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A Review of Food Security for Grizzly Bears in British Columbia

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Executive Summary

The Research Advisory Committee of the Grizzly Bear Foundation has identified food security as a major issue associated with the well-being of grizzly bears and one that would benefit from more research, conservation and education initiatives. This report aims to define food security and examine why it is important to the conservation of grizzly bears inhabiting British Columbia (BC).

The goal is to understand food security in order to focus conservation efforts on the foods most critical to grizzly bears. For food to be secure it must be of *sufficient quality to drive sustainable reproduction, and available and accessible with minimal risk of bear mortality*. For bears, security means that the food itself is *free from danger or threat,* which applies to when the bear accesses the food as well as the stability of the food itself.

Grizzly bears have a broad and expansive diet that provides for many forage items, but not all foods are of the same quality/digestible energy. There is a direct link between consuming high quality foods and grizzly bear reproduction. In BC, food has been identified as the ultimate factor limiting grizzly bear populations even though human-caused mortality was very common. In the spring, bears primarily add lean body mass, whereas in the fall excess protein and sugars are converted to lipids/fat. Consuming high quality foods in late summer and fall is vital to accumulate fat that will be used to sustain the bear during hibernation and fuel successful reproduction.

For female bears it is during hibernation when the embryos may implant on the uterine wall, but this will only occur if she has enough fat to sustain her and an offspring(s). For the purpose of this report critical foods are late summer/fall foods as their consumption contributes the most to the reproduction and survival of bears.

BC is large and topographically diverse, and critical grizzly bear forage items tend to be area specific. Research on bears is used to identify critical grizzly bear foods and there are large gaps in our knowledge about what bears eat over much of the province. Broadly, outside of important Coastal salmon areas, black huckleberries are thought to be the primary energy-rich food consumed by grizzly bears in BC. Little is known about grizzly bear use of interior salmon spawning streams. In the boreal forests it appears that bears consume more terrestrial meat. Terrestrial meat is thought to be important in areas that contain healthy ungulate populations and have a low quality or abundance of plant foods. Grizzly bear use of whitebark pine seeds is not well understood in BC and is an area that would benefit from further research.

Food security is not simply about conserving critical food resources, it is inextricably linked to habitat connectivity, core security areas, and minimizing the risk of human-caused mortality. To persist grizzly bears require large, intact landscapes that contain a suite of resources and are secure enough to minimize the risk of human-caused mortality as bears move across habitat types tracking available forage items. Therefore, securing critical foods requires the maintenance of corridors/habitat between critical patches. We also need to establish a longer-term monitoring program of a representative sample of populations and their primary foods. Monitoring forage quality versus quantity is particularly important given the decline in some critical food resources and the uncertain effects of climate change.

Population recovery requires a clear understanding of how diets in populations have shifted over time, which foods contribute most towards population growth, and the availability, abundance, and locations of those high quality foods. In those GBPUs where populations are healthy and not in need recovery, which is a large part of the province, we need to manage bear habitat to avoid declines and reduce human-bear conflicts to limit bear mortality.

To be effective at conserving and restoring critical grizzly bear habitat, thereby securing grizzly bear foods, conservation plans must be based in science and developed in cooperation with industry (forestry, mining, hydro-electric projects, pipelines, etc.), governments, the public, and First Nations. Effective habitat protection measures and restoration management initiatives need to occur now, especially with the uncertainty of climate change.

Photos, clockwise from top left:

Berries: Wild blueberries, CC0.

Salmon: The grizzly bear begins by removing the salmon skin to eat because it contains the most fat/lipids and is high in digestible energy, ©Shawn O'Connor

Grasses: A grizzly munches on grass, © Sandy Brown CC BY SA 2.0.

Ground squirrel: Ground squirrels are among the terrestrial meat sources for grizzlies, CC0.

Definition of Abbreviations

BEC	-	Biogeoclimatic Zone
CDC	-	Conservation Data Centre
COSEWIC	-	Committee on the Status of Endangered Wildlife in Canada
CWH	-	Coastal Western Hemlock
DFO	-	Department of Fisheries and Oceans
DNA	-	Deoxyribonucleic acid
ECCC	-	Environment and Climate Change Canada
FLNRO	-	Ministry of Forests, Lands and Natural Resource Operations
GBPU	-	Grizzly Bear Population Unit
GIS	-	Geographic Information System
GPS	-	Global Positioning System
IR	-	Indian Reserve
MM	-	McGillvary Mountains
MOE	-	Ministry of Environment
MOF	-	Ministry of Forests
MU	-	Management Unit
RSF	-	Resource Selection Function
SARA	-	Species at Risk Act
SERC	-	Spatially Explicit Capture Recapture
SIA	-	Stable Isotope Analysis
SN	-	Stein Nahatlatch
VRI	-	Vegetation Resource Inventory
WBP	-	Whitebark pine (*Pinus albicaulis*)
WMP	-	Wildlife Management Unit

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Photo © Dave Blogg

1.0 What is Food Security for Grizzly Bears?

The Research Advisory Committee of the Grizzly Bear Foundation has identified food security as a major issue associated with the well-being of grizzly bears and one that would benefit from more research, conservation and education initiatives. Food security exists "when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (World Food Summit 1996). But, what does food security mean for grizzly bears? Inherent within this definition is that food, defined as digestible energy, must be of ***sufficient quality to drive sustainable reproduction, and available and accessible with minimal risk of bear mortality***. Security means that it is ***free from danger or threat,*** which applies to when the bear accesses the food as well as the stability of the food itself. This technical report examines why food security is important to the conservation of grizzly bears in BC by:

- Summarizing the major food issues facing grizzly bears inhabiting the different regions of BC;
- Examining past and present research conducted to identify critical grizzly bear foods;
- Identifying gaps in knowledge regarding grizzly bear food security in BC;
- Determining if threats to critical grizzly bear foods exist; and,
- Determining what is being done (if anything) to address any gaps or threats.

British Columbia provides a number of rich and diverse habitat types for grizzly bears. The success of bears in different topographic regions of BC reflects that grizzly bears have evolved to rely on different high quality food resources according to the habitat types they occupy (i.e., where they live); BC's coastal bears tend to rely on rich and predictable salmon runs, while interior bears may rely more on the seeds of white bark pine, certain species of berries, and/or terrestrial meat. Therefore, protecting salmon runs will benefit salmon-feeding bears but not those inhabiting non-salmon bearing watersheds. Critical grizzly bear forage items vary according to the different topographic regions of BC.

Although classified as carnivores the diet of grizzly bears is often that of an opportunistic omnivore, comprised primarily of lush forbs, grasses, sedges, berries and roots; however, bears will capitalize on terrestrial and/or aquatic meat sources when available. The omnivorous nature of grizzly bears allows them to adapt their foraging behaviours to capitalize on the available resources (Barnes 1990). Their broad and expansive diet provides for many forage items (Appendix I), but not all foods are available to be consumed at all times and not all food is of the same quality/digestible energy. Unlike ruminants (e.g., deer, moose, elk) bears only have one stomach and therefore cannot digest mature plants. Instead they must track the phenology of plants, consuming only those parts that are digestible, such as the new growth/shoots of forbs in spring.

Often biologists will define grizzly bear habitat use based on seasons and those seasons normally correspond to the availability of different forage items, such as green-up (spring), early and/or late berries (summer into early hyperphagia), and fall (hyperphagia). Although all seasons are important to survival and reproduction, during the late summer bears enter hyperphagia, which literally is a period of intense eating with the goal being to rapidly increase their body mass prior to hibernation. The availability of high quality foods in late summer and fall is vital to accumulate fat that will be used to sustain the bear during hibernation and fuel successful reproduction when the bear is not eating, urinating or defecating (Belant et al. 2006). For female bears it is during hibernation when the embryos (blastocysts) may implant on the uterine wall, but this will only occur if she has enough fat to sustain her and an offspring(s).

1.1 What are Critical Foods?

Grizzly bears can adapt to a variety of habitat conditions and consume a diverse array of foods. However, critical foods are those that provide the greatest contribution to survival and reproduction.

For the purpose of this paper critical foods are defined as those that contribute the most to the fitness of bears and will therefore be area specific (e.g., catchable salmon, white bark pine, huckleberries, young ungulates (neonates), possibly buffalo berry, etc.). **Fitness** is a term used in Evolutionary Biology to evaluate **reproductive success** with the most successful individuals being those that contribute the most to **future generations** (i.e., genetic contribution to the gene pool).

In the spring after waking from hibernation, bears are primarily adding lean body mass (musculature and connective tissue), whereas in the fall excess protein and sugars are converted to lipids/fat (Hilderbrand et al. 1999a, Belant et al. 2006, Mowat and Heard 2006). An increase in the consumption of meat in the fall diet of bears relative to spring and summer diets has been reported in the north (Milakovic 2008), central-eastern (Ciarniello et al. 2003), and southeastern (McLellan and Hovey 1995) regions of BC as well as in the United States (Mattson et al. 1991). During this time, the diet of BCs coastal bears is focused on salmon – a relatively predictable and high energy food source. Berries, unless they are the overwintering variety, are generally not available to bears in spring; however, when consumed in fall they add fat because they consist largely of carbohydrates (sugars, starches, fibres). The amount of fat an individual bear has is important for hibernation as well as implantation of embryo(s) that have been delayed until an adult female is denning. Simply put, fatter bears tend to contribute more offspring to the population and are said to be more “fit” individuals (Hilderbrand et al. 1999a).

BC is a large province with variable topography and ecosystems, and the goal of this paper is to understand food security in order to focus conservation efforts on the foods most critical to grizzly bears in BC, therefore this paper focuses on the critical/high energy late summer and fall grizzly bear forage items within the different topographic areas.

1.2 Why is Food Security Important?

Poor food conditions could cause a short-term population decline but degradation of high quality forage items in perpetuity will result in a profoundly negative impact on that grizzly bear population because food/digestible energy is directly related to grizzly bear reproduction.

Landscapes that contain high quality bear foods tend to have a greater density of bears (Hilderbrand et al. 1999b, Mowat and Heard 2006). BC is a rich and diverse Province resulting in temporal and spatial variation of high-quality grizzly bear forage items across the province. McLellan (2015) identified food as the ultimate factor limiting brown bear populations even though human-caused mortality was very common. In areas with an abundance of critical foods, especially if that food is salmon, bears tend to have the potential for increased reproductive success, and have larger body mass, and much higher population density in some areas (Hilderbrand et al. 1999a,b). Female grizzly bears that have access to high quality forage will produce more cubs than those living where high quality forage is rare. Females with <20% body fat rarely reproduce (Robbins et al. 2012).

On a provincial scale, grizzly bears in BC are doing well with an estimated population of 15,000 individuals (BC MOF 2012). However, declining or at least poor food resources are suggested to have been one of the factors in the extirpation of grizzly bears from some Grizzly Bear Population Units (GBPUs) or for limiting recovery potential. B. McLellan states that at a local level, bears in some areas of southwestern BC are under threat:

> "The Garibaldi-Pitt and Stein-Nahatlatch grizzly bears are in decline and are at seriously low numbers and in the Northern Cascades they're almost gone…Much of the Garibaldi-Pitt is rock and ice with little high energy food sources except some spawning salmon in the southern end. In other places like the Stein-Nahatlatch, high-energy foods make recovery difficult, particularly because the population is extremely isolated, with little migration from other areas" (B McLellan in Ball 2016).

McLellan brings up two important aspects of population viability: (1) lack of critical, high-energy foods; and, (2) population isolation. A lack of critical foods means populations will grow slowly even in the absence of human-caused mortality. These foods must be identified and then further protected or augmented. Population isolation has little to do with food security unless it is food that is limiting the population (B. McLellan pers. comm.). Population isolation refers to maintaining connectivity between populations so dispersing bears naturally augment or even "rescue" a subpopulation if it declining or at risk (i.e., metapopulation theory). In general terms, the "rescue effect" allows dispersing individuals (i.e., those leaving that population to search out life elsewhere, such as subadults or in the case of food limitations, hungry individuals) to offset grizzly bear mortality within spatially separated subpopulations; the individual that leave one population in search of another suitable place to live allows the receiving population to persist through immigration. For bears, the importance of the connectivity of habitats may be particularly important to those populations that are being largely impacted by human-caused mortality (i.e., top-down population regulation) or those where foods are severely limiting (i.e., bottom-up population regulation).

Photo © Max Goldberg

2.0 Population Regulation Processes: Top Down and Bottom Up

We can secure critical foods for grizzly bears but it will not make a difference if when bears access the food they die.

Although apex predators, population regulation of grizzly bears is controlled by both bottom-up and top down processes. **Bottom up** process tend to ***favour population growth*** by securing food resources, habitats needed for survival, and/or space. Contrary, **top down** processes tend to ***control populations through mortality events***, such as starvation, disease, and predation (e.g., competition, hunting, poaching). For grizzly bears, humans are the ultimate predator controlling populations whether that is directly through hunting or human-bear conflicts (top down) or indirectly through habitat loss (bottom up). In areas where foods are of lower quality or in low abundance, bear populations are not resilient to human-caused mortality. In those areas reproduction is already very low and any additional morality augments the decline. Although we can study the processes separately, in reality in wild systems it is complicated to unlink these processes as they act to regulate or limit populations.

2.1 Regulating and Limiting Factors

Factors that **limit** populations tend to occur ***regardless of population density***, such as predation. Factors that **regulate** populations are ***dependent on density*** (i.e., density dependent regulation hypothesis). Food supply is a complex issue because it can be limiting to a population by naturally being in short supply and it can regulate a population by becoming limiting at high densities. Therefore, there is a functional relationship between fitness and carrying capacity. Although this review of food security largely focuses on bottom up process (i.e., foods), to effectively secure high quality foods for grizzly bears top down population processes cannot be ignored – minimizing the risk of human-caused mortality through protecting habitat has to be a fundamental part of securing critical grizzly bear foods.

Photo © Jitze Couperous

3.0 Grizzly Bear Food Habitat Research Studies (Selected)

In order to secure critical grizzly bear foods we must identify what those critical foods are and how they are spatially distributed throughout the province. BC is large and topographically variable, ranging from coastal rainforests rich with spawning salmon, to dry interior habitats, sub-boreal and boreal forests, to Coastal to Rocky Mountains sub-alpine and alpine habitats. The elements that favour the growth of certain plants, such as sunlight, water, air, temperature, soil and nutrients, vary across the province, as do the species that rely on them for survival. Research conducted on grizzly bears is used to identify critical grizzly bear foods and evaluate habitat quality within specified study areas.

