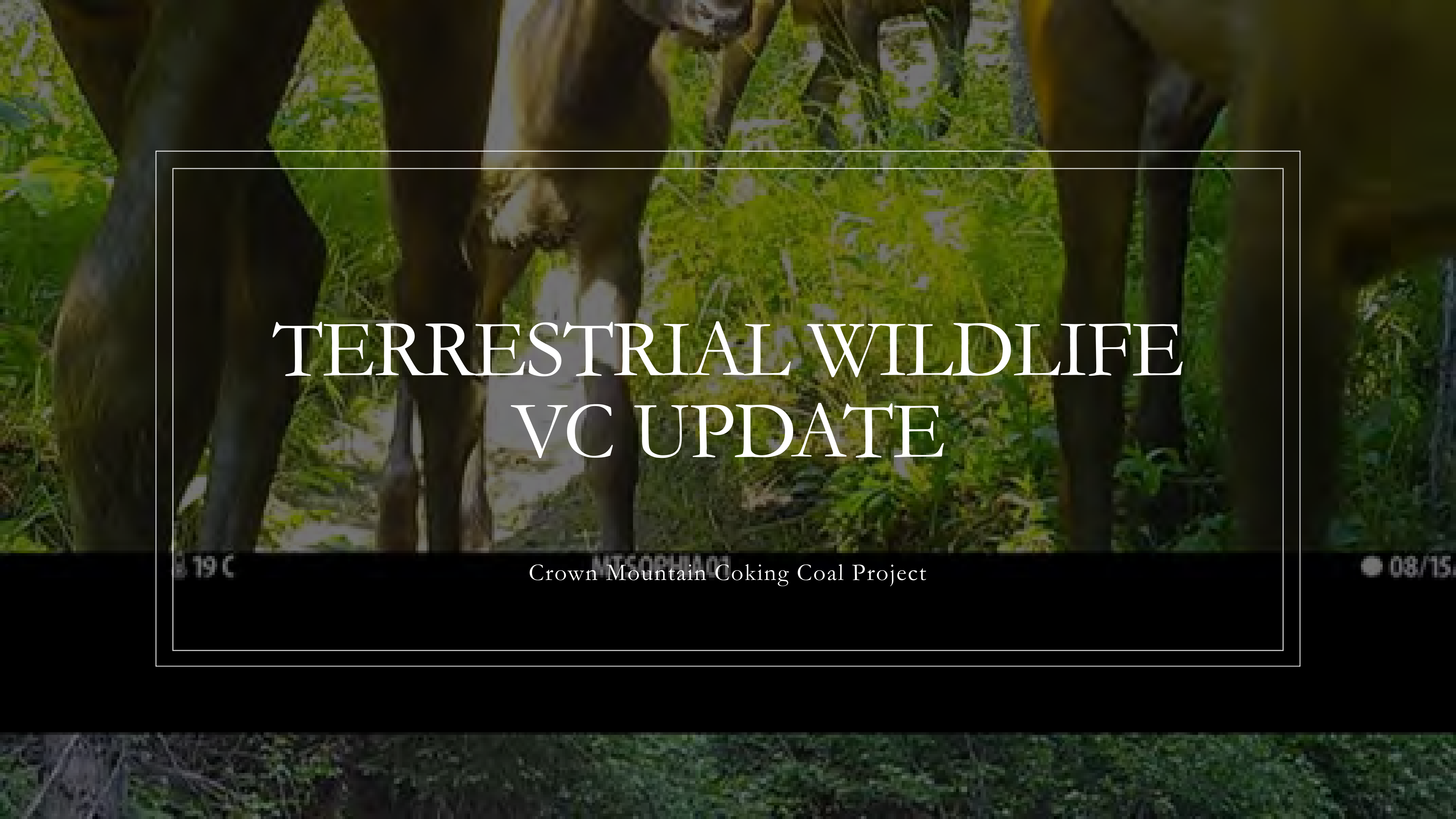
Appendix 4-II

Wildlife Modelling Meeting - November 2019



TERRESTRIAL WILDLIFE VC UPDATE

Crown Mountain Coking Coal Project

Wildlife VC Habitat Model Goals

To provide species-specific quantitative measures of

- Occurrence
- Habitat availability (quality and quantity)
- Distribution

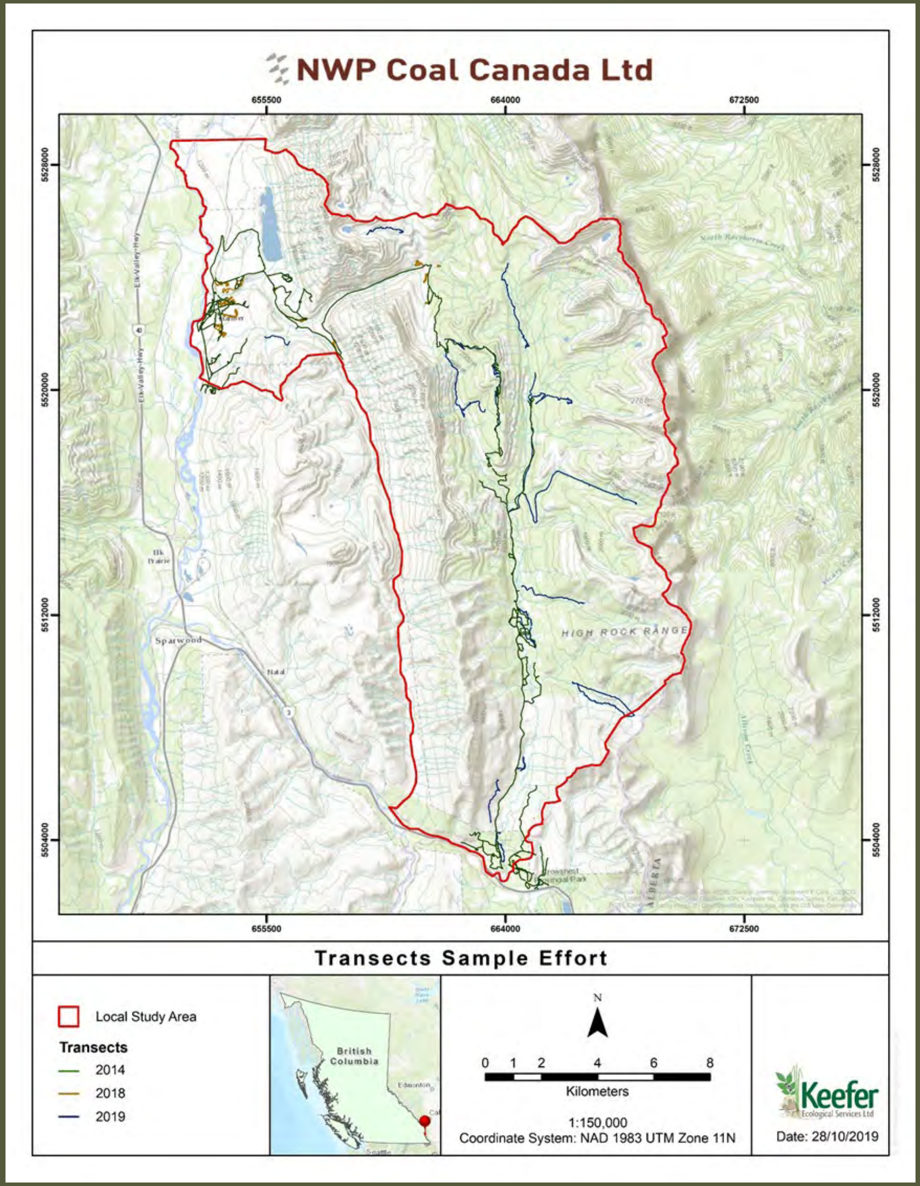
Wildlife VC Habitat Model Approach

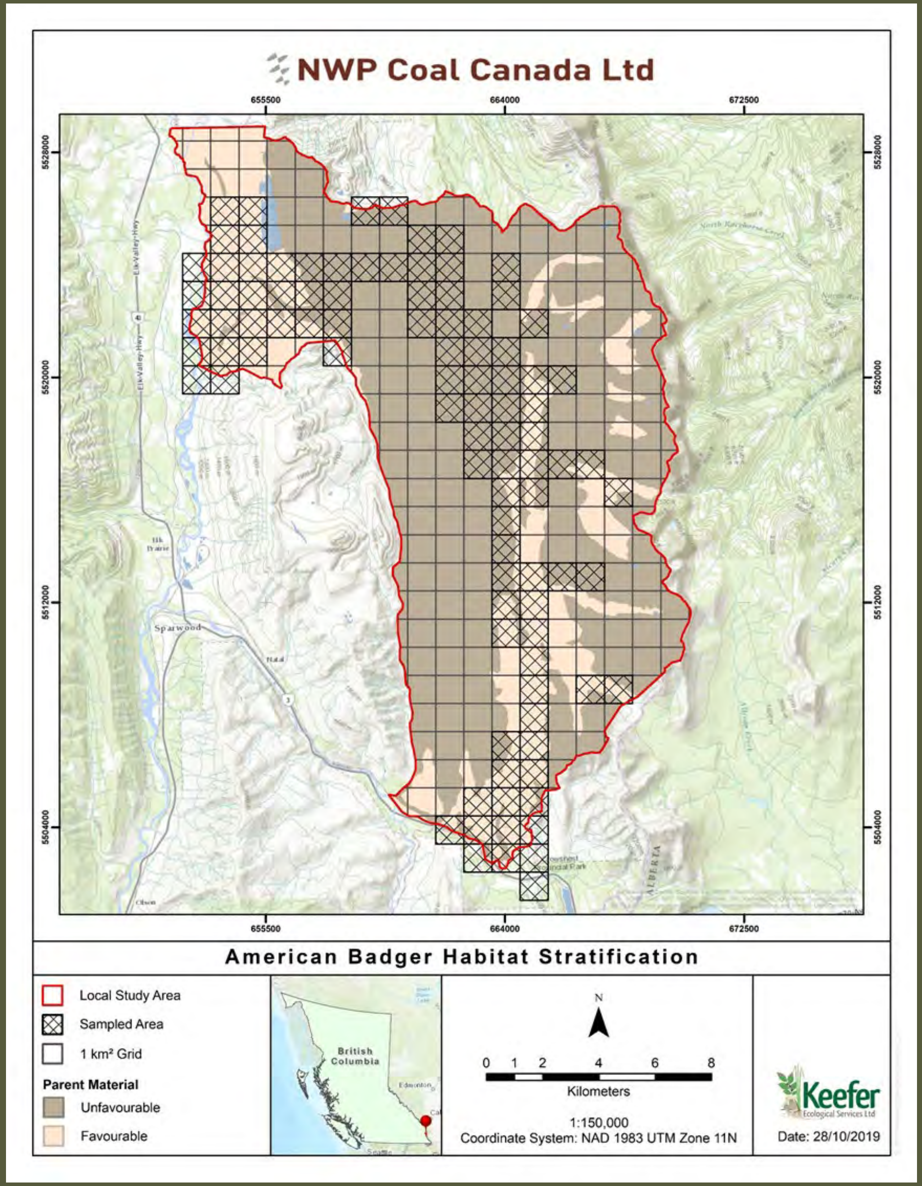
- Occurrence was estimated using an occupancy modeling statistical sampling design framework (MacKenzie et al., 2002)
- Provide inferences on ecological factors (i.e. habitat quality) influencing species site use (MacKenzie et al., 2018)
- Predictive species distribution maps (MacKenzie et al., 2018)

REVIEW & UPDATE

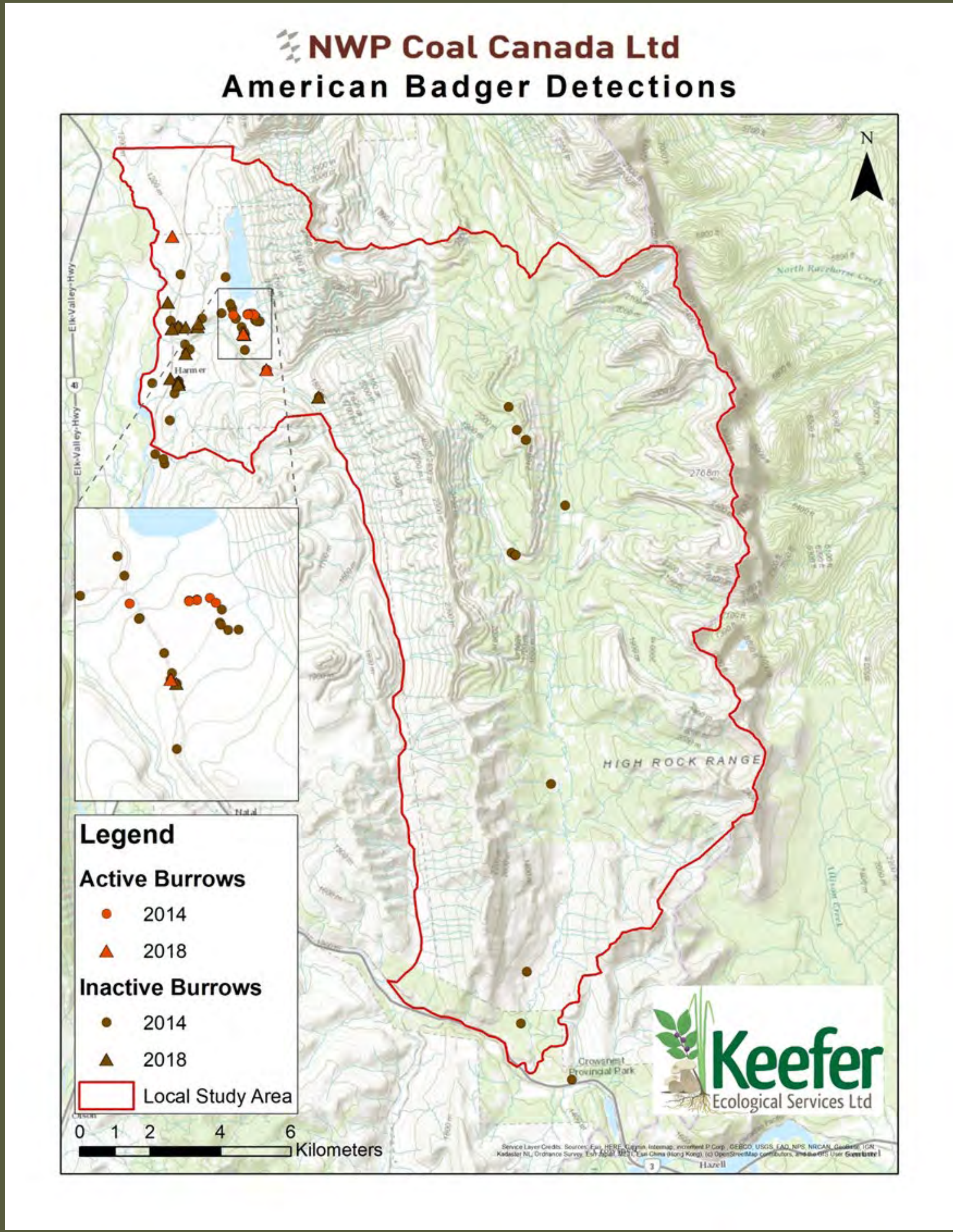
Badger Baseline Report

Sample Effort



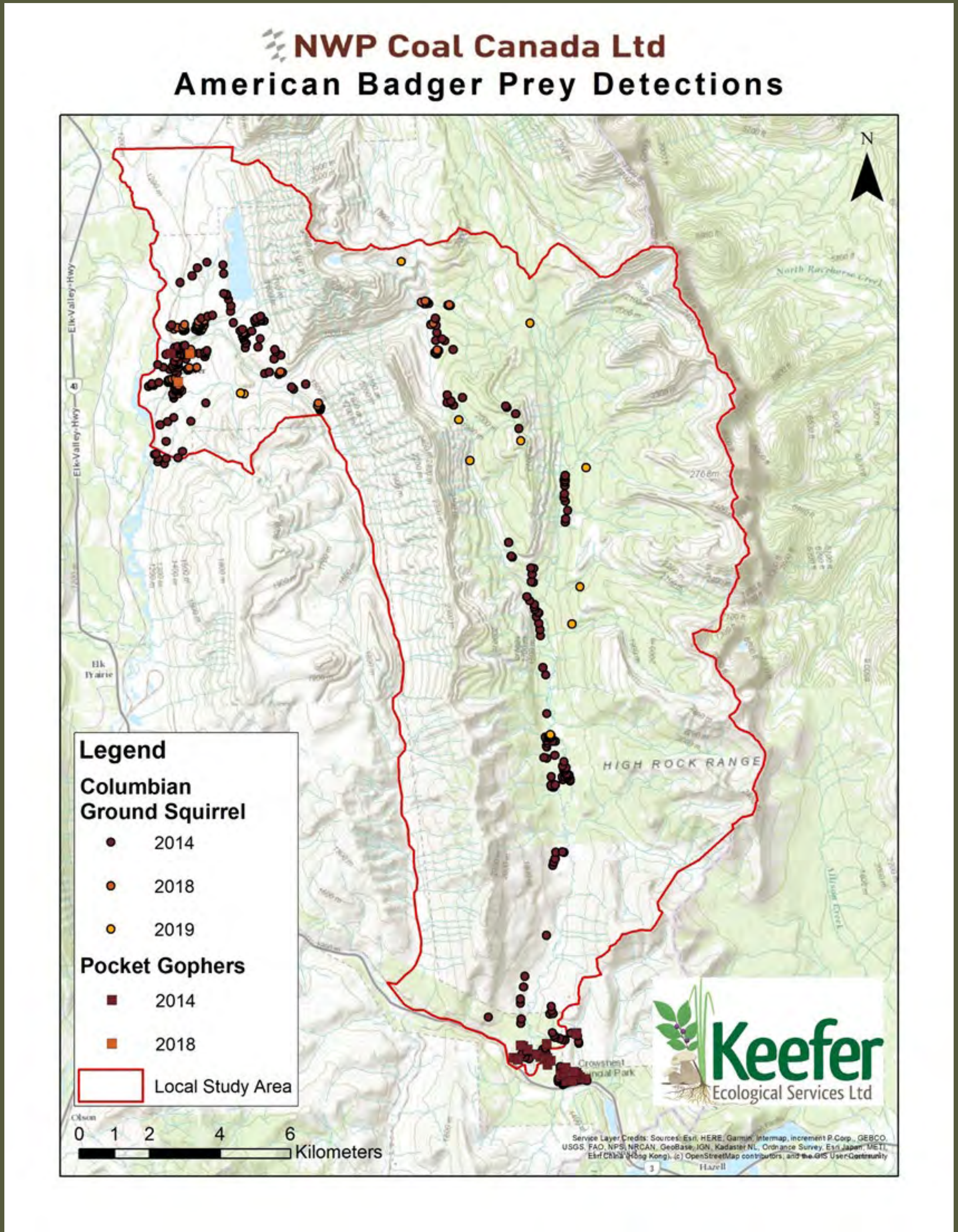


- ▶250 km transects
- ▶112 (1 km2) grid cells



Sample Size

- ▶73 American Badger (burrow) detections



Sample Size

- ▶469 Columbian Ground Squirrel Detections
- ▶30 Northern Pocket Gopher Detections

