WILDLIFE MONOGRAPHS

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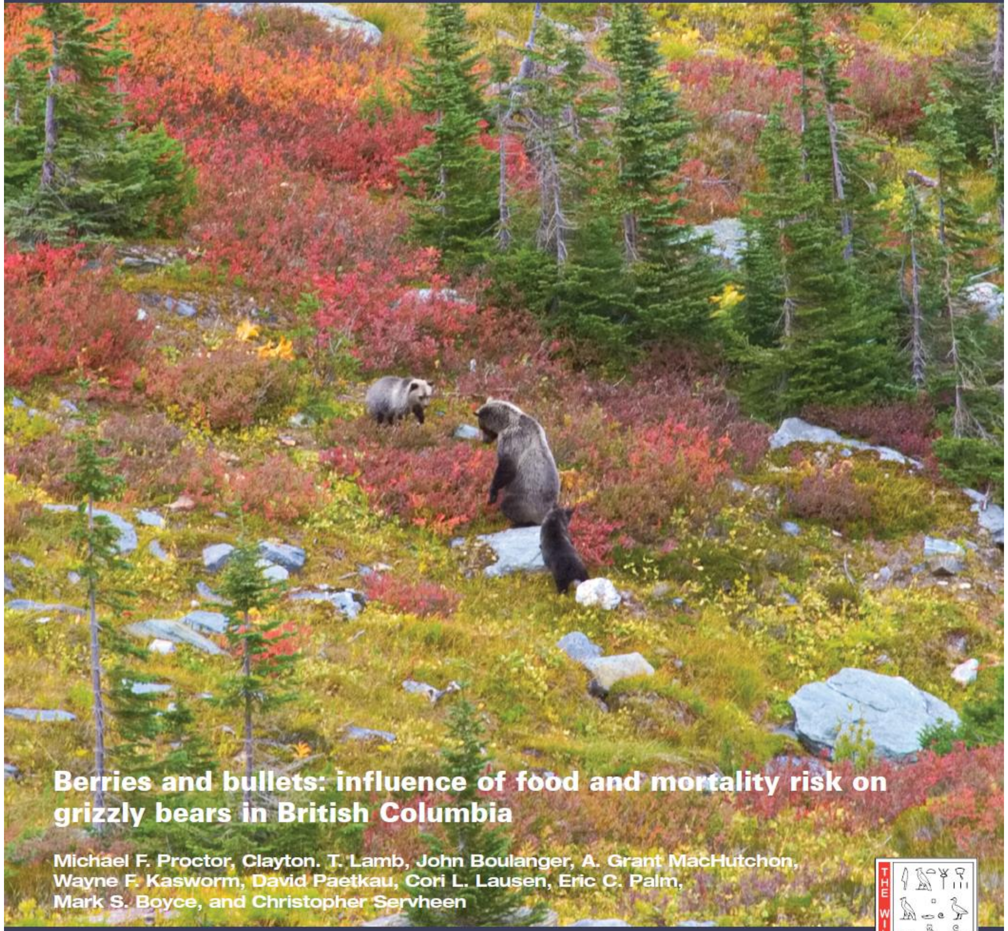

Berries and bullets: influence of food and mortality risk on grizzly bears in British Columbia

Michael F. Proctor, Clayton. T. Lamb, John Boulanger, A. Grant MacHutchon, Wayne F. Kasworm, David Paetkau, Cori L. Lausen, Eric C. Palm, Mark S. Boyce, and Christopher Servheen

THE WILDLIFE SOCIETY

Supplement to The Journal of Wildlife Management

Bottom up vs top down influence on wildlife populations

Tigers and their prey: Predicting carnivore densities from prey abundance

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Traditionally mortality is the management focus for GB – we can manage it
Female survival most important factor driving population vitality

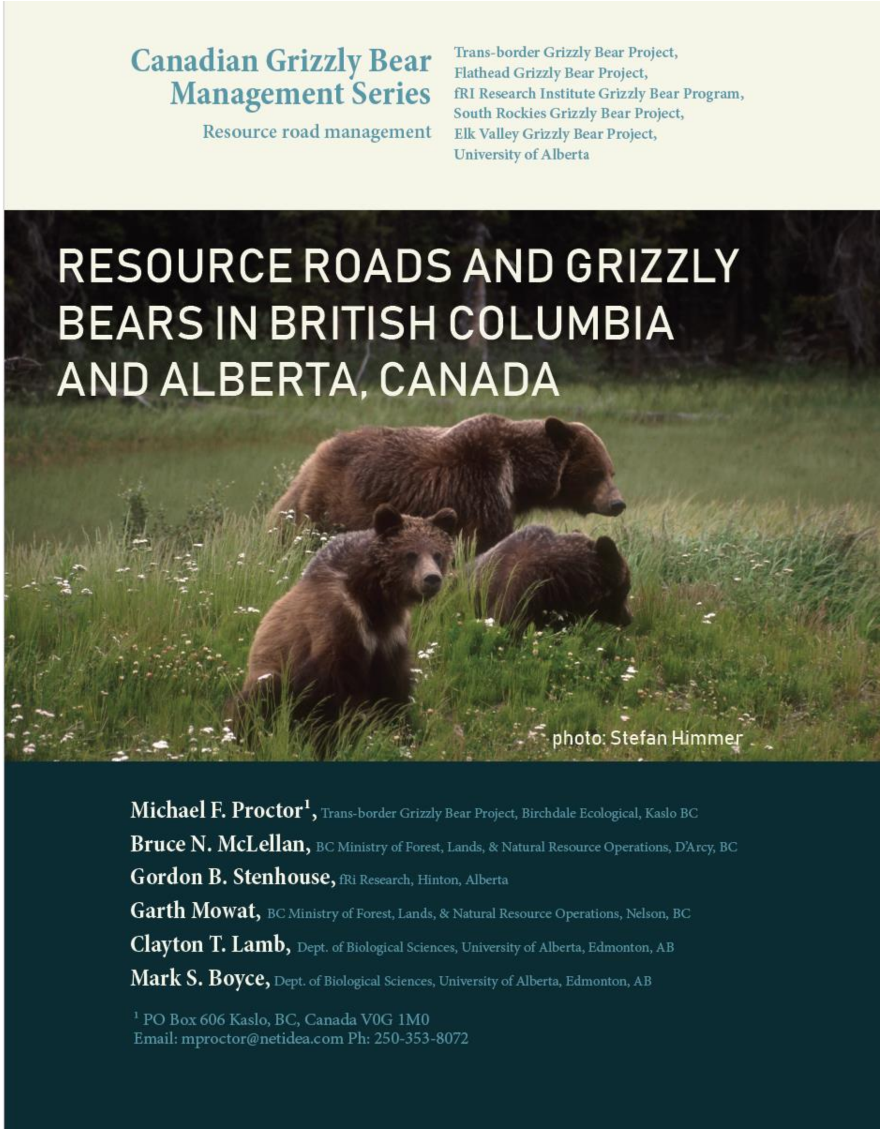
Mainly because we haven't been able to identify and spatially model and then manage food supply, but also because reducing mortality works

Backcountry roads very important for GB mortality & survival

But managing for road access is HUGELY controversial and unpopular

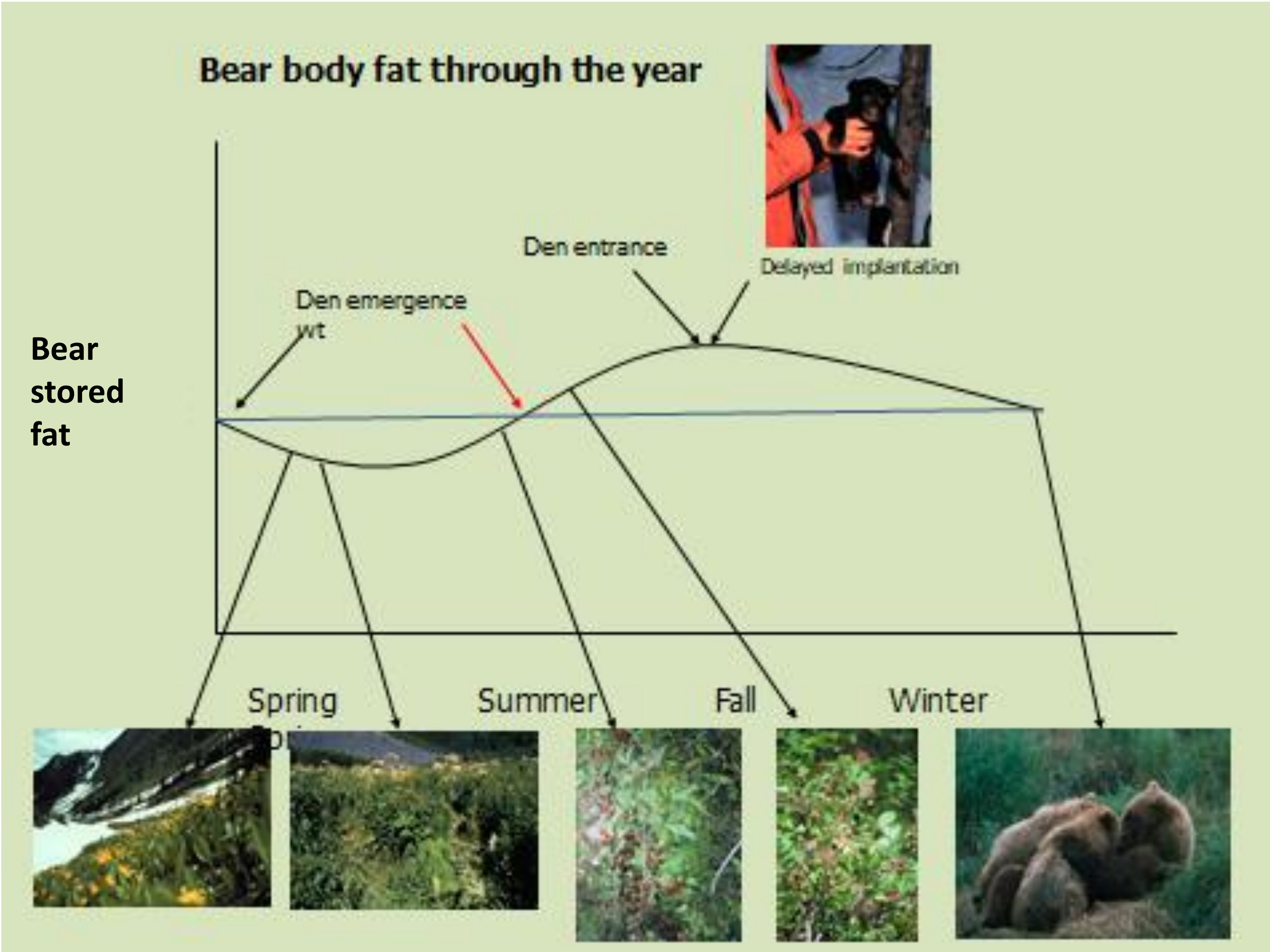
So if we were ever going to actually implement access management in BC for the benefit of GBs and other species, we need to do it strategically

Get the most bang for our buck



Bears are omnivores and in much of Southeast BC (Selkirk & Purcells Mts) huckleberries are the driver of GB reproduction (McLellan papers)

Hyperphagia for fat storage for hibernation, reproduction, and cub rearing



It with all this in mind that I decided to let my radio collared GBs show me where all the best huckleberry patches were

Others had tried to model huckleberry plants and they weren't predictive

So I did a pilot, I clustered late summer GB locations and visited them to see if they took me to huckleberry patches – they did most of the time.

I decided to try to predict and model the huckleberry patches that were important for GBs across the Purcell & Selkirk Mts.

Then I decided to see how it predicted
Habitat Selection,
Fitness, &
Density
when mortality risk was included -> “Berries and Bullets”

Was food or mortality more important in each of these processes?

or

QUESTIONS

1. Could we develop a direct foods model for huckleberries that was more predictive than surrogates (greenness, canopy openness, shrub habitat, etc)

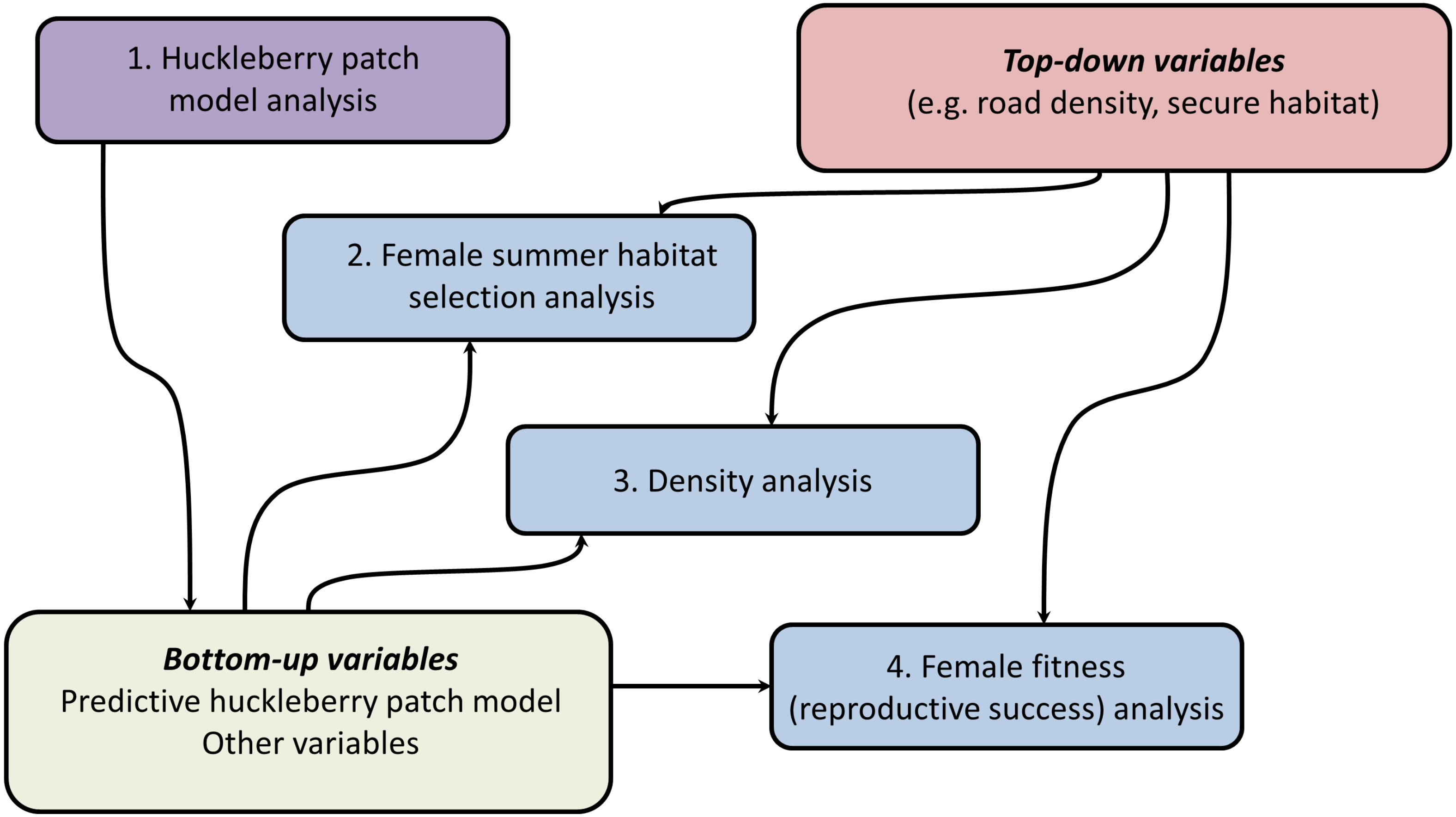
2. Which was more influential in Habitat selection, Fitness, & Density Bottom-up food or top-down mortality risk?

