Grizzly Bear Habitat Management in the Bridge River Restoration Area

2011 & 2012 Final Report

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Ministry of Forests, Lands and Natural Resource Operations
Ministry of Environment

Project: 12.W.BRG.02
Prepared: March 2013

Acknowledgements

This Project was funded by the Fish and Wildlife Compensation Program (FWCP) on behalf of its program partners BC Hydro, the Province of British Columbia (BC) and Fisheries and Oceans Canada; these partners work together to conserve and enhance fish and wildlife populations impacted by the construction of BC Hydro dams. Project management was provided by Francis Iredale (MFLNRO) and Jared Hobbs (MFLNRO). The Lillooet Grizzly Bear working group includes: Bruce McLellan (MFLNRO), Jared Hobbs (MFLNRO), Francis Iredale (MFLNRO), Tony Hamilton (MOE), Michelle McLellan, Yvonne Patterson, John Surgenor (MFLNRO) and Sue Senger (St’at’imc Environmental Lead).

Joanne Nielson from the BC Conservation Foundation (BCCF) was responsible for coordination for field technical staff including: Stephanie Keightley, Jake Hupman, Cliff Leslie, Craig McLean, Becky Phillips, Rhys Walters, Nicola Bickerton, and Cait Fremlin. Each of these individuals provided field support during the project; we appreciate their hard work and professional approach to the collection of field data. We are also grateful to Michelle McLellan (BCCF) for providing expert-based ranked mapping of spring habitats within the study area.

We wish to thank the local First Nations for allowing us access to their lands, welcoming us into their communities, and providing letters of support for the project. In particular, we recognize Matt Manuel, from the Lillooet Tribal Council and Larry Casper (Stewardship advisor: St’at’imc government services). We also would like to thank Breanne Patterson (FWCP Biologist) for accompanying us and assisting us with some of the field survey work.

We thank Vivian Birch Jones and Dr. Ian Routley of the Lillooet Naturalist Society for assisting us with implementation of community engagement events, such as the “Salmon in the Canyon” festival and the 2012 BC Naturalist annual field trip. We also appreciate their mutual hospitality during the field seasons.

We would like to thank pilots Katie Jerez and Kevin Jackson (CC Helicopters Ltd), Scott Taylor (Blackcomb Helicopters Ltd) and Chris Morin (Squamish Aviation) for safely piloting us around the beautiful and rugged Lillooet and South Chilcotin watershed basins.

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Acronyms

1. BC CDC- British Columbia Conservation Data Centre
2. BCCF- British Columbia Conservation Foundation
3. COSEWIC- Committee on the Status of Endangered Wildlife in Canada
4. DEITF- Describing Ecosystems in the Field
5. DEM- Digital Elevation Model
6. FRPA- *Forest and Range Practices Act*
7. FWCP- Fish and Wildlife Compensation Program
8. GBPU- Grizzly Bear Population Unit
9. GIS- Geographic Information System
10. GPS- Global Positioning System
11. GWM- General Wildlife Measure
12. MFLNRO- Ministry of Forests, Lands and Natural Resource Operations
13. MOE- Ministry of Environment
14. SSAC- St'át'imc Stewardship Advisory Committee
15. TEK- Traditional Ecological Knowledge
16. THLB- Timber Harvesting Land base
17. TSA- Timber Supply Area
18. VRI- Vegetation Resource Inventory
19. VM – Vaccinium membranaceum (common name: Huckleberry)
20. WHA- Wildlife Habitat Area

Introduction

The Grizzly Bear (*Ursus arctos*) is British Columbia's (BC's) largest terrestrial carnivore. Historically, Grizzly Bears had a circumpolar distribution, but anthropogenic influences upon bears and bear habitat have led to a systemic range contraction (COSEWIC 2002). Globally, the species has been extirpated from over 50% of its range (COSEWIC 2002). Grizzly Bears still occur in Canada, the United States (U.S.A.), and approximately 42 Eurasian countries, being extirpated from North Africa about a century ago. In North America, Grizzly Bears are found in Alaska, the Yukon Territory, Northwest Territories, parts of Nunavut, Alberta, and British Columbia (Gyug *et al.* 2004). Within the U.S.A their range continues southwards into Montana and includes a small disjunct population in the Yellowstone Ecosystem that also includes portions in Idaho and Wyoming.

Throughout their range Grizzly Bears usually occur at low densities and for a North American mammal are slow to reproduce; for females are usually a minimum of five years of age before they have their first litter. To compensate, adult survivorship is high. Within British Columbia, the Grizzly Bear is listed as "Vulnerable" (Blue-listed) by the BC Conservation Data Center (CDC) and as "Special Concern" (SC) by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (CDC explorer, 2010; Hamilton *et al.* 2004). The species is not currently listed under the Federal Species at Risk Act (Schedule 1), however, it is listed on the BC Conservation Framework as Priority 2-Goal 2; as such, habitat protection and monitoring are recommended by the provincial government. In order to facilitate effective Grizzly Bear management and recovery, the province of British Columbia has identified 56 Grizzly Bear Population Units (GBPUs). GBPUs identify individual Grizzly Bear populations, often bound by physical features that restrict Grizzly Bear movement (NCBRT 2004). Of BC's 56 GBPUs; 47 are viable, and nine are threatened. British Columbia has committed, under the BC Conservation Strategy, to recover Threatened GBPUs to viable populations (MELP 1995).

Grizzly Bears have large home ranges that encompass a variety of habitat types, thus the recovery of Grizzly Bear populations will involve a variety of management actions, including, but not limited to:

- reduction of human/bear interactions,
- identification and management of critical foraging habitats,
- access management; and,
- maintenance of important connectivity corridors.

The project area includes the Lillooet Timber Supply Area (TSA). This area encompasses portions of two GBPUs: the Stein-Nahatlatch and the South Chilcotin. Both units are classified as threatened (MELP 1995). As such, the identification and conservation of foraging habitats at both a landscape and stand-level scale, in conjunction with the conservation of adequate security and thermal cover, is an important recovery objective within both GBPUs. In recognition of the low population status of Grizzly Bears in the Lillooet TSA (n = 24 within the Stein-Nahatlatch GBPU, and n ~ 200 in the Chilcotin GBPU) there was an additional allocation of Timber Harvesting Land Base (THLB) budget designated for management of Grizzly Bear Habitat within the TSA. Specifically, a Forest and Range Practices Act (FRPA) Section 7 Notice was signed in 2005 that enables the protection of up to 8000 ha of THLB, over and above the normal THLB allocation afforded by FRPA policy (not limited, but assessed if it reaches 1% of THLB by district). This exceptional measure was intended to afford adequate conservation of seasonally important Grizzly Bear habitat that overlaps the THLB within the Lillooet TSA. Both GBPUs are rated as a very high conservation priority by the Ministry of Forests, Lands and Natural Resources Operations (MFLNRO) (Apps 2009), the Conservation Framework and the Fish and Wildlife Compensation Program 2011 Bridge-Seton Action Plan (FWCP 2011).

This report describes the results of a two-year project funded by FWCP. The overall project objectives include:

1. To locate, evaluate and precisely map seasonally important Grizzly Bear habitats to enable efficient implementation of conservation and management measures within important Grizzly Bear habitat areas.
2. To verify key berry production habitat areas; including both current and potential berry producing habitats, for management designation both on and off the timber harvesting land base (THLB).
3. To propose designations for habitat management using existing tools including: Wildlife Habitat Areas, Specified Areas, Park Management Plans and the Wildlife Act.
4. To continue to raise awareness, and communicate information, regarding Grizzly Bear management and recovery to stakeholders and partners.
5. To create an opportunity for capacity development within the St'at'imc First Nation through the addition of St'at'imc environmental technician to the project team, and to incorporate Traditional Ecological Knowledge (TEK) through the creation of a consulting St'at'imc reference group.

The assessment and spatial identification of important bear foraging habitats will be used to inform and implement conservation and management measures under the Forest and Range Practices Act (FRPA). The designation of "Specified Areas" (under the authority of the Government Actions Regulation (GAR)) will enable the management and conservation of Grizzly Bear habitat to support species recovery within both recovering Grizzly Bear population areas. In addition, information from this two year project will be used to assist the Fish and Wildlife Compensation Program (FWCP), the St'at'imc Nation and the Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) in meeting conservation and management objectives within the Bridge-Seton footprint and Lillooet TSA.

Study Area

The project area occurs entirely within the Lillooet TSA in the Cascades Forest District. This area also occurs within the traditional territory of the St'át'imc Nation. The eastern edge of the project area extends north along the Fraser, from Lytton, to French Bar. From its eastern edge the project area continues west to include the Kwoiek, Stein, Cayoosh, Seton and Carpenter River watersheds. This area includes two threatened Grizzly Bear Population Units (GBPUs): the Stein-Nahatlatch and the South Chilcotin Ranges (Figure 1). The Downton and Carpenter reservoirs have negatively impacted Grizzly Bear habitat by flooding 2,234 hectares (ha) and 4,669 ha of river and valley bottom habitat respectively (BC Hydro 2002). The South Chilcotin Mountains Park and Stein Valley Nlaka'pamux Heritage Park overlap the study area.

The project area falls within two eco-regions: the Interior Transition and Chilcotin. The Interior Transition eco-region includes the eastern portion of the southern Pacific Ranges, and has a range of climates, from the western moist maritime climate of the coast, to the semi-arid centennial climate of the southern interior of British Columbia (Ecological Framework of Canada 2012). The Chilcotin eco-region lies within the rain shadow of the Pacific Ranges of the Coast Mountains (Ecological Framework of Canada 2012). The mean annual temperature for each eco-region is approximately 6° C and 3.5° C respectively. Dominant trees include Engelmann spruce (*Picea engelmannii*), sub-alpine fir (*Abies lasiocarpa*), lodgepole pine (*Pinus contorta*), aspen (*Populus tremuloides*), interior Douglas-fir (*Pseudotsuga var. glauca*), ponderosa pine (*Pinus ponderosa*) and whitebark pine (*Pinus albicaulis*). Alpine tundra and krummholz communities occur above 1900m, with Engelmann spruce, sub-alpine fir and whitebark pine as the leading conifer species in the subalpine zone. At lower elevations lodgepole pine and Douglas-fir occur within well-drained (drier) areas; within more mesic areas, white spruce (*Picea glauca*), aspen, and cedar (*Thuja plicata*) occur. These watersheds contain important Grizzly Bear food as identified by St'át'imc elders, including spring beauty (Claytonia spp)- skwenkwín, Cow Parsnip (*Heracleum lanatum*)- skwenkwín, Saskatoon (*Amelanchier alnifolia*)-Stáqwem, Soopolallie (*Shepherdia Canadensis*)- Xúsum, and huckleberry (*Vaccinium membranaceum*)- ou-sha. (Senger 2013).

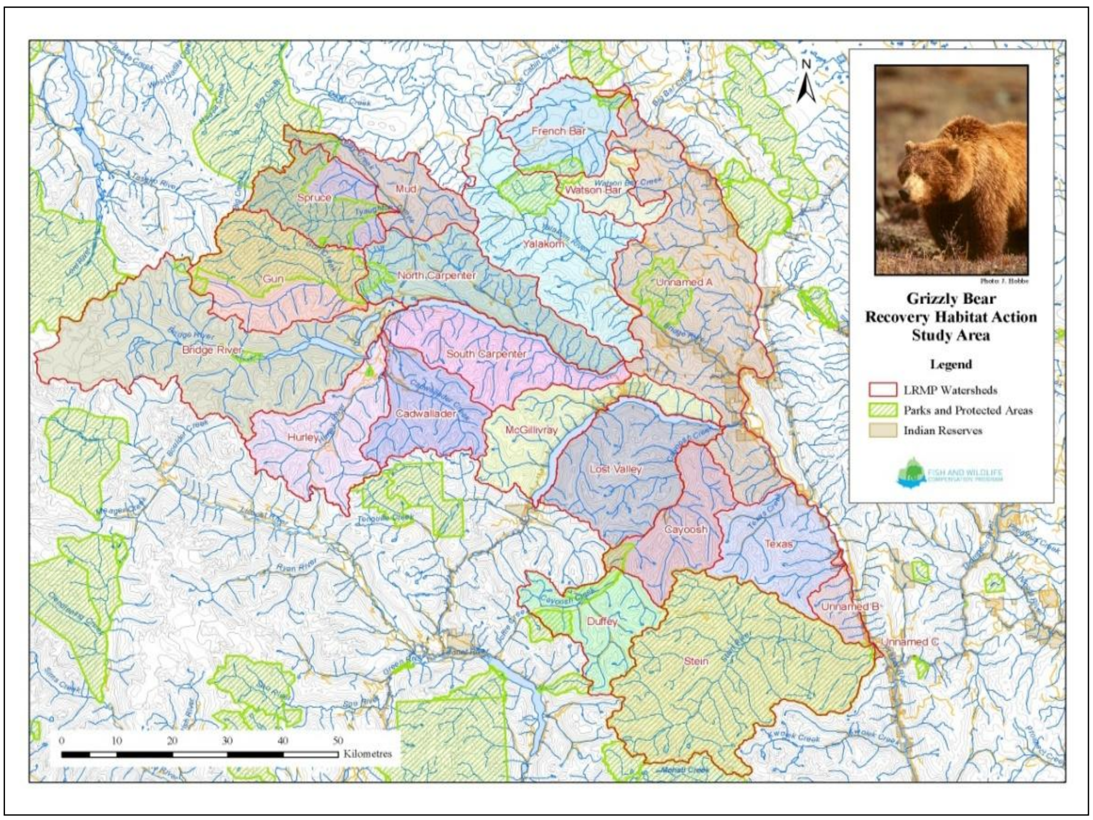

Figure 1: Map depicting extent of study area within the Lillooet TSA. Each watershed is identified as a separate color on the map. Watershed boundaries are depicted in red.

Methods

Grizzly Bear Planning Workshop: Pre-Project Planning 2011

Project participants met in Kamloops in April 2011, prior to initiating fieldwork. The purpose of this informal workshop was to facilitate advanced project planning, review previous/existing related (Grizzly Bear) projects, and to coordinate and synchronize expertise pertaining to Grizzly Bear habitat management. Regional bear and habitat experts included: Tony Hamilton (MOE), Bruce McLellan (MFLNRO), Jared Hobbs (MFLNRO), Francis Iredale (MFLNRO), Sue Senger (St'at'imc Environment Lead), Michelle McLellan (BCCF), Yvonne Patterson (MSc candidate-University of Victoria) and John Surgenor (MFLNRO).

Specific workshop objectives focused on developing a prioritization schema for project implementation, and coordination of project related expertise and activities within the Lillooet TSA. During the workshop, implementation priorities were assigned to each of the 22 watersheds within the project area. This was achieved by using an expert informed matrix of: threats, biological importance and existing knowledge. Additionally, project focus was defined to include activities that would be used to inform management of three discrete habitat types. These habitat types are relevant to Grizzly Bear management at the landscape scale and include:

1. Spring foraging habitat,
2. Whitebark Pine foraging habitat
3. Summer/fall berry habitat

To facilitate a shared understanding of issues and available science all existing relevant project data and reports, from previous projects conducted within the Lillooet TSA, were uploaded to a confidential government share-point site to enable reference by team members. A project task schedule, including delegation of responsibilities, was also developed. Tasks were assigned to team members to enable efficient planning and implementation of fieldwork priorities and to ensure necessary activities would be completed within appropriate biological timing windows.

Spring Habitat Assessment

Spring Habitat Modeling: 2011 & 2012

Prior to project initiation, T. Hamilton and S. Senger developed a Predictive Ecosystem Mapping (PEM) based spring habitat model. This first attempt was based on existing PEM, as developed by Shamaya Consulting and Silvatech Consulting Ltd. (2004), and aimed to remotely predict, or model, the spatial distribution and abundance of spring Grizzly Bear foraging habitats within the Lillooet TSA. Upon project onset the PEM-based spring habitat model was reconciled against color ortho-photos at a 1:20,000 scale and compared with existing data from bear site investigation, ortho-photo imagery, global position system (GPS) bear collar locations, and field data (M. McLellan 2012). As a result of this more intensive review and field calibration of the model, the need for an alternative approach to identify spring Grizzly Bear foraging habitat within the Lillooet TSA was confirmed.

As an alternative to the PEM based model, Michelle McLellan (team member), was sub-contracted to lead development of an expert based mapping approach, to more accurately depict distribution, and amount, of suitable spring Grizzly Bear foraging habitat within the Lillooet TSA. Spring and wetland habitats were precisely mapped in areas where Michelle had first-hand experience (through site visits and field assessment) and where multi-year data from 20 GPS radio-collared bears within the project area were available. Digital ortho-photos (from 2004-05) were interpreted to precisely map habitats. For areas with limited expert-based experience or where bear use data were incomplete (M. McLellan. 2012), ortho-interpretation and Google Earth (Google Inc. 2011) satellite imagery were used to tentatively map additional spring forage opportunities in those areas. Using this process an expert-based map was developed. Evaluation of both the PEM model and the expert-based mapping products were analyzed, in a GIS environment, by reconciling both products against existing Grizzly Bear telemetry monitoring data (n=13,314 foraging location points) from the Texas, Cayoosh, Duffey and Lost Valley watersheds (McLellan. 2012).

Suitability rankings were assigned to inform conservation prioritization in our management of spring bear foraging habitats (M.McLellan. 2012) as a component of this project. Spring foraging habitat was qualified in the following categories: High, Medium, Low, Nil and Classify (i.e. requiring field verification). The following habitats were considered as representative of spring forage sources for bears: avalanche chutes, herbaceous meadow, shrub and wet meadows and riparian habitats. In the winter of 2011 and spring of 2012 further expert based mapping of spring habitat occurred over the remaining watersheds within the project area. This expanded approach allowed for the inclusion of both wetland and riparian habitats, and increased emphasis on mapping polygons rated as “High” or “Medium” quality spring habitat, and decreasing emphasis on mapping “Low” and “Marginal” quality spring habitats. Wetland habitats were assigned where flat terrain is dominated by hydrophilic species, often with patches of open shallow water. Riparian habitats were mapped in close association with stream or river bank areas; these are often partially forested and often have high ground cover of bear foods such as cow parsnip, dandelions (*Taraxacum officinale*), grasses and sedges.

After completion of this phase of the project in 2012 spring grizzly bear foraging habitats were mapped for the following 22 watersheds: Texas, Cayoosh, Duffey, Lost Valley, Hurley, Cadwallader, McGillivary, Hurley, Mud, Gun, Spruce, Bridge River, North Carpenter, South Carpenter, French Bar, Watson Bar, Yalakom, Stein, “Occupied/Not Identified 1, 2, 4” and “Unoccupied”. Spring habitats were not mapped for the following five watersheds: “Unoccupied 2”, “Occupied-not Identified 3 and 5”, Siska and Kwoiek.

After completion of the expert-based spring habitat mapping, field assessment of spring habitat polygons was conducted using ground-based and aerial surveys. The expert model was converted (using GIS Roam) and loaded onto Apple© iPad GIS tablets (hereafter referred to as GIS tablets). The expert-based mapping products, were reconciled against ortho-imagery (converted using GIS Roam and loaded onto a GIS tablet) as an additional digital data source in the field. This method was used to enable quick comparison, in the field, of both products and to enable efficient prioritization of field assessment activities. Polygons were identified for field assessment using either aerial or ground-based methods based on access and the uncertainty of the assigned rating. Polygons that occurred within the Timber Harvesting Landbase (THLB) were assigned a higher priority for ground assessment (e.g. many areas within the “Gun Lake” Watershed.

Spring Habitat Ground Assessment: 2011 & 2012

Biophysical attributes; such as forb content, quality and quantity, are important components of spring foraging habitat for bears (Serrouya *et al* 2011). As such, a list of important foraging forbs was compiled based upon the previous research, input from team members (McLellan 2007), and TEK. Ground assessment of Grizzly Bear spring habitat polygons occurred in June and July during the early-mid flowering phenology of key forage species. These include: Spring Beauty, Yellow Glacier Lily

(*Erythronium grandiflorum*) and Cow Parsnip (see Appendix 1 for a list of important Grizzly Bear forage plants).

Spring polygons were assessed using a combination of measurements including: methods from the Describing Ecosystems in the Field manual (DEITF Manual) (DEITF 2010) and previous bear site-use investigation forms developed by Michelle McLellan, and input from team members. In the field, surveyors traversed each polygon to assess forage quality, distribution and abundance to derive a field rank which was assigned to each sampled polygon.

Spring polygons were broadly categorized as wetland, avalanche chute or herb meadow complexes; and based on overall cover characteristics, polygons were further divided into five vegetation communities: 1) Open Herb, 2) Low Shrub 3) Tall Shrub, 4) Tree and 5) other (e.g. Rock, Snow, and water). Percent cover was estimated based on both visual assessment and ortho-interpretation while in the field (i.e. using GIS tablets) to delineate vegetation communities. Vegetation layers were described using characteristics consistent with the DEITF (2010) Manual (e.g. trees less than 10 meters in height were assigned to the “shrub” layer). In addition to completing a field form description of each polygon, photos of each assessed site were taken in each of the four cardinal directions. Additional site attributes collected included: date, observers, watershed ID, habitat type, plant community, aspect and a Universal Transverse Mercator (UTM) coordinate using a Garmin Map60Csx GPS.

Within each of the vegetation communities surveyors recorded presence of important bear foods, in five percent cover increments, to denote spatial cover of plants species within each specific vegetation community. The category of “Trace” was assigned to plant species that were determined to have less than five percent cover. Percent cover was assessed based on the DEITF (2010) principles of assessing cover within a 400m^2 plot (see Figure 2).