Habitat Variable Development: American Badger

HABITAT COMPONENT	RELATION TO AMERICAN BADGER FITNESS (+/-)
Parent material	Suitable soil for burrowing (prey capture, security, rest, reproduction and shelter) (+)
Prey	Food resources (+)
Canopy closure	Conditions not suitable for vegetation foraged by prey (-)
Roads	Risk of mortality (-), suitable soils for burrowing (as above) and conditions favouring vegetation foraged by prey (+)
Urban areas	Risk of mortality (-), suitable soils for burrowing (as above) and conditions favouring vegetation foraged by prey (+)
Water	Nutritional requirement (+)

Habitat Variable Development: American Badger Prey

Habitat Component	Relation to Ground Squirrel Fitness (+/-)
Parent material and drainage	Suitable soil for burrowing (security, rest, reproduction and shelter) (+)
Solar radiation	Suitable conditions for vegetation foraged (e.g., grass) (+)
Open Canopy Forest & Grass	Conditions suitable for vegetation foraged (+)
Closed Canopy Forest	Conditions not suitable for vegetation foraged (-)
Cutblock	Conditions suitable for vegetation foraged (+)
Shrubs	Conditions suitable for vegetation foraged (+)
Elevation	Suitable conditions for burrowing and vegetation foraged (+)
Roads	Risk of mortality (-), suitable soils for burrowing (as above) and conditions favouring vegetation foraged (+)
Mines	Disturbance (-), conditions suitable for burrowing and vegetation foraged (+)
Urban Areas	Disturbance (-), conditions suitable for burrowing and vegetation foraged (+)
Water	Nutritional requirement (+)

Habitat Variable Development: Data Sources

Covariate	Original map classes (descriptions)	Unit of Measure	Data Source
Favourable parent material	Glaciolacustrine; Till-Morainal (Stoniness: Not Stony); Eolian; Fluvial (Stoniness: Not Stony, Slightly Stony) TEM: SMU3 fine textured soils	Percent cover of grid cell (%)	Soils Landscape of Canada & BC Ministry of Environment, BC Soil Information Finder Tool Terrestrial Ecosystem Mapping (TEM)
Unfavourable parent material	Colluvial, Fluvial Undifferentiated bedrock, Fen Landcover: Rock/Rubble (Bedrock, rubble, talus, blockfield, or rubbley mine spoils)	Percent cover of grid cell (%)	Soils Landscape of Canada & BC Ministry of Environment, BC Soil Information Finder Tool Canadian Land Cover, Circal 2000
Open canopy forest & grassland	BC & AB: Annual Crop Inventory 2018 Landcovers: Grassland; Annual and Perennial croplands and pasture; Coniferous and Broadleaf open and sparse forests (10-60% crown closure) TEM:	Percent cover of grid cell (%)	Government of Canada, Agriculture & Agri-Food Canada, Annual Crop Inventory 2018; Canadian Land Cover, Circal 2000
Closed canopy	Landcover: Coniferous and Broadleaf dense forests (greater than 60% crown closure)	Percent cover of grid cell (%)	Canadian Land Cover, Circal 2000
Urban areas	Compact settlements, 500m buffer (cities, towns and villages) Isolated built up units, 500m buffer (manufacturing plants, rail yards, military camps, waste disposal areas, leisure areas, liquid storage areas, building, and ritual cultural areas)	Mean distance in grid cell to nearest urban area (meters) Calculated using ArcGis 10.7 (Euclidean distance)	BC Ministry of FLNRORD- Geo BC, Baseline Thematic Mapping Present Land Use Version 1 Spatial Layer; Residential areas from Alberta Biodiversity Monitoring Institute, Human Footprint Inventory 2016; AB Waste disposal areas, residential areas, leisure areas, liquid storage areas, buildings, ritual cultural areas from Topographic Data of Canada- CanVec Series

Habitat Variable Development: Data Sources

Covariate	Original map classes (descriptions)	Unit of Measure	Data Source
Cutblock	Consolidated cutblocks (2010-2018)	Percent cover of grid cell (%)	Harvested Areas of BC (Consolidated Cutblocks), 2019
Mines	Mine spoils, tailings, open pit mines, reclaimed	Mean distance in grid cell (metres)	BC Ministry of FLNRORD- GeoBC, Baseline Thematic Mapping Present Land Use Version 1 Spatial Layer; EV CEMF shapefile [ev_disturbance] VRI-Forest Vegetation Composite Polygons and Rank 1 layer Alberta Biodiversity Monitoring Institute, Human Footprint Inventory 2016
Elevation	British Columbia Alberta	Metres	BC Ministry FLNRORD- GeoBC Altalis
Solar radiation	Maximum daily solar radiation from May to August, 2019	Watt hours/metres^2	Calculated from Elevation covariate using ArcGis 10.7, Spatial Analyst toolbox; Area Solar Radiation
Water	BC: Lakes and streams AB: Hydrography Landcover: Wetland (land with water table near/at/above soil surface)	Mean distance in grid cell to nearest water source (meters)	BC Ministry of FLNRORD- GeoBC, Freshwater Atlas Lakes & Freshwater Atlas Stream; AB Altalis Base Features Hydrography
Roads & Highways	Secondary roads (paved roads, 10m buffer); Tertiary roads (gravel roads and trails, 8.5m buffer); Highways (paved & unpaved, 15m buffer)	Mean distance in grid cell to nearest road (meters)	GeoBC Atlas, Integrated Transportation Network; BC Ministry of FLNRORD, EV CEMF, Shapefile [Merged_Roads_2017_CE]; Alberta Biodiversity Monitoring Institute, Human Footprint Inventory 2016

Methods: Matrix Development

SITE ID	# Samples	# Badger Detections	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Sample 11	Sample 12	Sample 13	Sample 14	Sample 15	Sample 16
33066	3	1	1	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.
33495	1		0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
33496	12		0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.
33497	12		0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.
33926	8		0	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.
33927	16	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
33928	5		0	0	0	0	0	.	.	.	.	.	.	.	.	.	.	.
34357	2		0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34358	3		0	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.
34359	2		0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.
34789	7	1	0	0	1	0	0	0	0	.	.	.	.	.	.	.	.	.
34790	1		0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
35220	4		0	0	0	0	.	.	.	.	.	.	.	.	.	.	.	.
35221	8		0	0	0	0	0	0	0	0	.	.	.	.	.	.	.	.
35652	2		0	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36083	6		0	0	0	0	0	0	.	.	.	.	.	.	.	.	.	.
36085	6		0	0	0	0	0	0	.	.	.	.	.	.	.	.	.	.
36086	6		0	0	0	0	0	0	.	.	.	.	.	.	.	.	.	.
36514	13		0	0	0	0	0	0	0	0	0	0	0	0	0	.	.	.
36515	1		0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36516	1		0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
36944	7	1	0	0	0	0	0	1	0	.	.	.	.	.	.	.	.	.
36945	12		0	0	0	0	0	0	0	0	0	0	0	0	.	.	.	.
37375	14		0	0	0	0	0	0	0	0	0	0	0	0	0	0	.	.
37376	9		0	0	0	0	0	0	0	0	0	.	.	.	.	.	.	.
37806	6		0	0	0	0	0	0	.	.	.	.	.	.	.	.	.	.
37807	3		0	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.
37808	3		0	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.
37809	1		0	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
38237	7		0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
38668	5		0	0	0	0	0	.	.	.	.	.	.	.	.	.	.	.
39099	11		0	0	0	0	0	0	0	0	0	0	0	.	.	.	.	.
39100	7		0	0	0	0	0	0	0	.	.	.	.	.	.	.	.	.
39103	3		0	0	0	.	.	.	.	.	.	.	.	.	.	.	.	.
39529	3	3	1	0	1	.	.	.	.	.	.	.	.	.	.	.	.	.
39530	5		0	0	0	0	0	.	.	.	.	.	.	.	.	.	.	.

Badger Detection Matrix LSA | DetectionCovariateVehicle | DetectionCovariateATV | DetectionCovariateWalking | DetectionCovariateObserver1 | De ...

Model selection procedure for factors influencing Columbian Ground Squirrel detectability (p) obtained from 959 (250 m) surveys of 102 (1 km2) grid cells in the Crown Mountain LSA.

Factors considered are: survey observers (O), whether the survey was conducted using a vehicle or on foot (M), open canopy forest and grasslands (OCG) and proximity to roads (RD). The model Ψ(.) assumes that occurrence is constant.

Model	AICc	ΔAICc	w	k	-2LL
p(O)	1022.33	0.00	1.00	4	1013.92
P(OCG)	1066.89	44.56	0.00	3	1060.65
p(M)	1104.75	82.42	0.00	4	1096.34
P(RD)	1127.14	104.81	0.00	3	1120.90
p(.)	1146.54	124.21	0.00	2	1142.42

AICc values; the relative difference in AICc values between each model and the model with the lowest AICc (ΔAICc); AICc model weights (w); the number of parameters in the model (k); twice the negative log-likelihood(-2LL).

Results

- Species detectability varied with survey observers

Results

Global model included:

- Open canopy forests & grasslands
- Unfavourable & favourable material
- Distance to roads
- Solar radiation
- Distance to urbans areas and mines
- Pearson Correlation test

Univariate model selection procedure for factors influencing Columbian Ground Squirrel site occupancy (Ψ) obtained from 959 (250 m) surveys of 102 (1 km2) grid cells in the Crown Mountain LSA. Habitat components considered are unfavourable parent material (UF), favourable parent material (FM), open canopy forest and grasslands, (OCG), closed canopy forest (CC), cut blocks (CB), elevation (E), solar radiation (SR), distance to water(W), distance to urban areas (UR) and distance to mines (MN). Columbian Ground Squirrel detectability varies with survey observers. The model Ψ(.) assumes that occurrence is constant.

Model	AICc	∆AICc	w	k	-2LL
Ψ (OCG)	1018.75	0.00	0.2966	5	1008.12
Ψ (UF)	1020.12	1.38	0.1495	5	1009.49
Ψ (FM)	1020.33	1.59	0.1346	5	1009.70
Ψ (RD)	1021.73	2.99	0.0669	5	1011.10
Ψ (SR)	102186	3.12	0.0626	5	1011.23
Ψ (UR)	1022.15	3.40	0.0542	5	1011.53
Ψ (MN)	1022.21	3.47	0.0526	5	1011.58
Ψ (.)	1022.33	3.59	0.0495	4	1013.92
Ψ (CC)	1022.52	3.77	0.0450	5	1011.90
Ψ (E)	1022.82	4.08	0.0388	5	1012.19
Ψ (W)	1023.63	4.88	0.0259	5	1013.00
Ψ (CB)	1023.80	5.05	0.0237	5	1013.18

AICc values; the relative difference in AICc values between each model and the model with the lowest AICc (ΔAICc); AICc model weights (w); the number of parameters in the model (k); twice the negative log-likelihood(-2LL).

Table 1. Model selection procedure for factors influencing Columbian Ground Squirrel site occupancy (Ψ) obtained from 959 (250 m) surveys of 102 (1 km^2) grid cells in the Crown Mountain Coking Coal Project Local Study Area, BC. Hypotheses considered are the influence of unfavourable (burrowing) parent material (UF) and favourable parent material (FM), open canopy forest, grasslands (OCG), maximum (May-Aug) solar radiation (SR), and proximity to roads (RD), urban areas (UR) and mines (MN). Columbian Ground Squirrel detectability varies with survey observers. The model Ψ(.) assumes that occurrence is constant.

Model	AICc	ΔAICc	w	k	-2LL	Ψ (SE)
Ψ (UF,OCG)	1017.67	0.00	0.1173	6	1004.79	0.78(0.09)
Ψ (OCG,FM)	1017.84	0.17	0.1078	6	1004.96	0.78(0.09)
Ψ (OCG,UF,RD)	1017.86	0.19	0.1067	7	1002.67	0.72(0.10)
Ψ (OCG,FM,RD)	1017.99	0.32	0.1000	7	1002.80	0.72(0.10)
Ψ (OCG,RD)	1018.67	1.00	0.0712	6	1005.79	0.73(0.09)
Ψ (OCG)	1018.75	1.08	0.0684	5	1008.12	0.78(0.07)
Ψ (OCG,UF,MN)	1019.87	2.20	O.0391	7	1004.68	0.79(0.12)
Ψ (OCG,FM,MN)	1020.05	2.38	0.0357	7	1004.86	0.79(0.12)
Ψ (UF)	1020.12	2.45	0.0345	5	1009.49	0.81(0.07)
Ψ (OCG,UR)	1020.16	2.49	0.0338	6	1007.28	0.77(0.09)
Ψ (UF,RD)	1020.16	2.49	0.0388	6	1007.28	0.74(0.09)
Ψ (FM)	1020.33	2.66	0.0310	5	1009.70	0.81(0.07)
Ψ (OCG,MN)	1020.97	3.30	0.0195	6	1008.09	0.81(0.07)
Ψ (UF,UR)	1021.26	3.59	0.0186	6	1008.38	0.79(0.09)
Ψ (F,UR)	1021.35	3.68	0.0154	6	1008.47	0.79(0.09)
Ψ (RD)	1021.73	4.06	0.0146	5	1011.10	0.79(0.09)
Ψ (UR,MN)	1021.84	4.17	0.0144	6	1008.96	0.75(0.08)
Ψ (SR)	1021.86	4.19	0.0141	5	1011.23	0.78(0.12)
Ψ (RD,SR)	1021.91	4.24	0.0138	6	1009.03	0.80(0.08)
Ψ (UF,SR)	1021.95	4.28	0.0135	6	1009.07	0.75(0.09)
Ψ (FM,MN)	1022.00	4.33	0.0132	6	1009.12	0.81(0.10)
Ψ (UF,RD,SR)	1022.04	4.37	0.0127	7	1006.85	0.78(0.09)
Ψ (FM,SR)	1022.11	4.44	0.0125	6	1009.23	0.74(0.11)
Ψ (.)	1022.33	4.66	0.0114	4	1013.92	0.82(0.06)
Model Average						**0.77(0.09)**

Results

- Columbian Ground Squirrel used approximately 77% of the sites surveyed
- 22% higher than the Naïve estimate 0.598

