Predicting grizzly bear food - Huckleberries - across the Columbia Basin

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Prepared for: Habitat Conservation Trust Foundation and the Fish and Wildlife Compensation Program

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Executive Summary

Understanding relationships among primary forces driving population process, such as bottom up food resources, and top down mortality events, are important for informing effective management to influence factors driving population dynamics and ultimately conservation status. Black Huckleberries (*Vaccinium membranaceum*) are the main energy-rich grizzly bear food and drive productivity of the bears in much of our south Selkirk and Purcell Mountain focal area and regionally. Yet little has been known about where and why huckleberries grow into useful patches for grizzly bears until recently. In our previous project we developed a highly predictive model of huckleberry patches important to grizzly bears for our focal region of the south Selkirk and Purcell Mts. This project is designed to continue that work and ultimately expand that model across the Kootenay Region 4 on southeast BC.

This past year we visited 338 potential huckleberry patch sites across the northern portion of Kootenay Region 4 between the Alberta border and the Okanagan. Two-hundred-forty-two of those sites were actual huckleberry sites while 96 were not. We combined these results with our previous 2 years sampling effort in our focal area (512 sites visited) and remodel huckleberry patches across the southern portion of the Kootenay region. Our best model had very good discrimination between predicting sites that were actually huckleberry patches and those that were not (89%, 70 is good). As in our focal area model, canopy cover was the most influential variable. Huckleberry patches were characterized by having low canopy cover (mean 13%) with very few sites being greater than 25%. Elevation of huckleberry patches ranged from 1400 m to 2100 m with a mean of 1764 m similar to our focal are results. When comparing our visited huckleberry patches to sites that were not patches, we found that BC's Biogeoclimatic Ecosystem Classification system BEC variants varied across the 3 mountain ranges as expected, while the site series that included huckleberry patches occurred in more than were available across the region (103). This was very similar to our focal area results as were structural stages. This project has 1 more year remaining where we will carry out field investigations of more sites in the northern portion of Region 4. Armed with those results we will develop final models for the region and do a more thorough evaluation that will include previous data from past DNA sampling surveys across the region.

Those final huckleberry patch results for the Kootenay region will be disseminated to relevant government land use and wildlife managers within MoE and FLNRORD, as we have done with our focal area results from our previous project. The management lever to be pulled from our results will be in habitat protections around our best huckleberry patches. Government managers are enthused about using our huckleberry predictions from our previous project in our focal area and are calling for us to expand this work so those benefits can be applied regionally. This project aligns with FWCP's Species of Interest Action Plan, and the Upland and Dryland Action Plan Research and Information Acquisition, Integrated Habitat planning and Habitat Restoration

Table of Contents

List of Tables

List of Figures

INTRODUCTION

Understanding the relationships among forces driving population process, such as bottom up food resources, and top down mortalities are important for informing effective management that can influence factors driving population dynamics and ultimately conservation status (Power 1992, Oriol-Cotterill et al. 2015). Variability across taxa on the relative importance of bottom up vs top down forces is wide (Dyer and Letourneau 1999, Grange and Duncan, 2006, Greenville et al. 2014). In some cases, underlying food conditions have been shown to be most influential and ever present, but top down forces can be additively influential with temporal and spatial variability (Grange and Duncan 2006; Pierce et al. 2012, Laundre et al 2014).

Grizzly bears (*Ursus arctos*) are often thought of as being a top predator applying top down control on other species. However, in southeast British Columbia their diet is predominantly vegetation based (McLellan and Hovey 1995, Mowat and Heard 2006) and they are subjected to substantial mortality forces from humans (McLellan et al. 1999, Nielsen et al. 2004*a*, Schwartz et al. 2010) as is the case with many other top predators (Kissui and Packer 2004, Oriol-Cotterill et al. 2015). Furthermore, the typical bottom up - top down interplay in grizzly bear population dynamics can be influenced by humans from both ends and in complex and interacting ways. Humans can have a landscape-level influence on grizzly bear food supplies as timber harvest and forest fires open canopies, and increase grizzly bear forage, while fire suppression can reduce food supplies (Minore 1975, Minore et al.1979, Hamer and Herrero 1987, Nielsen et al 2004*a,* McLellan 2015). Also the interface of habitats that provide foraging resources can interlace with a mosaic of anthropogenic mortality risk that is spatially variable creating a complex assortment of safe, productive, unsafe and unproductive habitats in all combinations (Nielsen et al. 2009). Understanding the relationship between bottom up and top down influence is particularly important for sensitive species or populations that may be threatened, particularly where conservation management is essential yet may be costly to society. The grizzly bear in southern British Columbia, Canada, is extensively fragmented (Proctor et al. 2012) with several fragmented or isolated population units with elevated conservation concern (McLellan 1998, Proctor et al. 2012, McLellan et al. 2016*a*). As the human footprint expands in southern BC, management of grizzly bears would benefit by applying accurate strategies to balance their program that consists of a spectrum of approaches that vary spatially with conservation status. While the grizzly bear hunt has been recently shut down, the province of BC is rebuilding its conservation assessment tool. I have been a part of that effort. The final conservation assessment will most likely be made public within several months. Suffice to say, that there are still grizzly bear population units that have conservation concerns within the new system. There is still great need to understand what is causing that conservation concern in many parts of the province including the role of food supplies and mortality risk.

Goals and Objectives and Linkage of FWCP Action Plans and specific Action(s)

Our goals were to expand a previously developed highly predictive huckleberry patches-important-to-grizzly-bear model from our focal area in the southern Selkirk and Purcell Mountains to the entire Kootenay Region 4 (Fig. 1).

Links to action Plans

Species of Interest Action Plan - Research and Information Acquisition - Integrated Habitat planning and Habitat-Based Actions - Habitat Restoration

Our goals are to identify, understand, and predict huckleberry patches important to grizzlies across the Columbia Basin for access protection and to inform timber harvest and silva-culture activities. Humans, including hydro development, have usurped most of the productive valley bottom habitats making backcountry habitats more important for grizzlies. High road densities reduce female survival in important habitats and fire suppression and timber harvest have altered patterns of huckleberry productivity. Understanding huckleberry patch occurrence and the ecological conditions where they occur is essential to protect important patches and manage our landscape activities to include a good huckleberry crop and improve their accessibility to grizzly bears, improving their conservation.

Upland and Dryland Action Plan: Research and Information Acquisition - Integrated Habitat planning and Habitat-Based Actions - Habitat Restoration

Our goals are to identify, understand, and predict huckleberry patches important to grizzlies across the Columbia Basin for access protection and to inform timber harvest and silva-culture activities. Human settlement and hydro development have usurped most valley bottom habitats making backcountry habitats more important for grizzlies. Fire suppression and timber harvest have altered patterns of huckleberry productivity in the backcountry. Understanding huckleberry patch occurrence and ecological conditions where they occur will inform protection of important patches and restoration of the huckleberry crop through good stewardship of landscape activities. Our results will improve upland habitats for grizzly bears.

