffer zone types and modification factors applied to Ecosystem Unit suitability classes.

Grizzly Bear Habitat Feature	Zone of Influence	Habitat Suitability Class Modification Coefficient
	Habitat Modification	
Travel Route	150m	+1
Linkage Zone	Variable (Area delineated only)	+1
	Habitat Effectiveness	
Mainline Haul Road (>1 vehicle/day)	500m	-1
Spur Haul Road (<1 vehicle/day)	250m	-1

2.3.3.4 Habitat Effectiveness

Habitat Effectiveness is a habitat's capability to support grizzly bears less the degree of displacement resulting from human disturbances (Gibeau 1998). Thus if the grizzly bears are displaced from 50% of the habitat area or for 50% of their normal foraging time then the Habitat Effectiveness is reduced by 50%. In the study area, grizzly bears will be displaced further from areas affected by logging roads where human activity is greatest.

2.3.3.4.1 Roads

Road density and intensity of use have been correlated to increased mortality of bears through accidental collisions with vehicles, legal hunting, poaching, and self-defence (McLellan and Shackleton1988, McLellan 1990, Mace *et al*. 1996, Mace and Waller 1997, Cannings *et al*.1999, Hamilton and Wilson 2001). Increased road density and the associated human activity also reduce habitat effectiveness through both spatial and temporal displacement of grizzly bears, habitat fragmentation, and disruption of normal movement patterns (McLellan 1989a, McLellan 1990, Herrero *et al*. 2000, Hamilton and Wilson 2001). Grizzly bears appear to respond negatively to road densities above a threshold of approximately 0.6 km of road/km^2 (Forman *et al*. 1997, Mace and Waller 1997). Impacts on grizzly bears will be most pronounced in areas where human activity displace them from prime habitat (Schleyer *et al*. 1984), important travel or linkage corridors, mating areas, and other critical habitats. Important considerations are the daily and seasonal activity patterns of both humans and bears in impacted areas.

In the Parsnip River area northeast of Prince George, Ciarniello *et al*. (2002) reported that grizzly bears avoided habitat within 2.5 km of roads. Mountain bears avoided habitat within 1 km of roads but their use of this zone increased extending out to 1.5 kilometres until at the 2.5 km distance habitat use was proportional to availability. They concluded there was an overall avoidance of road networks by mountain bears. In contrast plateau bears used habitat within 500 m of roads in proportion to availability, actively foraged along roadsides in spring, and often travelling along reclaimed logging roads. Mountain bears were located in close proximity to reclaimed roads approximately 5 times more often than spur roads or mainline roads.

Munro (1999) reported that female grizzly bears in the Revelstoke to Golden corridor used habitat within 10 km of major transportation corridors less than expected. In contrast, males and "highway bears" used areas within 0.5 km of transportation corridors more often than expected in spring but similar to expected use in summer. In the same study area, Ramcharita (2000) reported that grizzly bears selected for prime habitats on avalanche slopes located adjacent to logging roads in areas that received infrequent traffic. He suggested that logging roads traversing these slopes likely provide easy access to preferred habitats.

In Banff National Park, Purves *et al*. (1992) recommended 500 m wide large carnivore travel corridors be preserved in valley bottom locations where human activity was high. A 200 m corridor was recommended for less intensely used areas. In the Lake O'Hara area a 250 m buffer zone was proposed for trails and facilities where human use exceeded 100 persons per month (Ptarmigan Geographic 1997). Both of these studies differ from the MacKay LU in the degree of habituation of grizzly bears to humans but provide insight into displacement effects of grizzly in different areas.

AEM (2002) reviewed a number of studies that reported displacement of grizzly bears within 250 m to 500 m buffer zones for gravel logging roads and trails. For consistency and for the purpose of this study these data are assumed to be similar for the MacKay LU. On the present study, existing road coverage was obtained from current TRIM data and overlaid onto the final habitat map. As indicated in Table 5, roads were divided into two categories ”mainline” and “spur” roads and buffers of 500 m and 250m, respectively were established for each. No data were available regarding traffic volume on these roads, but mainline roads were predicted to average more than 1vehicle/day and spur roads less than 1 vehicle/day (AEM 2002). Introduction of the road buffer zones onto the final habitat map resulted in numerous split polygons and splinter polygons. Boundaries of the road buffers were adjusted to fit adjacent TEM lines and new polygons were created whenever the minimum polygon size was attained to justify a polygon split. New polygons created when road buffers split existing units were generally identified by the number 8 prefix. Ecosystem units for polygons within the road buffer areas were uniformly decreased by 1 habitat suitability class (e.g., from Moderately High (2) to Moderate (3) for all seasons (Table 4).

Table 5. Summary of road buffer data used to create the Habitat Effectiveness map.

Buffer Zone	TRIM Layer – Description	Road Type	Vehicles/day
500m	DA25000110 - Loose, 1 lane, undivided	Mainline	>1
	DA25000120 - Loose, 2 lane, undivided	Mainline	>1
250m	DA25150000 - Rough road, (unimproved)	Spur	<1
	DA25150100 - Road overgrown, inaccessible by 4X4	Spur	<1
	DD31700000 – trail	Spur	<1

2.3.3.5 Final Habitat Effectiveness Modelling

The model used here is not as rigorous as a formal Habitat Effectiveness model and the results should be considered as an approximation of habitat effectiveness only (USDA Forest Service 1990, Mattson and Knight 1991). As indicated, AEM (2002) provides a review of the rational used to establish the current road buffer zones. At the time of this study there were no industrial camps located in the study area so no displacement buffer zones were included in the habitat effectiveness mapping for this disturbance feature.

