ECOLOGICAL RELATIONSHIPS BETWEEN GRIZZLY BEARS AND FOREST MANAGEMENT IN THE COAST-INTERIOR TRANSITION OF BRITISH COLUMBIA

2007 YEAR END REPORT
March 31, 2008

PROJECT: 07.W.BRG.03

Prepared for:
Upper St'at'imc Language, Culture, and Education Society

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Prepared with financial support of BC Hydro Bridge Coastal Fish and Wildlife Restoration Program

Executive Summary

Information gathered on grizzly bear abundance, distribution, and habitat use in the Lillooet area is essential for improving our understanding of these Threatened bear populations. Forest management and other development activities can now be properly evaluated against population recovery objectives. This report summarizes the third field season of the multi-year, multi-partner study on grizzly bears designed to collect detailed data on movements, habitat use, and demographics in two study areas: Cayoosh and Whitecap. Twelve GPS-collars were operational in June, 2007. Over 13,530 locations were obtained for these bears. A sample of these locations were visited by experienced field crews to collect site, vegetation, and bear behaviour data. Four collars stopped working earlier than anticipated, but the remaining collars functioned into the fall post-berry season. Further analysis on the full 3-year dataset is required to complete the project objectives as outlined.

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Introduction

The Lillooet area lies near the southwestern edge of the grizzly bear population distribution in British Columbia and includes the Stein-Nahatlatch and South Chilcotin Grizzly Bear Population Units (GBPUs) which are listed as Threatened. This multi-year project has been designed to evaluate several hypotheses related to the impacts of development and other human influences on grizzly bear habitat selection, movement and population trends at this southern fringe. This includes an assessment of a full suite of forestry activities (e.g. roads, harvesting, and silviculture), and the impacts of hydro-electric power generation within the study area. Objectives are being met by the annual monitoring of GPS-collared bears and modelling of habitat values based on spatially-explicit resource selection functions. Increasing the knowledge and information available about grizzly bear populations and their habitats is key to creating better resource management decisions for all resource users and for the St'at'imc Nation.

This project was initiated with a three year BCRP workplan, but has been extended to accommodate the realities of field research on large mammals. The first field season in 2004 was unsuccessful due to a number of technical and administrative difficulties which resulted in no bears being collared. In 2005, five Lotek GPS-Argos collars were used to track 3 female and 2 male bears in the Cayoosh study area. This satellite-linked collar technology was unstable on grizzly bears and little more than 1,000 locations were successfully recorded. Field investigations in 2005 were conducted on approximately 10% of the bear points. The 2006 season was significantly more successful using 10 downloadable Lotek GPS collars (i.e. no satellite links) which resulted in over 13,600 bear locations for the season. Field crews sampled 293 locations to obtain data on bear use sites (147 plots) and habitat availability (146 random paired plots). This report summarizes the 2007 field season which was the third year in which GPS-collared bears have been monitored in the Lillooet area. Population recovery will only occur through acknowledgement of a wide variety of factors affecting viability, and implementation of carefully-designed compensatory activities.

Goals and Objectives

The Lillooet Grizzly Bear Working Group's mission statement is:

> *Empowering local people to participate in grizzly bear population recovery and habitat conservation within the Lillooet area to ensure viable and healthy grizzly populations and habitats across their natural ranges.*

Objective 1: The primary objective is to provide an empirical basis for evaluating current Grizzly bear/forestry guidelines. This necessitates the identification of critical bear habitats and movement behaviors that are also of interest to the restoration activities related to the hydro-electric facilities in the Lillooet area. The data will enhance the quality of resource decisions related to Grizzly bears and will empower decision-makers to employ practical adaptive management approaches (e.g. by applying and monitoring special silvicultural practices to maintain Grizzly bear forage supply at a landscape level). The end result will be greater certainty in planning and decision making for results-based forest management, and healthier Grizzly bear populations.

Objective 2: The project will promote more effective and efficient use of forest resources by ensuring that timber netdowns for Grizzly bear habitat are applied only where necessary to meet population-wide or site-specific objectives.

Objective 3: The project will improve forest practices as they pertain to Grizzly bear conservation, thus potentially increasing market acceptability and market share through provision of a successful model of multiple-use. Empirical information specific to current best management practices and monitoring of appropriate population and habitat targets will enable certification by demonstrating sound species conservation and science-based management practices in a sustainable, adaptive management framework.

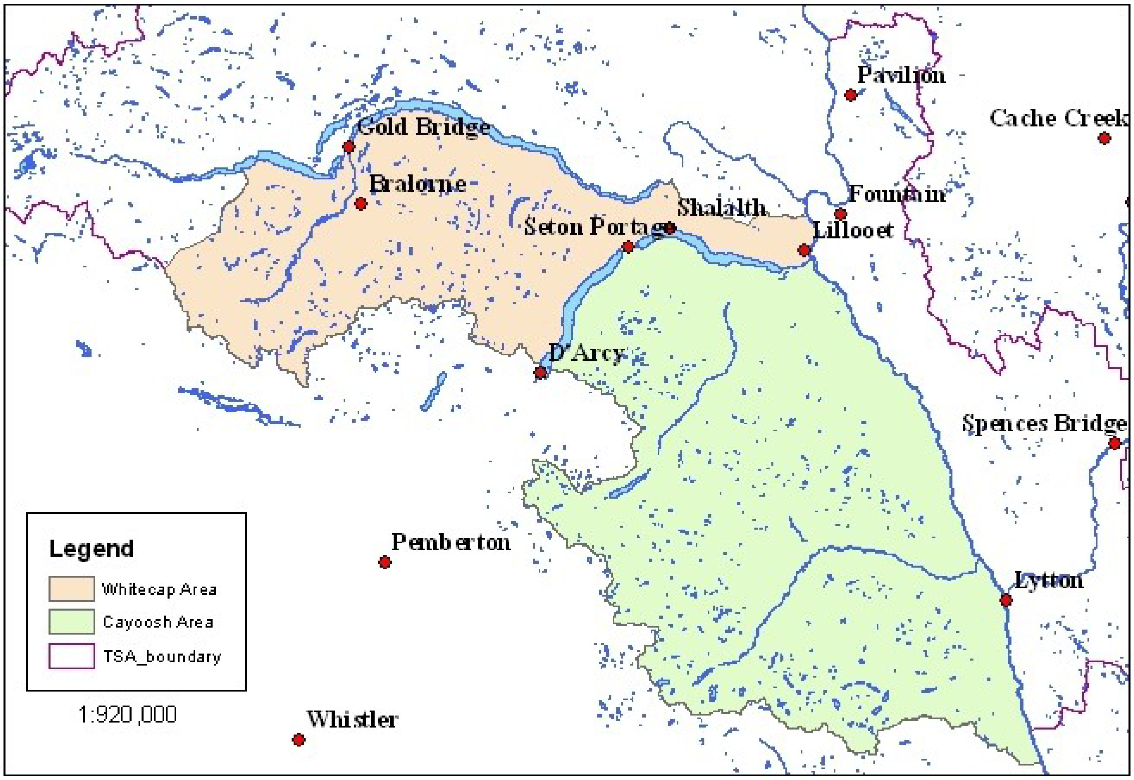
Objective 4: The project will examine historic information about Grizzly bear habitat and populations in the study area with the specific objective of setting appropriate population recovery targets and the potential for mitigative habitat restoration. An understanding current habitat quality, quantity and distribution (as demonstrated by collared animals and examined using habitat mapping) will be used to set the stage for subsequent habitat restoration planning. The focus will be on the change in habitat supply created by the construction of the Terzaghi and LaJoie dams on the Bridge River.

Objective 5: Although the project is centred in the Lillooet area, inferences and products will have broader utility throughout the coastal-interior transition in southern BC. Results will be made available to a wide range of users through continued multi-stakeholder involvement in project oversight, and development of products directed by a comprehensive extension plan that includes guidelines, public presentations and peer-reviewed publication.

Study Area

The study area is within the St’at’imc Territory and is most easily described as corresponding to the Lillooet Timber Supply Area (TSA) of the Cascades Forest District. Habitats represent a coast to interior transition. Bears may be found using everything from the very dry Interior Douglas Fir valley bottoms (e.g. IDFdk2) through the higher elevation Montane and Subalpine Englemann Spruce, Subalpine Fir forests and parkland areas (e.g. ESSFdk2) to the alpine tundra of the mountain tops. Bears have been collared in two main areas: Cayoosh and Whitecap, as illustrated in Figure 1.

Figure 1: Map of the study area showing the two key collaring areas.



Methods

Collared Bears

Spring capture took place from Jun-3 to Jun-6, 2007 due to the heavy snow which precluded an earlier start. Bears with functioning collars from 2006 were located and assessed from the air using a helicopter (Bighorn Helicopters, Hughes 500D). When there were concerns about the 2006 collars, the bear was heli-darted and the collar was checked or replaced. New bears were heli-darted and also fitted with a tracking collar.

Monitoring of bears began May-15, 2007 to take advantage of the 2006 collars that were still functioning. Monitoring flights using a Cessna-337 (Silvertip Aviation) were conducted to download GPS locations approximately every two weeks until Oct-25. Collar locations obtained in each two week period were assessed and a sample was chosen for field visitation. Many factors contributed to the decision regarding which points were chosen, including the number of points obtained in the two week period, the number of sites visited to date per bear, and the distribution of the points per bear. Access restrictions, weather conditions, and the efficiency with which points could be visited also had to be considered during the selection process. If bear use was verified at a GPS location, sampling followed a standard protocol to collect site, vegetation, and bear behavioural information. As in previous years, variables recorded included the identification of all plant species, percent cover and plant phenology, site variables including slope, aspect and ecosystem classification, and bear use descriptions and measurements of feeding, bedding, digging, caching and other bear activities. Analysis of the field data included the determination of bear seasons for each individual based on the bear's activities and movement to certain habitat types with particular food sources. Seasons identified include Herb/Bulb, Early Fruit, Berry, and Post-Berry seasons. This report summarizes the 2007 season for the project. A comprehensive analysis of all three years of field data has yet to be completed.

Forest Resource Management
Field sampling in the Cayoosh study area was conducted again in 2007 to continue investigating the relationship between forest practices, site characteristics, and bear forage production. Openings were chosen to provide a range of ages, forest harvest methods, and silvicultural treatments. An assessment of stocking levels, canopy closure and bear forage response was recorded, and photographs were taken of each site. Notes and photographs were also taken when either the block layout or road design reduced habitat effectiveness for grizzly bears.

A preliminary model of critical spring habitat for grizzly bears was created and a draft class 1 habitat map prepared. Draft revisions to the Best Management Practices (BMPs) developed during the Lillooet Land and Resource Management Plan (LRMP) process were also undertaken. Detailed methodology is contained in the draft document: Best Management Practices: Grizzly bear habitat protection and impact mitigation in the Lillooet Timber Supply Area.

Historic Impact Assessment
Historical information on human settlement and development from 1858 to 1962 was collected from a wide array of sources including Ministry of Mines annual reports, books detailing the gold rush history, museums, photographs, published memoirs of the era, and interviews with knowledgeable individuals. This data was compiled and linked to a recently updated grizzly bear habitat suitability and capability map for the Lillooet TSA. Working at a grizzly bear population scale, changes to the habitat capability, suitability, effectiveness, and mortality risk resulting from the hydro-electric footprint in the Bridge River valley were assessed. Detailed methodology is contained in the report entitled: An assessment of historic human impacts on grizzly bear habitat in the Bridge River Valley, provided in Appendix IV.

Results

Collared Bears
The 2007 field season began with twelve collared bears post-spring capture. Several collars either dropped off the bears or experienced premature low batteries, which affected the total number of locations obtained. The collar used on GM09 had an unanticipated safety-release malfunction and dropped unexpectedly in June. A summary of the collaring history for bears monitored in the study between 2005 and 2007 is provided in Table 1.

Table 1: Collaring history for study animals from 2005 to 2007 in a) Cayoosh study area and b) Whitecap study area.

a) Cayoosh study area

Bear	2005	2006	2007
Females:			
GF1	Two 2-yr cubs	Two COY~	Only 1 cub
GF2	Two 2-yr cubs	Died*	-
GF3	No cubs	No cubs	Died*
GF8	-	-	Two 2-yr cubs
GF9	-	-	No cubs
Males:			
GM1	Collar failure	Collar failure	Collared
GM2	Collar failure	Not recaptured	Not recaptured
GM3	-	Collared-dropped in Oct	Not recaptured
GM5	-	Collared	Collared-dropped in Jun - Not recaptured
GM6	Not collared	Not collared	Not collared
GM7	-	-	Collared

~ COY=Cubs of the Year
* Follow up site investigations in each case indicated natural mortality.

b) Whitecap study area

Bear	2005	2006	2007
Females:			
GF4	-	Three 1-yr cubs	Three 2-yr cubs Collar dropped in Jul
GF5	-	Two 1-yr cubs	Two 2-yr cubs
GF6	-	Two 2-yr cubs	Two COY~
GF7	-	No cubs	No cubs
Males:			
GM4	-	Collared	Collared
GM8	-	-	Collar failure in Jul
GM9	-	-	Collar failure in Jun

Eleven monitoring flights, averaging 2.9 hours each, were used to download the bear collars. This frequent monitoring of collars ensured that the field crew had access to recent GPS locations at which bear behaviours could be recorded (i.e. recent sign of bear use.) Overall, the GPS collars averaged a 74% fix rate in the Cayoosh study area and an 80% fix rate in the Whitecap study area for 2007. A three-year summary of locations by bear by study area is provided in Table 2.

Table 2: Summary of the total GPS-locations obtained to date for the project by study area.

Bear_ID	**3D**			**3D Total**	**2D Total (all years)**	**Grand Total**
YEAR:	2005	2006	2007			
GF1	201	756	483	1440	345	1785
GF2	414			414	101	515
GF3	350	2128		2478	644	3122
GF8			541	541	69	610
GF9			705	705	154	859
GM1	28	301	2300	2629	449	3078
GM2	17			17	26	43
GM3		1902		1902	540	2442
GM5		516	95	611	213	824
GM7			602	602	161	763
Cayoosh Total:	1,010	5,603	4,726	11,339	2,702	1,4041
GF4		2663	1233	3896	801	4697
GF5		848	520	1368	303	1671
GF6		1338	3063	4401	442	4843
GF7		676	556	1232	270	1502
GM4		2544	2824	5368	1091	6459
GM8			472	472	70	542
GM9			136	136	51	187
Whitecap Total:	0	8069	8804	16873	3028	19901
Grand total:	**1,010**	**13,672**	**13,530**	**28,212**	**5,730**	**33,942**

The field crew (Michelle McLellan, Bryce Bateman, Yvonne Patterson and Robin Steenweg) conducted site investigations at 184 grizzly bear use and 179 random-paired locations. The Herb/Bulb season in 2007 was longer than in past years, lasting from early April until mid-June for some Whitecap area bears, and until early September for some Cayoosh area bears. The early fruit season was absent for all but three of the Whitecap area females that were feeding heavily on Saskatoons (*Amelanchier alnifolia*). The Berry season, which is normally defined by a shift onto *Vaccinium spp*., was later and shorter than in past years, with only four bears known to have used this food source in 2007 (i.e., there were few berries available). Many bears shifted directly onto Post-

Berry food sources which included digging for bulbs and feeding on Whitebark pine nuts (*Pinus albicaulis*) either by climbing trees to access the cones directly (Figure 2), or by excavating squirrel middens. Grizzly bears fed on a variety of mammals in 2007 including ungulates (moose, deer, mountain goats), black bears, marmots and even voles.

Figure 2: Yvonne Patterson collecting hair from a Whitebark pine tree branch where a female bear had been climbing to access cones.

Forestry Resource Management
Twenty seven openings were visited and examined in 2007, for a total of nearly 70 openings for two years. In general, harvested stands in the wetter ecosystems of the Cayoosh study area retain bear forage production for up to 25 years or more, when forest canopy gaps are sufficiently large within the block to enable berry shrubs to grow and fruit. In several cases where forests adjacent to high value bear forage areas were harvested, it would have been possible to maintain the habitat effectiveness of the forage area if a wider old growth buffer had been left between the opening and the feeding unit. Changes to the way in which block edges are managed (e.g. by ensuring an adequate buffer remains between the opening and the forage unit) are one example of how the revised BMPs can improve forest resource management. At the time of writing this report, the critical habitat map and draft BMPs were still undergoing intensive review and revision, with the intent that the initial areas for critical habitat protection will be identified in 2008/09 for inclusion in a Forest and Range Practices Act (FRPA) Section 7 Order.

