North Coast LRMP

Environmental Risk Assessment Report

Grizzly Bears: Benchmark Scenario Analysis

DRAFT
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Executive Summary

The environmental risk assessment (ERA) for Grizzly Bears in the North Coast LRMP area consists of five individual assessments that are summarized in an overall evaluation of risk associated with the Benchmark Scenario:

a) Risk to critical habitat supply;
b) Risk to landscape level forage supply;
c) Risk of displacement from preferred habitats due to roads and road use;
d) Risk of habituation and/or displacement from preferred habitats due to recreation and tourism use; and
e) Risk of bear mortality due to roads and nodes of human activity.

With the exception of bear mortality, risks were assessed by comparing future habitat quality (amount, suitability and effectiveness) with current condition. Mortality risk was more subjectively assessed based on available kill data. Risk thresholds were identified to be consistent with the primary goal of the Provincial Grizzly Bear Conservation Strategy to maintain the diversity and abundance of grizzly bears throughout BC. Therefore a principle of no-net-loss was applied at the landscape and plan area. Within that framework, the following risk scale was applied to estimate the magnitude of risk. Note that all assessments were based on a comparison with current, rather than historic, landbase condition.

Risk	Deviation from current condition
Very Low	0 to 10%
Low	10 to 20%
Moderate	20 to 30%
High	30 to 40 %
Very High	> 40%

1) Critical Habitat Supply

Risk to critical grizzly bear habitat was assessed by interpreting a small scale predictive ecosystem map of the planning area (ssPEM) into 6 habitat capability classes and comparing the interpreted map to the timber harvesting landbase (THLB). All class 1 and 50% of the class 2 habitats were assigned critical status. Risk was assigned using two indicators, assessed by landscape unit and by watershed: (a) the ratio of commercially-forested critical habitat to total critical habitat and (b) the ratio of commercially-forested critical habitat to total THLB.

No net loss of critical grizzly bear habitat is recommended because of the seasonal importance of critical habitat to individual bears. However, risk classes were applied to identify landscape units and watersheds of particular concern.

Risk to critical habitats outside of protected areas under the benchmark scenario ranged from low to very high in specific landscape units and watersheds. Landscape units determined to be at high risk are Stagoo, Bishop, Chambers, and Scotia. Landscape units determined to be at moderate risk are Big Falls, Kwinamass, Triumph, Somerville, Khyex, Observatory West, Sparkling, and Marmot.

Individual watersheds may be at higher or lower risk, based on the same indicators. Of 183 watersheds with greater than 1 ha of THLB, 71 were classed as moderate risk or higher. These 71 watersheds account for over half of the THLB in the 183 watersheds evaluated at this scale.

2) Landscape Level Forage Supply

A spatio-temporal analysis was conducted of landscape level forage supply based on the amount of mid-seral forest expected within each watershed and landscape unit over time, outside of protected areas. The suitability of grizzly bear habitat was interpreted from Broad Ecosystem Unit mapping and translated into an estimated number of grizzly bears based on empirical information linking habitat quality to bear density. These estimates did not incorporate the influences of salmon, roads, or displacement by human contact.

Results indicate very little change in the minimum number of bears over time (166 bears at time = 0 compared with 161 bears at time = 250 years). Most change occurred in areas of lower habitat suitability classes. This translates to an overall estimate of very low risk to landscape level forage for grizzly bears as a result of current management. However there is, significant variance between individual landscape units and watersheds.

Of the 249 watersheds assessed, 16 have been proposed as "Identified Watersheds," based on a greater than 5 % reduction in bear estimates over at least one time step. Identification of watersheds was supported by a greater than 30% of the total forested in closed canopy midseral forest (20-140 years) at any one time step and/or a higher than average ratio of THLB to total forested. The highest risk watersheds occur in the following landscape units: Triumph, Khyex, Big Falls, Kitsault, Bishop, Scotia, Kitkiata, Somerville, Sparkling, Kwinamass and Chambers.

3) Risk of Displacement from Preferred Habitats due to Roads and Road Use

Risk of displacement of grizzlies from preferred habitat due roads was assessed based on estimated use patterns on existing and potential roads. Watersheds were identified as potentially at risk as a result of roads when: 1) there was greater than 10 km of total new main road 3) there was a significant increase in total road density, and 3) the reduction in number of simulated bears was greater than 5% in any one time step.

In the 250-year time frame simulated by the North Coast Landscape Model (NCLM), there is a 312% increase in the total km of active roads in the occupied grizzly bear portion of the NCLRMP. Although this could indicate a very high risk of displacement, most of the new roads are logging spurs, indicating a low risk to the planning area as a whole. Similarly, simulation results suggest that there will be a 302% increase in the amount of area with road densities greater than 0.6 km/km^2, the threshold that significant grizzly bear displacement has been documented. This result could suggest a very high risk due to road density. However, most of the new roads built are logging road spurs and therefore, an overall low risk of road-related displacement is actually more likely.

The simulation model suggested an 14 % decline in habitat effectiveness resulting in a reduction in the estimated minimum number of grizzly bears over time (158 bears at time = 0 compared with 137 bears at time=250). Although this translates into low risk across the NCLRMP, individual watersheds show higher risk, particularly on connected road networks where both industrial and public traffic occurs.

4) Risk of Habituation and/or Displacement from Preferred Habitats due to Recreation and Tourism Use

The current risk of habituation and displacement associated with recreation and tourism use was based on an examination of estimates of current user-days for land-based activities throughout the NCLRMP. Estimates of future user days for these sites were not available, however the sensitivity of the risk assessment to changes in recreation and tourism use was evaluated.

The current influence of human use, when combined with the displacement influence of roads as described above is an additional 5% loss of minimum effectiveness (an additional reduction of seven bears based on estimates of displacement effect under current management). Recreational and tourist use at Tsamspanaknok (Sam) Bay, Kwinimass River, Upper Ecstall River, Khtada Lake, and Kitkiata is of note because of the overlap of these areas with high grizzly bear habitat values.

5) Risk of Bear Mortality due to Roads and Nodes of Human Activity

The risk of bear mortality was subjectively assessed by examining the grizzly bear kill distribution since 1975 in relation to existing and projected future roads, concentrated tourism and recreation use areas and settlement in the NCLRMP. Mortality levels within the NCLRMP are currently assessed to be within acceptable levels of human-caused mortality. New road construction into the Khyex Landscape Unit, potential upgraded roads into Work Channel (both connecting to Hwy 16) and a potential upgraded road into Kitsault constitute high mortality risk if built and managed without application of mitigation strategies such as restricting motorized access to industrial uses only. Connected roads that enhance marine access may also increase mortality risk in the future.

6) Combined evaluation of environmental risk to grizzly bears

With the exception of loss and alteration of critical habitat, the overall risk to grizzly bears is low to moderate when considered for the NCLRMP as a whole, even when current estimates of salmon biomass are factored into the analysis. However, the risk to bears is distributed unevenly across the plan area. Nine concentrations of risk were identified when examined at the watershed and landscape unit scales. These correspond with concentrations of high levels of current and future human activity, including access, in areas of high suitability habitat.

This analysis did not assess the implications of changes in future abundance of salmon. However, it is an underlying assumption of this work that any reduction in salmon availability will increase risk.

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1.0 Definitions

Blue-list	Sensitive or vulnerable species as identified by the Ministry of Environment, Lands and Parks. Blue-listed species are considered to be vulnerable and "at risk" but not yet endangered or threatened. Populations of these species may not be declining but their habitat or other requirements are such that they are sensitive to disturbance. The blue list also includes species that are generally suspected of being vulnerable, but for which information is too limited to allow designation in another category.
Broad Ecosystem Inventory	An ecologically based classification system that provides an ecosystem perspective for resource management and land use planning. The unit of classification in this system is the Broad Ecosystem Unit (BEU). BEUs emphasize the site characteristics that determine the function and distribution of plant communities in the landscape. Mapping of BEUs combines the Ecoregion Classification system and the Biogeoclimatic Ecosystem Classification (BEC) system.
Critical wildlife habitat	Part or all of a specific place occupied by a wildlife species or a population of that species and recognized as being essential for the maintenance of the population e.g., wetlands, breeding sites, mineral licks, birthing sites, riparian zones, colonies, rookeries, hibernacular, winter range, over-wintering area, caves, talus slopes, avalanche chutes, denning sites, nesting sites, and cliffs).
Habitat capability	A habitat interpretation for a species that describes the greatest potential of a habitat to support that species. Habitat potential does not reflect the present habitat condition or successional (seral) stage.
Habitat displacement	The alienation of wildlife species from preferred habitat due to point, linear or dispersed human activities.
Habitat effectiveness	Habitat effectiveness can be considered the “usability” of habitat. Habitat effectiveness is a function of a large number of factors, including core security (especially for adult females), access to critical seasonal habitats, access to adequate amounts of forage, un-fragmented home ranges, linkages across human fractures to maintain genetic continuity, the degree of displacement from preferred habitat.
Habitat loss	The direct removal of habitat such that capability becomes nil (e.g. roads, development “footprint”)
Habitat suitability	A habitat interpretation that describes the current potential of a habitat to support a species. Habitat potential is reflected by the present habitat condition or seral stages. Suitability can be altered (positively and negatively) by human

activity.

Mortality risk The risk of loss of bear life from fatal human–bear interaction, including hunting, poaching, road kills and defence of life. Risk is a function of (a) frequency of bear-human encounters; and (b) the lethality of those encounters.

Seral stage Sequential stages in the development of plant communities (e.g. from young (or early seral) stage to old growth (or old seral)) that successively occupy a site and replace each other over time. Seral stages change as a result of natural disturbance or human-caused modification.

2.0 Introduction

2.1 Grizzly bear populations on the North Coast

Grizzly bears (*Ursus arctos*) are currently blue-listed in BC, signifying that the species is considered to be vulnerable and "at risk" but is not yet endangered or threatened. Grizzly bears are a “Higher Level Plan species” managed under the Identified Wildlife Management Strategy (MoF and MELP 1999). The conservation of grizzly bear populations and their habitat should be addressed at regional spatial scales due to their low population densities, large home ranges, and sensitivity to a wide variety of human influences. However, grizzly bears also depend on resources at the landscape, watershed and stand scales. Therefore, objectives for habitat and security must be addressed during strategic land use planning to match their cross-scale requirements.

Grizzly bears are indicator, umbrella and keystone species of coastal ecosystems. Potentially sensitive to human development, they may be surrogates of ecosystem health. Because of the wide variety of habitats they use on a seasonal basis, managing for them may also address the habitat needs of numerous other species. Their heavy use of spawning salmon establishes them as an integral part of a web of nutrient exchange (Reimchen et al. 2003) and predator-prey relationships. Grizzlies are also a well-recognized symbol of coastal wilderness and are highly important to First Nations.

At one time, grizzlies were found throughout British Columbia, with the exception of some coastal islands. Today grizzly bears have disappeared from much of the south and south-central parts of BC and local populations are declining in many settled areas of the province. However, overall, BC has some of the last large areas of remaining habitat and contains approximately quarter of the North American population (MELP 1995; Hamilton and Austin 2002).

Grizzly bears occur in relatively high densities along the coast of BC. The distribution of grizzlies in the North Coast is restricted primarily to the mainland with only rare occurrences on some of the offshore islands. Grizzly bear population units (GBPUs) stratify grizzly bears into relatively self-contained populations separated by natural and human-caused interruptions to regular movement (e.g., heights of land, large lakes, inlets, major highways, valley bottom agriculture, and settlement) and represent the land area occupied by resident adult females. Seasonally transients may occur outside this “occupied line” but GBPUs represent the land that will be actively managed for grizzly bears and their habitat. Within the North Coast LRMP there are large portions of three GBPUs: (Stewart, Khutzeymateen and North Coast) and minor overlap with two GBPUs (Kitlope-Fjordland, and Bulkley Lakes). All GBPUs in the North Coast are currently classed as viable (Table 1). The population estimates in Table 1 are from the 2002 provincial grizzly bear estimate (Hamilton and Austin, 2002).

Table 1. Grizzly Bear population estimates for Population Units that overlap the NCLRMP area (Hamilton and Austin, 2002).

Grizzly Bear Population Unit	Estimated number of bears in each GBPU that overlaps the NCLRMP			Estimate of density of bears (# of bears/1000 km^2 of useable habitat)
	Current estimate: minimum	**Mid-point of the current estimate**	**Current estimate: maximum**	**Mid-point of current population estimate**
1. Kitlope - Fjordland	186	242	299	26
2. Stewart	119	152	185	38
3. Khutzeymateen	200	262	325	36
4. North Coast	144	195	245	31
5. Bulkley Lakes	355	476	597	25
TOTAL	**1004**	**1327**	**1651**	*N/A*

2.2 Strategic planning issues related to grizzly bears

There are three key strategic planning issues related to bears: habitat supply, displacement risk, and mortality risk. Habitats can be directly lost, altered, fragmented, or alienated by human activity. Bears can be displaced from preferred habitat or killed as a result of bear-human conflict. Displacement and mortality primarily occur in roaded areas or where there are concentrations of human activity. Each of these planning issues need to be addressed to provide an overall strategy for bear conservation.

Habitat Supply: quality, quantity and distribution: Grizzly bears require habitat that provides for their nutritional, security, thermal, reproductive and "space" needs on a seasonal basis. To meet these varied needs, bears use an array of habitats, ranging from subalpine to valley bottom, old growth to young forest, and wetlands to dry areas. With the exception of denning areas, avalanche chutes and rich subalpine meadows, the prime habitat of coastal grizzlies occurs predominantly below treeline and is largely concentrated in valley-bottom ecosystems often associated with important salmon streams (Hamilton 1987, McCrory 1988, MacHutchon et al. 1993, Himmer et al. 1995).

Because bears use variety of strategies to meet habitat requirements, management of grizzly habitat must be considered at several spatial scales – from specific food-producing microsites (called "critical habitat") to landscape level forage supply to overall habitat supply at the sub-population and population scale. Habitat quality, quantity and distribution is primarily affected by removal of forest structure through logging and more permanent modifications such as the development of roads, settlements, and other infrastructure (Mace et al. 1999, McLellan 1998).

Roads and road use: Increased road access is one of the greatest threats to grizzly bears (Mattson et al. 1996, Mace et al.1996, Gibeau et al. 2002) primarily due to an increase in mortality risk associated with increased bear-human interaction and a greater potential for illegal killing and killing bears to "protect life and property" (Benn, 1998, Suring and Del Frate, 2002). Road access above a certain traffic level can also cause displacement from preferred habitats (Archibald et al. 1987, Mace et al. 1999), although some bears may habituate to roads and traffic (Mattson et al. 1992). Extremely high levels of traffic can fragment grizzly populations (Munro 1999, Proctor et al. 2002). Bears are also influenced by the behaviour of people using the road e.g., whether they stop, get out of the car, or engage in activities away from the vehicle, such as fishing, hunting or hiking (Wielgus et al. 2002).

Human activity: Concentrated recreational and tourism use can habituate bears (Jope 1985, Olsen et al. 1997 and 1998) or displace them from preferred habitat (McLellan and Shackleton 1989, Mace and Waller 1996). Bears may habituate to the presence of humans in order to avoid other, potentially aggressive, bears that may be more wary (Mattson et al. 1996). Predictability of the human behaviour allows bears to choose their proximity to people (Fagen and Fagen 1994a and 1994b) but the strategy can be a risky one: habituated bears have a higher likelihood of being killed by humans that wary ones (Mattson et al.1996, Benn 1998). Since bear viewing brings large numbers of people to areas where bears congregate, this activity has a high potential to cause bear habituation and/or displacement (Chi and Gilbert 1999, Smith 2002). Restrictions on legal grizzly bear hunting have been imposed in the vicinity of some viewing sites to avoid conflicts between viewers and hunters and to minimize the potential for the killing of habituated animals (Titus et al. 1994, Alaska Department of Fish and Game 2000).

2.3 Environmental risk assessment

This environmental risk assessment was designed to assess the benchmark scenario. Existing and future risk to grizzly bears was evaluated as though current management of land and resources was carried forward into the future. Future analyses will look at alternative management scenarios and their associated implications for grizzly bears. The starting point for risk evaluation (t = 0) was the present day. No analysis was done to look at changes to grizzly bear habitat and mortality/displacement risk under historic conditions (pre-industrial development). Potential declines in the availability of spawning salmon were not assessed.

Table 2 summarizes the assumptions used in the assessment about the type of management that is occurring in the benchmark scenario i.e., assuming that current management conditions are applied into the future.