The seasonal habitat effectiveness values for each polygon were calculated by using the original habitat suitability values for each ecosystem unit. These habitat suitability classes were then modified by increasing one class if they occurred within a riparian travel corridor or linkage zone and decreasing by one class if they occurred within a road buffer zone. As with the initial habitat suitability calculations the final habitat effectiveness ratings were calculated by eliminating the resulting lower value ecosystem units (≥3) from the calculations and using only ecosystem units rated High (1) or Moderately High (2). Habitat Effectiveness was then calculated by multiplying the ecosystem rank by the decile proportion within the polygon. In a similar manner to the initial calculations of habitat suitability ratings the ecosystem units rated High were assigned a value of 2 and those rated Moderately High a value of 1. Similarly the formula for a polygon composed of 5 deciles of Moderately High, 3 deciles of High, and 2 deciles of Low rated ecosystem units would be (5x1)+(3x2)+(2x0) = 11. The final ratings ranged from 0 to 20 and these were then bracketed to create six classes of Habitat Effectiveness Ratings (Appendix V).

2.3.4 Mitigative Measures

The dominant primary land use in the MacKay LU is forestry. While harvesting of forests may cause long term disruption of habitat supply it often creates greater short-term supply in the form of early successional vegetation. Establishment of a logging road network has also increased other human uses in the MacKay including hunting, angling, ATV use, snowmobile use, hiking, skiing and other non-consumptive uses. All of these types of human activity are known to cause displacement of grizzly bears from high value habitat resulting in reduced habitat effectiveness.

Impact mitigation focussed on the following:

1) Preservation of identified seasonally critical habitat areas and map units, and seasonally important ecosystem unit types;
2) Restoration and enhancement of habitat suitability values at both the stand level and landscape level; and
3) Preservation or improvement of habitat effectiveness.

As a requirement of the study, Wildlife Habitat Areas (WHA) were determined by reviewing the final habitat maps to identify clusters of seasonally critical habitat. In addition the final habitat database was queried to identify polygons consisting of Pole Sapling or Young Forest in the ICHwk2 and ESSFwk1 that would be suitable to apply restorative forestry techniques.

3 RESULTS AND DISCUSSION

3.1 Field Investigations

The field survey was conducted between August 5th and 10th, 2003. A total of 106 habitat plots or polygon assessments were completed along with 29 Grizzly Bear Activity Site evaluation plots. Table 6 presents a summary of the distribution of plots by BEC zone. A helicopter was used for 3 days of the field survey, which permitted efficient access to remote sites, and a variety of habitat types with good geographical distribution. One day was spent sampling habitat types along the Horsefly and MacKay River main haul roads.

Field sampling concentrated on evaluating the best available grizzly bear habitat within all BEC zones and a range of elevations and aspects. The results of the field plot assessments are included as Appendix II, and the results of the grizzly bear activity site evaluations are included as Appendix III. Site photos of plots were included and a range of representative habitat types are presented in Colour Plates 1 to 20.

Table 6. Number of Habitat Evaluation and Bear Use Plots Completed in Each BEC zone.

BEC Zone	Number Of Plots		
	Detailed Plots	**Polygon Assessment**	**Bear Activity Site**
ICHwk2	11	7	16
ESSFwk1	10	14	7
ESSFwc3	21	21	3
ESSFwcp3	9	8	3
AT	4	1	0
Total	**55**	**51**	**29**

3.2 Grizzly Bear Ecology

Of the 29 bear activity sites investigated the majority were at locations that scats (n=20) were found. Activities were recorded as travelling (17), feeding (9) and bedding (2). Only 2 plots were confirmed grizzly bear sites, 2 were black bear, and the rest were of unknown bear species. Only one confirmed grizzly bear feeding site was investigated which was a digging for ground squirrel in the ESSFwcp3 in the MacKay River headwaters. Several older diggings for ground squirrel were encountered at higher elevation sites but no tracks or other evidence was observed to distinguish whether grizzly bear or wolverine made them.

Plate 1. Dense shrub and herbaceous cover in the MacKay River riparian zone (ESSFwk1 FTt3; Mk081).

Plate 2. Dense willow shrubbery in an ESSFwk1 FB3b ecosystem unit along the MacKay River (MK106).

Plate 3. Seepage inclusion within a cutblock in an ICHwk2 STt3B5 ecosystem unit (MK090).

Plate 4. Seepage at edge of cutblock in western part of study area in an ESSFwc3 FG2 unit (MK055).

Plate 5. Older cutblock in an ESSFwk1 FDk3 unit provides abundant green forage (MK076).

Plate 6. Dense devil's club cover in an ESSFwk1 FD6 ecosystem unit (MK101).

Plate 7. Sedge meadow (ESSFwc3 SS2) in the western part of MacKay study area (MK058).

Plate 8. High habitat suitability (ESSFwk1 BV3b unit) with a variety of green forage (MK046).

Plate 9. Abundant fireweed cover in an ESSFwc3 FRw3 unit and typical view of cutblock patterns (MK001).

Plate 10. Green forage and berry production (ICHwkw HMw3 unit) on a south facing cutblock (MK021).