Historic Impact Assessment
Over 600 records were used to build an understanding of the human settlement and development impacts in the Bridge River Valley from 1858 to 1962. The impact assessment analysis demonstrates that the flooding of the valley permanently removed highly capable grizzly bear habitat, which had included salmon, ungulates and areas of rich riparian vegetation, and that these losses were incurred by a bear population already in decline as a result of human settlement and mining in the valley.

Discussion

The 2007 field season was very successful and nearly doubled the point location data available on grizzly bears in the Lillooet area. There are some concerns, however, that data gaps preclude a robust habitat selection analysis at this time, despite the volume of data for 2006 and 2007. These gaps have arisen from 1) malfunctioning collars, such that only partial data is available for some animals, and 2) the overall small sample of bears being used to generate results such that some age and sex classes are poorly represented (e.g. only one year – 2007 – has a complete annual dataset of adult male bear locations in the Cayoosh study area). More time is required to properly assess the composition of the 3-year dataset and to conduct preliminary resource habitat selection function analyses.

The process of identifying critical grizzly bear habitat has been initiated. It is expected that this will result in the first habitat protection orders for grizzly bears in the Lillooet area in the 2008/09 fiscal year. Because the efficacy of the habitat map and BMP revisions relies to a large extent on the cooperative implementation of the strategies by forest resource managers, care is being taken to generate as much initial support as is possible with our forestry partners. That means that a draft BMP document has yet to be released for general comment while the details of the map and BMPs are still being crafted.

The historic impact review for the footprint area has been completed and the report provided to BCRP. Work on historic issues, however, will continue to improve our understanding regarding the impacts of road development, forest seral stage distribution, and prey species distribution changes including salmon over the last 150 years. As our understanding of historic impacts improves, changes to recommended mitigation and restoration activities will be forth coming.

Overall, tracking grizzly bears with GPS collars and conducting intensive field investigations of habitat use has greatly improved our understanding of grizzly bears in the study area. Continued technical problems with collar operation and the resulting dataset have slowed down our original delivery timeline for resource selection functions. It was overly optimistic to suggest that the analysis on the full three year dataset could be completed in the same time frame as the summary of the 2007 field season. Similarly, the process of revising the best management practices for forestry has also been contingent upon initial summaries of the project data, which have taken longer to produce than originally anticipated. The three-year dataset has been compiled by Chris Ens, GIS-specialist for the Integrated Land Management Bureau, Kamloops, which includes assigning each data point an elevation, aspect, predictive ecosystem unit, road density class, and other key attributes which will be used to build the resource selection functions. These functions will have improved reliability because of the information synthesized from over 384 bear use site investigations. The bear locations have also been assembled into a movement path dataset for each bear which will become part of the home range analysis yet to be completed. Work on these final products will continue with the expected goal of publishing the results in peer-reviewed journals as the various components are completed.

Recommendations

Completion of the original project objectives is required to provide a comprehensive understanding of bear habitat use in relation to forest management practices. Applications for project continuation and for the development of a burning plan to mitigate bear habitat impacts from the hydro-reservoirs were rejected at the technical review stage by BCRP. Renewed support from this agency with respect to grizzly bear population recovery is recommended.

Much work remains to be to recover the Stein-Nahatlatch and South Chilcotin GBPUs. Future directions should include implementation of the recommended strategies from the reservoir footprint impact analysis, continued GPS-monitoring of grizzly bears to improve the age class, sex and spatial distribution of the dataset, and the development of objectives to address climate change, Mountain Pine beetle, and other habitat impacts likely to put increasing pressure on these small bear populations and their remaining habitats.

Acknowledgements

The following people participated as members of the Lillooet Grizzly Bear Working Group (GBWG) in 2007/08:
Chief Larry Casper, Seton Band
Tony Hamilton, Large Carnivore Specialist, Ministry of Environment
Sue Senger, Landscope Consulting Corp., Project Coordinator
Bruce McLellan, Research Ecologist, Ministry of Forests
Clayton Apps – Associate Member – Aspen Wildlife Research, DNA project lead
Don Brown – Associate Member – Ainsworth LP, Forest Planner
Michelle McLellan, Field Crew Leader
Bryce Bateman, All Relations Wildlife Research, Field Crew Member
Yvonne Patterson, Field Crew Member
Robin Steenweg, Field Crew Member

GIS-Analyst:
Chris Ens, Integrated Lands Management Bureau, Kamloops

Pilots:
Clay Wilson, Bighorn Helicopters
Dave Mahr, Silvertip Aviation

Funding and in-kind contributions for all Grizzly bear projects underway were received from the following supporters:
Upper St’at’imc Language, Culture, and Education Society
Lillooet Tribal Council
Lillooet TSA Association
BC Hydro Bridge Coastal Fish and Wildlife Restoration Program
Habitat Conservation Trust Fund
Ministry of Environment
Ministry of Forests
Squamish-Lillooet Regional District
Bridge River Lillooet Newspaper
St’at’imc Runner Newspaper

Appendix I: Financial Statement

	Budget		Actual	
	BCRP	Other	BCRP	Other
Income				
Total Income by source	$106,616.00	$123,000.00	$106,616.00	$132,000.00
Grand Total Income	$229,616.00		$238,616.00	
Expenses				
Project Personnel				
Consultant Fees	$101,116.00	$36,000.00	$101,116.00	$38,884.00
Materials & Equipment				
Misc. Equipment		$16,060.00		2188.36
bear collars		$15,000.00		$14,722.13
Heli/pilot/fuel		$27,000.00		$21,352.95
fixed wing		$28,940.00		$32,672.39
Travel expenses				$7,977.65
Administration				
accounting, space, phone:	$5,500.00		$5,500.00	
Total Expenses	$106,616.00	$123,000.00	$106,616.00	$117,797.48
Carryover for collar repairs for 2008			$14,202.52	
Grand Total Expenses	$229,616.00		$238,616.00	
Balance	$0.00		$0.00	

Appendix II: Performance Measures-Actual Outcomes
Project:#06.W.GRB.05

Performance Measures – Target Outcomes													
			Habitat (m^2)										
Project Type	**Primary Habitat Benefit Targeted of Project (m^2)**	**Primary Target Species**	Estuarine	In-Stream Habitat – Mainstream	In-stream Habitat – Tributary	Riparian	Reservoir Shoreline Complexes	Riverine	Lowland Deciduous	Lowland Coniferous	Upland	Wetland
Impact Mitigation													
Fish passage technologies	Area of habitat made available to target species												
Drawdown zone revegetation/stabilization	Area turned into productive habitat												
Wildlife migration improvement	Area of habitat made available to target species	Identification of barriers to movement											
Prevention of drowning of nests, nestlings	Area of wetland habitat created outside expected flood level (1:10 year)												
Habitat Conservation													
Habitat conserved – general	Functional habitat conserved/replaced through acquisition and mgmt	Assessment of footprint impacts strategies - recommended for mitigation											
	Functional habitat conserved by other measures (e.g. riprapping)												
Designated rare/special habitat	Rare/special habitat protected												
Maintain or Restore Habitat forming process													
Artificial gravel recruitment	Area of stream habitat improved by gravel plmt.												
Artificial wood debris recruitment	Area of stream habitat improved by LWD plcmt												
Small-scale complexing in existing habitats	Area increase in functional habitat through complexing												
Prescribed burns or other upland habitat enhancement for wildlife	Functional area of habitat improved												
Habitat Development													

New Habitat created	Functional area created											

Appendix III: Confirmation of BCRP Recognition

Eight presentations on this project were provided in the 2007-08 fiscal year, and all funding sources are acknowledged during these events. Newspaper updates and advertisements for sighting record contributions were provided in the Bridge River Lillooet Newspaper and the St'at'imc Runner. Although funding agencies are always recognized during interviews, newspaper article content is at the discretion of the editors.

BCRP was explicitly listed as a funding agency on the project poster presented at the International Bear Association Conference in Monterrey Mexico, Nov 2007. Ongoing community interactions are vital to the success of grizzly bear management in the Lillooet area and all team members participate in promoting bear issues within their various networks.

Appendix IV: A Preliminary Assessment of Historic Human Impacts on Grizzly Bear Habitat in the Bridge River Valley

A PRELIMINARY ASSESSMENT OF HISTORIC HUMAN IMPACTS ON GRIZZLY BEAR HABITAT IN THE BRIDGE RIVER VALLEY

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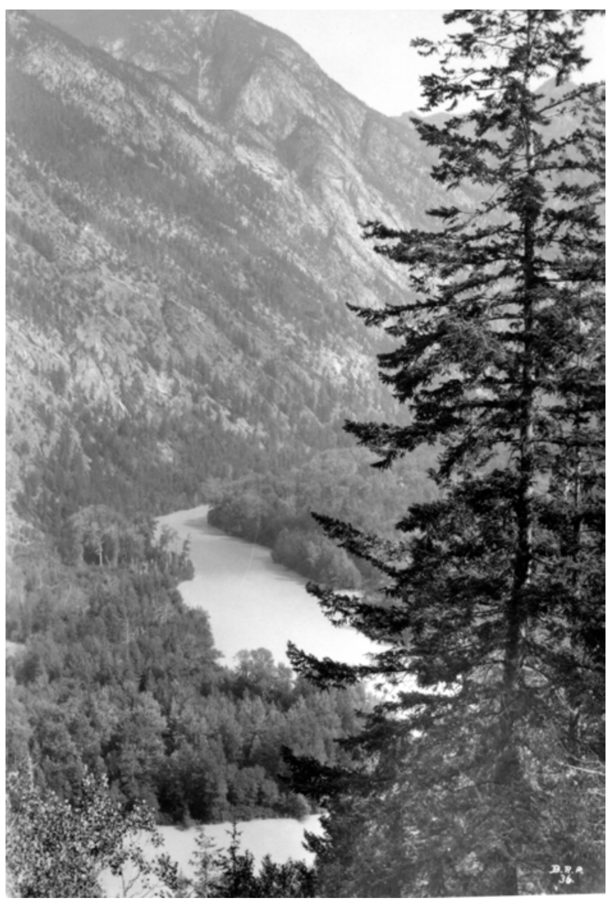

Prepared with financial support of BC Hydro Bridge Coastal
Fish and Wildlife Restoration Program and Habitat Conservation Trust Fund

Executive Summary

Grizzly bear populations in the Stein-Nahatlatch and South Chilcotin Grizzly Bear Population Units are listed as Threatened by the provincial government. Understanding the factors that have affected these populations over time is critical to setting realistic recovery targets for these areas. Human-caused changes occurring from 1858 to 1962 in and around the Bridge River valley, including the hydro-electric development, were summarized and mapped using a wide variety of historical information sources. The resulting impacts on grizzly bear habitat capability, suitability, effectiveness and mortality risk were assessed for five twenty-year time intervals, with particular emphasis placed on examining the footprint impacts of the Carpenter and Downton reservoirs.

Our analysis demonstrates that the grizzly bear population had already been significantly affected by the time the valley was fully flooded (1960). However, full flooding of the reservoirs permanently removed the high capability habitat from this landscape. Impacts were disproportionately high for female grizzly bears that used the Bridge River valley bottom as part of their home ranges. This magnified population impacts by precluding future female reproduction from the valley bottom home ranges.

The critical habitats lost to the hydro-electric footprint cannot be recovered. All mitigation and habitat restoration activities should be based on a cumulative effects framework that fully considers the positive and negative consequences to grizzly bear recovery of any further changes to the Bridge River and its tributaries. Recommended mitigation strategies include the development and implementation of the cumulative effects framework, bear-human conflict prevention in all communities, high elevation burning to restore alternative habitats for bears, minimizing motorized access, and improving prey species habitats. The Bridge River impoundments, and the human influences that preceded them, cumulatively affected grizzly bear population viability. Population recovery will only occur through acknowledgement of these influences, and implementation of carefully-designed compensatory activities.

Cover photo: Bridge River pre-development, 1921, courtesy of BCRP

Acknowledgements

We wish to thank all of the funding agencies that have supported the Lillooet Community Grizzly Bear Inventory Project including: BC Hydro Bridge Coastal Fish and Wildlife Restoration Program, Habitat Conservation Trust Fund, Integrated Land Management Bureau, the Lillooet TSA Association, the Lillooet Tribal Council Tech Committee, Upper St'at'imc Language Culture and Education Society, Squamish Lillooet Regional District, and the Fraser Basin Council.

This report would not have been possible without the assistance of the Lillooet Museum and the Lillooet District Historical Society, particularly Susant Bell; the Clinton Museum and the Clinton Historical Society, particularly Mike Brundage, and the Bralorne Pioneer Museum and the Bralorne Pioneer Museum Society. Individuals who contributed significantly to this report by sharing their knowledge of specific places or events include Phil Branca, Chris Kind, Aggie Alexander, Albert Joseph, Fred Shields, Michelle Edwards, Randy James, Tim Cody, Burt Klineburger, and Bain Gair. We also want to thank all the members of the bear team for their contributions over the years: Larry Casper, Bruce McLellan, Don Brown, and Clayton Apps. Further, we wish to fully acknowledge and thank our excellent field team: Michelle McLellan, Bryce Bateman, Yvonne Patterson, Robin Steenweg, Rhys Walter, and Carla Brown. Michelle provided preliminary summaries of the field data that we used to inform our decisions about revised habitat suitability ratings. Although we did all of the GIS work for this analysis ourselves, we also wish to credit Chris Ens, Kamloops ILMB GIS operator extrodinaire, for his continued GIS mentoring and for providing essential datasets we used in our analysis.

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Introduction

Grizzly bears in the Stein-Nahatlatch and South Chilcotin Grizzly Bear Population Units (GBPUs) in the Lillooet area are listed as Threatened (Hamilton *et al.* 2004). Recent population studies suggest that the bears may be genetically isolated from each other and from neighboring GBPUs (Apps *et al.* 2007). Potential causes of the low population and apparent genetic isolation include habitat loss, habitat fragmentation, displacement and mortality (McLellan 1998). It is generally accepted that the flooding of the Bridge River Valley (BRV) to develop hydro-electric power contributed to the loss of habitat for many species in the Lillooet area, including grizzly bears (BC Hydro 2002). However, a better understanding of the habitat changes resulting from the hydro developments - in their historical context - will enable a more comprehensive approach to habitat restoration and mitigation activities, including mortality risk reduction.

The quality, quantity and distribution of grizzly bear habitats that existed in the past cannot be fully quantified, but can be modelled through retrospective analysis by applying our current knowledge of grizzly bear habitat requirements to historic information about the area. There are four evaluations of habitat status that are currently used for bears:

1) **Capability** is the idealized ability of any one location or ecosystem to support bears - if the ecosystem is forested, the highest capability is typically assigned to the seral stage (age) that has the most vegetative forage in the forest understory;

2) **Suitability** is the current ability of any one location or ecosystem to support bears - again, if the ecosystem is forested, it is the value of the current seral stage;

3) **Effectiveness** is the current "useability" of the habitat, that is, it's suitability combined with an assessment of human displacement - for example, a patch of habitat between two lanes of a divided highway may be highly suitable, containing abundant bear food, but it is extremely ineffective because of its isolation created by the traffic on the highway; and, finally,

4) **Mortality risk** is a relative measure of how likely grizzly bears using any one location are going to be: a) shot in defense of life or property or b) shot illegally, either as a perceived threat or poached by illegal hunting. Mortality risk has a direct relationship with the frequency of bear-human encounters, and the “lethality” of those encounters.

Habitat capability is seldom changed except under permanent roads, buildings, or water impoundments, but suitability, effectiveness and mortality risk can change dramatically. Because grizzly bears are long-lived, have large home ranges, and depend upon a wide variety of foods, it would have been insufficient to simply examine the habitats beneath the footprint of the reservoirs when considering the impact of the hydro development on the bear population. The value of the habitat within the footprint was considered in the context of the surrounding habitats and the concurrent changes happening throughout the area. This larger scale better reflects the population-level impacts that resulted from development.

This report meets Objective #4 from the BRCP project #06.W.BRG05

Goal

To retrospectively examine landscape-scale changes in grizzly bear habitat capability, suitability, effectiveness and mortality risk in the context of the settlement of the Bridge River Valley and the subsequent development of hydro-electric power [ca. 1858-1960].