STUDY AREA

Our study area had 2 scales. First, was a finer-scale area where our GPS telemetry and genetic data were collected and huckleberry patch related field-site visits occurred in the South Selkirk, South Purcell, and Yahk areas (Fig. 1). Second, was the entire Kootenay Region 4 (Fig. 1) where we modelled and predicted huckleberry occurrence as a first step in this process, and then preliminarily applied our huckleberry patch model to initiate region-wide evaluation and patch model improvement. This project is designed to expand our focal area model from our previous project across the entire Kootenay region.

The region is mountainous and predominately covered by conifer forests with patches of deciduous forest throughout. It consists of mountain valleys, upland forests, avalanche, riparian, and alpine habitats. The region is relatively wet with much of the annual precipitation received as snow in winter, especially at higher elevations. Summers can be somewhat dry and hot. The predominant ecosystem types are Interior Cedar Hemlock (ICH) at lower elevations, Englemann Spruce Sub-alpine Fir (ESSF) at higher elevations and Interior Douglas Fir (IDF) in the drier eastern portions. Elevations generally increase south to north in each mountain range within our study area. The timber industry operates generally throughout our study area except for a few provincial parks.

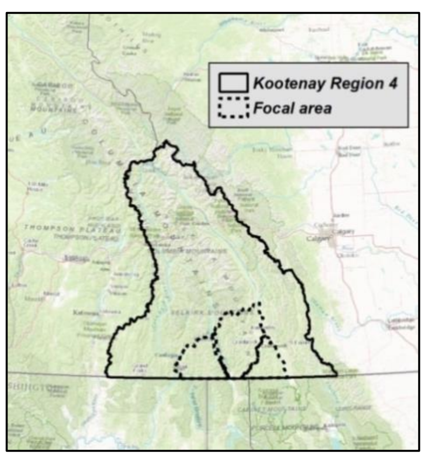

Figure 1. Location of huckleberry investigation in southeast British Columbia, Canada. The dashed line represents the focal region where we identified huckleberry patches through site visits of clustered locations of grizzly bear telemetry data. The solid line represents the boundary of the Kootenay region, where huckleberry occurrence was modeled and the huckleberry patch model is being expanded into.

METHODS

Phases

Project start-up began as planned in June 2017 and included project field planning. Planning included selecting specific field sites to visit and development of digitized map layers for use in the field including our predicted huckleberry patch polygons across the Basin, Google Earth imagery, BC BEC zones, road layers, and more. Sites to be visited were huckleberry patches predicted from our previous project that developed our huckleberry patch model in the S Selkirk & Purcell Mts.

Field work occurred in the berry season, July - September 2017. We planned to visit a minimum of 100 predicted huckleberry patches to determine if they were in fact huckleberry patches used by bears and measure a suite of ecological characteristics as in our previous project. Site visits were to occur throughout the Columbia Basin, year 1 focusing on the southern areas including the Flathead, S Rockies, Central Purcells and Selkirks, Valhalla, and eastern Granby area. Site visits were carried out by our bear ecology expert field team, Grant MacHutchon and Stephan Himmer, 2 long time grizzly bear field ecologists. They selected the best huckleberry patch within a polygon and use that to measure ecological variables over a 20m x 20m area. We measured aspects of the huckleberry patch, including plant density, plant canopy cover, modal height, fruit abundance and patch quality and a suite of ecological variables consistent with FLNRO ecological assessment protocols.

Most of the preparatory analytical steps have already been established in our previous project. We already have an excellent suite of ecological variables in GIS layers to develop our model with, and we have the appropriate modeling technique selected for use (Boosted Regression Tree). Preliminary evaluation was carried out by model discrimination tests and ROC scores to assess how well the model predicted the data it was developed from. Ultimate evaluation of the entire region 4 will come after Year 2 in this project, when we have 2 full years of filed data to model and test more rigorously.

We will develop annual draft reports for funders in the springs of 2018 (this report) and 2019. The Year 2 report will be a more thorough and comprehensive treatment of our project and its finding. This will include our Columbia Basin-wide huckleberry patch model, a final map of those predictions, and an evaluation of the model's ability to predict presence and absences of huckleberry patches and actual grizzly bear habitat use through our GPS telemetry database. And finally, it will include details of our huckleberry patch model and timber harvest patterns hopefully with scientific support for our recommendations for optimal locations for cut blocks to be considered for huckleberry patch management through appropriate silva-culture activities across the Basin.

At the end of year 2, spring of 2019 we will update all our Basin wide results. This will be the final report and results details, including the entire basin where our model evaluates well. This report will include our methods, evaluation process, maps of important huckleberry patches, relevant underlying GIS layers for use in government agencies integrated planning. Providing recommendations as to which patches might benefit from access controls, which areas across the basin might benefit from timber harvest and huckleberry friendly silvacultural activities. We will also disseminate all results to interested stakeholder groups through our project website and include results in the many public and scientific presentations I make annually while acknowledging our project funders, FWCP and HCTF.

The results of this project, including reports and GIS layers of all resulting huckleberry patches, will be distributed to all FLNRORD wildlife and forestry managers on an annual basis.

Huckleberry modeling overview

We modelled huckleberries in 2 ways. First, we modeled huckleberry occurrence across the entire Kootenay region (Fig. 1), resulting in a map of where huckleberry plants occur. We modelled huckleberry occurrence from 10,129 ecological/vegetation plots that recorded the presence or absence of huckleberry plants during a program to classify the ecology of the region (Biogeoclimatic Ecosystem

Classification (BEC) Program, Fig. 2). These results were used on the current analysis but was completed in our previous project (Proctor et al. 2017)

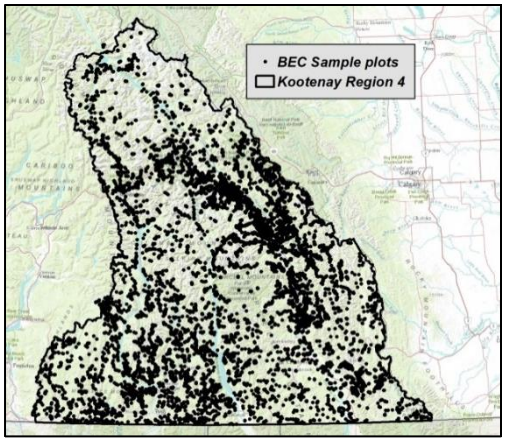

Figure 2. BC's Biogeoclimatic Ecological Classification system forestry plots across Kootenay Region 4 used to model huckleberry plant occurrence.

Second, we modeled huckleberry patches important to bears in our focal study area. Originally we used used the huckleberry patches used by bears that we identified through GPS telemetry research and field-site visits. After evaluating that model, (and it passed very well), we used that model to predict huckleberry patches in the surrounding area and used those predictions as a starting point for field visits. Our ultimate goal was to expand our model, using more widespread input data across the Kootenay Region 4. We are in year 1 of that model expansion project. Below we detail the methods for our original huckleberry modeling as it underpins, and is the same as the work in this project.

Field site visits

We identified potential berry patches across our study area using our existing 10-year, 44 bears (20 female, 24 male), ~50,000 bear locations GPS telemetry data set to find habitat-use clusters during the berry season, July 15- Sept. 15 (Fig. 3). We had done a pilot test of this method and were quite successful at identifying berry patches. This methodology allows the bears to help us identify the location of important berry patches that they use. In the summers of 2014 and 2015 we visited 512 of the most promising of these habitat-use clusters to determine which ones were in fact huckleberry patches (Fig. 4a & b).