There are a number of research methods (i.e., radiocollaring for habitat use studies, scat analyses, field site visits hair gathered off barbed wire) biologists may use to identify grizzly bear foods. Some studies may be designed to directly address the question of critical foods through site investigations and/or scat analysis, while others may use surrogates, such as habitat information obtained from existing Geographic Information System (GIS) layers (e.g., Vegetation Resource Inventory (VRI) or satellite imagery). In order to evaluate a research project's contribution to understanding food security and its ability to identify critical foods it is important to understand how the research was conducted. Some common methods to determine the diet of bears include:

- **Site visits** require on the ground habitat **investigations** of grizzly bear use sites (e.g., site visits on randomly selected bear locations, visiting GPS clusters, backtracking to kill sites) or random locations. Ground visits to selected sites may also be used to monitor habitat attributes, such as berry production and abundance and bear use of specific plants. The site-specific habitat data gathered at bear use and/or randomly visited locations are often analysed using modeling procedures and statistical analysis comparisons of habitat attributes (e.g., use versus available).

- **Scat** (i.e., fecal) **analyses** to estimate the proportion of forage items in the diet. This method provides a direct and quantitative measure of the amount of each forage item contained in the scat; however, it may be subject to bias due to the differential digestibility of prey items (Roth and Hobson 2000). This may be particularly true when meat is consumed because it is highly digestible in comparison to berries and therefore can result in an underestimation of meat in the diet (McLellan pers. comm.). Precise correction factors for terrestrial meat remain unknown.

- **Stable-isotope analysis** (SIA) on grizzly bear tissues or remotely collected hair typically uses stable carbon (d13C) versus (d15N) nitrogen isotope ratios as they are reflected in the tissues of consumers. Sulfur is now being used in some circumstances. Stable isotopes do not decay over time and the isotopic ratios within a geographic area tend to reflect the local food chains. Simply put, stable isotope analysis is a measure of the assimilated nutrients, and is normally obtained from bear hair, claw or bone. This method is reflective of the diet when the hair or claw was growing and not at the time of collection. The results are also subject to the part(s) that were used to determine diet (e.g., was the hair cut into sections or an average across the whole hair, etc.) and for hair, as to whether the hair was a guard hair or under fur.

Although an advancement in examining the diet profiles for bears, current SIA tends to be limited to three primary forage categories: salmon/marine nutrients, terrestrial meat, and plants. Plants are a very broad category and include numerous species. Terrestrial meat may include deer, moose, microtines, ants, etc. Further, when examining the proportions of prey in grizzly bear diets SIA is highly sensitive to the fractionation values used in models (Milakovic 2008). Thus, SIA provides a profile of what an individual ate by category but at this time cannot identify what, when or where those foods were consumed.

- SIA can be combined with mapping techniques to predict the occurrence of forage items, but since it cannot provide site-specific information (e.g., what patch bears were using) it limits our ability to focus conservation initiatives. Therefore, researchers typically think there is uncertainty about the meaning of some aspects of isotope variation. However, methods are being refined and some of the uncertainty can be addressed if signatures from specific foods can be identified.
- **Bear Capture & Radio-Collaring Data**. Researchers may use the location data collected on radio-collared bears to visit bear use sites on the ground to determine the activity of the bear and then relate that to the habitat type the bear was using (e.g., Ciarniello et al. 2014). Location data may also be used to produce Resource Selection Function (RSF) models, which are statistical techniques that provide the relative probability of use of a resource unit by bears (e.g., habitat types). For example, during whitebark pine (WBP) masting we may model the number of bear locations that were within mapped WBP stands and examine whether it statistically differs from their use (locations within) of the other habitat types. The values obtained give us the relative importance of that habitat type to the other types available during the selected time period.
- Bear body size and condition may be used as a surrogate to infer the quality and/or quantity of the habitat. How fast a grizzly bear can consume food (i.e., ingestion rate) is as important as how much (i.e., kg/day), and what (i.e., plants, salmon, terrestrial meat) is ingested. In areas were salmon is the critical food consumed researchers may watch the bear and record how many salmon it ingests per foraging bout, but in non-salmon areas this information is difficult to accurately obtain on wild bears. As a surrogate for ingestion rate, researchers that capture bears tend to use changes in body composition and mass because that takes into account ingestion rate, quality of forage items consumed, and the energy required to obtain food. This research requires capturing bears multiple times to record changes in body condition.

3.1 Identifying Critical Grizzly Bear Foods

This next section briefly discusses the results of a selection of research projects that have or are currently working to identify critical grizzly bear foods in BC. Grizzly bears are extremely mobile and may traverse vast areas that do not respect political boundaries, regardless of whether those boundaries are provincial, Grizzly Bear Population Units (GBPU) or Wildlife Management Units (WMU). The results of these studies help us to biologically and ecologically identify critical grizzly bear foods as they occur spatially throughout BC. Study results are presented by moving north-south down the west coast of BC, then across to the interior, and from the southern US border north to the Yukon (Figure 1).

3.1.1 Coastal BC (Salmon System Projects)

The spatial distribution and temporal migration of spawning salmon influence how grizzly bears use habitats (Barnes 1990). Spawning salmon are extremely high in fats/lipids and the predictability of the salmon spawn is important to grizzly bear reproduction. Bears may use the same areas for fishing year after year (Barnes 1990) and spawning salmon are a critical food for BCs coastal grizzly bears.

3.1.1.1 Central Coast Grizzly Bear Project

Area:	***Primary Researchers***:	***Critical Foods Identified:***
Central coast (GBPUs: Kitlope-Fiordland, Northcoast, Kwatna-Owikeno, Tweedsmuir. All Viable). **Project 1** *on Figure 1.*	Megan Adams Chris Darimont	Spawning salmon

The Raincoat Foundation has been active in non-invasive research on grizzly bears in the central coast of BC. Past research projects have used SIA to determine salmon in the diet of male and female grizzly bears (Adams et al. 2017). They have also examined top-down human-bear conflicts concluding that the number of bears killed due to conflicts increased when salmon biomass decreased (Artelle et al. 2016). This research is in conjunction with the Central Coast Bear Working group and the five partner Nations: Heiltsuk, Wuikinuxv, Kitasoo/Xai'xais, Nuxalk and Gitga'at. To add to work completed in this study area the following projects are proposed PhD research through the University of Victoria:

Berry phenology: Recent work in Alaska has provided an understanding of the importance of certain berry species for grizzly bears even during times when salmon are available (e.g., red elderberry, Deacy et al. 2017). As climate continues to change and phenology of berries and salmon change, the portfolio of food available for bears will continue to shift. The suite of available berries on the central coast differs and warrants additional research in terms of shifting timelines of availability and use by bears, especially coupled with declining salmon across the region.

Project Status: This work is seeking funding.

Inconsistent salmon availability: Salmon on the central coast have faced multiple stressors, including the lasting population-level effects of canneries and commercial fisheries, changing open ocean conditions for early marine survival, and freshwater habitat degradation from commercial logging. As such, salmon runs are likely an order of magnitude less than prior to commercial fisheries (e.g., Rivers Inlet, Boulanger et al. 2004). Also, across the central coast, runs fluctuate both in space and across years. We need to understand the consequences for grizzly bears: when salmon are not available, what food(s) do they switch to? What population densities might be supported under current salmon availabilities, and what might we expect if salmon continue to decline? What are the grizzly population consequences for increased restoration of salmon habitats? Or more or less exploitative fisheries? As both federal and Indigenous governments increasingly look to allocate salmon to wildlife in their fishing management plans, these questions are becoming increasingly urgent.

Project Status: This work is seeking funding.

A shared niche between bears and people: Bears and people have lived together on the central coast for the better part of the past 10,000 years. They share the same suite of foods, from intertidal to plants to salmon. Post-colonization by Europeans and decline of formerly massive resource extraction activities (i.e., canneries), the central coast has the lowest human population density now than ever before; bears are sharing less space with humans. Traditional practices of "resource maintenance" (e.g., creek cleaning for fish, pruning and cleaning of crab apple trees, burning for increased berry production, or harvesting shoreline plants, such as rice root) for increased production, have now greatly declined. Increasingly relevant at this intersection between bear foods and Indigenous society is the interest of Indigenous governments to ask the following questions: How has the decline of traditional food practices by people affected food availability for bears? How might restoration of these practices affect food availability for bears, and co-existence for people and bears that remain on the central coast? How do current commercial fisheries and local food fisheries for salmon affect availability for, and consumption by, bears? These are questions of coexistence in social-cultural-ecological systems in which bears form just one important part.

Project Status: This work is seeking funding.

Gaps & Challenges: Lack of radio-collared data to determine how far bears are drawn to this system and to identify and conserve other important habitats and corridors. However, the Nation that this research partners with is not in favour of capturing and radio-collaring bears.

- There has been some work examining the health of salmon ("salmon ecosystem function") in this area, but it focused more on salmon fisheries and allocating salmon biomass to GBPUs (Levi et al. 2012).
- Lack of information on the state/health of the Rivers themselves as spawning habitat.
- The lack of identification of other critical foods is a gap in this project's area. Back-up foods should be identified for years of salmon failure and is a proposed project.

3.1.1.2 Orford Bay Fish Habitat Enhancement Project

Area:	***Primary Researchers***:	***Critical Foods Identified:***
Southwest coastal Bute Inlet (GBPU: Toba-Bute, Viable but borders an extirpated GBPU) **Project 2** *on Figure 1.*	Lana Ciarniello Homalco Nation	Spawning salmon, roots in estuary, possibly red elderberry and salmon berry

The Homalco Nation (HN) is proposing to undertake a river restoration project in order to rehabilitate, rebuild, restore, and maintain important fish spawning and rearing habitat within, and immediately adjacent to, their Indian Reserve #4(IR), Orford Bay. Orford Bay is approximately half way up Bute Inlet and is critical spawning habitat for Chum (*Oncorhynchus keta*), Coho (*O. kisutch*) and pink (*O. gorbuscha*) salmon. The Homalco Nation Grizzly Bear Habitat and Family Relationship Study began in June 2015 within IR#4. The focus of the study was not to identify critical foods although all known food items were documented. IR#4 is a small area being only 3.3 km^2, yet the salmon spawn draws a minimum of 52 grizzly bears (23M:29F) to the area beginning mid-August (Ciarniello in prep). Twelve (8 female: 4 male) of the 52 bears identified to use Orford Bay in 2015 had been previously detected in grizzly bear DNA work that occurred in the Toba in 2008 (C. Apps), in the Southgate watershed in 2010 (C. Apps), and one male bear was detected ~67 km (Euclidian distance) in the upper Homathko River in 2010 (Chilcotin Coast Bear Project, C. Mueller). This information suggests that during spawning bears are being drawn great distances. Orford Bay is a very important bear viewing operation for HN and it was through the research on the bears that the health of the river system was questioned due to frequent bank erosion events.

Due to the importance of maintaining this river system to bears and fish in 2016-17, a Geomorphic and Habitat Restoration Overview assessment of the Orford River and Algard Creek was undertaken (NHC 2017). The assessment concluded that the instability of the lower 2.6 km of Algard Creek threatened to remove the salmon spawning habitat. The extensive sedimentation, debris jams, channel braids, and instability of critical spawning habitat of Algard Creek was primarily the result of three factors: (1) decades old forestry activities that contributed to slope instability; (2) Department of Fisheries and Oceans's (DFO) unmaintained additional salmon spawning infrastructure and habitat; and, (3) natural channel instabilities. If not mitigated, the active erosion of Algard Creek will lead to the Orford River and Algard Creek joining upstream of the existing confluence. When the rivers meet the run size will be adversely affected, and the spawning habitat will be severely degraded due to the introduction of sediment laden river water from the Orford River as well as the sheer volume of Orford water into Algard Creek. There is the possibility that the spawning and rearing habitat could be entirely removed (NHC 2017). Logging on steep slopes has resulted in failed cut banks, road failures, road surface erosion, and gully and landslide erosion. Dumping the logs into the estuary has degraded the fish habitat within the estuary.

This project aims to maintain and rehabilitate critical fish spawning, rearing and early marine estuarine habitat that is known to be of major importance to southcoast grizzly bears within the Toba-Bute and Klinaklini-Homathko GBPUs). IR#4 borders one extirpated and two threatened (Squamish-Lillooet & South Chilcotin Ranges) GBPUs. The target species for critical food restoration are salmonoids, particularly Chum, Coho and Pink salmon, however, Chinook (*O. tshawytscha*), Steelhead (*O. mykiss*), and Cutthroat (*O. clarkii*) trout will also benefit from river restoration. Specific watershed objectives are to:

- Restore, protect, and maintain fisheries values which may have been adversely affected by past forest harvesting practices, installed infrastructure, and natural occurrences;
- Reduce the possibility of further bank erosion by applying mitigation techniques;
- Reduce the amount of sediment entering the system from upstream sources;
- Rehabilitate and maintain existing side-channels;
- Rehabilitate riparian areas; and,
- Create or enhance fish habitat.

Project Status: This work is seeking funding.

Gaps & Challenges: This project requires and interdisciplinary team of fisheries biologists and forest companies as well as DFO. Forest harvest activities continue within the area.

- Lack of radio-collared data to determine how far bears are drawn to this system and to identify and conserve other important habitats and corridors.
- Lack of information on the health of the salmon in the system.

- Lack of information on use and availability of berries. There is no monitoring of berry production or abundance.
- Coastal ecosystems are rich in many other forage items that may be of high quality such as clams and mussels. There is a general lack of information on the value of marine nutrients to coastal bears.

3.1.2 Coastal to Interior Salmon Bearing System Projects

3.1.2.1 Chilco River Grizzly Bear Project

Area:	***Primary Researchers***:	***Critical Foods Identified:***
Tatlayoko Valley & Upper Chilko River (GBPUs: South Chilcotin Ranges, Threatened & Homathko-Klinaklini, Viable). **Project 3** *on Figure 1.*	Cedar Mueller Michael Proctor	Spawning salmon

From late August through October, the upper Chilko River contains the third largest sockeye salmon (*Oncorhynchus nerka*) run in BC. It also contains Chinook salmon, coho salmon, and steelhead trout. Although there are spawning beds near Chilko Lake that draw a very large number of bears, the area is likely also an important movement corridor for interior bears to access the coast (Mueller and Boulanger 2013). The Chilco River Grizzly Bear Project used DNA fingerprinting on grizzly bear hair obtained from barbwire sets to identify individual bears gathered from 2006-2012. Bear hair traps were placed in "important" low elevation spring habitat and along salmon spawning streams ranging from the Upper Chilko River to the Upper Homathko River for detections of bears in fall. The objective was to determine the number of bears and examine bear movement between spring and fall habitats. The main objective was to collect baseline scientific information on grizzly bears to inform grizzly bear management and conservation policy (Mueller and Boulanger 2013). The project did not address any other high quality grizzly bear foods.