Objectives

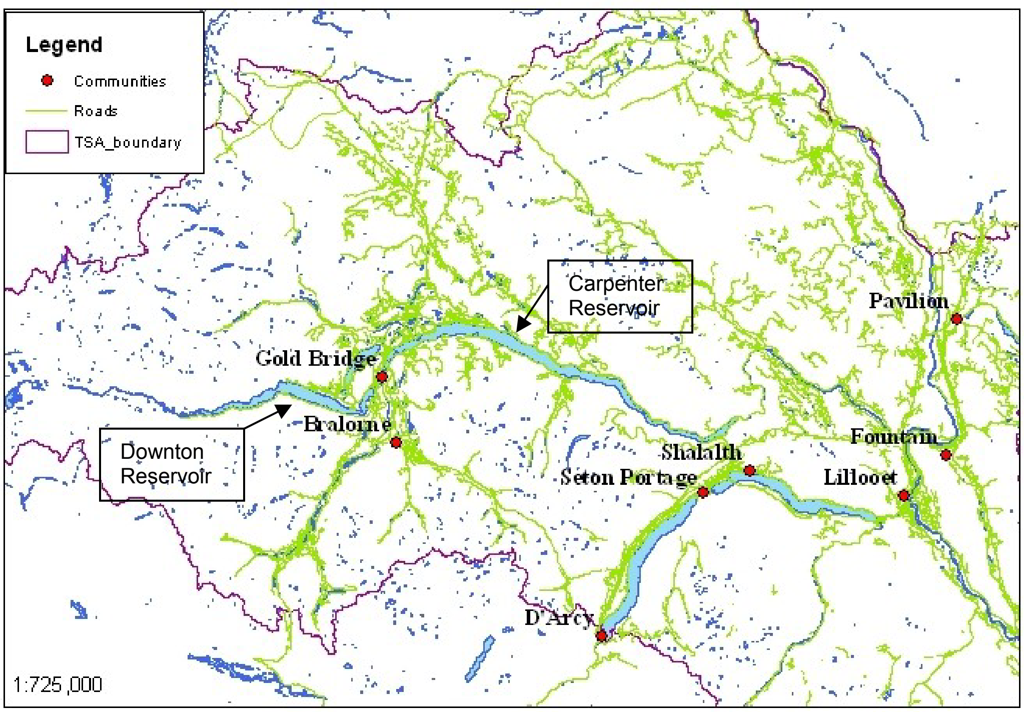
The objectives of this report are:

1. To provide a summary of the key impacts to grizzly bear habitats that occurred as the Bridge River Valley became developed [ca. 1858-1960] and relate these impacts to existing spatially-explicit habitat mapping for grizzly bears.
2. To evaluate the change in historic habitat capability, suitability, effectiveness and mortality risk of the hydro-electric footprint in the Bridge River Valley.
3. To use this analysis to provide direction for mitigative habitat restoration and population recovery targets for grizzly bears.

Study Area

The study area lies within the St'at'imc Territory and the Lillooet Timber Supply Area (TSA). The habitats available vary from very dry Interior Douglas Fir Valley Bottoms (e.g. IDFdk2) through the higher elevation montane and subalpine Englemann Spruce Subalpine Fir forests and parkland areas (e.g. ESSFdk2) to the alpine tundra of the mountain tops.

Figure 3: Map of the study area showing the locations of current communities and roads.



Methods

Data Compilation

Historical information on human settlement and development from 1858 through to the early 1960's was collected from a wide array of sources including Ministry of Mines annual reports, books detailing the gold rush history, museums, photographs, published memoirs of the era, and interviews with knowledgeable individuals. This information was assigned to one of the following categories: Mining, Human settlement, Agriculture, Roads, Hydro, and Forestry and entered into a master MS-Access relational database. For example, the number of men working on a given mining crew was assigned to the Mining category. References to the crops grown on particular farms were assigned to the Agriculture category, and so on. Whenever possible, each record was also assigned to a specific reference point on the study area map to enable a spatial representation of the data in a Geographic Information System (GIS). Many of these locations came directly from historic maps obtained while searching for data, and others were determined from the descriptions provided in the text. Information that was relevant to grizzly bears but not directly related to human use, such as references to the condition of forests, locations of ungulate herds or fish runs, and direct references to bears were coded in the database as Habitat, Wildlife, Fish, and Bears respectively.

Records were assigned to one of five twenty-year non-overlapping time intervals (time steps), starting at 1858 and ending with 1962. Specific locations with multiple entries per time step were then amalgamated into a single database row. For example, five references to a particular farm recorded between 1900-1920 became one entry for the farm in the time step linked to an x-y coordinate associated with the farm's location as read from a historic map. A preliminary assessment of the potential positive and negative influences of these activity records on grizzly bear habitat capability, suitability, effectiveness and mortality risk were assigned at this stage of the database development. To continue with the farm example, this preliminary assessment was developed as follows: habitat capability is generally unaffected by a farm (nil), but habitat suitability is often improved by land clearing which creates more open canopy areas and irrigation which improves vegetation and bear forage opportunities (+). Alternatively, habitat effectiveness is reduced by human activity, increased access, and displacement from this improved habitat (-), and mortality risk becomes extremely high with farmers defending their livestock (+risk). Once this temporal summary was completed for the entire database, the historic records were ready to link to the grizzly bear habitat suitability map for the study area.

A point-over-polygon approach using ArcMap 9.2 (ESRI Inc., Redlands, CA, USA) provided the intersection between the historic records (points) and the bear habitat suitability map (polygons). Where points landed on the edge of suitability polygons, a 500m buffer around each location was created. Polygons with minimal overlap with a buffered location were discarded. However, where the buffer overlapped a significant area of an adjacent suitability polygon, that whole other polygon was considered affected by the human influence and was included in the analysis.

Once the final selection of affected polygons was completed, the degree to which any given polygon was influenced by human use or development was determined by examining the number, type, and distribution of human influences within the polygon. Remaining polygons were assumed to be functionally naturally. Each human-influenced polygon began with 100% capability, 100% suitability, 100% effectiveness and 0% mortality risk unless there was a known impact pre-1858 that may have already influenced bears (e.g. native settlement). The percentage change in each of these factors was then estimated in a subjective process known as "stepping down" the polygon to account for the human-created change. Polygons with multiple influences distributed throughout the polygon were assigned higher percentages of change than when the impacts were localized in only one part of a large polygon. The intent was to consistently assess the impacts, create the percentage of change, and then use this percentage to simulate changes in habitat class or mortality risk.

Class maps for habitat capability, suitability, effectiveness and mortality risk were created using a standard classification system for assigning wildlife habitat ratings (Table 1). The initial capability and suitability classes assigned to each polygon were based on a revised habitat suitability/ capability map from the Lillooet LRMP. All classes were initialized with the midpoint value for the class range (Table 1). The stepdowns of the four factors over time were then simulated by multiplying the percentage change between time intervals by the class value. The results of these calculations for each time step were then translated back into classes using the limits set in Table 1. For example, a class 1 capability polygon that began with the mid-point value of 87.5 would only drop to a class 2 rating when the percentage impact calculation fell below 74.9 (e.g. a 15% impact). Keeping the broad class structure (ranges of 25 percentage points) enabled mapping of stepdowns for any one time interval and provided a credible means of simulating relative approximations of human impacts consistent with the quality of the information available. More precise assignments of absolute changes could not be obtained from the historical information.

Footprint Impacts

The footprint of the hydro-electric reservoirs in the BRV is represented by a single large lake polygon on the Broad Ecosystem Inventory map used to assign capability and suitability (QBEI_TAG=031_48169). Therefore, there was no starting suitability and capability class for this polygon on the existing map (i.e. lakes are not rated). To correct for this, the starting class for this polygon was set to class 1. Data collected suggested that this polygon contained a salmon run to Tyaughton Creek, was prime riparian habitat with regular oxbows (i.e. areas of slower water, bogs, and marshes), contained ample forage and winter range for ungulates, had abundant small mammals including beaver (occasionally important as bear food), and was recognized as a wildlife movement corridor. Data from GPS-collared bears in the study area today confirms that male bears track rich riparian areas in search of food (BCRP Project# 06.W.BrG05). The wide valley-bottom riparian habitat is also a relatively rare habitat type in the study area, indicating that it warranted a higher class rating than the steeper and drier habitats around it. Specific human influences that were known to have occurred within the footprint of the reservoirs (e.g. several farms, the community of Minto, a sawmill at the mouth of Tommy Creek, etc.) were assigned locations as if the reservoirs did not exist. Again, historic maps were used to locate the impacts as accurately as possible. The summary process of assessing the impacts of these specific influences was identical to the process described above.

Figure 4: Hunting Guide W.C.G. Manson with a trophy bear, circa 1900-1920

Courtesy of the Lillooet District Historic Society

Table 3: Class rating system used in this analysis. Initial class values for each polygon were assigned as the midpoint value of the class percentage range and the calculation limits were used to determine when a change in class occurred.

Class	Interpretation	Percentage Range	Midpoint Value	Limits
1	Very High	75-100	87.5	>74.9
2	High	50-75	62.5	>49.99 and <75
3	Moderate	25-50	37.5	>24.99 and <50
4	Low	5-25	15.0	>4.99 and <25
5	Very Low	1-5	2.5	>0.99 and <5
6	Nil	0	0	<0.99
unk	unknown	-	999	>100

Results

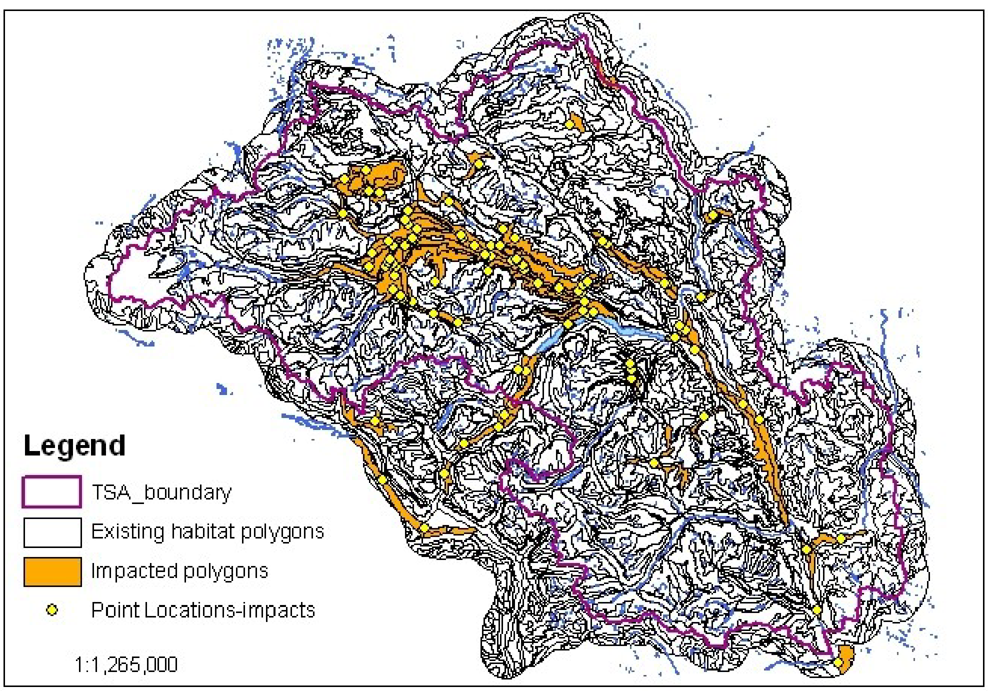
The amount of information collected on each stepdown factor varied between time steps. Approximately 670 records of historic human influence were assembled for a spatial analysis of impacts on habitat capability, suitability, effectiveness and mortality risk (Table 2). It should be noted, however, that this analysis focused primarily on vegetation. It was not possible to spatialize the protein availability (e.g. the ungulate or other prey species distribution) in the form of a “meat map” at this time. Similarly, although detailed information was collected on human travel corridors, trails and roads, it was not possible to spatialize that data set at this time. The information on prey species, roads and seral stage distribution were only included heuristically.

The first point-over-polygon assessment of the data resulted in 66 habitat polygons flagged as affected by significant levels of human influence. This increased to 92 polygons following the point buffering. The location of the identified polygons relative to the existing habitat suitability mapping for grizzly bears is shown in Figure 3. Because the objective of this analysis was to identify the historical context of the hydro-electric development in the BRV and its impacts to grizzly bears, the results presented here focus specifically on changes in the footprint polygon in the context of surrounding impacts.

Table 4: Summary of the number of data points available by 20-year time steps for each impact factor. The condensed point row indicates the total number of data points remaining after data were temporally condensed as described in the methods.

Time Step	**1**	**2**	**3**	**4**	**5**	Total
	1858 -1878	1879 -1899	1900 -1920	1921 -1941	1942 -1962	
Impact Factor:						
Agriculture	4	5	15	2	22	48
Forestry	0	0	4	0	10	14
Human settlements	10	2	13	25	36	86
Hydro	0	0	1	6	10	17
Mining	2	61	182	95	15	355
Roads	7	6	39	8	22	82
Total Points:	23	74	254	136	115	602
Total Condensed Points:	11	29	51	41	47	179
Other Data:						
Bears	1	0	4	4	9	18
Fish	0	0	2	0	8	10
Wildlife	0	0	2	1	27	30
Habitats	0	0	0	0	10	10
Total Other Data:	1	0	8	5	54	68

Figure 5: Map showing the location of polygons identified as having historical impacts relative to the remaining habitat polygons contained on the existing provincial habitat suitability map.



The Reservoir Footprint Polygon

Changes occurring within the reservoir polygon from 1858 through to 1962 are summarized in Table 3, including the initial assessment of the percentage change in impact and the resultant class category changes over time. A detailed accounting of each of the variables is provided below, but only selected maps are provided in the figures. A full set of maps for each twenty year period for each variable examined are provided in Appendix 1. The same rating system and color scheme is used in all four cases, therefore, for habitat capability, suitability and effectiveness class 1 is the best-case scenario for bears, while for mortality risk a class 1 rating is the worst-case scenario.

Habitat Capability

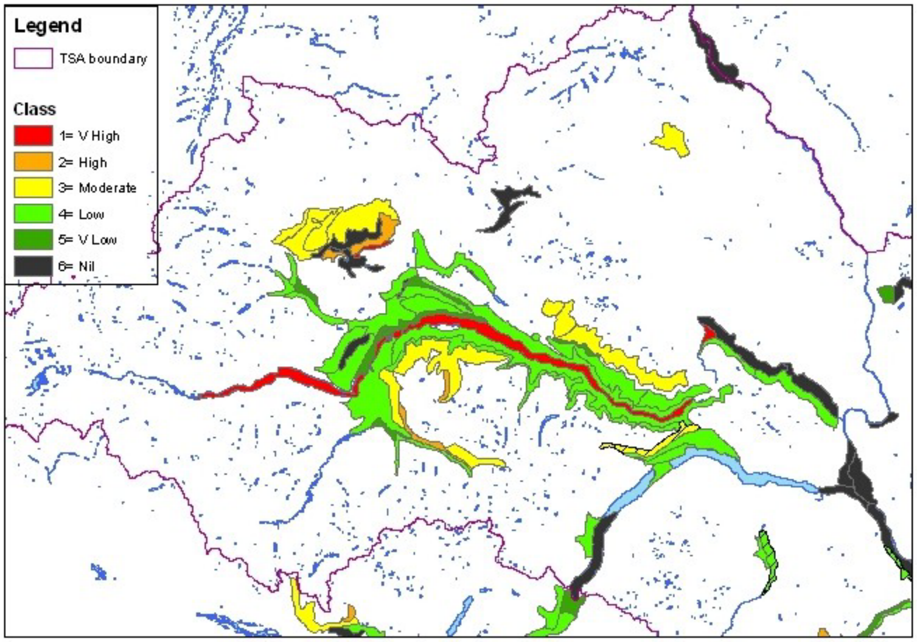
The reservoir polygon began with a class 1 (Very high) capability rating. This rating did not change substantially until the 1921-1941 period when substantial building of settlements and related road began. The polygon dropped to a class 2 (High) at this point and then down to class 4 (Low) by the 1942-1962 period through the progressive loss of habitat under the expanding impoundment. The footprint polygon would be rated as class 6 (i.e., Nil or no habitat value) by the year 1960 when the area was fully flooded, but because there was partial habitat capability throughout most of the time step the resulting classification over the entire period was averaged to class 4. The first major change in habitat capability class is illustrated in Figure 4.

Table 5: Illustration of how the assigned percentage change in capability (CAP), suitability (SUIT), effectiveness (EFFECT) and mortality risk (MORT) translates into the class stepdowns for the footprint polygon. The impact summary column provides some of the key factors which influenced the magnitude of the percentage change assigned in each time step.