Table 2. Current management assumptions used in the benchmark scenario assessment

Resource use	Activity	Current management assumptions
Forestry	Clearcut harvesting	• 100% clearcut harvest • Average rotation age of 175 years (Bolster 2002) • Old seral retention within landscape units as per the *Landscape Unit Planning Guide* • Within block retention as per *Landscape Unit Planning Guide* • Forest Practices Code riparian mgmt • Replanting as per Species Selection Guidelines • Establishment of IWMS Wildlife Habitat Areas for all listed species limited to 1% of District AAC • IWMS Wildlife Habitat Areas not established for grizzly bears (most sites within District would not fit definition of provincially significant)
	Roads	• Mainstem road development from tidewater • Few connected road networks • No restriction of public access on connected road networks
Recreation/tourism	Wildlife viewing	• No restrictions on land-based viewing outside of the legal tenuring by LWBC

Risk to grizzly bear habitat was assessed by comparing future habitat quality with current condition. Habitat quality for bears was assessed in three ways:

Habitat capability identifies the idealized habitat potential of an area without consideration of current seral stage distribution (zero capability units, e.g. human settlements or reservoirs are removed);

Habitat suitability identifies the habitat potential once the current seral stage distribution is taken into consideration (other human influences are not considered); and

Habitat effectiveness identifies the outcome of the "stepdown" of suitability after the modelled displacement effect of traffic and human use (outside of settlements).

Habitat suitability has been equated to grizzly bear density using ratings tables that link numbers of bears to subjective estimates of habitat quality (Hamilton and Austin 2002). Similarly, habitat effectiveness can be linked to density to predict potential changes in bear populations over time under different management scenarios.

The primary goal of the Provincial Grizzly Bear Conservation Strategy is to maintain the diversity and abundance of grizzly bears throughout BC. Therefore, examining risks to population persistence or occupancy at the thresholds of population viability were not applied for this species. Instead, a principle of no-net-loss of critical habitat was applied for landscapes and the plan area as a whole. The following risk scale was applied to estimate the magnitude of risk. Note that all assessments were based on a comparison with current, rather than historic, landbase condition.

Table 3: Risk classes used in environmental risk assessments of grizzly bears for the NC LRMP benchmark scenario

Risk Class	**% deviation from current**
Very low	0 – 10
Low	10 – 20
Moderate	20 – 30
High	30 – 40
Very high	Greater than 40%

Due to uncertainties inherent in the data used and relatively small amount of verification work undertaken to date re actual bear populations in the North Coast, is important to consider the outputs of the environmental risk assessment in a *relative,* as opposed to *absolute,* sense. For example, they give a reliable means of comparing watersheds and landscape units one to another or predicting how an individual landscape's effectiveness might change over time.

3.0 Assessment of Habitat Supply

Two types of habitat supply for grizzly bears were assessed: critical habitat (stand-level habitats considered critical to meeting bear life requisites), and landscape level forage (based on seral stage distribution and its implication for understory productivity). Critical habitat supply was evaluated only at the landscape unit and watershed scales. Landscape level forage supply was evaluated at the regional, landscape unit and watershed scales.

3.1 Critical Habitat Supply

The Khutzeymateen Grizzly Bear Study (MacHutchon et al. 1993) and an earlier evaluation of the Khutzeymateen by McCrory (1988) provide a solid foundation of information about stand-level habitats that are consistently used by grizzly bears to meet their life requisites on the North Coast. Other coastal grizzly bear research from BC (Hamilton 1987, Himmer et al. 1995) and SE Alaska (Schoen et al.1994) support these assumptions about critical seasonal habitats. A list of critical habitats in the North Coast includes: beaches and beach margins, estuaries, rich non-forested wetlands, the edges of forested and non-forested bogs, herb-dominated patches on avalanche chutes (particularly south-facing ones), herb-dominated subalpine parkland meadows, skunk cabbage swamps, floodplain ecosystems, and areas where bears fish for spawning salmon (Hamilton 1987, McCrory 1988, MacHutchon et al. 1993, Himmer et al. 1995, Hilderbrand et al. 1999, Titus and Beier 1999, MacHutchon 2001). Den cavities and surrounding stands are also considered critical.

The majority of critical grizzly bear habitats in the NCLRMP are non-forested. Bears typically use these units for feeding on a wide variety of food plants but also require forested thermal and security cover adjacent to these habitats for resting, escape (e.g. trees for cubs to climb), marking and movement. Removal of this cover greatly reduces the suitability of the non-forested unit, particularly for bedding.

3.1.1 Indicators

The following indicators were used to assess critical habitat supply at the landscape unit and watershed scales. These two indicators need to be assessed separately to allow full evaluation of the degree of risk.

Indicator	Rationale
1. Ratio of commercially-forested critical habitat to total critical habitat	The ratio of commercially forested critical habitat to total critical habitat provides a direct indication of the magnitude of the potential loss of critical habitat by watershed or landscape unit.
2. Ratio of commercially-forested critical habitat to total THLB.	The ratio of commercially forested critical habitat to total THLB indicates the degree of potential impact on timber supply. Where the ratio is high there is a proportionately greater potential economic loss from reserving critical habitat.

3.1.2 Data inputs

Small-scale predictive ecosystem map (ssPEM) was produced as an input to the Coast Information Team's Ecosystem Spatial Analysis (EBA Engineering Consultants, 2002). The objective of the ssPEM project was to produce a seamless ecosystem map using the kinds of tools and approaches that have been recently developed for predictive ecosystem mapping in British Columbia (http://www.for.gov.bc.ca/hre/ecogen/furinfo.htm). Key input databases included several existing coverages: large-scale biogeoclimatic linework, mosaiced Landsat satellite imagery (and derived land cover classes), digital elevation model (DEM) data (and DEM-derived products of aspect, slope, and estimated soil moisture regime), and existing provincial and industrial forest cover inventory (EBA 2002). Site series (Banner et al. 1993) were predicted by applying a number of rules (knowledge tables) derived from expert opinion and iterative analysis. Where it was not possible to predict individual site series using this method, units were aggregated to create composite sites series.

The timber harvesting landbase was the 2000 mapping developed to support the North Coast LRMP benchmark scenario work.

3.1.3 Analysis methods

a. Interpreting ssPEM to identify critical habitat

The first step in the analysis of critical habitat supply was to determine all possible combinations of ecological units in the ssPEM hierarchy i.e., ecosection, biogeoclimatic zone, subzone and variant, aggregated ecosystem, and seral stage. Each of these units were assigned one of six habitat ratings according to the Resource Inventory Committee Standards for Wildlife Interpretation (RIC 1999) to rank the NCLRMP into six classes of habitat quality (ssPEM ratings are summarized in Appendix 1). For the purposes of this analysis, all occurrences of all class 1 and 50% of the class 2 habitats were considered critical[1].

b. Identifying extent of overlap between critical habitat and the THLB

The interpreted ssPEM map was overlain on the Timber Harvesting Landbase using ArcInfo (ESRI GIS and Mapping Software). The analysis assumed that all of the THLB would be harvested eventually, posing a potential risk to the suitability and effectiveness of any one critical habitat polygon. Because adjacent forest cover is essential to the functional integrity of the critical habitats, a 50m buffer was added to all non-forested critical habitat polygons and assumed to be part of the critical habitat unit.

The overlap between critical habitat and the THLB was analyzed to determine the ratios of commercially-forested critical habitat to total critical habitat and commercially-forested critical habitat to total THLB. Summary statistics from the GIS resultant file were generated using Statistical Analysis Systems (SAS) software (SAS Institute 2003).

3.1.4 Risk assessment methods

Seasonally critical habitat must be available within occupied areas for the home ranges within them to remain viable. Therefore, any reduction in critical habitat availability is considered a risk. For this analysis however, the risk classes identified in Table 3, Section 2.3 were applied to stratify risk at the landscape and watershed scale. Risk was assumed to be directly proportionate to the both indicators: the higher the overlap of critical habitat on the THLB, or the higher the proportion of the THLB that was critical habitat, the higher the risk.

Grizzly bears are extremely slow dispersers (McLellan and Hovey 2001) and show high fidelity to established home ranges. Therefore, both indicators were examined only at the watershed and landscape unit scales. No overall NCLRMP risk was determined.

3.1.5 Results

Table 4 summarizes the results of the comparison of critical habitat to the THLB. Results for the plan area as a whole suggest a 17% average overlap of critical habitats and the THLB and an average 16% of the THLB classed as critical at the landscape unit scale.

Results by landscape unit

<u>a. Ratio of commercially forested critical habitat to total critical habitat</u>

Several landscape units and watersheds showed significantly higher than average proportion of total critical habitat in the THLB. Critical habitats in the Stagoo LU appear to be at high risk

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[1] During operational application, other classes may also be designated as critical, depending on: 1) total landscape supply of that unit; 2) juxtaposition to other important habitats; and 3) the presence of non-mappable important seasonal resources (e.g. spawing salmon, coarse woody debris for insect feeding, a den or dens). Similarly, some class 2 units may not be designated as critical based on field assessment (e.g. size, configuration, dispersion in the landscape, pattern of human influence).

(37% overlap) although the total area of THLB in the Stagoo is relatively low. Critical habitats in the Khyex, Observatory West, Sparkling, Scotia, Big Falls and Marmot landscape units had between 20 and 25% overlap with the THLB, indicating moderate risk.

b. Ratio of commercially forested critical habitat to total THLB

A number of landscape units appear to be at moderate to high risk based on the proportion of the total THLB that is classed as critical habitat. Critical habitat in the Bishop, Chambers and Scotia represents between 30 and 40% of the LU's total THLB. In the Big Falls, Kwinamass, Triumph and Somerville LUs, between 20 and 30% of the THLB is critical, indicating moderate risk.

Table 4. Critical Habitat compared to the THLB within landscape units (bolded values exceed a moderate level of risk).

Landscape Unit	**Area of THLB (ha)**	**Total Area of Landscape Unit (ha)**	**Area of Critical Habitat on the THLB (ha)[2]**	**Ratio of commercially-forested critical habitat to:**	
				Total critical habitat	**Total THLB**
Stagoo	1747	39314	650	**0.37**	0.15
Khyex	3437	51350	880	**0.26**	0.16
Observatory West	749	27228	184	**0.25**	0.06
Sparkling	1965	35250	474	**0.24**	0.14
Scotia	5352	33040	1092	**0.20**	**0.32**
Big Falls	4593	31964	936	**0.20**	**0.28**
Marmot	3864	42452	766	**0.20**	0.18
Belle Bay	1730	32603	337	0.19	0.09
Johnston	3296	45430	623	0.19	0.14
Kwinamass	4780	33037	891	0.19	**0.27**
Khtada	2481	30608	443	0.18	0.13
Chambers	4383	27378	761	0.17	**0.32**
Brown	996	24140	168	0.17	0.09
Bishop	4979	24430	795	0.16	**0.40**
Quottoon	3365	35900	520	0.15	0.15
Skeena Islands	917	7313	119	0.13	0.15
Kitkiata	2917	35995	374	0.13	0.11
Triumph	3719	20657	463	0.12	**0.25**
Union	2130	20081	243	0.11	0.14
Somerville	5232	31699	488	0.09	**0.23**

2 Includes all Class 1 and 50% of Class 2 critical habitat identified using ssPEM

Landscape Unit	Area of THLB (ha)	Total Area of Landscape Unit (ha)	Area of Critical Habitat on the THLB (ha)[2]	Ratio of commercially-forested critical habitat to:	
				Total critical habitat	Total THLB
Hartley	2498	31355	220	0.09	0.09
Kitsault	7977	62865	637	0.08	0.14
Kumealon	3569	33741	270	0.08	0.07
Kaien	2598	26720	185	0.07	0.07
Tuck	2566	16800	143	0.06	0.07
Total/Average	**81838**	**801352**	**12664**	**0.16**	**0.17**

Results by watershed

At the watershed scale, results indicate a number of watersheds ranging from moderate to very high risk (see list in Appendix 2). Of 183 watersheds with greater than 1 ha of THLB, 33% (N=60) had greater than 20% overlap with the THLB. Similarly, 63 watersheds had over 20% of the critical habitat in the watershed on the THLB. When both indicators were combined, 71 watersheds are classed as moderate risk or higher. These 71 watersheds account for over half of the THLB in the 183 watersheds evaluated at this scale (41,091 ha).

3.1.6 Conclusions

Without critical habitat protection in the form of established Wildlife Habitat Areas as per the Identified Wildlife Management Strategy, risk under the benchmark scenario to critical habitats outside of protected areas in the NCLRMP is moderate to very high in specific landscape units and watersheds. Any loss of critical habitat will be detrimental because these seasonal habitats represent the essential units on which individual bears and the population depends. A "no net loss" principle is recommended whereby development would occur only where there is no practicable alternative.

3.1.7 Assumptions and limitations

- *Access to salmon spawning areas*

  This analysis does not include explicit assessment of impacts to salmon fishing areas because fishing areas are not restricted to any one or group of site series. Unfettered access to spawning salmon is essential for the well-being of individual coastal grizzly bears and populations (Hilderbrand et al. 1999). Bears that normally reside in coast-interior transition areas will move over 100km to fish in the late summer and fall. While productive riparian areas are afforded considerable protection under current legislation and regulations, grizzly bear fishing areas may require special protection, which may impact the THLB.

- *Bear denning areas*

Denning habitats are also not restricted to any one site series and so are not explicitly addressed in this analysis. Dens are typically dug under the root masses of old-growth trees at or near the Coastal Western Hemlock/ Mountain Hemlock Biogeoclimatic zonal line. Den sites are also often in small patches of timber or "stringers" of trees between avalanche chutes (MacHutchon et al. 1993). Risk to dens from conventional harvesting is typically low because of the ruggedness of the terrain, however, helicopter logging can pose a significant threat to these habitats. In addition, some dens are actually inside old growth tree structures at lower elevations, often used in association with late-spawning salmon. Risk should be determined during forest planning at the operational scale using site-specific field assessments.

- *Seasonality of critical habitat*

These analyses do not examine seasonal distinctions among critical habitat. Risk was evaluated on an annual basis. Seasons of scarcity (e.g. early spring) are combined with seasons of plenty (e.g. late summer). As such, results may underestimate the potential risk to critical habitat. The seasonality of critical habitat must be considered because bears require access to critical habitat across all seasons. For example, patches of low elevation early spring feeding habitat cannot be 'traded off' against high elevation summer units. The value of any one patch should be evaluated against the total watershed and landscape supply of that habitat *in any one season* (MoF and MELP, 1995).

- *Use of the timber harvesting landbase*

The extent of overlap with the THLB was used as the best available indicator of risk to critical habitat. However, risk may have been underestimated because of potential future changes in the THLB as market conditions vary. Similarly, timber harvesting off the THLB has been documented in the NCLRMP, potentially underestimating even the current risk to critical habitat.

- *Accuracy and precision of ssPEM mapping*

Because it is a model, rather than field-verified mapping, the ssPEM interpreted critical grizzly bear habitat map is, at best, an approximation of the amount and actual location of critical habitat in the NCLRMP. The ssPEM map is likely reliable only at 1:50,000 or 1:100,000 spatial scale (M. Eng, pers. comm.). Patches of critical habitat are as small as 1 ha (e.g. a skunk cabbage swamp), well beyond the precision of ssPEM.

3.2 Landscape Level Forage Supply

The assessment of long term landscape forage supply for grizzly bears was primarily based on examination of the amount of mid-seral forest over time within landscape units and watersheds. Seral progression can be represented by grouping forest age classes into young, mid, mature, and old seral stages. Both young and old seral forests provide suitable forage for grizzly bears. The limiting factor is the amount of mid-seral forest (age 20 – 140 years – see Table 5), since forests in these age classes (also called the “stem exclusion phase”) are dense and dark with little understory growth (Alaback 1982, Alaback and Herman 1988, Klinka et al 1996, Pojar et al. 1999). When large areas of suitable habitat are logged within a short time period and managed to regional stocking targets, there is a bulge in the amount of mid-seral forest as regeneration occurs, reducing the amount of forage available through the rotation (Schoen et al. 1994, Greenough and Kurz 1996, Michelfelder 2002). The issue of stable forage supply is exacerbated when regenerating stand establishment is assisted by vegetation management, including the application of herbicides (Hamilton et al. 1991).

3.2.1 Indicators

The following indicators were used in the assessment of landscape level forage supply at the landscape unit and watershed scales. These indicators were assessed in combination.

Indicator	Rationale
1. Ratio of THLB to total forested landbase	The greater proportion of total habitat supply that is managed on short rotations, the greater the risk to stable landscape level forage supply.
2. Seral stage distribution (with and without stratification by grizzly bear habitat suitability class)	The greater the amount of mid-seral forest within a watershed or landscape unit, relative to other seral stages, the greater the risk to understory productivity and associated forage supply.
3. Number, distribution and density of grizzly bears (estimates of relative and absolute abundance)	Numbers of bears are estimated based on the habitat suitability as reflected by the seral distribution. As such, the estimated number of bears provides a direct translation of the changes in habitat supply through time to local bear populations.