Bear numbers were related to salmon escapement, with more bears returning to the river after a season with greater salmon numbers (Mueller and Boulanger 2013). Some bears travelled vast distances to feed on salmon and used coastal as well as interior spawning areas. One male bear was located where the Southgate River joins the Bute Inlet (Mueller & Apps DNA comparison). C. Apps first detected this bear through DNA in spring 2010 where the Southgate River meets the Bute Inlet. In the fall of the same year, he was located through DNA in the Chilko; he travelled a distance > 100 km to the interior for salmon.

Project Status: Additional research using DNA hair sets and GPS radio-collars was proposed for 2017 (Mueller and Proctor). The goal was to further understand the extent of ecological and spatial influence the Chilko River salmon has on grizzly bears throughout the Chilcotin Region, particularly for females Also of interest was what habitats and foods were important in the non-salmon seasons and in years when salmons runs were poor. Research was deferred in 2017 due to fires within the study area and also awaits permission from First Nations. Initial funding through Habitat Conservation Trust Fund has been secured for this project but GPS collaring money has not been secured.

Gaps & Challenges: This project highlights the distance bears will travel to capitalize feeding on salmon but it does not discuss or address salmon health or quality of these river systems. However, there was intention to integrate researchers from UBC that were studying this fish run (Proctor pers. comm.).

- General lack of radio-collared data to identify habitat corridors and monitor movement. This aspect of research is seeking funding. It would also require approval from First Nations.
- Lack of the identification of back-up foods in years of salmon failure. This aspect of research relies on radio-collaring bears and is seeking funding.
- Unregulated bear viewing may limit bear access to salmon and is not addressed.

3.1.2.2 Central Interior Salmon Project

Area:	***Primary Researchers***:	***Critical Foods Identified:***
Central Interior (GBPUs: Nation, Nulki, & Francois, Viable; Blackwater-West Chilcotin, Threatened) **Project 4** *on Figure 1.*	Shelley Marshall	Interior Kokanee salmon

This is a proposed project and currently the importance of kokanee (sockeye, *O. nerka*) to interior grizzly bear populations is unknown. Interior populations of grizzly bears rely primarily on plant matter (including berries) and terrestrial meat sources (e.g., ungulates) to meet their energetic requirements because they lack access to abundant salmon resources like their coastal counterparts. Although grizzly bears are known to consume kokanee in some interior areas, little is known about the importance of kokanee to these grizzly bear populations. These kokanee may function as a seasonally important food source, similar to many anadromous salmon systems. Grizzly bears in the plateau region of the central interior have relatively low forage availability compared to nearby mountainous areas. Access to these kokanee in late summer and early fall may act as a key seasonal food type critical to improving reproductive success.

This project aims to determine the nutritional importance of kokanee to grizzly bears by:

- Quantifying the use of kokanee by grizzly bears in key areas within the study area with accessible spawning kokanee (relative dietary importance (% of diet) through isotope analysis and absolute intake (kokanee kg/bear) through mercury analysis). This includes examining the relative kokanee use between male and female grizzly bears to infer population level impacts of kokanee availability on grizzly bear densities.
- Estimating population trend based on annual variation in kokanee escapement levels and relative berry abundance.
- Quantifying mercury levels in grizzly bears to infer potential neurotoxicological impacts of mercury as a contaminant (e.g., reproduction impairment).

If kokanee are a key food for interior bears, fluctuations in kokanee availability must be incorporated into grizzly bear management and larger ecosystem management. From a management perspective, this will highlight the need to (1) incorporate kokanee as a predictor of grizzly bear population size and (2) consider fluctuations in this key resource in management decisions that affect these grizzly bear populations.

Research has discussed the importance of salmon to sustain grizzly bear populations and thus recommend incorporating bear needs into escapement decisions. Fluctuations in kokanee populations are natural but larger declines may occur because of changes in stream flows and temperatures resulting from climate change and the on-going, large scale landscape change occurring in interior BC through Mountain Pine and Spruce beetle salvage harvesting. BC's current grizzly bear population model does not include kokanee as a predictor of grizzly bear density despite recognition that kokanee are utilized in certain interior systems. Long-term declines in kokanee abundance should be factored into grizzly bear population estimates. The urgency of this project lies in the uncertainty associated with changes to kokanee populations and potential consequences to grizzly bear populations, particularly these ones in low density GBPUs.

Project Status: This is a proposed project on a potential critical food for interior grizzly bears that is seeking funding for all components.

Gaps & Challenges: Very little is known about the value of kokanee to the diet of interior grizzly bears. Heard and Mowat (2006) used hair obtained from a DNA grid in the Nation GBPU (Mowat and Fear 2004) to measure stable isotope ratios. The diet of grizzly bears was primarily plant based (50%) followed by meat (25%) and kokanee (26%) (Mowat and Heard 2006). However, the Nation results should be cautiously interpreted since the samples were gathered within a short time period. Mowat (pers. comm.) commented that there was only "one bear that ate much salmon…. However, when the hairs were collected may be too early in the year to get the full picture, especially if salmon arrive late in the year" (Mowat in Ciarniello and de Groot 2014). This project fills a critical gap for interior grizzly bears.

3.1.3 South Coast Grizzly Bear Projects

3.1.3.1 South Coastal Mountains General

Some grizzly bears in the southern Coast Range of British Columbia occur in small, largely isolated subpopulations (Apps et al. 2014, McLellan et al. 2017). Bears inhabiting most of the isolated South Coast GBPUs are endangered or have been extirpated, potentially making this area a high priority conservation concern and in urgent need of habitat conservation and/or enhancement. Research in this region began in 2004 with the initiation of a multi-year (6 years of field sampling) regional study addressing questions of population abundance, distribution and connectivity across the south Coast Ranges (Apps et al. 2014). In general, the work included a hair trapping grid to sample DNA that progressed across a ~50,000 km^2 area between 2004 and 2010. The DNA hair trapping was led by C. Apps with help from B. McLellan and S. Rochetta. Starting in 2005 in the Stein-Nahatlatch GBPU, a telemetry based component began and individual bears were captured and collared with GPS units in an attempt to determine what was limiting these bears. The collaring component expanded to include the McGillivray Mountains in the South Chilcotin GBPU in 2006. The field work on this aspect of the project was led by M. McLellan with help from B. McLellan. In 2007, a GPS collaring program was initiated in the Squamish-Lillooet GBPU (hereafter, "Squamish study") led by C. Apps with help from B. McLellan and S. Rochetta. The objective of the Squamish study was to address grizzly bear movements and response to habitat and human activity. In 2015, GPS collars were put on grizzly bears in the central portion of the South Chilcotin GBPU. This part of the project is led by F. Iredale with help from B. McLellan.

3.1.3.2 South Coast Regional Grizzly Bear Population Study: hair trapping

Area:	***Primary Researchers***:	***Critical Foods Identified:***
Regional (~50,000 km^2 South Coast Ranges) and Squamish-Lillooet **Project 5** *on Figure 1.*	Clayton Apps Bruce McLellan Steve Rochetta Tony Hamilton	Spawning salmon

Among several other objectives, this large-scale regional DNA-based population study examined variation in grizzly bear diet across the greater South Coast Ranges region (~50,000 km^2). Inferences were based on isotopic signatures of grizzly bear hair samples from across the region from 2004 – 2012. This work assessed the relative importance of marine nutrients, terrestrial meat and plants in grizzly bear diet across the region and by sex. The results were presented spatially across the Region and by gender, and were discussed in the context of regional population abundance, distribution and connectivity (Apps et al. 2014).

3.1.3.3 Squamish-Lillooet ("Squamish") Study

Area:	***Primary Researchers***:	***Critical Foods Identified:***
Squamish-Lillooet GBPU, Threatened **Project 6** *on Figure 1.*	Clayton Apps Bruce McLellan Steve Rochetta	Spawning salmon, huckleberry

The Squamish-Lillooet study uses both GPS collaring and DNA hair trapping to investigate several aspects of grizzly bear ecology, with a focus on space-use and movements relative to influential factors of habitat and human activity. Inferences will be directly relevant to understanding short- and long-term implications of cumulative human impacts on grizzly bear recovery and conservation. Data will also contribute to tracking population responses. Predictive outputs that are empirically tested will serve to direct appropriate mitigation and conservation strategies (Apps et al. 2016). To this point, the Squamish study does not provide empirically-based results with respect to food habits. What is known to date regarding food habits is derived from field observation and anecdotal evidence, as well as modelling relationships with surrogate variables. The study area is ecologically diverse and includes coastal and coast-interior transition landscape, also with great variation in terms of human use and influence (Apps et al. 2016).

The Squamish study has 4 more years of field work in order to enhance their spatial/temporal representation, especially in some coastal areas for which they have almost no data. The primary researcher is proposing to add a site investigation component to better understand grizzly bear diet and provide empirical support for the work to date.

Project Status: This project will be active for four more years.

- This project is seeking funding for site investigation work to support understanding of seasonal food habits and ecology.
- Seeking funding to support a Southwestern BC Grizzly Bear Conservation and Recovery Plan, with associated activities and extension outputs based on the science derived from both the regional population study and the more localized studies.

Gaps & Challenges: Adding a field component would require helicopter access (costly) given the mountainous nature of this area, the remoteness of bears from human access, and the great degree of ecological variability across the study area. However, the lack of site investigation data is a critical gap in further understanding diet profiles that the researchers have not been able to complete due to a lack of funding for this component.

3.1.3.4 South Chilcotin Grizzly Bear Habitat Selection Project

Area:	***Primary Researchers***:	***Critical Foods Identified:***
South Chilcotin GBPU, Threatened **Project 7** *on Figure 1.*	Francis Iredale Bruce McLellan	Whitebark pine, buffaloberry, spawning salmon

The intent of South Chilcotin Grizzly Bear Habitat Selection project was to investigate hierarchical resource selection patterns, diet composition and identify movement corridors of grizzly bears occupying the central portion of the threatened South Chilcotin GBPU. This is an active project that is using resource Selection Function modelling techniques on the location data acquired from radio-collared male and female grizzly bears (Iredale pers. comm.). Food availability and selection of critical food resources across the study area varied amongst bears and by age and sex class. Selection patterns were further confounded due to the heterogeneous spatial and temporal distribution of food resources. Regardless, all bears showed strong fall selection patterns for whitebark pine habitat during hyperphagia. The high lipid content of whitebark pine nuts appears to be an integral food component for bears occupying the study area (Iredale pers. comm.). Whitebark pine nuts were obtained through the excavation of squirrel middens in the fall. During low cone crop years (such as 2017) bears switched to feeding on buffaloberry. Feeding on huckleberry was low in this study, which may be due to unfavorable habitat conditions for the plant (xeric /dry conditions). Some male bears with larger home ranges also selected for salmon bearing streams situated within the Taseko system (Iredale pers. comm.). The adaptability of bears to switch critical food resources highlights the need to conserve more than one critical food in each WBP system. The researchers also noted that during low whitebark masting events bears appeared to use lower elevation habitats, including burns and cutblocks (Iredale pers. comm., analysis pending).

Project Status: This project is on-going for 2018.

- This project seeking funding for additional habitat work on grizzly bear foods. This project works in conjunction with the overall southwest Grizzly Bear Project.

Gaps & Challenges: This project provides knowledge on the value and use of whitebark pine to grizzly bears in threatened GBPU.

- General lack of knowledge in the importance of fish in this system, especially to female bears.
- General lack of knowledge of grizzly bear use of lower elevation habitats in low masting years calls for examination of top-down population regulation processes (e.g., road densities, human-bear conflicts).

3.1.1.5 Stein-McGillvary Grizzly Bear Project

Area:	***Primary Researchers***:	***Critical Foods Identified:***
Stein-Nahatlatch and McGillvary Mountains (GBPUs: South Chilcotin & Stein Nahatlatch, Threatened) **Project 8** *on Figure 1.*	Michelle McLellan Bruce McLellan Yvonne Patterson for WBP monitoring	Huckleberry, saskatoon berry, whitebark pine

A PhD research project through Victoria University of Wellington in New Zealand this study began in 2005 with radio-collaring bears. M. McLellan's dissertation examines the difference in population trends between two adjacent grizzly bear subpopulations: McGillvary Mountains (MM) in the South Chilcotin Range GBPU, and the Stein Nahatlatch (SN). Although both GBPUs are classified as threatened the densities are 21.4 bears/1,000 km^2 in the MM subpopulation versus 3.2 bears/1,000 km^2 in the SN subpopulation. After 7 years of monitoring population trends the McGillvary Mountain population was reported to be growing, while the Stein-Nahatlatch population was stable or declining (M. McLellan pers. comm.). Although the areas border each other the two subpopulations are not currently connected. There has been no female movement and limited male movement between populations. The population isolation, low density, and low cub survival of grizzly bears in the Stein-Nahatlatch raises concerns over its persistence.

In order to determine if the differences in population trends are due to food limitations this work compares the types of habitats available, the quality of those habitats, and how bears use each of habitat types in each study area. The researchers are using data collected on radio-collared bears to visit bear use locations and to produce RSF models to examine the relative probability of use of a resource unit by bears (e.g., habitat types). They are also modelling huckleberry occurrence with the goal of producing a spatially georeferenced berry abundance layer. Future analyses include combining stable isotopes analysis on bear hair with site investigation data to further define diet and determine the importance of berries to these bears (M. McLellan pers. comm.).

Diet profiles revealed that huckleberries (41%) and Saskatoon berries (27.5%) were the primary berry species consumed by bears in the MM, while huckleberries were the predominant berry consumed by bears in the SN (88%) and Saskatoon berries were absent. Saskatoon berries are available a month earlier (mid-July) than huckleberries (mid-August) so bears in the MM had a month longer berry foraging season than bears in the SN. There were also more foraging options and larger huckleberry patches available in the MM (M. McLellan pers. comm.). Generally, bears in the SN seem to have more individual variability in diet composition than bears in the MM. To date the results show that these bears are likely food limited and indeed in the Stein Nahatlatch, one bear died of starvation, which is an extremely rare event.