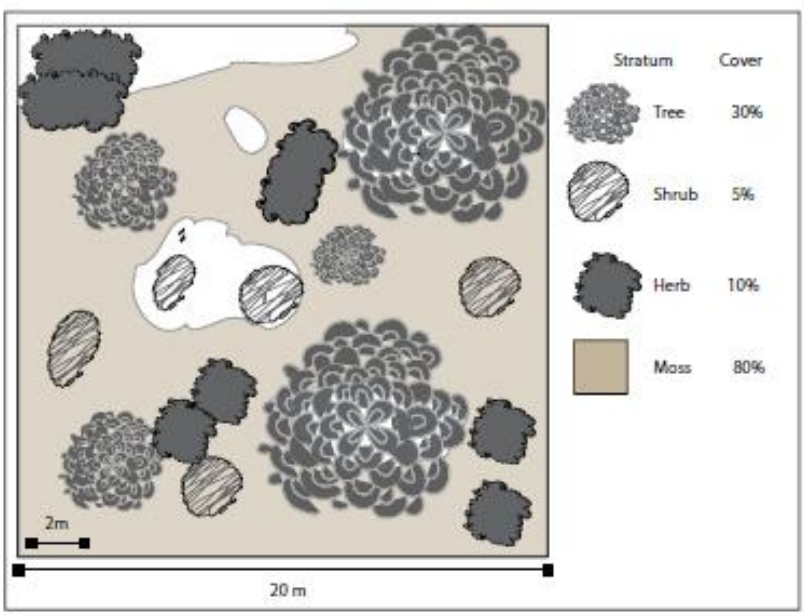

Figure 2: Plant community cover assessment diagram from DEIF (2010).

The spatial distribution of important bear foods was also described for each assessed polygon using the following quantification schema described below (see Table 1).

Table 1: Description of codes used to assess forage quality within designated spring forage polygons.

Code	Description	No of Plants
1	Rare individual	1
2	Few sporadic individuals	2-5
3	Single patch of species	1 patch (<25% of plot)
4	Several sporadic individuals	>6
5	Few patches or clumps	2-5 patches <25% of plot
6	Several well-spaced patches	>6 patches <25% of plot
7	Continuous occurrence well-spaced plants	Many
8	Continuous occurrence of species with few gaps	Many
9	Continuous dense occurrence of plans	Many

Out of necessity (in consideration of project scope) forage abundance, quality and cover were assessed at different times in different areas as the field sampling period progressed. As such, these variables changed chronologically within and between sites as the season progressed or as elevation and/or aspect changed. In order to allow more accurate comparison of forb quality and abundance among polygons, field staff recorded both vegetative and reproductive phenology of important bear forage species to allow a *post hoc* assessment of the seasonal timing, distribution and abundance of various important bear forage plants.

Finally, bear activity (both Grizzly Bear and American Black Bear (*Ursus americanus*) within each polygon was assessed by recording evidence of use by bears including; rub trees, digging and grazing. In addition, for all rub trees found, surveyors recorded a UTM and collected hair samples to contribute to a simultaneous DNA mark-recapture program (B. McLellan. 2011 *report in prep*). Presence or evidence of use, by both marmots and microtines (e.g. meadow voles) were also documented when observed.

At the end of each polygon assessment, an overall quality rank of High, Medium, Low, or Nil was assigned to the polygon based upon presence, abundance and distribution of forage species and bear sign. This overall ranking was used to concisely describe the perceived value of the polygon as bear spring foraging habitat. This quality rank will be used to guide management priority in subsequent conservation of spring bear foraging habitat. Higher quality habitats will be afforded larger "tree retention" buffers to reduce anthropogenic displacement of bears from key foraging habitats. Field data were entered into Microsoft© excel for analysis and field based polygon ranks were used to calibrate the predicative accuracy of both the PEM-based model and the expert based habitat mapping.

During the 2011 field season field efforts were applied predominantly within the South Chilcotin GBPU. During the 2012 season field efforts were applied to the remaining areas of the South Chilcotin GBPU (as required) and to the Stein Nahatlach GBPU.

Spring Habitat Aerial Assessment: 2011 & 2012

In recognition of the extensive size of the project area, an alternative method for more rapid, less intensive, field verification of spring-habitat mapping was also developed. This alternative method relied on expert-based aerial assessment of spring forage habitat quality to assign an overall quality rank to each polygon. Areas were prioritized for aerial survey based on habitat risk, habitat quality (distribution and abundance of potential spring habitat at the landscape scale) and ease of ground access. Areas that were relatively remote were better suited for coarse aerial assessment; this strategic change was made in consideration of project expenses required for application of more rigorous ground-based assessment methods described above. Finally, uncertainty of remote (GIS based) assignment of habitat quality was also included in the prioritization of spring habitats that were assessed using this method. Watersheds that featured the highest number of spring polygons with the assigned expert rank of "Classify" (i.e. uncertain and requiring field assessment) were assigned a relatively higher priority for aerial sampling.

To enable efficient navigation in the field (helicopter and on the ground) a NAD 83 UTM centroid coordinate was created for each spring polygon using ArcGIS 9.3 and Geographic Information Systems XTools Pro. Each polygon, and its associated centroid, was assigned a sequential unique numeric identifier that denoted watershed (e.g.: DU1 represented Duffey polygon number one). Centroid UTMs were exported from ArcGIS 9.3 and converted for use in a field setting using aftermarket software (GPS utility and GPS File Converter) to produce a proprietary GDB (Garmin Database file) for subsequent upload onto a Garmin Map60Csx GPS unit. GPS units were used for coarse navigation between polygons, or areas, and, once the aircraft and crew were within the polygon, GIS tablets were used to constrain field evaluation to each specific polygon as it was being evaluated.

Aerial data assessment procedures were developed by the project team. A Bell 206B Jet Ranger with a pilot, navigator and two observers were used on two subsequent flights to assess mapped spring habitat polygons efficiently from the air. For each spring polygon, surveyors recorded the following attributes:

- Point ID: pre-assigned (recorded in the field again for confirmation),
- Habitat Type: descriptive code to denote avalanche chute, wetland, herb meadow or a wetland shrub complex,
- Dominant Shrub species,
- Dominant Shrub percent cover,
- Dominant Forage (herbaceous (forb)) species: Note only Glacier Lilly, Cow Parsnip and/Solomon's Seal were assessed and recorded as a reflection of the limitation of high-speed aerial assessment method,
- Dominant Forage (herbaceous (forb)) species: percent cover recorded,
- Bear Use: sign or bear presence noted

Based on presence, abundance, amount and distribution of observed food sources and other important characteristics (e.g.; deposition of rich organic soil at the run out zone of the avalanche chute) Bruce McLellan (FLNRO bear biologist) assigned field expert-based suitability rank scores to each polygon (High/Medium/Low or Nil). This overall field-rank was recorded to concisely reflect habitat quality based on visual (aerial) expert-based field assessment. During the flight Francis Iredale took notes and Jared Hobbs led flight navigation and provided guidance on polygon extent and location for assessment. During the flight, all anecdotal sightings of Grizzly Bears were also spatially recorded using a Garmin Map60Csx GPS unit.

Whitebark Pine Habitat Assessment

Whitebark Pine Habitat Modeling: 2011 & 2012

Whitebark Pine distribution was assessed at the watershed level using a spatial model. The program, ArcMap 9.3, was used to query the provincial forest cover Vegetation Resources Inventory (VRI) data for all stands containing Whitebark Pine, within the Lillooet TSA, as a primary or secondary leading species. This initial model (Model 1) was subsequently refined (Model 2) to include aspect and elevation as derived from a Digital Elevation Model (DEM). These refinements were based on expert input from Yvonne Patterson (Univ. Victoria MSc Candidate- Thesis in prep.) and based on preliminary field observations from data collected in year 1 (2011) using Model 1. The parameters of Model 2 are included in appendix four.

Whitebark Pine habitats were predictively mapped, using GIS-based modeling, for each watershed within the study area. Mapped polygons were converted and uploaded into field GIS tablets using GIS Roam and Data Connect software. Overview paper maps were also produced: (predicted) Whitebark Pine habitat polygons were reconciled against Terrain Resource Inventory Mapping (TRIM) (including roads, contours and water) to enable efficient field planning that considered access, distribution and amount of Whitebark Pine habitat at the landscape scale. Field planning included consideration for efficient verification using two different methods described below.

Whitebark Pine Aerial Assessment: 2011

Whitebark pine aerial assessment was conducted using a Cessna 206 fixed wing aircraft with pilot, navigator, and two observers onboard. Two aerial flights were conducted on August 6th and 7th, 2011 during relatively clear skies with high ceiling conditions. These conditions ensured good visibility of Whitebark pine stands and optimal conditions for accurate identification of tree species (to the extent possible).

To enable efficient navigation in the field (aircraft and on the ground) a NAD 83 UTM centroid coordinate was created for each Whitebark pine polygon using Model 1. This was completed using ArcGIS 9.3 and Geographic Information Systems XTools Pro. Each polygon, and its associated centroid, was assigned a sequential unique numeric identifier. Centroid UTMs were exported from ArcGIS 9.3 and converted for use in a field setting using aftermarket software (GPS utility and GPS File Converter) to produce a proprietary GDB (Garmin Database file) for subsequent upload onto a Garmin Map60Csx GPS unit. GPS units were used for coarse navigation between polygons, or areas, and, once the aircraft and crew were within the polygon, GIS tablets were used to constrain field evaluation to each specific polygon as it was being ranked.

For each Whitebark Pine polygon assessed we recorded the following attributes:

- Polygon ID: pre-assigned number (recorded again for confirmation),
- Habitat Type: three variables were assessed including; mixed or pure stand, % composition of Whitebark Pine and distribution pattern (contiguous or patchy),
- Health: three variables were assessed including; extant status (Alive, Dying, or Dead), evidence of blister rust, pine beetle, burn and percent composition of dead versus alive within the forest polygon
- Model accuracy: we assessed the spatial accuracy of the Whitebark Pine model using the GIS tablet with underlying rasterized ortho-photo imagery.

- Estimation of polygon size (in hectares).

During both flights, Yvonne Patterson performed the evaluation of Whitebark Pine stand characteristics. After each flight, the aerial assessment data was entered into Microsoft Excel for review and summary.

Whitebark Pine Ground Assessment: 2011 & 2012

For this project component we used the "Relevé" sample design; this method is a cost-efficient alternative to more rigorous (albeit, more statistically robust) approaches. This sampling design uses belt-transect methodology to collect ground-based stand-level data on forest health and composition. To improve statistical rigor we stratified polygons (using Model I), at the landscape scale, based on characteristics of both elevation and aspect. This approach was adopted and modified from Tomback *et al.* (2004) with revision and input provided by Yvonne Patterson.

Sampling occurred in both 2011 (using Model I) and 2012 (using Model II) between July and mid-September, however, the most intense sampling was completed in August (both years) to coincide with sporulating (canking) "aecia" that are symptomatic of Whitebark pine blister rust infection (Tomback et al. 2004). We assessed Whitebark pine polygons at the stand level (a stand is defined as a spatially continuous group of trees and associated vegetation having similar structures and growing under similar soil and climatic conditions (Oliver and Larson 1990)). To compare stand characteristics both within and between polygons we used a 100 meter linear belt transect (two meter total width) and measured stand characteristics:

- Transect Description: transect ID (sequential and unique), observers, date, aspect, UTM (start/end), VRI classification (leading or secondary) or GIS Model rank (High, Medium, Low, Nil), Bearing, Elevation and Photo ID.
- Site Description: slope, fire history, estimated percent cover of Whitebark Pine (based on quantitative subjective visual estimate), other conifer species present, dominant forbs/shrubs (top three).
- Wildlife Value: bear sign (i.e. bedding, digging, trail marking, scat, rubbing) and squirrel middens (recorded number of middens or sign observed along transect)
- Photographs: taken at the start and end of each belt-transect.

To enable comparison of data from individual transects, where elevation was being examined as an influential variable on Whitebark Pine dominance, transects were sampled along a fixed contour line (using major (100m) contour intervals where possible) at elevations between 1,500-2,100 m ASL. Transect start points were placed at least 15 meters into the stand to mitigate influence from "edge" effects. Elevation data were based on GPS elevation; a transect bearing, perpendicular to the slope, was followed to maintain consistent elevation from transect start to finish.

From the transect start point a 100m transect was measured, along a consistent trans-slope bearing. Along the transect we recorded each tree species (e.g. Lodgepole, Balsam fir, Spruce and Whitebark Pine) where any portion of the tree crown intersected the 2 m belt transect. For each Whitebark Pine tree encountered we recorded the following variables:

- Diameter at breast height (DBH)
- Tree health: healthy, sick, recently dead or dead snag (this was based on vigor and symptoms as described below).
- Tree vigor: few dead or dying limbs, >25% dead or dying limbs, >50% dead or dying limbs or >75% dead or dying limbs.

- Symptoms: cankers present, pitch tubes present, blister rust evident, insect infestation, older cambium feeding and/or newer cambium feeding.
- Presence of cones was also recorded as an indicator of the individual tree's reproductive maturity.
- The number of major stems for each tree.

At the transect end-point we calculated the basal area of the stand using a basal area prism (prism size was pre-determined). Prisms plots were completed with the observer standing at the center of the plot. The observer rotated clockwise, from 0° to 360°, and noted trees that were "in" or "out" of the plot (trees with offset images were counted out and vice versa). Basal area was calculated by collecting DBH for each Whitebark pine tree that was "in" the prism plot: a minimum of five and a maximum of sixteen trees were required per plot to determine basal area (as per the DEIF (2010)).

Vaccinium membranacium (VM) Berry Habitat Assessment

VM Berry Habitat Spatial Modeling (GIS): 2011 & 2012

The spatial identification and delineation of suitable *Vaccinium membranacium* (hereafter may also be referred to as VM) berry habitat was the most challenging field component of the project. We first set the following definitions:

- **Suitable Berry Habitat:** areas that are currently supporting a healthy shrub component of *Vaccinium membranaceum*. Typically these sites occur in open areas with little or no canopy shading.
- **Capable Berry Habitat:** areas that are currently supporting a suppressed component of VM. Typically these sites occur within closed canopy forests where VM relative density, or abundance, is being negatively influenced by over-story shading.

To inform the spatial identification of both suitable and capable VM berry habitats we analysed known suitable VM berry foraging sites (as presented by M.McLellan) from mapped known areas (based on telemetric monitoring data from summer/fall-season bear foraging points) against the PEM database to identify appropriate Broad Ecosystem Units (BEU) (in the first and second deciles from the PEM model attributes). All BEU units that intersected with known VM berry foraging habitats were selected for inclusion within the model as both capable and potential suitable VM berry habitat. In addition, vegetation plot data from bear use sites and from Biogeoclimatic Ecosystem Classification (BEC) and PEM field plots were analyzed for the presence and relative abundance of berry shrubs, including *Vaccinium membranaceum*, *Shepardia canadensis*, and *Amelanchier alnifolia.* Broad Ecosystems chosen for further sampling included: EF, ER, PF, FR, RD and the "FR equivalent" (from the IDFww1 BEC variant).

Next we used expert input (T. Hamilton and S. Senger, with review and comment from the project team members) to identify characteristics within the VRI data that consistently characterized known VM berry foraging areas as mapped by M.McLellan. From discussion and analysis we determined the following model selection criteria that would be used for GIS based prediction of the spatial distribution of VM berry habitats within the Lillooet TSA. It is important to note that this model was intentionally and specifically developed to predict the occurrence of VM; it is not appropriate to use the VM Berry Model to predict important fall berry forage habitats for other species of berry producing forage foods.

Capable Berry habitat:
Specific Broad Ecosystem Units (BEU) of the wetter Bio-geoclimatic (BGC) variants were identified for further investigation from analysis of the vegetation plots, as follows:

- ESSFdv1/dv2/dv2/mw2/xc3: Engelmann Spruce – Subalpine Fir – Dry (EF), Engelmann Spruce – Riparian Forest (ER), Parkland Forest (PF)
- MSmw1/dc1/dc3: Engelmann Spruce – Subalpine Fir – Dry (EF)
- CWHms1: Amabalis Fir – Western Hemlock (FR), Western Redcedar – Douglas-fir (RD)
- IDFww1: Western Hemlock (FR)

The next step in our VM berry habitat modelling process required a further refinement of modeled capable habitat. This last step was required to produce a spatial model of currently suitable VM berry producing habitat that could be used for fall foraging by bears.

Suitable Berry habitat:
To identify habitats that are currently growing VM (irrespective of productivity) we queried the capable habitat (Type One) layer by intersecting it with VRI and selecting for:

- Early seral stages (where the seral stage from the projected seral stage attribute in VRI was 1 & 2); or,
- Low height classes (where tree height from the projected height class attribute in VRI was <5m)
- The final component for the process for identifying currently suitable VM habitat required a "cross-walk "query. We analyzed the polygons generated by the GIS query against forest opening data provided by Chris Enns (developed previously), and against fire-created opening data from F. Iredale, to ensure no natural openings or recent clear-cuts had been missed due to inaccuracies in the VRI.

Finally, all isolated polygons that were smaller than 10ha in size were excluded from the model based on team consensus that habitats <10ha would not provide sufficient quantities of VM to attract habitual and/or annual use by Grizzly Bears. Polygons that were smaller than 10ha in size that were adjacent to other polygons were amalgamated; this step was completed in ArcMap by using the "dissolve" function.

The preliminary model of suitable habitat (VM Berry Model 1) was used to guide field sampling in session one (Sept 8-15, 2011. During session one (2011) dry BEC variants were observed to have lower relative densities (at a given elevation and aspect) when compared to wet and/or moist BEC variants. As such, for session two (Sept 23-30, 2011) Berry Model 1 was refined to include a quality scaling according to BEC variant. This new model was called Berry Model 2. For Berry Model 2, a predictive (GIS based) quality rating of "High" was assigned to all polygons that occurred in moist or wet BEC variants; a quality rating of "Low" was assigned to all polygons that occurred in dry or xeric BEC variants. Berry Model 2 was also used to guide field sampling in year two of the project (field season of 2012).

To enable efficient navigation in the field (aircraft and on the ground) a NAD 83 UTM centroid coordinate was created for each suitable berry habitat polygon. This was completed using ArcGIS 9.3 and GIS X-Tools Pro. Each polygon, and its associated centroid, was assigned a sequential unique numeric identifier. Centroid UTMs were exported from ArcGIS 9.3 and converted for use in a field setting using aftermarket software (GPS utility and GPS File Converter) to produce a proprietary GDB (Garmin Database file) for subsequent upload onto a Garmin Map60Csx GPS unit. GPS units were used for coarse navigation between polygons, or areas. When we were within the polygon, GIS tablets were used to constrain field evaluation to each specific polygon as it was being evaluated.

VM Berry Habitat Ground Assessment: 2011

In recognition of the extensive size of the project area we chose a non-random sample design that allowed us to focus our assessment of VM Berry habitats classified as suitable by the VM Berry model on areas that were relatively accessible. We used Trucks and ATVs to access the majority of sites and where necessary, we used a Bell 206 helicopter to access polygons that were too remote to access by foot. For each polygon of berry habitat assessed, we used a paired transect approach that included an assessment of suitable habitat and a paired assessment within an adjacent capable habitat polygon. Each transect was assigned a unique identifier that included watershed unit. Transect start-points were determined using field GIS tablets to ensure transects started within an area that was representative of the polygon. For transects within capable habitats we used the GIS tablets to ensure that transects would not include large gaps in the canopy cover as edge-effects would likely effect VM densities.

During the first field season (2011) for each transect, we assessed the relative abundance of VM by walking a 100 meter transverse slope transect, and counting the number of individual VM plants that were encountered[2]. Where feasible, information regarding relative berry abundance (e.g. site productivity) was also collected by assessing fruit production. To measure fruit production we would count the number of stems bearing fruit (expressed as percentage) and the average number of berries per stem (Refer to Appendix 1 for an example of the data form). Finally, we conducted a minimum of four randomly placed berry productivity sample plots per transect.

2: it should be noted that phenological progression, during the sampling period, prevented comparable productivity assessments in many areas of the South Chilcotin GBPU. In addition, berry production can be highly variable in the study area on annual basis, hence our reliance on both berry shrub abundance and relative berry biomass.

VM Berry Habitat Ground Assessment: 2012

For the 2012 field season the sampling methodology was adjusted; we adopted a 100 m drop-line transect methodology. With this method, technicians would assess the abundance of berry producing plants by walking a 100m transect and measuring vegetation that was directly underneath the tape. Ground cover >30cm in length was recorded and classified as either bare ground, water, coarse woody debris, moss, herb, shrub, berry (to species) or tree. For all berry-producing plants that are classified as Grizzly Bear foods we recorded phenology codes for both Vegetative and Generative stages (see Appendix 2). Plants without evidence of berry production were given a “Nil” value for generative stage. At the end of each transect, we conducted 3.99 m radius circle plots and counted all stems with heights great than 50 cm to estimate stem density. “Overall berry loading” was recorded for all transects and is a qualitative estimate of the average berry loading of all berry-producing plants within a transect, and was measured on a four-point scale (Nil, Low, Medium and High).

In addition to collecting data on VM berry producing plant density and productivity, we also collected data on previous harvest history as silvicultural prescriptions may influence berry abundance between sites (e.g. artificial stand origin versus natural stand origin). We also noted structural stage and fire history (where previous fire was evident). Data were also collected on dominant forb species, canopy closure, percent slope, aspect and elevation (m ASL). Wildlife values were also noted; these included squirrel middens and/or bear sign (e.g. bed, dig, trail, scat, or rub tree).

After each transect, each polygon was assigned a qualitative field ranking (High, Medium, Low or Nil), derived from a combination of VM abundance, abundance of other berry producing plant species and bear use (as indicated by scat, beds, droppings, rubs, and digs). Calibration of overall value was accomplished by examining known VM berry foraging areas (known to have high bear use as determined in previous studies via telemetry and GPS Collar Data). These ‘field rankings’ of VM Berry habitat quality were used to comparatively assess the accuracy of VM Berry Model II during post field-season analysis.