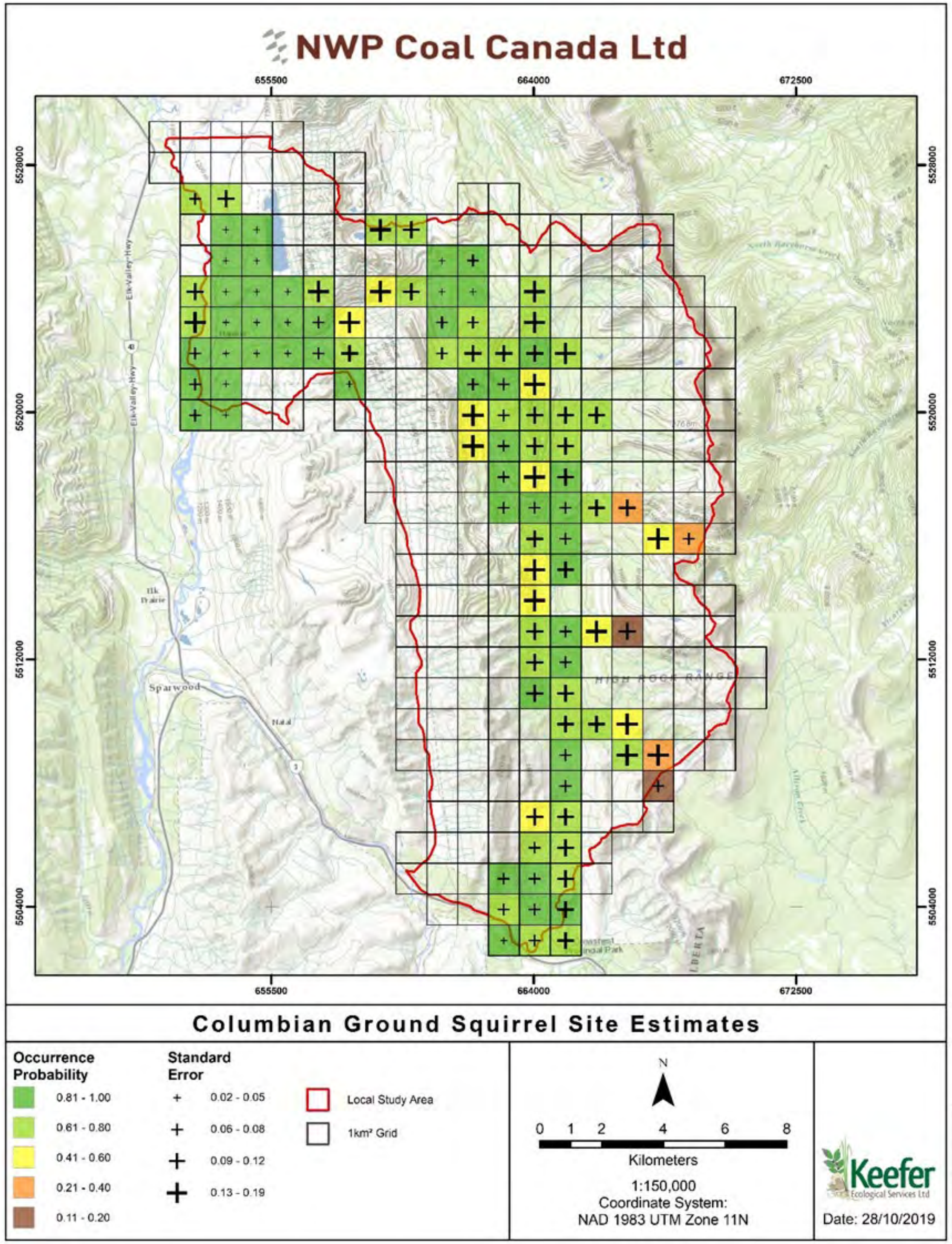
Table 2. Habitat variables influencing Columbian Ground Squirrel occurrence in the Crown Mountain, British Columbia (2014-2019), ranked according to their relative contribution (∑w)/, β co-efficients and associated standard errors (SE). ∑w is the weight of evidence or relative amount that a variable contributes to Columbian ground squirrel occurrence at a (1 km^2) site (n = 102). The β-coefficient is the strength and direction (±) of influence.

Variable	**∑w**	**β**	**SE**
Open Canopy Forest, Grasslands	0.71	**1.056**	**0.500**
Unfavourable Parent Material	0.39	**-1.661**	**0.448**
Roads	0.35	**0.842**	**0.426**
Favourable Parent Material	0.32	**1.630**	**0.452**
Mines	0.14	0.812	0.576
Urban Areas	0.07	0.560	0.371
Solar Radiation	0.07	-0.636	0.401

Results

Most important predictors of Columbian Ground Squirrels:

- Unfavourable parent material
- Favourable parent material
- Open Canopy Forest and Grasslands
- Proximity to roads



Site-specific Estimates

- Columbian Ground Squirrel used approximately 77% of the sites surveyed
- 22% higher than the Naïve estimate 0.598
- Baseline occurrence estimates that future change can be measured against.

Table 4. Model selection procedure for factors influencing American Badger site occupancy (Ψ) obtained from 582 (500 m) surveys of 97 (1 km^2) grid cells in the Crown Mountain Coking Coal Project Local Study Area, British Columbia. Hypotheses considered are the influence of unfavourable parent material (UM) and favourable parent material (FM), primary prey (PP), open canopy forest, grasslands and crops (OCG) and distance to mines (MN). American Badger detectability varies with survey observer. Ψ(.) assumes that occurrence is constant.

Model	AICc	∆AICc	w	k	-2LL	Ψ (SE)
Ψ (OCG)	320.60	0.00	0.3085	5	309.94	0.38 (0.09)
Ψ (OCG,UF)	320.62	0.02	0.3054	5	307.69	0.41 (0.11)
Ψ (PP)	321.27	0.67	0.2207	5	310.61	0.40 (0.11)
Ψ (MN)	323.05	2.45	0.0906	5	312.39	0.39 (0.10)
Ψ (UF,MN)	324.45	3.85	0.0450	6	311.52	0.39 (0.12)
Ψ (UF)	326.62	6.02	0.0152	5	315.96	0.41 (0.10)
Ψ (.)	326.70	6.10	0.0146	4	318.27	0.40 (0.11)
Model Average						**0.40 (0.12)**

Results

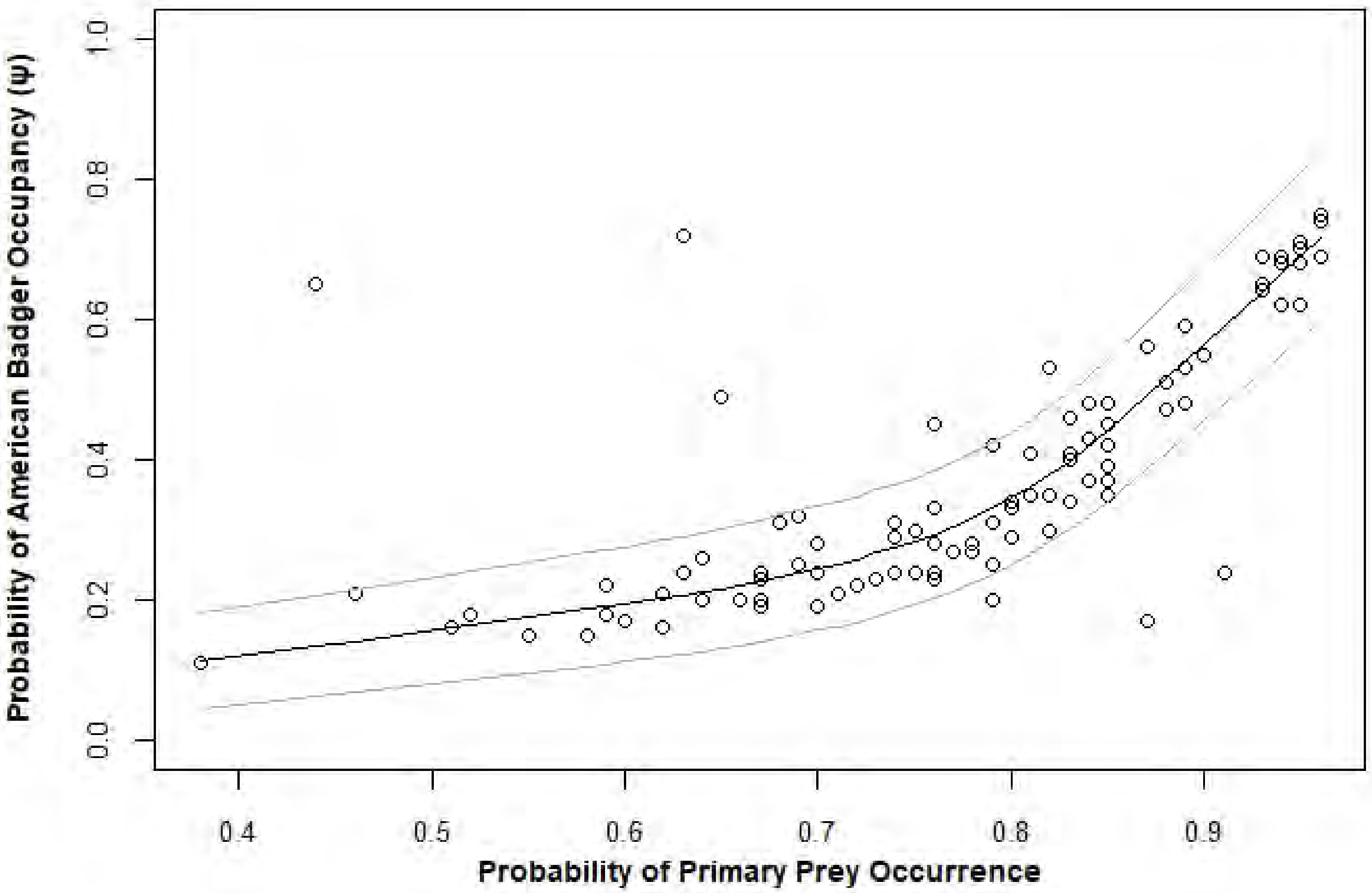
- American Badgers used approximately 40% of the 97km2 sample of potential habitat
- 45% higher than the Naïve estimate 0.22

Results

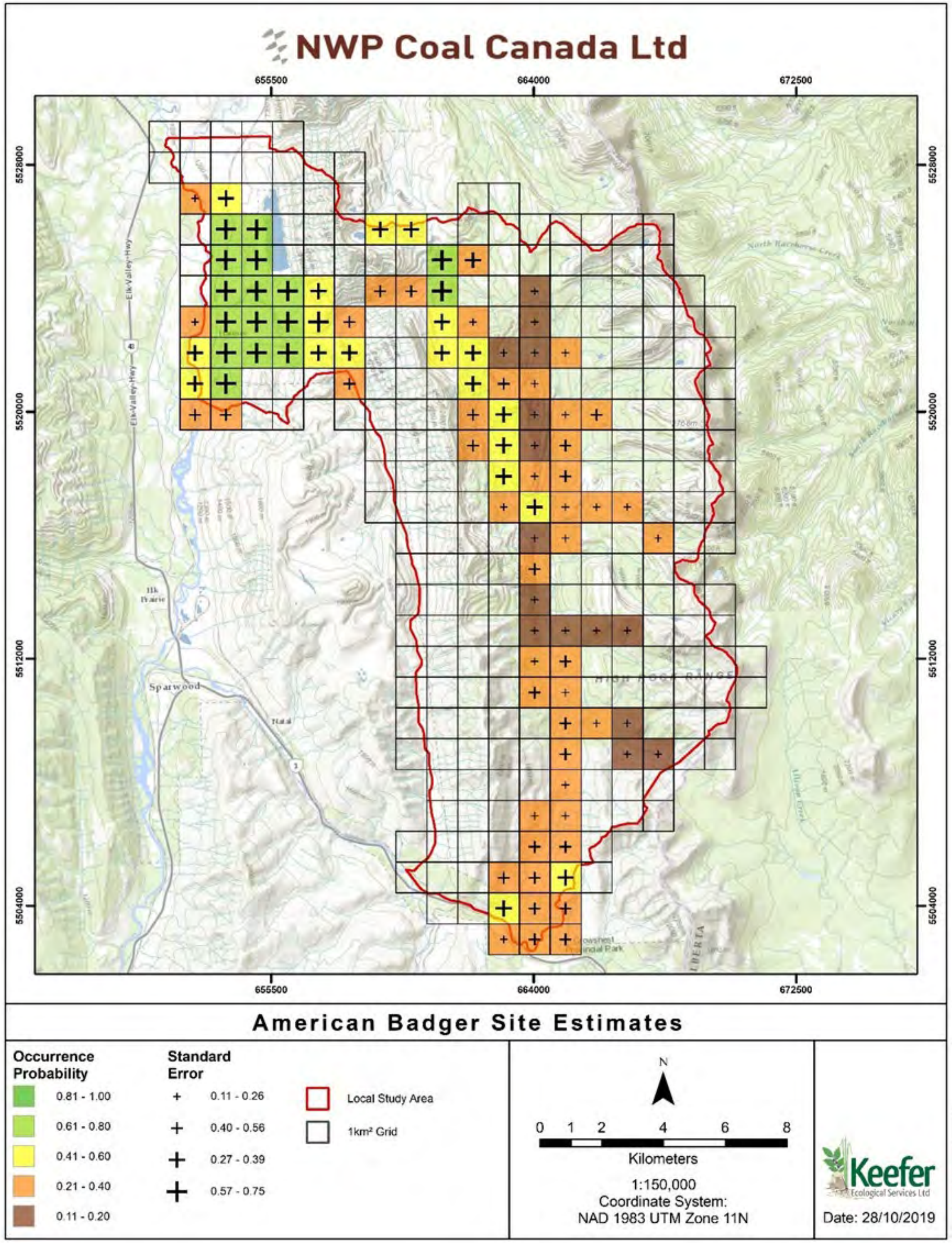
Table 2. Habitat variables influencing American Badger occurrence in the Crown Mountain, British Columbia (2014-2019), ranked according to their relative contribution (∑w), β co-efficients and associated standard errors (SE). ∑w is the weight of evidence or relative amount that a variable contributes to American Badger occurrence at a (1 km^2) site (n = 97). The β-coefficient is the strength and direction (±) of influence.

Variable	∑w	β	SE
Open Canopy Grass	0.61	**0.865**	**0.322**
Unfavourable Material	0.37	**-0.514**	**0.254**
Primary Prey	0.22	**8.270**	**3.091**
Mines	0.14	**0.959**	**0.434**

Bold entries indicates robust impact (±1.96 × SE not overlapping zero).

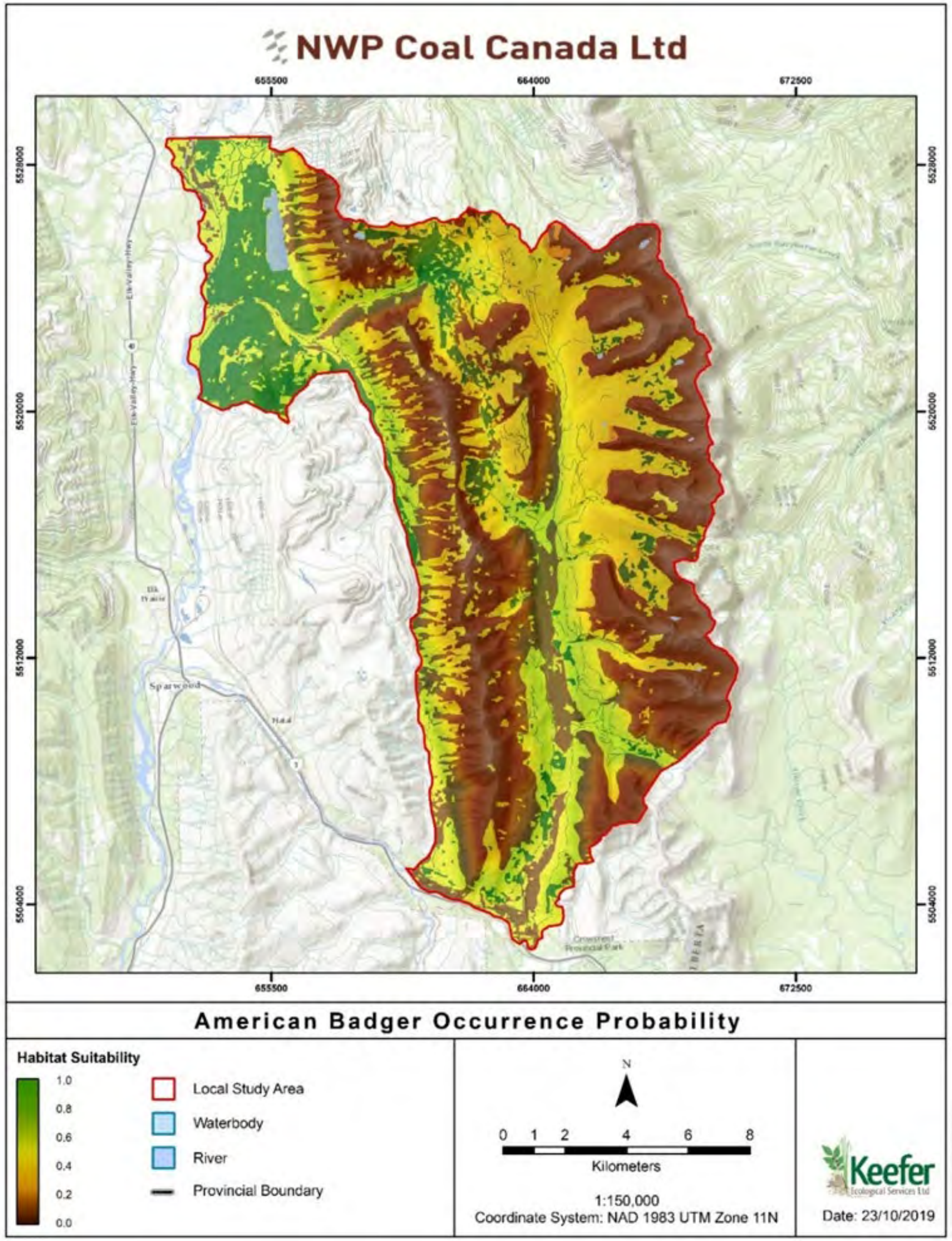


- Mean site occupancy was Ψ = 0.501 (SE = 0.102) at sites with >80% primary prey occurrence (n = 44) compared to Ψ = 0.248 (SE = 0.087) at sites with <70% primary prey occurrence (n = 53)