3.2.2 Data inputs

The Broad Ecosystem Inventory (BEI) is mapped at 1:250,000 using a combination of ecoregion classification, biogeoclimatic ecosystem classification and satellite images. The BEI for the LRMP was updated in 2000. Broad Ecosystem Units (BEUs) subdivide Biogeoclimatic variants and phases into a permanent area of the landscape that supports a distinct type of dominant vegetation cover, or distinct non-vegetated cover (such as lakes or rock out-crops) (RIC 2000). One of the clear advantages of using the Broad Ecosystem Inventory (BEI) for modelling is that each forested unit is defined as including potential (climax) vegetation and associated successional stages (see Section 3.2.3). Unit classification is further subdivided by “modifiers”

(RIC 2000) that characterize topographic and soil features (e.g. coarse soils, north facing aspects).

Inputs into to the NC Landscape Model are described in Morgan et al. (2002).

3.2.3 Analysis methods

The North Coast technical team used the North Coast Landscape Model (NCLM) implemented in a modelling tool called the Spatially Explicit Landscape Events Simulator (SELES) to examine the long-term pattern of forest cover within each landscape unit and watershed in the NCLRMP. The NCLM estimated how predicted patterns of timber harvesting, based on current management (clearcut harvesting, Forest Practices Code management for riparian and biodiversity), would affect the amount of mid-seral forest in each Broad Ecosystem polygon at five time steps: 20, 50, 100, 200 and 250 years into the future. Note that BEI-based seral stages are not the same as seral stages derived from forest cover age class mapping (Table 5).

Table 5: Comparison of forest cover and BEU-based seral stages

Biodiversity Guidebook seral stage	Biodiversity Guidebook seral stages definitions for NDT1	BEU seral stage descriptor	BEU seral stages
	-	Non-forested	Up to 100+ years
Early	< 40 years	Recent disturbance	< 20 years
Mid	40 – 79 years (CWH) 40 – 119 years (MH)	Young forest, coniferous Young forest broad-leaved or mixed	20 – 59 years
		Mature forest, coniferous Mature forest, broad-leaved or mixed	60 – 140 years
Mature	80 – 250 years (CWH) 120 – 250 years (MH)		
Old	> 250 years	Old	> 140 years

The rating of bear habitat suitability for each unique combination of BEU, seral stage and modifier is an enhanced application of the Fuhr-Demarchi method (Fuhr and Demarchi 1990, Hamilton and Austin 2002). Habitat capability of each combination of BEU and modifier was made equivalent to the highest suitability rating. The structural condition of BEUs (as opposed to tree or stand ages within them) determines their suitability. A mixed density and species composition of trees with canopy gaps that provide opportunities for understory growth is more suitable than closed canopy, uniform species, even-aged stands. Forested BEUs in the North Coast were rated roughly the same for suitability when they were early or old seral stages.

However, early seral open clearcuts in many units are ranked higher than the old seral forests on the same sites because of their higher forage production (Hamilton et al. 1991).

The Fuhr-Demarchi method is based on the premise that different ecological units vary in their ability to support grizzly bear food resources and that these variations are linked (linearly) to bear density. The higher that any one land area is ranked for its ability to provide grizzly bear foods, the higher the density estimator attached to it. Each of the six habitat suitability ranks represent a density estimate (minimum and maximum) from zero to a maximum of 100 bears/1000km^2 (Table 6).

Appendix 3 summarizes the ratings used for the BEUs in the North Coast. The probable number of bears sustained within three spatial scales (watershed, landscape unit and grizzly bear population unit) was derived by running the SELES output through a SAS program (SAS Institute 2003).

Table 6. Habitat suitability ranks and associated bear density estimates (RIC, 1999)

Habitat Suitability Ranks	% of Provincial Benchmark	Estimated bear density (bears/1000 km^2)
Class 1	76 - 100	76 - 100
Class 2	51 - 75	51 - 75
Class 3	26 - 50	26 - 50
Class 4	6 - 25	6 - 25
Class 5	1 - 5	1 - 5
Class 6	Nil	0

3.2.4 Risk assessment methods

This risk assessment compared the predicted landscape pattern under current forest management to the current landscape condition. Watersheds and landscape units were potentially at risk for landscape level forage supply when the reduction in number of simulated bears was greater than 5% in any one time step. This evaluation of risk was supported when: (a) there was greater than 30% BEU-based mid-seral forests any stage in a rotation, as shown through temporal analysis; and/or, (b) the ratio of timber harvesting landbase to total forested landbase was greater than the 18% average for the occupied areas of the NCLRMP.

There is no research indicating an actual threshold amount of mid-seral forest that will provide adequate landscape level forage supply for bears. The 30% threshold for amount of mid-seral was derived from the *Forest Practices Code Biodiversity Guidebook* and is the average % for mid-seral that would remain if targets for mature and old and early were applied to the CWH in NDTs 1 and 2 (MoF and MELP 1995b). Midseral forests were not extensive historically because natural stand-replacing events were rare (Dorner and Wong 2003).

3.2.5 Results

Significant changes in seral stage distribution occurred across all years of simulation as old growth was gradually converted to managed stands. The greatest magnitude of change over time occurs in BEU-based seral stages 2 and 4 (coniferous-dominated stands between 20 and 140 years) up to t = 250 years (Figure 1). At t = 250 years, all of the THLB is assumed to be managed on an average continuous rotation of 175 years (Bolster 2002). Seral stages 3 and 5 are not showing change because they are deciduous. Red alder and black cottonwood stands are exempt from the mid-seral determination because they supply forage continuously regardless of age (Table 5).

Results indicate very little change overall in the estimated minimum number of bears over time (166 bears at time = 0 compared with 161 bears at time = 250 years, Table 7). One of the factors mitigating the reduction in bears is that open clearcuts become available forage areas for the first 10 – 15 years of the succession, which compensates for loss of old growth forage and the creation of closed canopy second growth. The greatest increases in mid-seral occurred among suitability classes 3, 4 and 5 (Table 8, Figure 2). Because these classes are assigned relatively low bear densities (Table 6), the impact on simulated bears is relatively low.

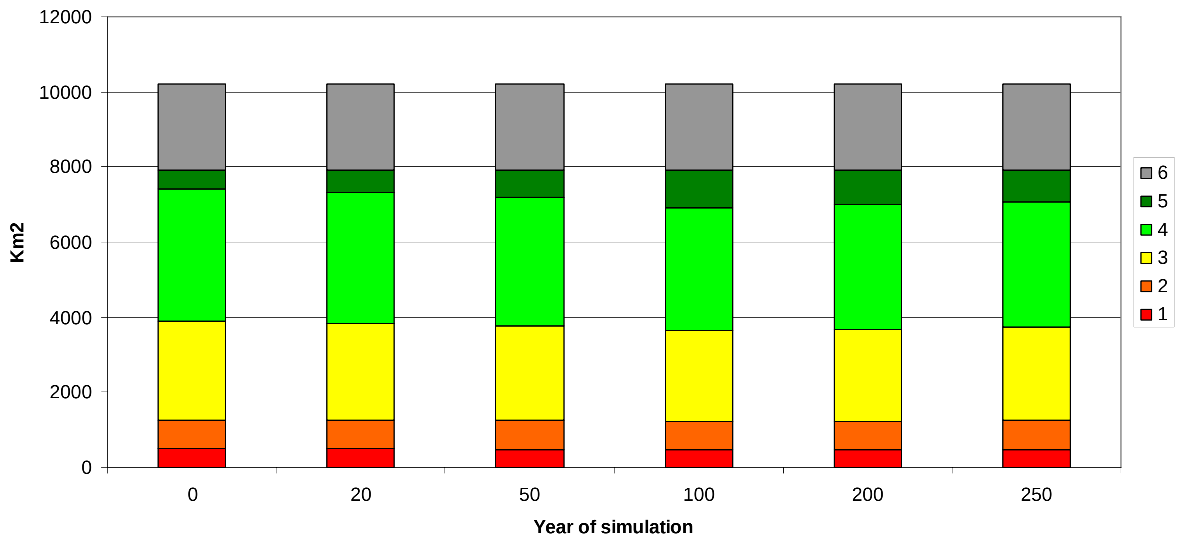
Table 7. Simulated number of bears at various time steps.

Year	Minimum Number of Simulated Bears
0	166
20	165
50	162
100	158
200	159
250	161

Table 8. Land area changes by suitability class across years of simulation.

	Area in each Habitat Suitability Class (km^2)					
Year	**1**	**2**	**3**	**4**	**5**	**6**
0	489	752	2661	3518	508	2287
20	489	769	2585	3488	596	2287
50	485	759	2517	3421	746	2287
100	481	754	2399	3290	1003	2287
200	481	759	2427	3326	935	2287
250	483	766	2481	3350	847	2287

Figure 2. Land area changes by suitability class across years of simulation



Although this translates to an overall estimate of very low risk to landscape level forage for grizzly bears across the entire NCLRMP, there is significant variance among individual landscape units and watersheds. Sixteen watersheds have been proposed for "Identified Watershed" status because they show a greater than 5% reduction in the minimum numbers of bears estimated over at least one time step simulated and they exceed thresholds of risk for the other indicators (Table 9.) The proposed Identified Watersheds are concentrated in 11 landscape units: Big Falls, Bishop, Chambers, Khyex, Kitkiata, Kitsault, Kwinimass, Scotia, Somerville, Sparkling, and Triumph.

Almost all of these watersheds have a relatively high ratio of THLB to total forested landbase. One of the watersheds in the Kitsault has a high ratio of THLB to total forested landbase but this only translates into a small change in the number of bears over time. This is likely due to the large amount of non-forested habitat in these watersheds, which offsets the large amount of the watershed available for harvesting.

Table 9. Proposed Identified Watersheds and supporting statistics (bolded values exceed identified thresholds of risk).

Watershed Code		**% change in minimum number of bears from t = 0 to each modelled time step**					**Maximum % mid seral forest in any one time step**[3]	**Ratio of THLB: total forested**
	Landscape Unit	**0 to20 yrs**	**0 to 50 yrs**	**0 to 100 yrs**	**0 to 200 yrs**	**0 to 250 yrs**		
LSKEWSD000056	**Big Falls**	> -5	> -5	> -10	> -10	> -10	**38**	**0.33**
LSKEWSD000058	**Big Falls**	> -5	> -5	> -10	> -5	> -5	28	**0.27**
KHTZWSD000026	**Bishop**	> -5	> -5	> -10	> -10	> -5	17	**0.20**
KHTZWSD000030	**Bishop**	> -10	> -5	> -10	> -10	> -10	23	**0.28**
LNARWSD000010	**Chambers**	> 0	< 0	> -10	> -5	< 0	23	**0.22**
LNARWSD000078	**Chambers**	> 0	< 0	> -5	> -5	< 0	23	**0.22**
LSKEWSD000035	**Khyex**	> -5	> -10	> -5	> -10	> -5	**36**	**0.36**
KITRWSD000131	**Kitkiata**	**> -15**	**> -15**	**> -15**	**> -20**	**> -15**	22	**0.25**
KUMRWSD000090	**Kitkiata**	< 0	< 0	< 0	> -5	< 0	15	0.13
KSHRWSD000029	**Kitsault**	> -5	< 0	> -10	> -5	> -5	**31**	**0.29**
KSHRWSD000044	**Kitsault**	> 0	> 0	> -5	< 0	> 0	**30**	**0.31**
WORCWSD000023	**Kwinamass**	> 0	< 0	> -5	> -5	< 0	26	**0.23**
LSKEWSD000049	**Scotia**	> -5	> -5	> -5	> -5	> -5	26	**0.23**
WORCWSD000100	**Somerville**	> -5	> -5	> -10	> -10	> -5	19	0.16
LSKEWSD000070	**Sparkling**	> 0	< 0	> -5	> -5	> -5	19	0.16
KHTZWSD000040	**Triumph**	> -5	> -5	> -5	> -10	> -5	**45**	**0.30**

[3] This table does not report by biogeoclimatic variant. The % mid-seral by variant are expected to be higher within low elevation units. These will be reported in later drafts of this document

Note that these results mask some of the risks that would be evident if the watershed were stratified by biogeoclimatic variants rather than considering seral stage balance through time on the whole forested landbase. The proportion of mid-seral would likely be greater (and risk proportionally higher) for low elevation variants in the CWH due to their accessibility and greater contribution to the THLB. This would also be reflected in a higher ratio of THLB to total forested in those variants.

3.2.6 Conclusions

Only a small number of watersheds in the NCLRMP are considered at risk of potential reductions in landscape level forage supply. The steep topography of the North Coast concentrates harvesting on low elevation valley bottoms, minimizing the area of THLB available within many of the watersheds. In addition, a significant proportion of the forested landbase within North Coast watersheds is excluded from the THLB due to unstable terrain and salmon habitat.

Under an average forest rotation of 175 years estimated for the NCLRMP there is insufficient time for understories to recover from a closed canopy situation (Alaback and Herman 1988, Greenough and Kurz 1996, Klinka et al., 1996). Planting, regional stocking targets, and vegetation management can accelerate canopy closure by 5 years. Under these conditions, the THLB may only be producing grizzly bear forage for 10-15 out of every rotation. This situation is potentially exacerbated by the economics of timber harvesting in the North Coast, which require high rates of harvesting within watersheds to offset expensive road construction and other operating costs (Daley 2003). High rates-of-cut of low elevation old-growth followed by aggressive basic silviculture can create extensive even-aged unproductive areas for grizzly bear forage as stands mature to closed canopy.

In some watersheds there may be a stable forage supply elsewhere on the landbase. However, as this analysis indicates, within intensively managed watersheds, over 30% of the total forested landbase may be out of forage production for 85% of a typical rotation. Limiting the amount of midseral forest within landscape units to no more than 30% of the forested landbase by watershed and BEC variant will significantly reduce the risk to stable forage supply in the 16 watersheds proposed for “Identified” status.

Although the overall risk outside of the proposed Identified Watersheds is estimated to be low, management can be applied to address loss of forage under closed canopies within individual forest stands. Specific site series offer different forage at different times and in different volumes (Hamilton 1987, Hamilton et al. 1991, MacHutchon et al.1993). A program of reduced stocking standards and other silviculture treatments for selected site series has been endorsed by the BC Ministry of Forests (MoF 2001) and included as Appendix 11 in the Prince Rupert Forest Region Establishment to Free Growing Guidebook. These stocking standards will contribute to the gappiness required to encourage understory production in mid-seral stands. Partial harvesting, variable retention, and stand tending may also contribute to greater understory productivity, thereby minimizing the effects of canopy closure on landscape level forage supply (Klinka et al. 1996, Michelfelder 2002).

3.2.7 Assumptions and limitations

Accuracy and precision of Broad Ecosystem Mapping:

- One of the cautions of this analysis outcome is the limitations of using Broad Ecosystem Units, which are a relatively coarse level of habitat measurement compared to more refined mapping such as Predictive Ecosystem Mapping.

Using forest cover age classes to simulate change in BEUs:

- Broad Ecosystem mapping is done at 1:250,000, while forest cover is mapped at 1:20,000. This scale mis-match, combined with inconsistent age class breaks (Table 5), likely results in some inaccuracies in area estimates and age class/seral stage correlations.

Resolution a the watershed scale:

- Reporting seral stage distribution on the forested landbase through time by watershed does not fully capture the spatial distribution of impacts. Reporting at BEC variants within watersheds would more fully assess the distribution of impacts across ecosystems. Ideally, such analyses would be done at the site series level.

Assumptions in SELES:

- There are many assumptions built into the SELES model, which simulates the change in forest cover parameters over time. The SELES model and associated assumptions and uncertainties are described in the report *North Coast Landscape Model* (Morgan et al, 2002).

4.0 Assessment of displacement risk

Roads, and the vehicle traffic and people that use them, have a variety of well-documented impacts on grizzly bears (see Jalkotzy et al 1998, Nietvelt 2002). These include direct loss of habitat under the footprint of the road, displacement from preferred habitats in a "zone of influence" around medium to high traffic road corridors, home range and population fragmentation associated with high traffic road networks, and increased mortality risk as a result of motorized access into former backcountry wilderness areas.

4.1 Displacement risk associated with roads and road use

Medium to high traffic levels on logging roads can displace bears from a zone of influence, which appears to be between 200m and 600m wide (Archibald et al.1987). Displacement has been shown to occur when road density exceeds 0.6km/km^2 and vehicle traffic is > 10 vehicle movements per week (IGBC Taskforce 1998, Mace et al. 1999).

Research also indicates that displacement is a function of variety of factors, including seasonal and daily frequency and timing of traffic, volume of traffic, noise of vehicles, amount and distribution of adjacent vegetation cover and the behaviour of the people in the road corridor (Kasworm and Manley 1990, Mattson et al.1992, Mace et al.1996, Mace et al.1999, Wielgus et al. 2002, Gibeau et al. 2002). There is some indication that people moving off roads e.g., to hunt, fish, hike, berry-pick, or for boating, forest surveying, mineral exploration and so on, can alienate grizzly bears from preferred habitat as readily as the traffic itself (McLellan and Shackleton 1989, Gibeau et al. 2002). In some situations, some bears may even become habituated to traffic where people remain in their vehicles, possibly even selecting the zone of influence deliberately to protect themselves or their offspring from other bears (Mattson et al. 1996). It appears that displacement is more likely to occur when the traffic or human presence is irregular, sporadic and unpredictable.