Data analysis

All data were entered into Microsoft Excel © spreadsheets and independently checked for errors. Subsets of the data were created and loaded into R-Studio (version 0.96.331), an integrated development environment for the open source programming language R (version 2.12.2, R Development Core Team 2011). Plots were created using the Excel. Data collected on polygon attributes (e.g. dominant understory plants, tree heights) were compiled for the three habitat types. Additionally, field ranks were compared with model ranks to determine model accuracy. Finally, we attempted to elucidate the effects of aspect, elevation, BEC subzone variant and watershed unit on the three habitat types. Percent cover estimates for WBP and Berry habitats were converted to proportions and arcsine transformed.

Traditional Ecological Knowledge (TEK)

A key objective for year two of the FWCP Grizzly Project was to incorporate Traditional Ecological Knowledge (TEK) through the creation of a consulting St’at’imc reference group. This was desired in recognition of the cumulative body of knowledge held by respective elders within the St’at’imc First Nation regarding the distribution and location of important grizzly bear habitats. A Micro-soft power-point© presentation was prepared by Dr. Sue Senger (St’at’imc Environmental Lead) with the intent of providing sufficient project background information prior to more formal meetings occurring. Following the presentation Dr. Senger lead two advisory committee sessions with respect to the identification and distribution of occurrence of important Grizzly Bear Habitats (Spring/Whitebark Pine and Berries) and capturing comments from elders with respect to the draft GWMs. A written report, and maps depicting historically known seasonal Grizzly Bear foraging areas, was reviewed with the project team.

Results

The results of each of four project components (including spring habitat mapping, whitebark pine habitat modeling, *Vaccinium membranaceum* (VM) Habitat Modeling and Traditional Ecological Knowledge are presented independently in the order listed above.

Spring Habitat - Expert Based Mapping: 2011-2012

Nearly 900,000 hectares of the Lillooet TSA were analyzed and mapped. Within that area the expert based model predicted 2.8% cover of open spring bear habitat (Table 4). The complete model consists of 2,267 polygons delineating 25,126 hectares of areas with high, medium, low and wetland habitats within the identified occupied watersheds west of the Fraser River in the LRMP area (Figure 3, Table 1). It also includes 360 auxiliary polygons (4,324 ha) delineating riparian and nil habitats. All of the polygons boundaries were based on ortho-mosaic photos. The majority of polygons (1,747 polygons) were classified visually from the ortho-mosaic photo often in conjunction with photographs and the vegetative component of BEC plots. An additional 500 polygons were classified based on personal experience, 27 sites were visited specifically for this project and ranked on the ground and additional 353 polygons were classified by helicopter in the Bridge river, Hurley, Spruce, Mud, Watson Bar, French Bar, and Occupied/Not Identified 1 (Aerial surveys 2011 and 2012).

Evaluation of both the PEM model and the expert-based mapping products confirmed that 34% of the known foraging location points occurred within spring habitat identified by the PEM model; 61% occurred within spring habitat identified by the expert model (McLellan. 2012). Activities other than feeding, such as movement and bedding, account for locations that occurred outside identified spring habitat areas. The inaccuracy of the PEM model was even more apparent when we analyzed location density of known bear forage points. The PEM model resulted in a location density of only 3.8 locations/ha whereas the expert-based mapping resulted in a location density of 13.5 locations/ha (McLellan 2012).

Using field ranking quantifiers to compare the expert model, the expert based model (McLellan 2012) was considered accurate if the field rank matched the expert rank for the corresponding polygon. Percent accuracy is the number of times field rank matched expert rank divided by the number of polygons of a particular expert rank. The expert based model averaged 79% accurate for “High” quality spring habitat (range: 0-87%), 62% accurate for “Medium” quality habitat (range: 0-100%) and 100% accurate for “Low” quality habitat (Table 2: average excluded lower sampled units). Summarized at the TSA scale, the expert based model correctly predicted field rank 65.5% of the time (Table 2). At the watershed level, the expert based model was most accurate for the Texas Creek and Hurley watersheds, with an average of 93.8% and 87.5% accuracy, respectively, while it was least accurate for the Yalakom and Gun watersheds (0% accuracy). For the most intensively sampled watershed (Duffey, n = 43), the expert based model was 67.4% accurate (Table 2). The most intensively sampled BEC subzone variant (ESSFdv1, n = 33) had an expert model accuracy of 81.8%, the third highest (Table 3). The second and third most intensively sampled BEC subzone variants: ESSFxc3 (n = 17) and ESSFmw2 (n = 16), had less than 60% expert model accuracy (29.4% and 56.3%, respectively).

Table 2: Grizzly Bear spring habitat model showing percent accuracy by watershed (average figures are presented, watersheds with lower sample sizes (n= 1-3) are excluded.

Watershed	n	Model accuracy			
		High	Medium	Low	Average
Cadwallader	3	-	66.7%	-	66.7%
Duffey	43	71.4%	60.0%	-	67.4%
Gun	1	-	0.0%	-	0.0%
Hurley	8	-	75.0%	100.0%	87.5%
Lost Valley	4	-	50.0%	-	50.0%
Mud	18	-	27.8%	-	27.8%
Texas Creek	16	87.5%	100.0%	100.0%	93.8%
Yalakom	3	-	0.0%	-	0.0%
Overall	96				65.5%

Table 3: Grizzly Bear Spring habitat model showing percent accuracy by BEC subzone variant (average excludes BEC subzones with lower sample sizes (n= 1-2).

BEC subzone variant	n	Model accuracy			
		High	Medium	Low	Average
CWHms1	2	-	50.0%	-	50.0%
ESSFdv1	33	82.4%	75.0%	100.0%	81.8%
ESSFdv2	1	-	0.0%	-	0.0%
ESSFdvp	1	-	0.0%	-	0.0%
ESSFdvw	7	100.0%	75.0%	100.0%	85.7%
ESSFmw2	16	45.5%	80.0%	-	56.3%
ESSFxc3	17	-	29.4%	-	29.4%
ESSFxv2	2	-	0.0%	-	0.0%
IMAun	1	100.0%	-	-	100.0%
MSdc1	4	100.0%	66.7%	-	75.0%
MSdc3	1	-	0.0%	-	0.0%
MSmw2	11	100.0%	50.0%	100.0%	72.7%
Overall	96				66.81%

The distribution of the spring food ranges from nearly 0% in the Occupied/not Identified 2 area to 8.8% in the Duffey watershed where there is 2,798 hectares of spring bear habitat. Furthermore the distribution of high vs low quality habitats varies substantially; for example, there is as much high quality habitat (1,225 ha) as low, medium and wetland habitats combined in the McGillivray watershed (Table 1). On the other hand the much dryer French Bar, Watson Bar, Yalakom, Occupied/Not Identified 1, North Carpenter and Mud Watersheds have virtually no high quality habitats and large areas of low quality habitats. Although spring bear foods exist, they are in a much lower density than in the wetter watersheds. Other spring foods such as desert parsley (*Lomatium nudicaule*) are likely to be a more prominent food source in these areas.

The Lillooet TSA includes most of the isolated Stein-Nahatlatch grizzly bear population and a large part of the Southern Chilcotin population. The Stein-Nahatlatch has an estimated 3.3% cover of open spring bear habitat spanning 10,212 hectares while the much larger South Chilcotin areas have roughly 2.5% open spring food cover amounting to 14,914 hectares (Table 4).

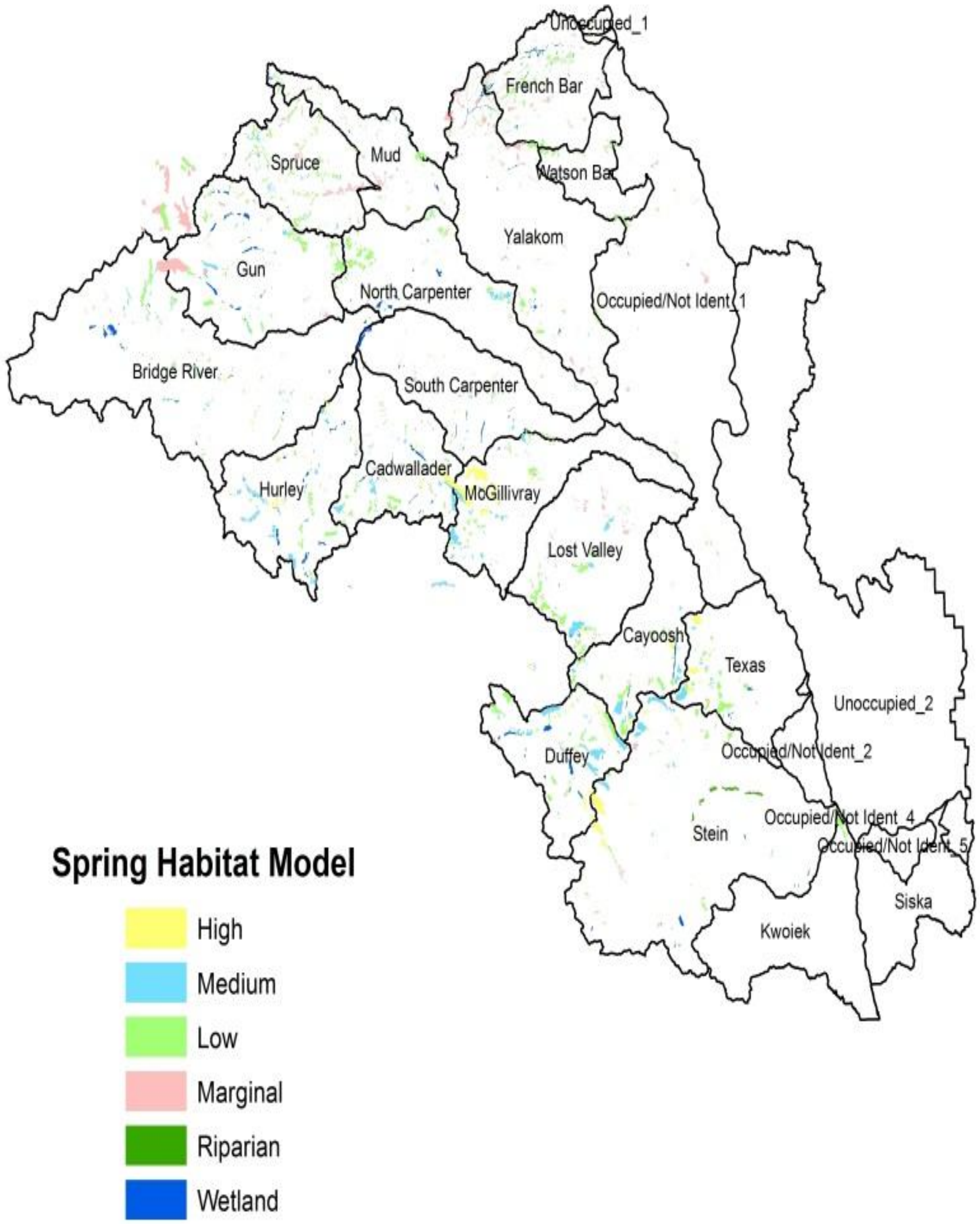

Figure 3: Grizzly bear spring habitat model in the Lillooet TSA. Black Lines delineate watershed boundaries. The model was not created for Unoccupied 2, Occupied not Identified 3 and 5, Siska and Kwoiek watersheds. Map produced by M.McLellan 2012.

Table 4: Distribution and proportion of Grizzly Bear spring habitat summarized by watershed, and by GBPU, for the Lillooet TSA (Hectares).

	Watershed	High	Medium	Low	Wetland	Total Hectares	Proportion of Watershed
South Chilcotin Grizzly Bear Population	Bridge River	42	254	735	355	1386	1.3%
	Cadwallader	381	577	598	180	1737	5.4%
	French Bar	0	14	738	220	972	3.3%
	Gun	5	253	1234	393	1885	3.8%
	Hurley	217	897	471	299	1883	4.6%
	McGillivray	1225	665	451	63	2403	6.1%
	Mud	0	68	363	73	505	2.0%
	North Carpenter	0	239	1010	178	1426	3.0%
	Occupied/Not Identified 1	0	11	230	21	261	0.2%
	Spruce	0	231	1113	16	1360	4.3%
	Unoccupied 1	0	0	14	1	15	1.1%
	Watson Bar	0	0	249	0	249	1.8%
	Yalakom	0	11	660	160	831	1.2%
	Total South Chilcotin	**1869**	**3220**	**7865**	**1959**	**14914**	**2.5%**
Stein-Nahatlatch Grizzly Bear Population	Cayoosh	178	524	857	121	1680	5.3%
	Duffey	450	1128	884	336	2798	8.8%
	Lost Valley	72	534	1037	29	1673	3.4%
	Occupied/ Not Identified 2	0	1	0	0	1	0.0%
	Occupied/ Not Identified 4	0	0	125	0	125	59.6% *
	South Carpenter	8	82	176	282	549	1.3%
	Stein	712	660	454	127	1954	1.8%
	Texas	406	298	676	53	1433	4.0%
	Total Stein Nahatlatch	**1826**	**3226**	**4211**	**949**	**10212**	**3.3%**
	LTSA Total	**3695**	**6446**	**12076**	**2908**	**25126**	**2.8%**

*Occupied/Not Identified 4 is a small area (200 Ha) that is mostly farmland. It contains one of the largest farms in the LTSA.

Spring Habitat Aerial Assessment: 2011-2012

Aerial surveys were conducted within the South Chilcotin GBPU on July 15th and 16th 2011 (this area included the Bridge River, Cadwallader, Hurley, McGillivray, Mud, North Carpenter and South Carpenter occupied watershed units) (Figure 4). Sixty of the 559 areas identified for field verification occurred within Parks or Protected areas; these were removed from the field assessment priority list based on their existing conservation status. During both flights we aerially assessed 214 areas. We ranked 13 polygons as “High”, 41 as “Medium”, 140 as “Low”, and 20 polygons as “Nil” (rock and ice).

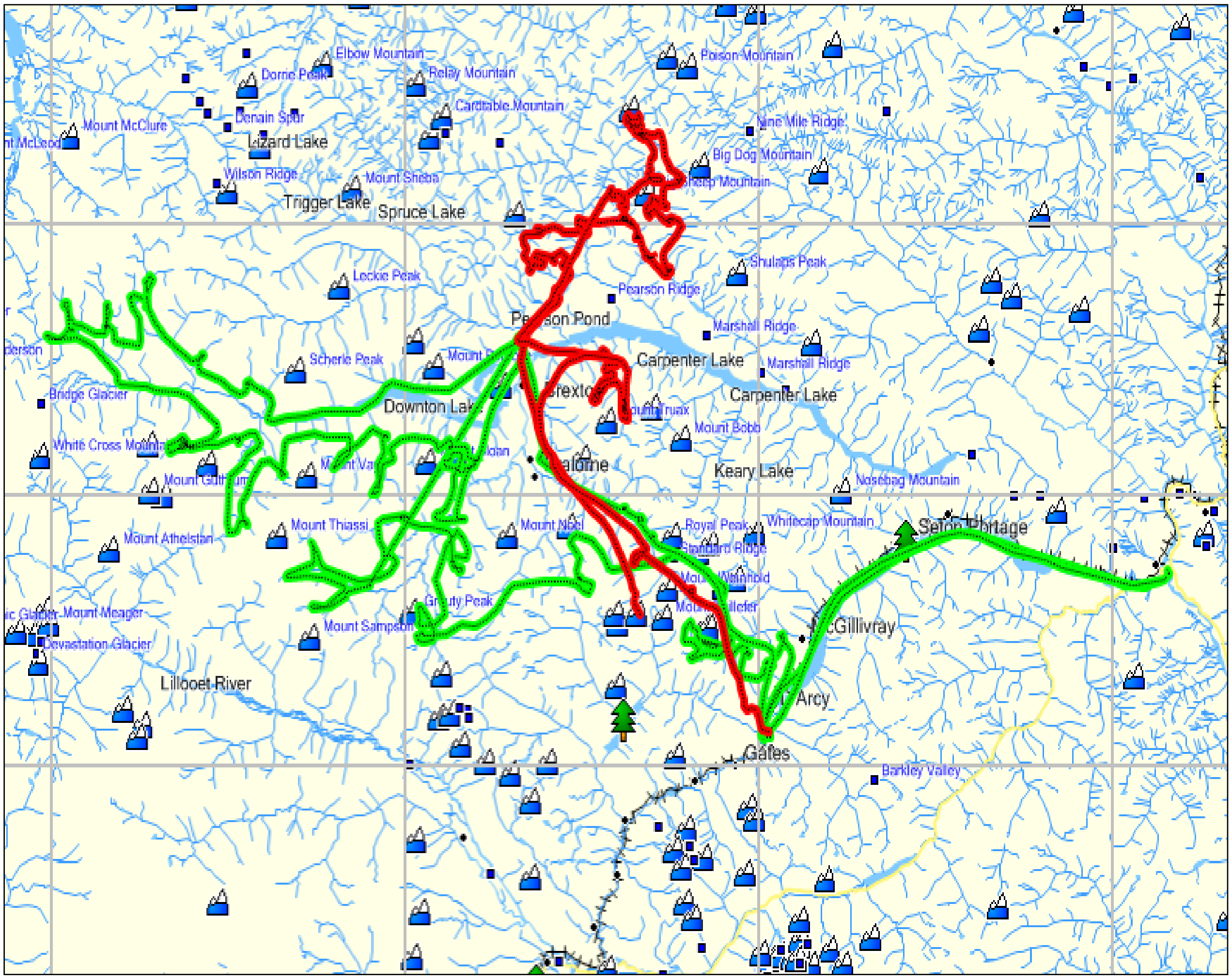

Figure 4: Flight path for July 15th (Green) and July 16th (Red) aerial spring habitat assessments.

The July 29th 2012 aerial assessment of the northeast watershed units (Watson Bar, French Bar, Yalakom) identified and ranked 182 polygons. Expressed as a percentage, polygon rankings are presented from highest to lowest: 49% of identified polygons were ranked as Low (n=89), 25% Nil (n=46), 16% wetland (n=28), 8% Medium (n=15), and 2% Riparian (n=4). A sample of important spring habitat features is presented in figure 5.

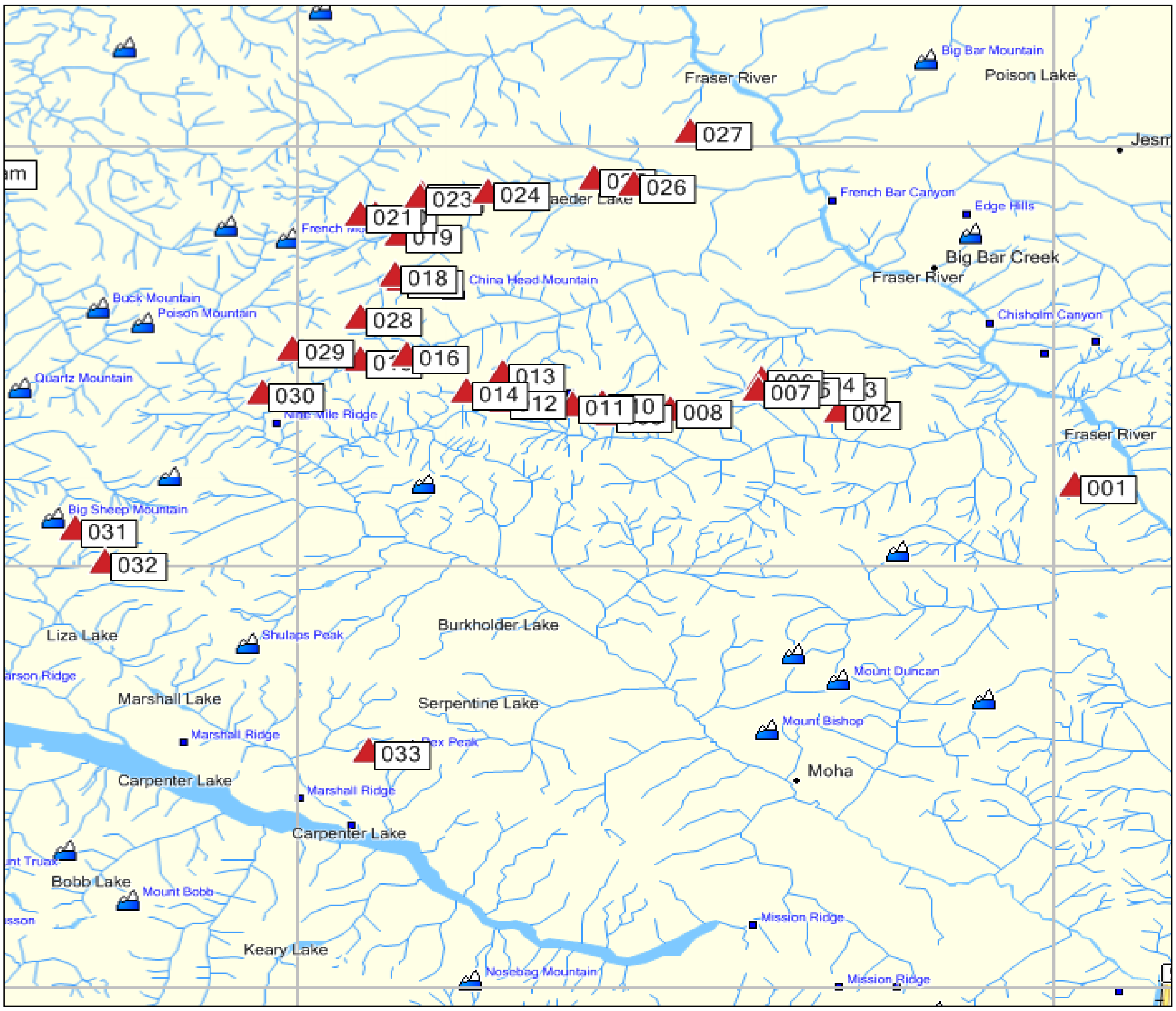

Figure 5: July 2012 aerial assessment of spring habitat features. Red triangles represent identified features (e.g. wetlands).