Plate 11. Habitat inclusion of *Equisetum arvense* cover in an ESSFwk1FTt6 ecosystem unit (MK080).

Plate 12. Dense *Valeriana sitchensis* cover in an old growth forest opening (ESSFwc3 FV7; MK072).

Plate 13. Representative view of upper elevation avalanche slopes in the ESSFwcp3 (MK004).

Plate 14. Prime spring/summer habitat (PFw2) on an avalanche slope in the ESSFwk1 (MK043).

Plate 15. Prime late spring and summer habitat in the ESSFwc3 east of Eureka Ridge (note trails).

Plate 16. Lush habitat (ESSFwc3 VD2) in a bowl on the northeast side of Eureka Ridge (MK069).

Plate 17. Open ESSFwc3 FH7 and VDk2 habitat in the upper MacKay River headwaters (MK009).

Plate 18. Lush growth of valeriana, cow parsnip, and grasses in an ESSFwcp3 FVw6 unit (MK003).

Plate 19. Poor habitat on an exposed ridgeline with very shallow soils in an ESSFwcp3 SD2 unit (MK083).

Plate 20. Windswept sedge plateau in the MacKay River headwaters ESSFwcp3 SD2 unit (MK007).

3.3 Habitat Suitability

3.3.1 Ecosystem Unit Ratings

Appendix IV presents seasonal habitat suitability rankings by ecosystem unit for the MacKay LU. This appendix is the equivalent to the "Ratings Table 1" presented by AEM (2002). As discussed in the methods section these are grizzly bear habitat suitability ratings for Living which take into account food and security cover values.

3.3.2 Critical Habitat

High value spring, summer and fall grizzly bear habitat maps are presented in Figures 2, 3 and 4, respectively. These maps indicate the distribution of prime habitat within the MacKay LU. The final Habitat Effectiveness maps for spring, summer and fall are presented in Figures 5, 6 and 7, respectively. This latter set of maps indicates the final distribution of prime habitat after taking into account road buffers, riparian travel corridors, and linkage zones. All coloured areas identified on these maps is for High (1) and Moderately High (2) rated grizzly bear habitat only and this prime habitat has been furthered separated into one of 5 classes as indicated on the map legend. Table 7 provides a summary, by season, of prime habitat supply (ha) and as a percent of the MacKay LU landbase.

3.3.2.1 Spring Habitat

High value spring habitat is distributed throughout the study area (Figure 2) with the greatest concentrations along the south facing slopes of Isosceles and Dutchman Mountains, and Mount Elsey in the Upper Horsefly River. Other patches of High value spring habitat occur on the south facing slopes of McCallum Peak in the Hawkley Creek drainage and on the south facing slopes of Mount Perseus in the Pegasus Creek drainage. Three smaller patches of High value habitat are located on warm aspects in the MacKay River headwaters and one in Eureka Creek drainage. In the western portion of the study area, one patch of High value riparian habitat exists along the Lower Horsefly River near Big Slide Mountain. Generally there is relatively even distribution of lesser quality habitat throughout the MacKay LU. High value spring habitat has been identified as a critical life requisite for grizzly bears (Saxena and Gazey 2000). At this time of the year bears emerge from den sites with depleted energy reserves and they require high value foods to replenish body reserves.

3.3.2.2 Summer Habitat

High value summer habitat is generally plentiful and well distributed throughout the MacKay LU (Figure 3, Table 7). This is primarily a reflection of succulent green forage, which does not appear to be a limiting factor for grizzly bears here. Many of these sites include avalanche slopes, seepage zones, wetlands, meadow complexes, riparian zones, and clearcuts. Although there is a good supply of summer habitat field investigations indicated limited berry crop production. This is a concern because as discussed above berry crops are an important food source for bears to accumulate winter fat reserves.

3.3.2.3 Fall Habitat

The MacKay LU has a very limited supply of High value fall habitat and there were no map units rated in the High (1) or Moderately High (2) Habitat Suitability Class in habitat map (Figure 4 and 7; Table 7). During the field program it was noted that there was a lack of fall root and berry crops available to resident grizzly bears. This lack of quality fall habitat has also been observed by local BC Ministry of Water, Land and Air Protection ecologist Geoff Price (pers. comm.). At this time of year lesser quality habitat will become increasingly important as bears attempt to gain fat reserves or maintain reserves for winter hibernation (Saxena and Gazey 2000).

Whereas the habitat effectiveness model significantly reduced the supply of spring and summer habitat there was only minor changes in the supply of fall habitat. This is because there was extremely limited High value fall habitat available in roaded areas. The negative counter effects of the road buffers largely negated any increases in habitat suitability within map units in the riparian corridor and so the habitat values here did not change.

In the CMPP, 94 % grizzly bear of activity sites located during the fall season were in the ICHwk2 zone (Riddell 2002). However, this high incidence of use was attributed to bears drawn to the Mitchell River, Penfold Creeks and other streams for spawning salmon. Grizzly bears are known to travel long distances and it is quite likely that resident grizzly bears migrate out of the area to exploit adjacent salmon spawning streams.