Research also indicates that grizzly bears in some study areas are more likely to use habitats nearby roads when there are no or few available seasonal alternatives (Wittinger et al. 2002). This phenomenon is described as a "friction" model where bears are attracted to seasonally critical habitats (e.g. spawning channels or spring habitats such as wetlands, avalanche chutes or estuaries) but concurrently repelled by the displacing influence of traffic. Although full study of this behaviour is not available, it does appear that the better the habitat quality in the zone of influence and the fewer the alternative habitats, the more likely bears are to tolerate traffic and use road corridors. In Montana, this has translated into the designation of Seasonal Secure Areas that are closed to all motorized access in a defined spring period (Wittinger et al. 2002)

4.1.1 Indicators

Risk to grizzly bear habitat use in zones of influence around roads was assessed using three different indicators, assessed at the landscape unit and watershed scale:

Indicator	Rationale
1. Changes in the total km of active roads through time	The greater the length of active road, the more opportunity for bear-human interaction
2. Changes in road density in the NCLRMP through time	Unlike length of active road, this indicator gives a spatially explicit picture of where displacement would occur.
3. Number of bears estimated to be displaced from zones of influence around medium to high density road networks	Numbers of bears are estimated based on habitat effectiveness, as reflected by changes in road density. As such, the estimated number of bears provides a direct translation of the changes in habitat effectiveness through time to local bear populations

4.1.2 Data inputs

Existing roads in the NCLRMP were derived by updating the existing forest cover road coverage to add roads included in approved forest development plans and to correct any errors and omissions as identified through discussions with Ministry of Forests staff and Forest Licensees. Future potential roads were identified by forest engineers and planners in response to topographic conditions.

Current traffic volumes were assigned using a combination of interviews and meetings with Forest District Staff and Licensees (Appendix 4). Only those roads estimated to have a traffic volume exceeding 10 vehicle movements per day were included in the analysis of displacement. Future road densities were determined by evaluating the expected timber volumes and applying a formula that links vehicle movements to volume harvested in any one time period (Morgan et al. 2002).

4.1.3 Analysis methods

Research indicates that the most effective way to model displacement from roads is to use a GIS method known as roving window analysis for road density determination. Roving window analysis highlights areas such as “T” or “Y” road junctions or a series of switchbacks as areas of particular concern regarding displacement. The NCLM model included a roving window road density layer based on estimated current and expected future traffic volumes (Morgan et al. 2002).

Road densities greater than 0.6 km/km^2 were modelled as displacing grizzly bears. The loss of effectiveness based on road density was translated into a number of bears affected per time period by applying the stepdown factors listed in Table 10 to the results of the assessment of landscape level forage supply (S 3.2.5). Output from the NCLM was summarized using SAS (SAS Institute 2003). The mitigating impact of habituation was factored in by not completely alienating the zone of influence. That is, although the suitability of the habitat inside the road corridor was reduced, it was not eliminated, even for road densities exceeding 1.2 km/km^2.

Table 10. Step-down factors used in modelling the effect of Road Density Class on grizzly bear habitat effectiveness

Road Density Class	Road Density Class definition (km/km^2)	Step-down factor: % change in habitat effectiveness
1	>1.2	- 0.50
2	0.6 – 1.2	- 0.25
3	> 0 and < 0.6	0
4	0	0

4.1.4 Risk assessment methods

Risk of displacement and subsequent impact on population welfare of bears was assessed based on the amount and distribution of future road development and its associated impact on habitat effectiveness and estimated bear density (described in Section 3.2.3). Watersheds were identified as potentially at risk as a result of roads when: 1) there was greater than 10 km of total new main road, 2) there was a significant increase in total road density, and 3) the reduction in number of simulated bears was greater than 5% in any one time step.

4.1.5 Results

There are a number of roads at t = 0 that already have significant displacement effect. This is based on modelling of existing roads and estimating the corresponding reduction in bear habitat effectiveness. These include roads in the Chambers, Scotia, Big Falls, and Triumph Landscape Units.

In the 250-year time frame simulated by the NCLM, there is a 312% increase in the total km of active roads in the occupied grizzly bear portion of the NCLRMP (Figure 3) (1565 km at time = 0 compared with 4884 km at time = 250 years). Although this could indicate a very high risk of displacement as a result of increase in the total length of active roads, most of the new roads are logging spurs (2805 km). Displacement from spurs is not as likely as displacement from main haul roads. The incremental displacement from new roads (514 km; N=56 watersheds) equates to an estimated low risk for the plan area as a whole.

Similarly, results suggest that there will be a 302% increase in the amount of area with road densities greater than 0.6 km/km^2, the threshold at which significant grizzly bear displacement has been documented (Figure 4). However, because much of the road density is associated with spurs, this indicator also equates to an estimated low risk for the plan area as a whole.

Figure 3. NCLRMP roads in occupied grizzly areas

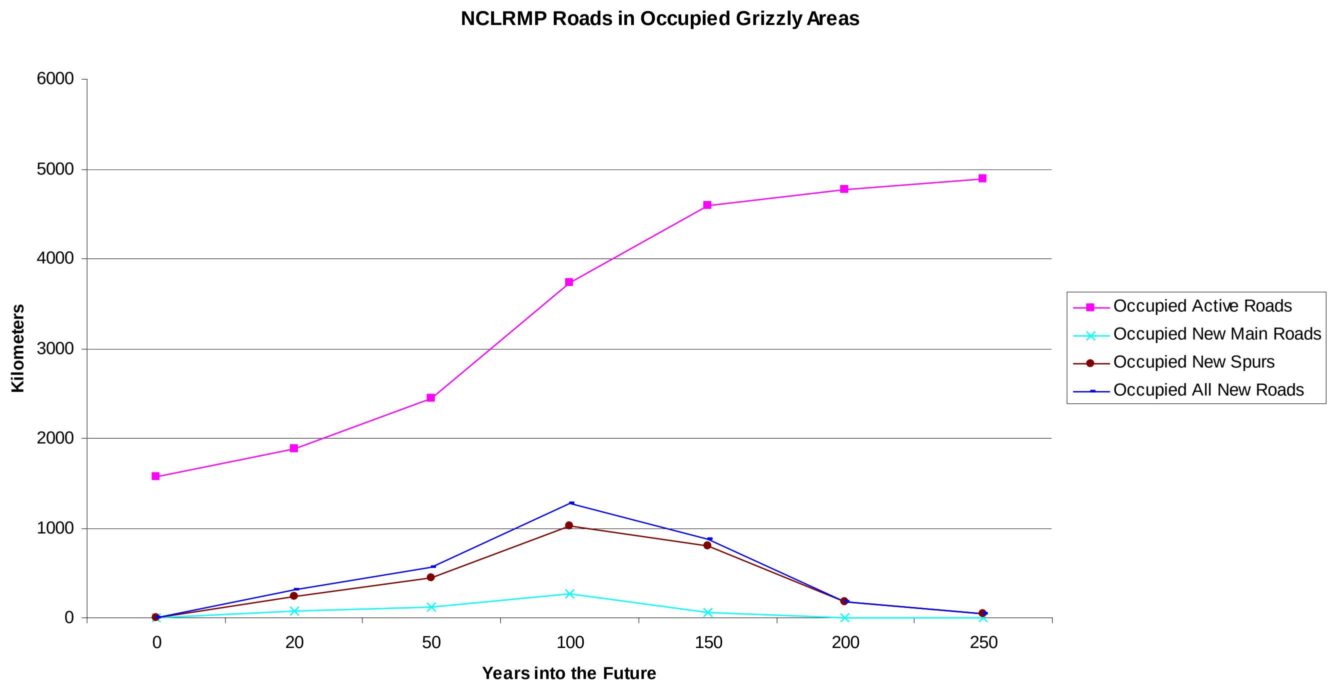
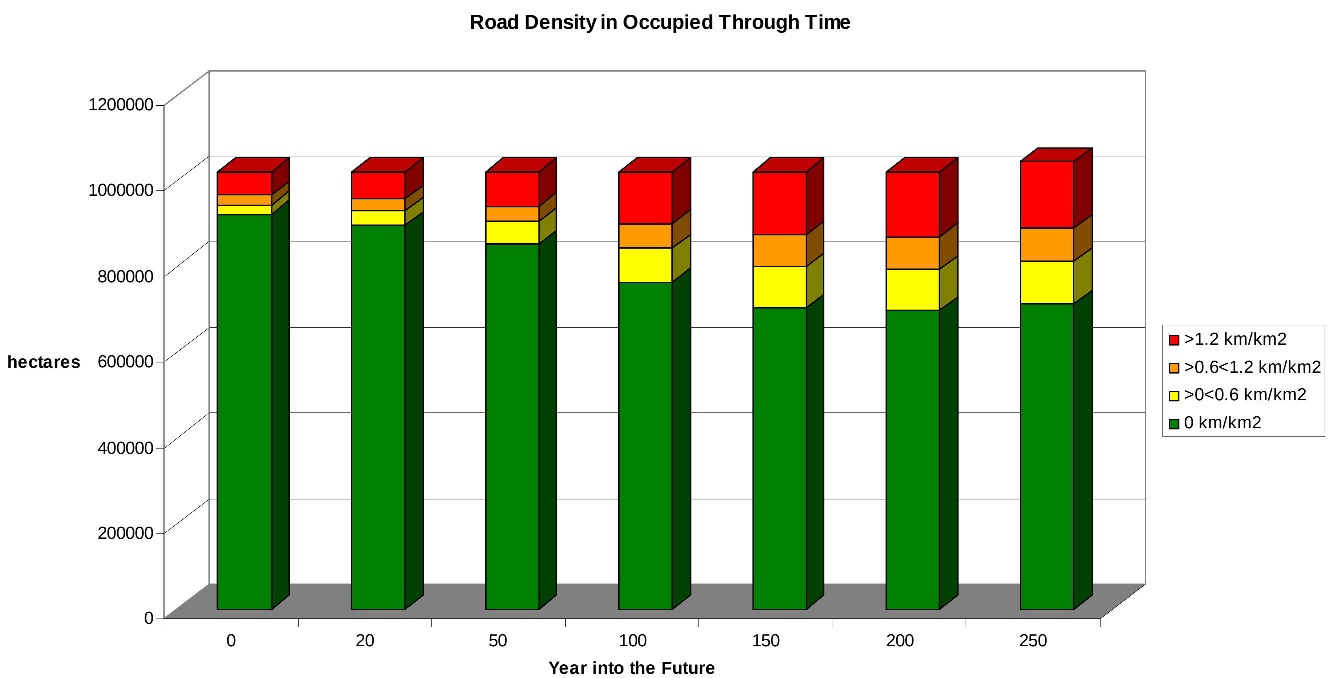


Figure 4. Road density in grizzly occupied areas through time



Using the minimum number of grizzly bears estimated from habitat suitability using Broad Ecosystem Units (N=166), the simulation model suggested road displacement resulted in a 9 to 19% decline (or "stepdown") in habitat effectiveness at any one time step. The simulation model suggested a 14% reduction in the estimated minimum number of grizzly bears over time (158 bears at time = 0 compared with 137 bears at time=250) (Table 11).

Table 11. Minimum number of estimated bears by time period, based on changes in seral stage distribution, and road density (where traffic volumes exceed 10 vehicle movements per day)

Year	**Minimum Estimated Number of Grizzly Bears**	
	Based on landscape forage supply (S 3.2.5)	**With road density added**
0	166	158
20	165	155
50	162	150
100	158	140
200	159	136
250	161	137

Although this translates into low risk across the NCLRMP, individual watersheds and landscape units show higher risk, particularly on connected road networks where both industrial and public traffic occurs (for example, a future potential road network in the Khyex drainage) (Table 12).

Table 12. Watersheds at risk based on road-related displacement indicators

Watershed Code	**Drainage**	**New Main Roads (km)**	**Connected to public roads**
LSKEWSD000048	Ecstall	76.2	N
WORCWSD000023	Kwinimass	37.5	N
LSKEWSD000006	**Khyex**	**36.8**	**Y**
LSKEWSD000009	**Skeena**	**25.9**	**Y**
LSKEWSD000047	Khtada	20.1	N
KUMRWSD000090	Quaal	17.9	N
LSKEWSD000071	Sparkling Creek	15.5	N
WORCWSD000116	Union Lake	14.6	N
KUMRWSD000287	Simpson Lake	13.9	N

Watershed Code	Drainage	New Main Roads (km)	Connected to public roads
WORCWSD000061	Talahaat Creek (tributary of Kwinimass)	13.6	N
LSKEWSD000070	Tributary of Sparkling	12.7	N
KUMRWSD000038	Baker Inlet/Kyngeal Lake	12.5	N
LSKEWSD000028	Tributary of Khyex	11.7	N
KUMRWSD000283	Bachelor Lake	11.7	N
KUMRWSD000379	Lowe Lake/ Gambie Lake	11.7	N
LSKEWSD000066	Muddy Creek/ Mitt Lake	11.6	N

4.1.6 Conclusions

As with other components of this risk assessment, these results of displacement risk are low for the NCLRMP as a whole but are higher within individual watersheds. Although a large number of kilometres of open road are found in backcountry areas of the North Coast, one of the mitigating factors is that most of these roads are part of isolated road networks that lead to tidewater and are not accessible to public traffic. Traffic levels during forest harvesting can be high on such networks, but low or nil during economic downturns or between logging phases or “passes”, reducing the influence of displacement of grizzly bears from these roads. Deactivation of shore-accessible roads minimizes the potential for off-road use by the public.

In North Coastal BC, some bears may have little choice than to enter the zone of influence as coastal roads are often located near important seasonal habitats in river valley bottoms to minimize gradients and reduce road construction costs. If new logging road networks are connected to public road systems, displacement impacts can be more problematic. The simplest mitigative solutions are to restrict vehicle use on such networks to industrial traffic only and avoid constructing roads near critical habitat.

4.1.7 Assumptions and limitations

Confounding influences of attraction and avoidance:

Despite extensive research, the actual impact of displacement from preferred habitat adjacent to roads on individual grizzly bear fitness or population welfare have not been determined. Sex-specific patterns, nighttime use of zones of influence, and annual and seasonal variation in avoidance/tolerance of human activities have all been documented.

4.2 Displacement risk associated with recreation and tourism activity

The overall level of recreation and tourism use in the NCLRMP was assessed to estimate impacts on bear habitat effectiveness. This assessment was based on estimates of current user-days for land-based activities within occupied grizzly bear habitat.

Concentrated recreational and tourism use can habituate bears (Jope 1985, Olsen et al. 1998) or displace them from preferred habitat (McLellan and Shackleton 1989, Mace and Waller 1996, Smith 2002). Habituation may be a means of finding security from other potentially aggressive bears that may be more wary of humans (Mattson et al. 1996, Nevin 2003).

4.2.1 Indicators

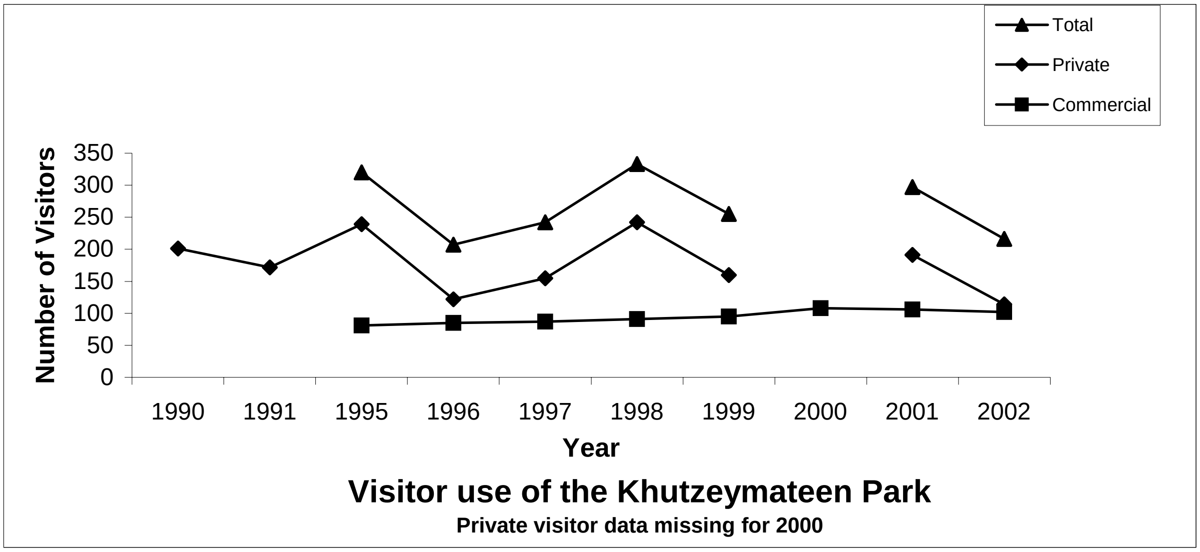
The following indicators were used to estimate the displacement effect of current tourism and recreation use:

Indicator	Rationale
1. User-day densities (people per day per km^2) per active season (April 1st to October 30th)	User day statistics provide an index of the potential magnitude of risk to bear displacement and habituation.
2. Number of bears estimated to be displaced from areas of high recreation and tourism use.	Estimated number of bears provides a direct translation of the changes in habitat effectiveness through time to local bear populations.