Spring Habitat Ground Assessment: 2011-2012

We conducted ground-based field assessments of selected mapped spring habitat polygons from June 22nd, 2011 through to August 10th, 2011 and between June 28th and Aug 5th 2012. We sampled four Bio-geoclimatic (BGC) zones over eight watersheds (Table 5), with a total of 112 polygons sampled. Spring habitat assessments were completed for 35 spring polygons in 2011, and 77 polygons in 2012. The most commonly sampled BEC subzone variants occurred in the ESSFdv1 (n = 34, within five watersheds), ESSFxc3 (n = 19, within two watersheds), and ESSFmw2 (n = 18, within two watersheds). The Duffey watershed was sampled the most out of all watersheds, with 46 polygons sampled (41% of total).

Table 5: Spring sampling effort, showing number of polygons sampled within each watershed, summarized by BEC subzone variant for each watershed sampled during the 2011 and 2012 field seasons.

Watershed	CWHms1	ESSFdv1	ESSFdv2	ESSFdvp	ESSFdvw	ESSFmw2	ESSFxc3	ESSFxv2	IMAun	MSdc1	MSdc3	MSmw2	Total
Cadwallader	0	2	0	0	0	0	0	0	0	2	0	0	4
Duffey	3	15	0	1	0	17	0	0	1	0	0	9	46
Gun	0	0	7	0	0	0	0	0	0	0	0	0	7
Hurley	0	4	0	0	0	1	0	0	0	1	0	2	8
Lost	0	2	0	0	2	0	0	0	0	0	0	0	4
Mud	0	0	0	0	0	0	19	1	0	0	1	0	21
Texas	0	11	0	0	4	0	0	0	0	1	0	0	16
Yalakom	0	0	0	0	1	0	0	5	0	0	0	0	6
Total	3	34	7	1	7	18	19	6	1	4	1	11	112

Of the three broad categories of spring static habitat classification, 51 polygons (46%) were classified as avalanche chutes, 43 (39%) were classified as herbaceous meadows, two polygons were classified as a combination of avalanche and herbaceous meadow, ten polygons were classified as wetland-shrub (9%), while three were classified as wetland (3%). At the plant community level 30 sites (27%) were classified as tall shrub, 43 sites (33%) were classified as herbaceous meadow complexes, 16 sites (14%) occurred within low shrub communities, 19 sites were a combination of tall shrub and herb communities (17%), six sites were a combination of low shrub and herb communities (5%), while four sites were a combination of all three (4%). As expected, percent cover of all key spring forage species (when species occurred in a polygon) tended to be highest in "High" ranking polygons, and lowest in "Low" ranked spring polygons. The average for total percent low shrub cover was 15% (SE±3.25) for "High" ranked polygons, 10% (SE ± 1.88) for "Medium" ranked polygons and 2.5% (SE±0.59) for "Low" ranked polygons. The low shrub species with the highest percent covers for "High" ranking polygons were thimbleberry (5% SE±2.06), and mountain ash (3% SE±1.8) respectively.

Overall, percent cover of critical spring herbs were positively correlated with field rank (Figure 6), with the strongest trends apparent for glacier lily, cow parsnip, valerian, nettle, and lupines. The average for total percent herb cover was 47% (SE ± 4.95) for "High" ranked polygons, 24% (SE ± 3.04) for "Medium" ranked polygons and 9% (SE ± 1.3) for "Low" ranked polygon. Specifically, average Cow Parsnip percent cover was 14% (SE ± 2.21) in "High" ranked polygons, 5% (SE ± 0.78) in "Medium" ranked polygons and

1.6% (SE ± 0.27) in "Low" ranked polygons. Average Glacier lily percent cover was 5% (SE ± 2.48) in "High" ranked polygons, 1.3% (SE ± 0.68) in "Medium" ranked polygons and 0.86% (SE± 0.41) in "Low" ranked polygons (Figure 6)[2]. Habitat quality rankings were positively correlated with overall bear use rating; 75% of "High" field ranked polygons had "High" bear use, and 37% of "Medium" and "Low" ranked polygons had the same ranking for overall bear use.

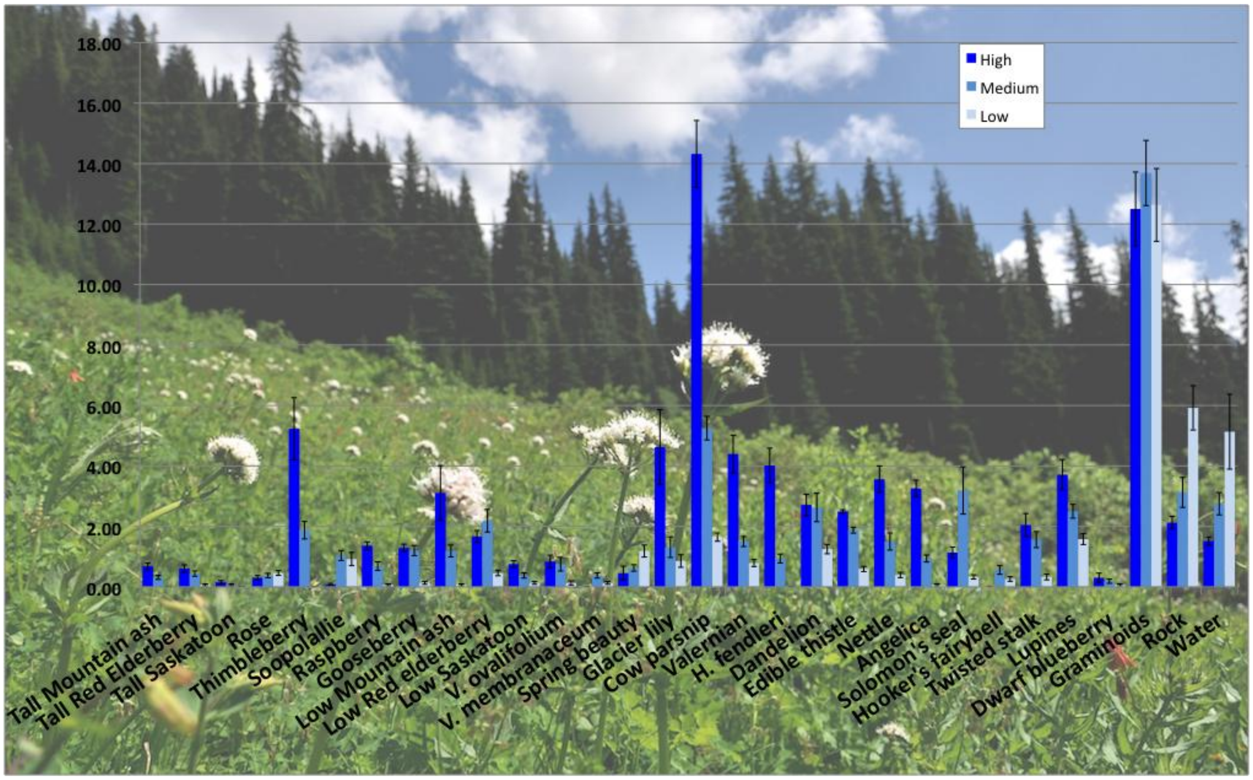

Figure 6: Percent cover estimates of forb forage species collected during the spring habitat assessment component of the project in 2011 and 2012. Estimates are provided for High, Medium and Low ranked spring polygons as applicable.

Of the 112 spring habitat polygons sampled (both years), 33 polygons were classified as "High" quality spring habitats, with 26 of those polygons found in the Duffey watershed (Table 6). Additionally, the Duffey watershed had the most polygons classified as "Medium" quality spring habitat (n = 17). The Texas Creek watershed was the only other watershed with "High" quality habitat (n = 7). The Mud watershed, the second most intensely sampled (after Duffey), with 21 polygons sampled had 15 polygons classified as "Low" quality, or 71% of all polygons sampled in that watershed.

2: These values are not corrected for flowering phenology.

Table 6: Summary of sampling effort, by watershed, showing number of polygons assessed, by watershed, for spring habitat within the project area (2011 & 2012). Assigned field rankings are also provided.

Watershed	High	Medium	Low	Total
Cadwallader	0	2	1	3
Duffey	26	17	3	46
Gun	0	1	6	7
Hurley	0	3	5	8
Lost	0	2	2	4
Mud	0	6	15	21
Texas	7	7	2	16
Yalakom	0	2	4	6

Of the 12 BEC subzone variants sampled, eight had polygons that were classified as "High" quality, nine had polygons that were classified as "Medium" habitat, and ten had polygons classified as "Low" quality. Nearly half (n = 15, 47% of total) of all "High" ranked spring polygons, and 30% of "Medium" ranked polygons were found in the ESSFdv1 subzone variant. One third of the polygons that were classified as "Low" quality spring habitat (n = 13), were located in the ESSFxc3 subzone variant (Table 7).

Table 7: Summary of sampling effort showing number of polygons assessed, by BEC zone, for spring habitat within the project area (2011 & 2012). Assigned field rankings are also provided.

BEC Subzone	High	Medium	Low	Total
CWHms1	1	2	0	3
ESSFdv1	15	12	6	33
ESSFdv2	0	1	6	7
ESSFdvp	1	0	0	1
ESSFdvw	2	3	2	7
ESSFmw2	5	9	4	18
ESSFxc3	0	6	13	19
ESSFxv2	0	2	4	6
IMAun	1	0	0	1
MSdc1	1	2	1	4
MSdc3	0	0	1	1
MSmw2	7	3	1	11

Whitebark Pine Habitat Assessment

The model that was used to predict the spatial occurrence of Whitebark pine habitat in 2012 (Model II) identified a total of 111,845 hectares of WBP habitat within the Lillooet TSA. The model identified 34,882 hectares of “High” WBP habitats, 33,532 hectares of “Medium” WBP leading stands, 8,008 hectares of “Low” WBP stands and 35,423 hectares of “Nil” ranked WBP polygons. The spatial distribution of WBP habitat expressed in hectares per watershed is presented in the subsequent table 8 and Figure 7. The proportion of WBP per watershed is expressed as percentage in brackets under total (Table 8).

Table 8: Hectares of Whitebark Pine habitat per watershed, as calculated by the WPB Model II, within the Lillooet TSA. The proportion of the total watershed area containing Whitebark Pine is expressed in brackets.

Watershed	High	Medium	Low	Nil	Total**
Duffey	979	987	261	1,108	3,335 (11%)
Hurley	1,322	521	174	1,209	3,226 (8%)
Texas	1,655	1,317	279	1,146	4,397(12%)
Spruce	2,979	1,994	281	1,100	6,354 (20%)
Stein**	6,772	6,511	1,807	5,922	21,012(19%)
Mud	661	672	134	812	2,279(9%)
Lost Valley	1,663	1,426	253	1,306	4,648(9%)
McGillivary	451	1,000	146	1,060	2,657(7%)
Yalakom	3,537	3,409	560	2,763	10,269(15%)
Cayoosh	725	698	92	1,111	2,626(8%)
Cadwallader	989	665	129	773	2,556(8%)
French Bar	262	832	92	1,140	2,326(8%)
Watson Bar	374	951	209	895	2,429(17%)
South Carpenter	1,319	1,051	261	718	3,349(8%)
North Carpenter	1,581	890	128	1,479	4,078(9%)
Gun	3,587	3,232	833	3,363	11,015(22%)
Bridge River	4,065	3,273	1,232	4,838	13,408(13%)
Occup/Not Id	1,278	2,305	689	1,901	6,173(6%)
Siska	70	402	75	1,187	1,734(7%)
Kwoiek	610	1,392	373	1,590	3,965(9%)
Total **	**34,879**	**33,528**	**8,008**	**35,421**	**111,836**

*Values do not account for recent fire events.

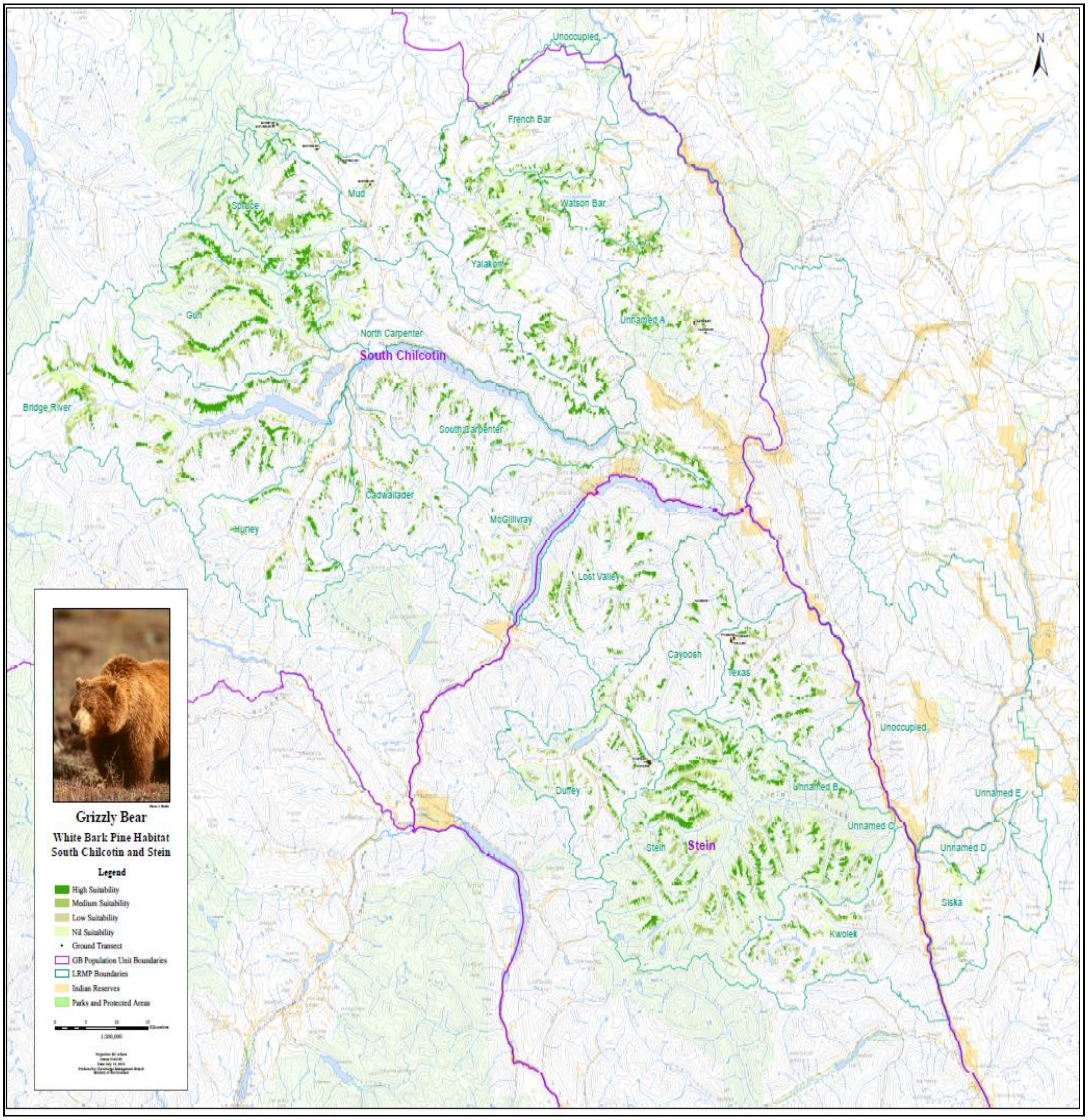

Figure 7: Colored polygons illustrate the distribution of modelled Whitebark Pine habitat within the Lillooet TSA. The polygons shown depict the results from Version II of the WBP model (2012).

Whitebark Pine Aerial Assessment: 2011

Aerial assessments for WBP were conducted using the WBP model I, with assistance from Yvonne Patterson, on August 6th and 7th, 2011. See table 9 for a summary of field assessment efforts applied in 2011.

Table 9: Overall summary of Whitebark Pine polygons assessed during field verification efforts in 2011. Ground and flight data results are presented.

Category	Number of polygons assessed
Field verified - Aerial	87
Field verified -Ground	127
Not Checked	1,589

A total of 87 Whitebark Pine polygons were assessed using aerial assessment methods. Of these, two were pure Whitebark Pine stands and 78 were mixed Whitebark Pine stands. The average area of the Whitebark Pine polygon assessed was 76.3 hectares (SE±8.54).

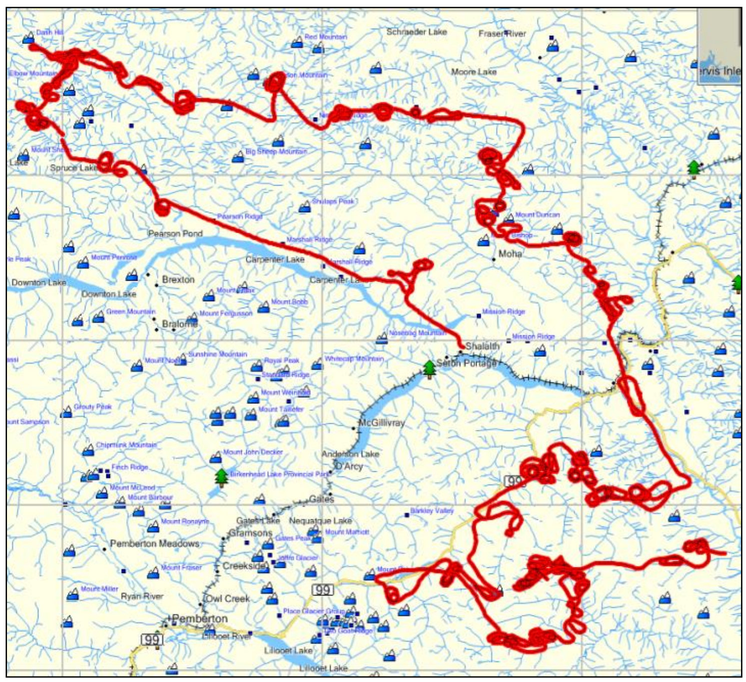

Figure 8: Whitebark Pine aerial assessment survey routes (shown in red) for August 6th and 7th, 2011.

Most of the polygons classified as Whitebark Pine, by the model, actually featured a patchy distribution of WBP even though WBP was still a leading species; only 38 polygons featured a contiguous distribution of WBP. Aerial assessment also provided a course measure of stand health as dead or dying trees were evident from low-elevation aerial survey. At this crude level, 60% (n=52) of 87 assessed WBP polygons were classified as dead or dying during the aerial assessment. Only 40% (n=35) of 87 assessed polygons were classified as alive or healthy. In summary, based on our in-flight observations (Figure 8) , Version 1 of the WBP VRI based model performed very well at accurately modelling the extent, amount and distribution of WBP habitat at the landscape and stand level: 87.5% of WPB polygons were field verified (from flight assessments) to be accurately mapped using this model.

6: It should be noted that confidence in aerial species identification of whitebark pine was much lower in stands where lodgepole pine (Pinus contorta) was also a leading or secondary species. This was most apparent in drier ecosystems within northern reaches of the study area

Whitebark Pine Ground Assessment: 2011 & 2012

We sampled two Biogeoclimatic (BGC) zones over nine watersheds (Table 11), with a total of 153 polygons sampled between August 18th and August 24th, 2011 and June 30th and September 17th, 2012. The ESSF BGC zone was divided further into 12 subzone variants. The most commonly encountered BGC zones were ESSFdv2 (n = 32, over three watersheds), ESSFdvw (n = 28, over five watersheds), and ESSFmw2 (n = 22, in one watershed). The Duffey and Yalakom watersheds were sampled the most out of all watersheds, with 39 and 38 polygons sampled, respectively (50% of total).

Table 10: Number of Whitebark Pine transects sampled within each BEC subzone summarized by watershed (2011-2012).

Watershed	ESSFdv1	ESSFdv2	ESSFdvp	ESSFdvw	ESSFmw2	ESSFmwp	ESSFmww	ESSFxc3	ESSFxcw	ESSFxv2	ESSFxvp	ESSFxvw	MSxk3	Total
Cadwallader	2	0	0	0	0	0	0	0	0	0	0	0	0	2
Duffey	4	0	0	0	22	2	11	0	0	0	0	0	0	39
French Bar	0	0	0	0	0	0	0	0	0	3	0	2	0	5
Gun	0	9	0	1	0	0	0	0	0	0	0	0	0	10
Lost Valley	2	0	0	3	0	0	0	0	0	0	0	0	0	5
Mud	0	0	0	0	0	0	0	11	2	0	0	0	0	13
Texas Creek	7	0	0	8	0	0	0	0	0	0	0	0	0	15
Unnamed A	0	10	1	7	0	0	0	5	0	0	0	0	3	26
Yalakom	0	13	4	9	0	0	0	1	0	9	1	0	1	38
Total	**15**	**32**	**5**	**28**	**22**	**2**	**11**	**17**	**2**	**12**	**1**	**2**	**4**	**153**

Results from the ground based assessment support known broad ecological relationships in regard to the spatial distribution of Whitebark Pine (COSEWIC 2010). As sampling was not random we can only state that there appeared to be a positive relationship in support of an increase in Whitebark Pine composition associated with south facing aspects (Table 15), and increasing slope (R^2= 0.225, $F_{(1, 151)}$ = 53.0, p<0.0001 (Figure 10). There was weak evidence to support a positive relationship between percent composition of Whitebark Pine and elevation (R^2<0.01, $F_{(1,152)}$= 1.138, p=0.189, Figure 9). Overall, the mean Whitebark Pine composition for all transects was 29.5% SE ±2.09. As expected, the mean composition of Whitebark Pine increased with increasing field rank (Table 12). From a landscape perspective, Texas Creek, Lost Valley, Mud and Cadwallader watersheds (n=36) had mean percent composition of Whitebark Pine above 35%, while French Bar and Unnamed A (n=31) watersheds had mean percent compositions of Whitebark Pine below 20% (Table 12). From a BEC variant perspective, the following BEC subzone variants ESSFdv1, ESSFdvw and ESSFmww (n=54) had mean percent compositions of Whitebark Pine greater than 35%; ESSFxcw, ESSFxvp, and ESSFxvw (n=17) had mean percent compositions of Whitebark Pine below 14% (Table 14). Bear foods were observed within 129 of 154 transects. Cones were observed in eight transects, berries were encountered in 83 transects, critical forb species were encountered in 114 transects. Dominant understory shrubs and plants included: falsebox (*Pachistima myrsinites*), lupines (*Lupines arcticus*), and juniper (*Juniperus communis*).