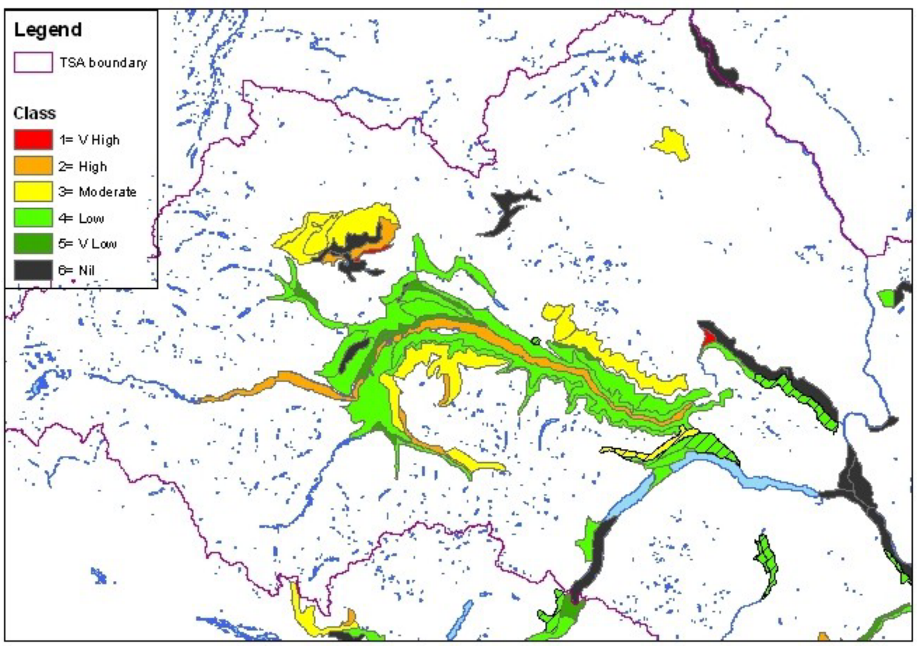
Assigned Percentage of Change for:					Class Stepdowns:				Impact Summary
Time Step	% CAP	% SUIT	% EFFECT	% MORT	CAP	SUIT	EFFECT	MORT	
initial					1	1	1	0	
1858-1878	100	90	20	80	1	1	4	1	Placer mining & exploration (e.g. 200+men in 1859)
1879-1899	100	90	20	90	1	2	5	1	Mining exploration & staking continues, 3 large farms
1900-1920	95	80	10	90	1	2	0	1	Mining, farms, auto traffic in the valley started 1912.
1921-1941	90	60	10	90	2	3	0	1	Hydro work start 1931, Minto has 300 residents in 1936, Farms, diversion dam, logging
1942-1962	30	40	10	70	4	4	0	2	Farms until at least 1949, sawmill at Tommy Ck, LaJoie completed, Terzaghi completed.

Figure 6: The first major change in historic capability for the footprint polygon can be seen by the difference in polygon classification between a) the 1900-1920 map (class 1) and b) the 1921-1941 map (class 2). [scale is 1:725,000]

a)



b)



Habitat Suitability

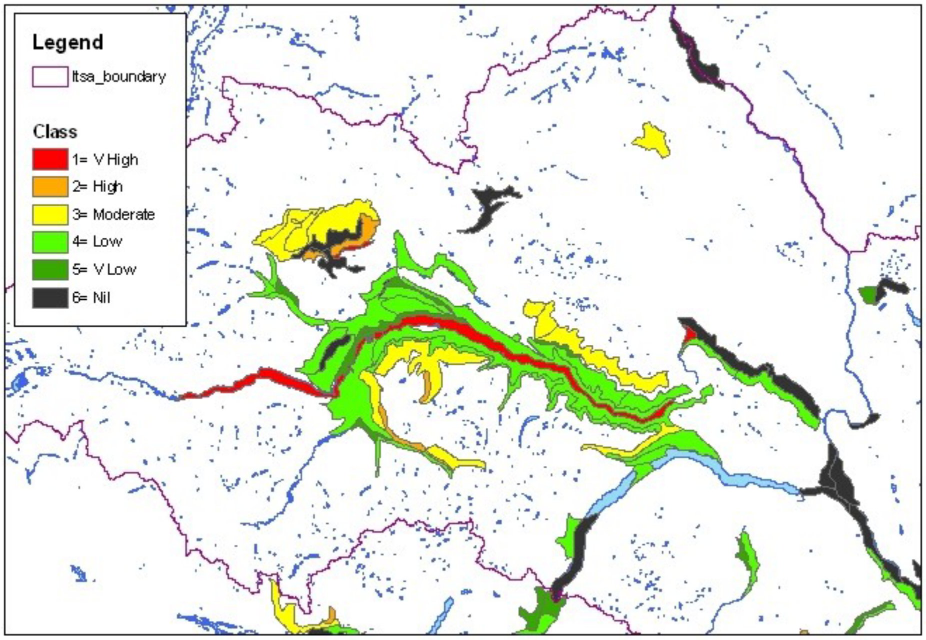
The footprint polygon was initially assigned class 1 (Very high) suitability status but had a 10% reduction in the first time step due to the placer mining and exploration activity throughout the valley bottom. This level of impact, however, does not alter the habitat suitability rating in the 1858-1878 period (e.g. Table 3. mid-point value of class 1 = 87.5 x 90% = 78.9% which is still class 1). The suitability rating drops to class 2 by 1879-1899 as a result of the continued development of the valley bottom with suitability gains from the farms offset by suitability losses due to mining activities. By the third time step (1900-1920) the loss of habitat directly to human settlement grew. By 1921-1941, these impacts were substantial, with communities like Minto (300 people in 1936) directly within the footprint polygon, dropping the polygon to class 3 (Moderate). Partial flooding of the valley to Cedarvale Creek occurred with the completion of the diversion dam in 1948 (BC Hydro 2002), which ended the salmon run in the upper watershed. By 1960 when Terzaghi dam was completed, the polygon was rated as class 6. Thus the overall ratings for the entire last time step was class 4 (Low) due to the partial habitat suitability that existed for much of this twenty-year period. Habitat suitability dropped to zero post-1962 since none of the original riparian habitat remained. The first major change in habitat suitability is illustrated in Figure 5.

Habitat Effectiveness

The reservoir footprint polygon was initially assigned 100% habitat effectiveness, however, it was assessed as having very low effectiveness (only 20%) in the first time period due to the extensive mineral exploration at the start of the gold rush. This dropped the polygon to a class 4 (Low) status in the 1858-1878 period. The displacement caused by the exploration activities was considered to be so high because of the number and distribution of the activities throughout the valley bottom, and the low tolerance for predators shown by people of that era. The effectiveness of the polygon continued to decline as people settled in the area and as automobile traffic began to flow through the BRV starting in 1912. While the previous figures have shown that the habitat capability and suitability remained quite high through to 1920, the probability that grizzly bears were using that habitat frequently was small due to the extensive human presence in the area. One local resident who lived on a farm now beneath the reservoir told of an incident where a grizzly bear was drawn to a deer carcass her father had hung and how her father and brothers drove the bear away. This is just one example of the type of displacement and bear-human interactions that would have occurred in the footprint polygon. The shift in habitat effectiveness between 1879-1899 and 1900-1920 is illustrated in Figure 6.

Figure 7: The first major change in historic suitability for the footprint polygon can be seen by the difference in polygon classification between a) the 1858-1878 (class 1) map and b) the 1879-1899 map (class 2). [scale is 1:725,000]

a)



b)

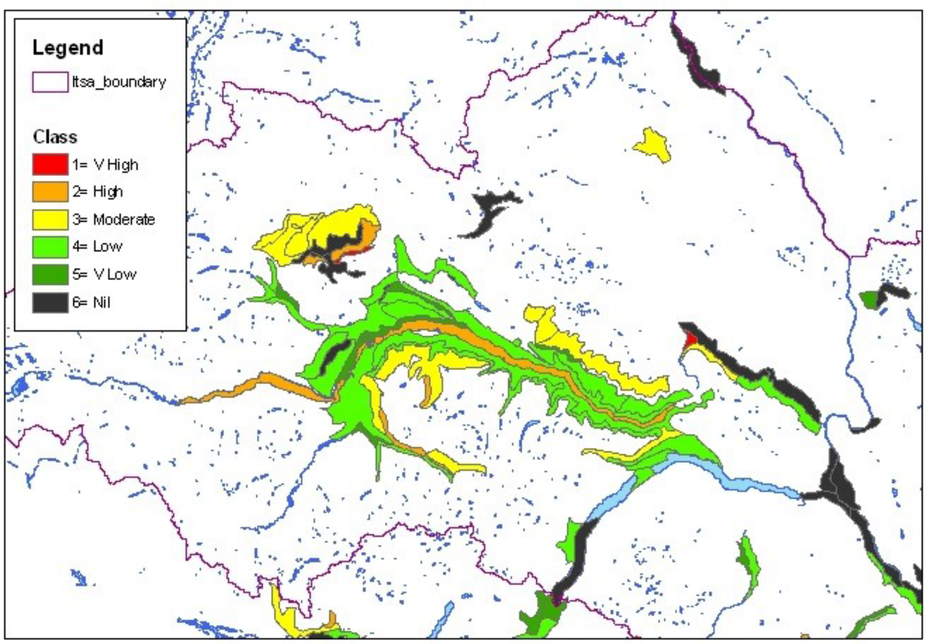
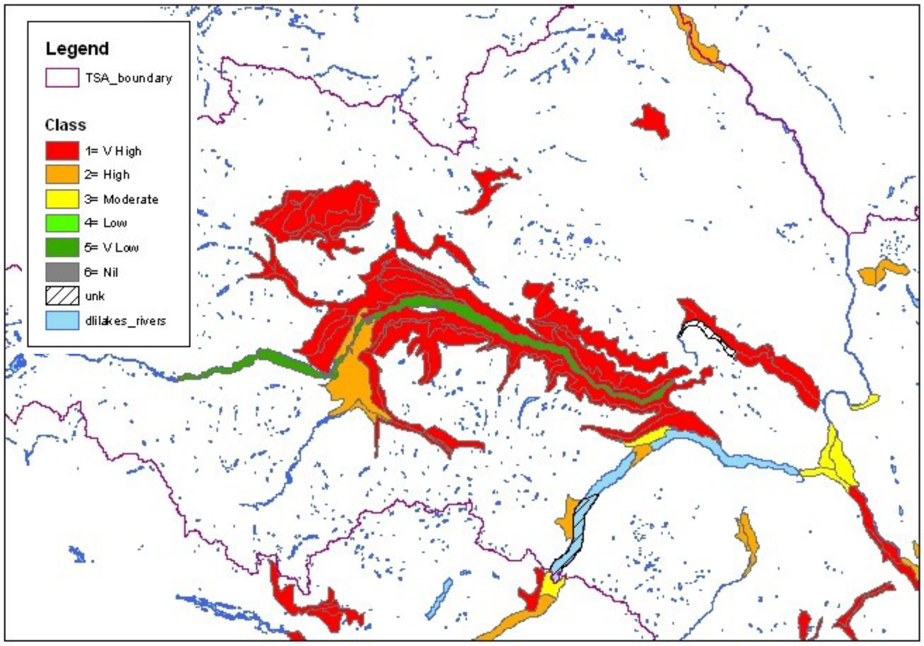
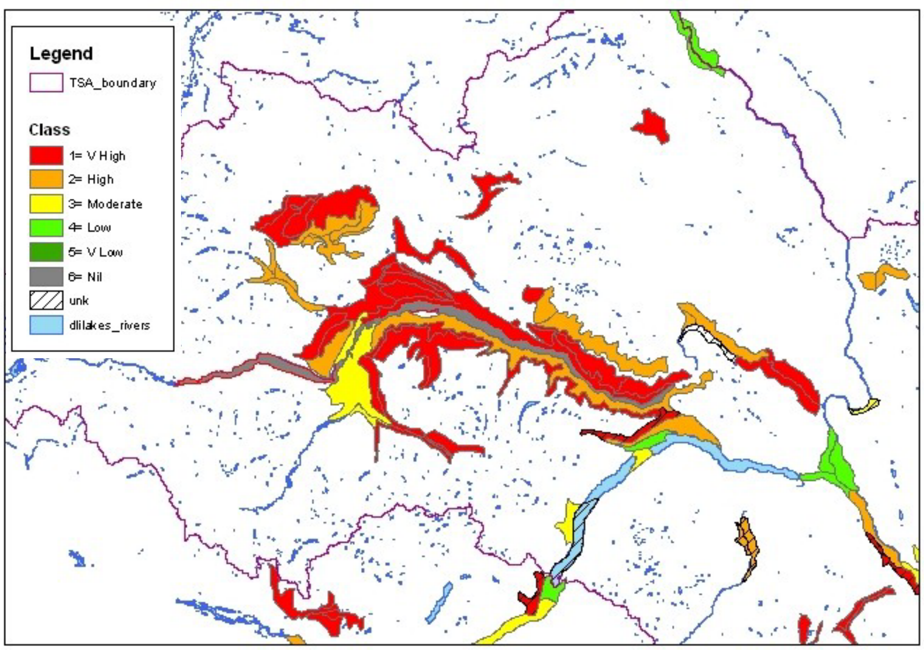


Figure 8: Change in historic habitat effectiveness for the footprint polygon as illustrated by the difference between polygon ratings in a) 1879-1899 when the polygon was already at class 5 status and b) 1900-1920 when the footprint polygon had dropped to class 6 and the effectiveness of surroundings areas was in decline. [scale is 1:725,000]

a)



b)



Mortality Risk

The reservoir footprint polygon was initially assigned 0% mortality risk which is the best case scenario for bears. However, the influx of people associated with the gold rush meant that a strong human presence and low tolerance for grizzly bears already existed in the valley bottom when our analysis began. This changed the polygon immediately to a class 1 (very high mortality risk) state in 1858-1878 because of the high probability that any bear encountering people would be killed. The footprint polygon remained in a class 1 state for most of the analysis, but risks to bears increased in the surrounding habitat as more people came into the valley. Furthermore, trophy hunting had developed into a lucrative business by the 1900-1920 time period, with no fewer than 96 hunting parties being outfitted from Lillooet for the Bridge River country between 1903 and 1910 alone, taking at least 22 grizzly bears in the process (Wood 1949, pp. 127). Bag limits for grizzly bears remained high even in 1948-49 when each hunter could legally kill both a fall and a spring grizzly bear (Wood, 1949, pp. 128). Thus the mortality risk to grizzly bears expanded outward from the valley bottom as more people settled, worked and recreated in the area. The mortality risk is shown as dropping to class 2 in Table 3 for 1942-1962 because the risk was minimal under the flooded reservoir by the end of this period, thus the average risk across the time step was lowered.

Discussion

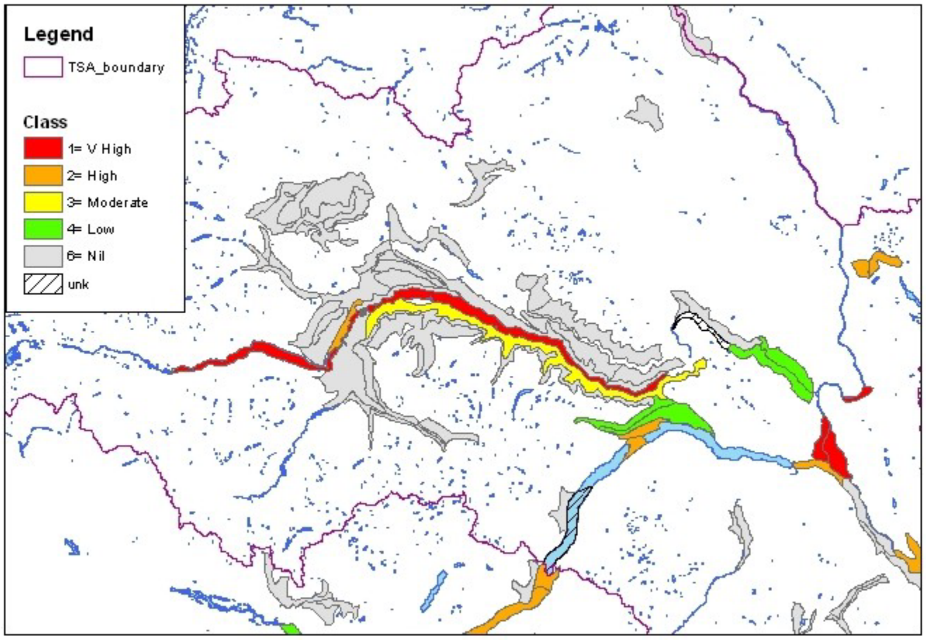
The welfare of any grizzly bear population depends on the adult females. Resident female bears are used provincially to assign grizzly bear occupation of the landscape (Hamilton *et al.* 2004). In all likelihood, the side tributaries of the Bridge River had resident adult female bears that moved into the valley bottom seasonally to exploit the rich riparian habitats in the spring and the salmon run in the fall. Female cubs learn to utilize the seasonal resources available within their mother's home range. As these female cubs mature, they take up home ranges within or adjacent to their natal home range (McLellan & Hovey 2001). Therefore, grizzly bear populations expand slowly from centers of female bear occupation. Expansion is even slower when human-caused mortality of females is area-concentrated. Male bears, on the other hand, may range widely in search of food and mates, and are occasionally reported outside the "occupied zone". From a recovery population perspective, however, resident female bears are the indicator of choice.