4.2.2 Data inputs

Existing levels of human user days were extracted from the combined Tourism Opportunity Study: Suitability Mapping (Geoscape 2001) and the Recreation Resource Analysis for the LRMP (Stoffels 2002). User-day statistics for Khutzeymateen Park were obtained from BC Parks (Figure 5) (J. Hahn, pers. comm.). Current estimates of user-days were also informed by an economic and client summary (N=4095) of 13 tourism operators in the NCLRMP (Pacific Analytics 2003). A summary of user day statistics is provided in Appendix 5. Future user day estimates for these sites were not available for this assessment.

Figure 5. Visitor use of Khutzeymateen Park.



4.2.3 Analysis methods

A map was produced of tourism and recreation sites within the NCLRMP that included only those features and activities that could potentially affect grizzly bears (e.g., summer activities only). Each line or point on this filtered map was linked to the watershed coverage. Annual user-days per watershed were then translated into user-days/km^2 categories as though the potential displacement was evenly spread across the watershed. Each user-day density category was then assigned a suitability "step down" factor to estimate loss of habitat effectiveness: the higher the user-day density, the lower the effectiveness (Table 13). Stepdown factors were then applied to the post-roads stepdown effectiveness estimate of 158 grizzly bears at time=0 (see Section 4.1.5, Table 11).

In the absence of a reliable method for estimating future recreational use, current levels of use were assumed to be carried forward into the future. Accordingly, a stepdown factor of 2.5%, based on the output of the habitat effectiveness model for t=0, was applied across time steps. The sensitivity of bears to future potential increases in recreational use was estimated by doubling the stepdown to 5%, equivalent to a doubling of the amount of displacement within the first 20 years.

Table 13. Step-down factors used in modelling the effect of Human Density Class on grizzly bear habitat effectiveness

Estimated Human Density Class (user-days per km^2)	**Step-down factor: % change in habitat effectiveness**
50.1 to 100	-0.75
25.1 to 50	-0.50
5.1 to 25	-0.25
0.1 to 5	-0.05
0	0

4.2.4 Risk assessment methods

Current risk from land-based recreation and tourism to grizzly bear habitat effectiveness was assessed by examining model output and it's consequent assignment to a number of bears. Watersheds were potentially at risk as a result of existing recreation and tourism use when the reduction in number of simulated bears was greater than 5%.

Specific watersheds were identified as being of higher risk where a high number of user days overlapped high value grizzly habitat (Figure 6).

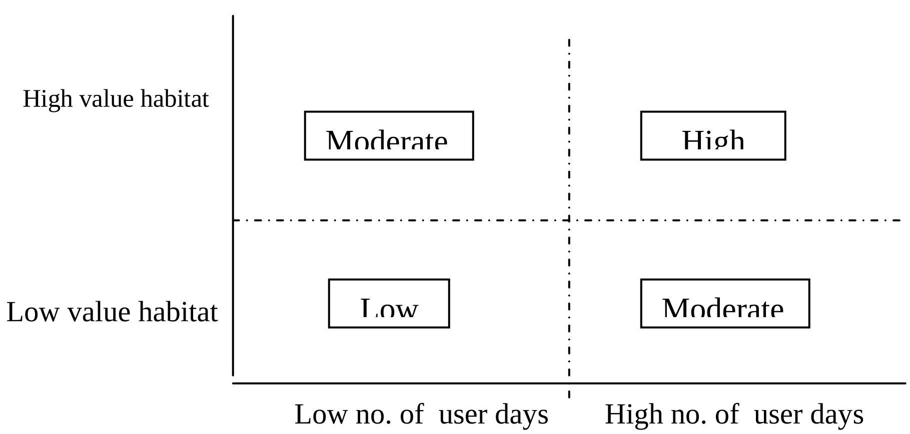


Figure 6. Categorization of risk linked to number of recreation and tourism user days

4.2.5 Results

Recreation and tourism use at 71 locations within and immediately adjacent to the NCLRMP were assessed for their potential influences on grizzly bear habitat effectiveness in the NCLRMP (Appendix 5). Results of the population model suggest that current land-based tourism and recreational use in the NCLRMP area is reducing habitat effectiveness by an additional 5% after the effects of roads have been considered (a drop from 158 to 151 at t = 0).

If the assumed 5% impact is considered to be constant through time, the simulation suggests there will be a 15% decline in the minimum number of bears (a drop from 151 at t=0 to 129 at t=200) (Table 14). The simulation also suggests that if the incremental impact from land-based tourism and recreation use is doubled to 10%, there will also be a 15% decline through time, to a minimum of 122 bears at t=200). These simulations indicate a low risk across the plan area as a whole.

Table 14: Minimum number of estimated bears by time period, based on a combination of landscape level forage supply, road density and recreation and tourism use.

Year	Minimum Estimated Number of Grizzly Bears		
	Based on roads and landscape level forage supply	**With current recreation and tourism use projected into the future**	**With recreation and tourism use doubled by t = 20 years**
0	158	151	142
20	155	147	140
50	150	143	135
100	140	133	126
200	136	129	122
250	137	130	123

Potential effects are very site-specific, involving individual and small groups of bears. Recreation and tourism use in the Upper Ecstall River, Tsamspanaknok (Sam) Bay, Kwinimass, Khtada Lake and at Kitkiata are of note because of their high number of user days combined with overlap with high grizzly bear habitat values (see Appendix 5).

4.2.6 Conclusions

Using the Risk Classes identified for this assessment (Section 2.3, Table 3), the estimated 5% reduction in overall habitat effectiveness under the current "footprint" of land-based recreation and tourism is classed as very low. If recreational and tourism use is assumed constant through time (at 5%) or is doubled to 10%, the simulation suggests a 15% decline in effectiveness after the effects of road displacement have been considered. This equates to a low risk, although the doubling scenario results in the "loss" of 7 to 9 more bears than if impacts are kept constant. However, as with other indicators, the risk is not evenly distributed. Carrying capacity measures or seasonal windowing for “at risk” locations should be considered.

High levels of habituation have occurred in Khutzeymateen Park (Himmer 1996) and Khutzeymateen Inlet (see Wakeman and Shymanski 2003). Visitor numbers to the Inlet and Park exceeded 1700 from May to September 2001 (Geoscape 2001). Ray and Williams (2003) suggest the Khutzeymateen Inlet “could be expected to see significant increases in levels of visitation generated by cruise tourism excursions”. Using the North Coast Tourism Opportunities Study, Ray and Williams (2003) also list a number of areas with “strong potential as grizzly wildlife viewing areas”: Khutzeymateen Provincial Park, Khutzeymateen (presumably the Inlet), Kwinimass River, Grandby Bay-Antioch, Kshwan River, Alice Arm, Stagoo Creek. Of these, only the Grandby Bay-Antioch has not been identified in this overall risk assessment as high or very high value grizzly bear habitat.

Bear viewing is particularly of concern since viewing concentrates human presence in areas where bears congregate seasonally. This increases the probability of habituation and displacement and has the potential to affect bears from a large proportion of a population unit. Potential effects include reduced habitat effectiveness and increased mortality risk due to bears being less wary of humans. An assessment of thresholds of habituation and displacement at several Alaskan and coastal British Columbian viewing sites was undertaken to guide discussions of management at bear viewing sites in the NCLRMP. The results of this assessment are provided in Appendix 6.

4.2.7 Assumptions and limitations

Lack of empirical evidence to quantify link between human use and bear displacement:

This assessment assumes that the greater the number of people at a recreation use area, the greater the potential for bear habituation and displacement. It is difficult to quantify the link between number of user-days and level of habituation. The management of these sites can have a significant effect on bear behaviour e.g., management of waste materials, timing of use (sporadic versus constant and day-use versus 24 hour). It is also difficult to ascribe a direct cause and effect relationship to the behaviour since, in any area, there will be bears that are habituated and bears that are more wary.

5.0 Assessment of mortality risk

The risk of bear mortality was subjectively assessed by examining the grizzly bear kill distribution since 1975 in relation to existing and projected future roads, concentrated tourism and recreation use areas, backcountry industrial sites (e.g., logging or mining camps), and settlement in the NCLRMP.

Grizzly bears are much more vulnerable to a variety of mortality risks when on or near connected road networks, near settlements or other human use areas where they may be attracted to human food sources or garbage. In addition to the legal hunt, bears are shot in legitimate self-defence, run over by vehicles, poached, killed maliciously, killed during conflicts over ungulate carcasses, or killed through misidentification as black bears (McLellan et al.1999). Habitat security (i.e. mortality risk-free areas) for adult females and their cubs are recommended as essential for maintaining the Central Rockies grizzly bear population (Gibeau et al. 2002). Grizzly bear population modelling has shown that the most sensitive input parameter in determining population trend is the survivorship of adult females (McLellan 1994).

The association of increased risk of grizzly bear mortality and public roads has been repeatedly demonstrated (Mattson et al. 1992, Benn 1998, McLellan et al. 1999, Benn and Herrero 2002). Similarly, mortality patterns of non-hunter killed grizzly bears clearly show an association with human settlements and backcountry infrastructure (Benn 1998, Miller and Tutterrow 1999, Cherry et al. 2002, Suring and Del Frate 2002).

5.1 Indicators

The following indicators were used to assess mortality risk within occupied grizzly areas:

Indicator	Rationale
1. Number and distribution of known and estimated dead bears	Concentrations of kill are potential indicators of a population “sink” (Doak 1995).
2. Number and location of connected road networks	Roads that enable easy public access because they are connected to other public roads were identified as the highest potential mortality risk
3. Size and location of settlement areas and industrial sites in relation to grizzly bear habitat suitability	Bear mortalities are typically higher around nodes of human settlement and activity.
4. Areas of concentrated backcountry recreation and tourism use in relation to grizzly bear habitat suitability.	Bear mortalities are typically higher around nodes of human settlement and activity.

5.2 Data inputs

Existing roads in the NCLRMP were derived by updating the existing forest cover road coverage to incorporate roads included in approved forest development plans and to correct any errors and omissions as identified through discussions with Ministry of Forests staff and Forest Licensees. Future potential roads were identified by forest engineers and planners in response to topographic conditions.

Site-specific levels of recreation and tourism use were taken from the combined Tourism Opportunity Study: Suitability Mapping (Geoscape 2001) and the Recreation Resource Analysis for the LRMP (Stoffels 2002), user-day statistics for Khutzeymateen Park (J. Hahn, BC Parks, pers. comm.) and a 2003 report on backcountry tourism activity (Pacific Analytics 2003). Settlement areas were identified based on the urban boundaries on forest cover maps and confirmed and corrected through consultation with the Skeena Queen Charlotte and Kitimat-Stikine Regional Districts.

The provincial Compulsory Inspection Data Base for grizzly bears contains information about all known grizzly bears killed in BC since 1975, including the map coordinates of the kills. Unreported grizzly bear mortalities were estimated as 1% of the population per year. Grizzly bear habitat suitability maps were also examined.

5.3 Analysis methods

Reported kill distribution by type and location were examined for potential patterns and compared to maps of existing and potential future roads, concentrated human use areas and grizzly bear habitat suitability. Summaries were made of Compulsory Inspection data by kill type and location.

5.4 Risk assessment

Risk was assessed subjectively through examination of a variety of inputs. Patterns were sought in kill distribution, in relation to roads and human use areas. Future mortality risk from connected road networks was estimated based on the likelihood of unrestricted public access into areas of moderate to high grizzly bear habitat suitability. Future mortality risk from nodes of human activity was not assessed due to lack of supporting data.

Criteria for estimating risk include:

- In assessing current records of bear mortality combined with estimated unreported kills, risk is considered high when there are high kill concentrations, proportion of females exceeds 30% and current mortality estimates exceed the acceptable mortality for acceptable human-caused mortality limit of 4%.

- If high risk conditions were identified, potential causative factors would be identified by looking at the location of the risk relative to land-based indicators (connected roads, settlement, industrial camps, and concentrated backcountry recreation and tourism use).

5.5 Results

Forty-eight grizzly bears were recorded killed within the NCLRMP since 1975. An additional 61 bears were estimated as the unreported kill in that 27-year period. Average mortalities per year (~2%) were well within the accepted limit of no more than 4% of the estimated minimum population (Austin and Hamilton 2002). However, safe mortality thresholds would not normally be calculated within administrative boundaries like the LRMP. Analysis completed elsewhere (Hamilton and Austin 2002) indicates that the overall mortality level for the Wildlife Management and Grizzly Bear Population Units that overlap the NCLRMP are similarly well within acceptable limits of human-caused mortality.

No patterns of kill distribution associated with motorized access currently exist in the NCLRMP. Forty-five of the 48 recorded kills were from legal hunters, 2 were problem animals, and 1 was a road kill on Highway 16. Examination of the recorded kill distribution yielded only two significant concentrations: Kiltuish and Alice Arm/Kitsault. Although the road to Kitsault is passible in the summer months, it is mostly 4-wheel drive and several of the bridges are in poor condition. Access to the Kiltuish River and Inlet is by aircraft or boat only.

New road construction into the Khyex Landscape Unit, potential upgraded roads into Work Channel (both connecting to Hwy 16) and a potential upgraded road into Kitsault (e.g., associated with the Anyox Independent Power Project) were identified as potential increased risks to grizzly bear mortality.

A visual assessment of settlements in relation to kill locations did not reveal any apparent patterns of kill distribution. Similarly, there are no apparent patterns of problem kill in relation to concentrations of human backcountry use – one bear was killed at Alice Arm, another at Union Bay.

5.6 Conclusions

Currently mortality levels within the NCLRMP are within the acceptable limits of human caused mortality. An assessment of potential factors affecting mortality risk show that connected road networks have the most primary potential for increased mortality risk in the future.

New road construction into the Khyex Landscape Unit, potential upgraded roads into Work Channel (both connecting to Hwy 16) and a potential upgraded road into Kitsault constitute high mortality risk increases if built and managed without application of mitigation such as restriction of motorized access to industrial uses only. Both situations would access highly suitable habitat, increasing the chances of bear/human encounters, and, if people are armed, the lethality of those encounters. Connected roads that enhance marine access may also increase mortality risk in the future.

Any human use in occupied grizzly bear habitat, including remote industrial camps (such as those for mineral exploration or tree planting), tourism or recreational facilities and settlement must be managed to prevent conflict with grizzly bears over human food, garbage and other attractants. Without specific provisions to prevent conflict, localized mortality risks will be very high.

5.5 Assumptions and limitations

Difficulty of predicting future mortality risk:

No empirical data are available to objectively predict future mortality risks in the NCLRMP. Mortality risk is both a function of the frequency of people encountering grizzly bears and the potential lethality of those encounters. Attempts to model all the potential influences on mortality risk and estimate total human-cause mortality are extremely complicated and depend on large datasets such as those assembled for Yellowstone (Mattson 1998, Cherry et al. 2002) and the Central Rocky Mountains (Herrero et al. 2000).

6.0 Overall risk to grizzly bears

Habitat suitability (described in Section 3.0) and effects of human activities, based on roads and nodes of activity (described in Section 4.0) were combined with indices of available salmon biomass to model the overall effectiveness of grizzly bear habitat. Effectiveness summaries were then correlated to bear density to produce composite bear sub-population estimates for the NCLRMP.

Risks associated with the modelled estimates of changes in bear density over time (based on the risk classes identified in Section 2.3 and applied in Sections 3.2, 4.1, and 4.2) were adjusted by combining them with the critical habitat assessment (Section 3.1) and qualitatively-derived estimates of future mortality risk (Section 5.0). This provided an cumulative assessment of risk to grizzly bear, from the range of factors, under the benchmark scenario (current management projected into the future).

6.1 Incorporating salmon into habitat suitability

Spawning salmon provides coastal grizzly bears with a critical food source (MacHutchon et al. 1993, Gende et al. 2001, Klinka and Reimchen 2002) and there is a close correlation between the availability of salmon, bear population density (Hilderbrand et al. 1999) and bear population status and trend (Himmer and Boulanger 2002).