Site-specific Estimates

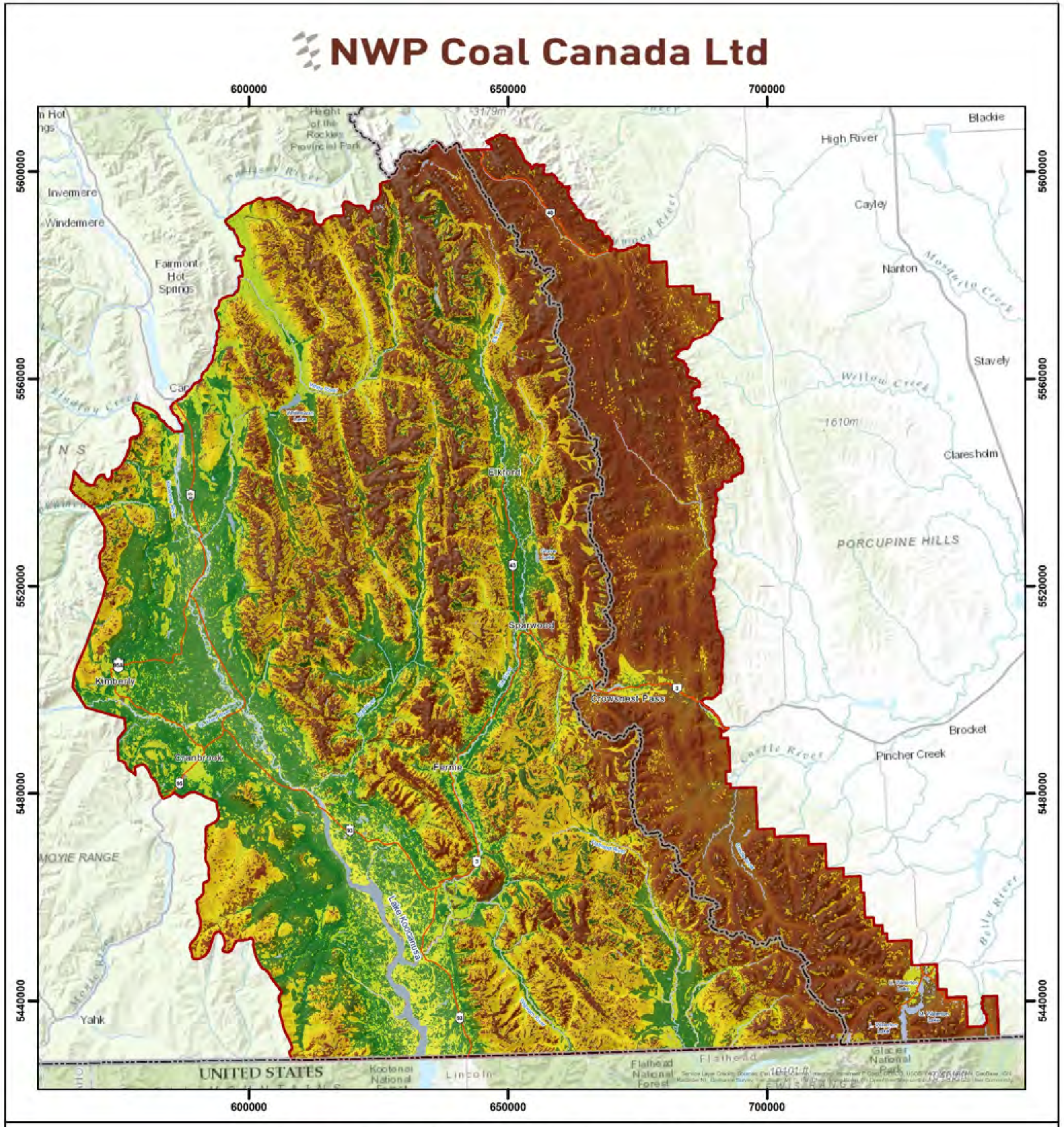
- American Badgers used approximately 40% of the 97km2 sample of potential habitat
- 45% higher than the Naïve estimate 0.22



American Badger Habitat Suitability

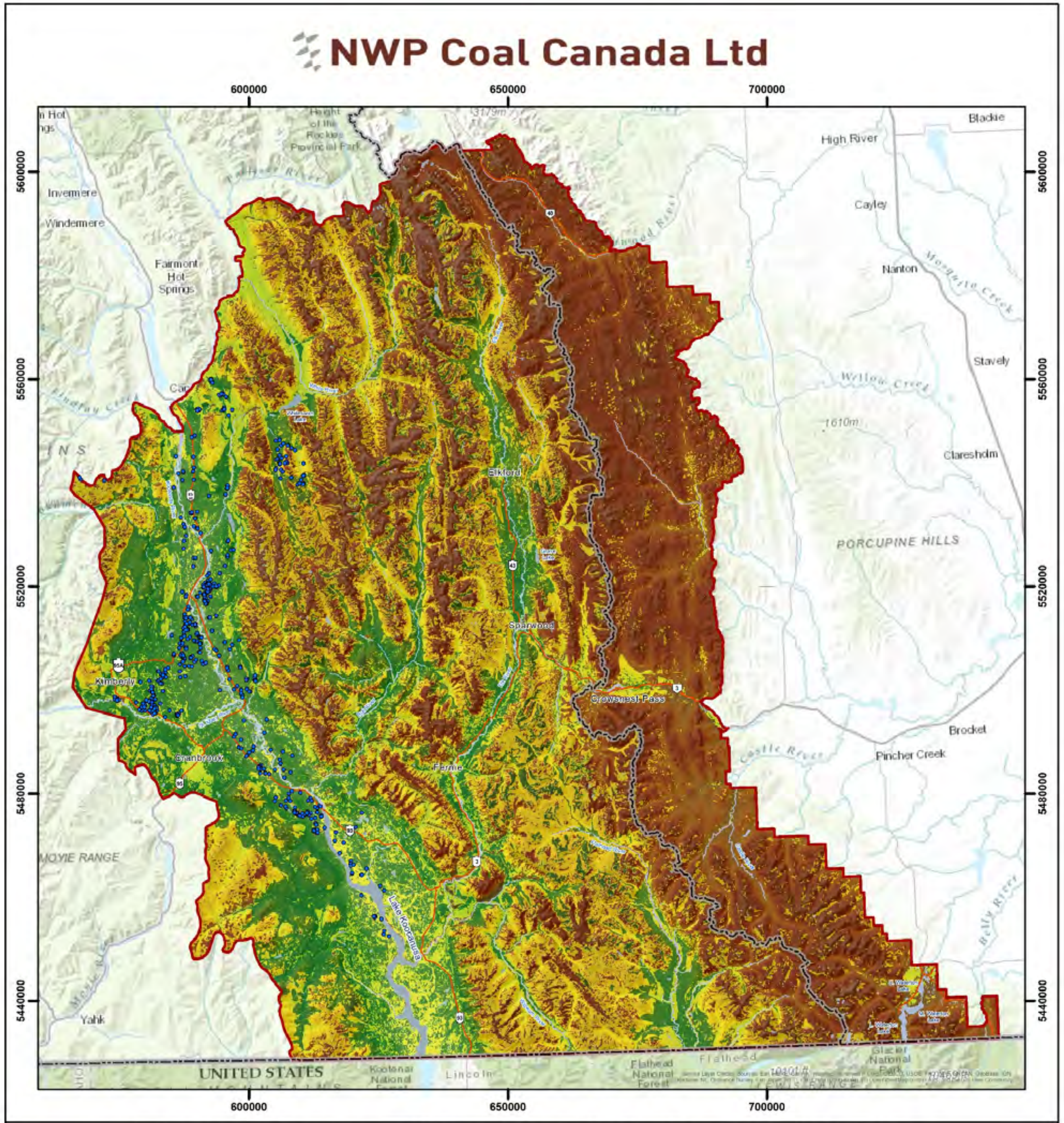
Habitat suitability model based on resulting regression equation from weighted model averaged estimates considering:

- Favourable and Unfavourable parent material
- Open Canopy forests and grasslands
- Distance to mines
- Prey (Columbian Ground Squirrel)



American Badger Habitat Suitability

- Habitat suitability model based on resulting regression equation from weighted model averaged estimates considering:
  - Favourable and Unfavourable parent material
  - Open Canopy forests and grasslands
  - Distance to mines
  - Urban and developed areas
  - Solar radiation



American Badger Habitat Suitability: Model Validation

American Badger Habitat Suitability

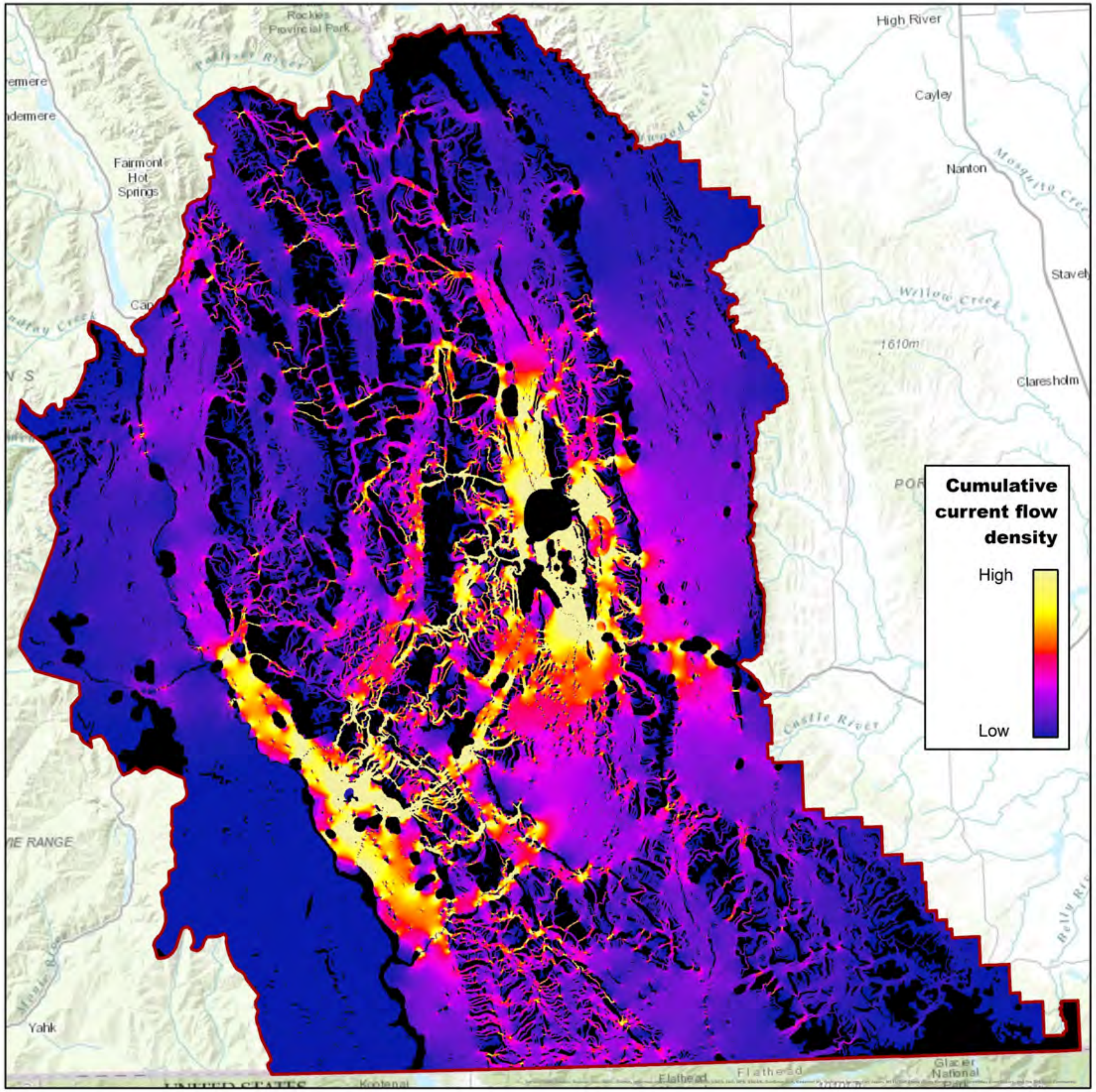
Predicted probability of habitat use, overlaid with 649 American Badger collar detections (1996-2002).

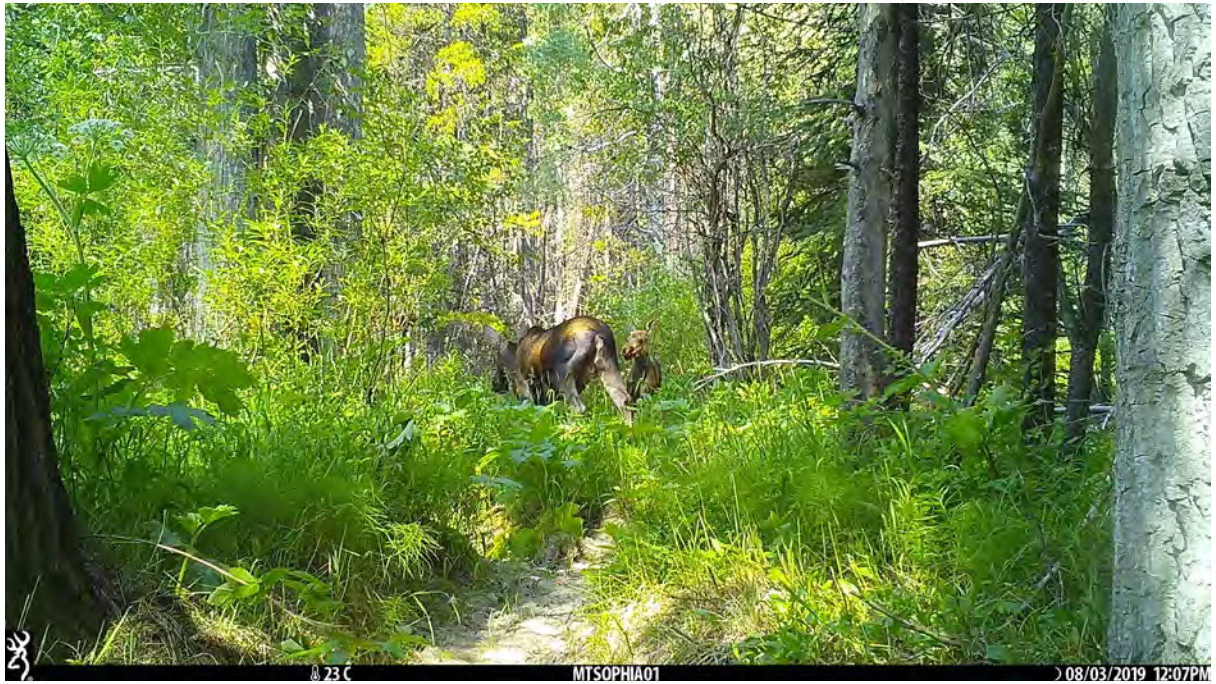
The mean predicted probability of habitat use for all GPS collar locations was 0.79

Connectivity

Least Cost Path Analyses (circuit theory)

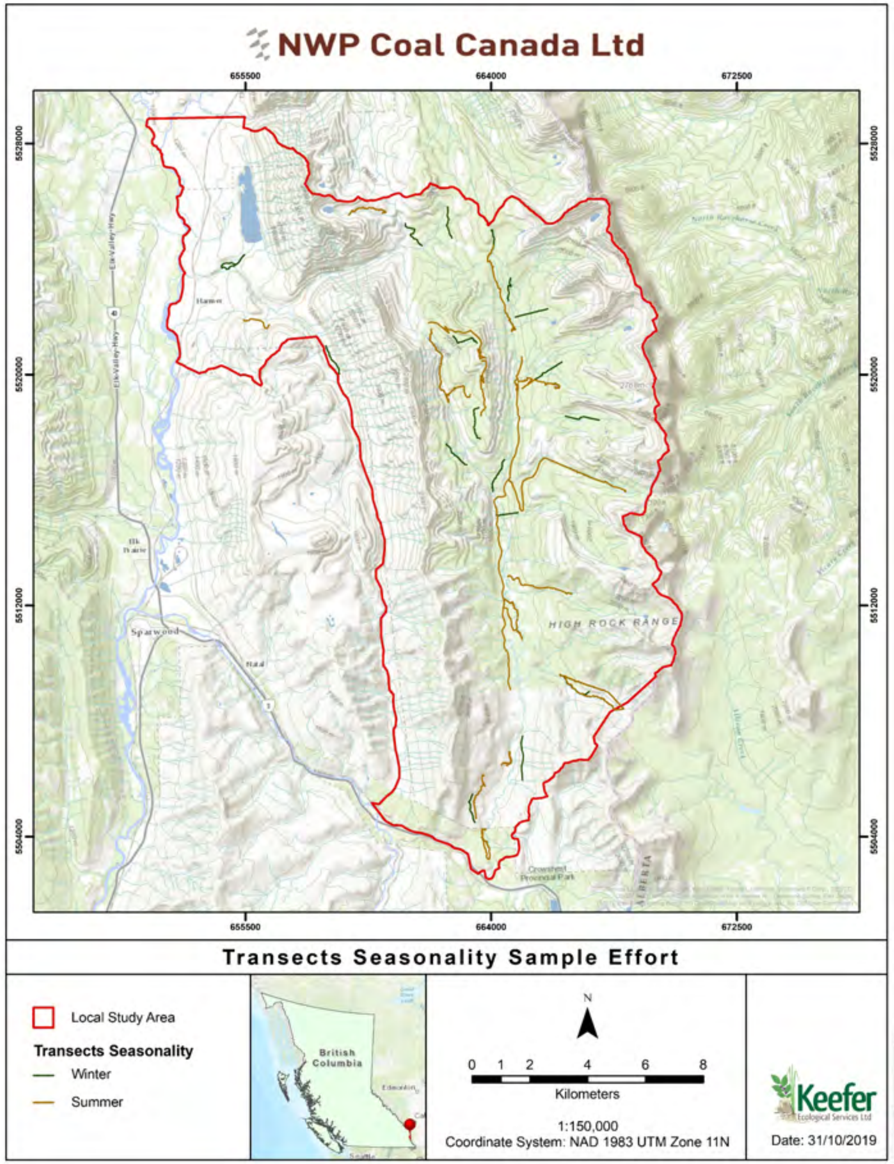
- Resistance surfaces based on habitat modeling
- Core habitats based on predictive model and CDC imap species known locations