Our analysis suggests that grizzly bear home ranges which included the BRV bottom were already significantly affect by humans before the reservoirs were fully flooded. Mining, trophy hunting, predator control, human settlement, and the loss of salmon by 1949 all would have reduced the numbers of bears using the valley bottom. Many of these impacts, however, save and except the loss of salmon, remained reversible until the valley was flooded. The reservoir permanently removed habitat capability for a bear population that was already in decline. These types of cumulative effects can undermine population stability whereby one or two human influences may be tolerable, but eventually one additional impact acts like the proverbial "straw that broke the camel's back". Maintaining and restoring adult female occupancy is key to population recovery.

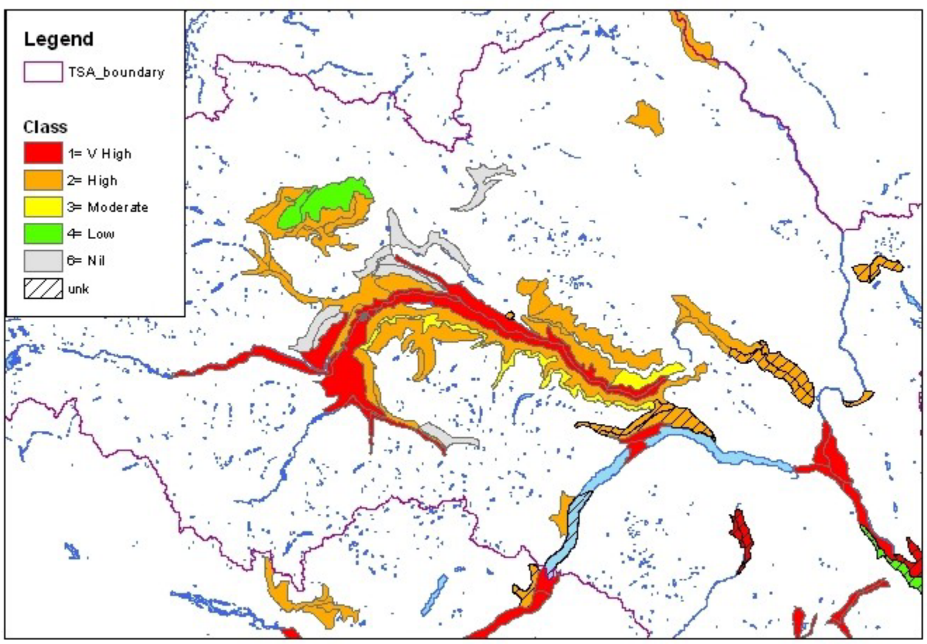
The direct consequences of flooding the BRV were to permanently remove habitat from female home ranges that included the valley bottom. This would not only have affected the survivorship and reproduction of the females present at that time, but it eliminated their future reproductive potential (i.e. their daughters and grand-daughters) from occupying these home ranges. Because female grizzly bears display strong home range fidelity they have great difficulty shifting into new locations (Proctor *et al.* 2004). This means that females frequenting the valley bottom would continue to search this area for seasonally available foods, thus exposing themselves to continued mortality risks even once

Figure 9: Changes in the historic mortality risk for the area surrounding the footprint polygon shown for a) 1858-1878 and b) 1921-1941. Note that the footprint polygon was already rated as having very high mortality risk by 1878, but this risk expands into areas around the footprint polygon as more people use the area. [scale is 1:725,000]

a)



b)



the foods were in decline. Furthermore, evidence suggests that the high country still had grizzlies bears, particularly in the more isolated drainages:

> "In summer, black bears are to be found anywhere within the forested areas, but grizzlies seek the timberline country where they prey upon marmots, which are mountain-dwelling rodents. Bears, especially grizzlies are scarce in the district as a whole, although grizzlies are locally reported as numerous in the valleys of Truax and Tommy Creeks." (Wood, 1949, pp. 44)

Although bears do not defend exclusive territories, the presence of bears occupying higher elevation home ranges would create both direct (e.g. encounters between bears) and indirect (e.g. consumed resources) competition for females displaced from now-flooded home ranges which included the valley bottom. The degree to which these changes in female home range distribution ultimately affected the population as a whole cannot be estimated until the DNA analysis for the South Chilcotin GBPU is completed later in 2008.

From a population recovery standpoint, the valley bottom riparian habitats lost beneath the reservoir footprint cannot be restored. Furthermore, efforts to encourage bears to use the reservoir edge, particularly along the Highway 40 side, would be mis-directed since this would only encourage grizzly bears to remain in an area where there continues to be high mortality risks from encounters with people (Figure 8). Restoration and mitigation activities can, however, be undertaken to support grizzly bear population recovery.

All activities aimed at grizzly bear habitat restoration and population recovery need to be implemented using a cumulative effects framework That is, each activity planned must be assessed for its full positive and negative consequences for both individual bears (if the activity falls within an existing home range) and for the population as a whole. Strategies that could provide significant population recovery benefits include the following activities:

1. Implementing a cumulative effects framework for all new hydro developments in the BRV, particularly for transmission lines, roads and water impoundments such that further impacts to grizzly bear habitat, existing home ranges, and mortality risk are prevented or entirely mitigated;

2. Reducing bear-human conflict throughout the BRV and its tributaries by creating Bear-Smart communities including Gold Bridge, Bralorne, Seton Portage, Shalalth, Bridge River, Lillooet, Cayoosh, and the cottage communities around the lakes including Gun, Tyaughton and Marshall Lakes. Additionally, all campsites, small-scale agriculture sites and bear-cattle conflict zones need to be addressed to reduce the mortality risk for the bear population.

3. Burning to create high elevation berry patches on key forested site series because *Vaccinium spp*. provide an important fall food source which improves female and cub survivorship (Note: burning will require the development of an operational grizzly bear habitat restoration plan for implementation);

4. Minimizing motorized access, particularly on the south side of the reservoirs, and prevent the creation of a loop roads or transmission line right-of-ways around either reservoir. Loop roads dramatically increase mortality risk for bears.
5. Supporting strategies to improve ungulate and other prey species populations throughout the BRV. This strategy will indirectly support grizzly bears and so is less of a priority than any of the preceding recommendations.

This current analysis of impacts relating to the hydro-electric development has some limitations. For example, the broad scale of the analysis precludes the assessment of smaller scale impacts (e.g. one habitat polygon located in the Blue Creek area of the Shulaps is listed as having class 6 (nil) capability from the existing habitat mapping). However, GPS-collared bear data (from project#06.W.BRG.05) indicates that this same polygon is in fact currently used by a male grizzly bear and contains areas of high-value herbaceous meadows. This discrepancy illustrates the limitation of a population scale analysis in that the overall rating of a polygon may not reflect the fine detail and use patterns of individual bears. Similarly this analysis could not fully consider the impacts from roads and trails because the mapping required to create 20-year road layers for the study area exceeded the budget available. Efforts will continue to build upon the historic database and the map layers (particularly for roads, trails, forest seral stage, salmon abundance, and the "meat map") to broaden our understanding of the cumulative effects on the bear populations. A complete analysis of the GPS-collared bear data for habitat selection functions and the DNA analysis of the South Chilcotin GBPU grid data will similarly enhance our understanding of past impacts. These further revisions, however, do not preclude moving ahead immediately with mitigation efforts. Every step forward taken now will improve the chances of grizzly bear population recovery.

Figure 10: Grizzly bear walking the shore of Carpenter Lake, 2007

Courtesy of Yvonne Patterson

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Appendix 1: Maps

The following maps illustrate the changes in habitat capability, suitability, effectiveness and mortality risk resulting from a stepdown analysis of historic impacts within the identified polygons. All maps are at a scale of 1:750,000 and use a standard rating system to convey changes. For habitat capability, suitability and effectiveness the class 1 rating represents the best-case scenario for bears. For mortality risk, the class 1 rating represents the worse case scenario of very high mortality risk.

Figure 11: Changes in historic habitat capability simulated for each twenty year period a) 1858-1878, b) 1879-1899, c) 1900-1920, d)1921-1941, e) 1942-1962. Habitat capability is the idealized ability of any one location to support bears. Capability is rarely lost except under permanent development, roads and water impoundments. A class 1 rating is the best-case scenario for habitat capability.

Figure 12: Changes in historic habitat suitability simulated for each twenty year period a) 1858-1878, b) 1879-1899, c) 1900-1920, d)1921-1941, e) 1942-1962. Habitat suitability is the current ability of any one location to support bears. Suitability changes over time. A class 1 rating is the best-case scenario for habitat suitability.

Figure 13: Changes in historic habitat effectiveness simulated for each twenty year period a) 1858-1878, b) 1879-1899, c) 1900-1920, d)1921-1941, e) 1942-1962. Effectiveness is the current "useability" of habitat in that it combines habitat suitability with an assessment of human displacement from that habitat. A class 1 rating is the best-case scenario for habitat effectiveness.

Figure 14: Changes in historic mortality risk simulated for each twenty year period a) 1858-1878, b) 1879-1899, c) 1900-1920, d)1921-1941, e) 1942-1962. Mortality risk is a relative measure of how likely it is that a bear using a location will be shot either in defense of life and property or harvested (either legally by a hunter or illegally by a poacher). Unlike previous figures, a class 1 mortality risk is the worse-case scenario for bears.