We collected relevant ecological data at each site consistent with data gathered in the provincial BEC program. We picked our plot centres to be in the middle of the best local huckleberry patch or, if it was not a huckleberry patch, where there was evident bear sign (e.g., root digs, bear bed), at GPS locations, or in a distinct ecosystem unit (e.g., site series or other ecosystem unit). For all locations sampled, we used the B.C. Government standard 20 m x 20 m plot. We dropped the full BC Government ecosystem plots (MoFR and MoE 2010) in 2015 in favour of the much quicker site assessment technique that we developed and also used in 2014. In this way, we were able to significantly increase the number of sites visited in 2015.

Following are the plot attributes we recorded:

Yes/No – Was it a huckleberry patch or not?
Description – A general description of the vegetation community, major indicator plants, major bear foods, and why a bear likely used area, if it did.
Biogeoclimatic Ecosystem Classification (BEC) zone, subzone, variant, and site series – Zone, subzone, and variant were based on regional BEC mapping. Site series was based on vegetation composition and site characteristics, regional BEC field guides, and our field experience in 2014.
Elevation – At the centre of the plot and read from a hand-held GPS in metres.
Slope – Percent slope gradient of the plot measured with a clinometer.
Aspect – Orientation of slope in degrees; "999" was recorded for level ground. Aspect was a fixed point measurement from the centre of the plot.
Mesoslope position – As per MoFR and MoE (2010), Site Description section, page 25.
Structural stage – As per MoFR and MoE (2010), Site Description section, page 21.
Site disturbance – As per MoFR and MoE (2010), Site Description section, page 27.
Canopy cover – Estimate of the percent tree canopy cover.
Huckleberry fruit abundance – As per MoFR and MoE (2010), Vegetation, page 17.
Huckleberry patch quality – A subjective assessment value between 1 and 10, where 1 was lowest quality & 10 was highest quality.
Huckleberry modal height – Measured height in centimetres.
Huckleberry cover – Estimated percent cover of black huckleberry.
Huckleberry fruit phenology – Recorded as “green”, “reddish hue, not quite ripe”, “generally ripe”, “overripe”, or “finished”.
Bear sign - Old or recent bear sign within or in the vicinity of the plot.

Environmental Predictors for huckleberry occurrence modeling
Environmental variables hypothesized to limit the occurrence of huckleberry (Table 1) include soil pH (Barney 1999; Barney et al. 2006), soil texture (Habitat Management Branch Province of BC 2000; Barney et al. 2006), climate (Holden et al. 2012), forest fires (Nielsen and Nielsen 2010), canopy cover (Minore 1984) and topography (Roberts et al. 2014).

We constructed ecologically meaningful derivations of all the hypothesized drivers of huckleberry occurrence mentioned above and produced spatial surfaces in 100- 300m resolutions across the entire study area for each predictor.

SOIL- Soil data was obtained from the BC government. These data are comprised of a categorical classification of soil type across the province as well as approximately 5,000 soil pits used to evaluate and refine these classifications. The soil pits include empirical information on the pH, texture, and composition of soil within each categorical soil type. We used the soil pits dug across the province to produce a spatial representation of the soils across the Kootenay region, including the pH, % sand, % silt, % clay, % coarse fragments and % organic matter of the soil. We only used the top 40 cm of each soil pit to derive our soil measures as we didn’t believe soils deeper than 40 cm would have a large effect on huckleberries, which are generally rooted quite shallow. In some cases, no soil pits were dug for specific soil types so we lacked empirical measures for this soil, which we remedied by interpolating information from similar soils across the province. We first classified the province into regions that shared the same biogeoclimatic zone (BEC), soil development type, and geologic parent material. We then calculated the soil characteristics for each region using soil pits from across the province and filled holes in our soil surface of the Kootenays with these data.

CLIMATE- We gathered climate variables using the Climate BC desktop application produced by the Centre for Forest Conservation Genetics at the University of British Columbia (http://cfcg.forestry.ubc.ca/projects/climate-data/climatebcwna/#ClimateBC). Climate variables included Frost Free Period, Mean annual Temperature, Mean Summer Temperature, Mean Winter Temperature, Mean annual Precipitation, Mean Summer Precipitation, Mean Winter Snowfall. We produced a grid of points spaced 300 m apart in ArcMAP 10.1 (ESRI) and extracted the climatic information to these points using Climate BC, and then converted this information into a raster surface with a 300 m resolution.

FIRE- Spatial information on forest fires was acquired from the Wildfire Management Branch of BC (data from 1920-2014, https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?from=search&edit=true&showall=showall&recordSet=ISO19115&recordUID=57060) and used to calculate time since last fire for each plot, and produce a time since last fire surface. We calculated time since last fire as the date the plot was conducted minus the date of the last fire that occurred prior to the plot being conducted. For our final map, we built a time since last fire surface across the region using 2015 as the current date and subtracting the date of the most recent fire from 2015. In many cases across the landscape a fire had not occurred (or not been recorded) in the last ~90 years, so we opted to bin the time since last fire variable into ecologically meaningful bins. We created 5 bins, 1) 0-20 years since last fire, 2) 20-50 years since last fire, 3) 50-80 years since last fire, 4) 80+ years since last fire, and 5) never burned.

CANOPY COVER- We gathered information on canopy cover from the Vegetation Resource Information data from the BC government and missing data was filled with cover information from industry partners.

TOPOGRAPHY – We calculated global radiation, compound topographic index (CTI) and slope using a digital elevation model and ArcMap 10.1.

Table 1. Environmental variables used to predict huckleberry patches used by grizzly bears.

Abbreviation	Name
aspect	Aspect
Canopy_cov	Canopy cover
CMD	Hargreaves climatic moisture deficit (mm)
cofrag_utm	Coarse Fragments in soils
cti	Compound Topographic Index
DD5	Degree-days below 5°C
FFP	Frost Free Period
fire_cnt	Number of fires in a region since 1900
globlrad	Global radiation
imi_DEM90m	Integrated Moisture Index
Last fire binned	Time since last fire binned into 5 categories
MAP	Mean Annual Precipitation
MAR	Mean annual solar radiation (MJ m-2 d-1)
MAT	Mean Annual Temp
MCMT	Mean coldest month temperature (°C),
MSP	Mean annual summer (May to Sept.) precipitation (mm),
MWMT	Mean warmest month temperature (°C),
NFFD	Number of frost-free days

orgcarp	Organic carbon % in soils
PAS	Precipitation as snow
PAS_wt	Precipitation as snow (Winter)
ph2	Soil ph, dissolved using water
phca_utm	pH of soils
PPT_sm	Precipitation in Summer
RH	Relative Humidity
roughness_500_90m	Terrain roughness
SHM	Summer heat-moisture index
slope	Slope
Tave_wt	Average Temperature- winter
tcaly_utm	% clay in soils?
tclay	Clay % in soils
Tmax_sm	Maximum Temperature - summer
Tmin_sp	Minimum Temperature - spring
Tmin_wt	Temperature Minimum - winter
tsand	Sand % in soil

Huckleberry Patch Modeling

For both occurrence and patch modeling we used boosted logistic regression trees (Elith et al. 2008) and functional environmental response variables (Table 1) to discriminate between the huckleberry patches used by grizzly bears and the available huckleberry shrubs across the landscape. Boosted Regression Trees (BRT) are an advanced form of a generalized linear model (GLM) and are increasingly used by ecologists, although they have been used in other fields for much longer (Elith et al. 2008). GLM's use individual covariates as terms in a model, whereas BRT's build regression trees (models that relate a response to their predictors by recursive binary splits) and use these trees as terms in a GLM framework. In a BRT, many trees are fit to the data, where an initial tree is fit to the data such that it correctly classifies as many observations as possible and subsequent trees focus on classifying those observations poorly predicted by previous trees (Shirley et al. 2013).