At the stand-level the average diameter at breast height (DBH) for Whitebark Pine trees was 19.24 cm (SE ± 0.295) and no relationship was detected between DBH and elevation (R^2 = 0.001, $F_{(1, 137)}$ = 0.1927, p = 0.6614. A total of 2,026 Whitebark Pine trees were measured, of those trees 45 (2.3%) showed evidence of cone production. Most trees measured exhibited few symptoms of poor health; 34% (n = 693) of trees had old cambium feeding, 9.5% (n = 193) of trees had new cambium feeding, 9.3% (n = 189) of trees had pitch tubes, 0.74% (n = 15) of trees had blister rust, 6.4% (n = 130) of trees had insect feeding, and 0.2% (n = 4) of trees had cankers.

Table 11: Percent composition of Whitebark Pine within assessed polygons (2011-2012), summarized by field rank.

Field Rank	Mean % composition WBP	# polygons
High	62% ± 2.7	47
Medium	29% ± 1.3	34
Low	23% ± 1.5	2
Nil	8% ± 0.07	70

Table 12: Percent composition of Whitebark Pine within assessed polygons (2011-2012), summarized by watershed unit.

Watershed unit	Mean % composition WBP	# polygons
Cadwallader	47% ± 19	3
Duffey	34% ± 3.4	39
French Bar	4% ± 3.5	5
Gun	26% ± 7.6	10
Lost Valley	52% ± 12	5
Mud	35% ± 7.5	13
Texas Creek	60% ± 8.2	15
Unnamed A	15% ± 2.4	26
Yalakom	21% ± 3.6	38

Table 13: Percent composition of Whitebark Pine within assessed polygons (2011-2012), summarized by BEC unit.

BEC unit	Mean % composition WBP	# polygons
ESSFdv1	49% ± 7.7	15
ESSFdv2	18% ± 3.2	32
ESSFdvp	25% ± 2.2	5
ESSFdvw	36% ± 5.2	28
ESSFmw2	34% ± 4.7	22
ESSFmwp	20% ± 15	2
ESSFmww	36% ± 7	11
ESSFxc3	34% ± 6.8	17
ESSFxcw	14% ± 1.0	2
ESSFxv2	9% ± 4.3	12
ESSFxvp	2%	1
ESSFxvw	11% ± 7.0	2
MSxk3	28% ± 24	4

Table 14: Percent composition of Whitebark Pine within assessed polygons (2011-2012), summarized by Aspect.

Aspect	Mean % composition WBP	# polygons
North	15% ± 5.2	5
Northeast	15% ± 2.5	9
East	27% ± 6.3	17
Southeast	35% ± 9.9	13
South	32% ± 4.8	38
Southwest	33% ± 3.5	39
West	30% ± 5.6	24
Northwest	19% ± 8.9	6
Flat	12% ± 6.0	2

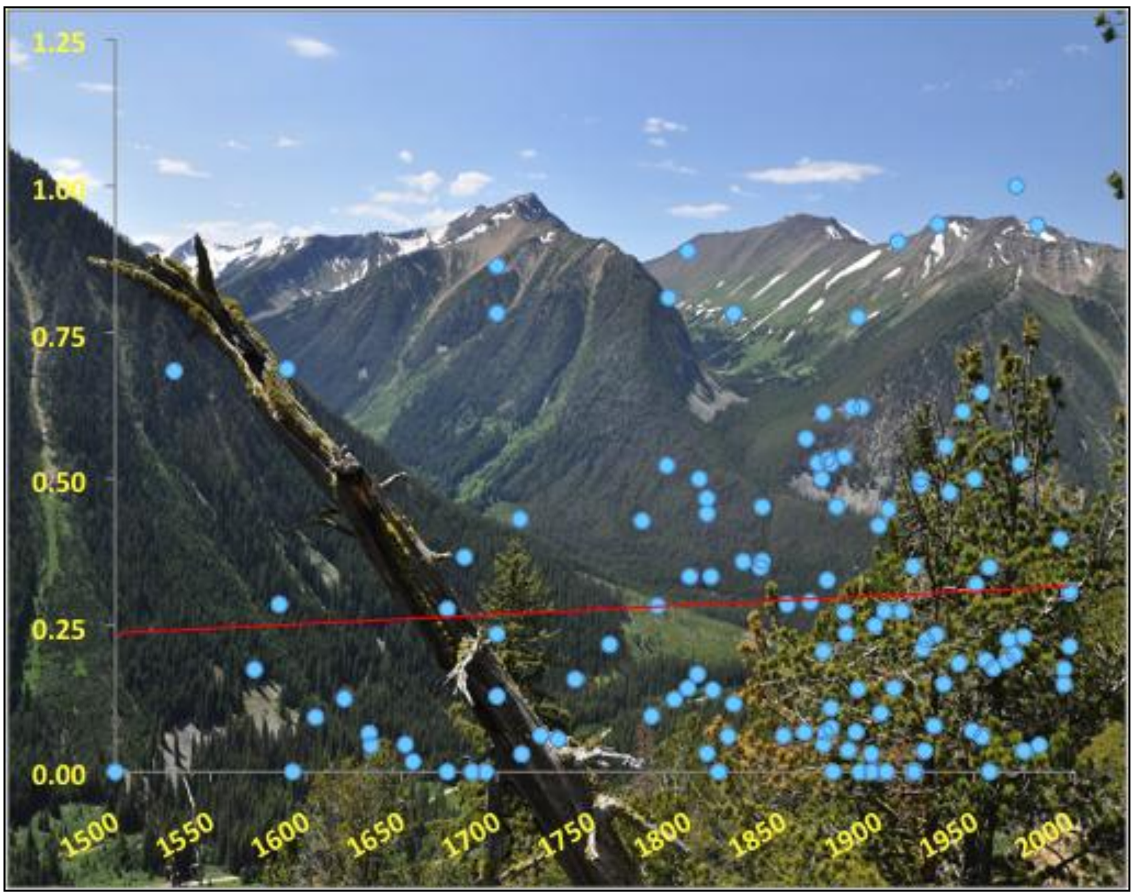

Figure 9: Regression, illustrating positive relationship between elevation (x axis) and WBP relative density (y axis) (Note: relative density of WBP was determined by using percent composition as an indicator of density). $R^2 < 0.01$, $F_{(1, 152)} = 1.0927$, $p = 0.2975$.

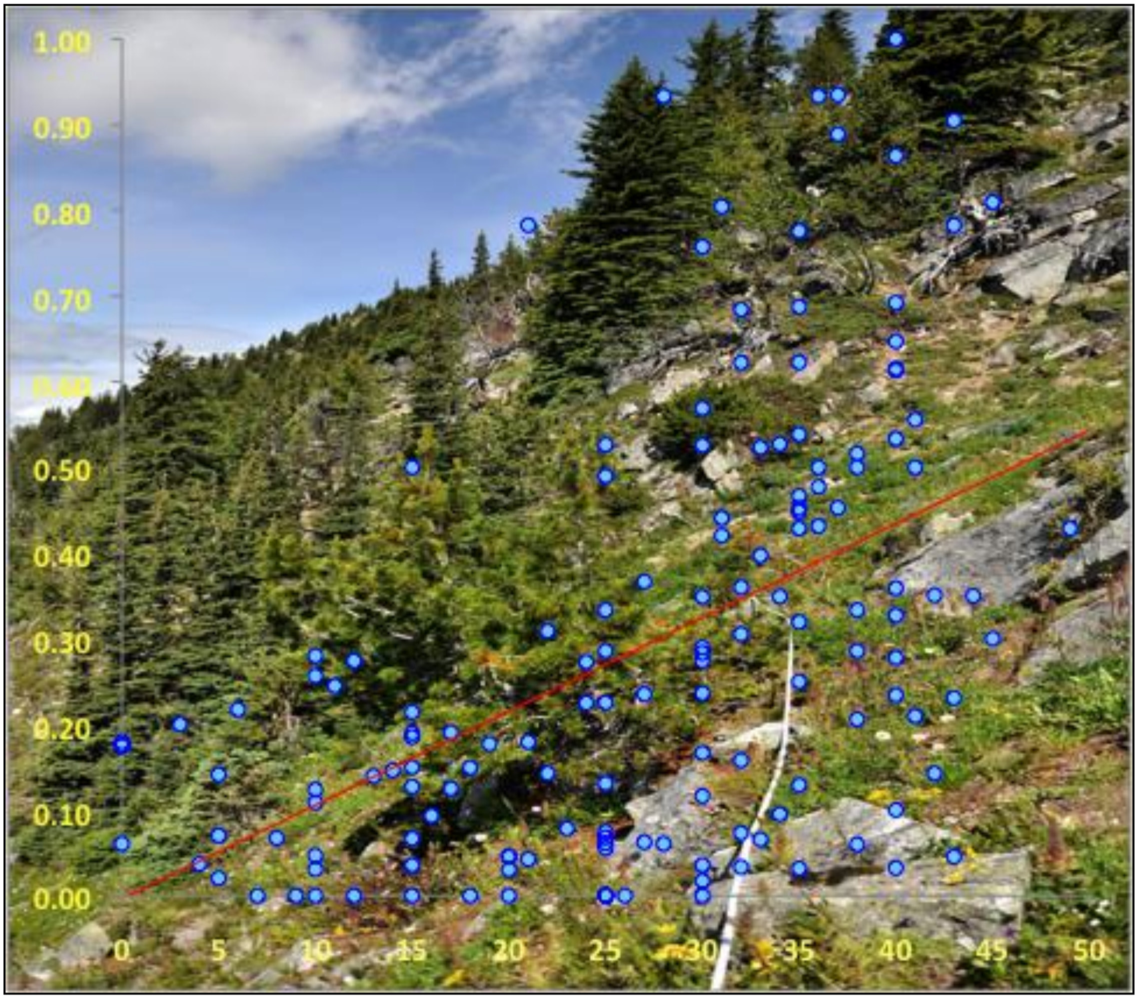

Figure 10: Regression, illustrating positive relationship between slope and WBP relative density (y axis) (Note: relative density of WBP was determined by using percent composition as an indicator of density). $R^2 < 0.01$, $F_{(1, 152)} = 1.0927$, $p = 0.2975$.

Accuracy of WBP Model I and II

Polygons that did not have a rank assigned by a model were not included in calculation of model accuracy. The GIS model was considered accurate if the model output rank matched the surrogate field rank. Overall, the second iteration of the WBP model (“Model II”) was slightly more accurate for predicting quality of WBP habitat (Table 15). When taken to the watershed unit level, Model II was the same/ more accurate for all watershed units except for Texas Creek (Table 15). Model II accurately predicted habitat quality more than 40% of the time for the Duffey, Lost Valley, Mud, and Texas Creek watershed units. Both iterations of the model were best at predicting “High” quality habitats, with both models accurately predicting “High” quality habitat 41% of the time (Table 16). When looking at model accuracy for BEC subzone variants sampled, Models I and II accurately predicted habitat quality more than 40% of the time for four out of the 13 subzone variants sampled (Table 17). Model II was the same or better at predicting habitat quality for 11 out of the 13 BEC subzone variants sampled, while it performed worse for two (ESSFdv1 and ESSFmww).

Table 15: Comparison of model accuracy, by watershed, for Version 1 and Version II of the WBP habitat model. Net adjustment for model II accuracy is expressed as a "+" for increase and "–" for decrease or no change.

Watershed unit	Model I		Model II		Change from I to II
	#	Accuracy	#	Accuracy	
Cadwallader	0	-	1	0%	n/a
Duffey	30	33%	35	51%	+
French Bar	4	0%	5	20%	+
Gun	8	13%	9	33%	+
Lost Valley	5	80%	5	80%	=
Mud	12	33%	12	42%	+
Texas Creek	13	54%	13	46%	-
Unnamed A	21	10%	25	24%	+
Yalakom	37	19%	37	24%	-
Overall	**130**	**27 %**	**142**	**37 %**	**+**

Table 16: Comparison of model rank for Version I and Version II of the WBP habitat model. Net adjustment for model II accuracy is expressed as a "+" for increase and "–" for decrease or no change.

Model rank	Model I		Model II		Change from I to II
	#	Accuracy	#	Accuracy	
High	54	41%	73	41%	=
Medium	76	17%	51	22%	+
Low	-	-	6	17%	n/a
Nil	-	-	12	83%	n/a
Overall	**130**	**27%**	**142**	**37%**	**+**

Table 17: Comparison of model rank, by BEC unit, for Version 1 and Version II of the WBP habitat model. Net adjustment for model II accuracy is expressed as a "+" for increase and "–" for decrease or no change.

BEC unit	Model I		Model II		Change from I to II
	#	Accuracy	#	Accuracy	
ESSFdv1	12	50 %	13	38 %	-
ESSFdv2	27	15 %	31	26 %	+
ESSFdvp	5	40 %	5	40 %	=
ESSFdvw	26	35 %	26	38 %	+
ESSFmw2	17	24 %	22	59 %	+
ESSFmwp	1	0 %	1	0 %	=
ESSFmww	8	50 %	8	38 %	-
ESSFxc3	15	40 %	16	50 %	+
ESSFxcw	1	0 %	1	0 %	=
ESSFxv2	12	0 %	12	17 %	+
ESSFxvp	1	0 %	1	0 %	=
ESSFxvw	1	0 %	2	50 %	+
MSxk3	4	0 %	4	0 %	=

An Assessment of Tree Health for Whitebark Pine Polygons

Whitebark pine stems (n = 2,026) were given individual scores for overall health; stems were either "Healthy", "Sick", "Dead", or "Recently dead". The percentage of trees that were scored as "Healthy" for each transect was calculated and used to find the mean percentage of healthy trees by watershed and by BEC subzone variant. Percent health does not take into account the number of trees that were in a particular transect (i.e. doesn't account for tree density), and is only meant to look at how healthy trees are in a particular area.

The watershed units with the healthiest polygons were the Gun, Unnamed A and Yalakom watershed units, with the mean percentage healthy greater than 76% over 65 polygons (Table 18). The Cadwallader and Lost Valley watershed units (n = 7) had the lowest mean score for tree health (Table 18). The French Bar watershed unit had the greatest variability in tree health.

The BEC subzone variants with the highest percent health within measured polygons were the ESSFxvp, ESSFxcw, ESSFmwp, and ESSFdvp BEC subzone variants, with the mean percentage healthy greater than 90% over 10 polygons (Table 19). The ESSFdv1 and ESSFmw2 BEC subzone variants (n = 34) had the lowest percent health of measured polygons (Table 19).

Table 18: Percent composition of healthy WBP within assessed polygons (2011-2012), summarized by watershed unit.

Watershed unit	Mean % healthy and SE	# polygons
Cadwallader	22% ± 11	2
Duffey	61% ± 3.8	38
French Bar	67% ± 33	2
Gun	78% ± 9.9	10
Lost Valley	47% ± 7.8	5
Mud	66% ± 6.5	13
Texas Creek	56% ± 9.6	14
Unnamed A	75% ± 4.9	24
Yalakom	76% ± 5.5	31
Overall	**67% ± 2.4**	**139**

Table 19: Percent composition of healthy WBP within assessed polygons (2011-2012), summarized by BEC unit.

BEC unit	Mean %healthy tree with standard error	# polygons
ESSFdv1	37% ± 6.6	13
ESSFdv2	67% ± 5.7	29
ESSFdvp	91% ± 6.0	5
ESSFdvw	76% ± 4.8	27
ESSFmw2	53% ± 4.2	21
ESSFmwp	90% ± 9.5	2
ESSFmww	80% ± 3.9	11
ESSFxc3	69% ± 5.5	17
ESSFxcw	100% ± 0	2

BEC unit	Mean %healthy tree with standard error	# polygons
ESSFxv2	80% ± 14	5
ESSFxvp	100% ± 0	1
ESSFxvw	67% ± 33	2
MSxk3	67% ± 33	3
Overall	**67% ± 2.4**	**138**

VM Berry Habitat Model Assessment

As described in the methods section, the model used to geo-spatially predict the occurrence of grizzly bear fall foraging (berry) habitats must be more precisely described as a predictive model that is relevant to only one of several species of berry that grizzly bears may feed on each fall. In particular, the model developed for this project was specifically attempting to predict the occurrence of Huckleberry (*Vaccinium membranaceum)* (VM). In this report, when we refer to the "Berry Model", and/or habitat classified by the berry model as capable or suitable we are more accurately referring to the "VM berry model" and/or "VM berry habitat". This seemingly minor distinction is important as the VM berry model should not be interpreted to predict, or map, the spatial distribution and/or quality of other potentially important grizzly bear berry foraging habitats. In addition, the model was not intended to allow any inference on VM productivity, despite attempts in 2012 to assess VM productivity against several covariates (elevation, slope, aspect, BEC). The model can, at best, be used to provide a ranked geo-spatial distribution of VM at the landscape scale within the Lillooet TSA. It **cannot** be used to predict the geo-spatial distribution of any other species of berry producing forbs nor can it be used to predict forage quality or VM productivity.

VM Berry Habitat Sampling Summary of Effort for 2011

Ground based field assessments, of both iterations of the VM Berry Model, were completed in two subsequent sessions in September (Sept 9-15th & Sept 23-30th, 2011). In total, we completed 67 transects in habitats classified by the model as "Suitable" and 45 transects in habitats (within 16 watershed units) in habitats classified by the model as "Capable". To allow comparative rankings of both suitable and capable habitats *between* areas, we utilized a paired transect design (note: in some areas capable habitat transects were 'shared' by several suitable habitat transects). Both the trinomial (High, Low and Nil) scaled model (used in 2012) and preliminary (binomial) model (used in 2011) identified the same number, and amount, of polygons (n=363) (i.e. identical selection criteria were applied for both models) (Table 20). Of these, we surveyed 67 polygons (18%) and assigned field ranks as described in Table 21.

Table 20: Summary of berry field rankings assigned during transects conducted in 2011 and 2012.

Quality Rank	2011	2012
High	16	19
Medium	9	41
Low	17	114
Nil	15	133
No Rank Assigned(Session 1)	16	0
Field verified - total	67 (31 in Session 1+36 in Session 2)	307 (115 Capable, 154 Suitable, 38 Fire)

VM Berry Habitat Sampling Summary of Effort for 2012

The results from year two (2012) of our VM Berry Habitat Model ground assessments warrant separate treatment in the report because we adopted a different sampling methodology in the second year of the project. In 2012, predicted VM berry producing habitats were sampled between August 13th, 2012 and September 30th, 2012. We sampled four BEC zones, within 13 watersheds (Table 22), for a total of 307 predicted VM berry producing polygons sampled. The Engelmann Spruce – Subalpine fir (ESSF) BEC zone, Interior Douglas fir (IDF) BEC zone, and the Montane Spruce (MS) BEC zone were divided further into subzone variants (six, three, and three variants respectively). The most commonly sampled BEC subzone variants were ESSFmw2 (n = 67, four watersheds), MSdc3 (n = 52, four watersheds) and ESSFxc3 (n = 50, three watersheds). The Hurley and Mud watersheds had the highest allocation of sampling effort (relative to all other watersheds within the Lillooet TSA): we sampled with 76 and 53 polygons respectively (Table 22). These polygons account for 42% of the total number of berry habitat polygons assessed in 2012.

Table 21: Summary of field VM berry foraging habitat quality ranks, summarized by watershed, as assigned during field transects completed in 2012.

Watershed	High	Medium	Low	Nil	Total
Bridge River	0%, n=0	50%, n=1	50%, n=1	0%, n=0	2
Cadwallader	6%, n=1	17%, n=3	67%, n=12	11%, n=2	18
Cayoosh	0%, n=1	9%, n=3	38%, n=13	53%, n=18	34
Duffey	15%, n=3	20%, n=4	20%, n=4	45%, n=9	20
Hurley	14%, n=11	33%, n=25	33%, n=25	20%, n=15	76
Kwoiek	36%, n=4	18%, n=2	9%, n=1	36%, n=4	11
Mud	0%, n=0	4%, n=2	49%, n=26	47%, n=25	53
North Carpenter	0%, n=0	0%, n=0	77%, n=10	23%, n=3	13
Spruce	0%, n=0	0%, n=0	29%, n=4	71%, n=10	14
Stein	0%, n=0	0%, n=0	10%, n=2	90%, n=18	20
Texas Creek	0%, n=0	25%, n=1	0%, n=0	75%, n=3	4
Unnamed A	0%, n=0	0%, n=0	5%, n=1	95%, n=21	22
Yalakom	0%, n=0	0%, n=0	75%, n=15	25%, n=15	20
TOTAL					**307**

Table 22: Summary of VM berry transects completed within each BEC unit, summarized by watershed for the 2012 field season.