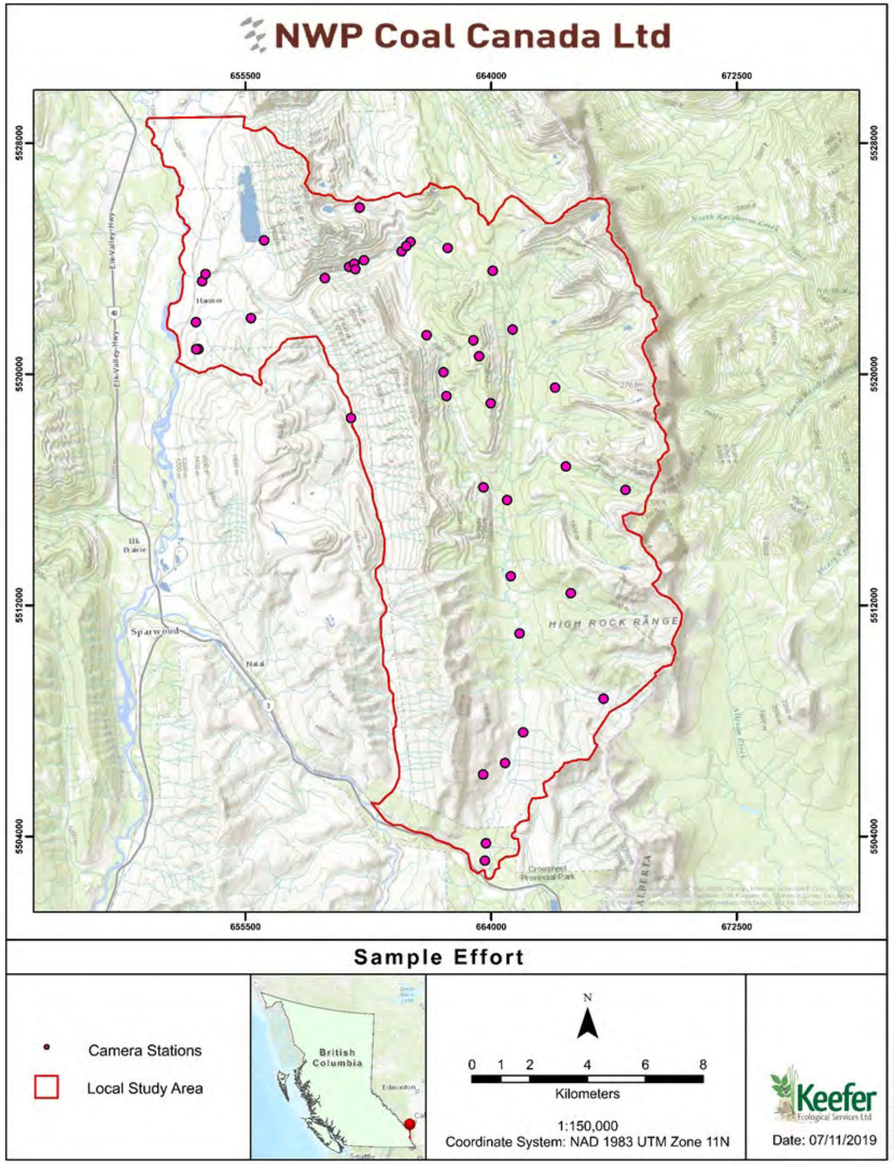




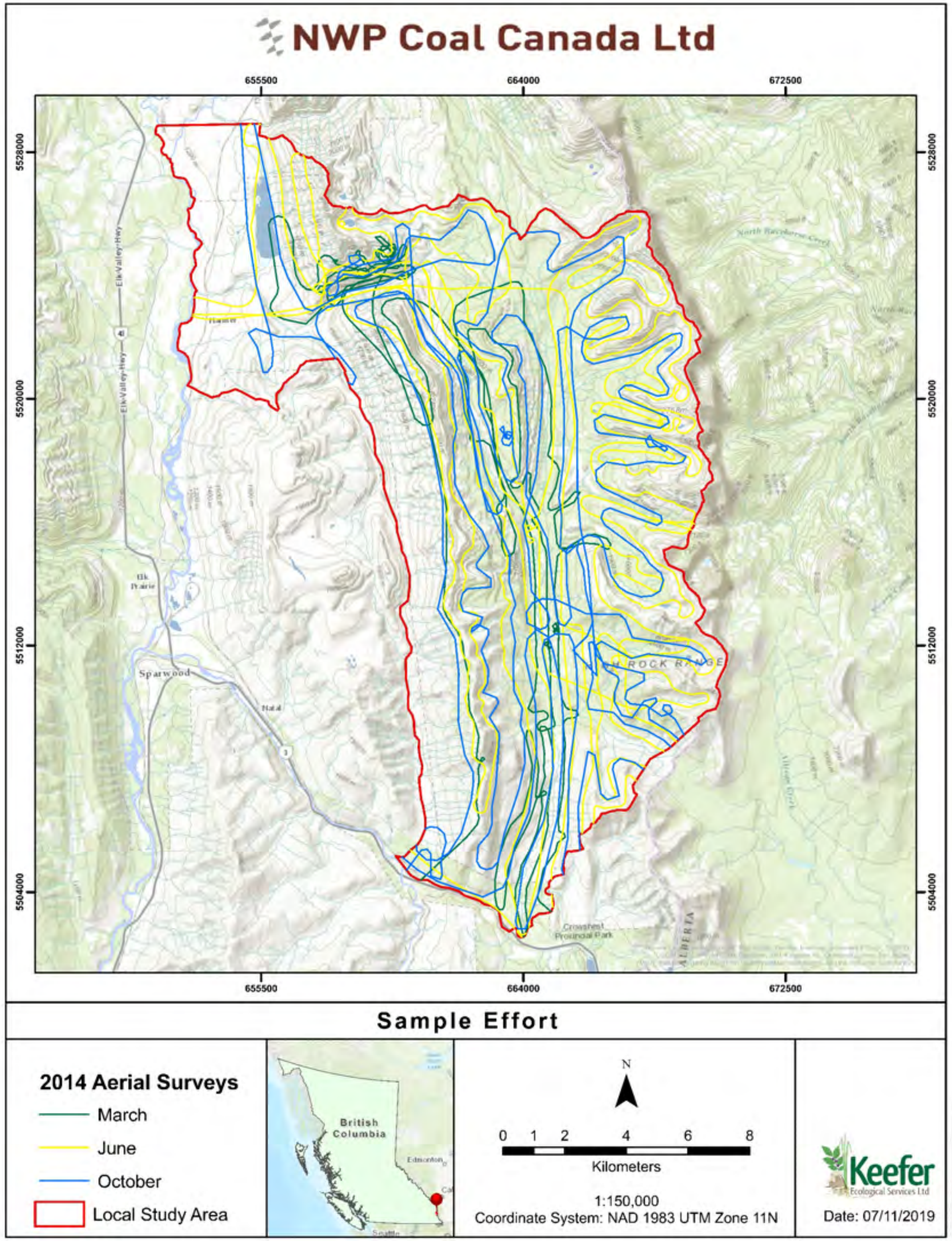
MOOSE MODEL DEVELOPMENT

Sample Effort



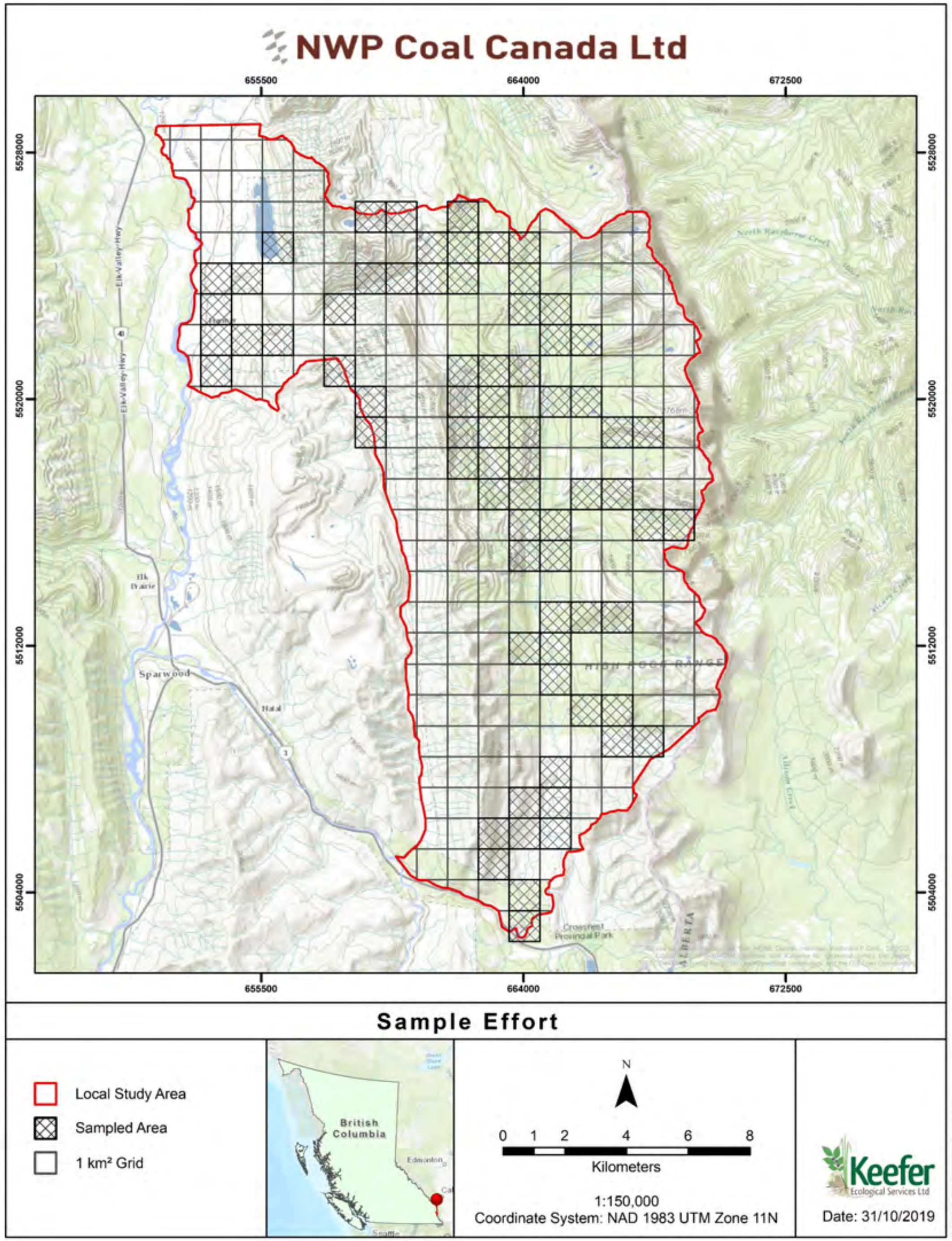


- ▶173.9 km transects
- ▶41 remote camera stations



Sample Effort

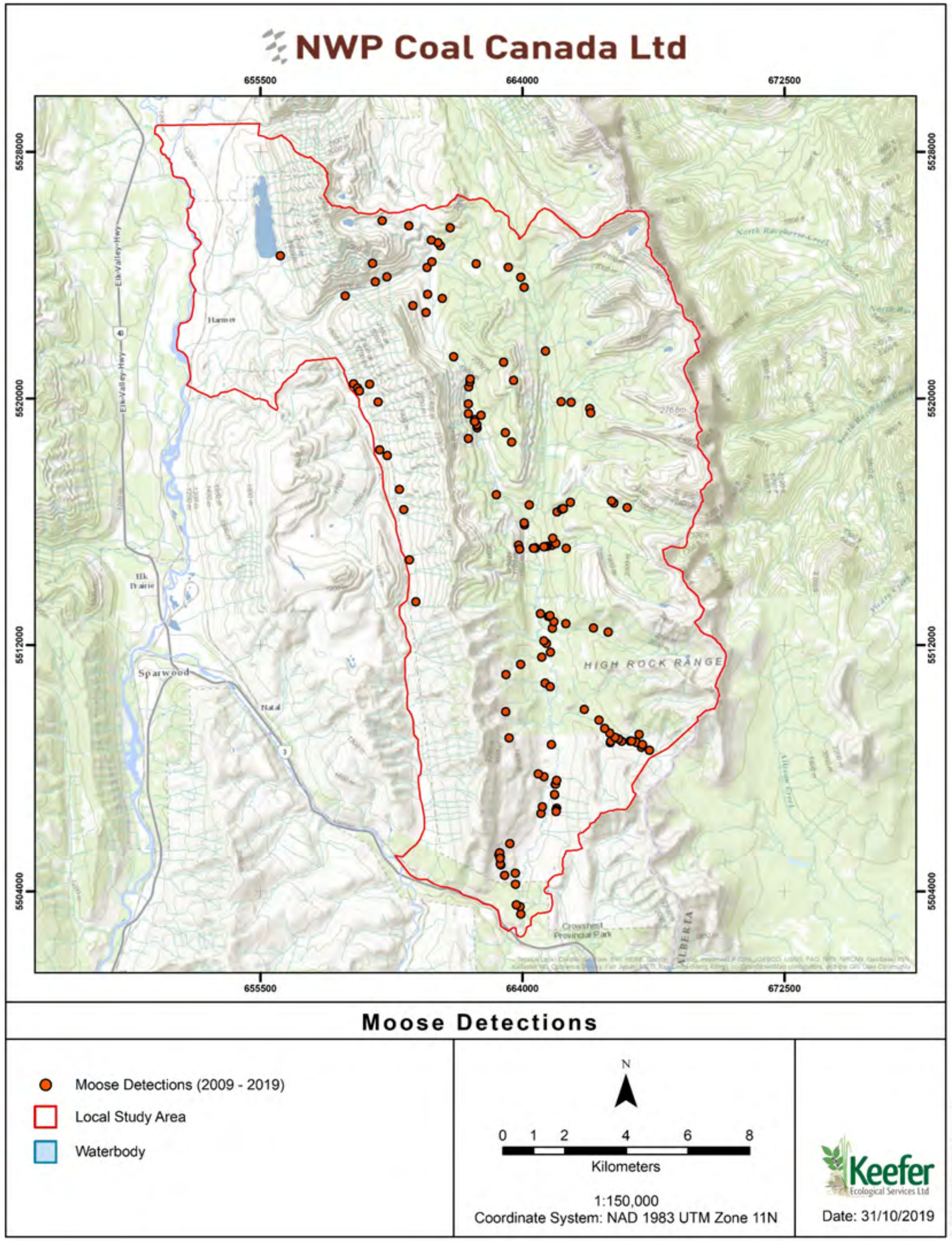
- 874 km aerial surveys:
  - March
  - June
  - October