BRT's were well suited to our application as this method could handle the complex, non-linear relationships we expected to find with these data, and BRT's are known to provide greater predictive performance than GLM's (Elith et al. 2006). In addition, compared to GLM's, BRT's do not face the same issues when fitting models with multicollinearity between predictors because trees are fit with recursive partitioning algorithms instead of matrix inversions (Shirley et al. 2013).

To fit the BRT we used the 'gbm' package (Ridgeway 2015) in Program R (R Core Team 2016). Another advantage of BRT's is that a priori model definitions are not required. Instead BRT's fit the meaningful ecological variables included to the data, and those variables that predict poorly do not affect results as these variables contribute very little to the model predictions. However, these variables that contribute little to model predictions can be removed from the model using a k-fold cross-validation and iteratively removing variables until an optimum is achieved.

A BRT is fit to data using three main parameters 1) Learning rate: the contribution of each tree to the model. Smaller learning rates result in relatively more trees required to fit the model, with each tree contributing a relatively small amount to the predictions providing a better fit of the model to the data. In general, a lower learning rate is preferred, such that at least 1000 trees are generated (Elith et al. 2008). 2) Tree complexity: The number of nodes or splits allowed in each tree, where trees with more nodes are more complex, and 3) Bag fraction: % of data used to train (those data used to build the model) and testing (data used to test predictions that were not involved in model creation) the model for each iteration (new tree).

We tested a number of learning rates (2,4,6,8) and tree complexities (0.0005,0.001,0.01) and selected as our top model, the model that minimized predictive deviance (Elith et al. 2008). Because we sampled more than one site in some clusters to produce an accurate representation of that cluster, we weighted observations inversely to the number of observations in each cluster, such that clusters with many samples were not over-represented in the data. Finally, we simplified our model using k-fold cross validation to remove uninformative parameters.

Using the gbm package, we calculated the relative influence of each predictor for producing huckleberry patches used by grizzly bears, and the marginal effect of each predictor across it's range.

RESULTS AND OUTCOMES

Project start up went as planned in June 2017 as did site visits in the berry season July – Sept 2017. We visit 338 sites (our goal was > 100) across the southern portion of Region 4, excluding areas we visited in 2014 – 2015 (Fig. 3). We determined 242 of those sites to be huckleberry patches while 96 were not (Fig. 3). We took these data and reran our huckleberry patch model (Fig. 4) using similar techniques as in Proctor et al. (2017). Our power to discriminate sites visited as huckleberry patches or not was excellent (Fig. 5, 89% AUC ROC score, 70% is considered good). Canopy cover was the predominant variable in predicting huckleberry patches as it was in our previous project (Figs. 6). Patches with lower canopy cover were more likely to have huckleberry patches (Fig. 7) with most patches being between 0 -10% canopy cover (Fig. 8). The mean huckleberry patch canopy cover was 13%). The Biogeoclimactic Classification System (BEC) variant varied across mountain ranges with Englemann Spruce Sub-alpine Fir variants with wet mild (wm), wet cold, (wc) and subzones general had more huckleberry patches than was available (Fig. 9). The 103 site series (Fig. 10) by far had the most huckleberry patches and structural stages 3a & 3b (short shrub dominated, Fig. 11) were where the huckleberry patches occurred relative to what was available in the ecosystem.

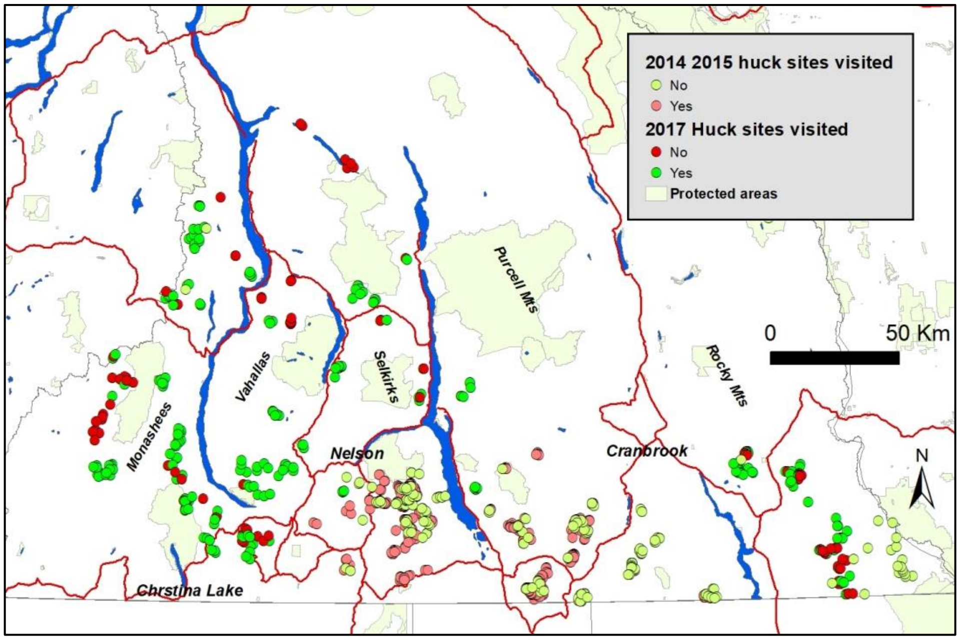

Figure 3. Map of our expanded study area with site visit locations in southeast BC. Bright green circles (Yes sites) indicate the site was a huckleberry patch used by bears. Bright red circles (No sites) indicate the site was not a huckleberry patch. Muted green and red sites were form 2014-2015 site visits.