Watershed	CWHms1	ESSFdv1	ESSFdv2	ESSFdvp	ESSFdvw	ESSFmw2	ESSFmww	ESSFxc3	IDFdc	IDFww1	IDFxc	MSdc1	MSdc3	MSmw2	Total
Bridge River	0	1	0	0	0	0	0	0	0	0	0	1	0	0	2
Cadwallader	0	7	0	0	1	4	0	0	0	0	0	6	0	0	18
Cayoosh	0	29	0	1	0	0	0	0	0	0	0	4	0	0	34
Duffey	7	0	0	0	0	13	0	0	0	0	0	0	0	0	20
Hurley	0	1	1	0	0	44	3	0	0	0	0	25	0	2	76
Kwoiek	0	0	0	0	0	6	3	0	0	0	0	1	0	1	11
Mud	0	0	0	0	0	0	0	25	0	0	0	0	28	0	53
North Carpenter	0	0	3	0	0	0	0	0	0	0	0	0	10	0	13
Spruce	0	0	0	0	0	0	0	4	0	0	0	0	10	0	14
Stein	0	0	0	0	0	0	0	0	9	3	8	0	0	0	20
Texas Creek	0	3	0	0	0	0	0	0	0	0	0	1	0	0	4
Unnamed A	0	1	0	0	0	0	0	21	0	0	0	0	0	0	22
Yalakom	0	0	16	0	0	0	0	0	0	0	0	0	4	0	20
Total	**7**	**42**	**20**	**1**	**1**	**67**	**6**	**50**	**9**	**3**	**8**	**38**	**52**	**3**	**307**

Using the parameters described in the DEITF manual the majority (82%, n=94) of assessed "Capable" berry habitat polygons were categorized as mature or old structural stage categories with a mean tree height of 21.8 m SE ± 0.523.Five percent of the (assessed) capable polygons had evidence of recent fire (n=6). The understory, within assessed capable polygons, was most often comprised of Kinnikinnick, rhododendron, *V. membranaceum* and soopolallie.

By comparison, 57% of the "Suitable" VM berry habitat polygons (n=154) were classified as either "Low Shrub - herb" (57%, n=88) or "Pole-sapling" / "Young-regen" (28%, n=44) (Table 23). Ninety-six percent (n= 148) were clear-cut originated. Of these 129 (84%) had been re-planted and 13 (8%) had been burnt to encourage regeneration of pole-sapling forests. Average tree height within 154 assessed suitable berry habitat polygons was 4.94 m SE± 0.258. Understory cover within VM berry habitats rated as suitable was generally comprised of fireweed, lupines, rhododendron, and *V. membranaceum*.

Table 23: Summary of VM berry structural stage: summarized by capable, suitable and fire, as defined during field transects completed in 2012.

Structural stage	Capable	Suitable	Fire
Forb dominated herb	1	0	3
Shrub – herb	0	2	0
Low shrub – herb	1	88	20
Tall shrub – herb	0	13	3
Pole sapling	4	33	0
Young forest	14	0	1
Mature forest	61	8	9
Old forest	33	0	2
Very old forest	1	0	0
Young-regenerating	0	10	0
Total	**115**	**154**	**38**

VM Berry Habitat: Distribution by BEC

In 2012, VM Berry Model sampling effort was focused on five BEC subzones within three BEC zones (CWH, ESSF, MS). In total we sampled nine variants within these five subzones (Table 25). The accuracy of the V.2 (2012) trinomial VM Berry Model was highest within the ESSFdv2 and ESSFxc3 BEC subzones (100%) (Table 24).

Table 24 summarizes VM distribution by BEC subzone based on field (on-site) quantification of VM density in each of the nine variants and based on ratings as assigned by the model. This analysis demonstrates that highest values for VM percent composition were highest within the wetter BEC subzones. This was true for both field values (based on transects) and predicted values based on the VM Berry Model (V.2).

To assess the predictive accuracy of the VM Berry Model (V.2) between different BEC subzones we assigned ratings of “high” or “low” to each field-assessed polygon. The assignment of each polygon as “High” versus “Low” was determined by categorizing field values for VM percent composition. “High” was defined to include all polygons containing a field value of VM percent composition greater than 15%. All polygons containing a field value of VM percent composition less than 15% were assigned a field rank of Low. Field ranks (based on this definition) were then compared to model ranks (from the VM Berry Model (V.2)) to assess comparative accuracy. The results of this analysis are also shown in Table 24.

Table 24: Summary of the VM Berry Model (V.2) demonstrating relative distribution within each BEC subzone. VM Berry Model accuracy as determined by comparison of field and model rank is illustrated in the last column, expressed as a percentage.

BEC subzone & variant (where relative precipitation is indicated by the first letter of the subzone: m/w/v=wet & x/d =dry)	n polygons			Accurate prediction of % comp VM by model
	%VM >15%	%VM <15%	Total	
High suitability				
CWHms1	4	0	4	0.0%
ESSFmw2	33	0	33	57.6%
Low suitability				
ESSFdv2	0	11	11	100.0%
ESSFdv1	0	27	27	81.5%
ESSFxc3	0	26	26	100.0%
MSdc1	0	22	22	90.9%
MSdc3	0	28	28	96.4%
Nil suitability				
ESSFmww	1	0	1	-
MSmw2	0	2	2	-
Overall	**37**	**114**	**151**	**51.3% (High) 93.0% (Low)**

In summary, the hypothesis that VM distribution was related to moisture, and would therefore occur in greater densities within wetter BEC subzones (i.e. subzone letters m, w and v), was well supported by our analysis. The distribution of VM (as predicted by the VM Berry Model II) within the entire Lillooet TSA is illustrated in Figure 17.

Both classifications (high & low), as rated by the VM Berry Model (V.2) occurred in the highest abundance within moist BEC variants (e.g.; ESSFmw2). The field assessments, from both years, supported this model prediction; in general, the percent cover of VM (as measured during field assessments) was relatively higher in moist BEC variants (Table 25 & Figures 11 & 12).

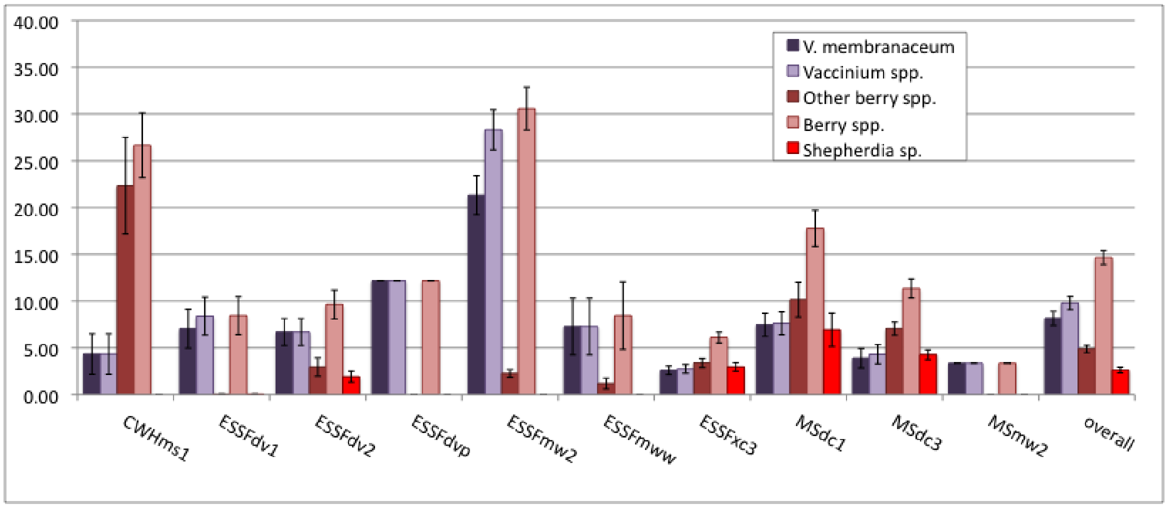

Figure 11: Percent cover estimates for Capable Berry habitat by BEC zone.

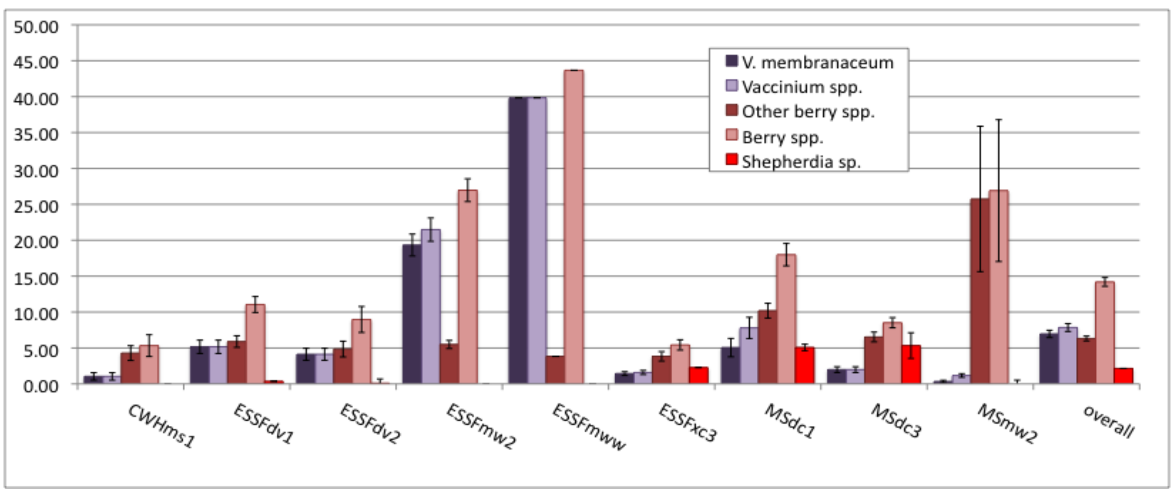

Figure 12: Percent berry cover estimates for Suitable Berry habitat by BEC zone.

VM Berry Habitat: Distribution by Aspect

Based on field assessments, VM was determined to have the highest percent cover values where polygons occurred with north and northeast aspects (Figure 13 & 14). Other berry species had highest percent cover in east, south and southwest aspects (e.g. *Shepherdia* sp. had the highest percent cover in northwest and southwest aspects). Overall, percent cover for all berry species was highly variable, and there does not appear to be a relationship between aspect and percent cover, most likely due to several potential confounding factors such as BEC subzone variant, elevation, slope, canopy closure, etc. that may obscure any direct relationship to aspect.

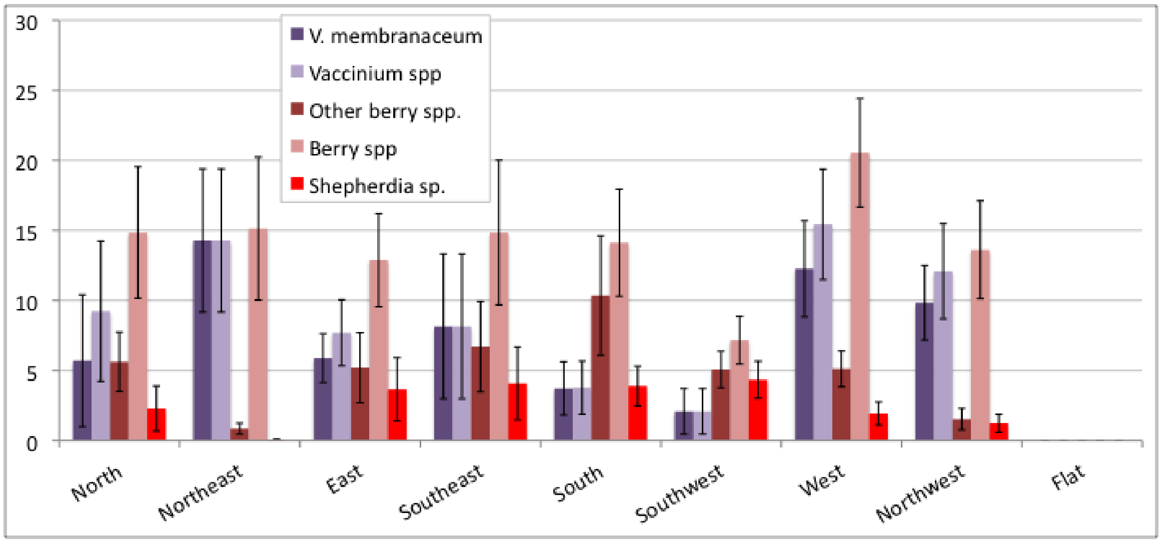

Figure 13: Percent cover estimates for capable berry habitat by aspect.

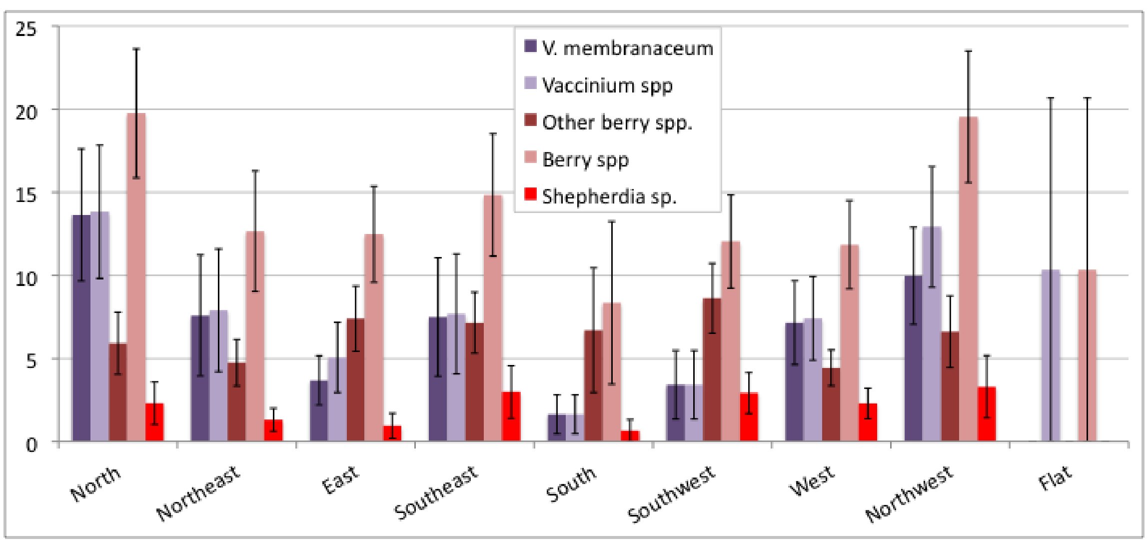

Figure 14: Percent cover estimates for suitable berry habitat by aspect.

VM Berry Habitat: Distribution by Watershed

The VM Berry Model (V.2) predicted that the drier watersheds and BEC subzones (e.g. within watersheds such as Texas, “unnamed A” and Mud) would have the lowest relative abundance of VM foraging habitats; this prediction was also confirmed by the field work conducted in 2012 (Figure 15 & 16). It should be noted that in the relatively dry watersheds (and BEC variants) within our study area the field results confirmed higher relative percent cover of other berry producing forage species (Figure 13 and Figure 14).

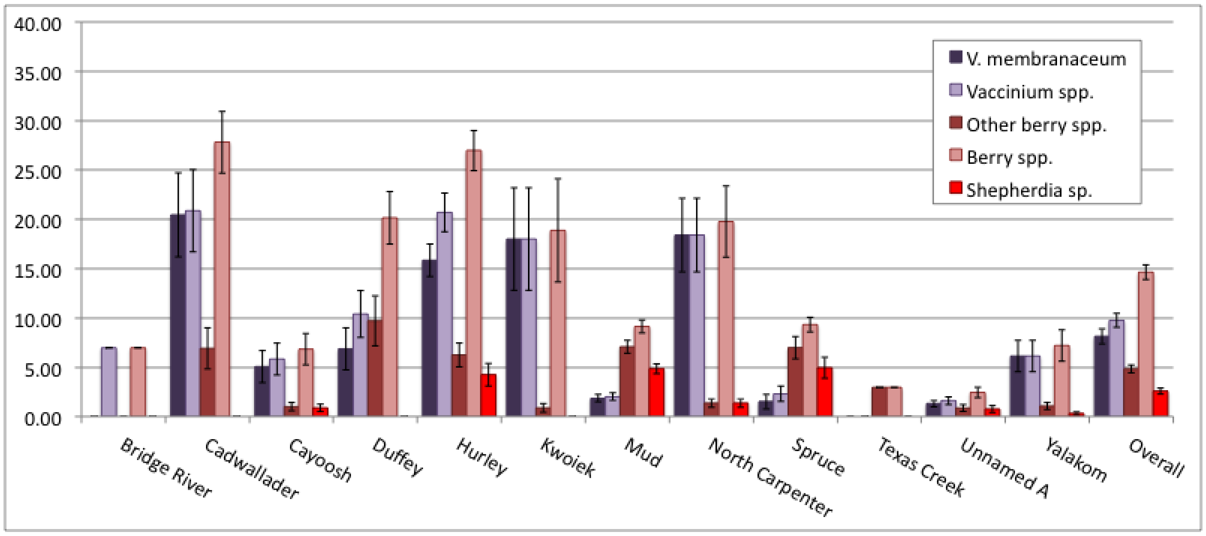

Figure 14: Percent cover estimates for Capable Berry habitat by watershed.

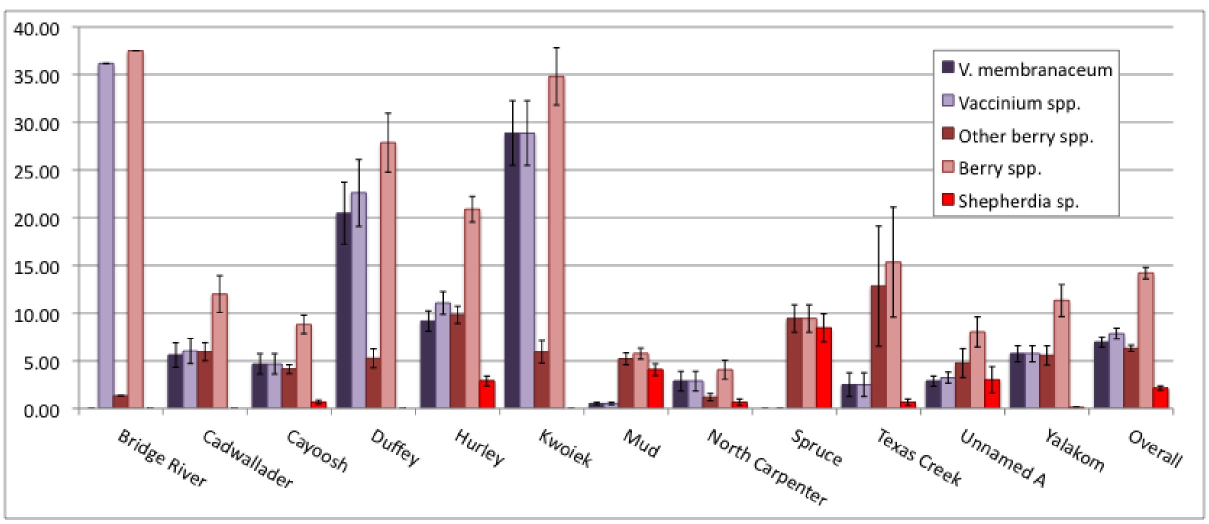

Figure 15: Percent cover estimates for Suitable Berry habitat by watershed.

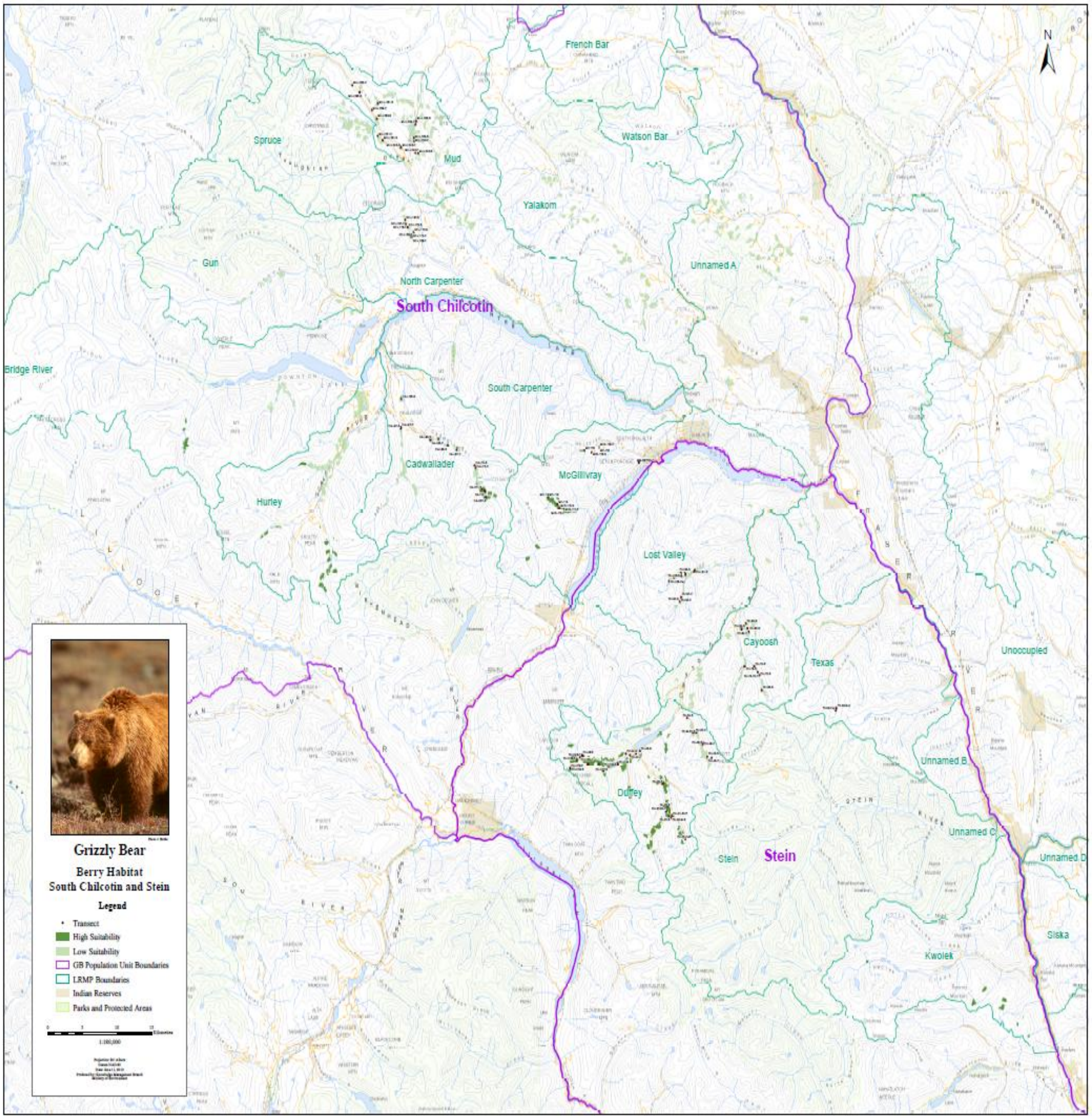

Figure 16: Distribution of VM (as predicted by the VM Berry Model II) and locations of all VM Berry sample transects collected within the Lillooet TSA.