3.4 Habitat Effectiveness

As indicated in Figures 5, 6 and 7 road buffers affect a significant portion of the MacKay LU. Construction of logging roads and trails into areas of prime habitat will have the most pronounced effect on habitat effectiveness. Comparison of Habitat Suitability Figures 1, 2 and 3 to the respective Habitat Effectiveness maps 4, 5, and 6 indicate that the heavily logged western portion and lower elevation sections of the MacKay and Horsefly valleys are most impacted. As indicated in Table 7 habitat effectiveness related to prime habitat has been reduced to 25%, 16% and 58% of the potential habitat suitability for the spring, summer and fall periods, respectively. This reveals a significant decrease in high value habitat effectiveness in the logged areas of the MacKay LU.

Whereas the habitat effectiveness model significantly reduced the supply of spring and summer habitat there were only minor changes in the supply of fall habitat. This is because there was extremely limited prime fall habitat available in the areas affected by the road buffers. The negative counter effects of the road buffers largely negated any increases in habitat suitability within map units in the riparian corridor and so the habitat values here did not change. It should be noted that the habitat effectiveness model used on this study pertains to high value habitat loss only. The current model does not incorporate disturbance coefficients used on standard Habitat Effectiveness modelling (Gibeau 1998, USDA 1990) and this must be kept in mind when interpreting the results.

Mainline roads in the study area appear to be well travelled but no quantitative determination of human activity levels was completed for this study. On the one day spent travelling along the Horsefly and MacKay mainline roads a total of 3 small vehicles were recorded. Two vehicles travelled along the Horsefly River main haul road and one truck was parked on the westside of the MacKay River which suggests low traffic volumes. However, a fire ban and travel restrictions were in place for many regions at the time of the field study and human activity levels may have been unusually low as a result.

Figure 2. High value spring grizzly bear habitat within the MacKay Landscape Unit.

Figure 3. High value summer grizzly bear habitat within the MacKay Landscape Unit.

Figure 4. High value fall grizzly bear habitat within the MacKay Landscape Unit.

Other human activity in the area includes summer and winter backcountry use of the Eureka Ridge area. The ridge and the series of lakes associated with the ridge appear to be frequented by various outdoor recreationalists. According to Rob Dolighan (pers. comm.) one of the lakes towards the north end of the ridge was previously stocked and may still attract anglers. A number of active trails exist on the ridge south of Eureka Creek and leading into the bowls located on the east-side of the ridge. Some of these may have been related to past mining exploration and extraction.

Riparian travel corridors are indicated in Figures 5, 6 and 7. Along the MacKay River especially much of the surrounding area has been logged increasing the importance of these corridors as security cover.

Table 7. Area of high value habitat within the MacKay Landscape Unit.

	Spring Habitat				**Summer Habitat**				**Fall Habitat**			
	Habitat Base		**Effectiveness**		**Habitat Base**		**Effectiveness**		**Habitat Base**		**Effectiveness**	
Class	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**	**ha**	**%**
1	412	1.8	182	0.5	611	0.2	487	1.4	0	0.0	19	0.1
2	452	1.3	52	0.2	1454	4.2	612	1.8	0	0.0	20	0.1
3	1665	4.8	841	2.4	4572	13.1	1474	4.2	373	1.1	372	1.1
4	4238	12.1	1029	2.9	5339	15.3	290	0.8	2405	6.9	1355	3.9
5	5564	15.9	987	2.8	7024	20.1	279	0.8	2430	6.9	1275	3.6
Total	12331	35.2	3091	8.8	19000	52.3	3142	9	5208	14.9	3041	8.7

3.5 Wildlife Habitat Areas

Three proposed Wildlife Habitat Areas (WHA) were selected because of their significant contribution to critical spring habitat for foraging and their potential as mating areas. These areas are defined in Table 8 and include groupings of south facing avalanche slopes in the following locations:

1. South facing slopes of Isosceles and Dutchman Mountains in the Upper Horsefly River.
2. South facing slopes of McCallum Peak in the Hawkley Creek drainage.
3. South facing slopes of Mount Perseus in the Pegasus Creek drainage.

Figure 5. High value spring grizzly bear habitat effectiveness within the MacKay Landscape Unit.

Figure 6. High value summer grizzly bear habitat effectiveness in the MacKay Landscape Unit.

Figure 7. High value fall grizzly bear habitat effectiveness within the MacKay Landscape Unit.

Table 8. Description of potential Wildlife Habitat Areas including TEM polygon numbers.

Location/Feature	Bear Season	Habitat	Core Polygons	Buffer Polygons	Comments
Upper Horsefly River: South facing slopes of Isosceles and Dutchman Mountains.	Spring	South facing avalanche chutes	19756 19901	19880 19885 19888 19895 519889 519897 519891 519762 519957 519900 519903 519910 19904 19905 519913 19937 19936 519938	• Extensive avalanche chutes along the south facing slopes of the Upper Horsefly River. • Includes a cluster of approximately 20 polygons of High and Moderately High value habitat. • Important habitat for foraging on early emerging graminoids and forbs in spring. • Important habitat for digging glacier lilies. • Potential mating areas in May to mid-July.
Hawkley Creek: South facing slopes of McCallum Peak.	Spring	South facing avalanche chutes	21261	521266 21254 21252 21324* *(north facing)	• Extensive avalanche chutes along the south facing slopes of the Upper Horsefly River. • Includes a cluster of approximately 5 polygons of High and Moderately High value habitat. • Important habitat for foraging on early emerging graminoids and forbs in spring. • Important habitat for digging glacier lilies. • Potential mating areas in May to mid-July.
Pegasus Creek: South facing slopes of Mount Perseus.	Spring	South facing avalanche chutes	21302 21447 21438 21436	21429	• Extensive avalanche chutes along the south facing slopes of the Upper Horsefly River. • Includes a cluster of approximately 5 polygons of High and Moderately High value habitat. • Important habitat for foraging on early emerging graminoids and forbs in spring. • Important habitat for digging glacier lilies. • Potential mating areas in May to mid-July.