   We predicted that food would be more important in habitat selection but mortality risk will be increasingly influential for fitness & density

3. Would the contribution of huckleberry patches to fitness and density decrease as roads densities increase (or secure habitat decreased)?

METHODS

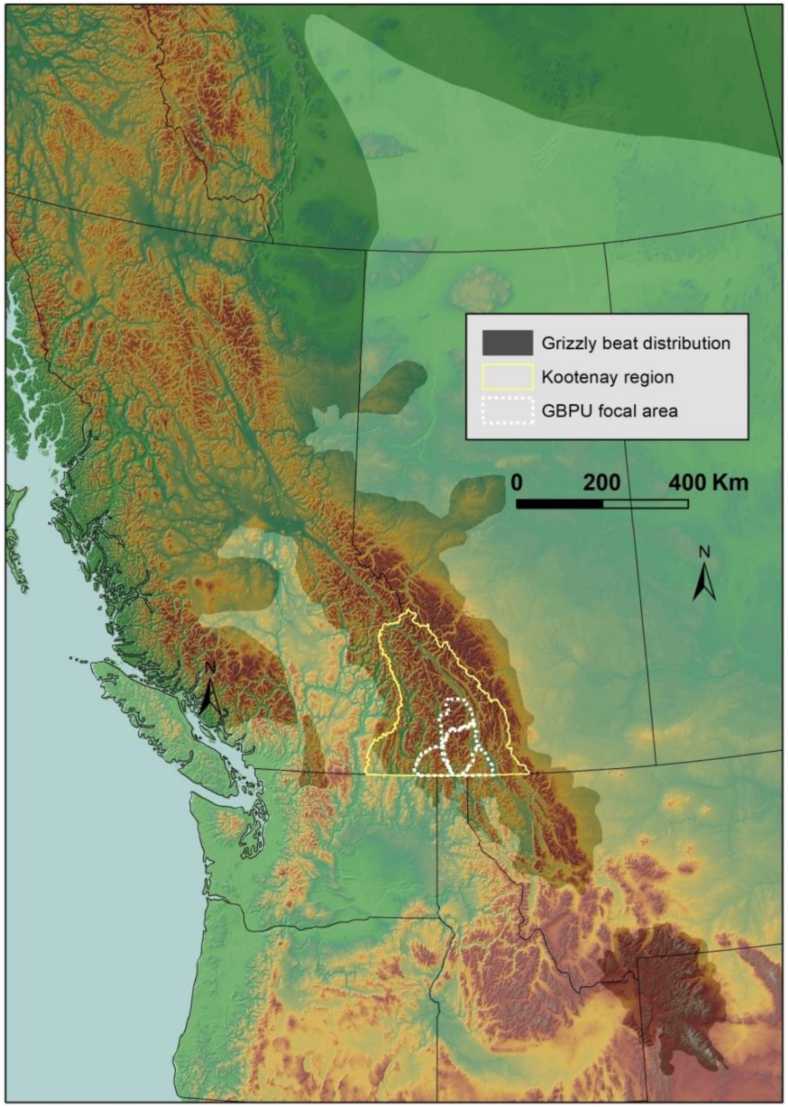
Bottom-up vs Top-down analyses across population processes



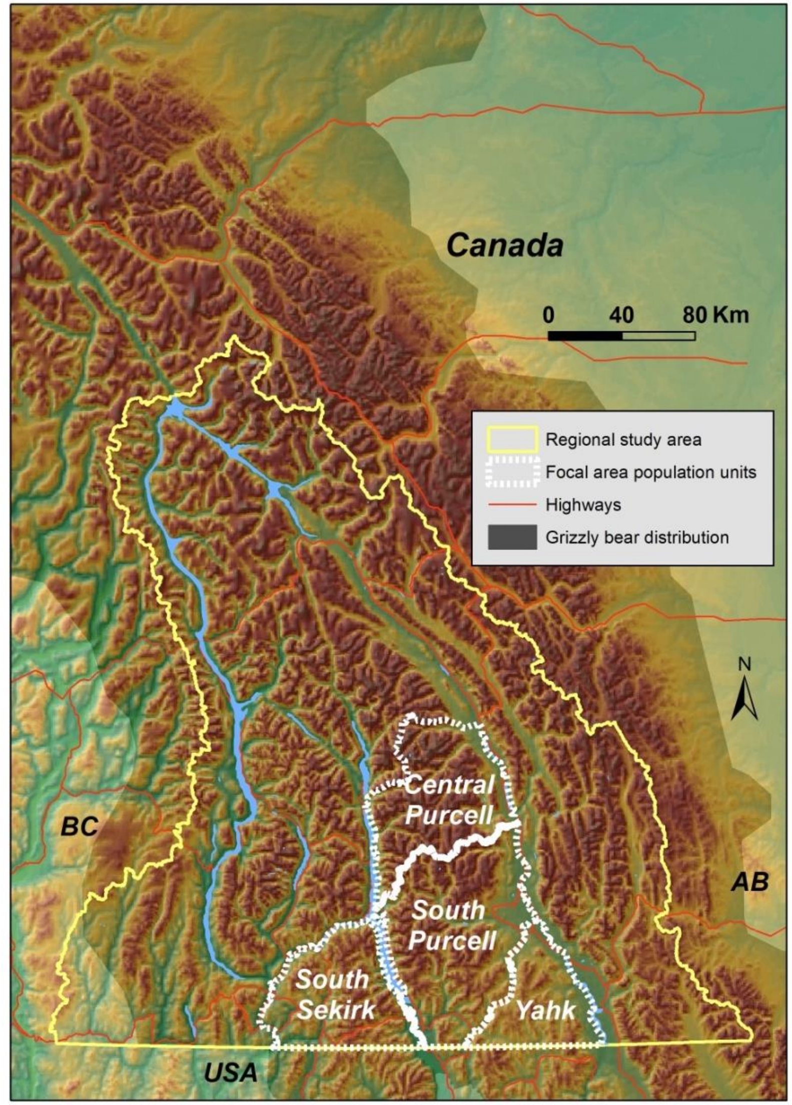
METHODS

Analysis	Model	Input data	Evaluation
Huckleberry occurrence	Boosted Regression Tree (BRT)	Presence vs absence	AUC ROC score
Huckleberry patch	Boosted Regression Tree (BRT)	Use vs availability	Habitat selection, fitness & density models
Female habitat selection	Resource Selection Function (RSF)	Use vs availability	K-fold
Female fitness	Resource Selection Function (RSF)	Presence vs absence	AUC ROC score
Sex-specific density	Spatial Explicit Capture Recapture (SECR)	Presence vs undetected	95% Confidence intervals

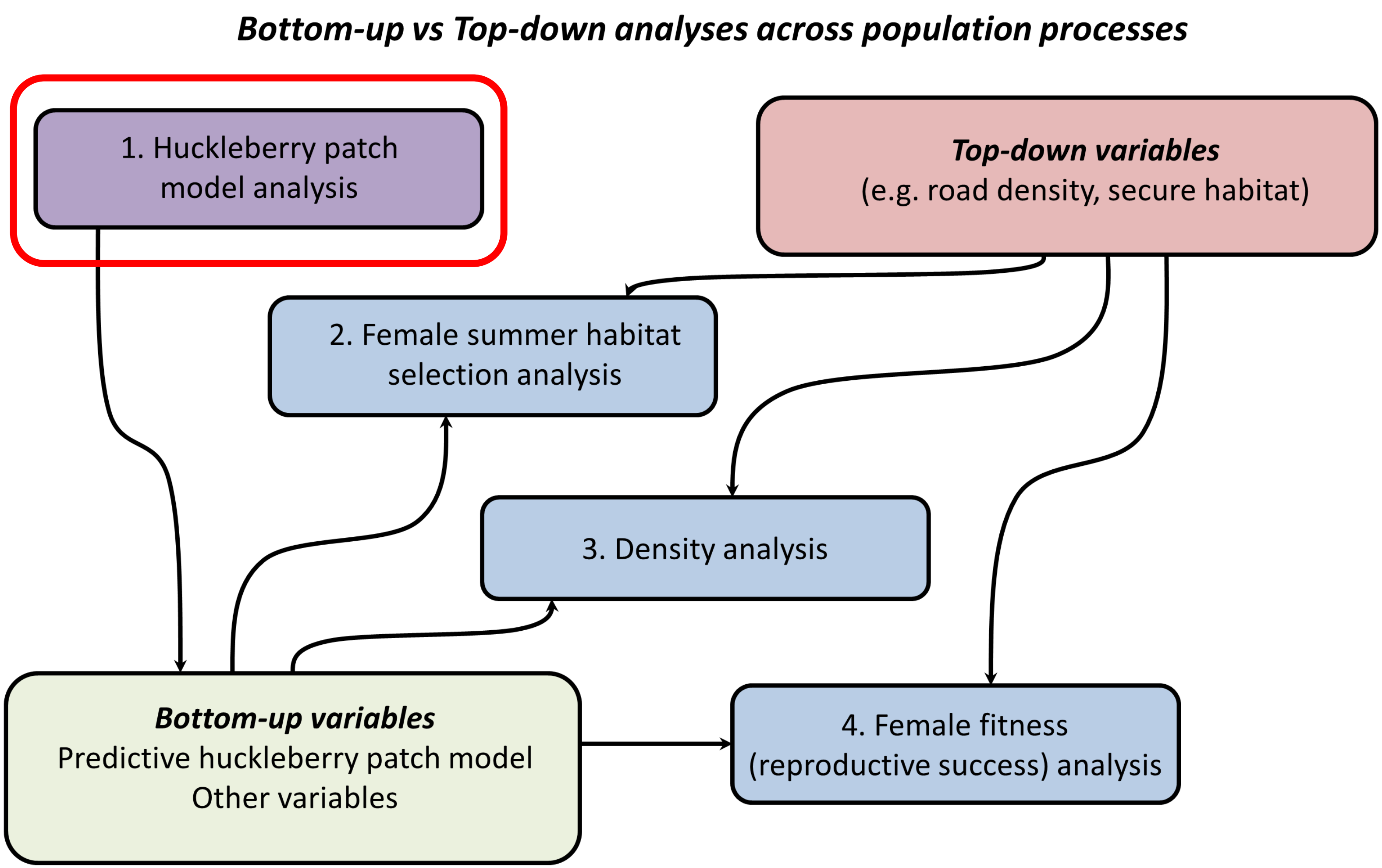
STUDY AREA



Grizzly beat distribution
Kootenay region
GBPU focal area
0
200
400 Km
N
N

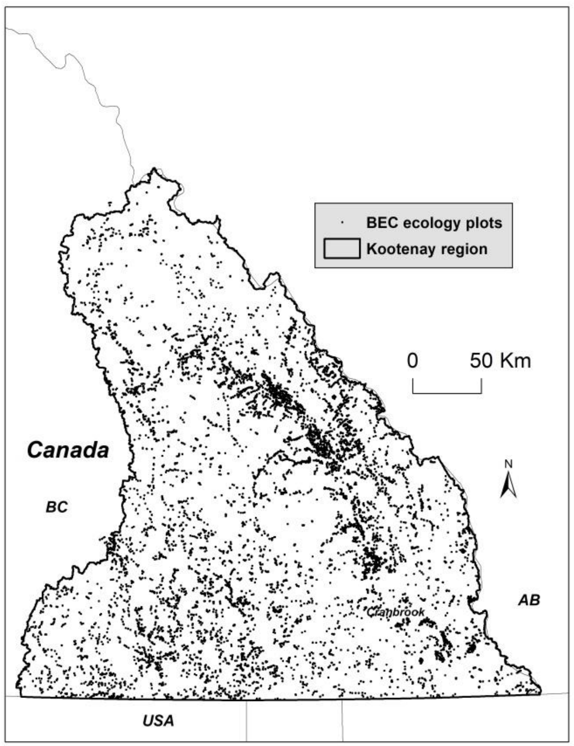


Canada
0
40
80 Km
Regional study area
Focal area population units
Highways
Grizzly bear distribution
N
Central Purcell
BC
South Purcell
AB
South Sekirk
Yahk
USA


Bottom-up vs Top-down analyses across population processes
1. Huckleberry patch model analysis
Top-down variables
(e.g. road density, secure habitat)
2. Female summer habitat selection analysis
3. Density analysis
Bottom-up variables
Predictive huckleberry patch model
Other variables
4. Female fitness (reproductive success) analysis

Predicting Huckleberry plant occurrence

BC's Biogeoclimatic Ecosystem Classification raw data

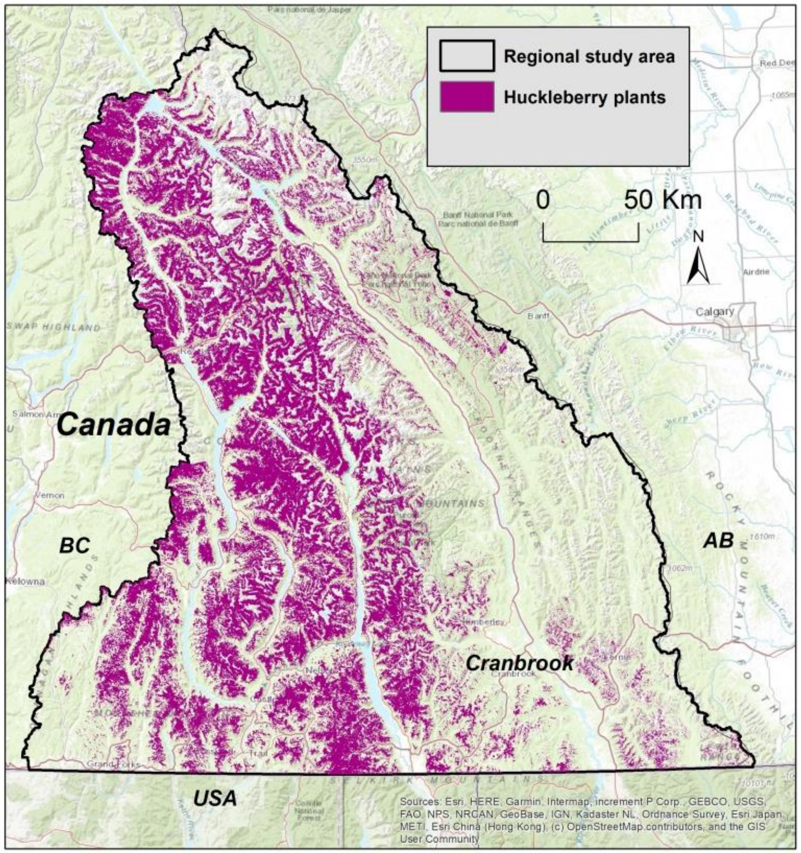


10,125 site visits
4,297 with huckleberry plants

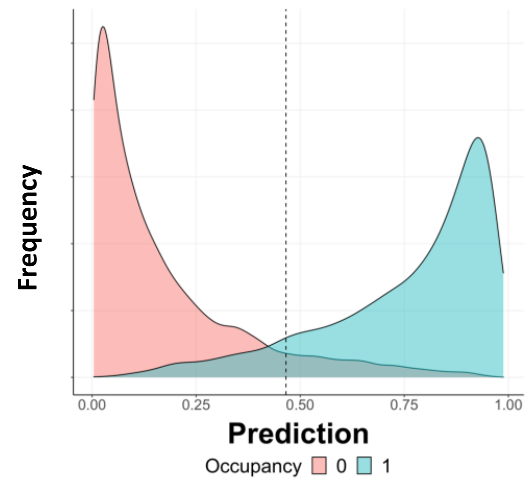
Abbreviation	Name
SOIL	
cofrag_utm	Coarse Fragments in soils
orgcarp	Organic carbon % in soils
ph2	Soil ph, dissolved using water
phca_utm	pH of soils
tcaly_utm	% clay in soils?
tclay	Clay % in soils
tsand	Sand % in soil
CLIMATE	
CMD	Hargreaves climatic moisture deficit (mm)
DD5	Degree-days below 5°C
FFP	Frost Free Period
MAP	Mean Annual Precipitation
MAR	Mean annual solar radiation (MJ m-2 d-1)
MAT	Mean Annual Temperature
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
PAS	Precipitation as snow
PAS_wt	Precipitation as snow (Winter)
PPT_sm	Precipitation in Summer
SHM	Summer heat-moisture index
Tave_wt	Average Temperature- winter
Tmax_sm	Maximum Temperature - summer
Tmin_sp	Minimum Temperature - spring
Tmin_wt	Temperature Minimum - winter
FIRE	
fire_cnt	Number of fires in a region since 1900
Last fire binned	Time since last fire binned into 5 categories
CANOPY	
Canopy_cov	Canopy cover
TOPOGRAPHY	
cti	Compound Topographic Index
globlrad	Global radiation
slope	Slope
aspect	Aspect