Estimates of salmon biomass in the NCLRMP were derived from Department of Fisheries and Oceans salmon escapement records linked to explicit watershed boundaries. A check of this link was completed for the large river systems that have more than one watershed along their main reach lengths (e.g. Nass, Skeena) by examining the spawning area location notes in the DFO salmon escapement catalogs. Spawners were assigned to one watershed/reach length on a majority basis. Historic maximums (by species by run) were used to establish minimum and maximum capability. A ten-year average of recent escapements from 1993-2002 was used to establish the suitability contribution to bear density.

Biomass estimates were derived from literature reports of average spawning weights by species and sex and assuming a 50/50 sex ratio. Biomass classes were derived based their relationship to the coastal maximum (the Bella Coola River system). The model attempts to account for bear population depression caused by recent salmon declines by incorporating these declines in the 10-year suitability average. Each class was assigned a bear density parallel to the way in which Broad Ecosystem rankings were assigned densities (see Section 3.2.3, Table 6). However, an arbitrary 2/3 vegetation 1/3 salmon rule was adopted: that is, 2/3 of the overall suitability density was assigned to the BEI based estimator, 1/3 to the salmon input.

Incorporating salmon biomass data into the habitat effectiveness model resulted in an additional 76-140 “salmon” bears being added to the BEI-derived suitability estimate for the plan area (76 minimum, 140 maximum). This adjustment to the base suitability estimates were then applied across risk factors (see Section 6.2). No attempt was made to model potential changes in available salmon biomass through time.

6.2 Assessment of overall habitat effectiveness

The assessment of overall habitat effectiveness combines salmon biomass with:

- Changes in habitat suitability through time due to landscape level forage supply (Section 3.2);
- Changes in habitat effectiveness through time due to roads (Section 4.1)
- Changes in habitat effectiveness in areas of concentrated human use (e.g., settlement areas, areas of recreation and tourism use) (Section 4.2)

Table 15 summarizes the best estimate of the current grizzly bear population in the NCLRMP (N=332 bears). The estimate is only for bears within sub-populations of GBPUs that overlap the NCLRMP. Since this planning boundary is arbitrary from a grizzly bear population standpoint, results should be interpreted cautiously. There is likely regular movement by grizzly bears in and out of the NCLRMP (e.g. from the Klekane / Altanhash into the Triumph/ Paril/ Kiltuish areas).

Table 16 summarizes the estimate of habitat effectiveness after factoring in the suitability increase from spawning salmon. Modelled changes suggest an overall reduction in suitability across the NCLRMP of 6 to 7% (from 242 minimum to 227 minimum at t=0) to account for losses in habitat effectiveness resultant from the current influence of seral stage distribution, roads and concentrated human recreation and tourism use. Declines through time in suitability and effectiveness resultant from changes in seral stage distribution, road density and recreation and tourism use are a maximum of 4, 10 and 10% respectively. If the impact of recreation and tourism is doubled to 10%, the overall simulation suggests a decline in the minimum estimate of bears from 242 at time=0 to 198 at t=200 (- 18%) (Table 16).

Table 15: Estimate of number and density of grizzly bears within North Coast sub-populations of provincial grizzly bear population units

Grizzly Bear Population Unit	Number of bears in each North Coast sub-population			Density of bears in each North Coast sub-population (# of bears/1000 km^2)
	Current estimate: minimum	**Mid-point of the current estimate**	**Current estimate: maximum**	**Current estimate of bear density based on mid-point of population estimate**
1. Kitlope - Fjordland	12	20	27	26
2. Stewart	51	75	99	25
3. Khutzeymateen	75	109	143	35
4. North Coast	83	119	155	35
5. Bulkley Lakes	6	9	12	41
TOTAL	**227**	**332**	**436**	*N/A*

Table 16: Summary of habitat effectiveness assessments in terms of estimated numbers of bears, with salmon biomass incorporated

Change in no. of bears through time

Time step	LU forage supply		Roads		Roads + human activity[4]	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**
0	242	469	234	451	227	436
20	241	466	231	446	223	431
50	238	460	226	436	219	421
100	234	452	216	414	209	400
200	235	454	212	406	205	393
250	237	458	213	409	206	396

Cumulative change across risk factors

[4] This result assumes the incremental stepdown for recreation and tourism at t = 0 is applied to each time step i.e., current levels of recreation and tourism use are assumed to remain constant into the future.

6.3 Overall assessment of risk

Table 17 combines all five risk factors (critical habitat supply, landscape level forage supply, road displacement, activity displacement, and mortality risk) into an overall evaluation of risk. Risks have been directly transcribed from the summaries in earlier chapters of the report and in the tables above. The overall risk is summarized with and without application of the mitigative methods proposed in the draft General Management Direction for Grizzly Bears to show the implications of applying objectives and targets to reduce risk.

Risk is assessed against baseline objectives for an environmental value and the magnitude of change (incremental and cumulative) away from that baseline. The risk classes identified in this analysis were developed based on objectives of no net loss of current numbers of bears and no change in current patterns of distribution, consistent with the provincial Grizzly Bear Conservation Strategy. The estimated overall reduction of 18% in bear numbers does not meet this objective. In terms of magnitude, the overall potential for risk is low to moderate using the risk classes identified in this assessment (Table 3, Section 2.3). However, given the uneven distribution of impacts across the landbase, the risk is higher in terms of change to individual grizzly bears and sub-populations. The analysis did not consider the risks of maintaining bears at or near their threshold of viability, since that would well outside of the objective of no net loss.

The risk criteria applied for this evaluation identify the magnitude of risk from any one factor and cumulatively across factors. Results clearly demonstrate that the spatial distribution of impacts is extremely uneven across the plan area. When risk is examined at the landscape and watershed scales, repeated patterns occur. For example, several of the watersheds proposed for “Identified” status to mitigate the impacts of changes in seral stage distribution also show the highest impacts of current and future displacement from roads – an obvious reflection of the intensity of forestry activity within them. Similarly, the relative impacts of displacement from concentrated recreation and tourism activity are highest where that activity overlaps seasonally with very high habitat suitability. Individual watersheds and landscape units show high and even very high risks in this simulation. The overall “low” risk for the plan area as a whole masks the extreme variation in current and potential future impacts at the finer spatial scales. Table 18 identifies nine concentrations of risk to grizzly bears in the NCLRMP.

The degree of application of the proposed objectives and targets in the General Management Direction for Grizzly Bears and their spatial distribution will determine the success of risk mitigation. The cumulative risks from:

- the loss, alteration or alienation of critical habitat;
- the alteration in the spatial and temporal availability of forage at the landscape scale;
- the displacement risk from vehicles and people along road corridors;
- the displacement risk (and habituation consequences) of high levels of seasonally concentrated land-based recreation and tourism activity; and

- the mortality risks associated with a wide variety of human influences

can be minimized through application of both general and site-specific objectives and targets for grizzly bears and their habitat. Application of such objectives and targets has the potential to reduce risk to within acceptable limits of change. Monitoring of habitat and populations is important to assess the effectiveness of the management approaches and identify potential problem areas in a timely manner. .

Note that this risk assessment is limited by the lack of simulation of future population trends if spawning salmon availability declines. Direct impacts on survivorship and cub production would be exacerbated by potential increased mortality risk if hungry bears came into conflict with people as they sought out alternative food sources. This analysis used a “1/3” contribution to bear density by spawning salmon. Recent evidence from Knight Inlet (Nevin 2003) indicates that the proportion of salmon in the fall diet of grizzly bears may be as high as 82%. Given that level of nutritional contribution (protein, fat), the “1/3” factor may be an underestimate of the contribution of salmon to bear density. Regardless, there is little doubt that a significant decline in the availability of spawning salmon has the potential to dramatically increase the risk to grizzly bears in the NCLRMP.

Table 17. Summary risk evaluation matrix

Risk evaluation parameter	Grizzly bear ERA – selected risk factors[5]				
	Critical habitat supply	**Landscape level forage supply**	**Road displacement**	**Displacement due to recreation use**	**Mortality risk**
Likelihood of impact	High	High	High	Very High	Very High
Evidence of Risk: Overall Plan Area	All watersheds with THLB within occupied show some risk to critical habitat	Estimated 3 – 4% reduction in the number of grizzly bears over 250 years	Estimated 9 - 10% reduction in the number of grizzly bears over 250 years	Estimated 9 - 10% reduction in the number of grizzly bears over 250 years	Any location with high potential for bear human conflict
Evidence of Risk: Landscape or Watershed	1/3 of watersheds have greater than 20% overlap with the THLB, 71 of 183 watersheds classed as moderate to very high risk	16 watersheds are classed as at risk and are proposed for identified watershed status due to expected proportion of total forested landbase in midseral (i.e. not producing forage)	The Khyex watershed is the only proposed road network in the plan area at high risk of potential displacement (a connected road network into high suitability habitat, with potentially high traffic levels)	Upper Ecstall, Tsampanaknok (Sam) Bay, Kwinimass, Khtada Lake and Kitkiata potentially at risk due to overlap of recreational and tourism values and high grizzly bear habitat suitability	A potential connected road network in the Khyex, and potential upgrades of existing roads to Kitsault and to Work Channel off of Highway 16 constitute very high mortality risks
Magnitude of impact	Low to Very High in specific Landscape Units	Low to High in specific Landscape Units and Watersheds	Low to Moderate in specific Landscape Units and Watersheds[6]	Low to Moderate in specific Watersheds	Low to Very High in specific Watersheds

[5] Suitability contribution by salmon biomass is incorporated into estimates in this table as a constant.

Risk evaluation parameter	Grizzly bear ERA – selected risk factors[5]				
	Critical habitat supply	**Landscape level forage supply**	**Road displacement**	**Displacement due to recreation use**	**Mortality risk**
	and Watersheds				
Duration of impact	Temporary or Permanent	Temporary or Permanent	Temporary	Temporary (seasonal)	Temporary or Permanent
Reversibility of impact	Possible	Possible	Possible	Possible	Possible
Availability of mitigation strategies	Yes	Yes	Yes	Yes	Yes
Effectiveness of mitigation strategies	Partial	Partial	Very Effective	Partial	Partial
Residual environmental risk without mitigation strategies applied	High	Moderate	Moderate	Moderate	Very High
Residual environmental risk with mitigation strategies applied	Low to Moderate	Low	Very Low	Low to Moderate	Low

Table 18. Areas of concentrated risk across the NCLRMP. Critical habitat has been removed as a factor because the risk occurs across all landscape units that are available for timber development.

Areas of concern	**Grizzly bear ERA – selected risk factors by location**			
	Landscape level forage supply	**Road displacement**	**Displacement due to recreation use**	**Mortality risk**
Bishop/ Paril/ Triumph/ Kiltuish	Identified watersheds (3)	Many existing active roads – moderate displacement risk	High existing and potential displacement risk due to high use of hotsprings, although habitat quality is low.	Some existing and future potential risk due to open camp. Kill concentration at the Kiltuish.
Kitkiata/ Quaal	Identified watersheds (2)	Existing but inactive roads – low displacement risk. Potential for future roads	Relatively low displacement risk	Moderate future potential if access increased.
Sparkling	Identified watersheds (1)	Potential road development in the future	-	Low future potential.
Scotia/ Big Falls/ Hayward	Identified watersheds (3)	Biggest existing and active road network in District – moderate displacement risk Also has risk from potential future roads	Moderate use at Hayward and up the Ecstall to Ecstall Lake and Lower Lake. Jetboat access. High potential for future risk based on recreational values and relative ease of access.	Moderate existing mortality risk and high potential future risk due to jetboat and roaded access.
Khtada	-	Potential road development in the future	Moderate level of use. High fisheries values may lead to future increased use if access developed into area and associated high risk of displacement.	Moderate future potential risk if access developed.
Khyex/ Kwinitsa/ Lachmach	Identified watersheds (1)	Existing Lachmach Road active but unmaintained – low displacement risk. Highest potential future risk due to	Highest recreational use in the District along Skeena Corridor. Currently high displacement risk, likely to increase in the	Moderate existing mortality risk. Very high potential future risk because of

Areas of concern	Grizzly bear ERA – selected risk factors by location			
	Landscape level forage supply	**Road displacement**	**Displacement due to recreation use**	**Mortality risk**
		connected road networks in the future	future.	upgrade to connected roaded access to Highway 16.
Chambers/ Tsamspanaknok (Sam) Bay	Identified watersheds (1)	Many existing active roads – moderate displacement risk	Currently low- moderate risk due to low use. High displacement potential at Sam Bay from land-based bear viewing on high value habitat.	Some existing and future potential risk due to open camp.
Kwinimass	Identified watersheds (1)	Existing inactive roads (low risk) and potential for future road development	Relatively low displacement risk at this time. May increase if bear viewing expanded.	Low existing and future potential risk increasing to moderate if roads and camp are re-opened.
Kitsault/ Alice Arm	Identified watersheds (2)	Existing roads are largely inactive (low risk) but high potential future risk if road is upgraded and opened to the public.	Existing moderate displacement at Kitsault and Alice Arm. Potential high displacement risk if road upgraded and opened to the public	Moderate existing mortality risk. Very high potential future risk if road upgraded and settlement and recreational use expanded.

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Appendix 1: Data inputs into the grizzly bear ERA

Table 1: Data inputs into grizzly bear ERA

Model parameter	Data source	Age and reliability of data
Habitat suitability	Broad ecosystem inventory (BEI)	The BEI for the North Coast was updated in 2000. Map scale is 1:250,000 and is therefore relatively coarse.
	Forest cover inventory	Updated to 1999. Last complete re-inventory was in 1995. Due to strict requirements for consistency re data and methods, the forest cover inventory is comprehensive, well-documented and rigorous.
Salmon distribution	Fisheries Information Summary System (FISS)	Includes data colleted since the 1920s. Data files were updated in 2000.
Salmon abundance	New Salmon Escapement Data System (NUSEDS)	Data encompasses the years 1950 – 2001.
Slope	Digital Elevation Model in TRIM	1996 Map compilation photography is as much as 15 years out of date - a program is underway to update areas.
Roads	Updated forest cover road layer	Derivative mapping based on forest cover inventory. Licensees were consulted to verify and improve map layer and provide input into potential future roads.
Settlement	Urban boundaries from forest cover	Confirmed with regional districts
Recreation and tourism use	User days data layer	Based on input collected between 2000 and 2002 as part of the NC LRMP recreation inventory, Tourism Opportunity Study, and backcountry tourism use report.

Appendix 2: Results of critical habitat assessment by watershed

The following table summarizes the results of the assessment of critical habitat overlap with the THLB. Ratios higher than 20%, indicating a moderate - high risk are bolded.