Whitebark pine also occurs in the diet profile of bears in the McGillvary Mountains beginning mid-August through October and in the Stein Nahatlatch from mid-June through October (M. McLellan pers. comm.). Whitebark pine is considered a critical grizzly bear food for this population but overall information is lacking on the importance and the relationship to the reproduction and survival of these South Coast subpopulations. There are some WBP plots where researchers have counted cones as an index of production (B. McLellan pers. comm.), but information on the results of this work are lacking. Y Patterson is the primary researcher examining WBP but did not respond to a request for further information. The role of WBP as a critical grizzly bear food is discussed further in Section 4.4.

Although spawning salmon are available, they do not appear to be a critical food for these populations. Only one collared male was known to feed on salmon in the Birkenhead River (M. McLellan pers. Comm.). This male had SN genes but his home range while collared was in the MM area and he was only ever captured in the MM part of the DNA hair snag monitoring grid. Preliminary SIA reveals 0-1% salmon in the average diet for the population though a few males had signatures to 10%. Historic bears (early 1900's) had 14-30% Salmon (M. McLellan pers. comm.).

In 2011, 5 permanent huckleberry productivity plots were established and are monitored annually. Permanent plots are important because they allow for the long-term monitoring of bear foods. They also monitor hundreds of non-permanent huckleberry plots (M. McLellan pers. comm.).

The project has found that bears in the South Coast Ranges are likely limited by the available food resources. The province is invoking measures under the Forest and Range Practices Act to manage for key forage foods (spring and fall) within the Stein Nahatlatch and portions of the South Chilcotin (Iredale Pers. Comm.).

Project Status: This project is ongoing for 2018. Completed the analysis of the 7 year population monitoring program (manuscript submitted). This project is seeking additional funding to continue with investigating and monitoring critical foods and developing predictive models to focus logging and fire for producing huckleberry, Saskatoon berry, and buffaloberry.

Gaps & Challenges: Studies suggest that the loss of high quality habitat and a lack of high-quality forage are limiting bears in the South Coast GBPUs, and the decline in whitebark pine may be critical. Further data is necessary to examine the value of WBP in the diet of these bears and to determine the appropriate management actions required to enhance this critical food.

Understanding why some areas produce an abundance of huckleberry and Saskatoon berries after logging while most areas do not is critically important for these and other bear populations.

- Monitoring and distribution of Saskatoon berries as a secondary important forage item.
- Identification and management of ecological traps in the case of WBP failure.
- Conserving WBP in the Southcoast will require working with the forest industry.

3.1.4 Southeastern BC Grizzly Bear Projects

3.1.4.1 Flathead Grizzly Bear Project

Area:	***Primary Researchers***:	***Critical Foods Identified:***
Southeastern BC (GBPU: Flathead, Viable) **Project 9** *on Figure 1.*	Bruce McLellan Garth Mowat	Black huckleberry, buffaloberry

Beginning in 1978, the Flathead Grizzly Bear Project is the longest grizzly bear research study in British Columbia. The research conducted in the Flathead Valley of BC has evolved into the most comprehensive dataset on grizzly bears in BC and includes the recognition of the role of critical foods to grizzly bear fitness. The diet of bears in the Flathead was predominantly vegetation based (McLellan and Hovey 1995, Mowat and Heard 2006, McLellan 2011), and during hypherphasia bears fed primarily on berries. Realizing the value of digestible energy to grizzly bears, in 1979 long transects were established in the Flathead berry fields and B. McLellan began to record subjective estimates of huckleberry production and these have continued for 40 years while production at permanent plots have been measured since 2010. This research included site visits to bear use locations and spring snow tracking and 1,100 scats were obtained for dietary analysis (B. McLellan pers. comm.). Black Huckleberry fields used by grizzly bears were mapped and identified as the primary energy-rich grizzly bear food that was positively influencing productivity of the bears (McLellan 2015). All other habitat types have also been mapped and bear food abundance has been measured.

The Flathead GBPU (~3,300km^2) is larger than the Flathead study area (~1,200 km^2) and had the highest hunter kill density in BC, the highest total reported kill density in BC, and yet a high density of bears remain. Spatially Explicit Capture Recapture (SERC) estimates from a DNA based inventory in 2007 found 65 bears/1000 km^2 across the 1,600 km^2 MU 4-01, which is an extremely high and rivals densities on coastal salmon streams (B McLellan pers. comm.). In the 1920s and 1930s the Flathead was burned and today there remains a band of habitat in the upper Engelmann Spruce Subalpine Fir BEC zone that contains large fields of huckleberries which are largely roadless, providing a *high quality secure food resource*. Buffaloberry also occurs throughout the area and every few years produce a productive berry crop. These two berry species are high in digestible energy and occur in abundance throughout the valley. The abundance of huckleberry in roadless areas has enabled the population to thrive despite high human-caused mortality (McLellan 2015).

Gaps & Challenges: This work is inexpensive because the area is well roaded, there is a high density of bears, and researchers built a permanent field camp. The Kenow fire of 2017 burned a vast amount of the study area and monitoring bear food response will be important.

- The significance of ungulates to the bears needs more work.

3.1.4.2 The Trans-Border Grizzly Bear Project

Area:	***Primary Researchers***:	***Critical Foods Identified:***
Southeastern BC, South Selkirk, South Purcell & Yahk GBPUs (Threatened) and secondarily across Kootenay Region **Project 10** *on Figure 1.*	Michael Proctor Clayton Lamb Grant MacHutchon	Black huckleberry

The Trans-border Grizzly Bear Project got started in 1998 and is the 2nd longest running grizzly bear research project in BC. Their recent focus has been identifying and mapping critical food resources for the Kootenay region's grizzly bears. Black huckleberry is the primary food consumed during hyperphasia in the Flathead, South Selkirk and Purcell Mountains study areas, and was shown to be driving population viability by being positively linked to grizzly bear productivity in the Flathead (McLellan and Hoovey 1995, McLellan 2011, 2015). Building on the knowledge that the digestible energy obtained from huckleberries was driving population productivity, M. Proctor et al. used GPS telemetry field site visit data and predictive habitat modelling procedures to identify and spatialize huckleberry patches that are important to grizzly bears across the southern Purcell and Selkirk Mts. and eventually the Kootenay region (Proctor et al. 2017). The objective of that work was to predict huckleberry patches that grizzly bears use over a larger area in order to be able to inform their management. This work was unique in that it focused on identifying huckleberry patches used by grizzly bears, rather than the occurrence of huckleberry plants. It turned out that huckleberry patches used by grizzly bears were a small subset of habitats were huckleberry plants occurred. They used site visits (> 700 to date) of 10 years of GPS telemetry data to identify huckleberry patches used by bears and combined that information with ecological modeling to predict those patches in areas where they did not have telemetry data. The resulting huckleberry patch model was then evaluated in several analyses. Using 5 years of DNA population survey data and 10 years of GPS telemetry habitat use data, they assessed food security and teased apart the relationship between bottom up food resources – top down mortality risk forces for grizzly bears in their study area. They found that food resources were the primary driver of female home range selection, habitat use, density and reproductive success and that mortality risk in the form of road densities was also influential and additive to food resources. They also found that the most accurate predictor of grizzly bear mortality (among several candidates) was the density of roads within the bears' range. This work showed across several ecological and population processes that both food resources and mortality risk in the form of road densities are important in grizzly bear management. Currently, this work is being expanded to include the entire Kootenay region. An important result is a spatially explicit map of huckleberry patches used by grizzly bears across their 12,000km^2 multi-mountain range study area.

This huckleberry patch modeling effort is being extended across the entire Kootenay region from the Alberta border to the Okanagan and from the US border north past the Revelstoke area. Field work entailing site visits in 2017 extended from the Alberta border east to the Okanagan, and in 2018 the northern Kootenay region will be included. The resulting huckleberry patch map for the entire Kootenay region should be available for management use by 2019. Uses will include informing access management decisions to insure food security for the region's grizzly bears. They have also developed a predictive future potential huckleberry patch model, identifying areas where given the appropriate land management (fire or timber harvest to open the canopy), huckleberry patches important for grizzly bears may result, providing the potential for habitat and food supply management for the region's grizzly bears.

Project Status: This work combines bear capture data with visits to bear use sites. To date, the capture and telemetry work is complete. Research to visit field sites has one more year in the northern Kootenay region and is fully funded.

Gaps & Challenges:

It currently does not take into account spring and early summer foods, however, while important, the spectrum of foods utilized in those seasons are not known to be critical, limiting, or inter-annually undulant in this region. Furthermore, this project has used their GPS telemetry data to model grizzly bear habitat use by sex and season, and this may be sufficient for modeling spring foods and identify habitats that would benefit from some level of protection in access management.

3.1.4.3 South Rockies Grizzly Project

Area:	***Primary Researchers***:	***Critical Foods Identified:***
Southeastern BC (GBPUs: South Rockies and Flathead, Viable) **Project 11** *on Figure 1.*	Garth Mowat Clayton Lamb	Black huckleberry, buffaloberry

In the South Rockies severe population declines of ~40% have been reported (Mowat and Lamb 2016). The research concluded that the population decline was likely due to "a decade of poor huckleberry production" paired with high human-caused mortality rates and source-sink dynamics (Lamb et al. 2017). Researchers estimate that the population will take an 5-10 years to recover (Mowat and Lamb 2016). The poor Huckleberry production was attributed to a number of dry summers throughout the last decade. In addition, the Southern Rockies GBPU has a high human-caused mortality rate both legal (Artelle et al. 2013) and illegal (Mowat and Lamb 2016). The researchers suspected that the unreported human-caused mortality in this population was high, likely increased due to the poor berry crops, and that current rates of unreported mortality may be underestimated (Mowat and Lamb 2016). In regards to critical foods, this project focuses on understanding how the abundance of bears foods across space and time influence grizzly bear population dynamics (see Lamb et al. 2017 for spatial portion, temporal portion untested to date). Similar to the larger scale BC food project (Section 3.1.4.4), one goal of this research is to create occurrence models for huckleberry and buffaloberry in the South Rockies and Flathead GBPU's. This project will also use annual huckleberry and buffaloberry production data collected as part of the Flathead and Elk Valley collaring projects. The long-term goal is to create annual indices or measures of buffaloberry, huckleberry and green vegetation productivity in order to test the influence of food on population dynamics while considering the interaction with mortality.

Elk Valley Collaring Project: In 2017, long-term buffaloberry monitoring plots were established in the Elk Valley to monitor annual variations in fruit phenology and productivity. These data will supplement GPS telemetry data from grizzly bears in an effort to determine how human-wildlife conflict and mortality are influenced by annually variable food resources (Lamb, pers comm.). This project is combining bottom up and top down population limitation processes by integrating foraging supply with mortality risk factors to examine population vitality (Lamb et al. 2017; Proctor et al. 2017).

Project Status: These projects are ongoing and have funding applications submitted for 2018. The projects are seeking additional funding to expand work and support site visits.

Gaps & Challenges: This work combines bear capture with visits to the sites used by bears.

This work stands to provide much needed insight into grizzly bear population dynamics in a human-dominated landscape and elucidate key temporal and spatial mechanisms driving human-wildlife conflicts.

- This work has not yet taken spring and early summer foods into account because of the difficulty in developing a single metric for a myriad of different plant species. These researchers have spent considerable time testing the methodologies to index green vegetation production and this remains a future goal of the project.

3.1.4.4 Province-Wide Predictive Grizzly Bear Food Mapping Project

Area:	***Primary Researchers***:	***Critical Foods Identified:***
Province-wide. See Appendix II for location of Province wide plots.	Clayton Lamb Garth Mowat Bruce McLellan Scott Nielsen Stan Boutin	Many, varies by region (please refer to Section 4)

In 2013, a PhD project through the University of Alberta began to further examine the use of predictive habitat modelling of critical bottom up food resources, and also to combine bear use of those foods with the risk of human caused mortality. From 2013-17, extensive fruit productivity assessments were conducted in order to improve the biological realism of the occurrence models (Appendix II). To date, ~1,000 plots of the 6,743 identified have been measured with the goal of creating occurrence models across BC (Lamb, pers. Comm.). The data gathered during site visits is being used to further refine the models. When complete, this project may yield our first province-wide look into berry resources. Proctor et al's Kootenay regional field site data is being incorporated into this effort. These predictive food maps will then be combined with DNA mark-recapture data and GPS telemetry data across the province as part of Clayton Lamb's PhD to better understand the interplay between food and grizzly bear population density, survival, and recruitment. Models for key plant species grazed by bears will also be constructed and incorporated into the above analysis where possible.

Project Status: The project is seeking additional funding to expand work and support site visits.

Gaps & Challenges: This work is requires ground visits conducted throughout the Province (Appendix II).

- In the future, additional foods may warrant monitoring. Spring foods may be important in that often they bring bears into contact with people because provincially they tend to occur at lower elevations. When bears and people come into contact the risk of mortality to bears increases. In addition, there are portions of BC where there is no abundant berry species which suggests that bear must be heavily reliant on green vegetation for at least part of the year.

3.1.5 Central and Northern Grizzly Bear Projects

3.1.5.1 Parsnip Grizzly Bear Project

Area:	***Primary Researchers***:	***Critical Foods Identified:***
Central BC, north of Prince George (GBPU: Parsnip, Nation, Nulki, Omineca, Moberly, Hart. All Viable) **Project 12** *on Figure 1.*	Lana Ciarniello Douglas Heard Dale Seip	Huckleberry, oval leaved blueberry, terrestrial meat; buffaloberry (mountains)

A PhD research project through the UofA, the Parsnip Grizzly Bear Project study area was largely contained within the Arctic watershed and bears did not significantly feed on fish. The project was not designed to identify critical grizzly bear foods but bear foods were recorded when the researchers visited a random subset of radio-collared grizzly bear locations. Female bears did not move between mountain and plateau landscapes and therefore their diet differed based on where they resided. In general, the diet of bears shifted from snow-free, largely open canopy (i.e., early seral) areas in spring where the forbs were first emerging, to ants/larvae and cow parsnip in later spring, to berries in summer, and a return to forbs in fall when most berry producing plants had largely senesced. Huckleberry and blueberries were the predominant berry species. Female mountain bears had very small home ranges and their only large movements were to an extensive burn/regrowth where huckleberries, soapberry, and ants were abundant. The use of terrestrial meat items in the diet increased in fall, but most of those were hunter-killed moose carcasses (Ciarniello et al. 2003, 2009). Stable isotope analysis performed on hair of study bears in the Parsnip supported the information gathered during field visits by showing that feeding on terrestrial meat was indeed higher in fall (Jones et al. 2006). There was also an increase in the use of roots of plants (i.e., *Osmorthiza* spp*., Taraxacum officinale)*; particularly as the weather became colder and the herbaceous green vegetation began to senesce.