Predicting Huckleberry plant occurrence

(A)



(B)



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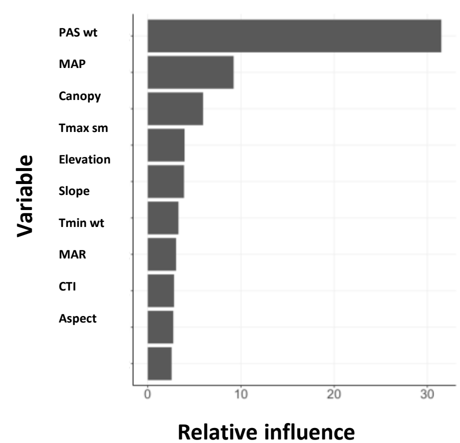
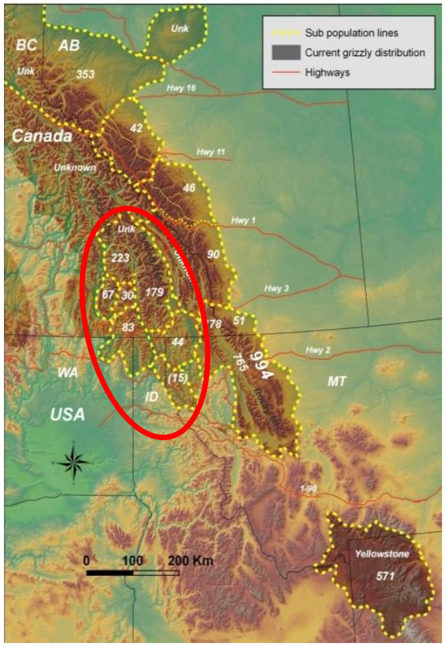


Huckleberry plants are everywhere in West Kootenays

Predicting Huckleberry patches

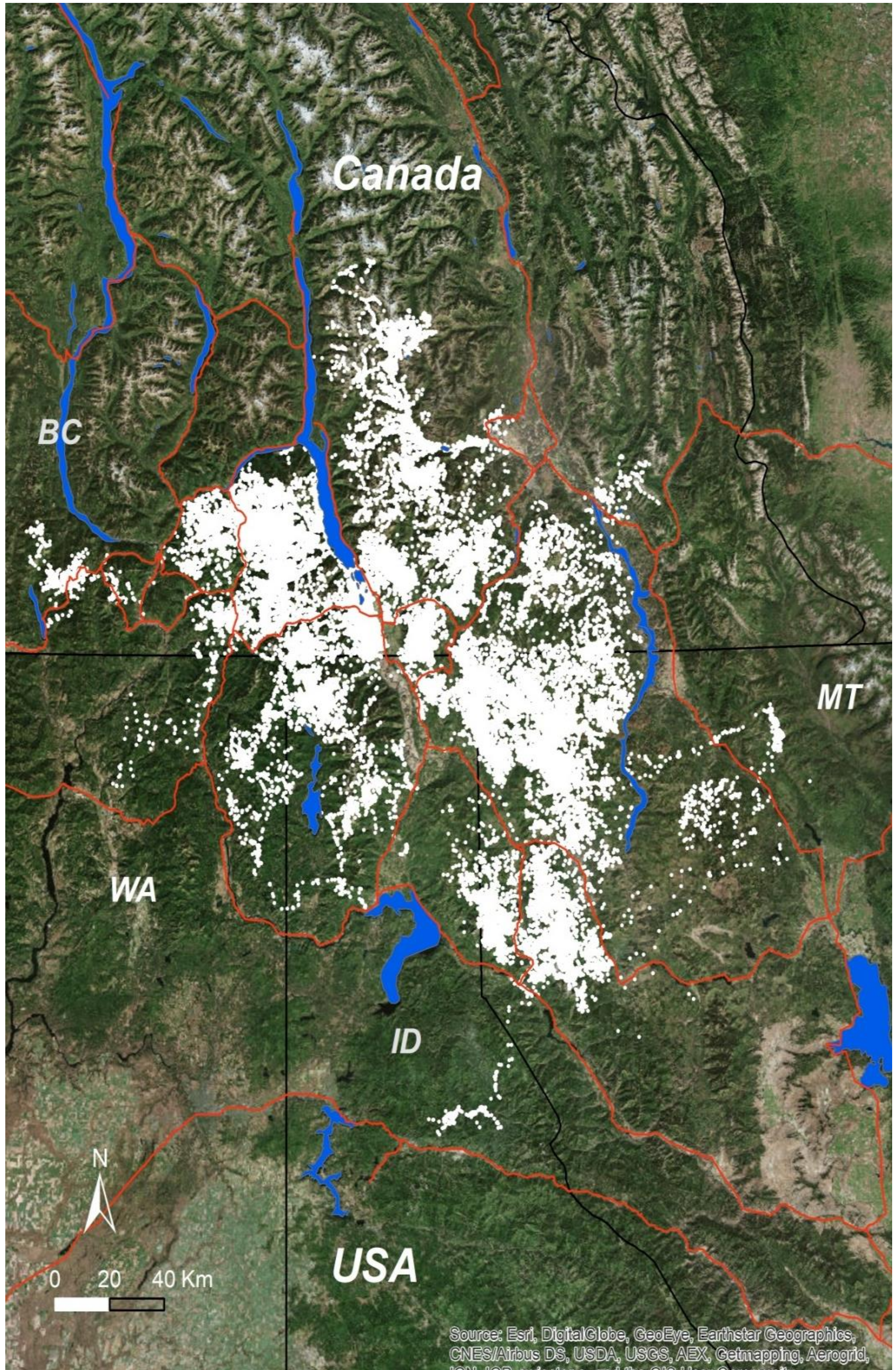
GPS telemetry



99 GRIZZLY BEARS
50 FEMALES
49 MALES

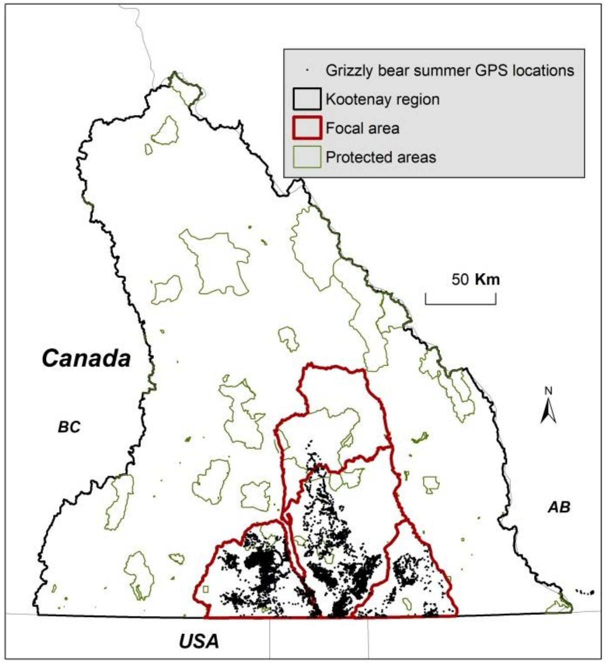
180,000 LOCATIONS

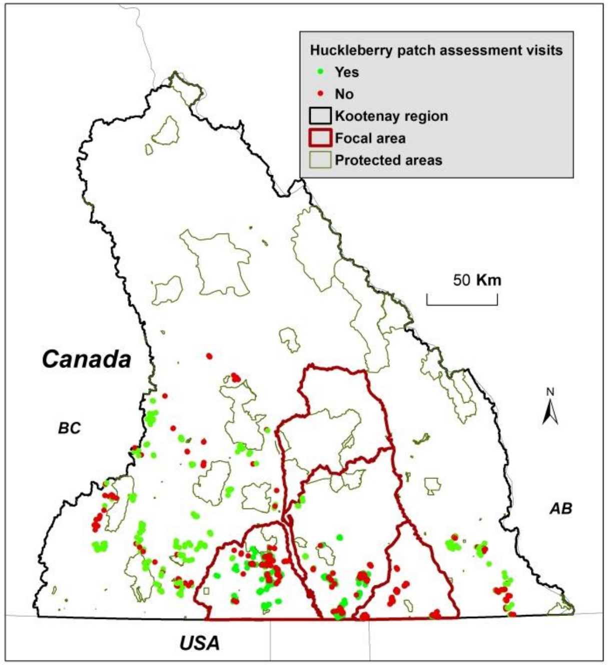
13 YEARS



Predicting Huckleberry patches

43 grizzly bears collared



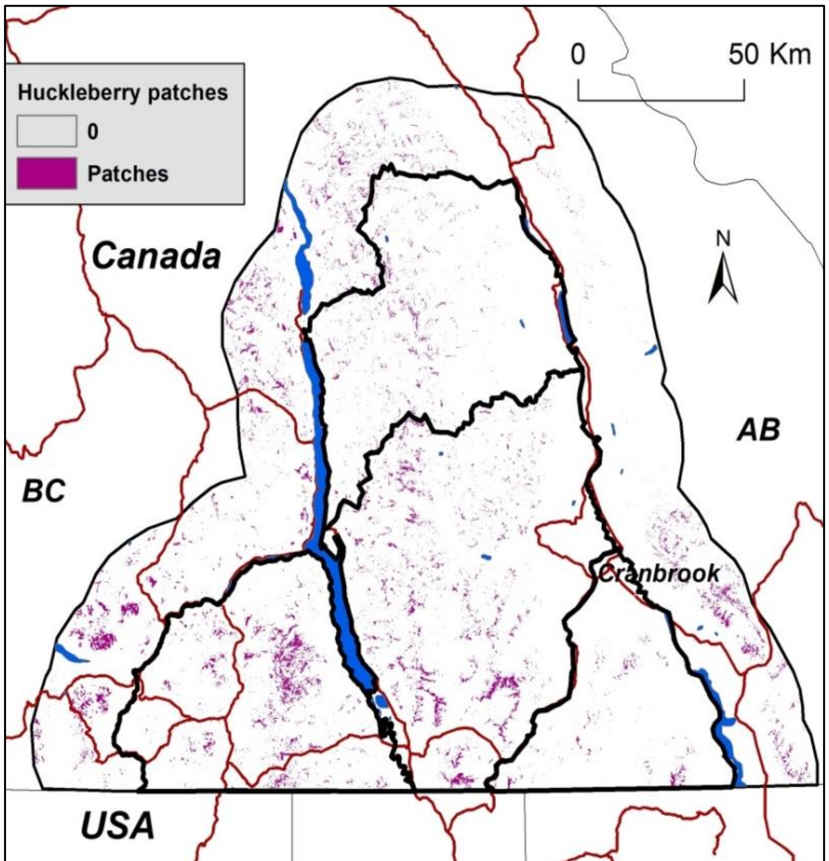


> 500 site visits within GPS location clusters

> 300 huckleberry patches identified

Predicting Huckleberry patches

a



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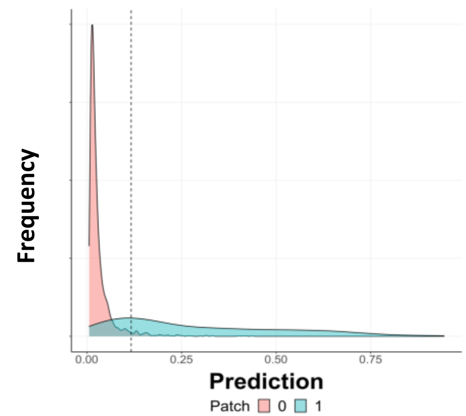
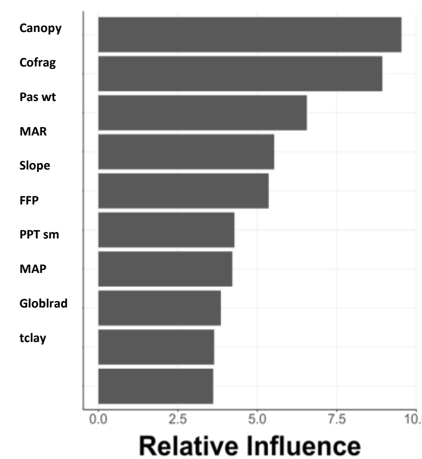
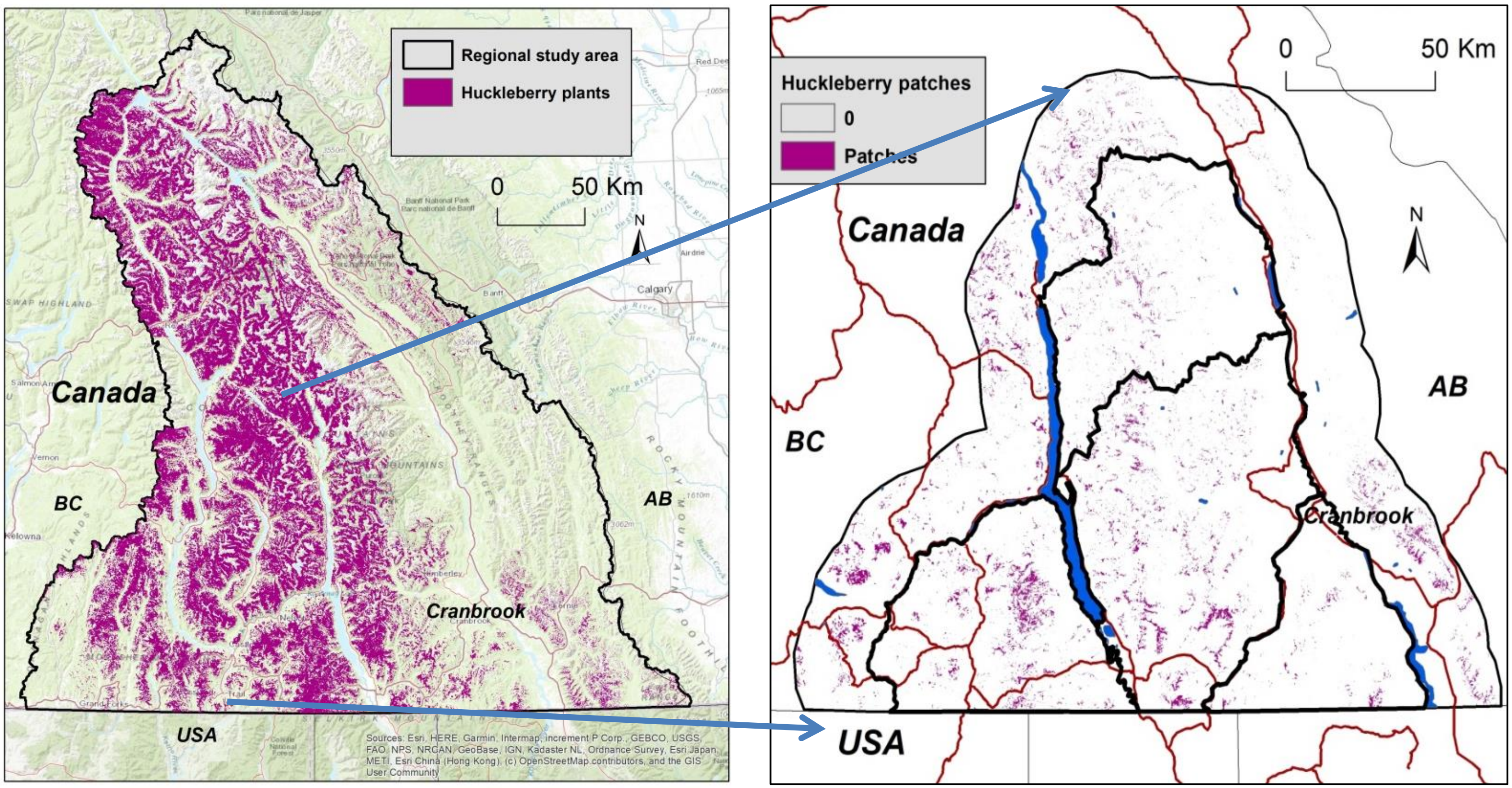