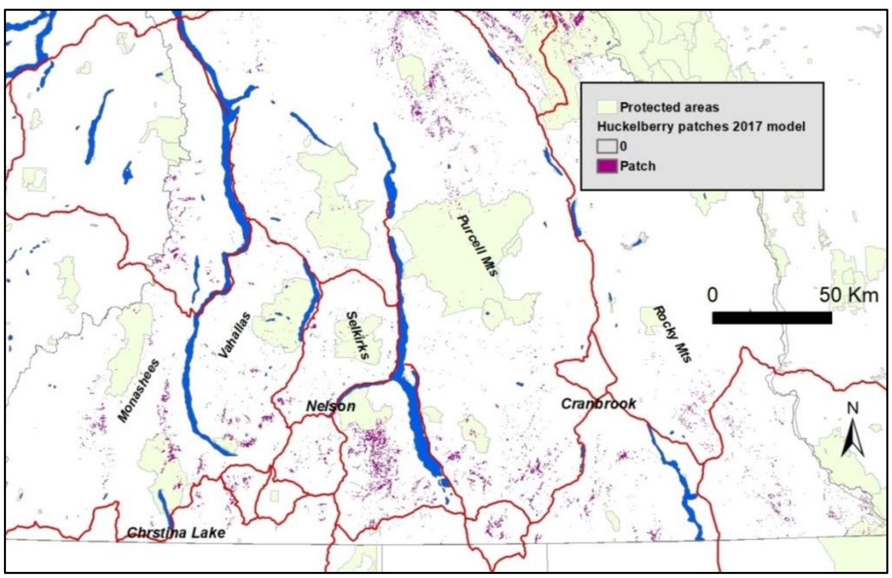

Figure 4) Preliminary predictions of huckleberry patches important to grizzly bears in the South Selkirk and Purcell Mts. of southeast BC.

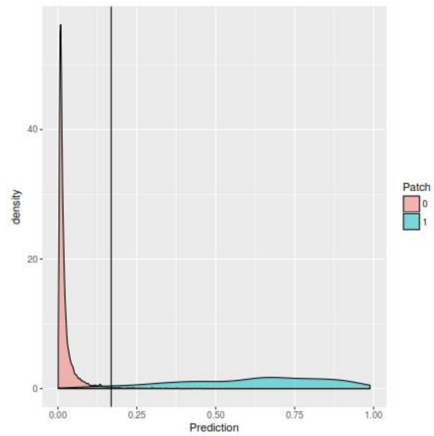

Figure 5. Top model discrimination plot, for used (Patch = 1) and available points (Patch = 0). X axis represents predictions from top model and Y represents the relative density of these predictions (Patch= 0,1). The vertical line depicts the cut point where sensitivity and specificity are maximized. Good discriminatory power results from little overlap between the distributions of used and available points, as can be seen here.

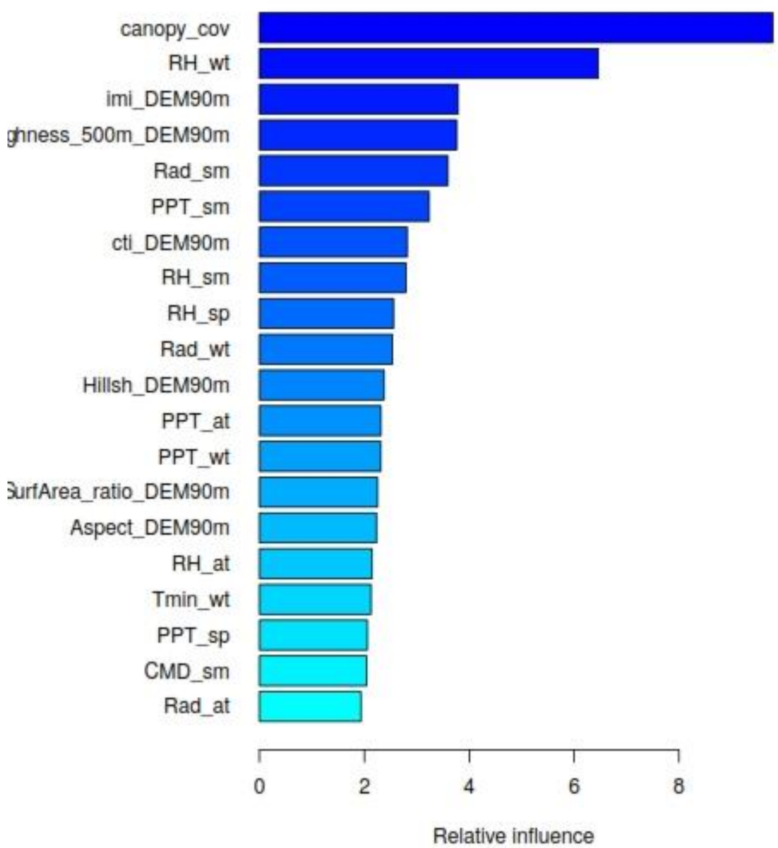

Figure 6) Relative influence of predictor variables for our top Huckleberry patch model was calculated as the relative number of times each variable was included in a tree, scaled such that the relative influence of all variables summed to 100%.