Project Status: Completed (1998-2003)

Gaps & Challenges: No other studies on grizzly bear food habits in this area.

- Since female bears are not moving between landscapes there is a need to protect critical foods in both mountainous and plateau habitats.
- There is a general lack of information on grizzly bear food security in northern BC.

3.1.5.2 Muskwa-Kechika Grizzly Bear Project

Area:	***Primary Researchers***:	***Critical Foods Identified:***
Northeastern BC (GBPU: Rocky, Viable) **Project 13** *on Figure 1.*	Brian Milakovic Katherine Parker	Terrestrial meat

A PhD research project through the UNBC, this study took place in the Besa-Prophet watershed in the northern Rocky Mountains, of the Muskwa-Kechika in northeastern BC (204,245 ha) (Milakovic 2008). The study did not specifically address critical grizzly bear foods, but rather used stable isotope analysis to quantify the relative contribution of seasonal diets that were made up of plants versus primary prey/terrestrial meat species consumed. The study area remained relatively non-impacted by humans.

The main findings related to critical grizzly bear foods were:

- Shrub and burned habitat classes were important to grizzly bears year-round
- Conifer dominated habitat types were consistently avoided
- Meat consumption was highest in fall for both male (65%) and female (50%) grizzly bears
- Elk was the primary meat type consumed in the fall by both female (15%) and male (21%) grizzly bears
- Moose, caribou and sheep were consumed at a lesser extent
- The majority of nutrients assimilated by male and female bear were from plants; however, the relative amounts of different plant species consumed could not be determined by stable isotope analyses.

Project Status: Completed in 2008

Gaps & Challenges: No other studies on grizzly bear food habits in this area. Bear use sites were not investigated. There is a general lack of information on grizzly bear food security in northern BC.

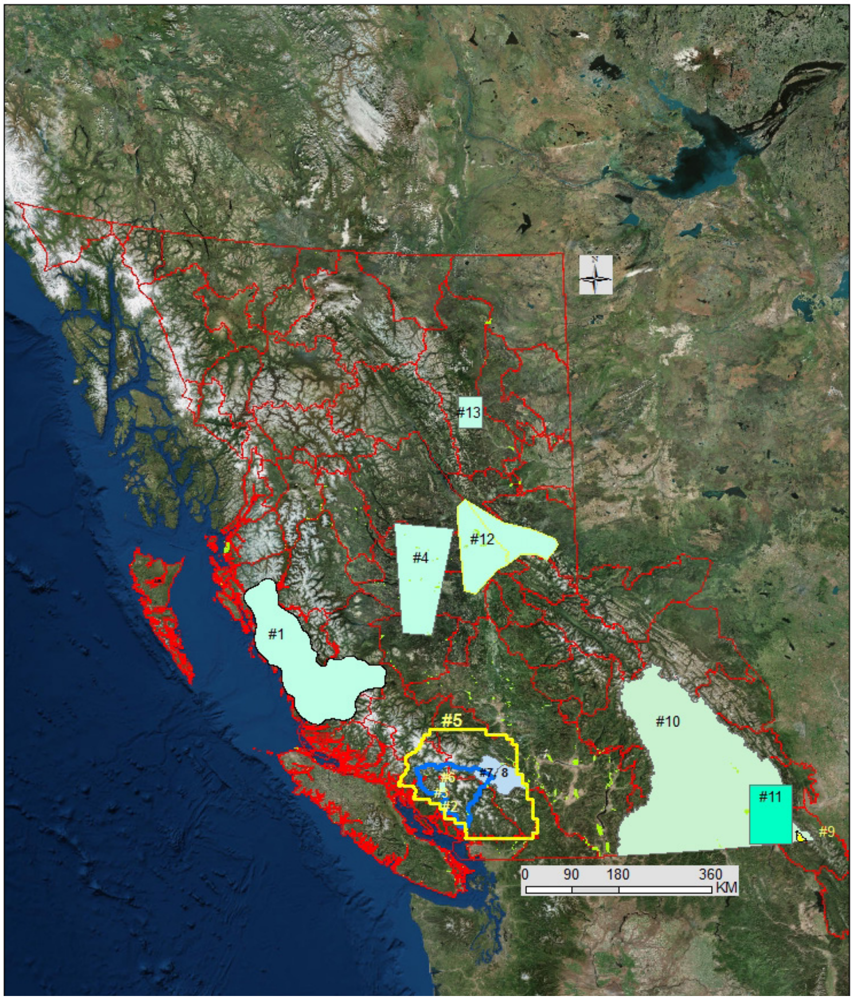

Figure 1. Location of Grizzly Bear Research Projects in BC identifying grizzly bear foods (Selected).

The red polygons are Grizzly Bear Population Units as designated by the Provincial government.

Project 1. Central Coast Grizzly Bear Project, Megan Adams and Chris Darimont.

Project 2. Orford Bay Fish Habitat Enhancement Project. Lana Ciarniello & Homalco Nation.

Project 3. Chilco River Grizzly Bear Project. Cedar Muller & Michael Proctor.

Project 4. Central Interior Salmon Project. Shelly Marshall.

Project 5. South Coast Regional Grizzly Bear Population Study. Clayton Apps, Bruce McLellan, Steve Rochetta, Tony Hamilton.

Project 6. Squamish-Lillooet ("Squamish") Study. Clayton Apps, Bruce McLellan, Steve Rochetta.

Project 7. South Chilcotin Grizzly Bear Habitat Selection Project. Francis Iredale, Bruce McLellan.

Project 8. Stein-McGillvary Grizzly Bear Project. Michelle McLellan, Bruce McLellan.

Project 9. Flathead Grizzly Bear Project. Bruce McLellan, Garth Mowat.

Project 10. The Trans-Border Grizzly Bear Project. Michael Proctor, Clayton Lamb, Grant MacHutchon.

Project 11. South Rockies Grizzly Project. Garth Mowat, Clayton Lamb.

Province-Wide Predictive Grizzly Bear Food Mapping Project. Clayton Lamb, Garth Mowat, Bruce McLellan, Scott Nielsen, Stan Boutin.

Project 12. Parsnip Grizzly Bear Project. Lana Ciarniello, Douglas Heard, Dale Seip.

Project 13. Muskwa-Kechika Grizzly Bear Project. Brian Milakovic, Katherine Parker.

Photo © Jim Lawrence, Kootenay Reflections

4.0 Spatial Distribution of Critical Grizzly Bear Foods across British Columbia

BC is a large province and the critical food(s) for grizzly bears differ based on where the bear resides. Bears can move great distances and across GBPUs but it is unlikely they will travel out of their primary areas. Protecting salmon streams will aid coastal bear populations but not those inhabiting non-salmon bearing systems.

Grizzly bears have a diverse diet and research has revealed many of the high-energy critical foods vary across BC. Further, females can sustain their smaller mass on diets based largely on plants and berries, while male bears rely more on meat to sustain their larger body size (Hobson et al. 2000).

Figure 1 and Appendix II show that there are some large gaps in knowledge on critical foods, particularly in Northern BC; however, the research conducted to date has provided us with a general knowledge of grizzly bear diet. Appendix I provides a working list of grizzly bear foods and then attempts to select those foods that are potentially critical by bear region based on the knowledge of critical foods in this report and author experience.

4.1 Berries

Black Huckleberries (Vaccinium membranaceum) are thought to be the primary energy-rich food consumed by grizzly bears in BC (B. McLellan, M. Proctor, C. Lamb pers. comm.) outside of important salmon areas, which is likely due to their broad distribution throughout the province. Huckleberry is a major grizzly bear food in the NW of BC (Babine area mix salmon), through parts of central-eastern BC and the northern Rockies (Parsnip Study Area, Ospika), Wells Gray Provincial Park, Glacier National Park, and north of Yoho (Westslopes Grizzly Bear study area), parts of the east and west Kootenays, and the Southern coast ranges (B. McLellan pers. comm.). The high energetic value and broad distribution of huckleberries is why they are the current focus of predictive grizzly bear mapping for BC.

In general all berries are important to bears because they optimize the composition of gains in body mass (i.e., fat or lean body mass) by providing a mixed diet of varying protein content (Rode and Robbins 2000). Consuming carbohydrate rich berries has been shown to offset the high protein obtained from salmon (Deacy et al. 2017). Bears equalize the fat/lipids with carbohydrates obtained from berries to maximize energy intake and gain body mass (Erlenbach et al. 2014).

The research presented in Section 3 revealed a number of berry species other than huckleberries that may be a high quality bear food where they occur and therefore warrant monitoring. Consideration may also be given to creating spatially explicit occurrence maps for the following berry plants:

- Buffalo berry (*Shepherdia Canadensis*) is an important bear food ranked second to huckleberry in the Flathead, Elk Valley, Westslopes, and Southcoast study areas (B. McLellan pers. comm.). It occurs in areas that may be too dry for huckleberries. It is beginning to be monitored in the Kootenays.

- Devil's Club (*Oplopanax horridus*) was a common late summer berry that was used by grizzly bears in central (Ciarniello et al. 2003) and coastal BC. In northern southeast Alaska it was reported to be a secondary food to salmon (Harrer and Levi 2018).
- Saskatoon (*Amelanchier alnifolia*) was identified as an important berry in the diet of bears in the South Coast (M. McLellan's work). It has a broad distribution ranging from sea level to the Rocky Mountains and therefore could be an important food within a number of GBPUs.
- Red Elderberry (*Sambucus racemose*) appears to be widely distributed across BC and has been shown to be the primary secondary food source for bears for the Kodiak brown bear in Alaska (Deacy et al. 2017). It was a very nutritionally important berry for these bears as it balanced the high protein in salmon with the carbohydrates in berries, which is required to convert to fat (Deacy et al. 2017).
- Salmonberry (*Rubus spectabilis*) is associated with moist forests and appears to be widely distributed across coastal BC. The berries ripen throughout July and I have heard First Nation legends that say one can predict the quality of the upcoming salmon run based on the abundance of salmonberries (Ciarniello pers. comm.). Salmonberry may be important for coastal bears during the early part of the salmon run.
- Crowberry (*Empetrum nigrum*) is a bear food across northern BC and its value to those bears may be worth investigating (B. McLellan pers. comm.).

4.2 Salmonoids

On the west coast of BC, spawning salmon are the critical food for grizzly bears and are known to draw bears in large numbers (Mueller and Boulanger 2013, Boulanger et al. 2004). Declines in coastal and interior (Fraser-Chilko) salmon populations may have significant impacts on bear populations in the region.

The percent salmon in the diet of bears decreases as one moves from the coast towards the interior (Fig. 1); however, a large number of bears continue to feed on salmon at Chilco Lake, which is ~260 km from the ocean (Mueller and Boulanger 2013). Moving eastward salmon comprises less of the diet and females start to consume less salmon than males (Mowat and Heard 2006). Mowat and Heard (2011) found high salmon signals as far east as Quesnel Lake and Wells Gray Park.

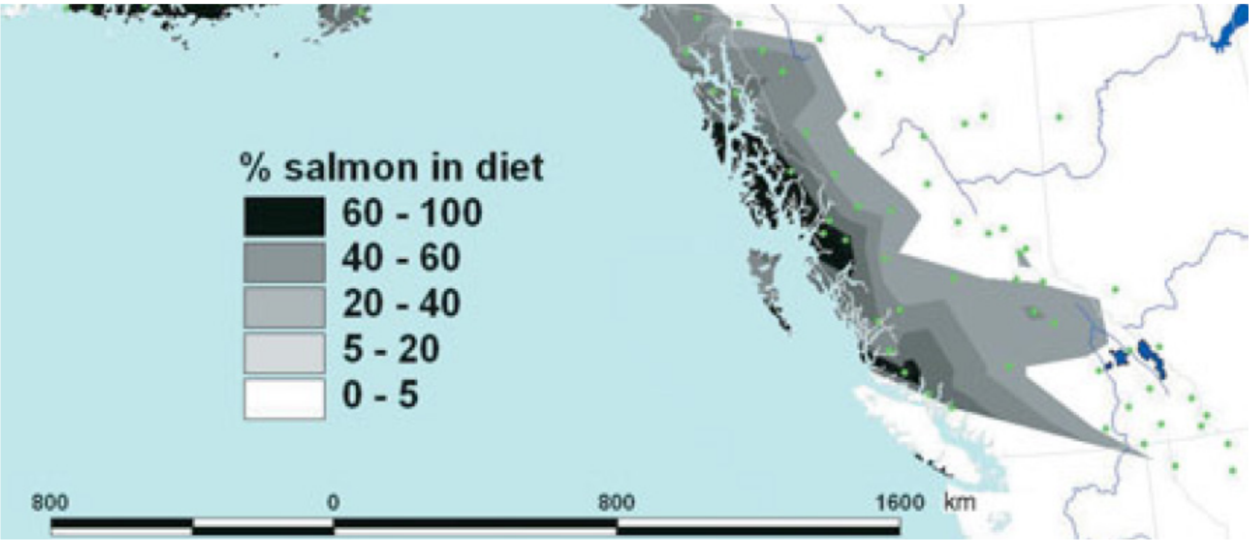

Figure 2. Interpolation of the amount of salmon in the diet of grizzly bears across British Columbia based on Mowat and Heard (2006).

Reprinted with permission from Garth Mowat and Douglas Heard.

Research is being conducted on salmon in the diet of bears, however, there are some gaps in our knowledge of salmon-bear systems:

- Use of Kokanee by interior bears (proposed project in this report by S. Marshall).
- Role of berries in reducing the protein ratio of salmon (proposed project in this report by M. Adams).
- Lack of radio-collared data on the movements of these bears to determine the salmon area of influence (i.e., how far away are these bears are coming from? Proposed project in this report by Mueller & Proctor).
- Lack of knowledge regarding how salmon fat content varies across the province and how that correlates to isotopic signatures (McLellan pers. comm.).
- Predicted declines in salmon due to increasing water temperatures.
- The influence of bear viewing operations on the availability of salmon to the bear population (project in waiting, gap).