c



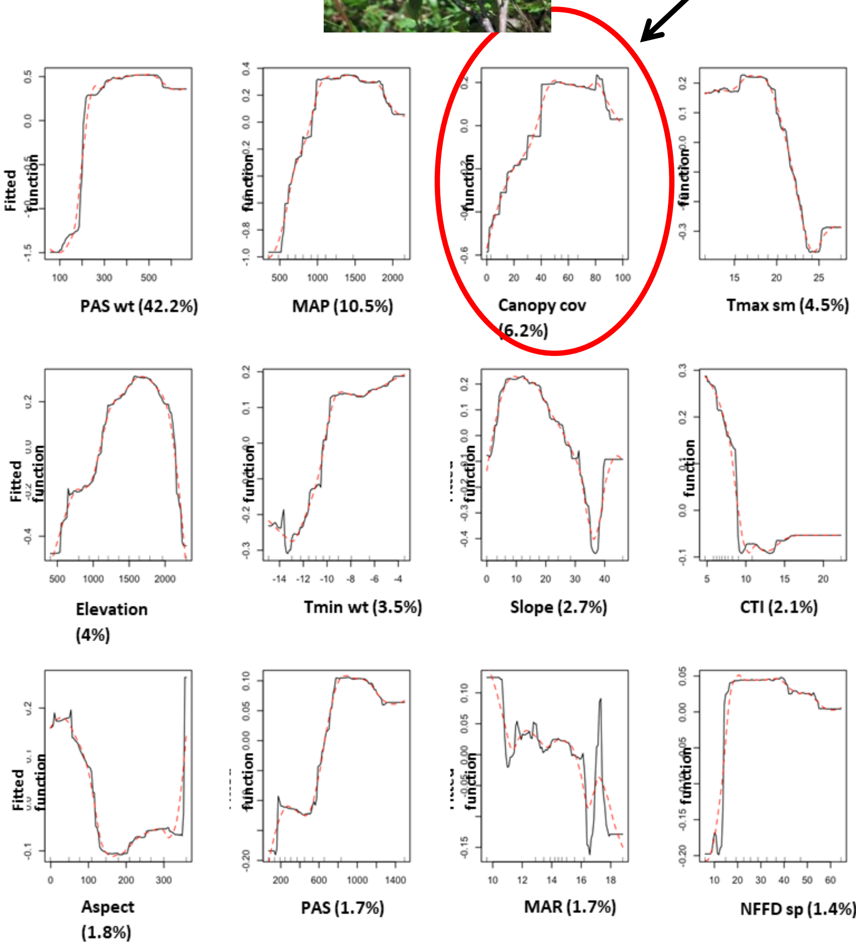
Huckleberry plants

Huckleberry patches
28% of occurrence

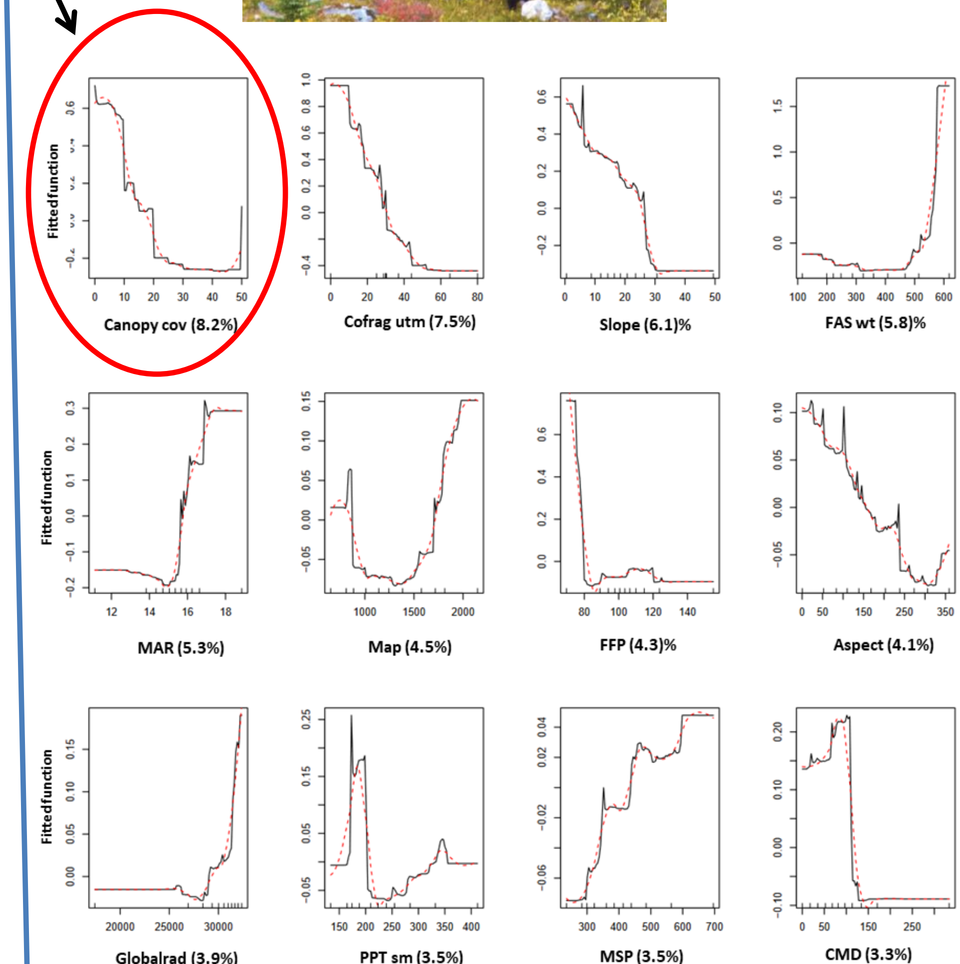


Huckleberry plants

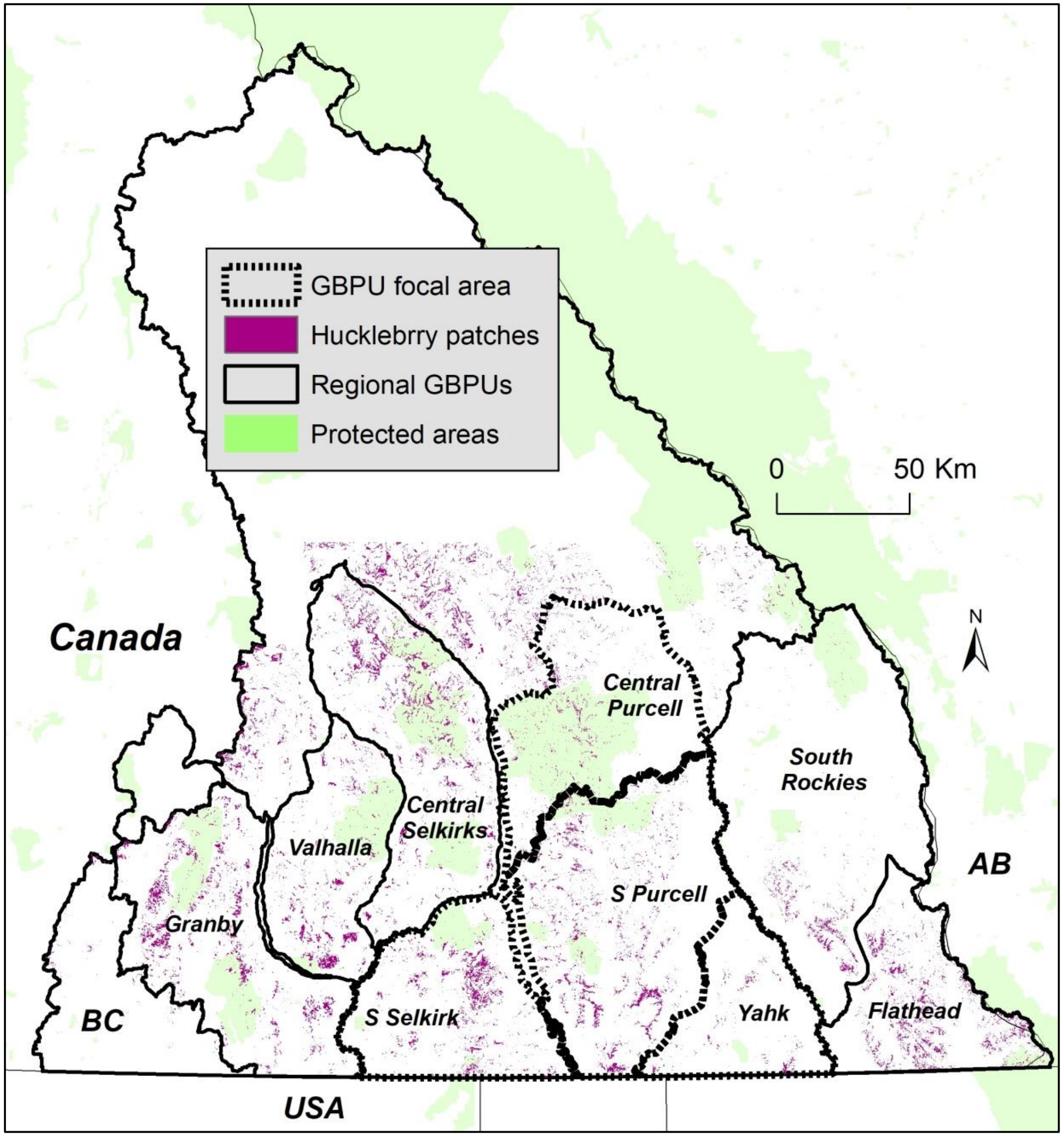
Canopy cover

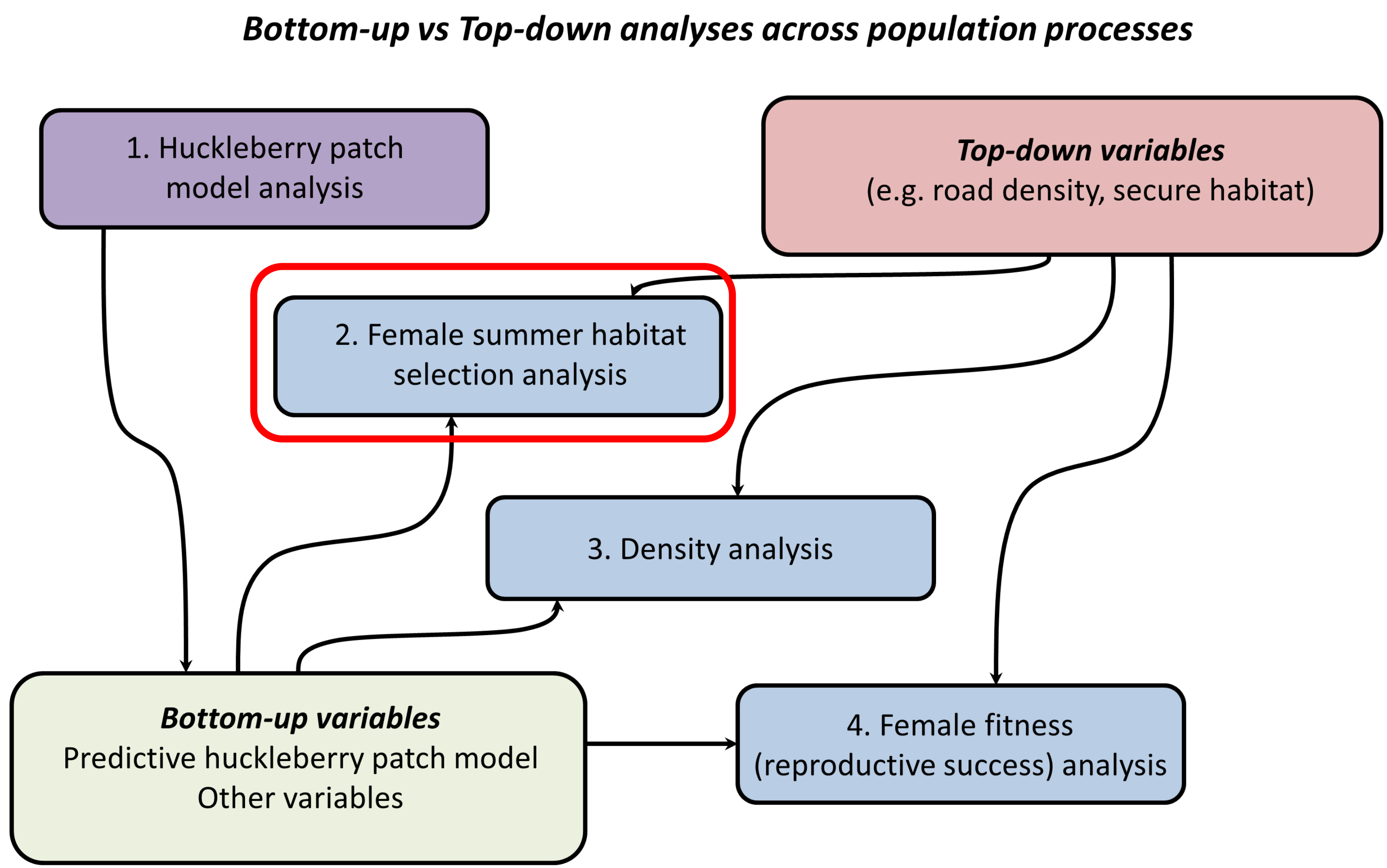


Huckleberry Patches



Huckleberry patches regionally





Bottom-up vs Top-down analyses across population processes
1. Huckleberry patch model analysis
Top-down variables
(e.g. road density, secure habitat)
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Other variables
4. Female fitness (reproductive success) analysis