3.6 Mitigation Measures

The main concerns for grizzly bears, appear to be displacement from prime habitat areas, reduced security cover adjacent to foraging areas, elimination or disruption of travel corridors, fragmentation of habitat, and increased mortality rates. Current logging operations in the MacKay LU are transforming a large portion of the unit's mature and old forest into early seral habitat. Associated with this is the construction of logging roads resulting in vehicle access to previously remote headwater areas. Important concerns related to road development are increased access by hunters, anglers, poachers, ATV riders, hikers, backcountry skiers, and other human activity. Other potential cumulative effects related to current development include increased industrial exploration and extraction of minerals, oil and gas, and increased commercial guiding and trapping. Increases in human activity will have adverse impacts on grizzly bear populations through increased mortality, reduced habitat effectiveness, and cumulative effects.

In the MacKay LU, there is ATV and non-motorized use on trails leading to ridge sites along Eureka Ridge and other remote portions of the study area. Field plots and habitat modelling (Figure 1, 2 and 3) indicate that many of the subalpine bowls and avalanche slopes along Eureka Ridge have significant amounts of high value spring and summer habitat. Backcountry access by ATV, hikers, anglers and other recreational activities can displace grizzly bears from habitat through sensitivity to visual or auditory disturbances (Mace and Waller 1997). McLellan and Shackleton (1988) indicate that pedestrian traffic may actually cause greater displacement of grizzly bears than regular vehicular traffic on roadways because grizzly bears are more readily habituated to the latter disturbance. In the Central Rocky Ecosystem, threshold levels of 20 human parties per week were found to significantly displace grizzly bears from foraging habitat (Herrero *et al*. 2000). Grizzly bears in that ecosystem are likely to be comparatively more habituated to humans and it is probable that bears in the MacKay LU will have lower thresholds to disturbance.

Schleyer *et al*. (1984) concluded that non-motorized recreational activity in critical grizzly bear habitat adversely affects habitat use patterns. As a result, grizzly bears will use more remote and higher elevation habitat that is inaccessible to humans. Continuous disturbance can result in permanent displacement or significant disruption of activity patterns. They suggest that even temporary displacement may cause bears to use marginal habitat and result in the displacement of subordinate bears into fringe lands where habitat may be poor quality or they are subjected to higher rates of human caused mortality. Mattson (1990) reported that selection of preferred habitat by adult male grizzly bears resulted in subadults and females using areas inhabited by people more often. This resulted in habituation and higher mortality rates. He indicated that this had major implications to bear populations confronted by even moderate densities of humans.

Sustaining viable populations of grizzly bears centres on maximising recruitment to the population and minimising mortality rates of adult females (Gibeau 2000, Herrero *et al*. 2000). To meet this goal it is essential to minimize human induced mortality and maintain habitat quality, supply and effectiveness.

The main concern regarding habitat supply is the deficiency of high value fall habitat. This may result in grizzly bears travelling more at this time of year in search of food, migrating out of the MacKay LU to local salmon spawning streams, or travelling to areas with more productive late season berry crops. In areas with human activity a greater level of movement by bears can result in more frequent encounters with humans and result in increased mortality rates on grizzly bears. With increased road access into the MacKay LU by hunters grizzly bears may have lethal confrontations as they seek out hunter-kill sites.

3.6.1 Forestry Guidelines

Forestry operations can adversely affect both habitat quality and habitat supply, both of which may lead to negative impacts on grizzly bear populations. In the short term, clearcut logging converts large areas of mature forest to early successional stages (i.e., Herb/Low Shrub) that generally increases habitat supply of green forage, berries, ants and often root crops. In addition, there may be increased opportunity for hunting and scavenging of ungulates, ground squirrels, and microtines associated with cutblocks. As noted above grizzly bears will actively use open areas, such as clearcuts, for foraging in the absence of human activity. However, availability of these food resources may be severely compromised by road access and human activity above threshold levels. As discussed above, displacement can significantly reduce effectiveness of this habitat type. Based on the existing road network in the MacKay LU and planned development, access management related to habitat displacement, reduction of habitat effectiveness, and increased mortality rates should have central management priority.

Over the long term, conversion of large tracts of mature forest to reforested clearcuts will result in a landscape dominated by closed canopy pole sapling and young forest in approximately 30 to 50 years. This could create a serious deficit of herbaceous and shrub cover severely impacting the resident grizzly bear population. Management initiatives should focus on restoring habitat diversity, productivity, and a continual supply of early successional habitat. A successful grizzly bear habitat management program should operate at both the landscape scale (watershed) and stand level (blocks of even-aged trees). The following recommendations are separated into these two levels of management.

3.6.1.1 Landscape Scale

At the landscape scale, forest planners need to preserve habitat connectivity and avoid excessive habitat fragmentation. Habitat connectivity can be maintained by establishing a network of travel corridors and linkage zones early in the planning process and ensuring retention of adequate security cover in these areas. Excessive fragmentation and a loss of habitat connectivity has been shown to lead to isolation of grizzly bear sub-populations and compromised long-term population viability (Gibeau 2000, Herrero *et al*. 2000). In the Rocky Mountain Ecosystem, Herrero *et al*. (2000) determined that female grizzly bears require about 9 km^2 of security area with suitable foraging habitat that is void of human disturbances to meet their daily living requirements.