Figure 9a): Habitat capability: 1858-1878

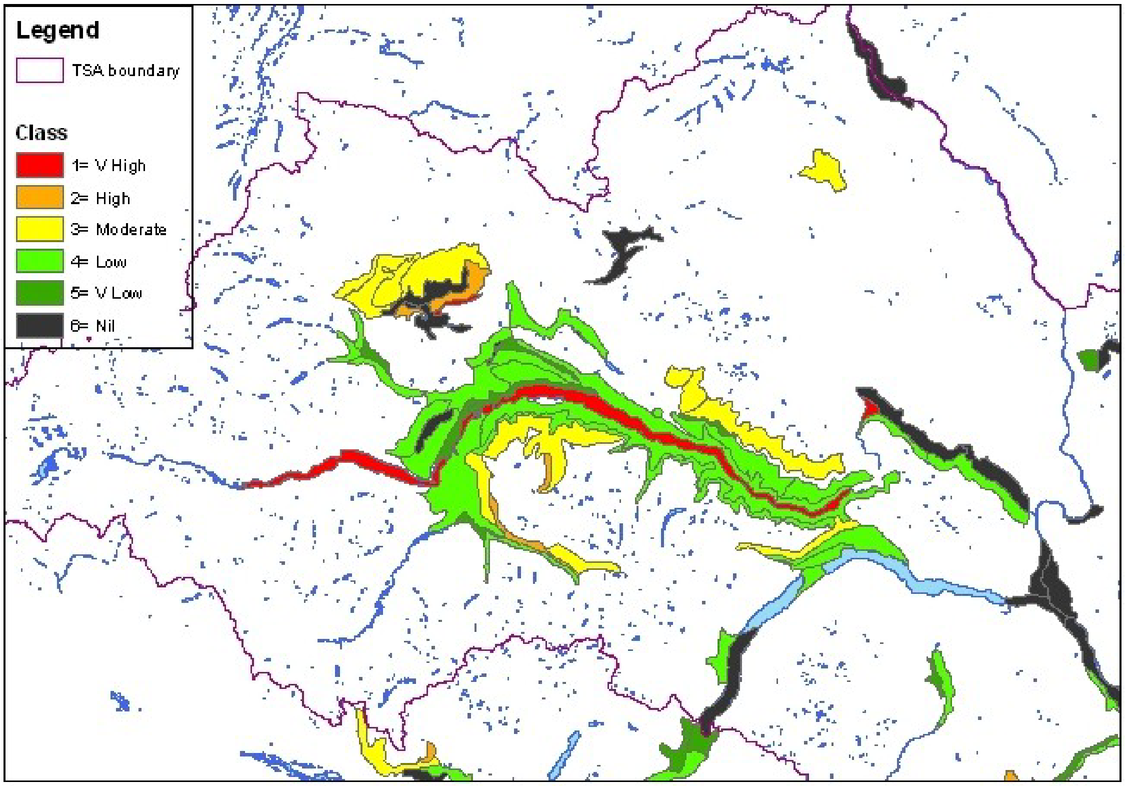

Figure 9b): Habitat capability: 1879-1899

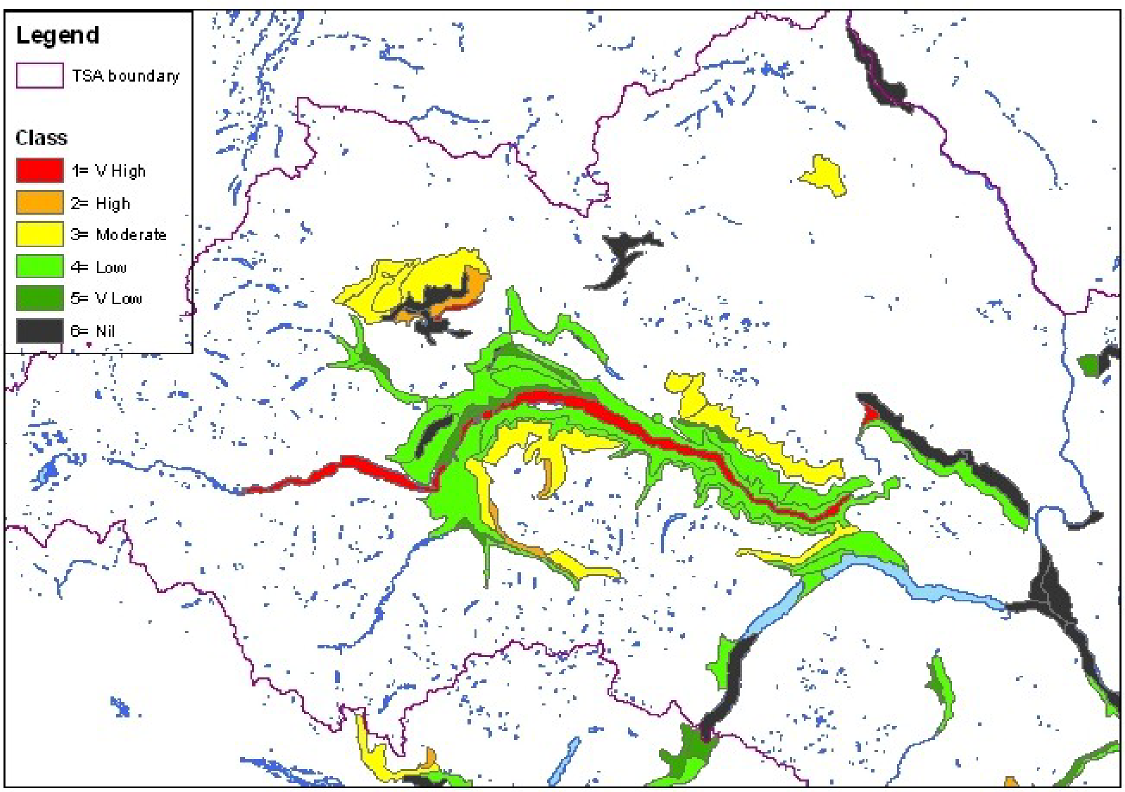

Figure 9c): Habitat capability: 1900-1920

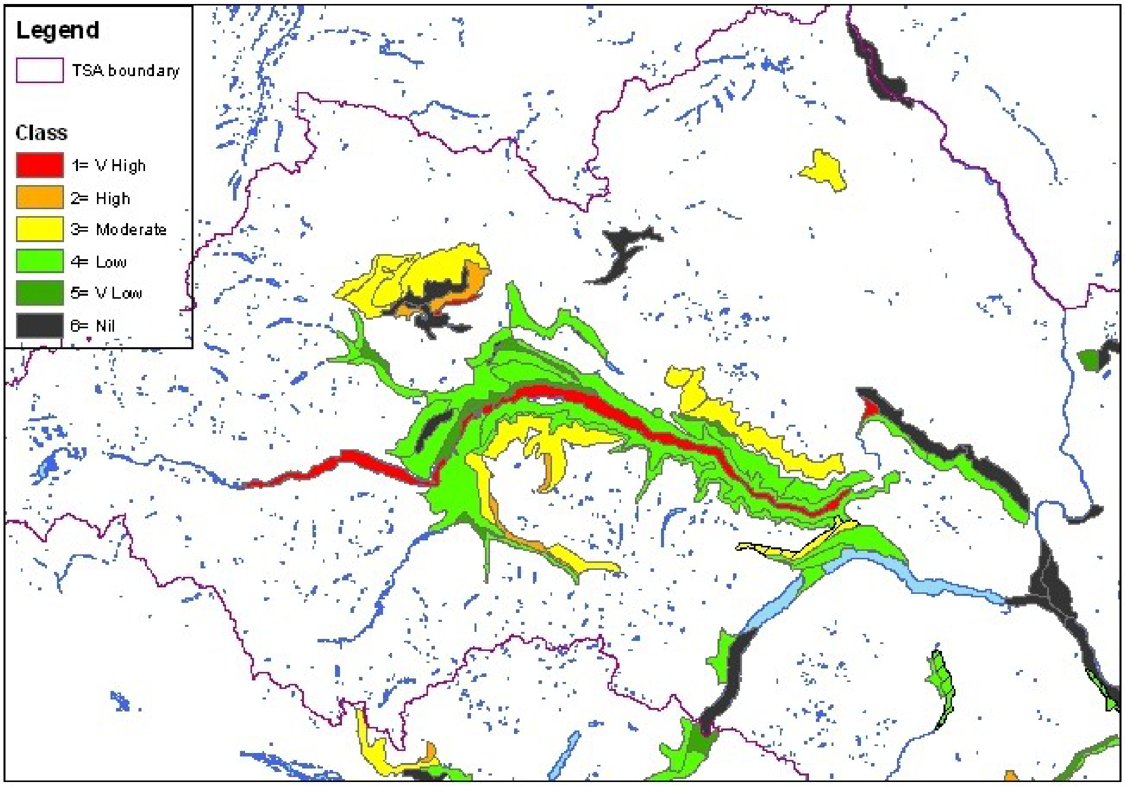

Figure 9d): Habitat capability: 1921-1941

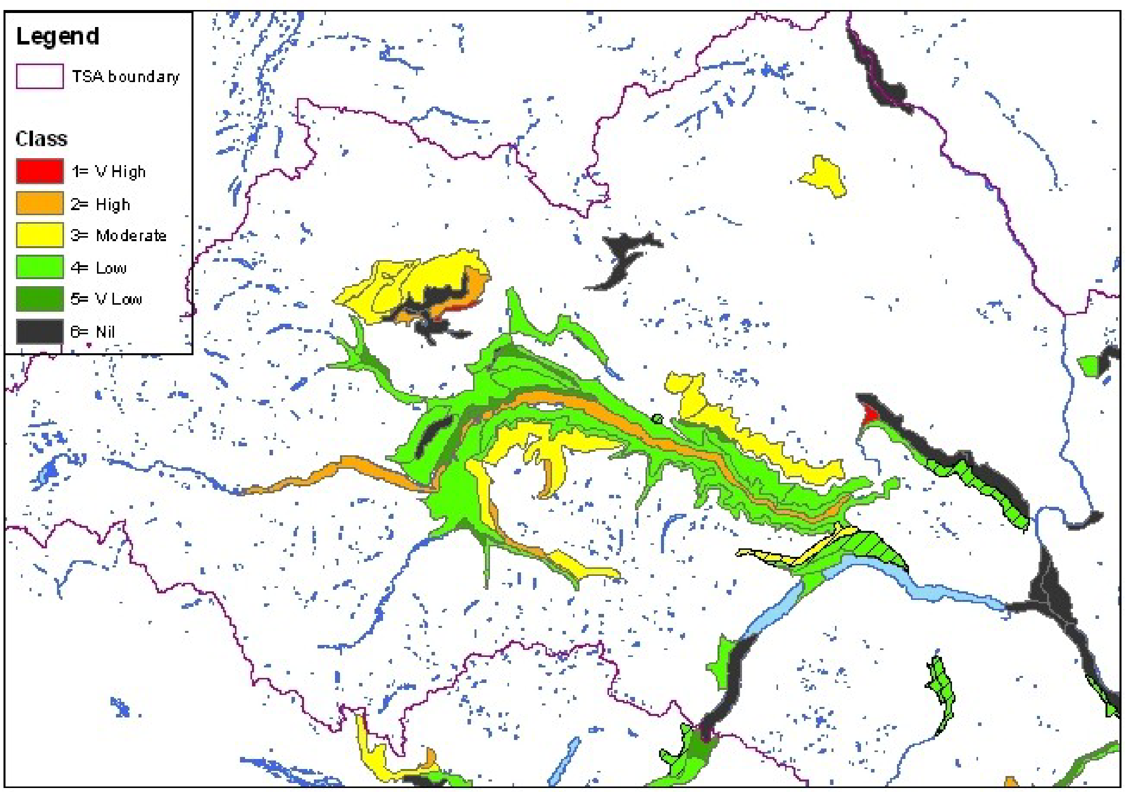

Figure 9e): Habitat capability: 1942-1962. Note that the reservoir polygon does not revert to Class 6 because for most of the time period from 1942-1962 the polygon retained some habitat until fully flooded.