Predictive variables

Surrogate variables

Huckleberry

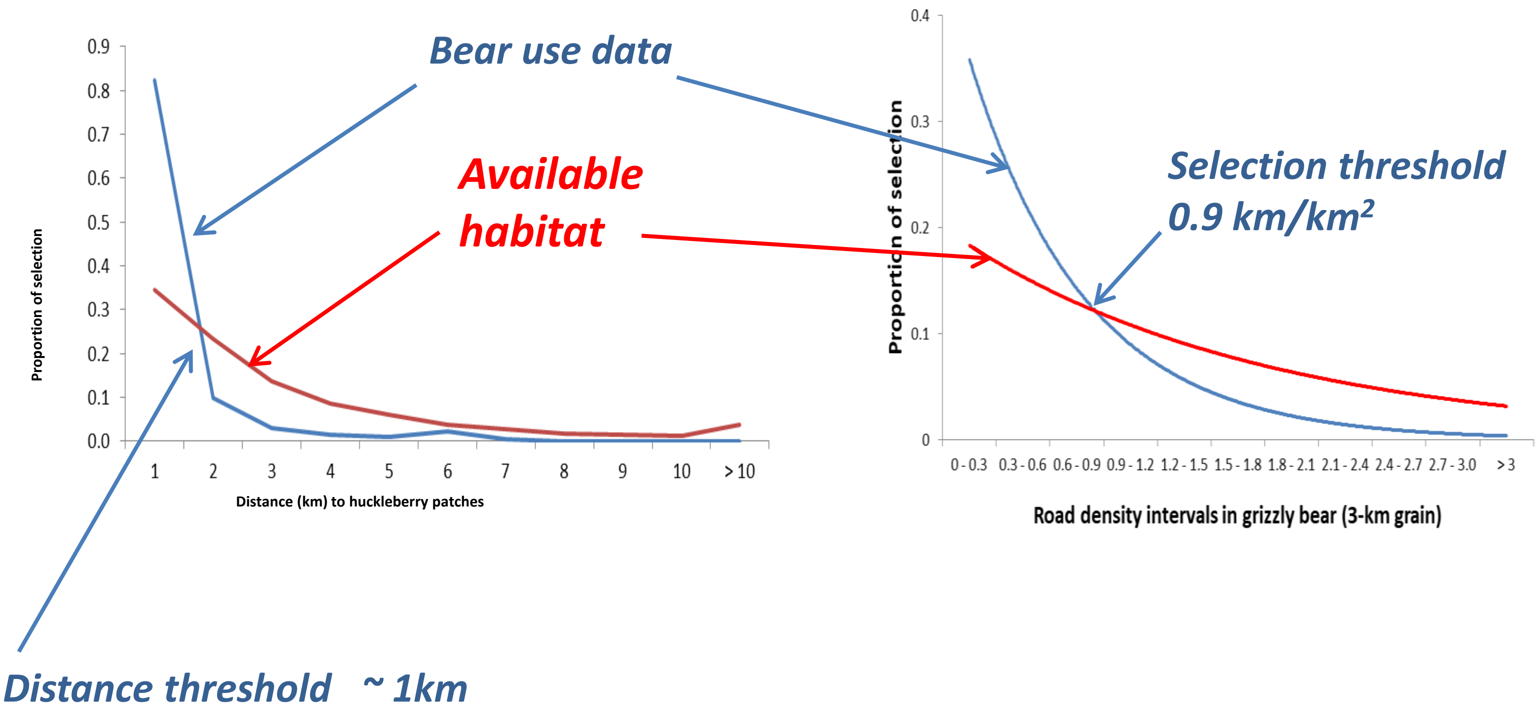
Human mortality risk

Variable category	Variable	Units	Data range	Analysis 1, 2, or 3[a]	Abbreviation
BOTTOM-UP					
Forest cover	Canopy cover	Percent	0–100	1, 2, 3	cc
	Recently logged	Categorical	0 or 1	1, 2	rlog
	Lodgepole pine	Categorical	0 or 1	1, 2	LP
	Douglas fir	Categorical	0 or 1	1, 2	DF
	Spruce-fir	Categorical	0 or 1	1, 2	SF
	Deciduous	Categorical	0 or 1	1, 2	Decid
Forest age class	0-20 years	Categorical	0 or 1	1, 2	0-20
	20-60 years	Categorical	0 or 1	1, 2	20-60
	60-80 years	Categorical	0 or 1	1, 2	60-80
	80-100 years	Categorical	0 or 1	1, 2	80-100
	100-250 years	Categorical	0 or 1	1, 2	>100
Land cover	Alpine	Categorical	0 or 1	1, 2, 3	Apine
	Avalanche	Categorical	0 or 1	1, 2, 3	Aval
	Riparian	Categorical	0 or 1	1, 2, 3	Rip
Ecological	Greenness	Continuous	0.002–0.997	1, 2, 3	green
	Wetness (CTI[b])	Index	3.4–27.2	1, 2, 3	CTI
	Solar radiation	kj/m^2	218–29,494	1, 2, 3	solar
Food resources	Huckleberry patch	Categorical	0 or 1	1, 2, 3	huck
	Huckleberry patch >	Categorical	0 or 1	1, 2, 3	huck5ha
	Huckleberry patch >	Categorical	0 or 1	1, 2, 3	huck10ha
	Distance to patch	km	0-12	1, 2, 3	huckdist
	Distance to patch >5	km	0-12	1, 2, 3	huckdist5ha
	Distance to patch >1	km	0-12	1, 2, 3	huckdist10ha
	Huckleberry plant oc	Categorical	0 or 1	1, 2, 3	huckocc
TOP-DOWN					
Human	Highway	Categorical	0 or 1	1, 2, 3	hwy
	Human development	Categorical	0 or 1	1, 2, 3	HOP
	Forest roads	Categorical	0 or 1	1, 2, 3	roads
	Distance to road	km	0 - 25	1, 2, 3	roaddist
	Road density	Km/km^2	0-5	1, 2, 3	roadden
	Human access	Index of remoteness	0-32000	1, 2, 3	access
	Secure habitat[c]	Categorical	0 or 1	1, 2, 3	sec
	Secure habitat 5k mi	Categorical	0 or 1	1, 2, 3	sec5k
	Secure habitat 10k m	Categorical	0 or 1	1, 2, 3	sec10k
	Secure habitat scalec	Categorical	1 or 1	3	sec3X[d]
	Secure hbaitat scalec	Categorical	2 or 1	3	sec8X[d]
GEOGRAPHY	Terrain ruggedness	Unitless	0–1,008	1, 2, 3	TRI

[a] 1 is Habitat use, 2, is Fitness, 3 is [b] compound topographic index. [c] >500m from road
[d] X indicates various proportions of secure habitat

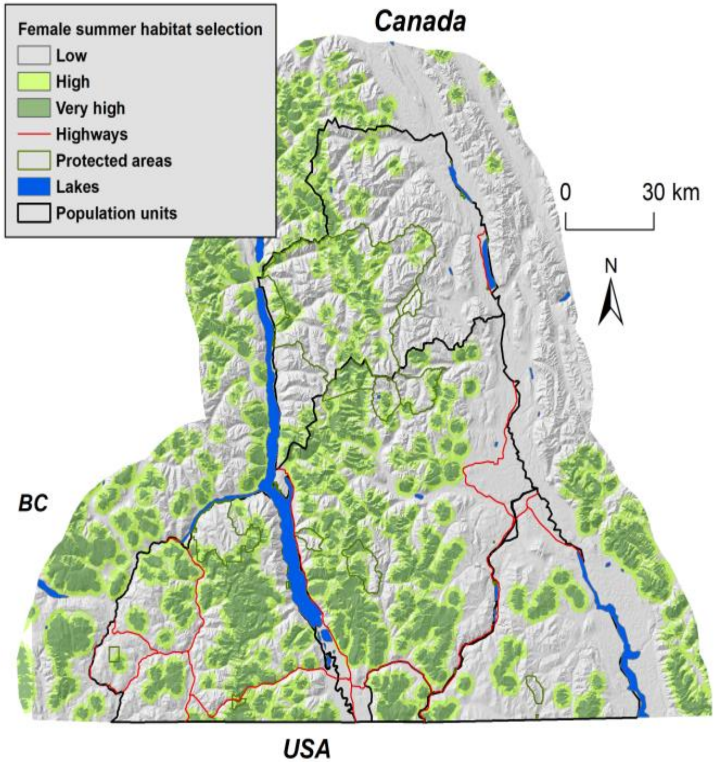
Female grizzly bear response

(A) Distance to huckleberry patches (B) Road density



Habitat selection

(A)



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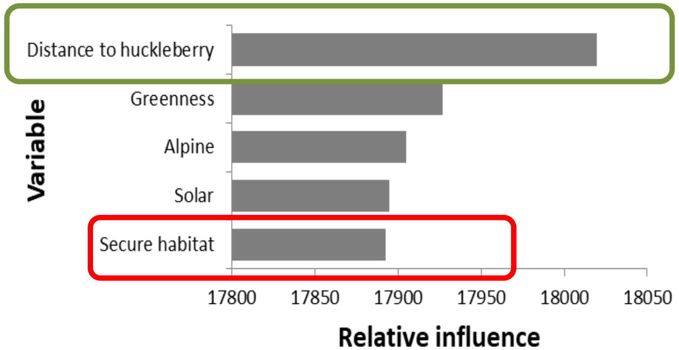

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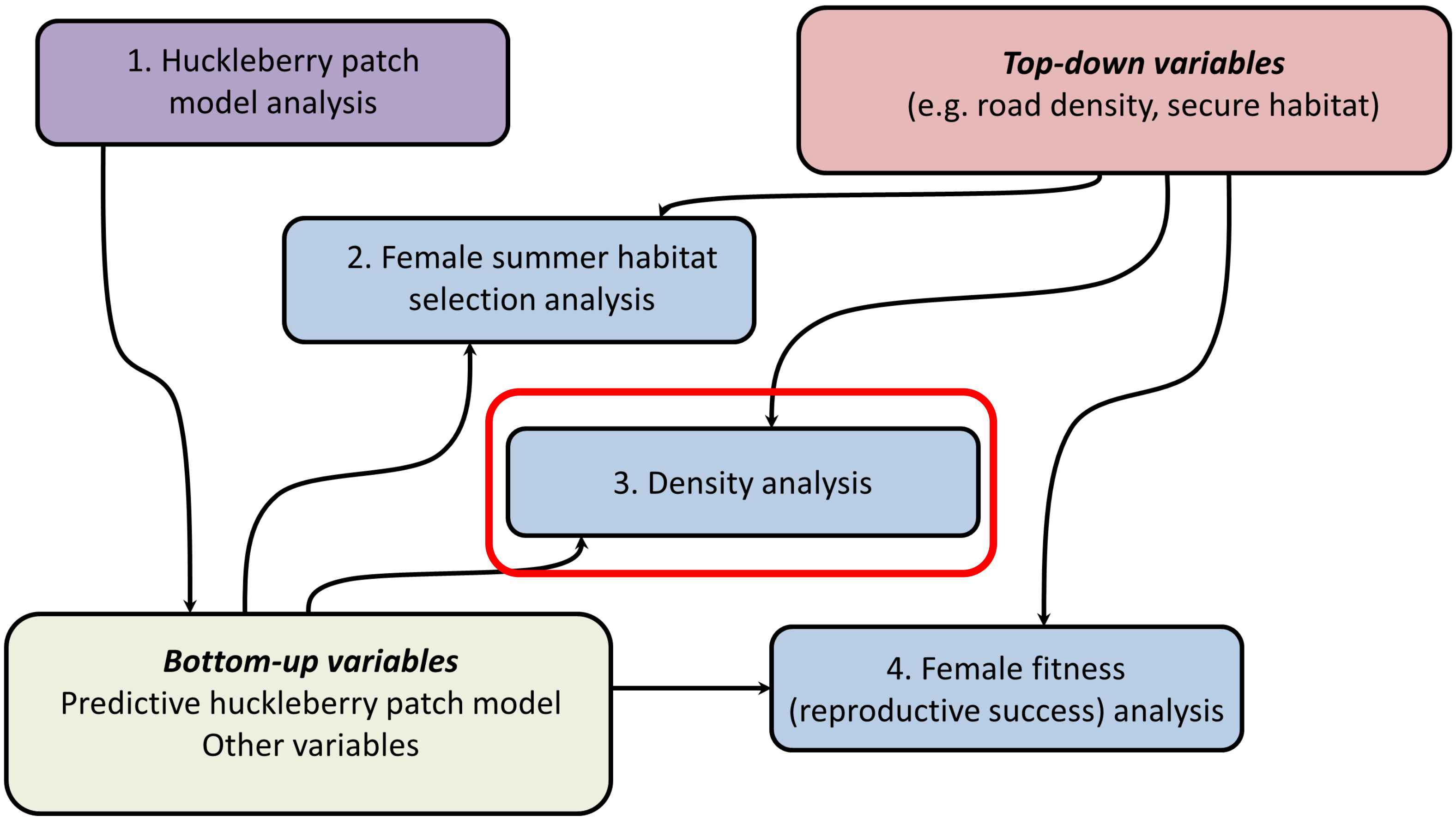
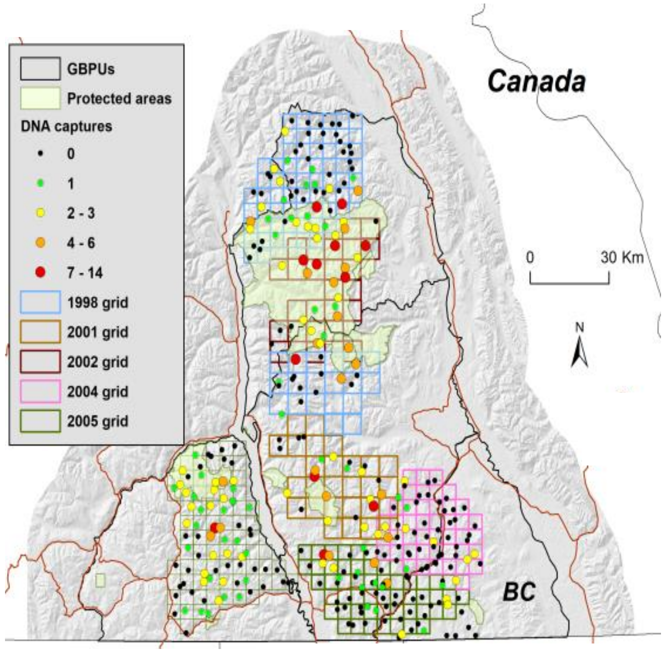


Grizzly bear Density estimation DNA detection survey

(A)