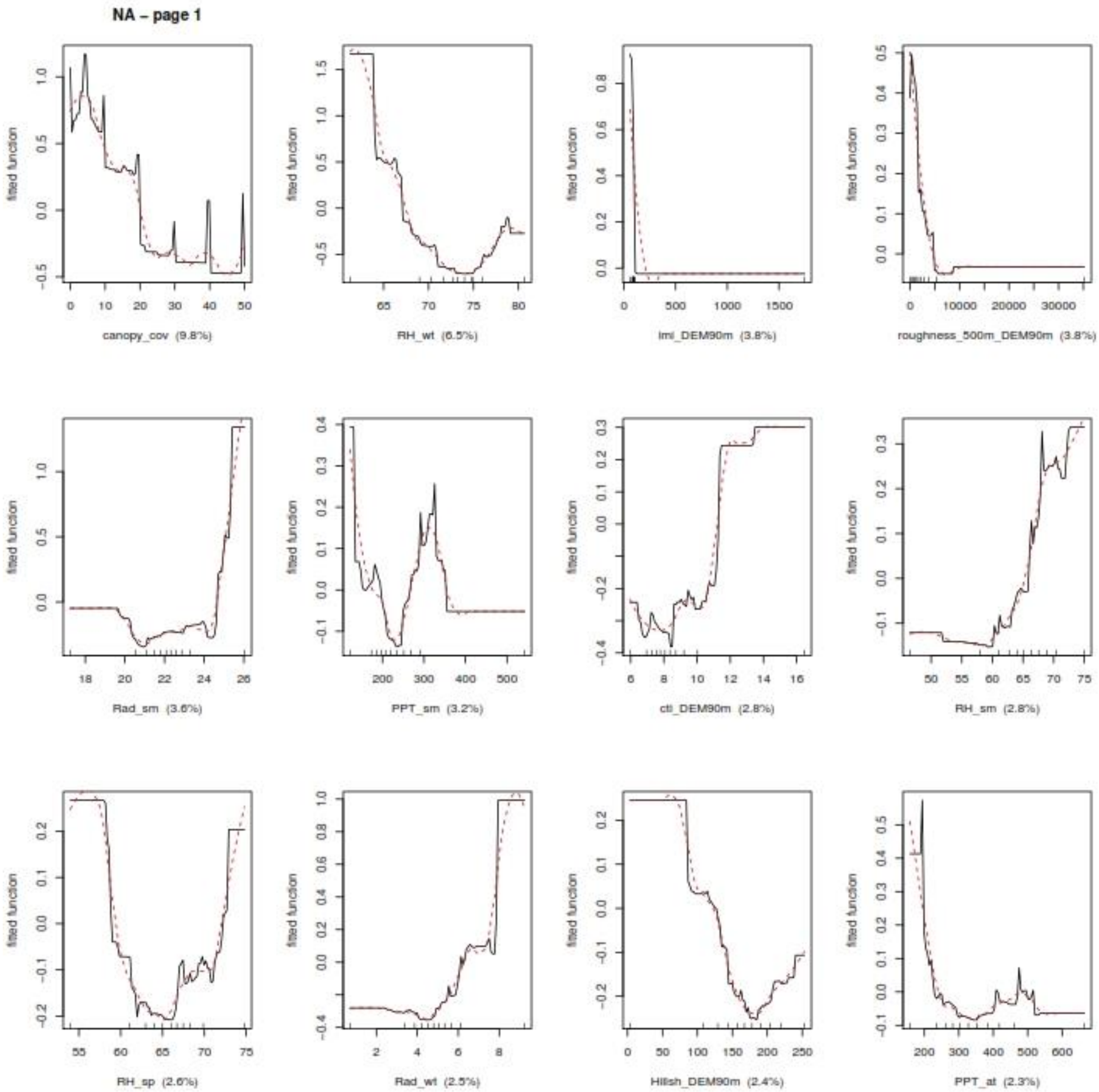

Figure 7. Marginal effects plots for the top twelve predictors in our top huckleberry patch model, depicting the direction, magnitude and shape of the relationship between predictor and response. Black lines are top BRT model predictions while the dotted red line represents a smoothed representation of this relationship fit using a loess smoother.

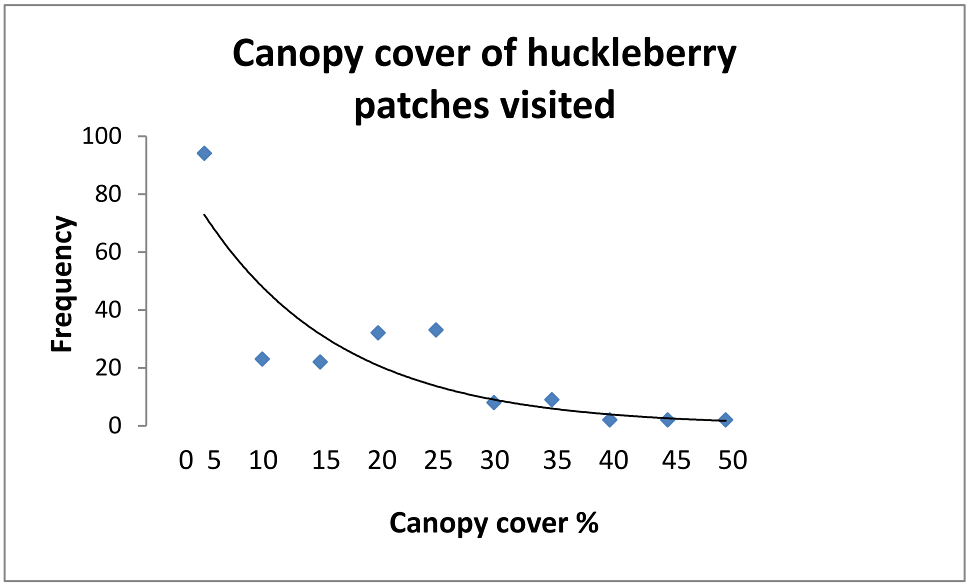

Figure 8. Canopy cover of visited sites that were determined to be huckleberry patches. The mean value was 13%.

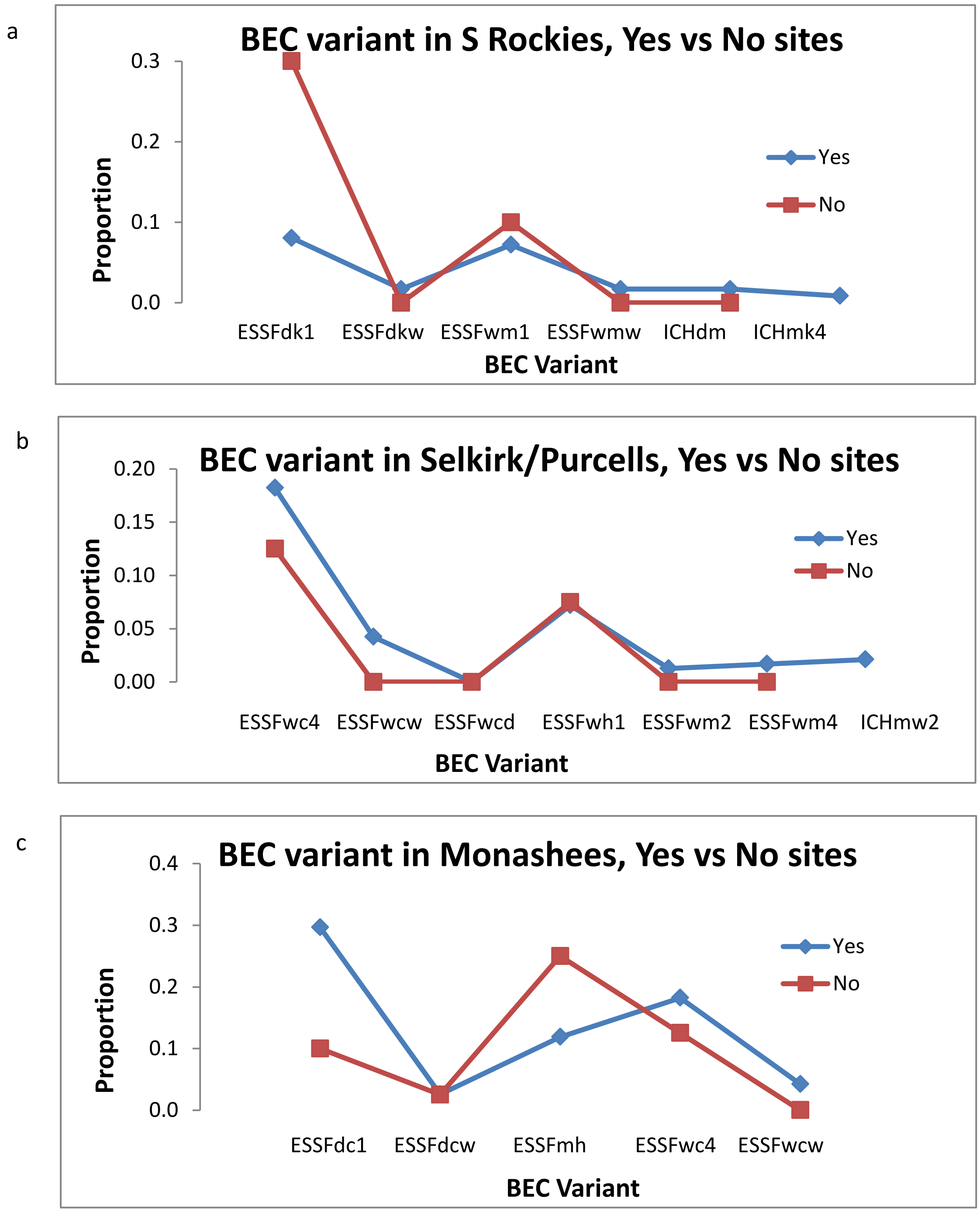

Figure 9. Biogeoclimatic Ecosystem Classification (BEC) variants in the a) South Rockies, b) south Selkirks & Purcells, and c) Monashee Mountain regions. ESSF is Englemann Spruce Sub-alpine Fir and ICH is Interior Cedar Hemlock natural climax forest. The first 2 lower case letters represent the local moisture and temperature regime, i.e., dk is dry cool, dc is dry cold, dm is dry mild, mw is moist warm, wm is wet mild, wc is wet cold, and wh is wet hot, and. The 3rd lower case digit represents local variants of each moisture temperature regime. Yes are sites we visited in 2017 that were categorized as a huckleberry patch. No are sites that were not a huckleberry patch.