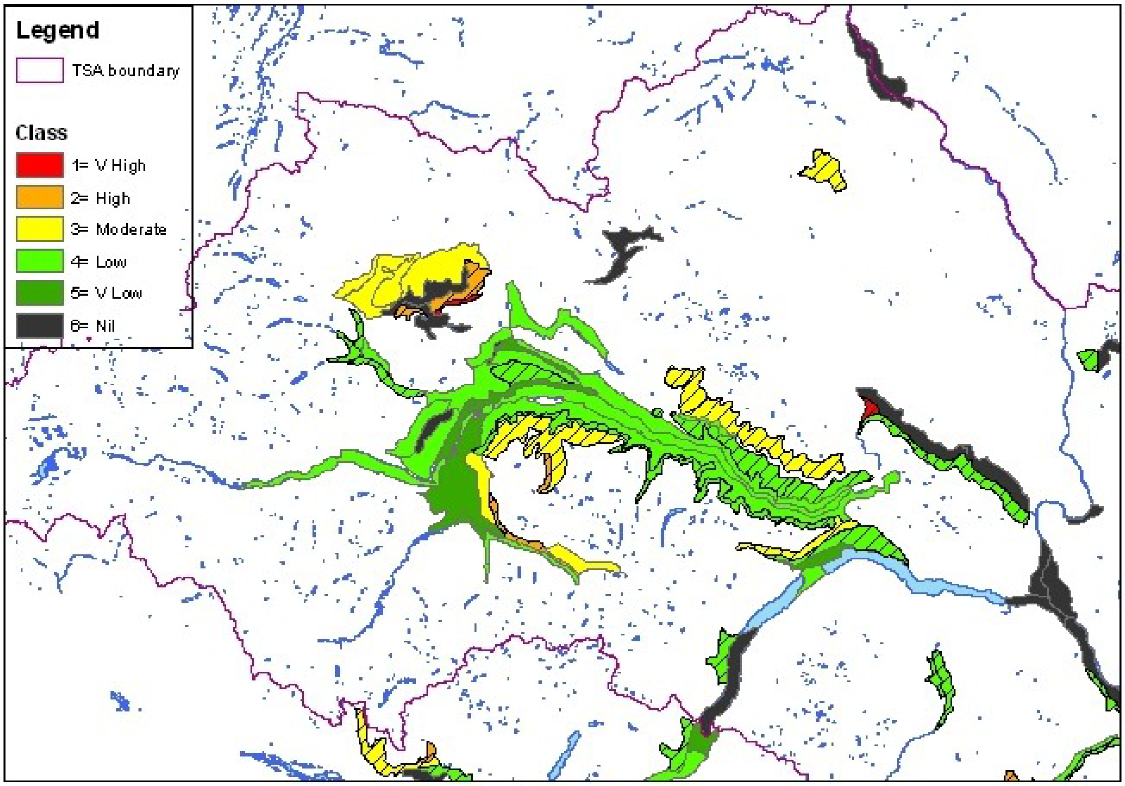

Figure 10a): Habitat suitability: 1858-1878

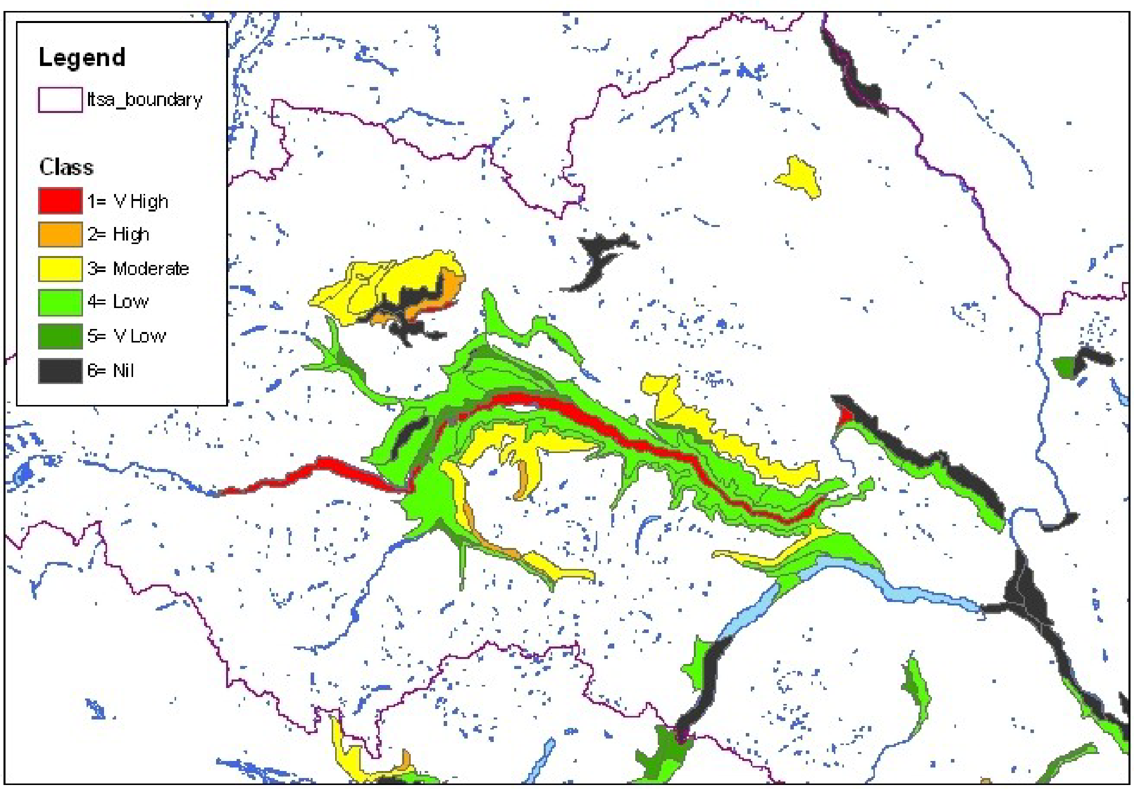

Figure 10b): Habitat suitability: 1879-1899

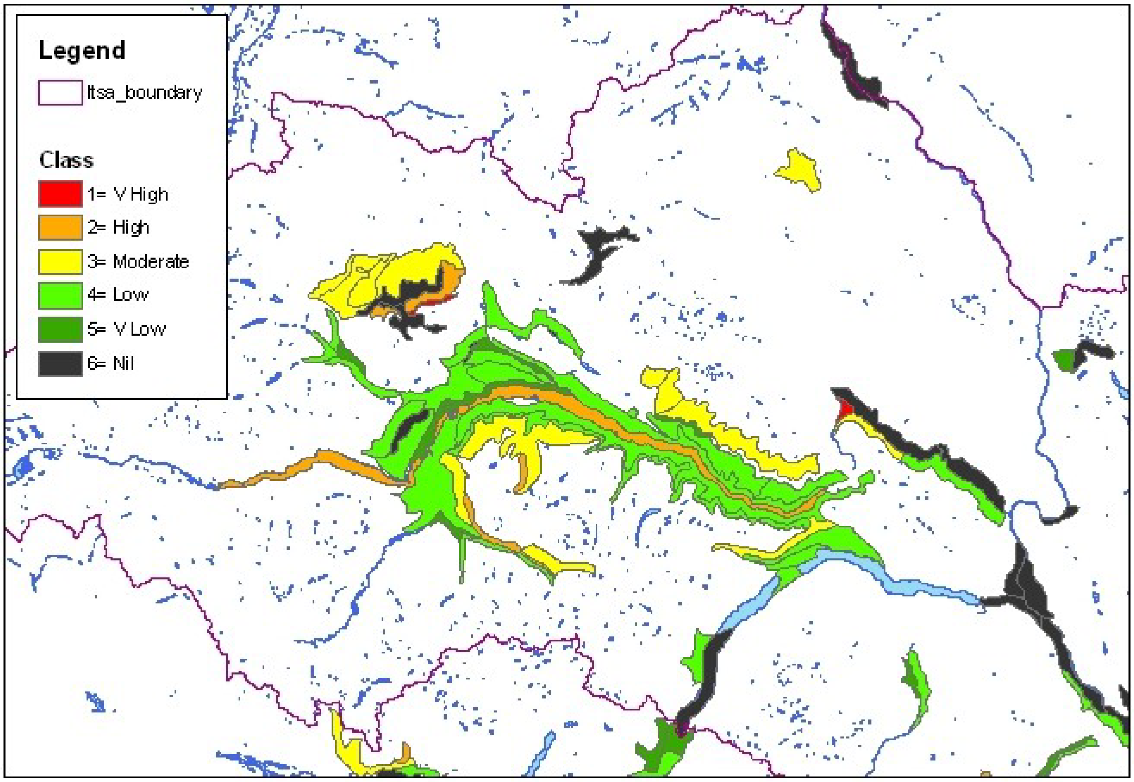

Figure 10c): Habitat suitability: 1900-1920

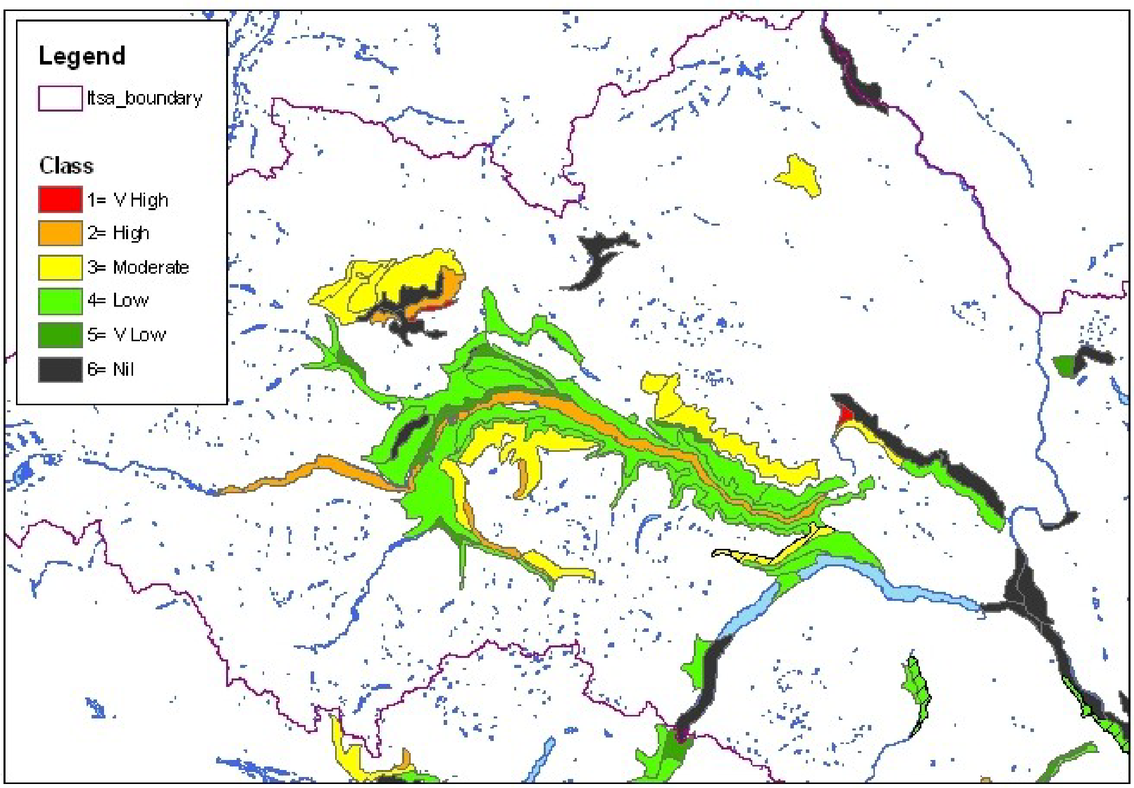

Figure 10d): Habitat suitability: 1921-1941

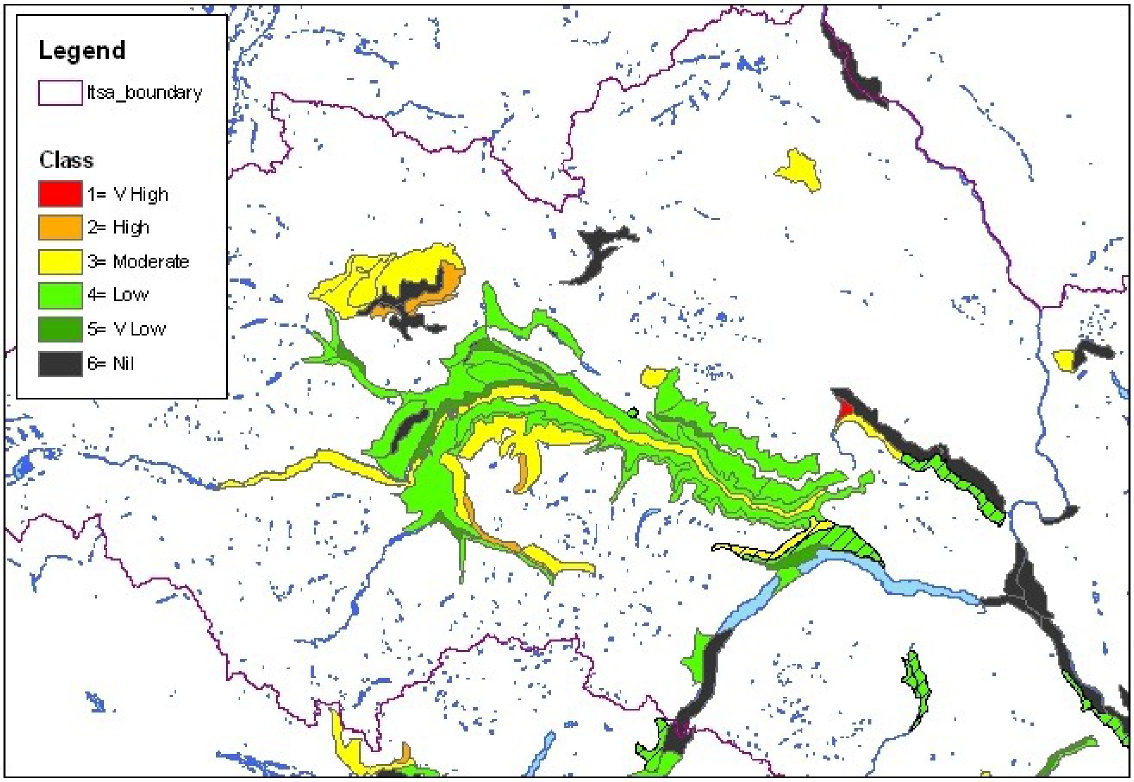

Figure 10e): Habitat suitability: 1942-1962

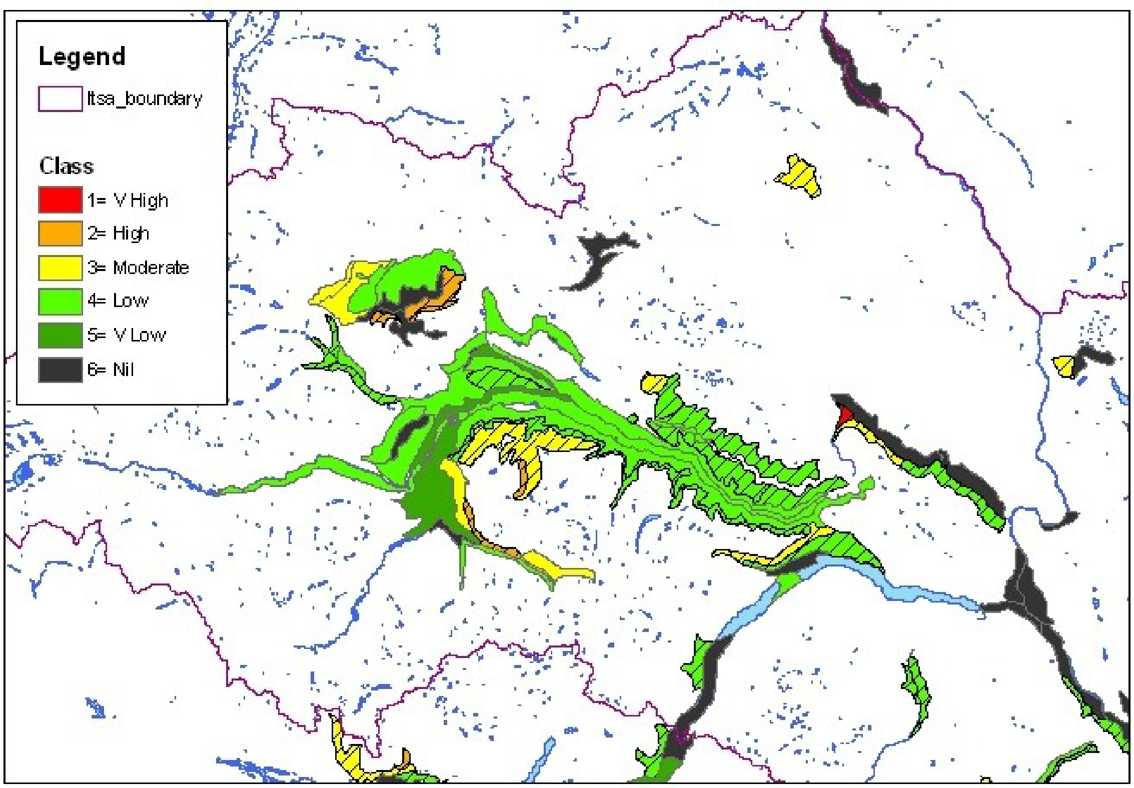

Figure 11a): Habitat effectiveness: 1858-1878

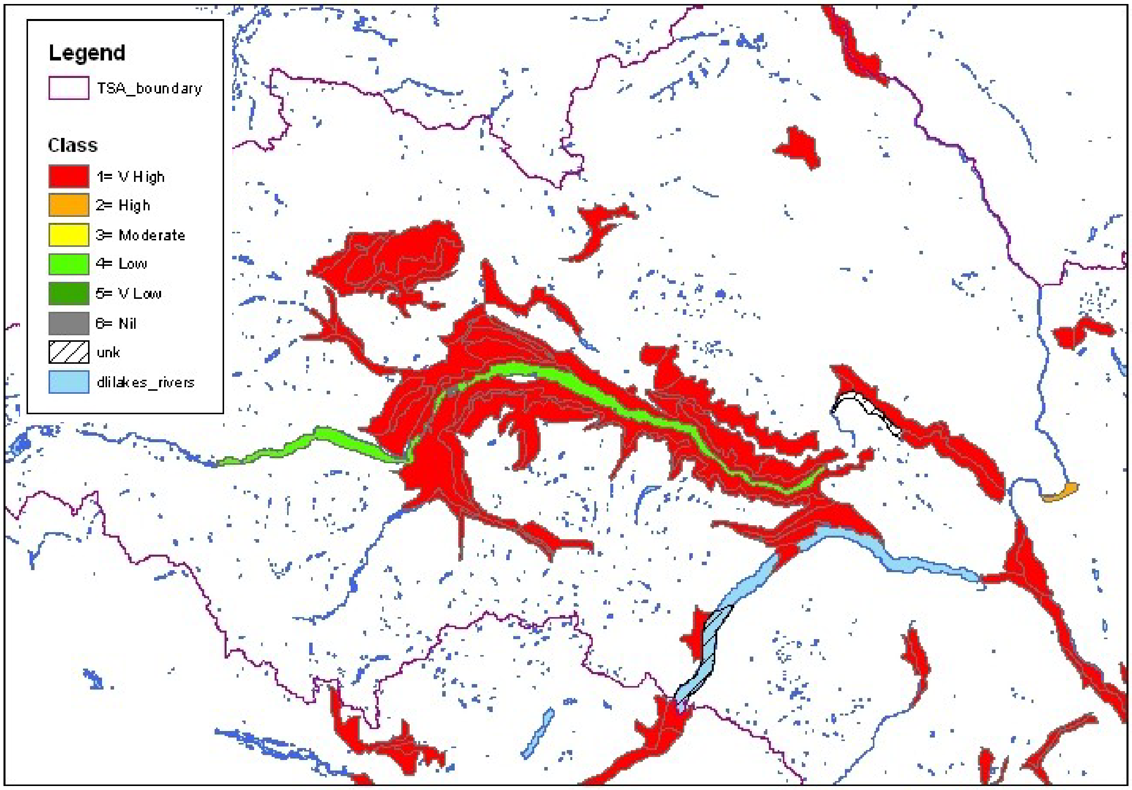

Figure 11b): Habitat effectiveness: 1879-1899

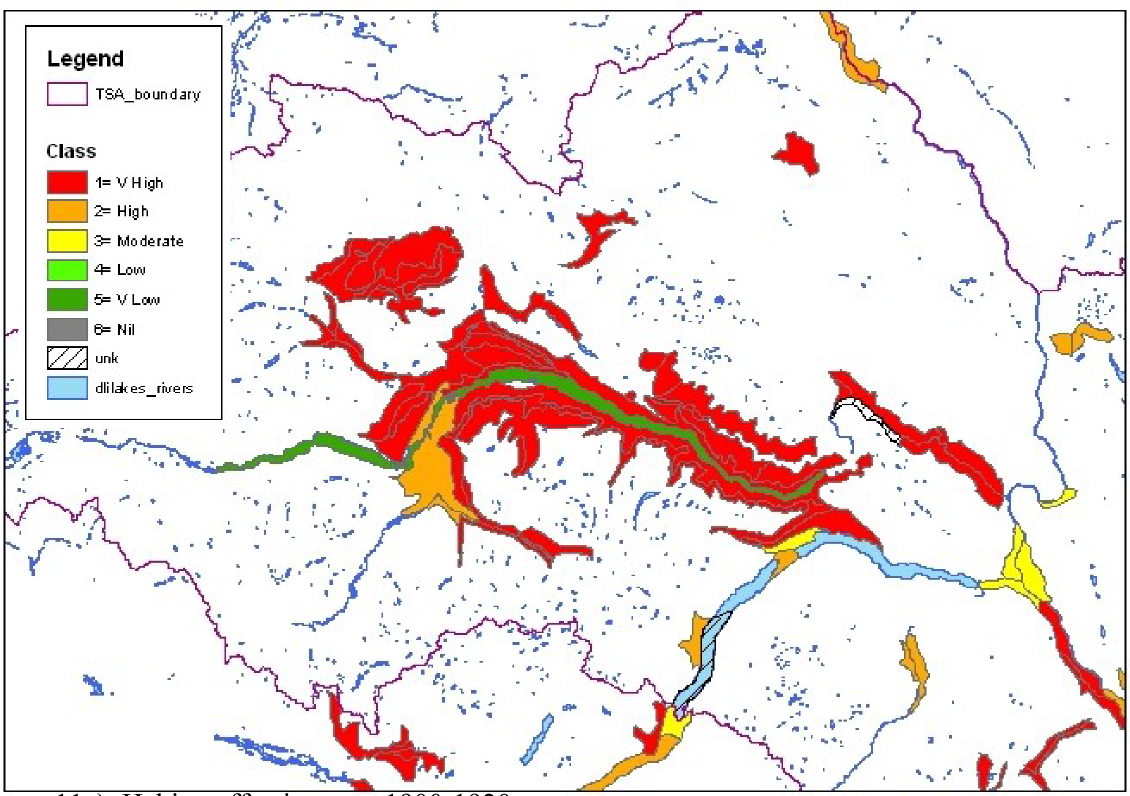