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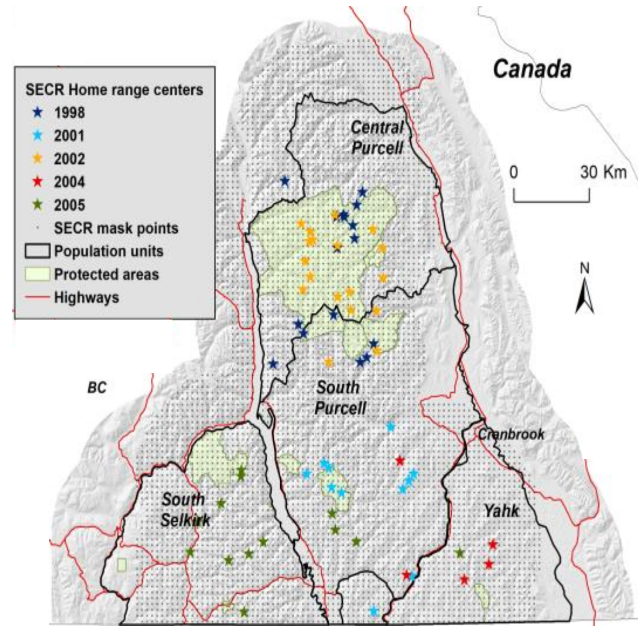
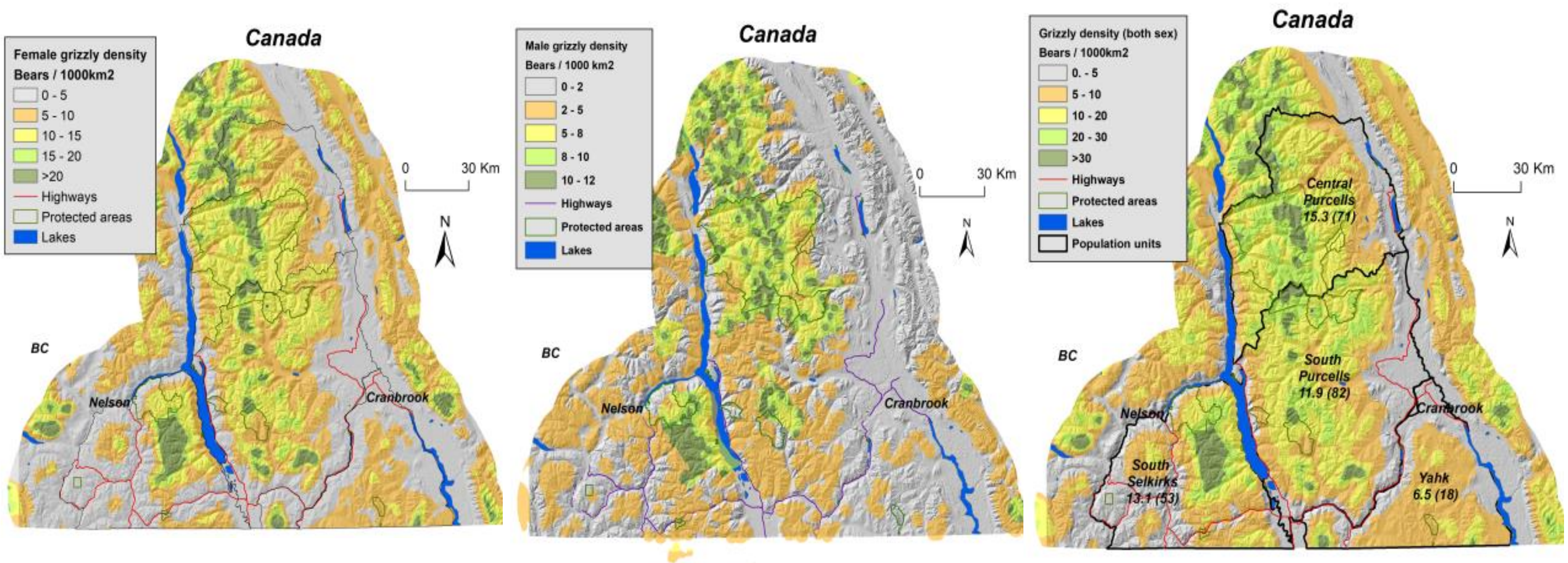


Figure 6. A barbed wire DNA sampling site with scent lure brush pile , a grizzly about to enter a site, and a hair sample left behind on the barb wire– which holds the DNA in its root.

Density: Spatially Explicit Capture Recapture (SECR)

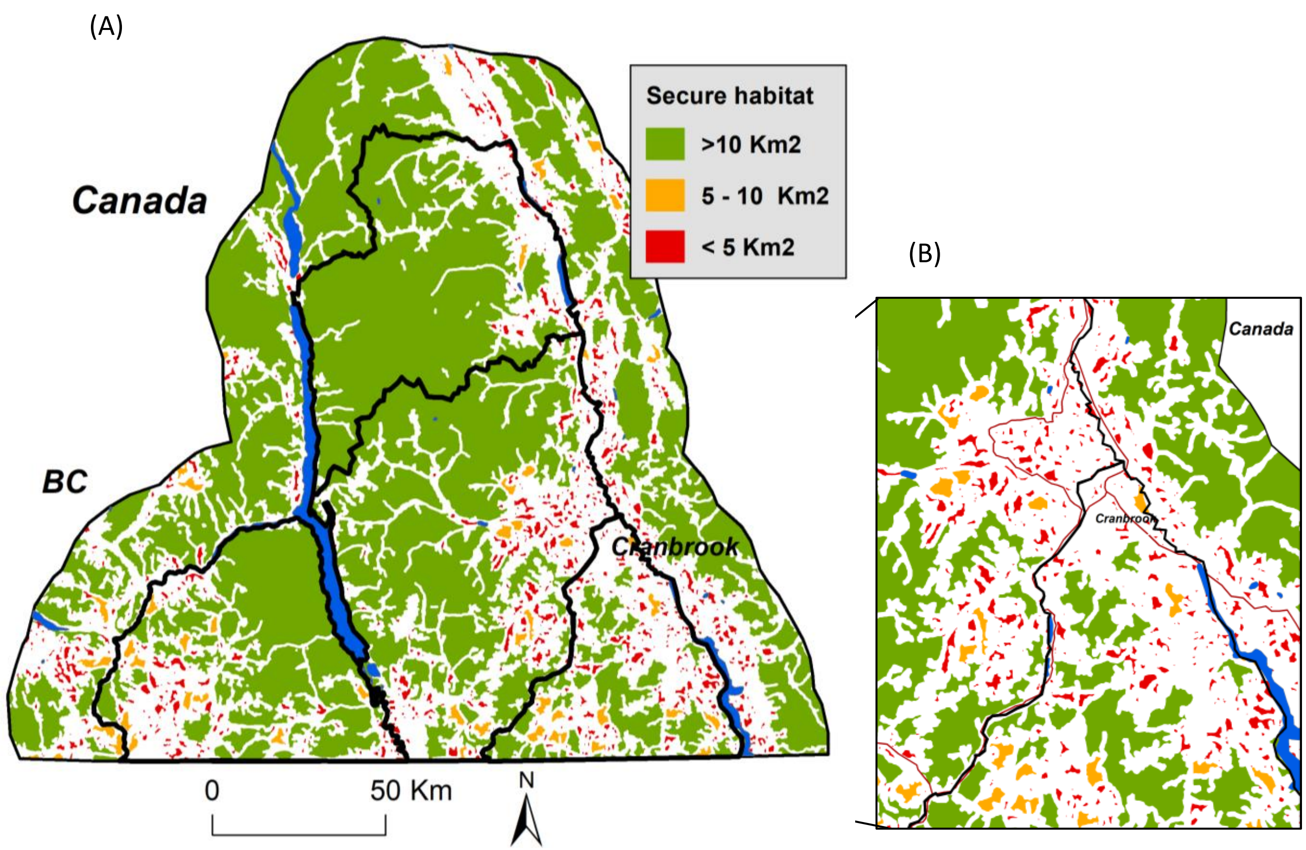
(A) **Females** (B) **Males** (C) **Both sexes**

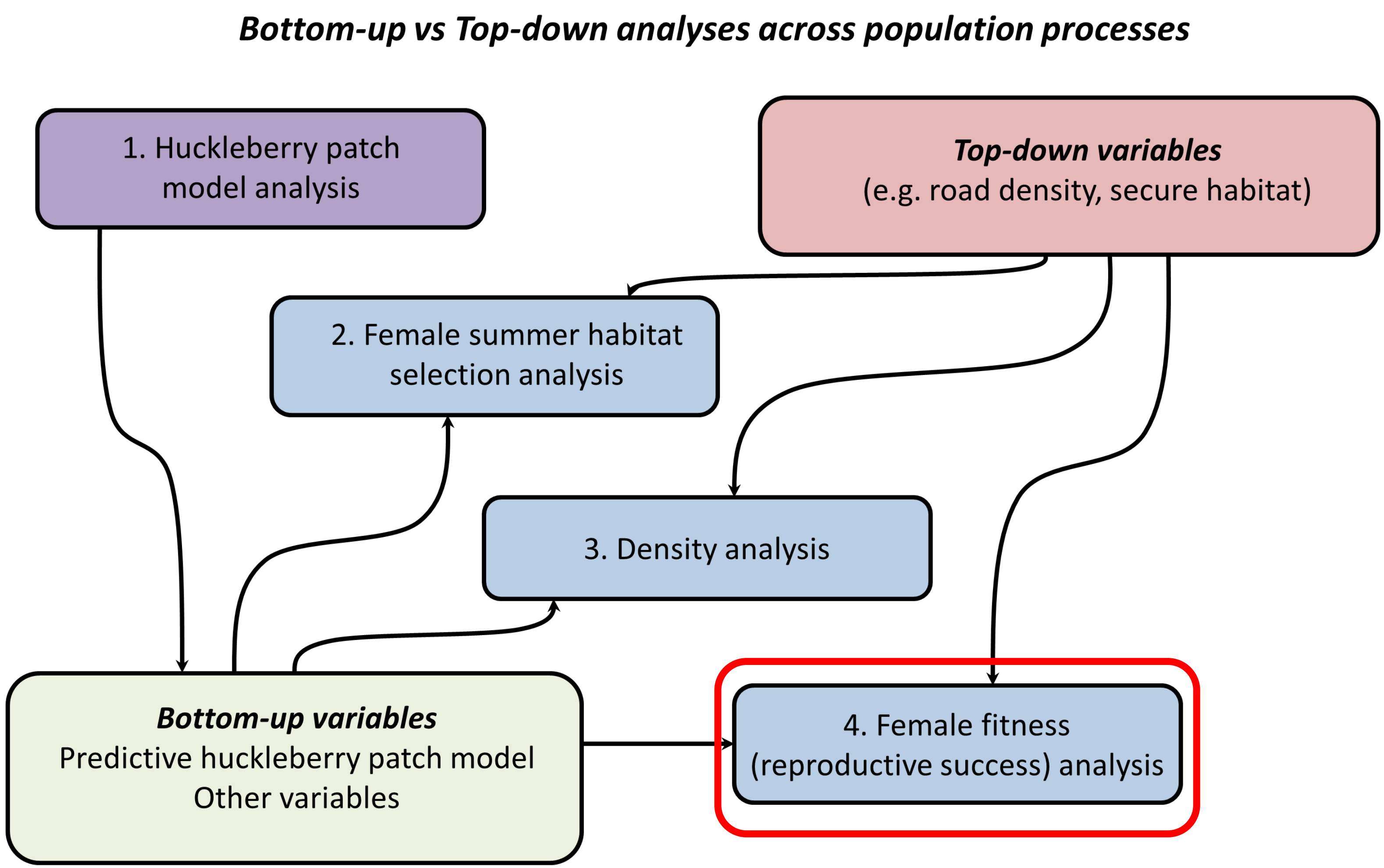


Top female model

Variable	Type	Coefficient	Standard error	95% confidence interval	
				Lower	Upper
Huckleberry 3k	Bottom-up	7.28	1.23	4.87	9.7
Secure habitat (73%) 8k	Top-down	3.15	2.16	-1.08	7.37

Secure habitat
(> 500m from an open road)

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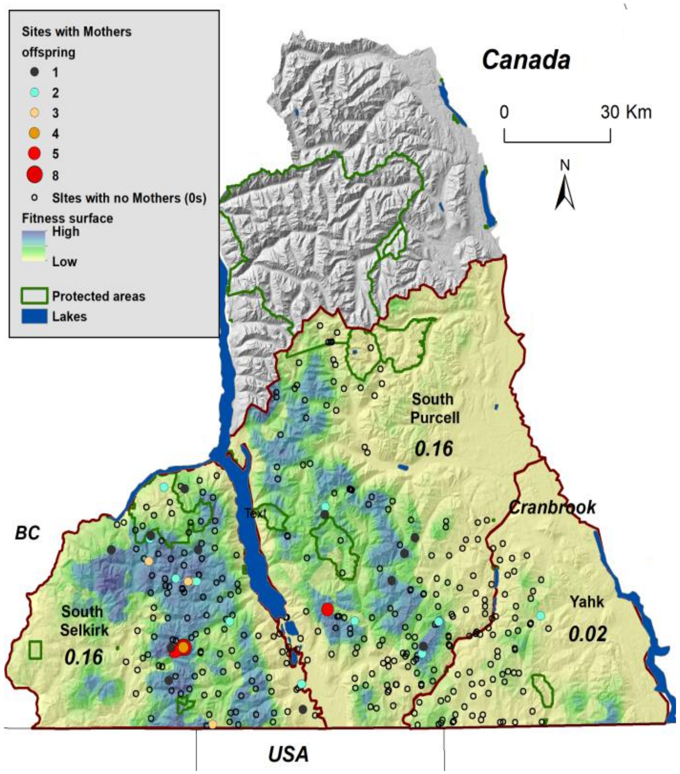
Female fitness

(A)



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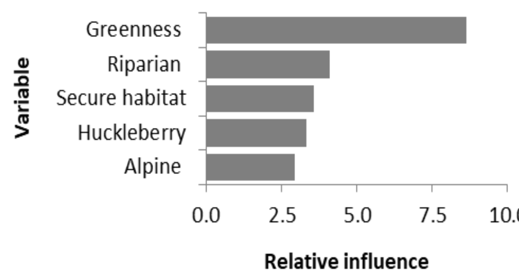
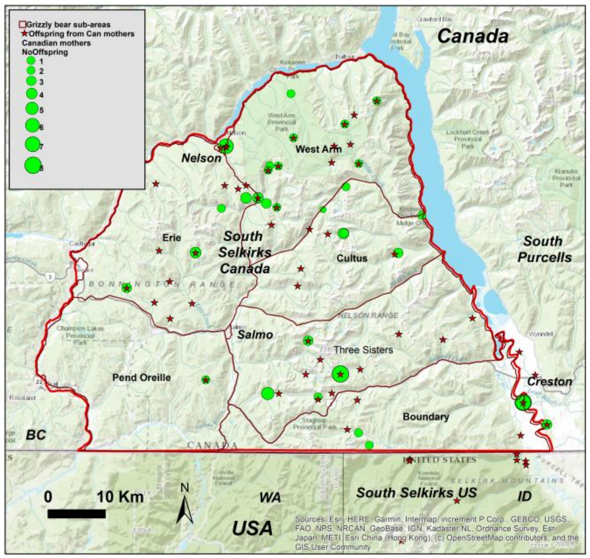
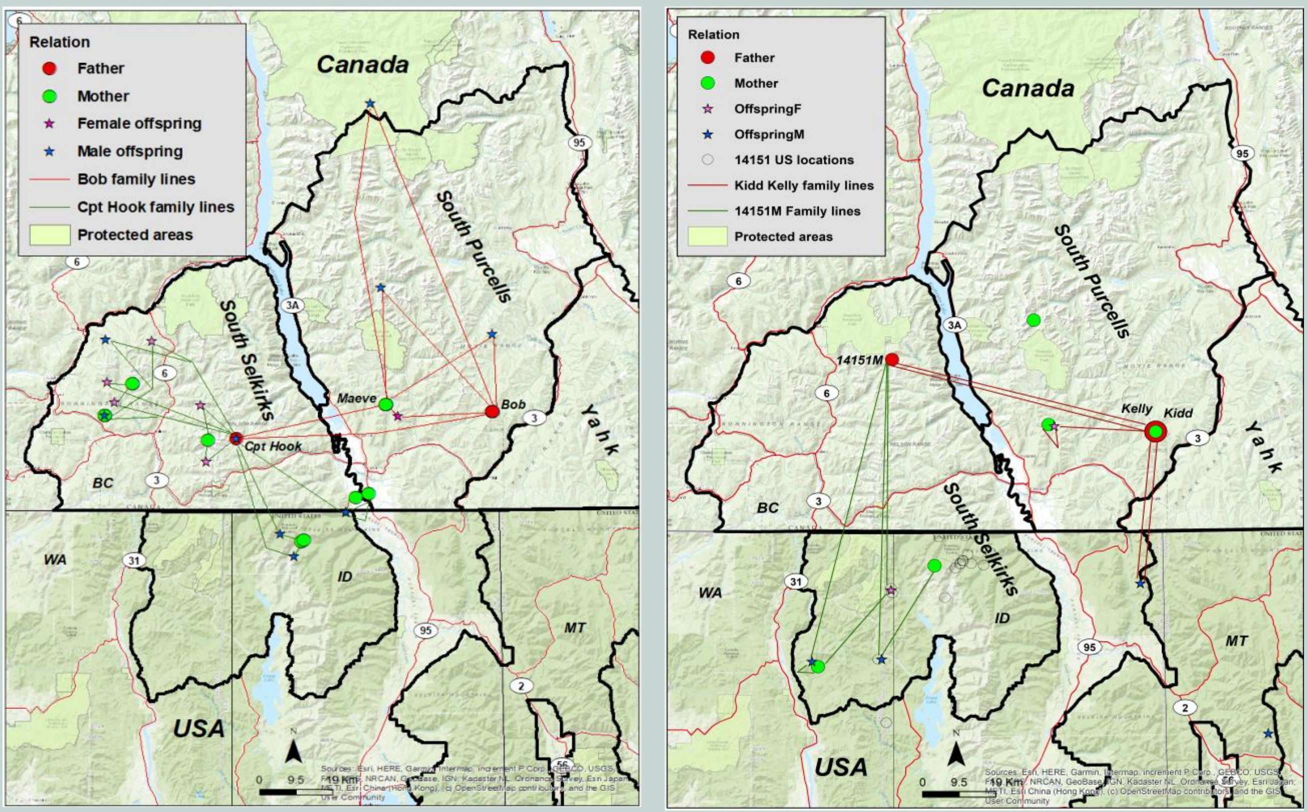