Watershed ID	Area of THLB (ha)	Total watershed area (ha)	Area of critical habitat on the THLB (ha)	Ratio of commercially-forested critical habitat to:	
				Total critical habitat	Total THLB
TSAYWSD000060	26	32	321	**0.93**	**0.81**
KITRWSD000149	13	46	0	**0.87**	**0.29**
KHTZWSD000029	115	223	48	**0.80**	**0.51**
KSHRWSD000038	80	138	182	**0.80**	**0.58**
KSHRWSD000021	11	15	12	**0.75**	**0.73**
KSHRWSD000077	120	235	67	**0.72**	**0.51**
KHTZWSD000034	381	1203	55	**0.69**	**0.32**
WORCWSD000315	18	190	41	**0.62**	0.09
KSHRWSD000040	418	1605	9	**0.60**	**0.26**
KHTZWSD000032	810	2362	1	**0.57**	**0.34**
LSKEWSD000040	916	3900	7	**0.54**	**0.23**
WORCWSD000296	116	374	17	**0.47**	**0.31**
WORCWSD000112	465	2260	8	**0.47**	**0.21**
WORCWSD001189	26	175	107	**0.45**	0.15
KHTZWSD000046	974	5340	16	**0.44**	0.18
WORCWSD000102	1030	4385	18	**0.43**	**0.23**
LSKEWSD000057	1074	4151	54	**0.43**	**0.26**
LSKEWSD000056	1280	6056	108	**0.42**	**0.21**
KHTZWSD000033	596	2307	164	**0.39**	**0.26**
LNARWSD000010	1654	10558	4	**0.38**	0.16
KHTZWSD000030	842	4034	304	**0.38**	**0.21**
WORCWSD000061	1012	4605	16	**0.37**	**0.22**
LSKEWSD000054	892	3727	383	**0.37**	**0.24**
KHTZWSD000026	2595	12933	45	**0.36**	0.20
LNARWSD000078	1549	8582	8	**0.34**	0.18
WORCWSD000113	139	585	29	**0.33**	**0.24**

Watershed ID	Area of THLB (ha)	Total watershed area (ha)	Area of critical habitat on the THLB (ha)	Ratio of commercially-forested critical habitat to:	
				Total critical habitat	Total THLB
LSKEWSD000049	1192	9781	30	**0.33**	0.12
WORCWSD000100	898	6151	50	**0.33**	0.15
WORCWSD000114	647	1585	99	**0.32**	**0.41**
LSKEWSD000074	82	568	53	**0.32**	0.14
WORCWSD000258	303	2975	364	**0.32**	0.10
WORCWSD000378	545	5585	43	**0.32**	0.10
WORCWSD000047	1077	4857	2	**0.31**	**0.22**
KUMRWSD000753	155	806	1	**0.31**	0.19
LSKEWSD000044	757	5103	246	**0.31**	0.15
KSHRWSD000137	374	2478	190	**0.30**	0.15
KHTZWSD000040	1703	8351	37	**0.30**	0.20
KSHRWSD000134	621	7454	314	**0.30**	0.08
KSHRWSD000063	288	1126	26	**0.29**	**0.26**
LSKEWSD000069	199	2494	68	**0.29**	0.08
KITRWSD000131	1187	7216	7	**0.29**	0.16
KSHRWSD000132	485	5631	505	**0.28**	0.09
KUMRWSD000272	121	853	46	**0.28**	0.14
KUMRWSD000684	114	1518	1	**0.28**	0.07
WORCWSD000807	626	1582	98	**0.27**	**0.40**
LSKEWSD000065	160	1846	171	**0.27**	0.09
KUMRWSD000676	427	1605	3	**0.27**	**0.27**
KSHRWSD000045	876	5934	76	**0.27**	0.15
KSHRWSD000024	1403	7010	22	**0.26**	0.20
WORCWSD000023	3665	27951	108	**0.26**	0.13
LSKEWSD000059	496	4789	3	**0.25**	0.10
LSKEWSD000035	478	3799	29	**0.25**	0.13
KUMRWSD000533	87	1219	49	**0.25**	0.07
LSKEWSD000058	1915	14780	35	**0.24**	0.13
WORCWSD000649	125	1760	134	**0.23**	0.07
WORCWSD000492	89	888	205	**0.22**	0.10

Watershed ID	Area of THLB (ha)	Total watershed area (ha)	Area of critical habitat on the THLB (ha)	Ratio of commercially-forested critical habitat to:	
				Total critical habitat	Total THLB
KSHRWSD000044	1315	8371	5	**0.22**	0.16
LSKEWSD000036	975	8348	14	**0.22**	0.12
LSKEWSD000028	784	7958	21	**0.22**	0.10
KSHRWSD000029	4292	23989	13	**0.21**	0.18
KSHRWSD000106	165	3574	0	**0.20**	0.05
LSKEWSD000038	194	1180	52	**0.20**	0.16
LSKEWSD000070	487	6059	331	**0.20**	0.08
WORCWSD001187	217	1902	23	0.19	0.11
KSHRWSD000078	244	2657	127	0.19	0.09
WORCWSD000116	565	5886	170	0.19	0.10
LSKEWSD000019	230	4475	150	0.19	0.05
KUMRWSD000442	327	2302	13	0.19	0.14
KUMRWSD000006	384	1682	134	0.19	**0.23**
KSHRWSD000023	207	5443	43	0.18	0.04
WORCWSD000246	185	970	6	0.18	0.19
WORCWSD000006	1179	8343	19	0.18	0.14
KSHRWSD000069	104	381	6	0.17	**0.27**
LSKEWSD000048	3659	42180	638	0.17	0.09
LSKEWSD000080	242	3419	2	0.17	0.07
KSHRWSD000089	159	1599	81	0.16	0.10
KSHRWSD000067	302	3289	162	0.15	0.09
WORCWSD000267	515	6488	70	0.15	0.08
WORCWSD000222	568	5653	415	0.15	0.10
WORCWSD000985	134	1231	32	0.15	0.11
LSKEWSD000006	1520	26219	1	0.15	0.06
LSKEWSD000066	408	7098	86	0.14	0.06
WORCWSD000146	364	1912	13	0.14	0.19
WORCWSD000171	198	2705	46	0.14	0.07
KITRWSD000133	160	2823	86	0.13	0.06
LSKEWSD000026	149	2560	52	0.13	0.06

Watershed ID	Area of THLB (ha)	Total watershed area (ha)	Area of critical habitat on the THLB (ha)	Ratio of commercially-forested critical habitat to:	
				Total critical habitat	Total THLB
KSHRWSD000140	127	2715	63	0.12	0.05
WORCWSD000188	461	1624	1	0.12	**0.28**
LSKEWSD000078	226	4609	25	0.12	0.05
KHTZWSD000043	578	8033	114	0.12	0.07
KSHRWSD000135	213	4980	17	0.12	0.04
WORCWSD001192	436	3417	6	0.12	0.13
LSKEWSD000061	244	5925	38	0.12	0.04
KUMRWSD000283	303	2837	22	0.12	0.11
LSKEWSD000076	49	1237	10	0.11	0.04
LSKEWSD000031	317	2510	89	0.11	0.13
LSKEWSD000071	289	4315	12	0.11	0.07
LSKEWSD000047	845	14755	721	0.11	0.06
KUMRWSD000005	1065	5538	77	0.11	0.19
WORCWSD000283	693	3492	42	0.11	0.20
KSHRWSD000139	186	3773	7	0.11	0.05
LSKEWSD000009	2500	22346	7	0.11	0.11
LSKEWSD000073	10	766	11	0.11	0.01
LSKEWSD000077	39	757	72	0.10	0.05
WORCWSD000229	73	2222	67	0.10	0.03
WORCWSD000241	271	3815	43	0.10	0.07
WORCWSD000227	97	1209	17	0.10	0.08
WORCWSD000692	275	1808	33	0.10	0.15
KITRWSD000148	180	445	249	0.10	**0.40**
LSKEWSD000062	149	3757	97	0.10	0.04
WORCWSD000675	185	594	1	0.10	**0.31**
KITRWSD000143	40	2382	21	0.10	0.02
KSHRWSD000128	135	5451	157	0.09	0.02
KSHRWSD000059	818	8489	8	0.09	0.10
WORCWSD000302	46	216	4	0.09	**0.21**
KUMRWSD000090	954	11843	233	0.09	0.08

Watershed ID	Area of THLB (ha)	Total watershed area (ha)	Area of critical habitat on the THLB (ha)	Ratio of commercially-forested critical habitat to:	
				Total critical habitat	Total THLB
KSHRWSD000124	28	825	4	0.08	0.03
LSKEWSD000037	257	3673	21	0.08	0.07
KSHRWSD000131	123	3152	13	0.08	0.04
WORCWSD000379	153	1209	1	0.08	0.13
WORCWSD000297	72	1080	7	0.08	0.07
LSKEWSD000060	77	3505	9	0.07	0.02
KUMRWSD000038	1077	9119	17	0.07	0.12
KSHRWSD000133	359	12000	4	0.07	0.03
WORCWSD001097	313	2963	0	0.07	0.11
KSHRWSD000042	114	2633	8	0.07	0.04
KITRWSD000145	7	17	176	0.07	**0.38**
KSHRWSD000142	238	1889	13	0.07	0.13
KUMRWSD000324	345	4685	18	0.07	0.07
WORCWSD000119	95	1025	31	0.07	0.09
KUMRWSD000769	68	534	21	0.06	0.13
LSKEWSD000034	139	824	78	0.06	0.17
LSKEWSD000068	15	854	25	0.06	0.02
WORCWSD001209	275	2839	16	0.06	0.10
KUMRWSD000287	322	5452	1	0.06	0.06
KSHRWSD000060	235	7105	94	0.06	0.03
KSHRWSD000095	33	1610	26	0.06	0.02
KUMRWSD000007	418	2440	14	0.06	0.17
KSHRWSD000031	94	1332	4	0.06	0.07
KSHRWSD000129	48	1154	4	0.05	0.04
KUMRWSD000004	199	2788	4	0.05	0.07
KUMRWSD000364	72	1811	14	0.05	0.04
WORCWSD001260	148	447	191	0.05	**0.33**
KSHRWSD000027	287	4157	1	0.05	0.07
KSHRWSD000017	5	2516	8	0.05	0.00
WORCWSD001230	159	918	3	0.05	0.17

Watershed ID	Area of THLB (ha)	Total watershed area (ha)	Area of critical habitat on the THLB (ha)	Ratio of commercially-forested critical habitat to:	
				Total critical habitat	Total THLB
KSHRWSD000030	312	9116	106	0.04	0.03
WORCWSD000147	225	1517	62	0.04	0.15
LSKEWSD000032	244	3230	29	0.04	0.08
WORCWSD001226	249	1064	2	0.04	**0.23**
WORCWSD001025	360	3309	25	0.04	0.11
WORCWSD000120	284	2230	73	0.04	0.13
LSKEWSD000064	132	5053	6	0.04	0.03
KUMRWSD000529	31	1758	17	0.03	0.02
WORCWSD000978	320	2719	9	0.03	0.12
WORCWSD001278	316	3315	204	0.03	0.10
KSHRWSD000138	429	17123	2	0.03	0.03
KITRWSD000141	51	515	167	0.03	0.10
WORCWSD000261	9	675	27	0.03	0.01
WORCWSD001049	196	1779	7	0.02	0.11
WORCWSD000307	357	3523	311	0.02	0.10
KUMRWSD000379	198	7988	5	0.02	0.02
KSHRWSD000039	80	2579	18	0.02	0.03
KSHRWSD000088	61	1670	20	0.02	0.04
WORCWSD000322	102	1874	164	0.02	0.05
KSHRWSD000130	18	1216	7	0.02	0.02
LSKEWSD000079	5	682	48	0.02	0.01
LSKEWSD000075	29	1139	4	0.02	0.03
KUMRWSD000026	313	3701	177	0.02	0.08
KUMRWSD000763	26	497	101	0.02	0.05
KHTZWSD000054	10	730	18	0.02	0.01
KSHRWSD000041	77	1184	44	0.02	0.06
KSHRWSD000043	15	3539	1	0.02	0.00
KSHRWSD000061	129	7652	4	0.02	0.02
WORCWSD001275	89	2916	5	0.01	0.03
LSKEWSD000072	12	1804	2	0.01	0.01

Watershed ID	Area of THLB (ha)	Total watershed area (ha)	Area of critical habitat on the THLB (ha)	Ratio of commercially-forested critical habitat to:	
				Total critical habitat	Total THLB
KSHRWSD000048	21	7117	3	0.01	0.00
LSKEWSD000063	22	1372	1	0.01	0.02
KUMRWSD000163	26	1476	13	0.01	0.02
KSHRWSD000068	11	1575	17	0.01	0.01
WORCWSD001019	38	840	3	0.01	0.05
WORCWSD000117	3	167	12	0.01	0.02
KSHRWSD000094	36	7672	6	0.01	0.00
Total/Average	**80889**	**765147**	**12659**	**0.18**	**0.13**

Appendix 3: Ratings tables for grizzly bear habitat suitability

Table 1 summarizes the ratings and rationale for grizzly bear habitat suitability by Broad Ecosystem Unit. The ratings and rationale for ssPEM were not included in this appendix due to their large size, but they are available upon request.

Table 1: Rationale for grizzly bear habitat suitability by Broad Ecosystem Unit

BEU	Rationale	Range
AG	Made all 3's but suspect that may be optimistic in some Ecosections	3
AH	Made all 4's but suspect that may be pessimistic in some Ecosections (northern had bog blueberry)	4
AM*	Minus 1 for "Northern" Ecosections, Plus 1 for COM Ecosections	2 or 3
AMs	Plus 1 for south facing. If forb unit, would be class 1, but can't distinquish forb from sedge dominated.	2 or 3
AM	Minus 1 for north facing	3 or 4
AT	All 5's - some probably deserve 6, but left as 5 for consistency.	5
AU	Always 6	6
AV*	Minus 1 for MHmm2 and MHun (rockier, steeper), IDF and MS (drier), SWB and BWBS (colder and drier).	1 or 2
AVn	Minus 1 for north facing (wonder also about the dry ESSF subzones, but did not discount)	2 or 3
AVs	Plus 1 for south facing.	1 or 2
CB*	Plus 1 for CPR and KIR (CWHvm1), HEL=4, HES and QCT are actually unoccupied islands (6). No differences for modifiers - aspect, soils likely not significant influences on bogs. Some of these may be class 2 on occasion, but pulled back to 3 for consistency. (All succession now fixed)	3 or 4
CH*	Minus 1 at ss6 for SBR (colder), OUF (drier), HEL (wetter) - from 3 to 4. Succession on generic: 353533	3 to 5
CHl	Minus 1 for shallow soils (eliminates ecosection stepdown)	4 or 5
CHm	Plus 1 for moist soils (except in HEL and vm2 where irrelevant - i.e. always "moist")	2 to 5
CHn	Minus 1 for north facing except in vm_ and vm1 (assumed herb cover in ss1, ss3 and ss5 and also warmer and drier for berries)	3 to 5
CHs, t	Plus 1 for south facing (berries, including salal) except for vh2, and OUF vm1 (barley occupied)	2 to 5
ES	All class 1, although some will need stepdown for human influence.	1
FR*	Most common coastal unit. Typically good after clearcutting, poor in closed canopy, ok as oldgrowth. Succession on generic: 253533 except in OUFCHWvm2 (envision dry rocky island unit: 254544	2 to 5
FRc	Minus 1 for coarse soils: 354544	3 to 5
FRl	Minus 1 for shallow soils: 354544, worse in OUFCWHvm2: 454544	3 to 5
FRm	Plus 1 for moist soils in oldgrowth - good possibility of devil's club: 253532 except for OUFCWHvm2: 354543	2 to 5

BEU	Rationale	Range
FRn	Minus 1 for north facing: 354544 except OUFCWHvm2: 454544	3 to 5
FRs, t	Same as generic: 253533 except OUFCWHvm2: 454544. Arguable that maybe the south facing should give the unit a plus 1 where Vaccinium concerned but coastal model has bears fishing over eating blueberries even if true that south facing has more fruit.	2 to 5
FRu	Same as generic: 253533	2 to 5
FS	Suppose they may swim or cool off in them sometime….	6
GB	Fishing from this unit captured by Salmon Biomass	6
GL	Glaciers always 6	6
HP*	Succession on generic: 3443, except in HEL CWHwh1: 3444	3 or 4
HPl, n	Minus 1 for shallow soils and north facing in oldgrowth: 3444 (assume some herbaceous foods in early seral)	3 or 4
HPs	Plus 1 for south facing: 2443 (assume some berry benefit, warmer = earlier snow free	2 to 4
HS*	Succession on generic: 353533 - good food when clearcut, tight canopy in mid seral, some foods in oldgrowth	3 to 5
HSl	Minus 1 for shallow soils in oldgrowth: 353534	3 to 5
HSm	Plus 1 for moist: 253533 (some potential for devil's club)	2 to 5
HSn	Minus 1 for north facing in oldgrowth: 353534	3 to 5
HSs, t	Plus 1 for south facing: 253533	2 to 5
ME*	Unable to discriminate between alkaline and non-alkaline except by looking at zone. ICH, CWH and SBS assumed to have some sedge feeding so given 2's. Rest assigned 3's.	2 or 3
MF*	Although early seral can be dominated by shrubs, berry production not high (late snowmelt?): Succession on generic: 3554. Minus 1 in early for OUF and HELMHwh: 4554 - Note:oldgrowth unit is higher for black bears for late summer Vaccinium (grizzly bears don't have this pattern, fishing instead)	3 to 5
MFl	Minus 1 for shallow soils in early seral: 4554	4 or 5
MFm	Plus 1 for moist: 3554	3 to 5
MFn	Minus 1 for north facing: already low berry production goes lower on north facing: 4554	4 or 5
MFs, t	Plus 1 for south facing for both early and oldgrowth: 3553, except for HELMHwh1: 4554	3 to 5
MFu	Same as generic: 3554	3 to 5
RO*	Rock is all 6's	6
RS*	Unusual pattern, but makes sense because of skunk cabbage. Succession on generic: 232321	1 to 3
SM*	Normally 1's except for in MH and SWB zone (2's there). MH telemetry indicates not that high and SWB overall lower potential. Land area also seems high in SWB in comparison to other zones.	1 or 2
SMn	Minus 1 for north facing (assumed slower snowmelt, fewer forbs, more heather)	2 or 3
SMs, t	Plus 1 for south facing - brings MH and SWB up to 1's.	1
SP	Slow perennial streams - all 8	8

BEU	Rationale	Range
SR*	Succession on generic: 132321	1 to 3
UR	Urban - all 6	6
WL*	Rated 1's in CWH and ICH and SBSmc, 2's in remainder of zones	1 or 2
YB*	Bog forest on outer coast. Succession on generic: 4554 except for OUFCWHvm1 - not much else out there: 3553	3 to 5
YBl	Don't understand bog forest on shallow soils - seems like impossible: 5555	5
YBm	Similarly, don't understand the concept of a moist bog. Same as generic: 4554	4 or 5
YBn	Same as generic: 4554	4 or 5
YBs, t	Would have been plus 1 for south facing in other Ecosections, but all the south facing occurs in the HEL: same as generic: 4554	4 or 5
YM*	Some foods, but generally low value. Succession on generic: 4554	4 or 5
YMl ,n	Minus 1 for shallow soils and north facing in oldgrowth: 4555	4 or 5
YMs, t	Plus 1 for south facing in early but can't rate any higher than 4 for the MHwh1 - just don't see that unit as offering much to grizzly bears: 3554	3 to 5
YMu	Same as generic: 4554	4 to 5
YS*	Although skunk cabbage present, this is the outer coast, high elevation unit. Some berry value. Succession on generic (although suspect succession very rare): 3554	3 to 5

Appendix 4: Data on road use in the North Coast

The following table summarizes the data assembled on road use in the North Coast. Road use was estimated through discussions with forest licensees.