Figure 11c): Habitat effectiveness: 1900-1920

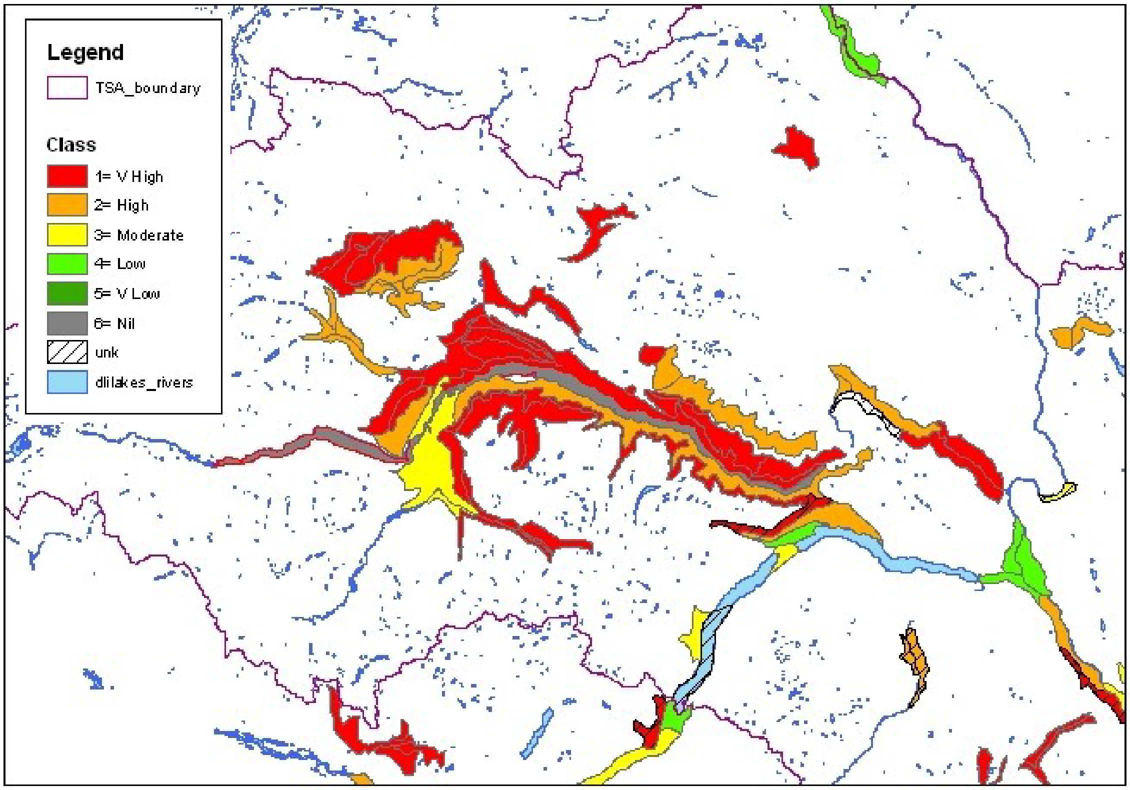

Figure 11d): Habitat effectiveness: 1921-1941

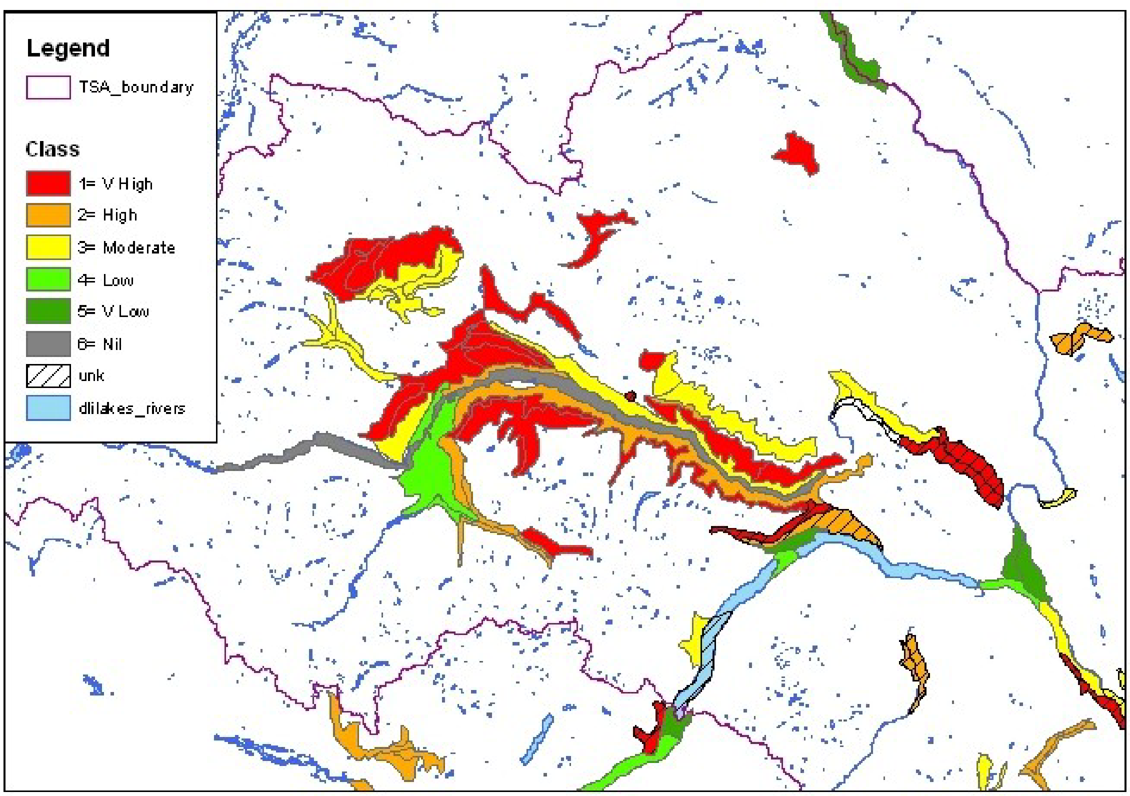

Figure 11e): Habitat effectiveness: 1942-1962

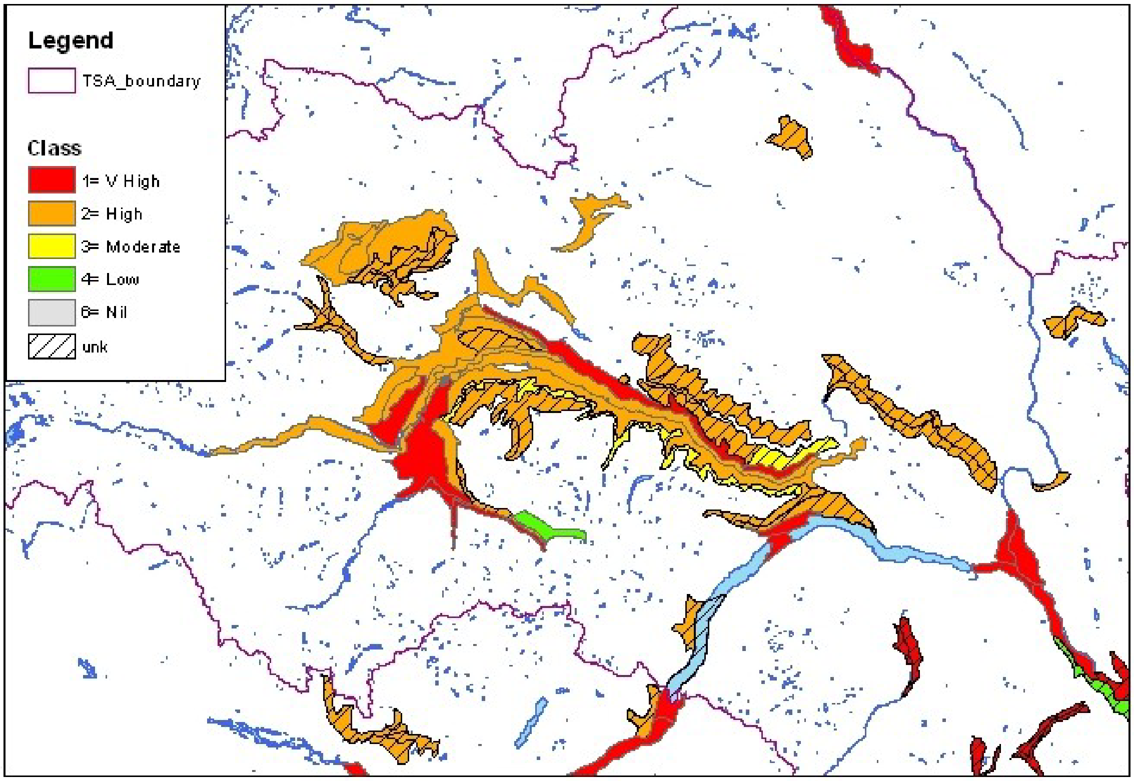

Figure 12a): Mortality risk: 1858-1878

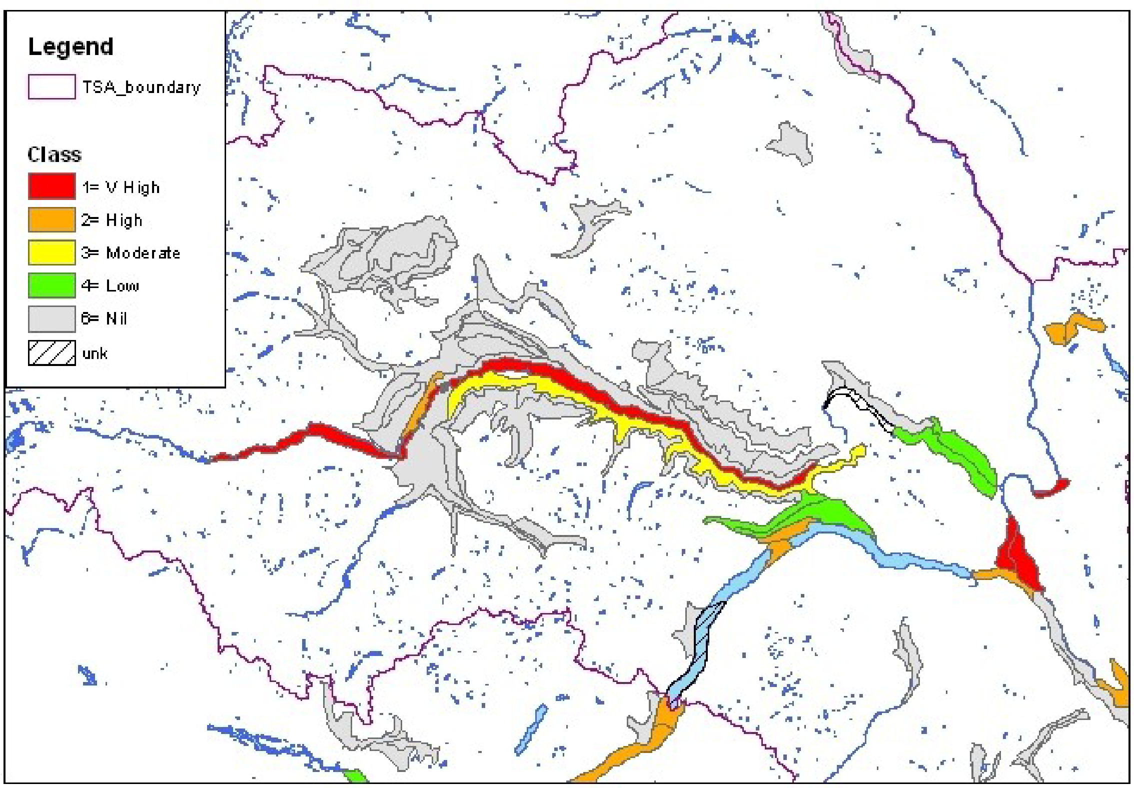

Figure 12b): Mortality risk: 1879-1899

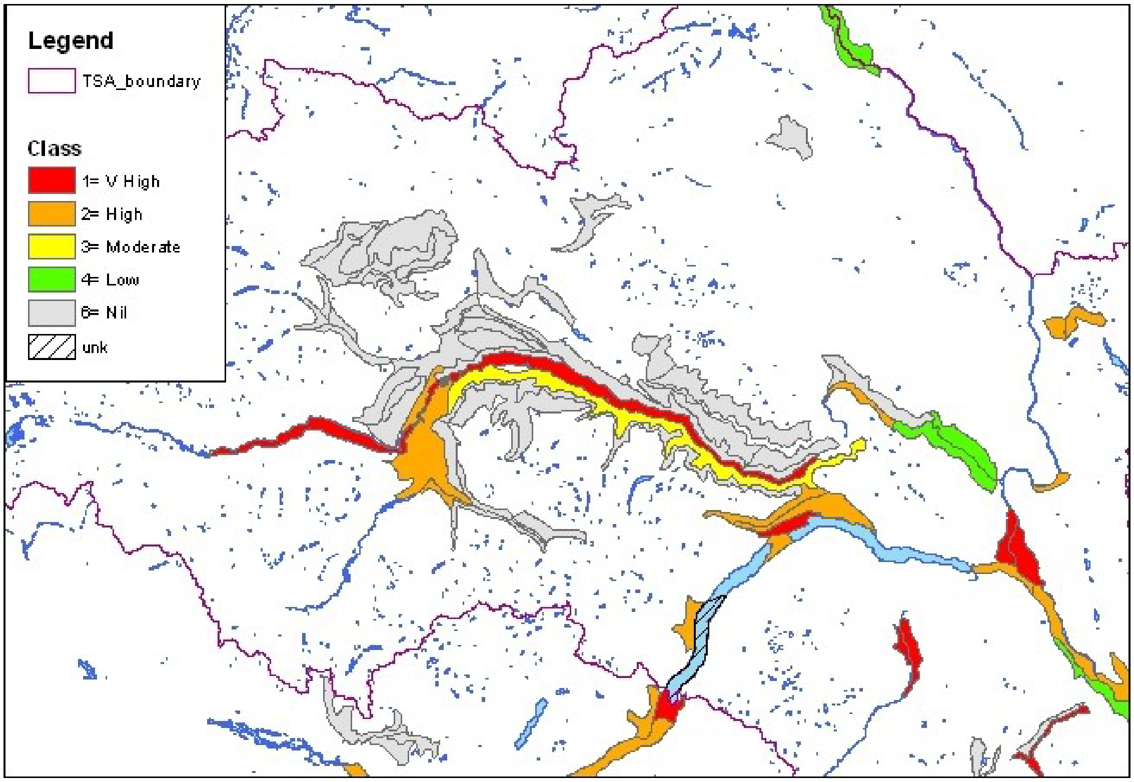

Figure 12c): Mortality risk: 1900-1920

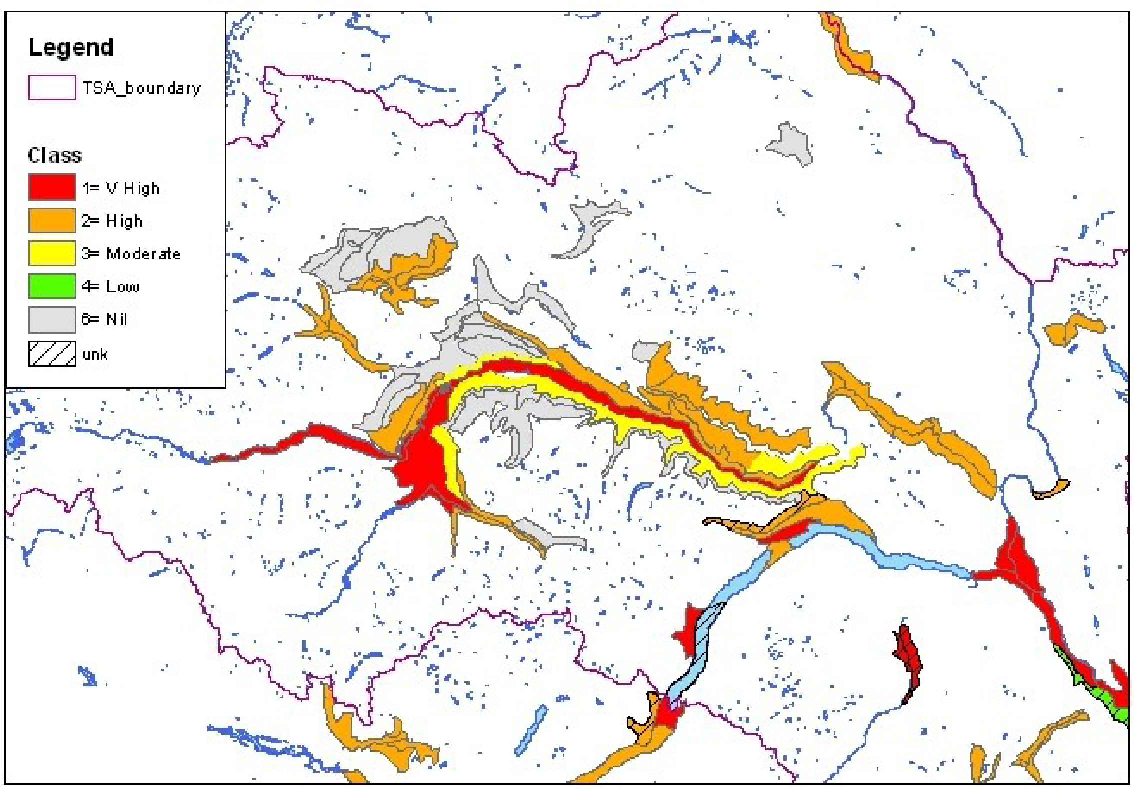

Figure 12d): Mortality risk: 1921-1941

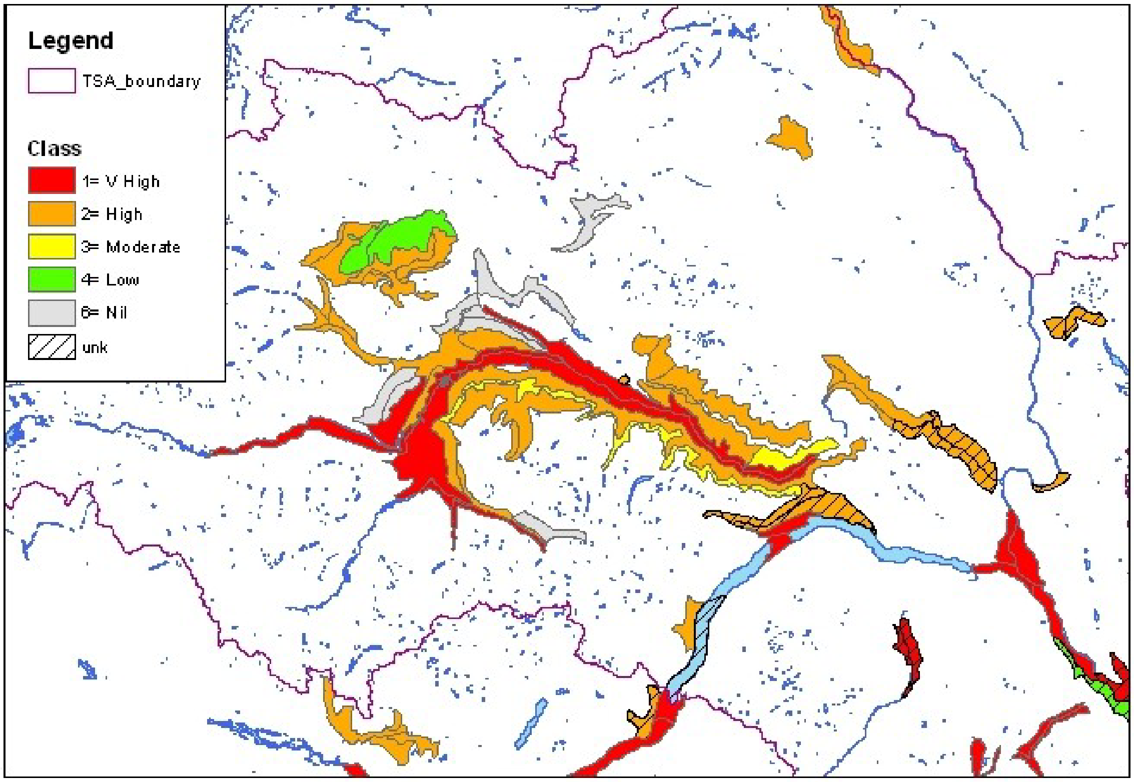

Figure 12e): Mortality risk: 1942-1962