To avoid succession of the landscape into extensive tracts of closed canopy forests planners need to allow sufficiently long rotation periods. This will ensure that a continuous supply of Structural Stages 2 (Herbaceous) and 3 (Shrub) habitat is available to grizzly bears within the MacKay LU on a continuous basis. Other important habitat considerations include maintaining a diversity of structural stages over the landscape with interspersion of security cover areas and foraging habitat.

In general, there is a good supply of green forage throughout the MacKay LU and proper management at the landscape and stand levels should ensure adequate supply of spring and early summer habitat. The most pressing requirement at present is to preserve and enhance the supply of late summer and fall habitat. In particular, huckleberry, blueberry and soopolallie habitat and patches of glacier lily must be preserved. Due to the current deficiency in prime fall habitat, grizzly bears can be expected to exploit lesser quality habitat and alternative food resources. Fall season habitat included thirteen (13) polygons of Moderate (3) habitat and these as well as the pockets of Low (4) and Very Low (5) habitat should be retained where possible. As discussed below restorative forestry can also increase the supply of fall habitat.

3.6.1.2 Stand Scale

At the stand level, forest planners should ensure a suitable frequency of forest gaps, reduced stocking rates, cluster planting to leave openings and other measures to ensure adequate light penetration for the production of forage and berry crops. Beaudry *et al*. (2001) noted that over the long term the replacement of gap rich mature and old-growth forests with large tracts of young closed canopy forests can significantly reduce the habitat supply of forage and berry producing areas. In old-growth forests the loss of large trees results in gaps allowing the growth of shrubs and herbaceous cover. The loss of "gap-phase" dynamics of old-growth forests resulting from increased harvest levels above the natural disturbance levels result in a landscapes dominated by second growth stands with close canopies. Beaudry *et al*. (2001) completed a preliminary analysis of mature forest canopy gaps in the Parsnip study area. In the ESSFwk2 grizzly bears selected mature and old growth forests that had relatively more gaps per ha than surrounding stands. Stands selected for averaged 24 gaps per 40 ha (3 to 65 per 40 ha range) and averaged 4.15 ha of gaps per 40 ha (0.212 to 18.075 ha range).

Zager *et al*. (1983) reported that cutblock size and shape could significantly affect habitat use patterns by grizzly bears and use depends mainly on distance to cover and open roads. He found that grizzly bears selected long narrow cutblocks with habitat that was within 50 m distance to cover and 50% of the bears studied used cutblocks smaller than 40 ha. Within security buffers adequate security cover should be preserved which is defined as 4 sight distances (i.e., average distance that would obscure a bear) or approximately 183 to 244 m (LeFranc *et al*. 1987). In riparian travel corridors adequate security cover will be 6 to 8 sight distances or 277 to 488 m (LeFranc *et al*. 1987).

An important theme in stand management is the retention of propagation materials to repopulate stands with grizzly bear food after harvesting. This involves the preservation of soils and reproductive materials such as shrub roots, perennial forb roots, graminoid rhizomes, glacier lily and spring beauty corms, and seed banks. Scarification of clearcuts is not recommended because of disturbance and elimination of roots and other reproductive materials. Use of herbicides in clearcuts is also not recommended. Hamilton *et al*. (1991) reported that herbicides could negatively affect the production of grizzly bear forage over the short and long term. Over the short term by directly killing forage plants and over the long term by creating dense stands of regenerating trees and young closed canopy forests. These stands restrict light penetration eliminating forage and berry-producing plants. This is an important consideration in MacKay LU where a large portion of the area has been reverted into forests of the same structural stage.

In areas affected by roads, land managers need to ensure that adequate security cover values are maintained to allow grizzly bear to utilize clearcuts. Finally, it will be important to establish ongoing monitoring of silvicultural techniques and use an adaptive management approach to adjust treatments where new data indicate success or failure.

3.6.2 Restorative Forestry

Restorative forestry efforts will largely focus on stand tending within second-growth forest stands. As discussed above, the conversion of large tracts of forest to the same structural stage will eventually result in a landscape dominated by closed canopy young forest. This loss of habitat diversity and productivity will potentially have severe impacts on grizzly bear habitat supply. As noted the MacKay LU has a relatively good supply and distribution of green forage but appears to have a deficit in soft mast and root crops. Most efforts in restorative forestry should therefore be directed towards improving sites with existing or potential berry and root crop production.

Table 9 identifies ecosystem units with good potential to enhance late summer and fall habitat ratings. A query of the final habitat database indicated that there were no Structural Stage 4 (Pole Sapling) and only two Structural Stage 5 stands (Young Forest) available to apply restorative forestry techniques. Table 10 indicates restorative forestry measures to apply to these two Young Forest stands. The following section provides a list of specific recommendations related to restorative forestry initiatives in the MacKay LU.

Table 9. Summaries of general forestry techniques to improve grizzly bear habitat supply.