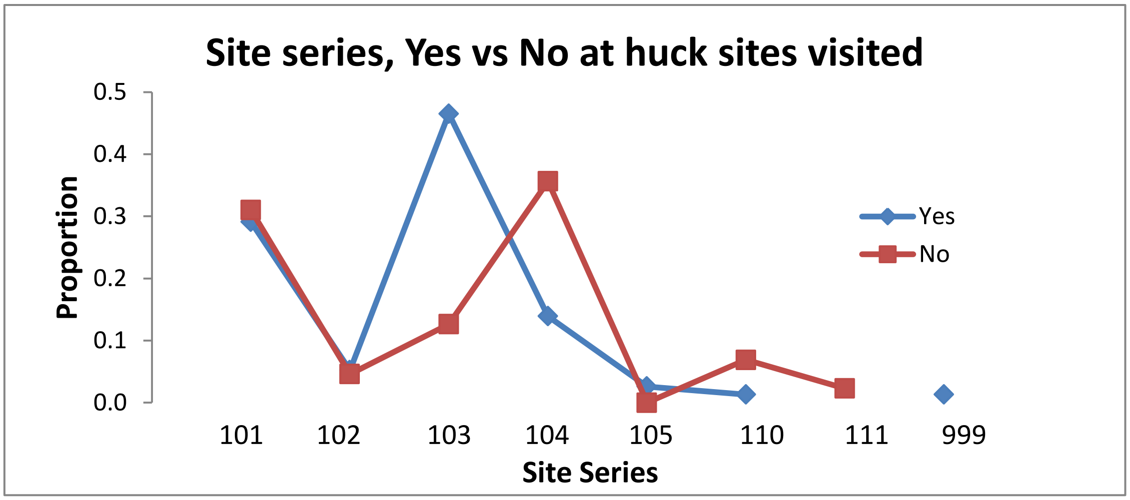

Figure 10. Biogeoclimatic Ecosystem Classification (BEC) site series in our South Selkirk, Purcell, Rocky and Monashee Mountain region. Yes are sites we visited in 2017 that were categorized as a huckleberry patch. No are sites that were not a huckleberry patch. Three digit codes represent similar relative soil moisture and nutrient regimes of site series among BEC variants. Site series 103 was the dominate site series that contained huckleberry patches in the ESSF. Site series from 102 represent sites with drier or poorer nutrients than zonal, which is site series 101, with the 102 being the driest and poorest. Numbers 110 to 114 represent wetter or richer nutrient sites than zonal. 999 are non-forested habitat.

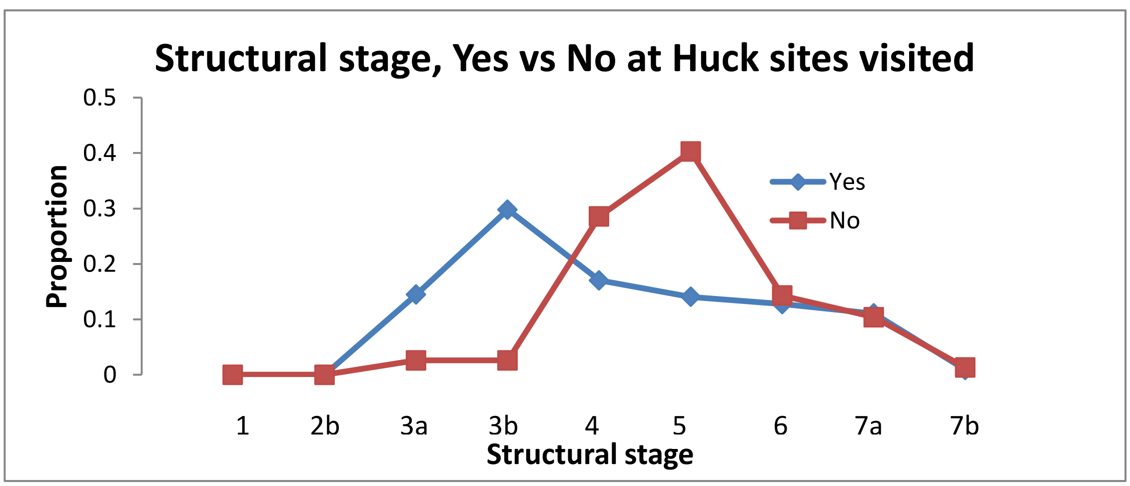

Figure 11. Biogeoclimatic Ecosystem Classification (BEC) structural stages across our study region in southeast BC. Yes are sites we visited in 2017 that were categorized as a huckleberry patch. No are sites that were not a huckleberry patch. Structural stage describes the forest structure (herb, shrub, young, old, etc.) throughout a forest succession progression. Structural stages 3a & 3b (short shrub dominated) tended to have more huckleberry patches when in several ESSF variants with site series 103.

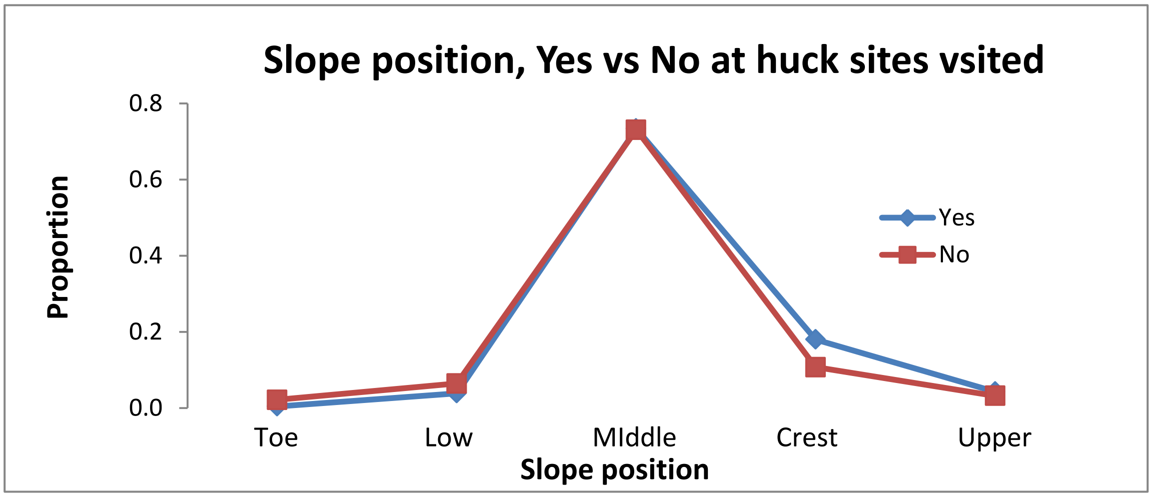

Figure 12. Slope position was very similar for sites with and without huckleberry patches used by grizzly bears across our study region in southeast BC. Yes are sites we visited in 2017 that were categorized as a huckleberry patch. No are sites that were not a huckleberry patch.