Accuracy of the VM Berry Model (V.2) 2012

To assess the predictive accuracy of the VM Berry Model (V.2) in the entire Lillooet TSA we analyzed (*post-hoc*) the percent composition of VM (as determined during field assessments) between both model ratings (high vs. low). The results of this analysis are presented in Table 25. In summary, field assessments of VM percent composition values associated with high-rated polygons were significantly higher than values (for VM percent composition) associated with low-rated polygons within the Lillooet TSA. Although this pattern was apparent, and obvious, for VM, the same pattern was not evident for other berry species. Table 25 also includes percent composition values for other berry forage species (as they were also collected during the field work completed in 2012). These values were included for further verification of the model's expected inability to predict the geo-spatial distribution of other berry species. As expected, there was no difference between percent compositions of other berry producing species, between high and low model ratings, as predicted by the VM Berry Model (V.2). This result was expected as the model was intended to rate only VM berry habitats; this result confirms our earlier expressed model caveat.

Table 25: Summary of values for percent composition of VM between high and low suitability VM berry habitat ratings (as assigned by the VM berry model V.2).

Berry/Group of berries	High Suitability (±SE)	Low Suitability (±SE)
V.membranaceum	18.6 ± 1.98	4.2 ± 0.61
Vaccinium spp	21.6 ± 2.14	4.65 ± 0.63
Other berry spp	4.58 ± 0.81	5.84 ± 0.58
All berries	26.19 ± 2.11	10.50 ± 0.79
Shepherdia	0.00 ± 0.00	3.13 ± 0.46

VM Berry Productivity: 2012

In 2012 we attempted to quantify berry habitat quality by measuring the amount of berries (or berry 'loading') within each polygon to determine a comparative estimate of forage quality between habitats. This was done in an attempt to link forage quality to bio-physical attributes (such as elevation, slope, aspect and BEC).

Overall, based on field assessment, berry loading was rated as low or nil for 78% of all berry habitat polygons classified by the model as suitable. In comparison, 87% of all berry capable polygons were rated as low or nil (Table 27).

There were only four watersheds, of 12 assessed, which contained any polygons with an assigned field rating of "High" for berry loading. These were located in the Cadwallader, Duffey, Hurley, and Kwoiek watersheds. Of these four watersheds, berry loading was highest for polygons located in the Duffey (33%) and Kwoiek watersheds (29%), respectively. All other watersheds assessed (n=9) had relatively lower field ratings for berry productivity (i.e. berry loading) within both capable and suitable habitats (Table 27 & 26).

Table 26: Percentage of polygons assigned to each productivity rank for each of 12 watersheds sampled in 2012. Percentages for each productivity rank are provided for capable (c) and suitable (s) polygons

Watershed	High		Medium		Low		Nil		Number	
	C	S	C	S	C	S	C	S	C	S
Bridge River	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%	1	1
Cadwallader	16.7%	0.0%	50.0%	12.5%	33.3%	62.5%	0.0%	25.0%	6	8
Cayoosh	0.0%	0.0%	0.0%	13.6%	25.0%	54.5%	75.0%	31.8%	12	22
Duffey	0.0%	33.3%	12.5%	25.0%	37.5%	16.7%	50.0%	25.0%	8	12
Hurley	11.5%	13.9%	23.1%	22.2%	42.3%	52.8%	23.1%	11.1%	26	36
Kwoiek	0.0%	28.6%	25.0%	42.9%	50.0%	14.3%	25.0%	14.3%	4	7
Mud	0.0%	0.0%	0.0%	7.4%	61.5%	48.1%	38.5%	44.4%	26	27
North Carpenter	0.0%	0.0%	0.0%	0.0%	100.0%	62.5%	0.0%	37.5%	5	8
Spruce	0.0%	0.0%	0.0%	14.3%	0.0%	28.6%	100.0%	57.1%	7	7
Texas Creek	0.0%	0.0%	0.0%	33.3%	0.0%	0.0%	100.0%	66.7%	1	3
Unnamed A	0.0%	0.0%	0.0%	0.0%	9.1%	27.3%	90.9%	72.7%	11	11
Yalakom	0.0%	0.0%	0.0%	0.0%	50.0%	58.3%	50.0%	41.7%	8	12

An analysis of berry productivity between BEC subzones, at the level of subzone variant, yielded slightly more definitive results. All high productivity berry habitats were located entirely within the ESSFmww and ESSFmw2 BEC subzone variants (Table 27).

Table 27: Percentage of polygons assigned to each productivity rank for each of ten BEC subzone variants sampled. Percentages for each productivity rank are provided for capable (c) and suitable (s) polygons.

Watershed	High		Medium		Low		Nil		n	
	C	S	C	S	C	S	C	S	C	S
CWHms1	0.0%	0.0%	33.3%	25.0%	33.3%	25.0%	33.3%	50.0%	3	4
ESSFdv1	0.0%	0.0%	0.0%	14.8%	25.0%	44.4%	75.0%	40.7%	12	27
ESSFdv2	0.0%	0.0%	0.0%	0.0%	55.6%	45.5%	44.4%	54.5%	9	11
ESSFdvp	0.0%	-	0.0%	-	100.0%	-	0.0%	-	1	-
ESSFmw2	18.2%	30.3%	36.4%	36.4%	22.7%	24.2%	22.7%	9.1%	22	33
ESSFmww	0.0%	100.0%	0.0%	0.0%	66.7%	0.0%	33.3%	0.0%	3	1
ESSFxc3	0.0%	0.0%	0.0%	3.8%	20.8%	38.5%	79.2%	57.7%	24	26
MSdc1	0.0%	0.0%	12.5%	9.1%	50.0%	77.3%	37.5%	13.6%	16	22
MSdc3	0.0%	0.0%	0.0%	7.1%	70.8%	53.6%	29.2%	39.3%	24	28
MSmw2	0.0%	0.0%	0.0%	50.0%	0.0%	50.0%	100.0%	0.0%	1	2

Traditional Ecological Knowledge

The St'at'imc TEK recognizes Grizzly bears as a core ecosystem value within their culture. Grizzly bears are recognized through oral history and stories, music, dance, carvings and art (Senger 2013). Some stories are published, such as the Duffy Lake, which is referred to as the "Mouth of the Grizzly" (Mack and Ritchie 1977) (Senger 2013). Known as a transformer, a powerful healer that works through dreams, as a guardian of the land, and as a teacher the Grizzly Bear is an endearing icon in local culture. In March, 2011, the St'át'imc Chiefs Council passed a resolution for recovery of this species. In July, 2011, the umbrella-species concept was presented at the International Bear Association Meeting in Ottawa. The St'át'imc Government Services (SGS) Environmental Program is continuing to document the wealth of cultural knowledge within the St'at'imc and continuing to document the tremendous overlap between the traditional diet of the St'át'imc people and the Grizzly bear. This information pertains to the use of the same sources for spring foods, berries, medicines and overlap in protein sources like fish and deer (Senger 2013).

Below are a few documented key messages from the first meeting (see attached Senger 2013 report for additional detail):

- A holistic approach is needed to manage Grizzly bears, and whole areas need to be protected, not just small pieces.
- Corridors, or areas the bears move through to access these important spring and summer habitat areas, are critically important.
- Use the guiding principles and vision from the St'át'imc Land Use Plan, Draft 2004.
- Opportunities for St'át'imc people to be on the ground with researchers are critically important to ensure that values, places and animals are respected, and to build capacity.
- Affirmation of the importance of oral history; traditional stories of the Grizzly bear indicate how bears are viewed by the people, that bears are part of the medicine wheel (animals of the West), and that dream work of the bears is important.
- A recommendation that St'át'imc plant names be included for some of the important spring bear foods and berries.
- Cultural awareness promotes better decision making and protection of St'át'imc values on the land. The role of the Grizzly as an umbrella species is important.

The following key messages were documented from the second meeting (see attached Senger 2013 report for additional detail):

- Biodiversity is very important. What berries are growing back after logging? This should be fully assessed and reported so that the best strategies for producing berries can be determined. The process of improving knowledge on berry production requires monitoring and adaptive management.
- Berries need to be assessed in relation to an old-growth Strategy. What is the current status of old-growth forests in relation to logging activities and what is being done to ensure old-growth forests, and the types of berries/plants that continue to exist in old-growth forests, are maintained. One community uses berries as "anchors" for forest harvesting plans. If berries are present in a logging block layout then the design and reserve areas are adjusted to protect existing berry patches. This ensures there will be plants to recolonize the harvested area faster than if these berries are damaged or removed. Use of this concept and terminology is recommended.

- Burning is a traditional management strategy of the St’át’imc people to maintain the productivity of berry areas and medicinal plants.
- Proportion of Landscape Units (LU) that are identified as having important berry picking areas in them, for LUs that are both within the St’át’imc territory and the Lillooet Timber Supply Area (TSA) are provided in Appendix 5 of the St’á t’imc Traditional Ecological Knowledge in Support of FWCP Grizzly Bear Recovery Habitat Action in the Bridge River Restoration Area 2012 (Senger 2013).
- Regarding Whitebark pine, there was little feedback from the St’át’imc Stewardship Advisory Committee (SSAC) in terms of either mapping areas or current use of this traditional food source. Some SSAC members could recall collecting pine nuts in their youth and there was discussion of ongoing use by elders today. Whitebark pine nuts were collected from squirrel middens and directly from trees.

Community Outreach

Grizzly Bear team members J.Hobbs and F.Iredale attended the 2011 “Salmon in the Canyon” festival hosted by the Lillooet Naturalist Club. A display was set up to promote the Grizzly Bear project and increase awareness of the Fish and Wildlife Compensation Program. All communication and outreach material complied with the signed FWCP contribution agreement.

In 2012, Vivian Birch-Jones of the Lillooet Naturalist Society organized a fall field trip in coordination with BC Nature. This well attended event enabled regional biologist Francis Iredale to lead a field tour with local naturalist members. The hike explored the Downton Valley and visited several mapped Grizzly Bear habitat types. During this activity, Francis discussed the importance of each habitat type: Spring, Whitebark Pine and Berries to the local bear population. In addition to the field tour, Francis and Craig Mclean gave a 45 minute PowerPoint presentation to the group. Finally, a follow up newspaper story was prepared by the Lillooet Naturalist Society and published in the October 17th, 2012 Lillooet News.

Discussion

The project area occurred within the Lillooet TSA; an area of approximately 1,125,025 hectares (ha). The project area encompasses six BEC zones and 46 variants; this is three times greater than the average number of BEC zones and variants for interior areas of comparable size elsewhere in BC (MSRM 2004).

Developing models to accurately model and depict the spatial distribution of important grizzly bear foraging habitats over such a large area, with such extreme climate variation between coastal and interior areas, proved challenging. To reduce uncertainty associated with predictive GIS model-based mapping one of three habitat types within the project scope; spring habitat, was mapped using expert based ortho-interpretation instead (i.e. it was not mapped based on predictive modelling). This expert-based mapping of grizzly bear spring foraging habitat was extensively field-verified in 2011 and 2012. As such, the spring habitat, as mapped in this project, provides a reliable and accurate depiction of the geo-spatial distribution of all spring grizzly bear foraging habitats within the project area. The modelled geo-spatial distribution of the remaining two habitat types (Whitebark Pine and VM Berry habitats) were noticeably less accurate; their respective accuracies are described above (see results) and discussed here. The following sections are intended to provide insight on key observations and disclose key inherent uncertainties for each of the three habitat types that were mapped or modelled.

Spring Foraging Habitat

Seasonal spring foraging habitat, within both the Stein and South Chilcotin GBPUs, is recognized at two distinct scales: stand and landscape (NCBRT. 2004). For example, at the stand-scale, security cover is a necessity whereas at the landscape level forage habitats must be well distributed (NCBRT 2004). The Stein-Nahatlatch has an estimated 3.3% cover of open spring bear habitat spanning 10,212ha while the much larger South Chilcotin areas have roughly 2.5% open spring food cover amounting to 14,914ha (McLellan 2012). Despite the relative difference in availability of spring foraging habitats the Stein Nahatlatch has a significantly lower grizzly bear population (n=24) relative to the Lillooet TSA portion of the South Chilcotin (n=203)(MFLNRO 2012). This suggests that spring habitat is not likely a limiting factor for grizzly bears in either of the two population units.

Throughout the mountainous regions, within the project area, avalanche chutes constitute important spring foraging habitats for Grizzly Bears as they support a diverse array of forage species. These forage species are supported by nutrient rich soils deposits that typically occur at the base of the slope. In addition, early season access to snow free micro-sites (McLellan 2008; Serrouya *et al.* 2011) also contributes to the lush spring growth associated with these areas. Field verification of habitat quality ranks, as assigned by M.McLellan's during the spring habitat mapping process, reinforced the accuracy of this approach. A separate report was authored, by M.McLellan (2012) to provide details regarding methodology and results for this component of the project. In summary, higher ranked (in GIS by MM) spring habitat polygons included higher proportions of cow parsnip, glacier lily and thistle. This pattern was observed within both GBPUs (with the exception of the watershed units in the northeast quadrant of the Lillooet TSA).

It should be noted that the ecological conditions in the more subdued terrain that typify the northeast portion of the TSA differ from the comparatively steep, rugged habitats that exist within the Stein GBPU and within the western portion of the South Chilcotin GBPU. Within this geographically unique portion of the TSA there is a paucity of information on actual bear use based on GPS telemetry information and; as such, our ability to predictively map bear forage use patterns, and habitats, was challenged. However, these drier watersheds (Unoccupied 1 and Watson Bar) support a lower density of bears (Apps *et al.* 2009). Bears occupying these drier areas likely exhibit different foraging strategies (i.e. selection for desert parsley, *Lomatium* spp.) compared to the wetter coastal climate. In order to more accurately map important grizzly bear spring habitats in these areas in future it will be important to gain a better understanding of bear movements, and bear use, within these areas. This information will likely be required to allow more efficient management of grizzly bears within the northeast quadrat of the Lillooet TSA and will better facilitate habitat protection through Specified Areas or Best Management Practices (BMPs).

In summary, the results of the field assessment of the expert-based GIS mapping process confirmed an accurate and comprehensive understanding of the amount, distribution and spatial location of most, if not all, key Grizzly Bear spring foraging habitats within the majority of the Lillooet TSA. This is a noted improvement over the original Predictive Ecosystem Model (PEM). The result from this project provide strong support for acceptance of the expert-based mapping approach as a more accurate and legitimate method for identification of the amount, distribution and spatial location of important Grizzly Bear spring foraging, bedding and security habitats.

Whitebark Pine Habitat

Whitebark pine (hereafter may be referred to as WBP) is considered to be a keystone species in subalpine ecosystems in certain portions of the project area. WBP stands retain snow and water, and its seeds (the largest of any conifer tree in British Columbia) are an important source of protein for a variety of wildlife, including Grizzly Bears (Pigott 2010). The seeds are an important early spring or late fall food, especially in late fall during years of poor berry crops or high cone production (masting). In addition, WBP masting (cone maturation) occurs when nutritional requirements of bears are high (Kendall 1980). Increased grizzly bear reproductive success has been proven to be positively correlated with years of abundant WBP seed cycles (Mattson & Jonkel 1990).

The declining health and limited distribution of WBP in North America is a management concern with implications that extend to wildlife management considerations, particularly in relation to management and recovery of Grizzly Bears within southern interior portions of the species' range in North America. Declines in WBP health have been attributed to an increase in pathogens/disease agents, human land use and exotic species. These declines are disconcerting (Jackson and Campbell 2008). Furthermore, fire suppression activities have also contributed to an increase in stand susceptibility to beetle attack (Taylor and Carroll 2004). Project results, within the Lillooet TSA, demonstrate that issues with stand health are not as pronounced, or severe, as they are in other areas however the continued resilience of WPB in the Lillooet TSA, to pestilence, is uncertain. Stand health was an issue within at least some of the assessed watersheds including the Cadwallader, Lost Valley and Texas Creek watersheds. Finally, WBP stands within the ESSFdv1 also had higher levels of stand health issues; this observation may be attributed to relatively higher WBP densities that facilitated more rapid transfer of pathogens to neighboring trees.

Aerial assessments proved to be an efficient and effective method for rapid survey, at the landscape scale, of WBP habitat; however, it was apparent that the accurate estimation of WBP abundance was challenged, in drier BEC variants, within the northeast quadrant of the study area. Within these areas lodgepole pine occurred sympatrically (as a leading or secondary species) and confounded accurate identification of WBP during aerial surveys. This may also provide at least a partial explanation for the relatively higher model accuracy within watersheds where lodgepole was less dominant (e.g. Lost Valley or Duffey). Similarly it was evident that, for areas where WBP and lodgepole pine grew sympatrically, the VRI data that purports to quantify relative density of tree species within a stand was also inaccurate. This results in a further weakening of our ability to accurately model, or geo-spatially quantify, WBP habitats in mixed lodgepole-WBP stands.

Ground based assessments were completed to more precisely evaluate model accuracy at the stand level. Several potential sources for sample bias are acknowledged. Firstly, there was a predilection to directing sampling disproportionately to lower elevation portions of each respective WBP polygon as a reflection of effort (and time) required to access higher elevation areas. As such, sample transects may not consistently be representative of the entire polygon. Secondly, basal area plots were restricted due to the size of the Prism selected for field use (6M prisms were used for all plots). An analysis of results demonstrated that only four prism plots (out of a total of 154 collected) included >5 trees. It is recommended, for future assessment, that a prism grade >6m is used to accommodate wide spacing and clumpy distribution characteristic of WBP stands. Finally, improvements to sample size (and predictive 'power') would have been achieved through incorporation of longer/wider transects but this was intentionally not incorporated as this would have resulted in an increase resource commitment. Despite these biases, and despite limitations to sample size, in general higher ranked WBP polygons (as predicted by the model-VII) generally corresponded well with higher assigned field rankings. This result was expected and intuitive as the model parameters were intentionally designed to rate habitats according to the percent of WPB as assigned by VRI mapping. Although this was an expected outcome it warrants emphasis as it provides confirmation that the model functioned as expected when compared to field assessments of habitat quality (i.e when comparing field quality ranks, or scores, against predictive ranks (or scores) assigned by the trinomial WBP Model (V.2)) (see Appendix four for score parameters).

Aerial and ground based assessments completed during this project quantified, and further substantiated, several ecological relationships that are consistent with described environmental conditions known to influence WBP distribution and density (COSEWIC 2010). Most notably, WBP dominance appeared to be closely and predictably associated with characteristic elevations, slopes and aspects within the Lillooet TSA with covariate relationships that are consistent with available literature for WBP. The prevalence of established WBP stands at higher elevations, steeper slopes, and south facing slopes (S, SSW, W, and SE) is likely attributed to its ability to outcompete other native coniferous species in these harsh climatic conditions. In relation to climate associations, field results also provided confirmation of increased relative abundance of WBP within the ESSFdv1, ESSFdvw and ESSFmw (BEC subzones. From a watershed perspective, WBP abundance was higher in relatively drier, cool environments (e.g. Watson, Gun, Yalakom). This finding correlates with Arno and Hoff 1989, who noted, WBP becomes more common on cool and moist sites.

In summary, the increased accuracy of V.1 versus V.2 of the WBP model is attributed to the addition of WPB percent composition (from VRI) and to the addition of parameters from the Digital Elevation Model (DEM) for aspect and elevation. These refinements were made to the model in 2012 in order to adaptively accommodate information derived from year one (2011) of the project. Future refinement to the WBP Model (V.2) should include a parameter to assign scores based on stand age, as presented in the VRI data. The inclusion of stand age class is recommended as this species does not initiate cone production until it reaches 30-50 years of age. Furthermore, WBP cone production peaks at approximately 60-80 years of age (Tomback 2001).

VM Berry Foraging Habitat

The stochastic variability of berry occurrence within the Lillooet TSA is a reflection of both landscape and site-specific factors such as soil, moisture, and disturbance events such as clearcuts or fires. This makes it challenging to use geo-spatial modelling to predict berry habitat. In addition, inter-annual variation in fruit production further confounded our ability to improve the predictive accuracy of our VM Berry Model. The two-year scope of this project was insufficient to allow more accurate determination of the geo-spatial arrangement, and annual productivity, of VM berry habitats within the Lillooet TSA. Furthermore, the geo-spatial prediction of other potentially important berry forage species was not even attempted as it was outside of the proposed project scope.