The vital rates of bears are directly linked to salmon productivity and salmon is extremely important in the diet of coastal bears (HIlderbrand et al. 1999a). In the Chilcotin more bears returned to the river after years with higher salmon availability (Mueller and Boulanger 2013). Securing this critical food for grizzly bears meaning securing salmon and that requires conserving and protecting salmon habitat.

4.2.1 Habitat Considerations for Salmon Spawning Systems

Research is being completed on many aspects of grizzly bear use of spawning streams but little is being done to examine the condition of the rivers that bears are using to maintain spawning habitat. In some, but not all areas, DFO records fish returns and uses that information as an indicator of salmon health, but it provides no indication of whether or not the system is subject to events that could immediately negatively impact spawning habitat.

For example, a number of these coastal watersheds have had a significant amount of logging adjacent or upstream of spawning habitat. Geomorphic assessments in some watersheds, such as the Orford River (proposed project), have identified landslides and road failures associated with industrial activities that significantly contribute to downstream transport of debris and sediment (NHC 2017, proposed project in this report).

Securing salmon as a critical food, especially in times of warming water temperatures, requires identification and management of erosion processes in the watersheds. This work would require working in cooperation with DFO, Fisheries Biologists, salmon habitat and restoration organizations (e.g., Pacific Salmon Foundation of BC), industry and First Nations.

4.3 Terrestrial Meat

Terrestrial meat is a broad term and may refer to rodents (marmots & microtines), newborn and adult ungulates, and ants. There remains a lot of uncertainty about the importance of terrestrial meat in the diet of grizzly bears. Generally, in the boreal forests of BC berries are less abundant and bears consume more terrestrial meat and it appears that meat is mostly ungulates, which are a very high energy and high protein diet (Milakovic 2008). Indeed, 45-65% of the diet of bears in the Muskwa and Cassiara areas was meat-based but that was determined through SIA and the species of meat was not identified (Fig. 2, Mowat and Heard 2006). In non-salmon bearing systems, males consume more meat than females (Hilderbrand et al. 1998, Jacoby et al. 1999, Milakovic 2008).

Terrestrial meat is thought to be important in areas that contain healthy ungulate populations and have a low quality or abundance of plant foods (B. McLellan pers. comm.). In BC, terrestrial meat in the diet of bears is higher in the northern part of the province than the south (Fig. 2, Mowat and Heard 2006). There is an energetic cost to obtaining terrestrial meat because bears must spend time hunting. It is likely that in areas where berries and other plant-based foods are productive and abundant, bears will feed more on berries because they are less costly (i.e., energetics and the potential for physical harm) to obtain; in those areas where there is a choice, berry habitats will be more important for bears.

There is more to learn about the combination of meat and plants and the contribution to bear fitness. Further, moose and caribou are in decline across BC due to competition with, or predation by, other species and how this will affect bears, particularly in the northern part of the province, is unknown.

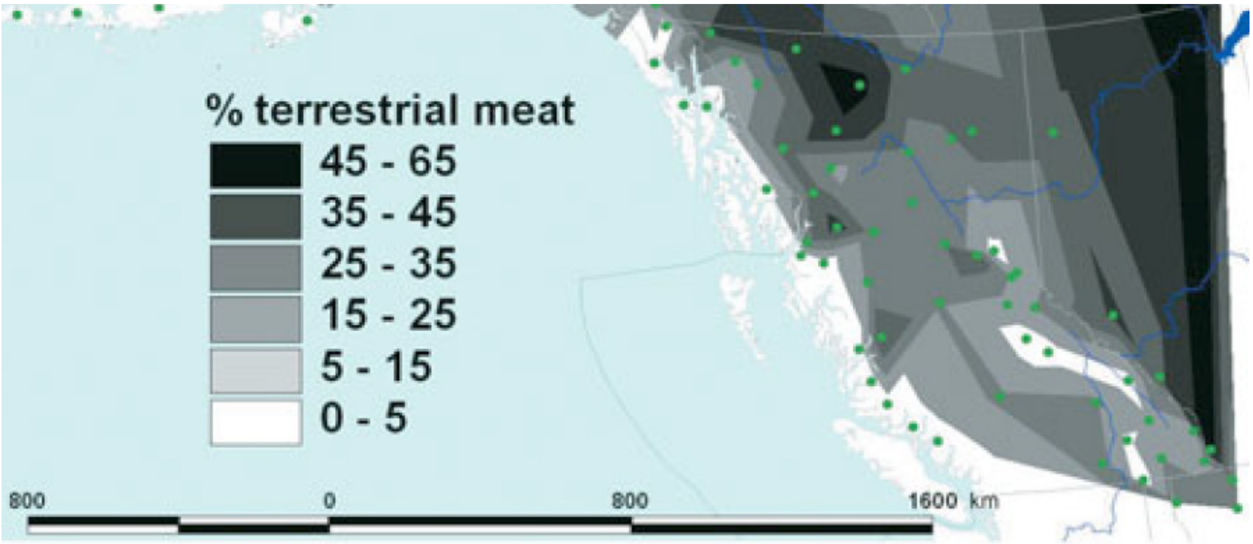

Figure 3. Interpolation of the amount of terrestrial meat in the diet of grizzly bears across British Columbia based on Mowat and Heard (2006).

Reprinted with permission from Garth Mowat and Douglas Heard (2014)

4.4 Whitebark Pine Seeds

Grizzly bear use of whitebark pine (*Pinus albicaulis*) seeds is not well understood in Canada and is an area that would benefit from further research. In BC, WBP pine occurs from the US border to 55˚N near Takla Lake covering ~145,000 km^2 (Pigott et al. 2015). The primary disperser of WBP seeds is the Clark's nutcracker (*Nucifraga columbiana*). WBP primarily occurs at high elevations on the dry side of the mountains. The seeds of WBP are high in fat (30-50%) and protein (>14%) and have a distinct sulphur isotopic signature to other vegetation, so are ideal for stable isotope analysis.

Typically, WBP produce mast cone crops once every 3 to 5 years and may not be available on an annual basis for consumption by bears. Regardless, WBP is known to positively affect population vital rates of grizzly bears; larger litter sizes and greater cub survivorship have been reported to occur in synchrony with cone masting in the Greater Yellowstone Ecosystem (GYE) and in Montana (Mattson et al. 2001, Schwartz et al. 2002). Further, in years of good WBP cone production the survival rates of grizzly bears were higher (Blanchard and Knight 1995, Mattson 1998, Schwartz et al. 2006). Higher survival is not only the result of the availability of a critical food but also because WBP grows best in the subalpine. In years of good cone production grizzly bears tend to remain in those high elevation habitats to feed on the seeds providing a natural separation between humans and bears, however, when there is a lack of food bears have been reported to seek out alternate foods at lower elevations where they are more likely to encounter humans (Schwartz et al. 2006).

The role of WBP in the diet of grizzly bears is an area that is lacking significant research in BC. It is within the last decade that researchers have begun to identify WBP as a critical food to bear populations where it occurs. Investigations into the role of WBP in the diet of radio-collared grizzly bears Banff National Park began in 2013 (Hamer 2018). Although the study is ongoing, Hamer (2018) reports that WBP seeds occur in the diet of at least 75% of the radio-collared bears investigated to date. In BC, WBP is thought to be a critical grizzly bear food in the South Coast Mountains (B. McLellan pers. comm.) and possibly in the SE Kootenay Region. No data exists on grizzly bear use of WBP for the central or northern interior. Similar to work conducted in the GYE, the importance of WBP seeds to the fitness of grizzly bears in BC is thought to increase in years with poor berry production (B. McLellan pers. comm.). The relative importance of WBP to grizzly bears is predicted using data on grizzly bear locations relative to WBP habitat identified from VRI mapping, and would benefit from ground-truthing predicted WPB habitats, monitoring cone production, and determining grizzly bear use of WBP throughout its provincial range.

Throughout North America WBP is being negatively affected by climate change and fire suppression. It is also in decline due to white pine blister rust fungus disease (*Cronartium ribicola*) and the mountain pine beetle (*Dendroctonus ponderosae*) epidemics. Augmenting the problem is that stands of dead WBP may be being successionally replaced, particularly by subalpine fir (*Abies lasiocarpa*) (Murray pers. comm.). Whitebark pine is Blue Listed in BC (CDC 2015) and is federally designated as Schedule 1 endangered under the Species at Risk Act (SARA) with “a high risk of extirpation from Canada” (COSEWIC 2010, 2012). There is a clear need to provide effective protection and enhancement recommendations for WBP. There is a Whitebark Pine Ecosystem Foundation of Canada and a Recovery document specific to BC, however, it states that “at present there is no real voice to advocate for whitebark pine in BC” (Pigott et al. 2015:95). There is a proposed Federal Recovery Strategy for whitebark pine in Canada, but it states that “information gaps prevent complete critical habitat identification at this time” and so recovery is limited due to “poor inventory data” (ECCC 2017). The final action plan is proposed to be completed by 2022 (ECCC 2017). Conservation of WBP will require working closely with the forest industry.

A lack of precise mapping of the occurrence and cone production of WBP is a critical gap in BC. Limited ground-truthing is occurring, but on a small/local scale. In the South Coast Region there were 4 transects with 10 trees each in Molybdenite and Downton ridges in the SN, and Sunshine and Yalacom ridges in the MM area (M. McLellan pers. Comm.). WBP is being monitored in the Yalacom valley (NE of the South Coast Grizzly Bear Project; by R. Moody). In the Kootenay Region, WBP is being monitored in the Eastern Kootenays (between Cranbrook and the Continental Divide) (Murray pers. comm.). The majority of the South Coast Mountain GBPUs are designated as threatened or extirpated so maintaining high quality foods in this area of BC is important to grizzly bear survival. Whitebark pine is a high elevation species and therefore the majority of monitoring requires helicopter access.

Recommendations:

More research is required to better understand bear consumption of WBP and how it relates to the availability and abundance of other critical foods.

- Dietary analysis on bear hair and its relationship to cone availability.
- Better identification of secondary foods that bears can rely on in years of low cone production.
- Mapping of secondary foods so management can predict and avoid HBC (ecological traps) for bears.
- Also an effort should be undertaken to identify stands that are actually used by grizzly bears, as not all of the WBP distribution may be utilized (i.e., similar to Proctor et al. for huckleberry).

In general, there is a province-wide need for WBP habitat mapping to spatially identify stands.

- More accurate GIS layer of WBP stands.
- Identify any stands that overlap with the timber harvesting land based.
- There is a province-wide need to annually monitor cone production.

4.5 Greens (Forbs, sedges, grasses) and Roots

Grizzly bear foods are diverse and vary by season and according to plant phenology and resource availability. Defining grizzly bear foods as those that contribute the most to fitness and therefore are consumed in the fall hyperphasia period (fat deposition) omits the contribution of spring and early summer foods. This was done in an attempt to focus on those efforts would be most beneficial to the fitness of bears, which is adding fat through increased protein consumption during hyperphasia. However, adding lean body mass in spring is also likely critical to being able to have excess protein in the fall.

Bears consume a diverse array of green vegetation in all different habitat types (Appendix I) and most forbs, grasses and sedges appear to be fairly abundant where they occur. The new shoots of green vegetation are primarily consumed by bears in spring. Spring foods, while important, are usually not limiting, and therefore most likely in excess of what grizzly bears use. Late weather warming conditions may affect the availability of spring foods, but overall they appear to be less undulating from year to year. Proctor (pers. comm.) notes that because spring foods tend to abundantly occur, and are generally consistent year to year, spring / early summer habitat use modeling using locations obtained on radio-collared bears may be good enough at this point to identify those important seasonal habitats.

The roots of plants may be important to bears in the spring and fall, such as Glacier lily (*Erythronium grandiflorum*) and Alpine Hedysarum (*Hedysarum alpinum*) in high elevation habitats (Coogan 2012) and rice root (*Frittallaria camschatcensis*) in estuaries (Adams pers. comm; Ciarniello pers. comm.). Appendix I identifies some foods that may be important spring and back-up (secondary) fall foods. Habitat and management plans should recognize and protect important habitats where these plants occur, such as estuaries, riparian areas, and avalanche chutes.

4.5.1 Surfing the Green Wave

Surfing the green wave looks at how closely timed animal movement is with tracking spring green-up, which corresponds to animals consuming the highest quality forage. The green wave hypothesis has recently been documented for ungulates and is currently being examined for grizzly bears in the interior of BC using a meta-dataset (Merkel, Mowat, Ciarniello, McLellan in prep.). The objectives of that work are to "assess whether grizzly bears inhabiting mountainous ecosystems of North America surf the green wave in spring and summer, and to examine the factors that facilitate or constrain green-wave surfing such as the timing of ungulate births, and the speed, duration, and smoothness of green-up within study areas varying across latitude." This work is currently underway.

5.0 Top-Down & Bottom-Up: Factors in Understanding the Role of Food Security on Grizzly Bears

Food security is not simply about conserving critical food resources. Food security is inextricably linked to habitat connectivity, core security areas, and minimizing the risk of human-caused mortality.

For food to be secure it must be free from danger or threat.

The human population is expanding and habitat suitable for wildlife is being increasingly lost or fragmented. Habitat loss, alteration, and fragmentation can place bears and humans in closer contact. Further, when high quality bear foods fail bears may be more likely to seek out alternate resources and can be drawn to human dominated landscapes to feed on human food and garbage (e.g., whitebark pine failure). When humans and bears clash disproportionately high bear mortality occurs for these 'problem' bears (Hebblewhite et al. 2003).

5.1 Resource Extraction Industries and Food Security

Bears do well with large landscapes that are relatively free from human modification. In BC, industrial activities are rapidly expanding and are affecting critical grizzly bear foods on a provincial scale. According to the Auditor General, habitat loss is the primary factor limiting grizzly bear populations in BC (Auditor General Report 2017). BC is well known for its forest industry, and during the past decade industrial activities such as mining and pipelines are increasing. For grizzly bears, industrial activities can have adverse effects that are additional to habitat loss, such as:

- the creation of monocultures and/or even age stands that may regenerate with little productive forage for bears;
- the degradation of habitat due to landscape changes that are unfavorable to bears (e.g., road failure collapsing into a critical salmon spawning river);
- the removal of strategic canopy cover resulting in a reduction of security cover for bears adjacent to important open habitats;
- the fragmentation of habitat resulting in restricted or limited movement between habitat patches;
- the creation of roads leading to increased human access into formerly pristine areas increasing human-bear conflict; and,
- the attraction of some bears to areas/habitats that hold a high risk of human-caused bear mortality , such as, clover along rail or roadways or road kills.