Family pedigrees

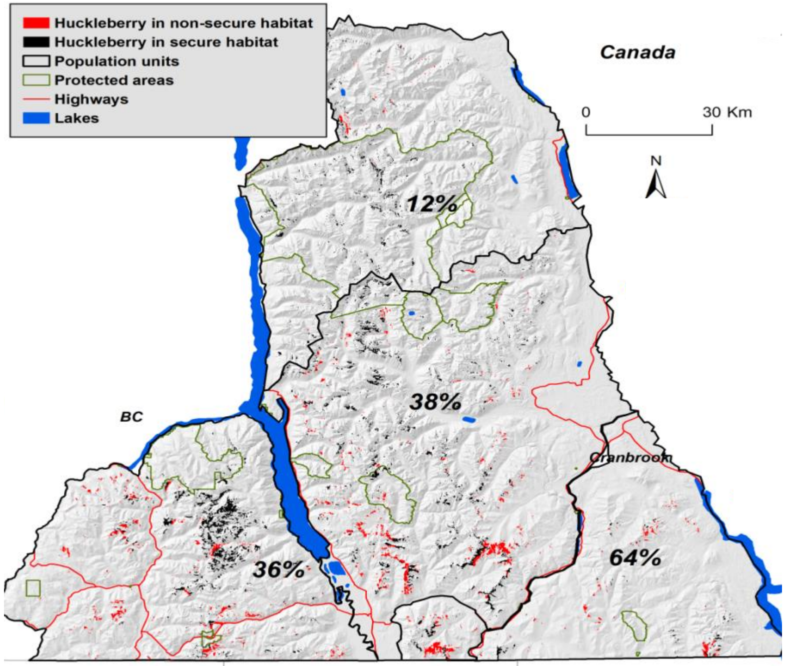
Figure 15a. Grizzly bear family pedigrees showing immigrants from the Purcell Mts. into the South Selkirk population. Panel **a)** depicts immigrant Cpt Hook, an offspring of Maeve and Bob from the Purcell Mts. and eventually had 13 offspring (5F, 8M) 8 different females in the South Selkirks. Panel **b)** shows Immigrant male 14151 an offspring of Kelly and Kidd from the Purcell Mts. and eventually had 3 offspring (1F, 2M) with two mothers. Bears with names were live captured and radio collared. 15141 was also detected in the U.S, open circles)

a b

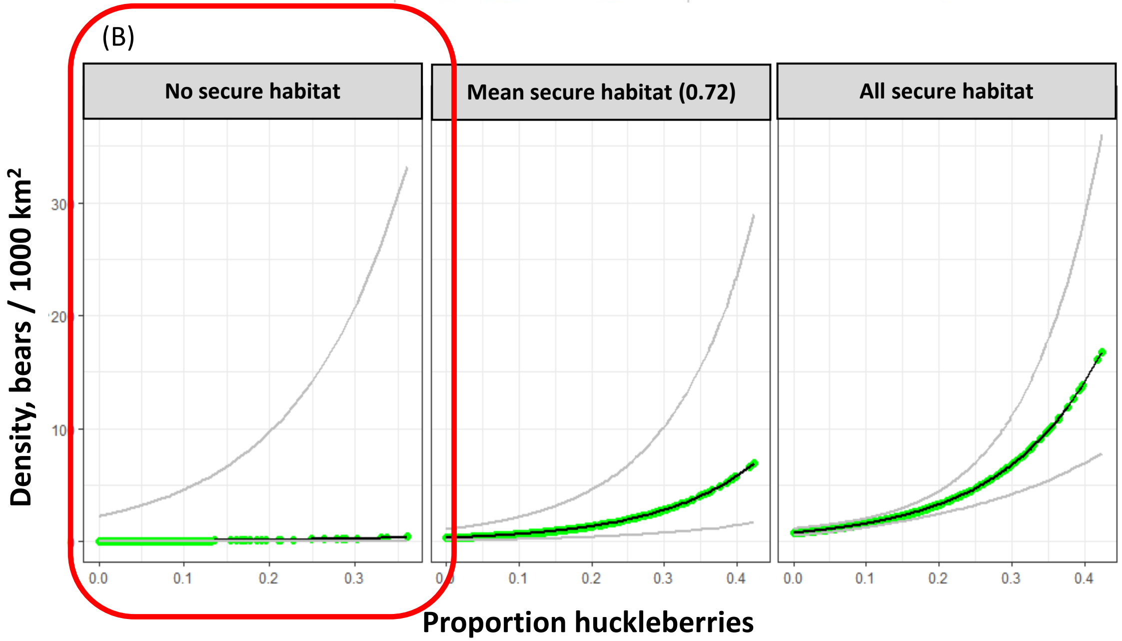


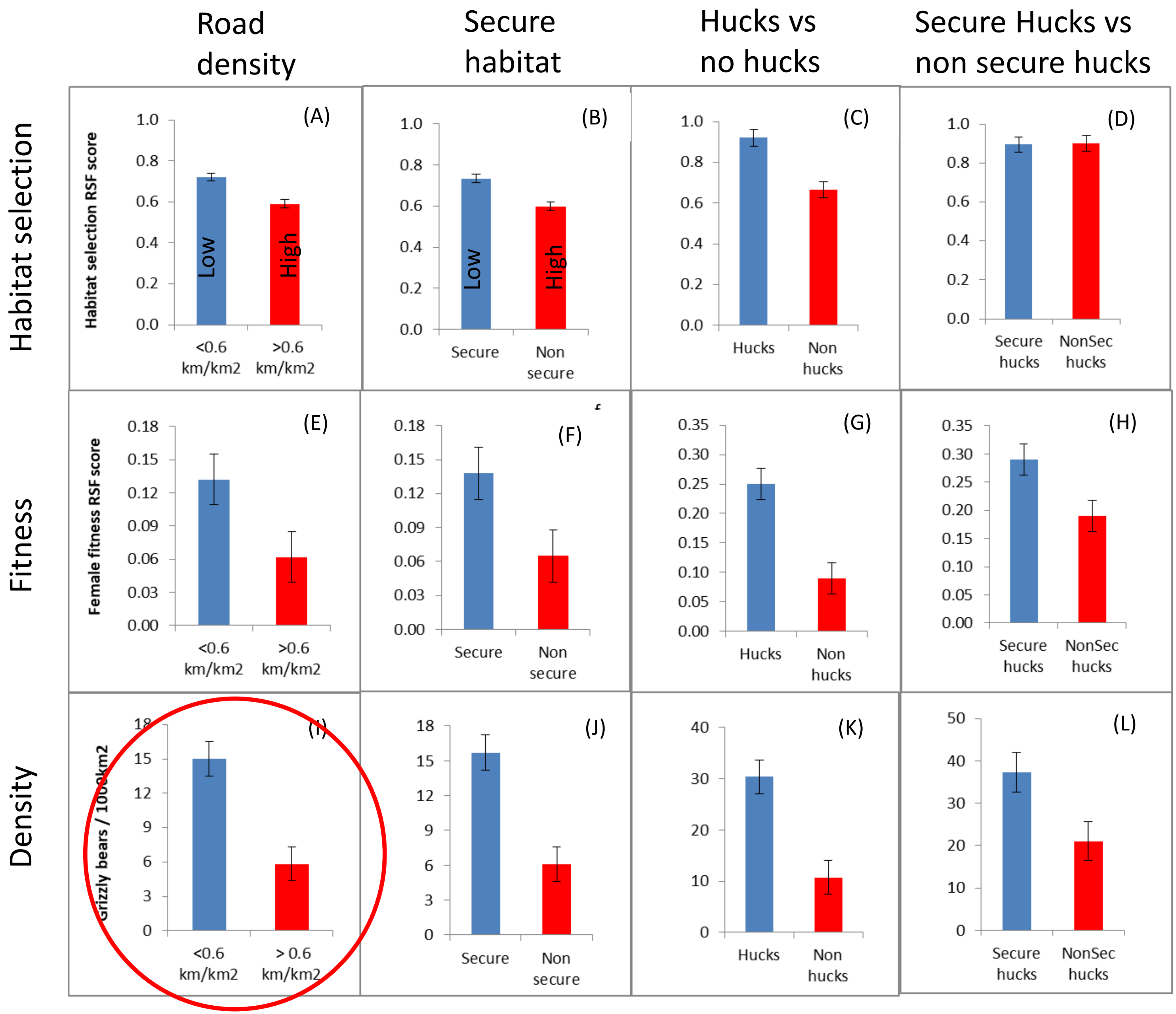
Results Synthesis

Compromised huckleberry patches

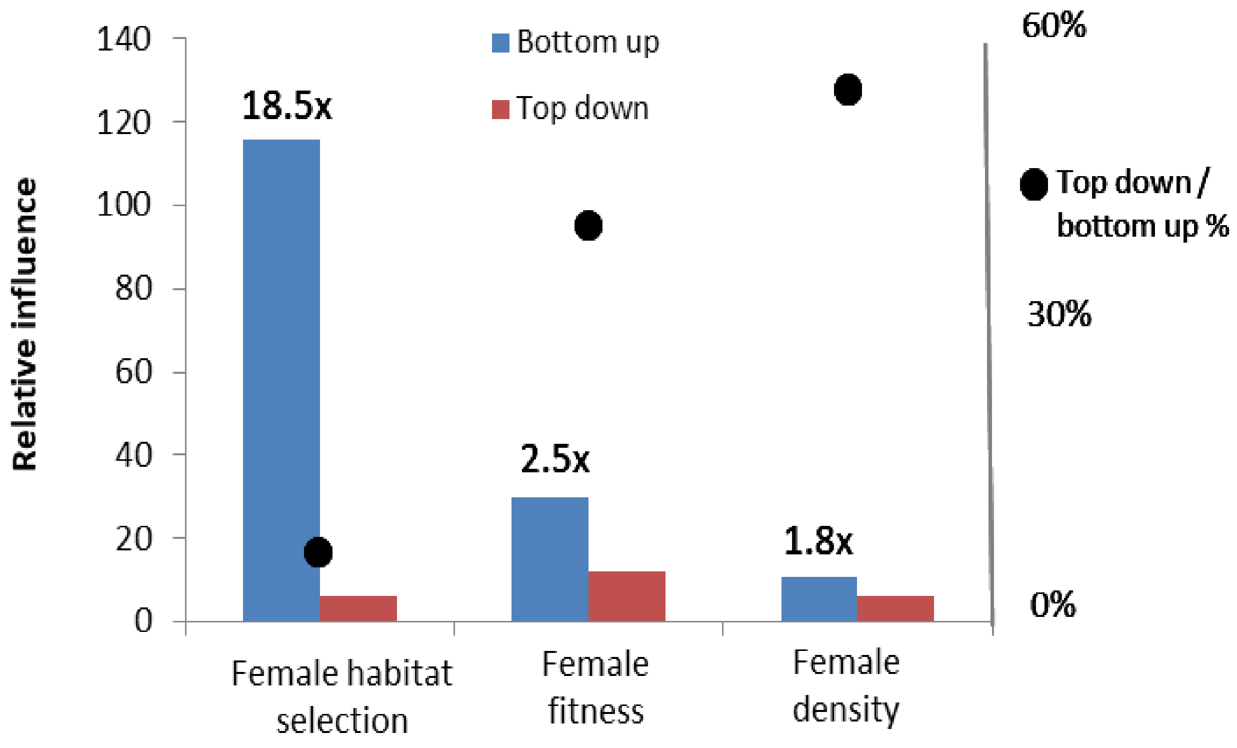


Red polygons
38% of all huckleberry patches in non-secure habitat (within 500 m of an open road)

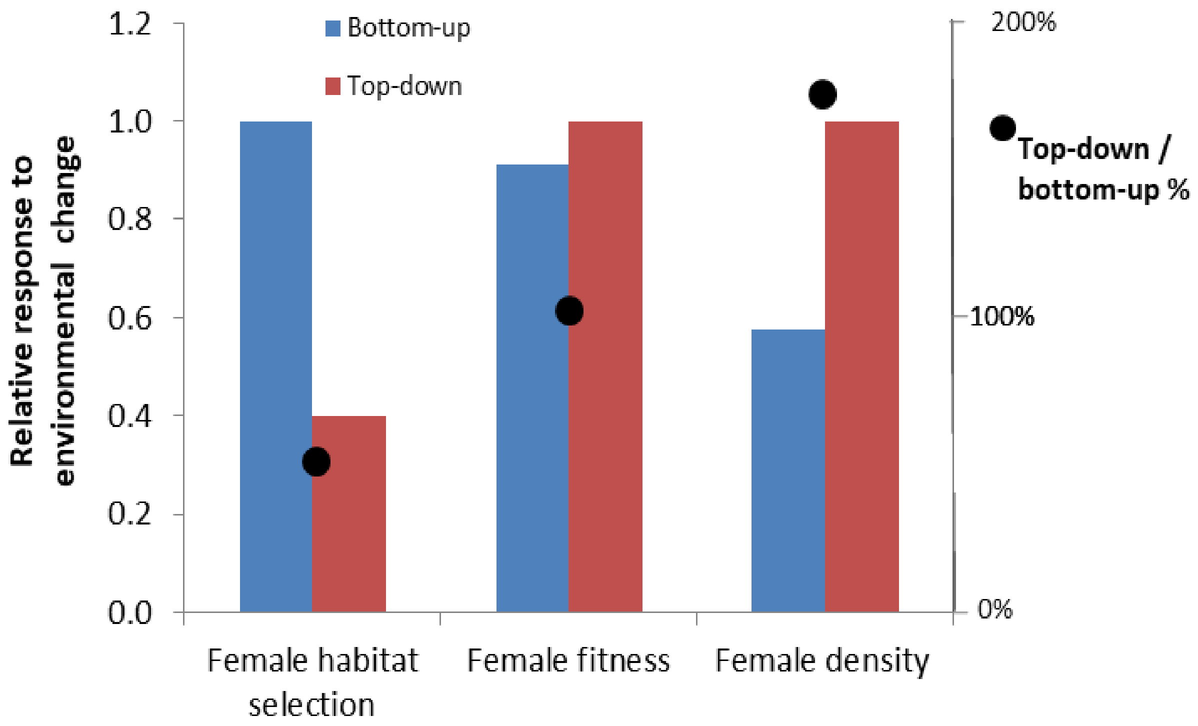



Road density
Secure habitat
Hucks vs no hucks
Secure Hucks vs non secure hucks
Habitat selection
Fitness
Density
Habitat selection RSF score
Female fitness RSF score
Grizzly bears / 1000km2
(A)
(B)
(C)
(D)
(E)
(F)
(G)
(H)
(I)
(J)
(K)
(L)
Low
High
<0.6 km/km2
>0.6 km/km2
> 0.6 km/km2
Secure
Non secure
Hucks
Non hucks
Secure hucks
NonSec hucks