Sample Effort

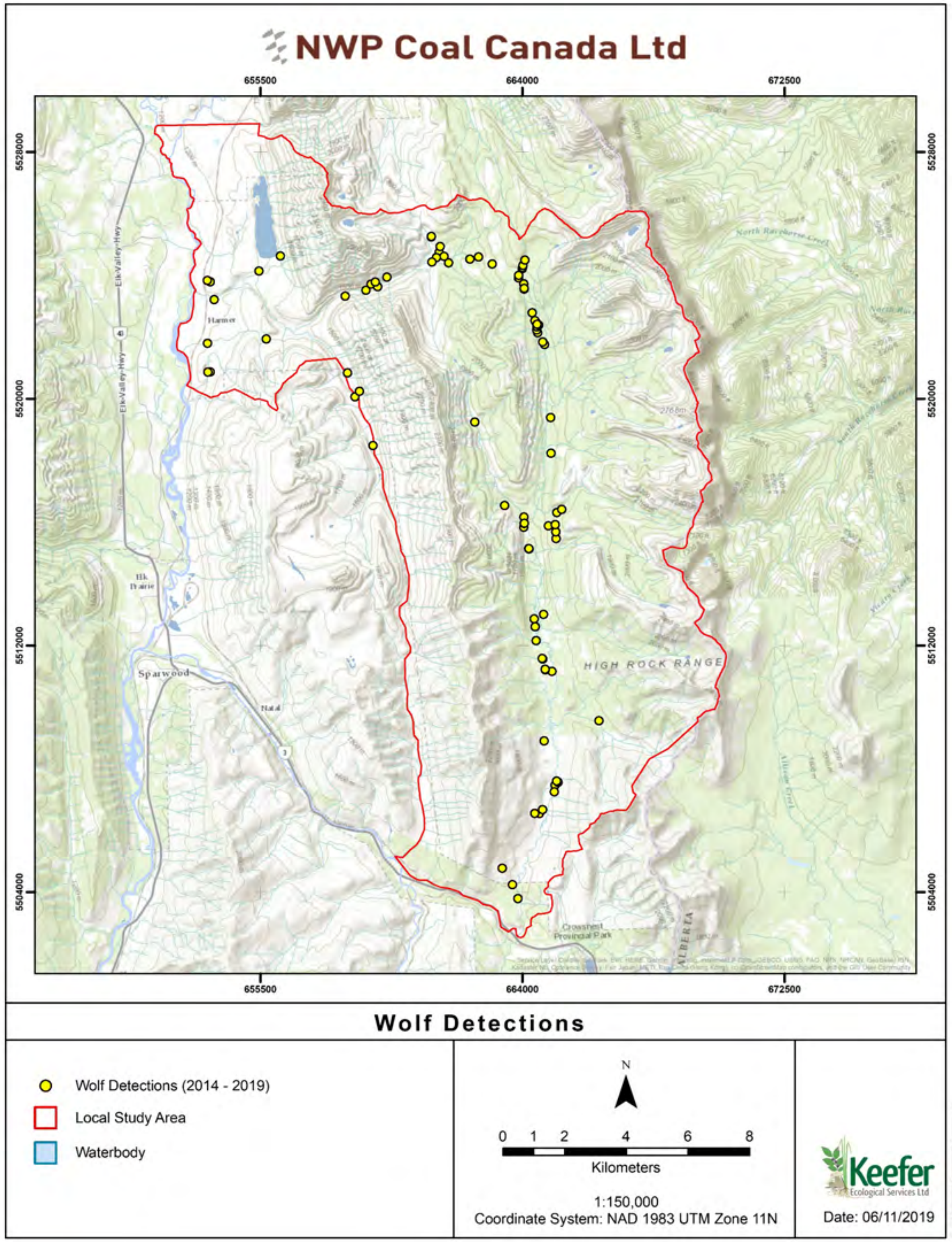
- 72 gird cells including:
  - Camera stations
  - Transects

- **Total**: 194 grid cells (including aerial surveys)



Sample Size

- 177 Moose detections in Local Study Area



Sample Size

- 132 Wolf detections in Local Study Area

Habitat Variable Development: Moose

Habitat Component	Relation to Moose (+/-)
Wolf	Predation risk
Elevation	Proxy for snow depth
Shrubs	Nutritious forage
Riparian	Forage with high nutritional content
Conifer & Broadleaf	Cover from predators, thermoregulation
Wetlands	Forage with high nutritional content
Burns	Forage with high nutritional content (regenerating)
Cutblocks	Forage with high nutritional content (regenerating)
Seepage points	Influence energetic condition by providing essential minerals
Roads	Predation risk, risk of mortality (humans)

Adjusted for seasonality

- Winter/Fall
- Summer/Spring

Habitat Variable Development: Wolf

Habitat Component	Relation to Wolf Fitness (+/-)
Rivers and streams	Facilitation of movement (+) and conditions suitable for prey (+)
Roads	Facilitation of movement (+), disturbance/ persecution (-)
Elevation	Conditions suitable for dens and movement (snow cover) (+)
Terrain ruggedness	Conditions not suitable for prey capture (-)
Rock/Rubble	Conditions not suitable for prey capture (-)
Canopy Closure	Cover for insulation, shade, protection of young (+)
Urban areas	Disturbance (-)

Covariates: Data Sources

Covariate	Original map classes (descriptions)	Unit of Measure	Data Source
Shrub containing habitat	Landcover: (Shrub tall)	Percent cover of grid cell (%)	Terrestrial Ecosystem Mapping (TEM), Canadian Land Cover, Circal 2000 (Vector_- GeoBase Series, 1996-2005)
Early seral stage forests	10-25 years old TEM structural stages 1 to 3	Percent cover of grid cell (%)	Vegetation Resources Inventory (VRI), Alberta Vegetation Inventory (AVI), Terrestrial Ecosystem Mapping (TEM)
Mid seral stage forests	40-80 years old TEM structural stages 4 to 5	Percent cover of grid cell (%)	Vegetation Resources Inventory (VRI), Alberta Vegetation Inventory (AVI), Terrestrial Ecosystem Mapping (TEM)
Old and mature seral stage forests	80- >140 years old TEM structural stage 6	Percent cover of grid cell (%)	Vegetation Resources Inventory (VRI), Alberta Vegetation Inventory (AVI), Terrestrial Ecosystem Mapping (TEM)
Urban areas	Compact settlements, 500m buffer (cities, towns and villages) Isolated built up units, 500m buffer (manufacturing plants, rail yards, military camps, waste disposal areas, leisure areas, liquid storage areas, building, and ritual cultural areas)	Mean distance in grid cell to nearest urban area (meters) Calculated using ArcGis 10.7 (Euclidean distance)	BC Ministry of FLNRORD- Geo BC, Baseline Thematic Mapping Present Land Use Version 1 Spatial Layer; Residential areas from Alberta Biodiversity Monitoring Institute, Human Footprint Inventory 2016; AB Waste disposal areas, residential areas, leisure areas, liquid storage areas, buildings, ritual cultural areas from Topographic Data of Canada- CanVec Series

Covariates: Data Sources Cont'd

Covariate	Original map classes (descriptions)	Unit of Measure	Data Source
Elevation	British Columbia Alberta	Metres	BC Ministry FLNRORD- GeoBC Altalis
Terrain Ruggedness	British Columbia Alberta		
Rivers	Primary rivers (); Secondary rivers (); Tertiary rivers ()	Mean distance in grid cell to nearest water source (meters)	BC Ministry of FLNRORD- GeoBC, Freshwater Atlas Lakes & Freshwater Atlas Stream; AB Altalis Base Features Hydrography
Roads	Primary roads (paved & unpaved, 15m buffer); Secondary roads (paved roads, 10m buffer); Tertiary roads (gravel roads and trails, 8.5m buffer)	Mean distance in grid cell to nearest road (meters)	GeoBC Atlas, Integrated Transportation Network; BC Ministry of FLNRORD, EV CEMF, Shapefile [Merged_Roads_2017_CE]; Alberta Biodiversity Monitoring Institute, Human Footprint Inventory 2016
Wetlands	Landcover: Wetland (land with water table near/at/above soil surface)	Percent cover of grid cell (%)	Canadian Land Cover, Circal 2000 (Vector_- GeoBase Series, 1996-2005)

Predator Model: Wolf

Results

Table #. Model selection procedure for factors influencing Wolf site occupancy (Ψ) in the Crown Mountain, BC. Habitat components considered are elevation (EV), terrain ruggedness (RU), proximity to roads (RD), proximity to rivers (RV), early seral forests (ESF), mid seral forests (MSF), old and mature forest (OMF) and proximity to urban and developed areas (UR). Wolf detectability varies with proximity to roads and seasons. The model that assumes that occurrence is constant Ψ (.) is shown for comparison.

Model	**AICc**	**∆AICc**	**w**	**k**	**-2LL**	**Ψ (SE)**
Ψ (EV,MSF)	538.42	0.00	0.6858	6	525.50	0.62(0.09)
Ψ (RD,MSF)	540.49	2.07	0.2436	6	527.57	0.66(0.10)
Ψ (EV)	544.57	6.15	0.0317	5	533.92	0.66(0.08)
Ψ (RD)	544.80	6.38	0.0282	5	534.15	0.71(0.08)
Ψ (.)	555.89	17.47	0.0001	4	547.46	0.63(0.07)
Model Average						**0.64 (0.09)**

Wolves used approximately 64% of the sites surveyed

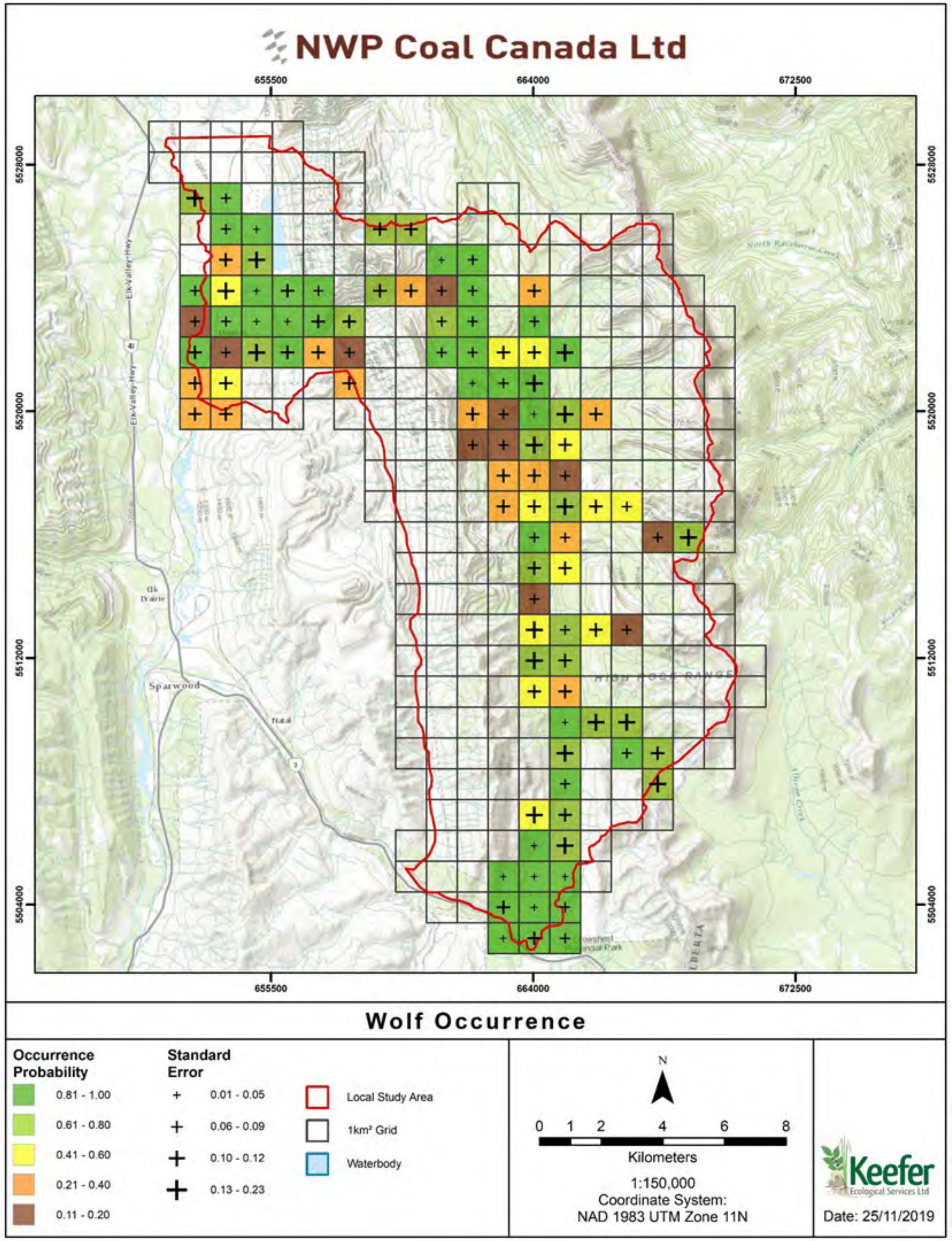
Table#. Habitat variables influencing Wolf occurrence in the Crown Mountain Coking Coal Project Local Study Area (2014-2019) ranked according to their relative contribution (∑w), β co-efficient and associated standard error (SE). ∑w is the weight of evidence or relative amount that a variable contributes to Wolf occurrence at a (1 km^2) site (n = 98). The β-coefficient is the strength and direction (±) of influence.

Variable	∑w	β	SE
Mid Seral Forest	0.929	**0.950**	**0.382**
Elevation	0.718	**-1.390**	**0.501**
Roads	0.272	**-1.671**	**0.822**

Bold entries indicates robust impact (±1.96 × SE not overlapping zero).

Results

- Most important predictors of Wolf occurrence
  - Strong negative association with Elevation
  - Positive association with Roads

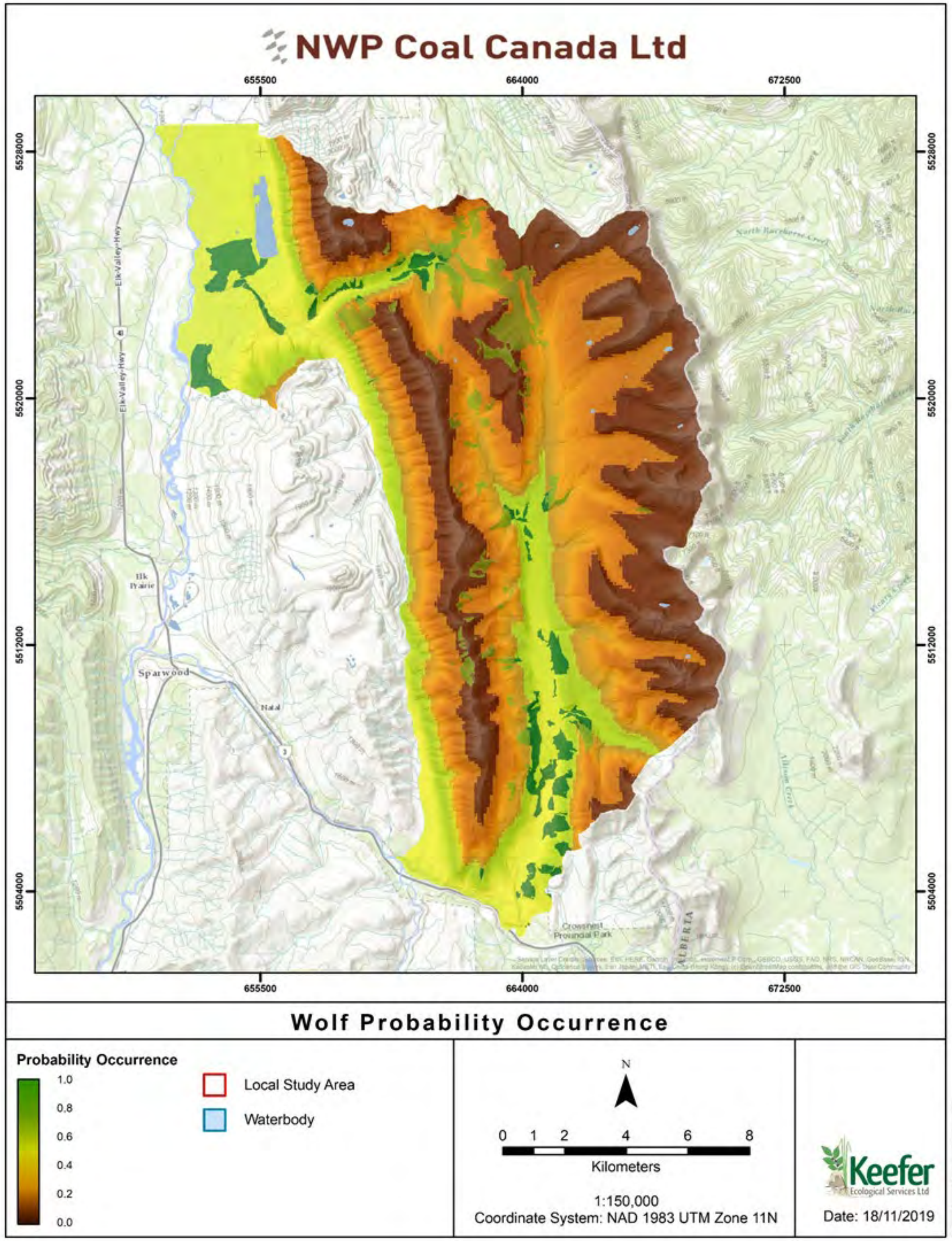


Site-specific Estimates

Habitat suitability model based on resulting regression equation from weighted model averaged estimates considering:

- Elevation
- Mid-seral stage forests
- Distance to roads

➢ Wolves used approximately 64% of the sites surveyed



Wolf Habitat Suitability

Habitat suitability model based on resulting regression equation from weighted model averaged estimates considering:

- Elevation
- Mid-seral stage forests
- Distance to roads

MOOSE

Fall/Winter Model
& Spring/Summer Model

Winter: Survey Covariates

Table #. Model selection procedure showing factors influencing Moose detectability (p) during fall-winter in the Crown Mountain Coking Coal Project Local Study Area, BC (2014-2019). Factors considered are: (8 day) camera-trap, (1 km) transect (CT) and 1.5 km aerial (A) surveys. Models with 557.2 (1 Km) transect surveys, 41 (8 day) camera surveys, 874.1 (1.5 km) aerial surveys of 194 (1 km^2) grid

Model	AICc	∆AICc	w	k	-2LL
p (.)	243.38	0.00	0.4191	2	239.30
p (A)	243.62	0.24	0.3717	3	237.46
p (CT)	244.77	1.39	0.2092	3	238.61

AICc values; the relative difference in AICc values between each model and the model with the lowest AICc (ΔAICc); AICc model weights (w); the number of parameters in the model (k); twice the negative log-liklihood(-2LL). (.) assumes the parameter is constant.