DISCUSSION

We met our annual goals for the 2017-2018 year. Field work was more successful than planned for, (we visited 338 sites and were planning on somewhere over 100). The predictability of our huckleberry patch model was excellent at 89% discrimination between sites found to be huckleberry patches and those not. Results were also similar to those in our focal area model (Proctor et al. 2017), open canopy lands, at higher elevations tended to develop into huckleberry patches important for grizzly bears. After year 2's results we will do a more thorough evaluation and forestry assessment. At that time we will have visited close to 1000 sites across the Kootenay Region. Our final model will allow us to attain our medium and longer term goals of influencing habitat management, including access controls around the most important huckleberry patches. This should have a beneficial outcome for female grizzly bears and their populations.

This is a preliminary Year 1 report, therefore the Discussion is limited.

Deliverables: Our year 1 deliverables are all contained within this report. In year 2 our deliverables will be similar but will include the entire Columbia basin and be more comprehensive with our recommendations for habitat activities in and around important patches. Besides being used to inform potential access management areas, we will apply a process we developed in year 3 for identifying areas that have the potential to be huckleberry patches post-timber harvest. We will identify these sites across the Basin that have all the ecological, soil, climate, and topographic characteristics as our actual patches, but lack canopy openness, one of the most important variables underpinning huckleberry patches. Our final deliverable will be a peer reviewed paper of our total project's results. We have a good record of translating our research into scientific papers and will continue that tradition with this project.

Risks & Benefits: The Huckleberry portion of this project has no real risks. Huckleberry patches and their ultimate protection through access management will be the primary benefit.

Performance measures: Our measures of success will be in the completion of our outlined activities, but more importantly in our ability to identify and predict huckleberry patches across much of the Columbia Basin. We are on track for ultimate completion of our performance measures.
We will consider our predictive ability reasonably successful if we can predict 75% of our known sample of huckleberry sites with less than 25% of false predictions, sites we predict as huckleberry patches, but that aren't really a patch. In this year's model we exceeded this threshold with an 89% predictability. Another measure of success will be in our ability to use the more important huckleberry patches we identify to inform access controls. This is already occurring from our focal area model. Success will also be in our ability to develop workable management strategies relevant to huckleberry production in areas that might benefit from more food resources.

Communication plan: One important result of this project will be the identification of important huckleberry patches across our study area. These will be made available to government wildlife managers and foresters, as well as forest companies operating in our study area with a set of recommendations on how to incorporate them into their activities. We will also attempt to integrate these important patches into any timber harvest or access management plans through discussions with government, industry, and stakeholders. We will develop a set of recommendations on what specific sites might be eligible for post-timber harvest management aimed to yield a huckleberry crop. And finally we will publish a peer reviewed scientific paper detaining our methods and results on predicting huckleberries. M Proctor gives approximately 12 presentations a year to various groups, scientific conferences, and working meetings. Our results, peer reviewed paper, will also be posted on our project website: <transbordergrizzlybearproject.ca>. FWCP has been acknowledged in both scientific papers mentioned below, all my reports, and in every one of the 56 presentations to the public, scientists, and working groups over the past few years.

Literature cited

Holden, Z. A., W. F. Kasworm, C. Servheen, B. Hahn, and S. Dobrowski. 2012. Sensitivity of berry productivity to climatic variation in the Cabinet-Yaak grizzly bear recovery zone, northwest United States, 1989–2010. Wildlife Society Bulletin 36:226–231. <http://www.cfc.umt.edu/research/forestlandscapeecologylab/files/Publications/Holden_2012.pdf>

Kasworm, W.F., T.G. Radandt. J.E. Teisberg, M. Proctor and C. Servheen. 2013. Cabinet-Yaak Grizzly Bear Recovery Area 2012 Research and Monitoring Progress Report. US Fish & Wildlife Service, Missoula, Montana. <https://www.fws.gov/mountainprairie/species/mammals/grizzly/CabYaak2012ReportFinal.pdf>

MacHutchon, A.G., and M.F. Proctor. 2013. Management plan for the Yahk and South Selkirk Grizzly Bear (Ursus arctos) sub-populations, British Columbia. Trans-Border Grizzly Bear Project, Kaslo, B.C.

McLellan, B.N. and F.W. Hovey. 1995. The diet of grizzly bears in the Flathead River drainage of southeastern British Columbia. Canadian Journal of Zoology 73:704-712.

McLellan, B.N. 2011. Implications of a high-energy and low-protein diet on the body composition, fitness, and competitive anilities of black (Ursus americanus) and grizzly (Ursus arctos) bears. Canadian Journal of Zoology 89: 546-558.

McLellan, B.N. 2015. Some mechanisms underlying variation on vital rates on grizzly bear in an industrial landscape. Journal of Wildlife Management 79:749-765.

McLellan, B. N., Proctor, M. F., Huber, D. and Stefan Michel. (IUCN SSC Bear Specialist Group). 2016a. Ursus arctos. The IUCN Red List of Threatened Species 2016.

Proctor, M.F., D. Paetkau, B.N. McLellan, G.B. Stenhouse, K.C. Kendall, R.D. Mace, W.F. Kasworm, C. Servheen, C.L. Lausen, M.L. Gibeau, W.L. Wakkinen, M.A. Haroldson, G. Mowat, C.D. Apps, L.M. Ciarniello, R.M.R. Barclay, M.S. Boyce, C.C. Schwartz, and C. Strobeck. 2012. Population Fragmentation and Inter-Ecosystem Movements of Grizzly Bears in Western Canada and the Northern United States. Wildlife Monographs 180:1-46. <http://igbconline.org/wpcontent/uploads/2016/02/2012_Proctoretal_Fragmentation_Monograph.pdf>

Proctor, M.F., S.E. Nielsen, W.F. Kasworm, C. Servheen, T.G. Radandt, A.G. MacHutchon, and M.S. Boyce. 2014. Grizzly bear connectivity mapping in the Canada-US trans-border region. Journal of Wildlife Management. 79:544-558. <https://www.fws.gov/mountainprairie/species/mammals/grizzly/PROCTOR%20et%20al%202015%20Linkage%20Paper.pdf>

Proctor, M. K, C. T Lamb, and A. G. MacHutchon. 2017. The grizzly dance between berries and bullets: relationships among bottom-up food resources and top-down mortality risk on grizzly bear populations in southeast British Columbia. Birchdale Ecological. Kaslo, BC.

Robbins, C. T., M. Ben-David, J. K. Fortin, and O. L. Nelson. 2012. Maternal condition determines birth date and growth of newborn bear cubs. Journal of Mammalogy 93:540–546.