However, timber harvest may also benefit bears. In some areas, timber harvest that opens canopies, especially those that are not regrown quickly to canopy cover (Proctor et al. 2017) can provide food resources for bears (Ciarniello et al. 2014). To minimize the likelihood of people killing bears (top-down population regulation) post-harvest road closures aimed at providing food security for appropriate sites must be implemented (Proctor et al. 2017, Lamb et al. 2017).

Minimizing the risk of human-caused mortality may be primarily achieved through the maintenance of pristine habitats and where that is not possible strict and effective management of human access.

Conservation of habitat must do done in cooperation with industry.

5.1.1 Backcountry Roads and Increased Human Access

Numerous studies on grizzly bears in BC have concluded that the roads associated with resource extraction activities lead to increased grizzly bear mortality (McLellan et al. 1999, Ciarniello et al. 2009, Proctor et al. 2017, Lamb et al. 2017), especially near areas of high human density (Mowat et al. 2013). And, habitats that attract bears to high-risk areas can result in local population declines (i.e., attractive sinks, Delibes et al. 2001, Lamb et al. 2017, Mowat and Lamb 2016). In BC, Lamb et al. (2017) confirmed that the risk of bear mortality could be managed by managing for road densities <0.6 km/km^2, supporting previous research in this area. To be effective the foraging benefits must improve reproduction and natural survival more than a potential increase in grizzly bear mortality due to increased human access. To effectively implement grizzly bear recovery efforts where appropriate and secure grizzly bear foods, issues such as motorized access, livestock grazing, and energy and mineral development must be addressed in cooperation with industry and the public.

5.1.2 Forestry and Food Security: Berries for the Bears Research Project

Berries for the Bears began in 1992 in the Great Bear Rainforest on the lower slopes and floodplains of the Coastal Western Hemlock (CWH) biogeoclimatic (BEC) zone in the Vancouver and Prince Rupert Forest Regions. It was a commercial forestry-based initiative with the objective to establish and maintain a commercially viable stand of trees, while managing for conditions conducive to the survival, growth, and productivity of grizzly bear forage throughout the rotation of the stand (Johnson and McLennan 2000). The trials were meant to be "an adaptive forest management process designed to maintain and restore important grizzly bear habitat while continuing to produce high-value timber" (T. Hamilton pers. comm.). Simply put it was a stocking standard where after commercial forest harvesting the re-planting of seedlings were spatially structured in such a way as to prevent closed canopies and encourage canopy gaps to promote the growth of berry producing species, particularly Devil's Club and salmonberry.

The project was designed to integrate silviculture and grizzly bear forage in Coastal BC. The original trials were established under a set of reduced stocking targets for concurrent achievement of grizzly bear forage objectives and timber production, achieved through a gap/ cluster arrangement at planting. In 1993, based on the initial trials the lower reforestation stocking standards for selected site series in the CWH zone where changed and those standards still apply today for the majority of Coastal BC (Hamilton pers. comm.). Unfortunately, very limited follow-up has been done on the effectiveness of the original trials.

Project Status: Seeking funding to provide a 25 year post re-examination of a large number of existing trials designed to integrate silviculture and Grizzly bear forage in Coastal BC (T. Hamilton pers comm.). The continued investigation of project efficacy was part of the original project's adaptive management design, but has not been funded to date.

5.2 Food Security and Habitat Corridors

To properly secure critical foods for grizzly bears, corridors between patches of critical food(s) need to be considered as important as the food(s) because they allow the foods to be accessible.

Weight gain in bears is limited by the digestibility of plant foods (Rode et al. 2001). The limited ability of bears to digest mature plants means that to maximize weight gain, and therefore optimize fitness, they must move between habitat types tracking where the most digestible foods are in abundance. In BC, grizzly bears use varying strategies to track and exploit critical foods such as capitalizing on elevational gradients (McLellan and Hovey 1995), or if they live entirely at low elevation moving between key habitat patches (Ciarniello et al. 2006), or potentially moving vast distances to access salmon streams during the spawn (Schindler et al. 2013, Mueller and Boulanger 2013). Therefore, securing critical foods for bears must also account for food *availablity* and *accessiblity*, and that requires the maintenance of corridors between critical patches. In addition to allowing for movement, habitat corridors also provide cover for security. In areas where human activity occurs cover becomes especially important for bears. Bears also use cover to avoid other bears, especially adult males (Mattson et al. 1992). Therefore, those corridors should also have a limited risk of human-caused mortality (e.g., roadless or low density of roads).

5.3 Climate Change and Critical Foods

Managing bear populations in times of uncertainty calls for conservatism.

Grizzly bears are extremely adaptable and can range widely making it difficult to predict how they will respond to climate change. The adaptability of grizzly bears means that they can adjust to changing food resources (Fortin et al. 2013). Due to the size of BC, it is likely that the habitat changes that result from climate change will vary across the province. Therefore, it is difficult to predict how climate change will affect the distribution and abundance of ecological communities; increasing temperatures and precipitation may favour some plant species used by bears while the distribution of other plant species could be restricted. Bears may use alternate food sources to meet their energetic requirements. Therefore, in some areas it may result in positive effects on grizzly bear forage items, while in other areas, such as those where WBP grows, forage items may be negatively affected. Regardless, changes in the distribution of vegetation will influence the distribution of mammals that rely on them including bears and ungulates.

In regard to bear behaviour, warmer winters will likely extend the foraging season due to foods being available later into fall/winter and earlier in spring. This means that bears are predicted to spend less time hibernating allowing for more time for human-bear conflicts to occur. The ability of grizzly bears to adapt to climate change via use of alternative foods can be misleading if those habitats also hold a higher risk of human-caused mortality. The decline of the European brown bear, which now exists primarily in isolated pockets, has been attributed to 12,000 years of climate change across Europe (Albrecht et al. 2017). The warmer winters resulted in more people living in bear habitat (habitat loss and human-bear conflicts) and lowered the reproductive rate of bears (Albrecht et al. 2017).

5.4 Competition with Commercial Berry Picking

Commercial berry picking is thought to be in conflict with securing critical grizzly bear foods but is an area where little information exits. In the Kootenay-Boundary Region the Ministry of Forests, Lands and Natural Resource Operations has identified commercial berry picking as a research priority but at this time has not investigated it further (Mowat pers. comm.). The competition between commercial berry picking and bears is a knowledge gap that should be examined.

6.0 Discussion and Conclusions

The role of critical foods is an important factor warranting support for future research and monitoring. The data gathered can be used to inform grizzly bear conservation plans.

To ensure critical foods are secure for grizzly bears they must be *available, accessible with minimal mortality risk, and of appropriate quality*. The availability of critical foods triggers seasonal shifts in movement patterns of bears. In BC, grizzly bears travel great distances to feed on spawning salmon (Adam et al. 2017, Mueller and Boulanger 2013) and critical berry species (Hovey and McLellan 1995, Ciarniello et al. 2007) during hyperphagia. To persist grizzly bears require large, intact landscapes that contain a suite of resources that are secure enough to minimize the risk of human-caused mortality as bears move across habitat types tracking available forage items.

Security issues facing critical grizzly bear foods across the Province are not clearly understood. Throughout BC grizzly bear populations are experiencing increasing impacts from human induced landscape changes such as, forestry, pipelines, hydroelectric developments, mining, recreation and expanding human settlement. In addition, all of the critical foods identified are subject to resource pulses – coastal salmon, interior kokanee, whitebark pine, and berry producing plants – being of increased resource availability at certain years/times and not others. Securing critical foods requires conservation of the food(s) and ensuring safe access thereby allowing bears to securely utilize the resource. To allow grizzly bears to adapt to uncertain habitat changes in the future, of utmost importance is to manage landscapes to allow for relatively safe movements of bear within and between populations (Proctor pers. comm.). Habitat and population connectivity will be required for bears to adapt to climate change (Proctor pers. comm.).

6.1 Focus of Future Work

There are challenges when attempting to quantify the mechanisms that influenced changes in population growth rate. In threatened GBPUs, and in general in areas where bears are under threat, more needs to be done to identify the drivers limiting populations. Population recovery requires a clear understanding of how diets in populations have shifted over time, which foods contribute most towards population growth, and the availability, abundance, and locations of those high quality foods. In those GBPUs where populations are healthy and not in need recovery, which is a large part of the province, we need to manage bear habitat to avoid any declines. Reducing human-bear conflicts in the front and back country, is likely the most important aspect of limiting mortality in areas where populations are healthy.

While there is still a lot to learn, the research conducted to date on grizzly bears in BC shows that we need to protect those habitats where we know that critical grizzly bear foods occur, manage for connectivity between patches, and manage for human-caused grizzly bear mortality. Effective habitat protection measures and restoration management initiatives *need to occur now*, especially with the uncertainty of climate change.

6.2 Identification & Monitoring of Critical Foods

We need a deeper understanding of the resources that limit bear productivity because this will allow for better understanding of factors driving trends and more informed habitat protection and restoration efforts to maintain sustainable populations. A number of critical foods have been identified but we have little knowledge of their role in driving populations:

- Whitebark pine requires monitoring and determining grizzly bear use: How many bears across the province rely on WBP and is there evidence to suggest that it is a limiting food? WBP could be driving populations in areas where it exists and a large gap in understanding and securing a high energy food, especially in threatened GBPUs.
- Interior Kokanee is a large gap for interior bears.
- Northern BC very little is known about the role of terrestrial meat and high-energy berries.

We need to establish a longer-term monitoring program of a representative sample of populations and their primary foods. Monitoring forage quality versus quantity is particularly important given the decline in some critical food resources and the uncertain effects of climate change. Monitoring should continue to provide thorough and detailed documentation of the uncertainty surrounding the loss, redistribution, and potential change in grizzly bear foods as a result of changes to the landbase through development or climate change. We need continued, permanent monitoring between the **availability** and **use** of critical grizzly bear forage in selected populations as it relates to:

- The distribution, abundance, quality and quantity of critical food sources.
- The vital rates and body condition of grizzly bears.
- Additional monitoring of more of the identified primary and secondary (back up) critical grizzly bear foods is especially important to predict grizzly bear use in years of non-mast, berry failure and/or low salmon returns.

To accurately make layers that predict grizzly bear use of critical foods researchers must visit the habitat use locations of bears (Proctor et al. 2017). Currently there is a reliance on obtaining habitat and terrain information from spatial GIS layers which are developed for purposes other than predicting grizzly bear use, such as forestry inventory. When using these layers we normally rely on using surrogates to infer actual habitat selection patterns. In the Kootenays the work on predicting huckleberries reveals that the occurrence of the plant versus those patches that are actually used by bears are not necessarily the same thing (Proctor et al. 2017). The site-specific information obtained when visiting bear use locations is an important factor in successfully predicting grizzly bear space use.

6.3 Enhancing Critical Fruit Crops

Additional research on how we can ensure a future fruit crop will be produced should be completed (B McLellan pers. comm. Proctor et al. 2017). In the Flathead as well as the Golden study areas, the huckleberry fields used by bears were all open areas burned by wildfire and between 1,600 and 2,000 m in elevation. But some open burns at the right elevation do not produce huckleberries. Why is it that some burns and clearcuts regenerate with abundant fruit and others do not? For example, in the Amiskwi in Yoho National Park is a large, open burn between 1,550 and 1,800 m in elevation that did not produced huckleberries. However, the

Waitabit and Bluewater burns just north of the Amiskwi are productive huckleberry habitat (B. McLellan pers. comm.). In the Hart Ranges of the Rocky Mountains the only significant movements made by female mountain bears was in berry season to a burn adjacent to Hook Lake that was abundant with huckleberries, buffalo berries and ants (Ciarniello et al. 2003). However, a burn on the adjacent plateau habitat had very few huckleberries.

In an effort to answer these questions in the Kootenay Region, Proctor et al. (2017) analysed their identified huckleberry patches used by grizzly bears relative to ecological site conditions and disturbance history (timber harvest, post-harvest treatments, wild fires, etc.) to attempt to elucidate patterns on why some areas yielded good patches and others did not. While not providing perfect answers, their work is a good beginning to this effort. One interesting results was that on sites with the appropriate conditions, those with canopy cover <30% for 30-60 years were more likely to yield a huckleberry patch used by grizzly bears and this was the same as in the Flathead (McLellan and Hovey 2001). These sites tended to occur above 1,500 m in their southeast BC study area. They also developed a predictive model on potential future huckleberry patches that might develop when the areas with the appropriate ecological, topographical, and microclimate conditions were accompanied by opening the canopy, through timber harvest or fire. Their future predictive huckleberry patch map is available for experimentation in cooperation with the forest industry and land use managers that may use harvest or fire to open canopies in appropriate sites.

In the southern Coast Mountains, huckleberry production is also unpredictable with some open burns and clear cuts, as low as 800 m in elevation, but up to 2,100 m elevation, producing good huckleberry crops that are fed on by grizzly bears. However, by far most open clear cuts do not produce huckleberries in the southern Coast Mountains (B. McLellan pers. comm.). Like Proctor and Lamb in the interior, M. McLellan has begun to develop a predictive model for huckleberry production in the Stein/Nahatlatch and South Chilcotin GBPUs, but this work should expand to the Squamish Lillooet area because that is where many low elevation huckleberry fields are used by grizzly bears. In the Squamish/Lillooet area, huckleberries are also productive and used by grizzly bears in narrow elevational band in the subalpine (B. McLellan pers. comm.). Determining the features that account for productive fruit crops would aid habitat enhancement initiatives.

6.4 Moving Forward to Secure Critical Foods

BC is a large and ecologically diverse province. It would be extremely costly and time consuming to conduct the extent of research required to unravel all of the forces that drive populations in the different areas. Therefore data across a subset of representative areas can be used to inform and develop representative predictive models. However, nature is complex and understanding the patterns in nature so they can be linked to predictive modelling can be tricky.