BEC Zone	Ecosystem	Management Action and Techniques
ICHwk2	RC,RO,ST, RD, SO, HC	• When planting increase light penetration in stands by reducing stocking standards and using cluster planting techniques. • Use variable stocking density planting to increase levels of stand diversity. • In Structural Stage 4 (Pole Sapling) and 5 (Young stands increase light penetration by and spacing/thinning and pruning to improve herbaceous forage and berry production (MELP 2001). • Avoid use of herbicide (Mattson 1990; Hamilton *et al*. 1991). • To promote forage and berry production in cluster planted stands herbicide may be used within clusters while avoiding areas between clusters (MELP 2001). • Where herbicide is applied avoid berry producing shrubs such as blueberry, huckleberry soopolallie, raspberry, thimbleberry, and currants.
ESSFwk1	FB, FF, FT, FD, FR, FO	• Same management techniques as for ICHwk2 types. • Allow limited wildfires and introduce controlled prescribed burns to increase blueberry, huckleberry and soopolallie cover on warm slopes.
ESSFwc3	FR, FA; FG; FH; FJ; FL; FQ; FR; FW	• Same management techniques as for ICHwk2 types. • Allow limited wildfires and introduce controlled prescribed burns to increase blueberry, huckleberry and soopolallie cover on warm slopes.
ESSFwcp3	FB,FL,FV	• Same management techniques as for ICHwk2 types. • Allow limited wildfires and introduce controlled prescribed burns to increase blueberry, huckleberry and soopolallie cover on warm slopes.

3.6.3 Access Management

Access management is the single most important issue related to maintaining viable grizzly bear populations in the MacKay LU and in other areas (McLellan 1989b, Purves *et al*. 1992, Mattson *et al*. 1996, Jalkotzky *et al*. 1997, Hamilton and Wilson 2001, Gibeau *et al*. 2001,). Development of an Access Management Plan and effective implementation will reduce human caused moralities and greatly improve habitat effectiveness. A recent report to the BC Minister of Water, Land and Air Protection recommended an aggressive program of access control to manage motorized vehicles and reduce grizzly bear mortality in new areas being harvested (Peek *et al*. 2003). In this report it was noted that access management programs need to address both spatial and temporal issues in order to be effective.

Table 10. Proposed habitat enhancement projects for the MacKay Landscape Unit.

MacKay Habitat No.	TEM Map Sheet	TEM Polygon No.	BGC Zone/ Ecosystem Unit	Recommendation
21182	093A109	21182	ICH wk2 10RD5	• Complete thinning and pruning of stands to increase light penetration. • Use hand brushing to remove competing trees and shrubs, however, avoid damaging berry-producing shrubs. • If using herbicide to control growth then avoid damaging berry-producing shrubs.
11076	093A108	11076	ESSF wk2 6FFw5-2FOsw5-FFsw5	• Complete thinning and pruning of stands to increase light penetration. • Use hand brushing to remove competing trees and shrubs, however, avoid damaging berry-producing shrubs • If using herbicide to control growth then avoid damaging berry-producing shrubs.

4 RECOMMENDTIONS

The following section provides specific recommendations aimed at maintaining and enhancing grizzly bear habitat supply.

4.1 Forest Harvesting and Silvicultural Practices

4.1.1 Landscape Scale

1. Establish a forest network of travel corridors in the MacKay LU. These should include preserving 150 m buffers along either side of the Horsefly River and MacKay River, and 75 m buffers along major tributary streams. Complete this network by delineating corridors through areas void of major streams while ensuring connectivity to the main riparian travel corridors. Use single tree and partial cutting within travel corridors and other buffer zones to ensure adequate security cover is preserved.

2. Establish travel corridors to connect areas of critical seasonal habitat. These will include avalanche chutes, wetlands, mesic subalpine meadows, berry production areas and other high value habitat.

3. Include travel corridors in areas with physical barriers to travel (e.g. cliff bands) to ensure adequate security cover provides a linkage between areas of contiguous forest cover.

4. Retain forest cover that extends into identified linkage zones and avoid building roads in the vicinity of these or into open habitat from which access could be gained by ATV's.

5. Avoid construction of roads into the upper headwater areas that allow access to open subalpine and alpine areas.

6. Locate main haul roads and staging areas in less important habitat as indicated in Figures 2,3 and 4 to reduce impacts on prime habitat and to minimize habitat displacement. For example in valleys with significant avalanche slopes locate roads a minimum of 150 m from the riparian zone on the opposite side of the valley.

7. Construct roads a minimum of 500 m outside of the major riparian travel corridors identified for the MacKay and Horsefly Rivers.

8. Maintain road densities of mainline roads below 0.6 km/km^2 and active spur roads under 1 km/km^2.

9. Establish an ongoing program to monitor berry crop habitat supply and production levels in the MacKay LU.

10. Depending on values at risk, allow wildfires to burn and use prescribed burns to enhance blueberry, huckleberry, and soopolallie berry production in the ESSFwk1 and ESSFwc3 (Peek *et al*. 2003).

11. Use spatial and temporal staggering of clearcuts at the landscape scale to create a mosaic of habitat types and avoid creation of extensive areas of forests with the same structural stage.

12. Avoid harvesting within 250 m of all high value habitat patches.

13. Avoid construction of mainline roads through or with 500 m of all high value habitat patches.

14. Avoid timber harvesting in the spring and in late fall. Schedule forest harvesting to avoid displacement of grizzly bears from seasonally high value habitat (see Figures 2, 3 and 4). Especially avoid prime avalanche chutes and riparian zones in spring and berry production habitat in fall.