V.membranaceum (VM) is one of several critical bear food sources and likely represents one of the most important late season sources of calories for Grizzly Bears in western Canada (Nielsen & Nielsen 2010); especially in systems devoid of high protein salmon diets. Modelling berry distribution and occurrence is complicated by ephemeral temporal shifts in forest canopy cover, forest suppression, and natural disturbance events such as fire. Further confounding factors include the ephemeral inter-annual variation with respect to fruit production as another key driver with respect to Grizzly Bear body condition (Neilsen & Nielsen 2010). To accommodate challenges associated with accurately mapping VM habitats the team agreed that any management plans produced, based on project results, will also include management guidance for capable habitats. This is necessary to facilitate encourage management activities that result in an appropriate temporal spatial distribution of suitable habitats on the landscape on the long term. In addition, separate management guidance will be provided for suitable habitats (to encourage conservation and management of sites that are currently growing VM). Finally, due to the difficulty associated with predicting, or even quantifying, VM productivity on an inter-annual basis we do not recommended any attempt to manage a subset of predictively mapped suitable habitats by attempting to manage for productivity except where those sites are already known (e.g. Connell Creek) on the landscape.

The distribution and abundance of VM at the stand and landscape level is attributed to moisture gradients. At the watershed level, the Kwoiek, Duffey and Hurley watersheds had the highest relative proportion of “High” quality berry habitats. This result was expected as most of the polygons sampled were in subzone variants categorised as “Moist warm”. Comparatively, the Unnamed A watershed had a lower percent cover of VM than other berry species for within habitats ranked as suitable by the VM Berry Model. This relationship was also expected as the associated relatively drier climate in this watershed is not conducive to VM growth. These relationships were further re-enforced at the stand level, as mean percent cover of VM was highest in stands located within the ESSFmw2 and MSmw2 BEC subzones.

Furthermore, and in parallel with the challenge associated with mapping spring habitats within the eastern portion of the South Chilcotin GBPU, berry producing habitats in the northeastern portion of the TSA were also unique (Hurley, Mud and Spruce watersheds had the highest percent cover of *Shepherdia* relative to the distribution and attributes of this habitat type within the rest of the TSA). Due to the sparse distribution and density of VM it is unlikely that VM is a significant bear food in this area; we suspect that buffalo berry (*Shepherdia canadensis*) may provide an alternative berry food source within this area, however without telemetric monitoring data foraging and habitat use patterns will be difficult to discern. Instead, we will depend on field data and expert based assessment of foraging options to develop recommendations for this portion of the Lillooet TSA.

Traditional Ecological Knowledge

It will be important to approach Grizzly Bear management from a holistic approach to ensure other important ecological values are captured and protected (i.e. umbrella species). The chiefs (of the LTC) have committed to recovering Grizzly Bear populations. The inclusion of TEK may be an important contribution that may shed insight as we collectively manage towards Grizzly Bear population recovery goals.

In addition to consideration for bear forage, berries are a key traditional food source for local band members. Geospatially, the Duffey, Hurley, Spruce, Gun and Yalakom watersheds are each noted as important collection watersheds for berries (Senger 2013).In consideration of both perspectives it will be important to use fire management (i.e. burning) to restore and revitalise habitats. It was recommended that we actively, through management, create low intensity burns (outside of the hot fire season). High intensity burns should be avoided, and managed, to ensure that important mineral and organic deposits in the top layer of forest soils are not destroyed (Senger 2013).

TEK meetings enabled project biologists to disseminate project results to local First Nation communities' in return important knowledge and insight with respect to the use of traditional management to protect and enhance important Grizzly Bear habitat. It is important to continue with a collaborative approach to engagement and open dialogue as we proceed with the designation of Specified Areas under GAR.

Management Recommendations

Grizzly Bear fitness, and ultimately the bear's ability to reproduce and survive, is dependent upon access to critical spring/summer/fall food. This is particularly important for interior Grizzly Bears as they do not have access to high protein food source (i.e. salmon) like their coastal conspecifics. Grizzly Bear research conducted in the Flathead watershed of southeastern British Columbia demonstrates that at least some grizzly bear populations are limited and perhaps regulated by food availability (McLellan 1994); the same pattern likely occurs across much of North America (McLellan 1994) including the Lillooet TSA.

The conservation and maintenance of viable Grizzly Bear populations represents a high priority for the British Columbia Fish and Wildlife Compensation Program, the provincial government, the St'at'imc First Nation and the Lillooet Naturalist Society. Protection of important seasonal Grizzly Bear habitat within the Stein-Nahatlatch and South Chilcotin GPBUs represents an important conservation initiative to ensure bears can meet their energetic demands for the entire year within their brief seven month activity period (McLellan and Hovey 1995).

Ecological information, including documentation of high-use areas and important seasonal foraging habitats for Grizzly Bears, was amassed through several multi-year studies using radio collaring and intensive field investigation methods. These studies were a critical component, in this project, to inform the development of predictive habitat models at the landscape scale for each of the twenty-six watersheds within the Lillooet TSA. At the landscape level, these habitat models will provide a foundation for development and application of species-specific conservation measures for grizzly bears. These General Wildlife Measures (GWMs) (see Appendix Five) will be applied within spatially identified specified areas that and will be legalized through the designation of legal orders under the *Forest and Range Practices Act.* The GWMs are intended to maintain the ecological integrity of identified habitats through the protection of key foraging sites and protection of adjacent security cover for all three habitat types analyzed during this project.

In addition to habitat management, each of the three habitat types that were defined (with varying degrees of accuracy) by this project constitute only a portion of an adult grizzly bear's annual foraging requirements. High quality habitats that are used by bears may prove to be population sinks if movement within or between these habitats, on an annual basis, results in increased mortality due to exposure to anthropogenic influence (e.g. if attractive habitats bring bears into close contact with roads or human settlements). As such, managers must consider the broader perspective to ensure conservation of connectivity habitat between important seasonal habitat areas.

Continued public education, and monitoring of Grizzly Bears movement patterns using radio-telemetry, will help to alleviate mortality associated with human bear encounters. The spatial identification of key habitats, and known bear movement patterns, will also facilitate the protection of important connectivity habitats within the core range of the Grizzly Bear population within the Lillooet TSA. Effective habitat protection under the *Forest and Range Practices Act* will need to consider relationships between habitat quality and survival at the landscape scale.

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Appendices

Appendix 1: Parameters used to determine Model II rank and Field rank for WBP polygons

	GIS model II		Field rank	
Parameter	Range	Points	Range	Points
Elevation	<1700 m	1	<1700 m	1
	1700 - 1900 m	2	1700 - 1900 m	2
	>1900 m	3	>1900 m	3
Aspect	320° - 80°	1	W	2.5
	280° - 320°	2	NW	1.5
	80° - 130°	2	E	1.5
	140° - 280°	3	SE	2.5
			S	3
			SW	3
			N	1
			NE	1
VRI (model) / % Composition (Field)	10% - 20%	0	0-20	0
	20% - 35%	4	20-35	4
	>35%	8	>35	8
Rank	Total points		Total points	
4 (Nil)	4-6		4-6	
3 (Low)	7		7	
2 (Moderate)	8-11		8-11	
1 (High)	12-14		12-14	

Appendix 2: Field data forms

Spring Habitat Assessment Form

Grizzly Bear Habitat Assessment Form – Spring / Summer Habitats

Site Information

Date: ______________________

Observers: JH FI NB BP KF RW

Drainage: ____

Plot ID: ____

Habitat Type (AV/WE/HM/WS): ____

Plant Community: _________________________ Aspect: _______________________

UTM (Z/E/N): ________/____________________/______________________________

Polygon Description		Site Photographs / #	
% open herb layer		North	
% tall shrub layer		East	
% tree layer		South	
% other _______________		West	

Bear Use Description

Overall Bear Use (circle): None / Low / Medium / High
Diggings: Yes / No Rock Flipping: Yes / No Bear Beds: Yes / No Scat: Yes / No
Describe and/or mark waypoint for rub trees: ________________________________
Hair Sample- UTMS: ____
Food Species Eaten: ____

Marmot colony present: Yes / No Vole Holes: Yes / No

Other Mammal activity (eg: Ursids, Sciurids – sps and behaviour/evidence)

____

Comments

____
____
____
____
____

Veg Plot

Cover Type	% cover	Dist	Phenology Code	
			Vegetative	Reproductive
Tall Shrub (Overall cover) (2-10m)		n/a	n/a	n/a
Mountain ash (Sorb spp)				
Red Elderberry (Samb rac)				
Saskatoon (Amel aln)				
Low Shrub (Overall cover) (<2m)		n/a	n/a	n/a
Rose (Rosa spp.)				
Thimbleberry (Rubu par)				
Soopolallie (Shep can)				
Red Raspberry (Rubu ida)				
Black Gooseberry (Ribe lac)				
Mountain ash (Sorb spp)				
Red Elderberry (Samb rac)				
Saskatoon (Amel aln)				
Oval- leaved blueberry (Vacc ova)				
Black Huckleberry (Vacc mem)				
Herb (Overall cover) (<15 cm)		n/a	n/a	n/a
Spring beauty (Clay Lan)				
Glacier Lily (Eryt gra)				
Cow parsnip (Hera lan)				
Valerian (Vale sit)				
Hydro fen				
Dandelion (Tara off)				
Edible thistle (Cirs edu)				
Stinging Nettle (Urti dio)				
Angelica (Ange sp)				
Solomon's seal (Smil sp)				
Hooker's fairybell (disp hoo)				
Twisted stalk (Step sp.)				
Lupines (lupi sp)				
Dwarf Blueberry (Vacc cae)				
Graminoid (Grass/Sedge)		n/a	n/a	n/a
Rock or Bare Ground		n/a	n/a	n/a
Water (where applicable)		n/a	n/a	n/a

Note for % cover: 3% or under=trace, then use increments of 5% from 5% up.

Overall Rating: ______________________________

Spring Habitat Assessment-Aerial Data Form

Point ID	Hab Type	Tall Shrub		Herb (circle or write in code for other)		Bear Use	Field Rank	Confidence	Comment	
	(AV/WE/HM/WS)	Species	%	Species	%				Access	Snow (y/n)
SC45	AV/WE/HM/WS			GL / CP / SolSeal:						
SC46	AV/WE/HM/WS			GL / CP / SolSeal:						
SC47	AV/WE/HM/WS			GL / CP / SolSeal:						
SC48	AV/WE/HM/WS			GL / CP / SolSeal:						
SC49	AV/WE/HM/WS			GL / CP / SolSeal:						
SC50	AV/WE/HM/WS			GL / CP / SolSeal:						
SC51	AV/WE/HM/WS			GL / CP / SolSeal:						
SC52	AV/WE/HM/WS			GL / CP / SolSeal:						
SC53	AV/WE/HM/WS			GL / CP / SolSeal:						
SC54	AV/WE/HM/WS			GL / CP / SolSeal:						
SC55	AV/WE/HM/WS			GL / CP / SolSeal:						
SC56	AV/WE/HM/WS			GL / CP / SolSeal:						
SC57	AV/WE/HM/WS			GL / CP / SolSeal:						
SC58	AV/WE/HM/WS			GL / CP / SolSeal:						
SC59	AV/WE/HM/WS			GL / CP / SolSeal:						
SC60	AV/WE/HM/WS			GL / CP / SolSeal:						
SC61	AV/WE/HM/WS			GL / CP / SolSeal:						
SC62	AV/WE/HM/WS			GL / CP / SolSeal:						
SC63	AV/WE/HM/WS			GL / CP / SolSeal:						
SC64	AV/WE/HM/WS			GL / CP / SolSeal:						

Whitebark Pine Habitat Assessment-Aerial Data Form

Point ID	Habitat Type			Health			Size		Comment
	Mixed(M) or Pure(P)	% WBP	Distribution (Cont. vs Patchy)	Alive (1), Dying (2), Dead (3), Unk (0)	% dead	Healthy (H), Blister Rust (Br), Beetle (Be), Burn (Bu)	ha	accurate as mapped?	

White Bark Pine Habitat – Ground Assessment Form

Grizzly Bear White Bark Pine Transect Form

Transect ID:	Date:	Recorders:
BEC Type: VD/ D/ M	VRI: Leading/Secondary	Bearing:
UTM start:	Photo #:	Aspect (D/Cardinal):
UTM end:	Photo #:	Elevation:

Site Description

Slope (%):   Fire History: Y / N   % estimated WBP:_____   other species:______________

Dominant Forbs/Shrubs (top 3):________________________________Comments:____________________________

Wildlife Value

Bear Sign Observed (circle those seen): Bed___ Dig___ Trail___ Scat___ Rub tree___

# of Middens Observed:___________________   Bear Food Present: Forbs / Berries / Cones

PRISM #:_______ **#WBP:**_________ **DBH:**_________________________ **#Other spp: ;**_________ **DBH:**_________________

Transect Tree Data:

#Ba:____________________ **#Bl:**____________________ **#Se:**____________________ **#Pl:**______________

	DBH	Health	Vigor	Symptoms	Cones (Y/N/?)	Comments
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						

**Only complete for White Bark Pine*

Berry Habitat Ground Assessment Form

Grizzly Bear Berry Assessment Form

Transect ID: ____________ Date: ____________ Recorders: ______________

Location/Drainage: ____________________ Habitat Model: Capability / Suitability

UTM Start: ____________________ UTM End: ____________________________

Bearing: ______________Photo #: ______________________ BEU: ________

Site Description

Slope (%): ____________________ Aspect: ____________________ Elevation: __________________

Structural Stage: ____________________ Fire History: Y N

Logging History: Y N Planted: Y N Treatment: burned/unburned Tree Height: _______________

Canopy Closure: ____________________

Dominant Forbs/Shrubs (top 3):__________________________

Vaccinnium membranacium (#) ________________#/100m__________Est % Cover: ____________

Distribution Code: __________________________ Field Rank-Quality: High/Medium/Low/Nil

Wildlife Value

Bear Sign Observed (circle those seen): Bed Dig Trail Scat Rub tree Other: ____________

Hair Sample Collected: __________________ Bear Food Present: Forbs Berries Cones

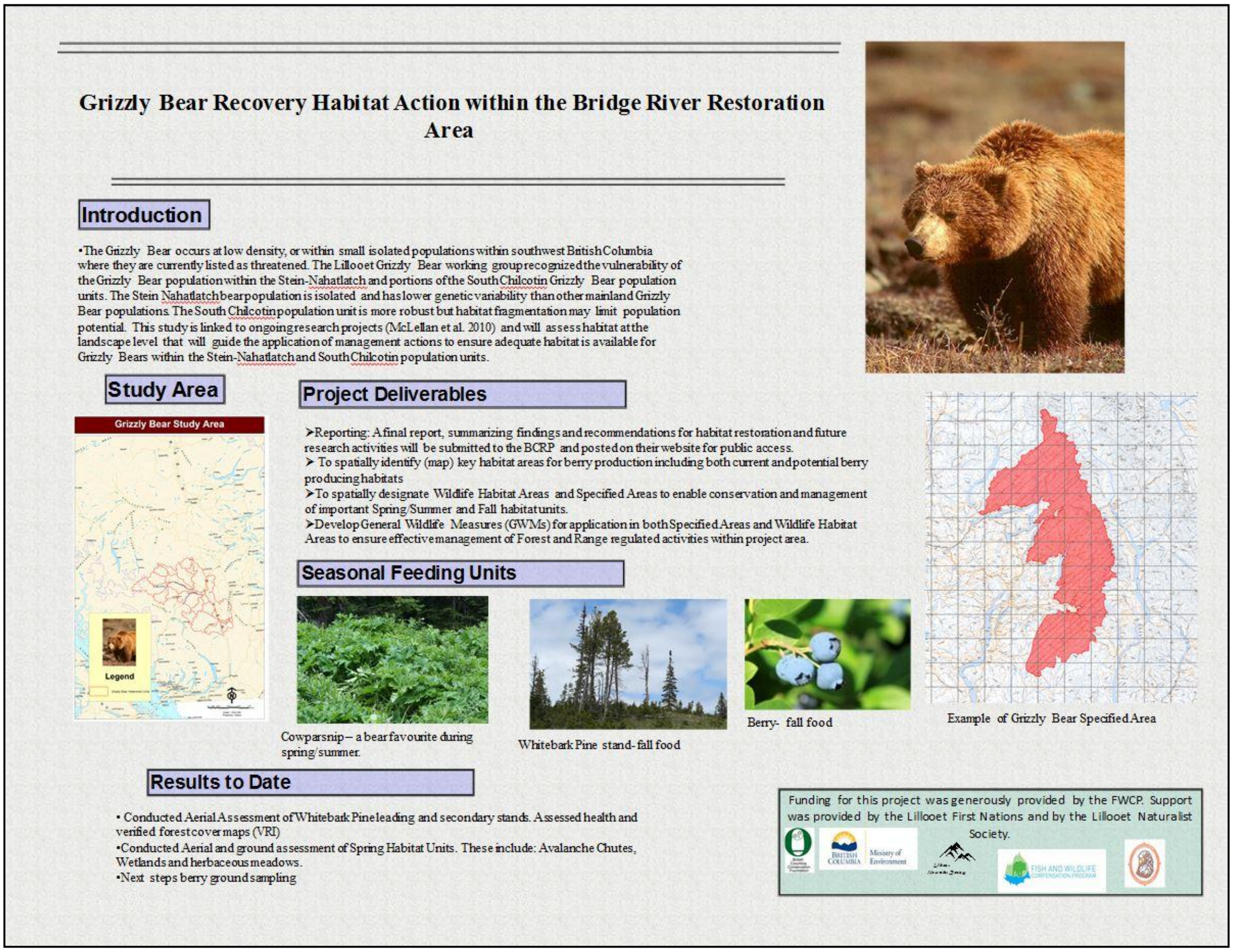
Other comments: ____

Berry Plot Data:

Plant	Species	PV	PG	% stems bearing fruit	Average fruit per stem		Plant	Species	PV	PG	% of stems bearing fruit	Average fruit per stem
1							5					
2							6					
3							7					
4							8					

BEC zone	Subzone Variant	Description
Coastal Western Hemlock (CWH)	ms1	Southern Moist Submaritime
Engelmann Spruce - Subalpine Fir (ESSF)	mw2	Stein Moist Warm
	mww	Moist Warm Woodland
	xv2	Big Creek Very Dry Very Cold
	xvp	Very Dry Very Cold Parkland
	xvw	Very Dry Very Cold Woodland
	xcw	Very Dry Cold Woodland
	xc3	Pavillion Very Dry Cold
	dvp	Dry Very Cold Parkland
	dvw	Dry Very Cold Woodland
	dv1	Cayoosh Dry Very Cold
	dv2	Tyaughton Dry Very Cold
Interior Mountain heather Alpine (IMA)	un	Undifferentiated
Montane Spruce (MS)	mw2	Stein Moist Warm
	xk3	Pavillion Very Dry Cool
	dc1	Cayoosh Dry Cold
	dc3	Tyaughton Dry Cold

Appendix 3: Public Outreach



Appendix 4: Whitebark Pine Habitat Model – V.2 (2012)

Parameters used to develop Version 2 (2012) of the WBP Model were divided into three categories, or parameters, as described below. The first two parameters are taken from a Digital Elevation Model (DEM). The final parameter was selected from VRI data.

<u>Elevation</u>

```
<1700m = 1 point
1700-1900 = 2 points
>1900 = 3 points
```

<u>Aspect</u>

```
320-80 = 1 point
280-320 & 80-130 = 2 points
140-280 = 3 points
```

<u>VRI- Percent cover of WBP:</u>

```
10%-20% = 1point
20%- 35% = 2 points
>35% = 3 points (4 points)
```

Based on this GIS intersect query a total score was derived for each polygon and ratings were assigned, based on total score, as follows:

- High: 12-14 points
- Medium: 8-11 points
- Low: 7 points
- Nil: 2-6 points

Appendix 5: Proposed General Wildlife Measures (GWMs)

Applied to Spring Habitat:

- Do not harvest trees, or construct roads or landings or yard through spring polygons and associated buffers (50m). Buffers must be windfirm;
- Do not permit spring grazing to occur by cattle within spring habitat polygons (April 15th-July 15th);
- Do not use herbicide or pesticide within identified spring habitat polygons; except for the use of beetle pheromones for control of bark beetle; and application of herbicide to control invasive plants or noxious weeds;
- Do not develop recreational structures, trails or facilities within Spring polygons;
- Do not blast, road construction, falling, yarding, or loading within 500 meters of spring habitat (April 15th-July 15th);
- Where known Grizzly Bear dens are identified establish a 50 meter reserve (e.g. WTP);
- Do not use domestic sheep, goats or cattle for vegetation management or as treatment of invasive plants.

Applied to Whitebark Pine Habitat:

- Do not harvest or build roads within Whitebark Pine Polygons, except where such activities (e.g. Thinning brushing and removal of disease trees will result in improved stand structure;
- Ensure pre-harvest levels of Whitebark Pine remain in stand species composition post-harvest through natural regeneration or by planting nursery stock;
- Do not develop recreational structures, trails or facilities within Whitebark Pine polygons.

Applied to VM Berry Habitat:

- Rehabilitate within block roads and trails on identified berry capable site series as provided in Table X, and where practicable spur roads off the main haul road leading to these site series, following harvesting of block(s);
- Use only selective and targeted vegetation management treatments around crop trees in berry polygons. Do not use herbicide to control berry producing species in the following groups: Vaccinium (huckleberry/blueberry), Amelanchier (sasksatoon), Sheperdia (soopolallie), Ribes (Current), Sorbus (Mountain Ash), Rubus (raspberry), Cornus (dogwood), Lonciera (twinberry), rose (rose, and Sambucus (elderberry);
- Wherever practicable, do not develop recreational structures, trails or facilities within berry polygons;
- Use spot burning to reduce debris reduction instead of broad cast burn;

- Maintain Vaccinium spp. Productivity in the BEC subzone and site series identified in Table X* using the appropriate forest activities. E.g. Where possible, timber harvesting should occur on a snowpack that would buffer disturbance to Vaccinium species. During site preparation prevent scarification or other practices that damage vaccinium rhizomes;
- Reduce stocking standards in the BEC variant and site series identified in Table X*;
- Retain large (>30cm dbh) coarse woody debris (CWD) with lengths >5m, or high stump where appropriate under current pest management regimes, to encourage ant colonization.

*Table currently under construction