In order to reflect that complexity we must understand the system, processes, and links to bear ecology. Developing models that reflect forces that control population dynamics requires inputs of both critical food layers, and mortality risk factors. These can be obtained through learning about bears' habitat use and food preferences by visiting the areas they are using. The majority of the modeling conducted to date largely uses surrogate variables (e.g., habitat type to infer forage items) and would benefit from the development of predictive GIS-based critical bear food layers such as berry occurrence or salmon availability (Proctor et al. 2017, Lamb, current PhD work). The more ground-truthing through field site visits, the more accurate and useful the predictive models will be. The more relevant and accurate models are the better our ability to identify habitats important to grizzly bears and target habitat maintenance, enhancement, or conservation initiatives.

Government management plans, particularly those dealing with human access on remote industrial roads for recreational purposes, salmon allocation policies, controlled burns, and climate change can all have important consequences for grizzly bears. Without adequate information on the foraging ecology of grizzlies there is a risk that habitat management or restoration activities could be misguided, thus wasting resources and time on unsuccessful activities that do not benefit bears (Proctor pers. comm.). To be effective at conserving and restoring critical grizzly bear habitat, thereby securing grizzly bear foods, conservation plans must be based in science and developed in cooperation with industry (forestry, mining, hydro-electric projects, pipelines, etc.), governments, the public, and First Nations.

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Photo © Karyn Schiller

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Appendix I. List of Grizzly Bear Forage Items

This list of grizzly bear forage items was first developed on the Parsnip Grizzly Bear Project by conducting site visits (microsite habitat work) to radio-collared grizzly bear locations, 1998-2003 (Ciarniello et al. 2003). This list has been continuously updated as I conduct additional research on grizzly bears throughout BC*. The green shaded forage items are those considered critical primary or secondary forage items to grizzly bears inhabiting the stated Region and have been subjectively delineated for the purpose of this report. The orange shaded items are foods that I think also may be highly important to grizzly bears in BC but are not mentioned in this report. Grasses, sedges, and other forbs known to be frequently consumed by grizzly bears are not highlighted since they are widely distributed.

CODE	Latin Name	Common Name	Region
TREES			
PINUALB	Pinus albicaulis	Whitebark pine	South Coast, SE interior throughout BC distribution?
RHAMPUR	Rhamnus purshiana	Cascara	
SHRUBS AND DWARF SHRUBS			
AMELAIN	*Amelanchier alnifolia*	Saskatoon	South Coast
ARCTUVA	*Arctostaphylos uva-ursi*	Kinnikinnik	Northern
CORNSTO	*Cornus stolonifera*	Red-osier dogwood	
CRATDOU	*Crataegus douglasii*	Black hawthorn	
EMPENIG	*Empetrum nigrum*	Crowberry	Northern
LONIINV	*Lonicera involucrata*	Bracted honeysuckle	
OPLOHOR	*Oploplanax horridus*	Devil's club	Provincial, central-northern
RIBELAC	*Ribes lacustre*	Bristly blackcurrant	
RIBEHUD	*Ribes hudsonianum*	Northern blackcurrant	
RIBEOXY	*Ribes oxycantholdes*	Wild gooseberry	
ROSAACI	*Rosa acicularis*	Prickly rose	
RUBUARC	*Rubus arcticus*	Dwarf nanoonberry	
RUBUIDA	*Rubus idaeus*	Wild red raspberry	
RUBULEU	*Rubus leucodermis*	Black raspberry/Blackcap	
RUBUPAR	*Rubus parviflorus*	Thimbleberry	
RUBUPUB	*Rubus pubescens*	Trailing raspberry	
RUBUSPE	*Rubus spectabilis*	Salmonberry	Coastal
SALIX	*Salix spp.*	Willow	
SAMBRAC	*Sambucus racemosa*	Red elderberry	Coastal / Provincial

CODE	Latin Name	Common Name	Region
SHEPCAN	*Shepherdia canadensis*	Canada buffalo-berry	Provincial
SORBSCO	*Sorbus scopulina*	Western mountain ash	
SORBSIT	*Sorbus sitchens*	Sitka mountain ash	
SYMPALB	*Symphoricarpos albus*	Common snowberry	
VACCICAE	*Vaccinium caespitosum*	Dwarf blueberry	
VACCIMEM	*Vaccinium membranaceum*	Black huckleberry	Provincial
VACCIMYRT	*Vaccinium myrtilloides*	Velvet-leaved blueberry	
VACCIOVA	*Vaccinium ovafolium*	Oval-leaved blueberry	Provincial
VACCIOXY	*Vaccinium oxycoccos*	Bog cranberry	
VACCPIARI	*Vaccinium parvifolium*	Red huckleberry	Coastal
VACCISCO	*Vaccinium scoparium*	Grouse-berry	
VACCIULI	*Vaccinium uliginosum*	Bog blueberry	
VACCIVIT	*Vaccinium vitis-idaea*	Lingonberry	
VIBUREDU	*Viburnum edule*	Highbush cranberry	
FORBES			
ACHILMIL	*Achillea millefolium*	Yarrow	
ANGEARG	*Angelica arguta*	White angelica	
ASTER	*Aster spp.*	Aster species	
ASTRAGU	*Astragalus spp.*	Milk vetch	
CALTLEP	*Caltha leptosepala*	Alpine white marsh marigold	
CIRSARV	*Cirsium arvense*	Canada thistle	
CLAYSIB	*Claytonia sibirica*	Siberian miner's lettuce	
DICEFOR	*Dicentra formosa*	Bleeding heart	
EPILANG	*Epilobium angustifolium*	Fireweed	
EPILCIL	*Epilobium ciliatum*	Purple-leaved willowherb	
EQUIARV	*Equisetum arvense*	Common horsetail	
EQUIPRA	*Equisetum pratense*	Meadow horsetail	
EQUIFLU	*Equisetum fluviatile*	Swamp horsetail	
ERYTGRA	*Erythronium grandiflorum*	Glacier lily	Sub&Alpine mtns, spring
FRAGVIR	*Fragaria virginiana*	Wild strawberry	
FRITTCAM	*Frittallaria camschatcensis*	Northern rice root	Coastal estuaries
HEDYALP	*Hedysarum alpinum*	Alpine hedysarum	
HEDYBOR	*Hedysarum boreale*	Sweetvetch	
HERALAN	*Heracleum lanatum*	Cow parsnip	Provincial, spring
HIERALB	*Hieracium albiflorum*	White-flowered hawkweed	
LATHOCH	*Lathyrus ochroleucus*	Creamy pea vine	
LATHNEV	*Lathyrus nevadensis*	Purple peavine	
LUPINUS	*Lupinus spp.*	Lupin	
LYSIAME	*Lysichiton americanum*	Skunk cabbage	

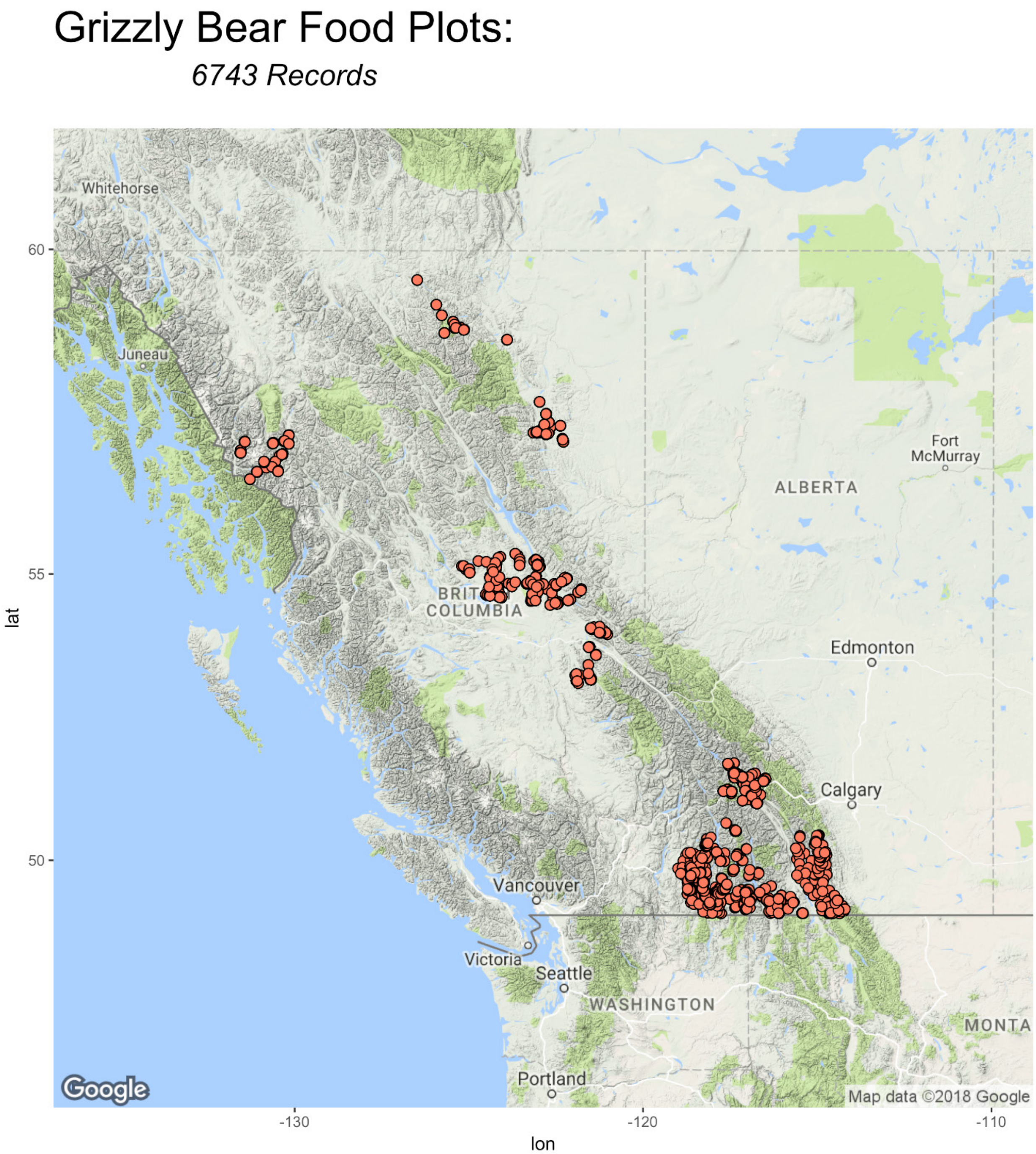
CODE	Latin Name	Common Name	Region
MAIASTE	*Maianthemum stellatum*	Star-flowered false solomon's-seal	
MENYTRI	*Menyanthes trifoliata*	Buckbean	
OSMORHI	*Osmorthiza species*	Sweet cicely	Provincial
OXYRDIG	*Oxyria digyna*	Mountain sorrel	
PEDIBRA	*Pedicularis bracteosa*	Bracted lousewort	
PETASAG	*Petasites sagittatus*	Arrow-leaved coltsfoot	
PETAFRI	*Petasites frigidus var. palmatus*	Palmate coltsfoot	
PLANTLAN	*Plantago lanceolata*	Plantain narrowleaf	
PLANTMAJ	*Plantago major (or ovate?)*	Plantain broadleaf	
POTEANS	*Potentilla anserine*	Silverweed	
POTEPAL	*Potentilla palustris*	Mash Cinquefoil	
RANUOCC	*Ranunculus occidentalis*	Western buttercup	
RUBUPUB	*Rubus pubescens*	Dewberry	
RUMEACE	*Rumex acetosella*	Sheep's sorrel	
RUMELAP	*Rumex lapponicus*	Sorrel	
SENETRI	*Senecio triangularis*	Arrow-leaved groundsel	
SMILRAC	*Smilacina racemosa*	False Solomon's seal	
SMILSTE	*Smilacina stellata*	Star-flowered false Solomon's seal	
STREAMP	*Streptopus amplexifolius*	Twisted-stalk	
TARAOFF	*Taraxacum officinale*	Common dandelion	Provincial
TRIFREP	*Trifolium repens*	White clover	
TRIFPRE	*Trifolium pratense*	Red clover	
URTIDIO	*Urtica dioica*	Stinging nettle	
VALEDIO	*Valeriana dioica*	Mash valerian	
VALESIT	*Valeriana sitchens*	Sitka valerian	
VERAVIR	*Veratrum viride*	Indian hellebore	
VICIAME	*Vicia americana*	American vetch	
FERNS			
ATHFIL-FEM	*Athyrium filix-femina*	Lady Fern	
DRYOEXP	*Dryopteris expansa/assimilis*	Spiny wood fern	
MATTSTR	*Matteucia struthiopteris*	Ostrich fern	
GRAMMINOIDS			
BROMUS	*Bromus spp.*	Bromes	
CALAMAG	*Calamagrostis spp.*	Reed grasses	
CAREX	*Carex spp.*	Sedges	Provincial, spring +
DESCCAE	*Deschampsia caespitosa*	Tufted hair grass	
FESTUCA	*Festuca spp.*	Fescue spp.	
POA	*Poa spp.*	Bluegrass species	
SCIRMIC	*Scirpus microcarpus*	Small-flowered bulrush	
TRISSPI	*Trisetum spicatum*	Spike trisetum	

CODE	Latin Name	Common Name	Region
TERRESTRIAL AND AQUATIC FOOD SOURCES			
-	*Alces alces*	Moose (adult and calf)	Central / Northern
-	*Bivalve molluscs*	mussel species - marine & freshwater	Coastal / Interior
-	*Castomomus commersoni*	Common white sucker	
-	*Castor canadensis*	Beaver	
-	*Cervus canadensis*	Elk	Northern
-	*Formicidae*	Ants	
-	*Odocoileus spp.*	Deer spp. (white & black-tailed)	
-	*Oncorhynchus gorbuscha*	Pink salmon	Coastal
-	*Oncorhynchus kisutch*	Coho salmon	Coastal
-	*Oncorhynchus nerka*	Sockeye salmon	Coastal / Interior
-		Kokanee salmon	Coastal / Interior
-	*Oncorhynchus tshawytscha*	Chinook salmon	Coastal
-	*Ovis dalli*	Stone Sheep	
-	*Marmota spp.*	Marmot	
-	*Microtinae spp.*	Small Rodents	
-	*Rangifer tarandus*	Caribou	
-	*Ungulate/bear*	Carcasses	
-	*Ursus americanus*	Black bear	
-	*Vespidae*	Wasps	

** The above table is considered a working list of known grizzly bear forage items and by no means is complete. This table is used with permission from Lana Ciarniello.*

Appendix II. Location of Plots of High Quality Grizzly Bear Foods in BC

Used with permission from Clayton Lamb, Michael Proctor and Garth Mowat



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