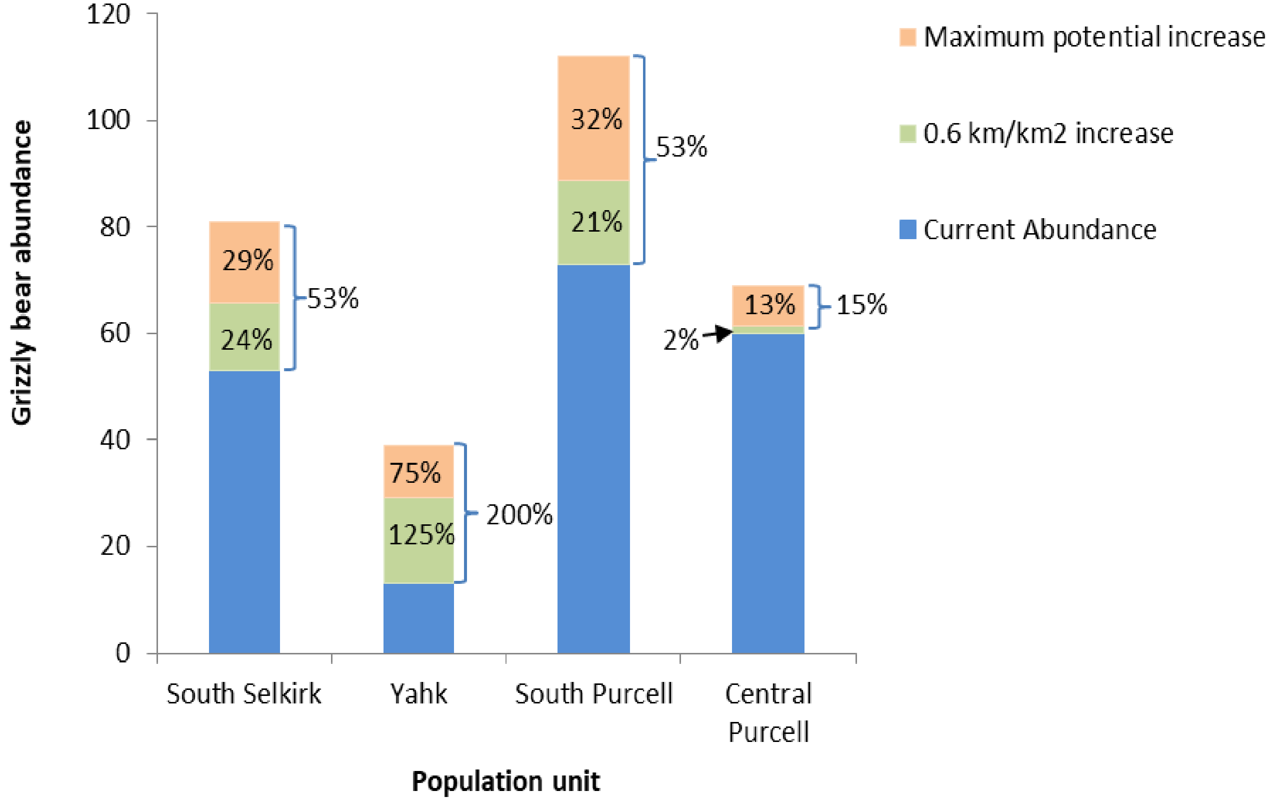
Bottom-up vs top-down influence

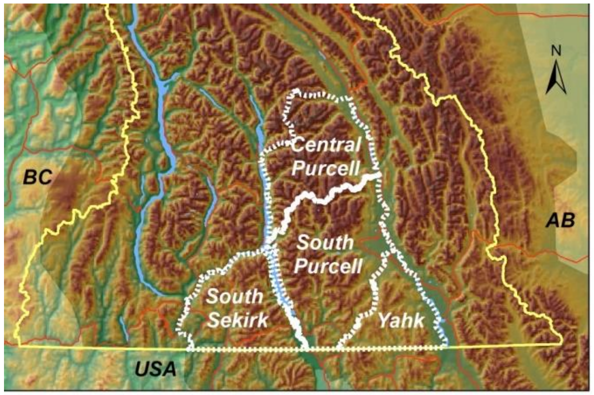


Simulating environmental change (10%) management options

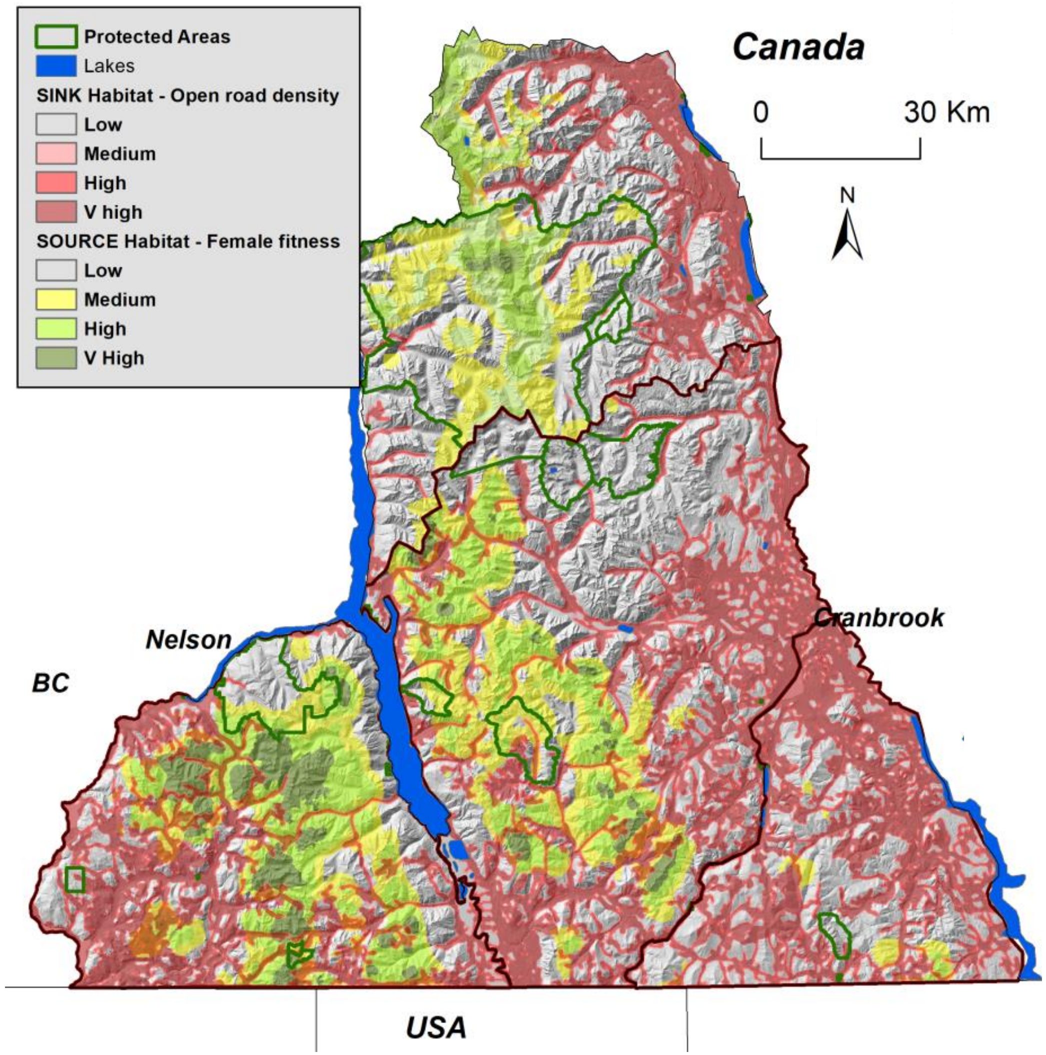


Carrying capacity





Source-like and sink-like habitat



What did we learn?

Food layers more predictive than surrogate variables

Bottom-up food resources very important to grizzly bear habitat selection, fitness and density

But not equally

Food most important for HABITAT SELECTION
Mortality risk increased in influence with FITNESS
And highest in DENSITY

Don't rely on habitat selection studies alone for managing grizzly bear population dynamics

What did we learn?

But how do we manage for bear foods? Very hard

We can manage for habitat security around bear foods to maximize their benefit to bears

Huckleberry patches near roads approaching useless for grizzly bears

Conservation management would benefit from considering both food and mortality risk

A very good option is some degree of access management – very unpopular in BC

What did we learn?

Here we showed the mechanisms and important influences of population processes

Most important food resources locally
And spatialized ON A MAP

We provided the tools for managers to strategically manage grizzly bear habitat to maximize benefit to bears while minimizing inconvenience to people

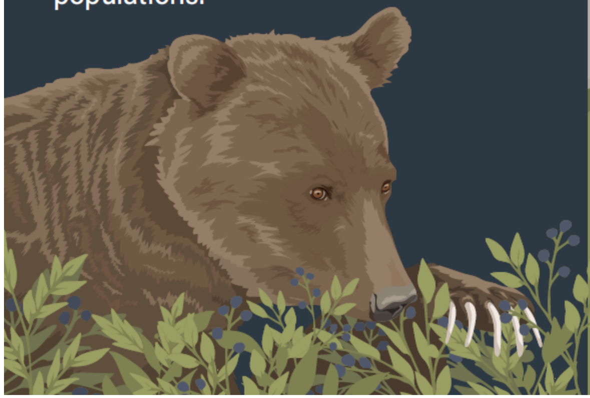
Apply some access management around the best huckleberry patches.

A great benefit to other species as well
Wolverine
Elk
Big horn sheep
Mountain goat
Western toads
Biodiversity

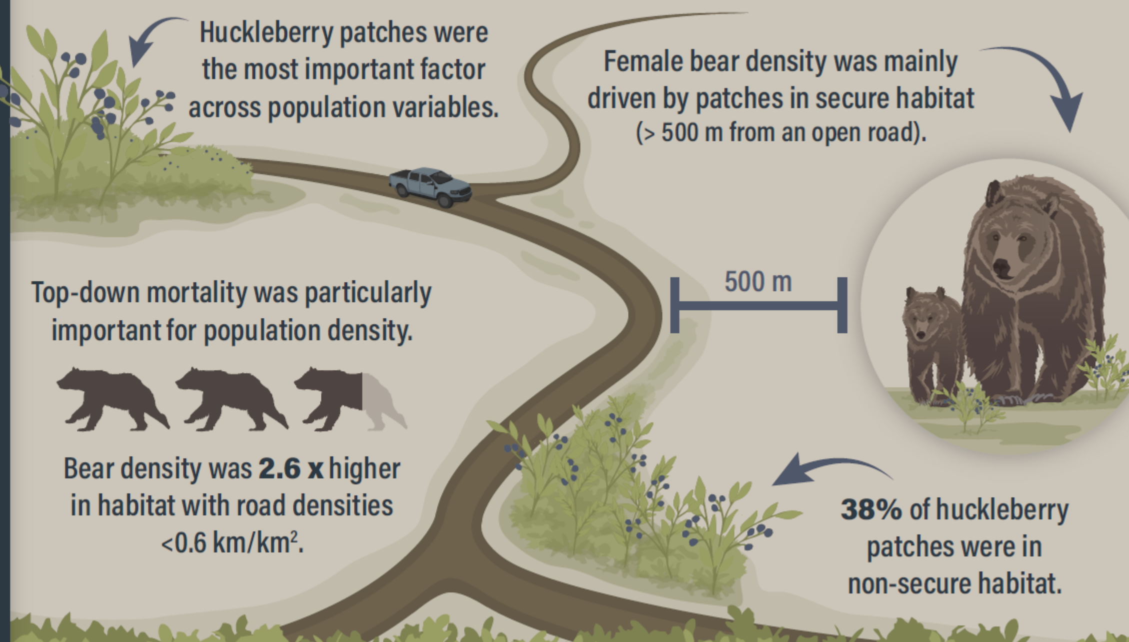
Berries and Bullets

In southeastern British Columbia, grizzly bear populations are influenced by forestry roads. Motorized human access shapes food availability, facilitates human-caused mortality, and displaces bears. Effective grizzly bear management requires understanding the relationship between habitat quality and mortality risk.

The key food source for bears in this area is huckleberry. Therefore, we compared our new huckleberry patch model (bottom-up influence) against road density and secure habitat (top-down mortality risk) to explore their relative influence on bear populations.



Analysis of bear populations (female habitat selection, reproductive success, and density) showed that both bottom-up and top-down influences were important for grizzly bear conservation:



Road density and access to secure habitat not only affect mortality risk but also limit food resources, mimicking the effect of habitat loss. This intensifies the negative effect of road density on grizzly bear populations. **Controlling motorized access in backcountry areas with huckleberry patches** (or any important food source in different ecosystems) would increase grizzly bear abundance and contribute positively to conservation efforts.

Trans-Border Grizzly Bear Project

Conservation status in BC grizzly bears

The old system

Figure 2a) Past map of threatened grizzly bear population units in British Columbia (Hamilton and Austin 2004). This was the understanding and policy when the Trans-border Grizzly Bear Project formed in 2004.

New improved system

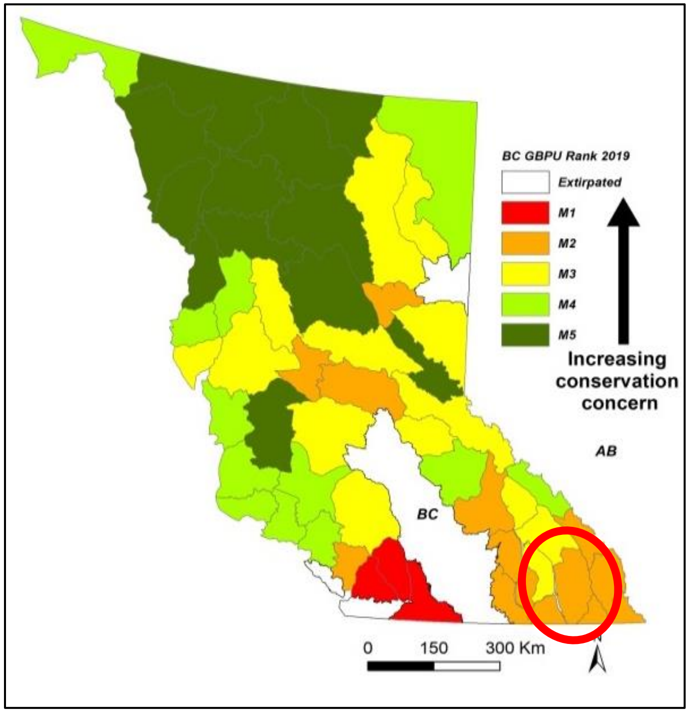


Figure 2b) Current map of conservation ranking of grizzly bear population units in British Columbia (Morgan et al. 2020).