15. Schedule timber harvesting to avoid disturbances within 500 m of seasonally important habitat patches.

4.1.2 Stand Scale

1. To enhance grizzly bear habitat food values, use single and group selection cuts in buffer zones, small irregular shaped cutblocks, seed tree cuts and shelterwood cuts (LeFranc *et al*. 1987, Zager *et al* 1983, Mowat and Ramcharita 1999).
2. Cutblocks should be under 40 ha in size. They should average 91 m wide and be no greater than about 183 m wide. Design cutblocks to maximize edge to interior ratios of stands (LeFranc *et al*. 1987).
3. Within large clearcuts, cover should be available within 91 m of any given point over 80% of the unit (LeFranc *et al*. 1987). Retain adequate wildlife patches (e.g., 7%) within stands for thermal/security cover, especially adjacent to berry producing sites, and areas supporting productive growth of succulent herbaceous vegetation (e.g., wetlands, seepage zones, etc.).
4. Retain 100 m treed buffers adjacent to major avalanche chutes and other high value habitat. Use partial and single tree logging of these buffers to within 25 m of the edge is acceptable providing adequate canopy cover is left (Mowat *et al*. 2002). Retain 50 m buffers around meadows, seepage sites and other small habitat patches (Saxena and Gazey 2000).
5. Ensure riparian corridors are linked to adjacent forested areas by forested travel corridors, which are at least 100 m wide. Leave 100 m wide strips between cutblocks for screening and travel corridors and for bedding. Retain sufficient cover in travel corridors to hide 90% of a grizzly bear at 61 m.
6. Leave 100 m wide security cover strips along roads adjacent to cutblocks. Use single tree selection cutting to harvesting leave strips.
7. Enhance ant abundance in cutblocks on dry warm aspects by retaining additional Coarse Woody Debris and stumps (Beaudry *et al*. 2001, Riddell 2002). Reduce fuel loads of small diameter woody debris using light burns.
8. Maintain drainage patterns when constructing and reclaiming roads to preserve wetland vegetation, mesic meadows, seepage zones, and other prime habitat.
9. Reduce stocking rates when reforesting stands in ecosystem units identified as being important for berry production. Decreasing canopy closure levels will promote both green forage and berry production. Use cluster planting techniques to leave openings for forage and berry producing shrubs (B.C. Ministry of Forests 2002).

10. Post-harvest treatment of cutblocks with berry production capabilities should avoid mechanical disturbance, herbicide, and slash piling and burning (Mowat and Ramcharita 1999). Zager *et al.* (1883) reported that canopy cover of berry producing shrubs was highest on cutblocks that were burned rather than bulldozed into slash piles. Use herbicide within cluster plantings only and avoid applying to openings. Use manual brushing of clearcuts and avoid removal of berry-producing shrubs.
11. To preserve forb and berry crops, clearcuts should be lightly burned and not scarified. High intensity burning of clearcuts can negatively alter site conditions and eliminates propagation materials required to replenish forage and berry producing plants Mattson (1990). Use broadcast burning to reduce fuel loads when they present a concern (Zager *et al.* 1983).
12. Maintain site conditions when harvesting by retaining some canopy cover for moisture retention. Also, minimize disturbance to the organic layer. Post-harvest scarification and harvesting on dry or exposed sites can seriously decrease berry-production for several years due direct impacts and desiccation of soils in clearcuts (Mattson 1990, Zager 1980).
13. Harvest berry-producing sites in winter to avoid excessive ground cover disturbance that can damage roots.

4.2 Restorative Forestry

1. Thin and prune stands as they reach the pole sapling and young forest stage to improve light penetration and enhance berry and green forage production. Restorative forestry should concentrate on forest stands associated with ecosystem units identified in Table 9.
2. In closed canopy stands on moist sites create openings to promote herbaceous and shrub cover growth.
3. Concentrate restorative forestry efforts on warm moisture receiving slopes for greatest effect. Typically, grizzly bear food production will be higher on these sites compared with cool slopes or dry sites.
4. Establish 50 m wide buffer zones adjacent to microhabitat inclusions by planting trees and tall shrubs. Important microhabitat inclusions will include seepage sites, wetlands, meadows, small high-gradient streams, productive berry and glacier lily patches, and other important habitat.
5. Plant trees adjacent to riparian areas and as required to increase buffer widths to 150 m along the Horsefly and MacKay River riparian travel corridor buffer zones. On tributary streams plant trees to establish 75 m buffers on either side of the stream.
6. Establish screened buffer zones along all active roads by planting 100 m wide treed strips.

4.3 Access Management

1. Develop and implement an Access Management Plan for the MacKay LU.
2. Use gates on the Horsefly and MacKay River mainline roads to restrict unauthorized access into headwater areas.
3. Implement seasonal closures of headwater areas and important habitat during the spring and fall.
4. Monitor access and ensure enforcement of the Access Management Plan.

5. Reclaim roads that will not be used in the near future.
6. Reclaim the first 300 m of spur roads and replant with shrubs and trees to prevent access to these area from main haul roads.
7. Maintain active road density to under 0.6 km/km^2 for main haul roads and under 1 km/km^2 for spur roads.
8. Post and enforce speed limits at 50 km/hr to minimize grizzly bear mortality.
9. Hand cut seismic lines and reforest as required.

5 PERSONAL COMMUNICATIONS

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Appendices