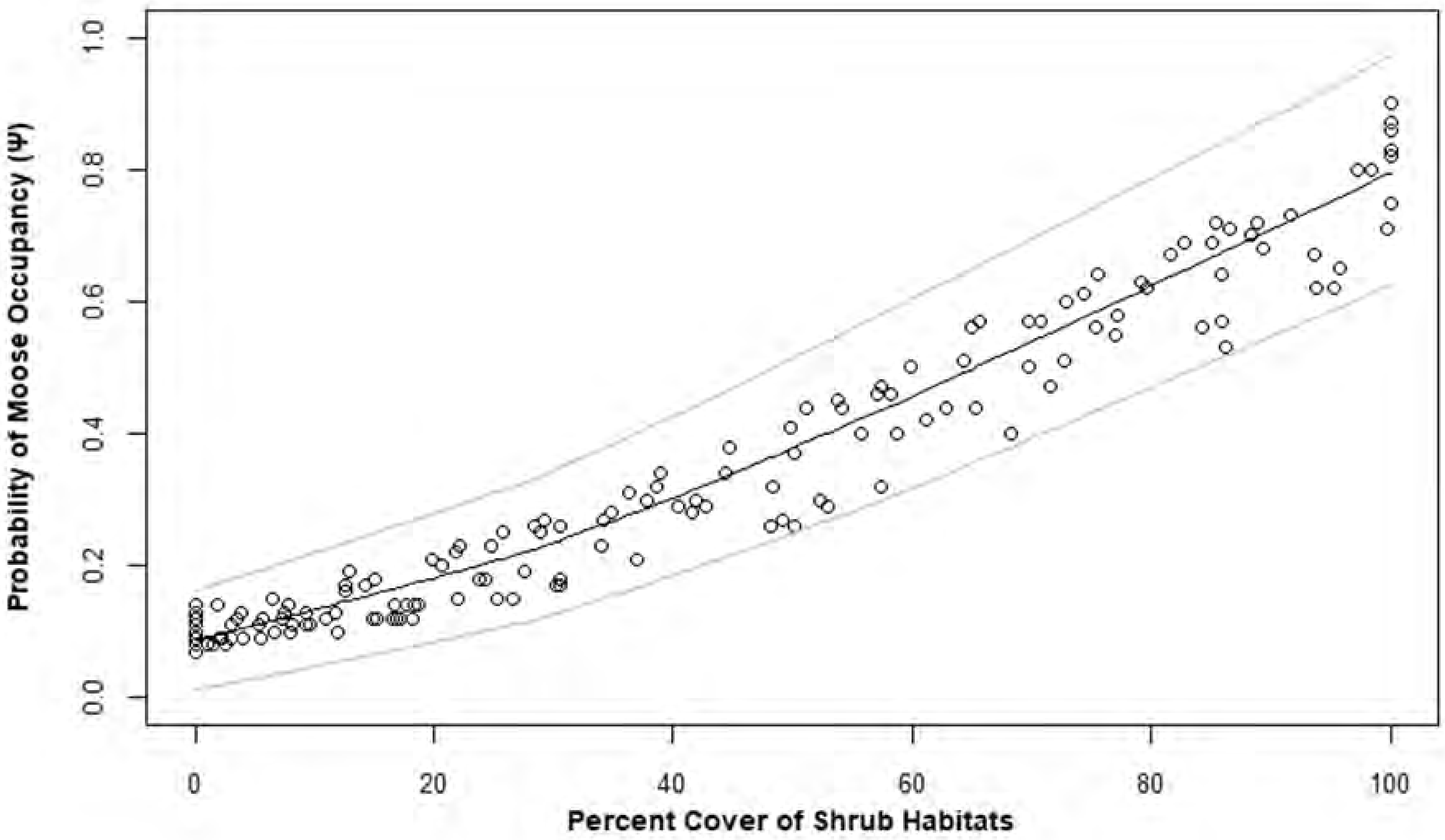
Table#. Habitat variables influencing Moose occurrence during fall/winter (Sept 22-March 22) in the Crown Mountain Coking Coal Project Local Study Area (2014-2019) ranked according to their relative contribution (∑w), β co-efficient and associated standard error (SE). ∑w is the weight of evidence or relative amount that a variable contributes to Moose occurrence at a (1 km^2) site (n = 156). The β-coefficient is the strength and direction (±) of influence.

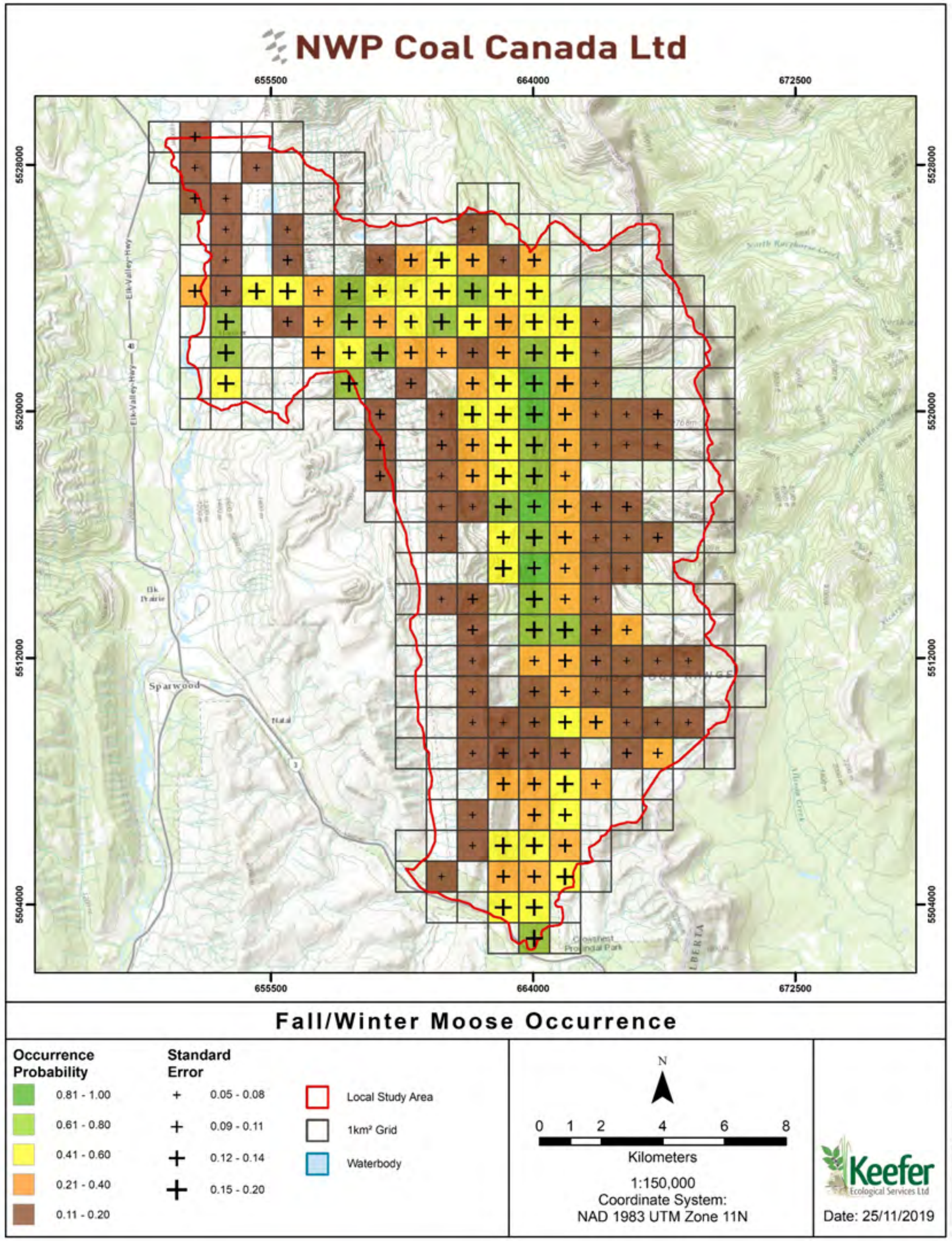
Variable	∑w	β	SE
Shrub Containing Habitats	0.97	**1.076**	**0.406**
Primary and Secondary Rivers	0.38	**-0.858**	**0.501**
Primary Roads	0.14	0.214	0.129
Old and Mature Forests	0.13	0.674	0.465
Wetlands	0.10	-0.440	0.384
Mid Seral Forest	0.08	-0.314	0.306
Predator Occurrence	0.06	-0.939	0.059
Secondary Roads	0.05	-0.179	0.078

Bold entries indicates robust impact (±1.96 × SE not overlapping zero).

Results

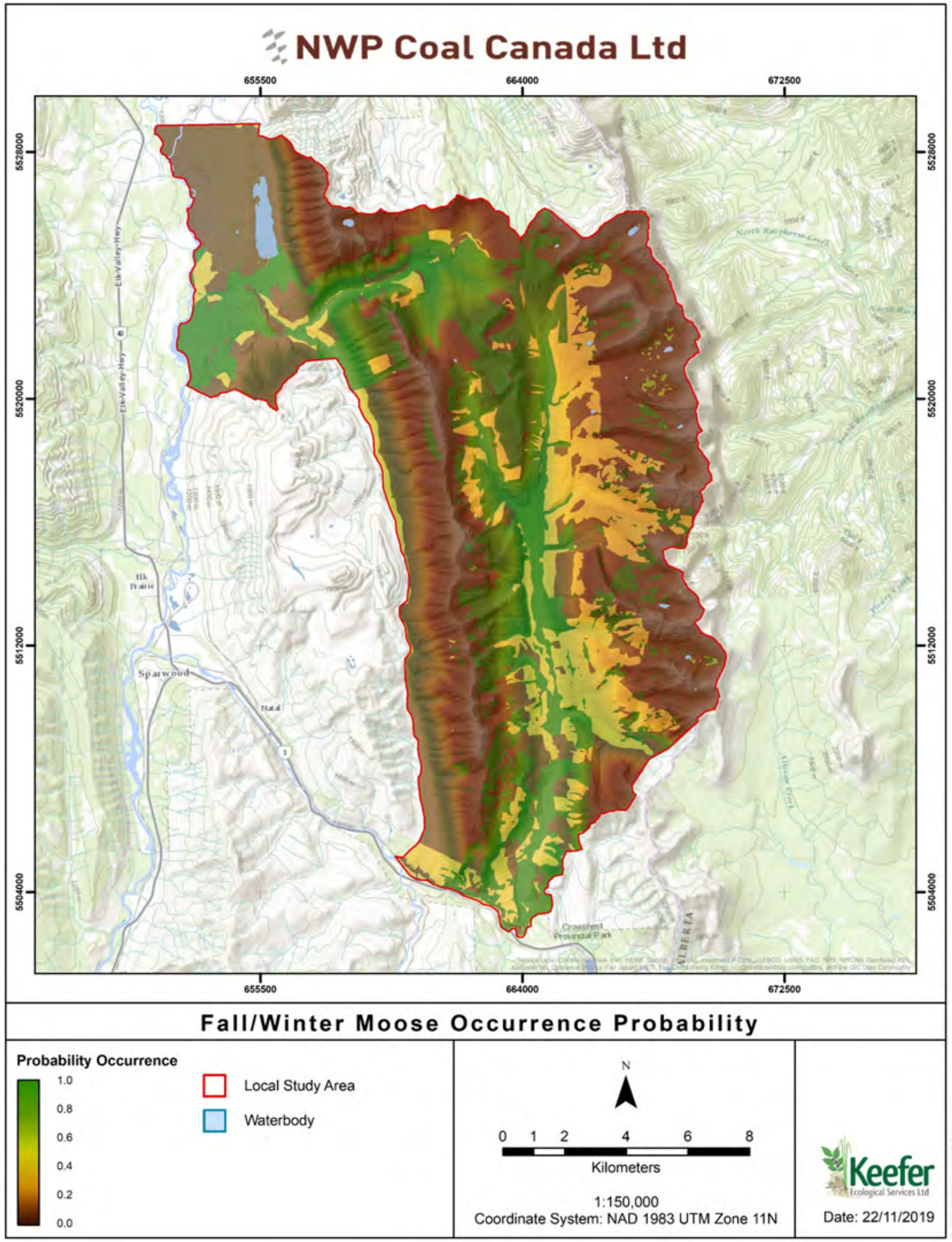
- Strong positive association with Shrub containing habitats &
- Positive association with primary and secondary rivers


Probability of Moose Occupancy (Ψ)
Percent Cover of Shrub Habitats
0.0
0.2
0.4
0.6
0.8
1.0
0
20
40
60
80
100



Site-specific Estimates

- Moose used approximately 30% of the sites surveyed during fall-winter
- 57% higher than naïve estimate (0.128)



Moose Habitat Suitability (fall-winter)

Habitat suitability model based on resulting regression equation from weighted model averaged estimates considering:

- Shrub Containing Habitats
- Primary and Secondary Rivers
- Primary Roads
- Old and Mature Forests
- Wetlands
- Mid Seral Forest
- Predator Occurrence
- Secondary Roads

Summer: Survey Covariates

Table #. Summary of model selection procedure for factors influencing Moose detectability (p) at a 1 km site (n = 134) in the Crown Mountain Coking Coal Project Local Study Area, BC. Factors considered are: survey method (camera-trap, transect or aerial survey; M), season (S), proximity to rivers (RV), primary roads (RD), secondary roads (SRD) and tertiary roads (TRD).

Model	AICc	ΔAICc	w	k	-2LL
p (M)	297.70	0.00	1.00	4	289.39
p (TRD)	353.12	55.42	0.00	3	346.94
p (.)	353.26	55.56	0.00	2	349.17
p (RV)	355.30	57.60	0.00	3	349.12
p (SRD)	355.34	57.64	0.00	3	349.16
p (PRD)	355.35	57.65	0.00	3	349.17

AICc values; the relative difference in AICc values between each model and the model with the lowest AICc (ΔAICc); AICc model weights (w); the number of parameters in the model (k); twice the negative log-liklihood(-2LL). (.) assumes the parameter is constant.

- Spring-Summer Moose detectability varied with survey method

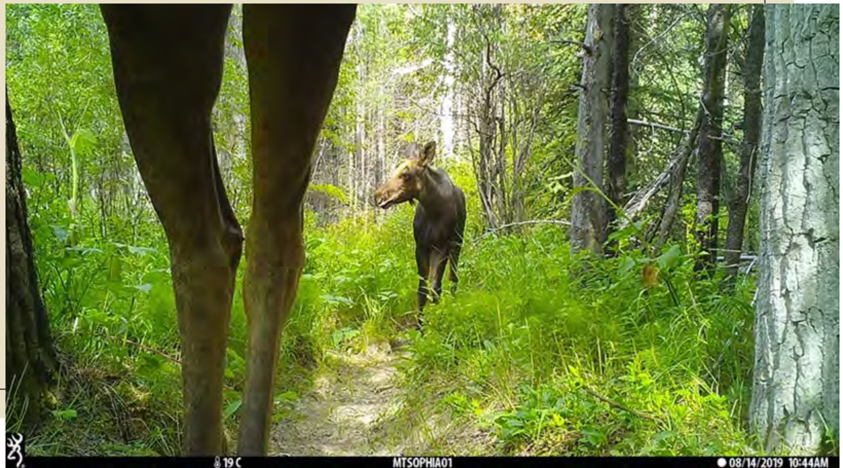
Summer: Overall Model Average Estimate

Table #. Model selection procedure for factors influencing Moose site occupancy (Ψ) at a 1 km site (n = 134) during spring-summer (2014-2019) in the Crown Mountain, BC. Habitat components considered are: elevation (EL), slope (SL), terrain curvature (TC), primary roads (PRD), secondary roads (SRD), tertiary roads (TRD), primary and secondary rivers (PRV), tertiary rivers (TRV), early seral forests (ESF), mid seral forests (MSF), old and mature forests (OMF), wetlands, and predator (Wolf) occurrence (PD). Moose detectability varies with survey method (camera-trap, transect or aerial). The model that assumes that occurrence is constant Ψ (.) is shown for comparison.

Model	AICc	ΔAICc	w	k	-2LL	Ψ (SE)
Ψ (OMF,ESF,TRV)	286.38	0.00	0.2607	7	271.49	0.77 (0.08)
Ψ (OMF,ESF,PRD)	286.46	0.08	0.2505	7	271.57	0.77 (0.06)
Ψ (OMF,SRD,WL)	287.36	0.98	0.1597	7	272.47	0.77 (0.06)
Ψ (OMF,ESR,TRV,SRD)	288.11	1.73	0.1098	8	270.96	0.79 (0.11)
Ψ (OMF,ESF,SRD,WL)	288.11	1.87	0.1024	8	271.10	0.78 (0.09)
Ψ (OMF,ESF,WL)	288.25	2.48	0.0754	7	273.97	0.78 (0.09)
Ψ (OMF,WL,TRV)	288.86	3.72	0.0406	7	275.21	0.72 (0.10)
Ψ (.)	290.10	11.32	0.0009	4	289.39	0.70 (0.11)
Model Average						**0.77 (0.08)**

AICc values; the relative difference in AICc values between each model and the model with the lowest AICc (ΔAICc); AICc model weights (w); the number of parameters in the model (k); twice the negative log-liklihood(-2LL). (.) assumes the parameter is constant.