Road segment No.	Road status	Area	No vehicles/day	No vehicles/wk	Vehicle type	Months of use	Comments
1	Existing	Kitsault	n/a	n/a	n/a	n/a	Bob Cuthbert explained that beyond 10km the road is not maintained
2	Existing	Kitsault	n/a	10	4x4 pickup truck	June-September	Increased vehicle movement in the summer months because there are dirt bike rentals. Bob Cuthbert explained that the road will not be used once the bridge near Alice Arm collapses.
3	Approved	Chambers	n/a	n/a	n/a	n/a	n/a
4	Existing	Scotia	17	n/a	logging truck	July-August	n/a
5	Existing	Scotia	19	n/a	logging truck	July-August	n/a
6	Existing	Scotia	37	n/a	logging truck	July-August	n/a
7	Existing	Scotia	40-80	n/a	logging truck	July-August	n/a
8	Existing	Scotia	n/a	n/a	n/a	n/a	n/a
9	Existing	Chambers	n/a	n/a	n/a	n/a	n/a
10	Existing	Paril	n/a	n/a	n/a	n/a	n/a
11	Existing	Triumph	n/a	n/a	n/a	n/a	n/a

Road segment No.	Road status	Area	No vehicles/day	No vehicles/wk	Vehicle type	Months of use	Comments
12	Existing	n/a	n/a	n/a	n/a	n/a	n/a
13	Proposed	Scotia	n/a	n/a	n/a	n/a	n/a
14	Proposed	Chambers	n/a	n/a	n/a	n/a	n/a
15	Existing	Lachmach	n/a			April-November	Needs brushing therefore no vehicle traffic
16	Existing	McNeil	n/a	7	Pickup Truck	April-November	No Recreation Site on FSR. People go there to dump garbage when the dump is closed
17	Existing	Lachmach	n/a	50	Pickup Truck	April-November	Outside of the peak months (July and August) there are 20 vehicle movements per week
18	Approved	Chambers	54	n/a	logging truck	July-August	Traffic volume based on 20km/hr speed with 3 logging trucks working and 55 cubic meter truck loads. These numbers were provided by Shawn Kenmuir from Triumph Timber. He also confirmed the months the roads were used this year.
19	Approved	Chambers	60	n/a	logging truck	September-November	Traffic volume based on 20km/hr speed with 3 logging trucks working and 55 cubic meter truck loads. These numbers were provided by Shawn Kenmuir from Triumph Timber. He also confirmed the months the roads were used this year.

Road segment No.	Road status	Area	No vehicles/day	No vehicles/wk	Vehicle type	Months of use	Comments
20	Existing	Chambers	50-60	n/a	logging truck	July-November	Traffic volume based on 20km/hr speed with 3 logging trucks working and 55 cubic meter truck loads. These numbers were provided by Shawn Kenmuir from Triumph Timber. He also confirmed the months the roads were used this year.
21	Existing	Chambers	50-65	n/a	logging truck	September-November	Traffic volume based on 20km/hr speed with 3 logging trucks working and 55 cubic meter truck loads. These numbers were provided by Shawn Kenmuir from Triumph Timber. He also confirmed the months the roads were used this year.
22	Existing	Chambers	54	n/a	logging truck	July-August	Traffic volume based on 20km/hr speed with 3 logging trucks working and 55 cubic meter truck loads. These numbers were provided by Shawn Kenmuir from Triumph Timber. He also confirmed the months the roads were used this year.
23	Existing	Chambers	60	n/a	logging truck	September-November	Traffic volume based on 20km/hr speed with 3 logging trucks working and 55 cubic meter truck loads. These numbers were provided by Shawn Kenmuir from Triumph Timber. He also confirmed the months the roads were used this year.

Road segment No.	Road status	Area	No vehicles/day	No vehicles/wk	Vehicle type	Months of use	Comments
24	Existing	Chambers	66	n/a	logging truck	September-November	Traffic volume based on 20km/hr speed with 3 logging trucks working and 55 cubic meter truck loads. These numbers were provided by Shawn Kenmuir from Triumph Timber. He also confirmed the months the roads were used this year.
25	Proposed	Chambers	60	n/a	logging truck	September-November	Traffic volume based on 20km/hr speed with 3 logging trucks working and 55 cubic meter truck loads. These numbers were provided by Shawn Kenmuir from Triumph Timber. He also confirmed the months the roads were used this year.
26	Existing	Scotia	15	n/a	logging truck	Jjuly-August	Traffic volume based on 25-30 km/hr speed with 2 logging trucks working in the area and 80 cubic meter load truck
27	Existing	Scotia	17	n/a	logging truck	July-August	Traffic volume based on 25-30 km/hr speed with 2 logging trucks working in the area and 80 cubic meter load truck
28	Existing	Scotia	17-40	n/a	logging truck	July-August	Traffic volume based on 25-30 km/hr speed with 2 logging trucks working in the area and 80 cubic meter load truck
29	Existing	Scotia	19	n/a	logging truck	July-August	Traffic volume based on 25-30 km/hr speed with 2 logging trucks working in the area and 80 cubic meter load truck
30	Existing	Scotia	20-40	n/a	logging truck	July-August	Traffic volume based on 25-30 km/hr speed with 2 logging trucks working in the area and 80 cubic meter load truck
31	Existing	Scotia	21	n/a	logging truck	July-August	Traffic volume based on 25-30 km/hr speed with 2 logging trucks working in the area and 80 cubic meter load truck

Road segment No.	Road status	Area	No vehicles/day	No vehicles/wk	Vehicle type	Months of use	Comments
32	Existing	Scotia	39	n/a	logging truck	July-August	Traffic volume based on 25-30 km/hr speed with 2 logging trucks working in the area and 80 cubic meter load truck
33	Existing	Paril	15	n/a	logging truck	September-November	Traffic volume based on 7-15 km/hr speed with 2 logging trucks working in the area and 50 cubic meter load truck
34	Existing	Paril	21-25	n/a	logging truck	September-November	Traffic volume based on 7-15 km/hr speed with 2 logging trucks working in the area and 50 cubic meter load truck
35	Existing	Paril	33	n/a	logging truck		Traffic volume based on 7-15 km/hr speed with 2 logging trucks working in the area and 50 cubic meter load truck
36	Existing	Paril	33	n/a	logging truck	September-November	Traffic volume based on 7-15 km/hr speed with 2 logging trucks working in the area and 50 cubic meter load truck
37	Existing	Triumph	21-25	n/a	logging truck	September-November	Traffic volume based on 7-15 km/hr speed with 2 logging trucks working in the area and 50 cubic meter load truck

Appendix 5: Recreation and tourism user-day statistics

Data on existing recreation and tourism user-days in the North Coast were drawn from a number of sources. These include the combined Tourism Opportunity Study: Suitability Mapping (Geoscape 2001) and the Recreation Resource Analysis for the LRMP (Stoffels 2002), user-day statistics for Khutzeymateen (J. Hahn, BC Parks, pers. comm.), and an an economic and client summary backcountry tourism operators the NCLRMP area (Pacific Analytics 2003). There are no estimates available for future user-days in the NCLRMP. Table 1 summarizes the information from the combined Tourism Opportunity Study and Recreation Resource Analysis.

Table 1. User-day statistics from the combined Tourism Opportunity Study and Recreation Resource Analysis.

Name of site	Location	No of user days/ active season
Haysport – abandoned community now in ruins		2500+
North Pacific Cannery Museum		2500+
Inverness Passage	Inverness Passage	2500+
Polymar (China) Bar - Skeena	Skeena River	2500+
Skeena / Kwinitsa River	Skeena River	2500+
Skeena River - Aberdeen Point	Skeena River	2500+
Skeena River - Loggers Launch	Skeena River	2500+
Alice Arm	Alice Arm	1000-2500
Bishop Bay	Ursula Channel	1000-2500
Lachmach Campsite	Work Channel	500-1000
Pt Edward Trails	Port Edward	500-1000
Tsamspanaknok Bay	Khutzeymateen Inlet	200-500
Anyox	Observatory Inlet	200-500
Crow Lagoon	Khutzeymateen Inlet	200-500
Davies Bay Su	Work Channel	200-500
Echo Cove	Nass Bay	200-500
Frizzell Hotsprings	Skeena River	200-500
Goat Harbour	Ursula Channel	200-500
Granby Cove	Observatory Inlet	200-500
Granite Cove	Douglas Channel	200-500
Hayward Cr - E of shore of Ecstal	Ecstall River	200-500

Name of site	Location	No of user days/ active season
Iceberg BaySu	Nass River	200-500
Khtada Lake		200-500
Kiskosh Inlet	Douglas Channel	200-500
Klewnuggit Inlet	Grenville Channel	200-500
Kumealon Inlet	Grenville Channel	200-500
Kwinimass River	Portland Inlet	200-500
Lowe Inlet	Grenville Channel	200-500
Maskelyne Island	Work Channel	200-500
Pt Essington	Skeena River	200-500
Baker Inlet	Grenville Channel	0-200
Bishop Cove	Ursula Channel	0-200
Dawkins Point	Observatory Inlet	0-200
Doben Island	Observatory Inlet	0-200
Eagle Cove	Observatory Inlet	0-200
Ecstall Lake & Lower Lake	Ecstall River	0-200
Egerton Point	Ursula Channel	0-200
ENSHESHESE RIVER	Work Channel	0-200
Fords Cove	Portland Canal	0-200
Georgie River	Portland Canal	0-200
Grenville Channel	Grenville Channel	0-200
Hastings Arms	Observatory Inlet	0-200
Hattie Island - Portland Canal	Portland Canal	0-200
Helen Bay	Portland Canal	0-200
Kitkiata Inlet	Douglas Channel	0-200
Kumealon Island Cove	Grenville Channel	0-200
Kumeon Bay	Khutzeymateen Inlet	0-200
Larcom Lagoon	Observatory Inlet	0-200
Legace Bay	Work Channel	0-200
Mach Lake	Work Channel	0-200
Maple Bay	Portland Canal	0-200
Marmot River	Portland Canal	0-200
Monkey Beach	Ursula Channel	0-200

Name of site	Location	No of user days/ active season
Mosley Point Cove	Grenville Channel	0-200
Nabannah Bay	Grenville Channel	0-200
Opposite Ormiston Point	Grenville Channel	0-200
Paradise Passage	Work Channel	0-200
Quaal River	Douglas Channel	0-200
Quottoon Head	Quottoon Inlet	0-200
Quottoon Narrows	Quottoon Inlet	0-200
Sainty Point Cove	Grenville Channel	0-200
Salmon Cove	Observatory Inlet	0-200
Saunders Creek	Grenville Channel	0-200
Simpson Lake	Grenville Channel	0-200
Strombeck Bay	Observatory Inlet	0-200
Sylvester Bay	Observatory Inlet	0-200
Thulme River	Quottoon Inlet	0-200
Union Inlet	Work Channel	0-200
Upper Ecstall	Ecstall River	0-200
Watts Narrows	Grenville Channel	0-200
Weare Lake	Grenville Channel	0-200

Appendix 6: Synthesis of studies into land-based bear viewing and associated habituation and displacement risk

Commercial and recreational interest in bear viewing in coastal British Columbia has increased dramatically. Coastal grizzly bear viewing user-days in 2003 were estimated at over 10,000 (Hamilton, unpublished data). Recent summaries of the economic values of coastal bear viewing identify it as a major component of the adventure/eco tourism industry on the coast (Smith 2001, Lemelin et al. 2001, Parker and Gorter 2003). Parallel increases in coastal Alaska (Titus et al.1994) have led to intensive management at several locations, ranging from the highly restricted lottery system at McNeil River State Game Sanctuary (Aumiller and Matt1994) to the loosely supervised situation at Fish Creek near Hyder.

Several researchers have examined the potential impact of bear viewing on grizzly bear displacement from seasonal food concentrations and habituation to human presence (e.g. Himmer 1996, Olsen et al. 1997, Chi and Gilbert 1999, Nevin and Gilbert 2001, Nevin 2003). Some bears will still use salmon spawning areas at even the highest use viewing areas (Fish Creek at Hyder and Brooks Camp in Katmai National Park and Preserve both have over 40,000 annual visitors). Although there is some indication that human influence may change daily use patterns, causing bears to feed more frequently at night, (Olsen et al. 1998), other research implies that night-time use by fishing grizzly bears is more a function of energetic efficiencies than daytime displacement (Klinka and Reimchen 2002).

Examination of user-days, estimates of habituation, displacement and zones of influence at several Alaskan and coastal British Columbian viewing sites suggests that a user day density of approximately 1500 people per km^2 per active season is the lower threshold of concern for grizzly bear habituation and displacement (and thus an appropriate low risk threshold) (Table 1). At that level, it appears that the most wary bears may either be displaced or change their activity schedule to avoid human contact. Above an upper threshold of 5000 people per km^2 per active season, observations suggest that the only bears not displaced are those that become highly habituated and may actually be using human contact to help ensure their security.

Although the absolute impacts of displacement and habituation are difficult to quantify, it is certain that highly habituated bears have a higher probability of mortality. At remote viewing sites, there is a direct conflict with legal grizzly bear hunting (Titus et al. 1994, Alaska Department of Fish and Game 2000), both because of the incompatiblity of the two recreational activities at the same location, and the concern about shooting human-habituated bears. The solution adopted by both the Alaska Department of Fish and Game and the BC Ministry of Water, Land and Air Protection is to close the area at and immediately around the fixed, land-based viewing sites to legal grizzly bear hunting. Unfortunately, the science available for determining the appropriate size of the closed area is uncertain. Decision making in this regard is a combination of biological, public policy and perceptual issues (Titus et al. 1994). One solution is to make the area closed to hunting equivalent to the home ranges of any adult female bear using the viewing area.

Study area	# of user days per active season	# of viewing platforms/ areas	Estimated size of zone of influence (km^2)*	Estimated user days/km^2 per active season	Area closed to hunting (km^2)	# of people permitted at the viewing site	Estimated level of habituation	References
Pack Creek, Stand Price State Wildlife Sanctuary, Admiralty I, Ak	1224 - 1600	1	2	612 - 800	246	24 per day	Moderate	Fagen and Fagen 1994a Fagen and Fagen 1994b Warner 1987
McNeil River State Game Sanctuary, Alaska Peninsula, Ak	790	1	2	395	999	10 per day	Low - moderate[7]	Aumiller and Matt 1994 Alaska Dept of Fish and Game 1996
Anan Creek, near Wrangell, SE Alaska	3000 max	1 + 0.8 km of trail	2.8	1071		20 per viewing session	Low-moderate.	Chi and Gilbert 1999
Brooks Camp, Katmai National Park and Preserve, Alaska	8-14000	2 (main platform at Brooks Falls)	4	2000-3500		40 at one time on Brooks Falls Platform	Moderate	Olsen and Gilbert 1994 Olsen et al. 1997 Olsen et al. 1998
Fish Creek, Hyder Alaska	30-40,000	1 and trail	2	15-20,000		No limit	High	
Khutzeymateen	258	Various	1	250	8345	Maximum	Low in	MacHutchon 1993

[7] Aumiller and Matt (1994) class bear behaviour modification as "wary", "neutral" and "habituated". The authors concluded that the McNeil bears were "neutral", which we have assumed equates to a low - moderate habituation.

Study area	# of user days per active season	# of viewing platforms/ areas	Estimated size of zone of influence (km^2)*	Estimated user days/km^2 per active season	Area closed to hunting (km^2)	# of people permitted at the viewing site	Estimated level of habituation	References
Grizzly Bear Sanctuary, North Coast, BC	(average)					10 people max on the estuary at one time	general, however some highly habituated	Himmer 1996
Khutzeymateen Inlet, North Coast, BC	1700	None	-	Cannot be calculated	8345	No limit	Moderate - high	Geoscape 2001
Glendale Cove, Knight Inlet, BC	3000	1 (are 5 sites, but one receives majority of use)	2	1500	17	Maximum of 50 visitor-viewing periods per day Maximum of 14 viewers during any viewing period. 4 viewing periods per day.	Moderate in general, however some highly habituated	Nevin and Gilbert 2001 Nevin et al 2001

* Zone of influence based on a standard 500 m diameter circle around each viewing platform i.e., equivalent to an area of approximately 2 km^2 (Weaver et al, 1986; Mace et al, 1999; Gibeau et al, 2002)