- Moose used approximately 77% of the sites surveyed during summer
- 68% higher than naïve estimate (0.246)



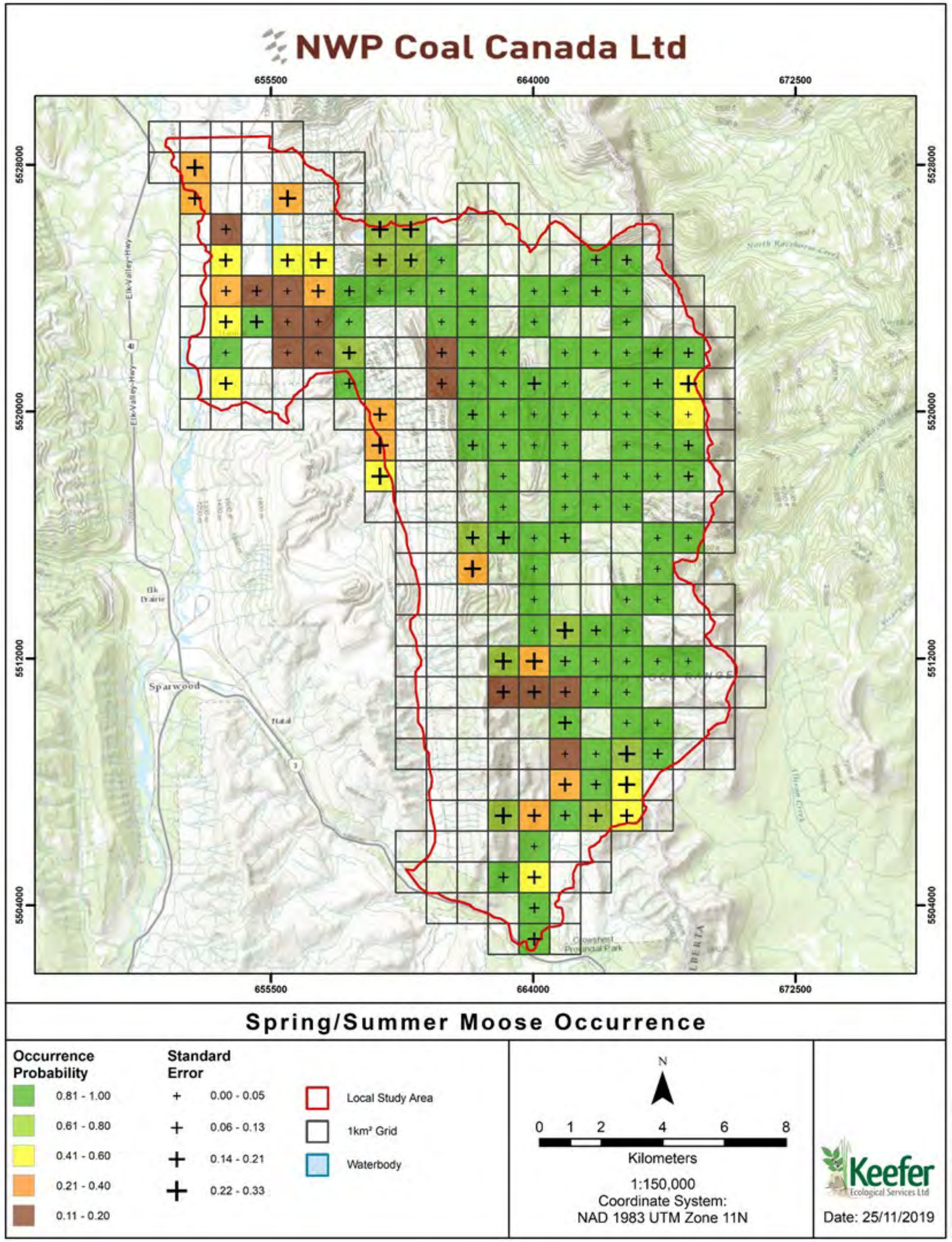
Summer: Habitat variables

Table#. Habitat variables influencing Moose occurrence during spring-summer (Sept 22-March 22) in the Crown Mountain, BC (2014-2019) ranked according to their relative contribution (∑w), β co-efficient and associated standard error (SE). ∑w is the weight of evidence or relative amount that a variable contributes to Moose occurrence at a (1 km^2) site (n = 134). The β-coefficient is the strength and direction (±) of influence.

Variable	∑w	β	SE
Old Mature Forest	0.96	**3.483**	**1.174**
Early Seral Forest	0.80	**-2.622**	**1.295**
Tertiary Rivers	0.37	**-2.742**	**1.202**
Secondary Roads	0.37	2.442	1.503
Wetlands	0.37	1.291	0.724
Primary Roads	0.34	2.539	1.348

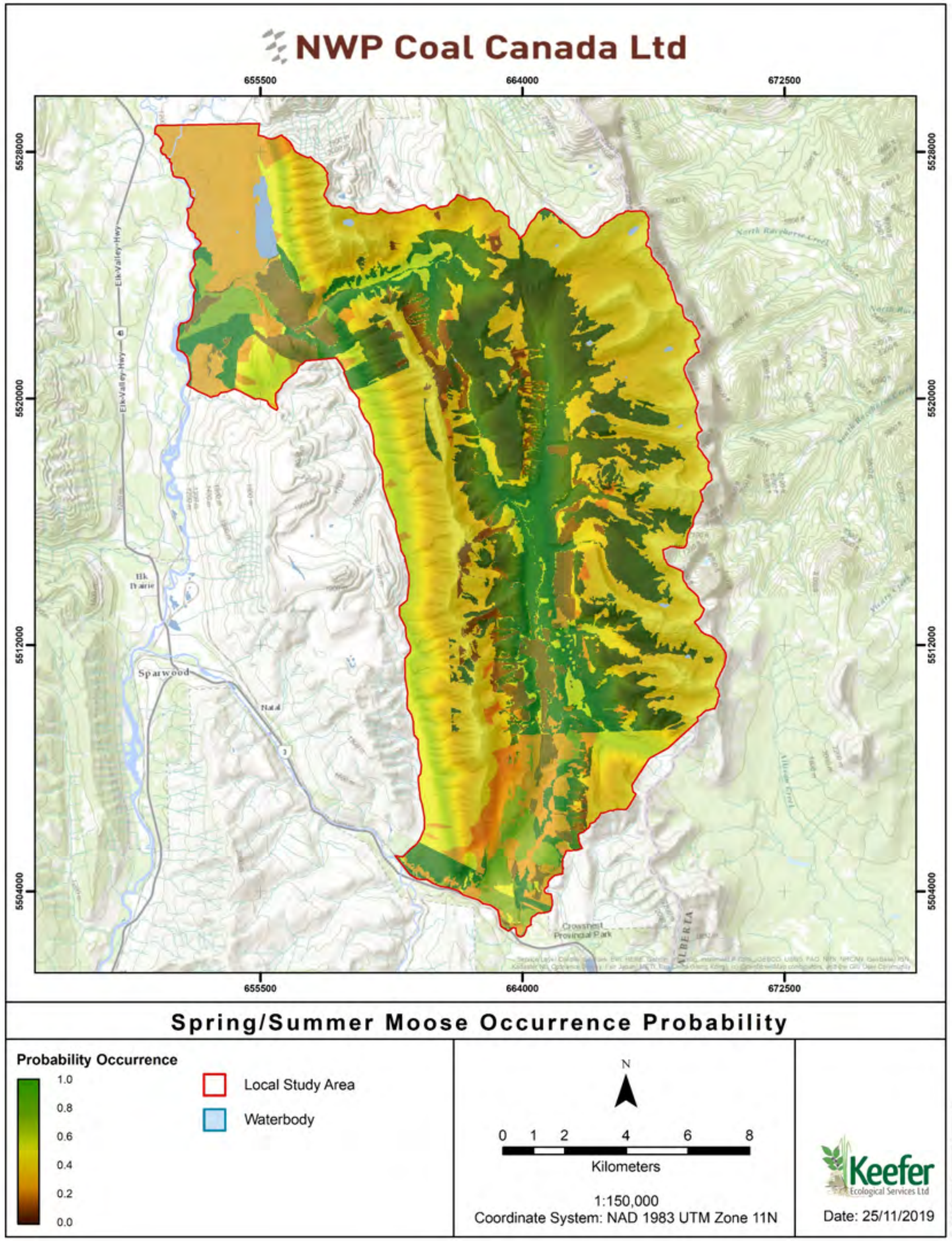
Bold entries indicates robust impact (±1.96 × SE not overlapping zero).

- Strong positive association with Old Mature forests & Tertiary rivers
- Negative association with Early Seral forests



Site-specific Estimates

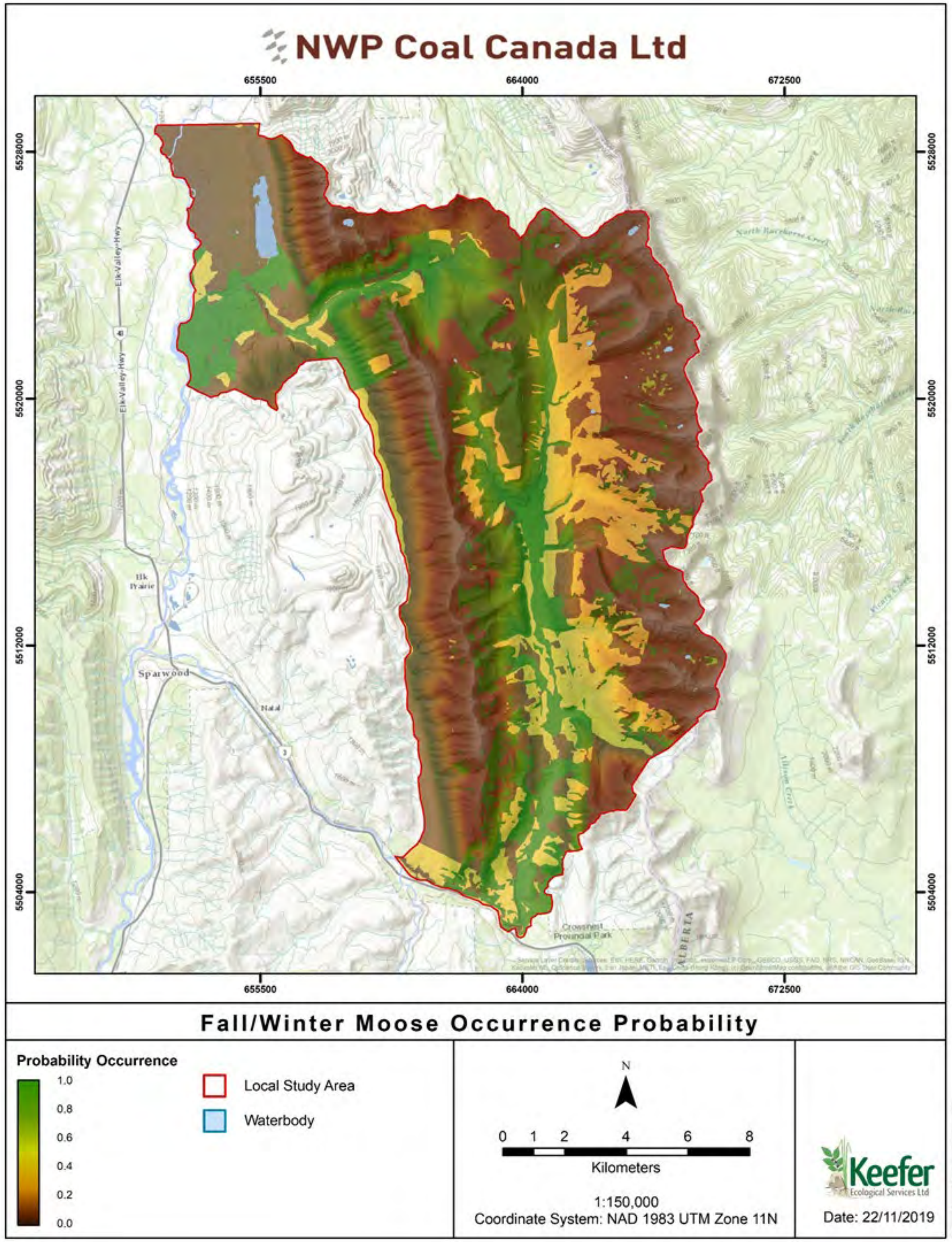
- Moose used approximately 77% of the sites surveyed during summer
- 68% higher than naïve estimate (0.246)

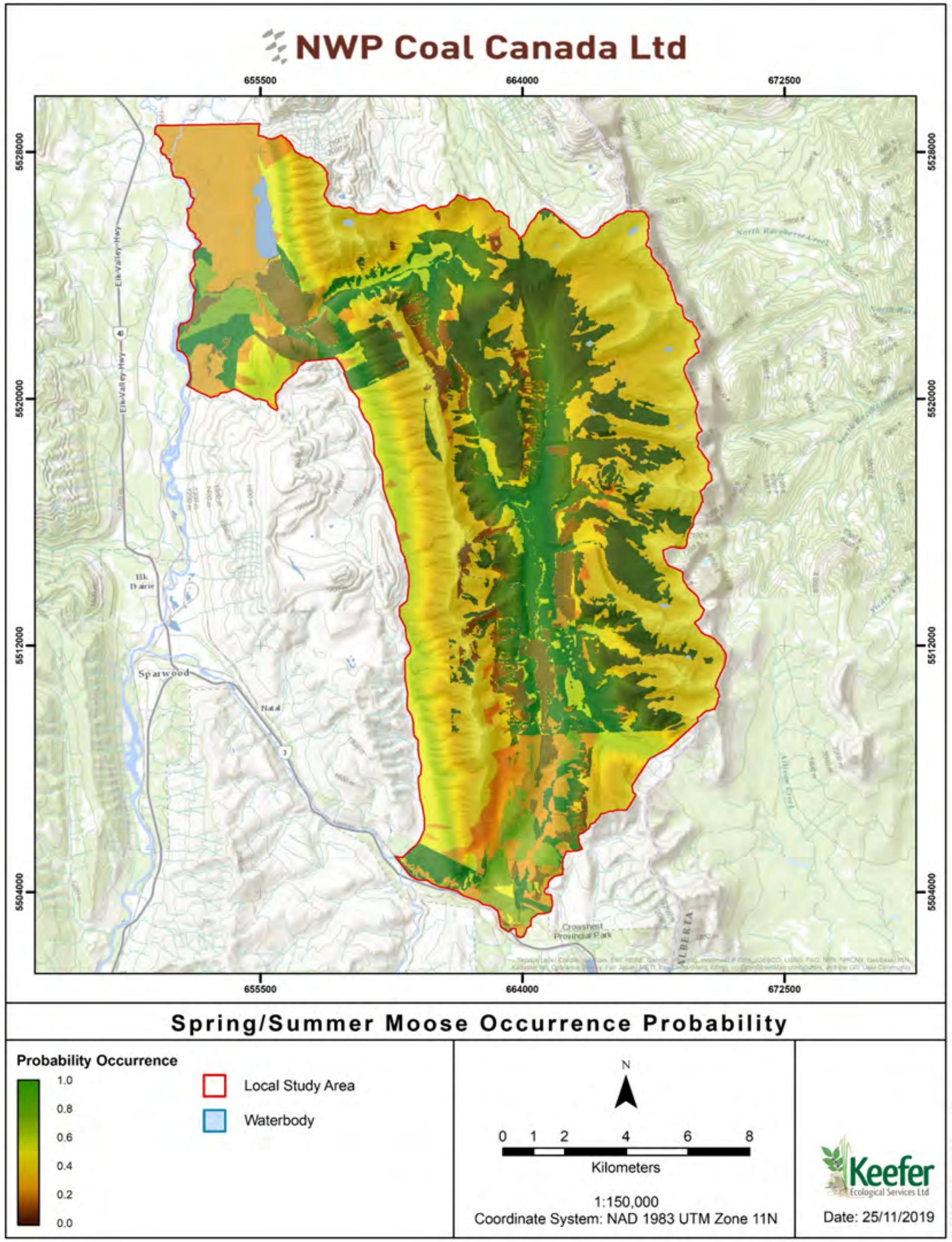


Moose Habitat Suitability (spring/summer)

Habitat suitability model based on resulting regression equation from weighted model averaged estimates considering:

- Old Mature Forest
- Early Seral Forest
- Tertiary Rivers
- Secondary Roads
- Wetlands
- Primary Roads


NWP Coal Canada Ltd
655500
664000
672500
5528000
5520000
5512000
5504000
Elk Valley Hwy
Sparwood
Natal
Elk Prairie
North Fork Michel Creek
Crowsnest Provincial Park
ALBERTA
Fall/Winter Moose Occurrence Probability
Probability Occurrence
1.0
0.8
0.6
0.4
0.2
0.0
Local Study Area
Waterbody
N
0 1 2 4 6 8
Kilometers
1:150,000
Coordinate System: NAD 1983 UTM Zone 11N
Keefer Ecological Services Ltd
Date: 22/11/2019


NWP Coal Canada Ltd
655500
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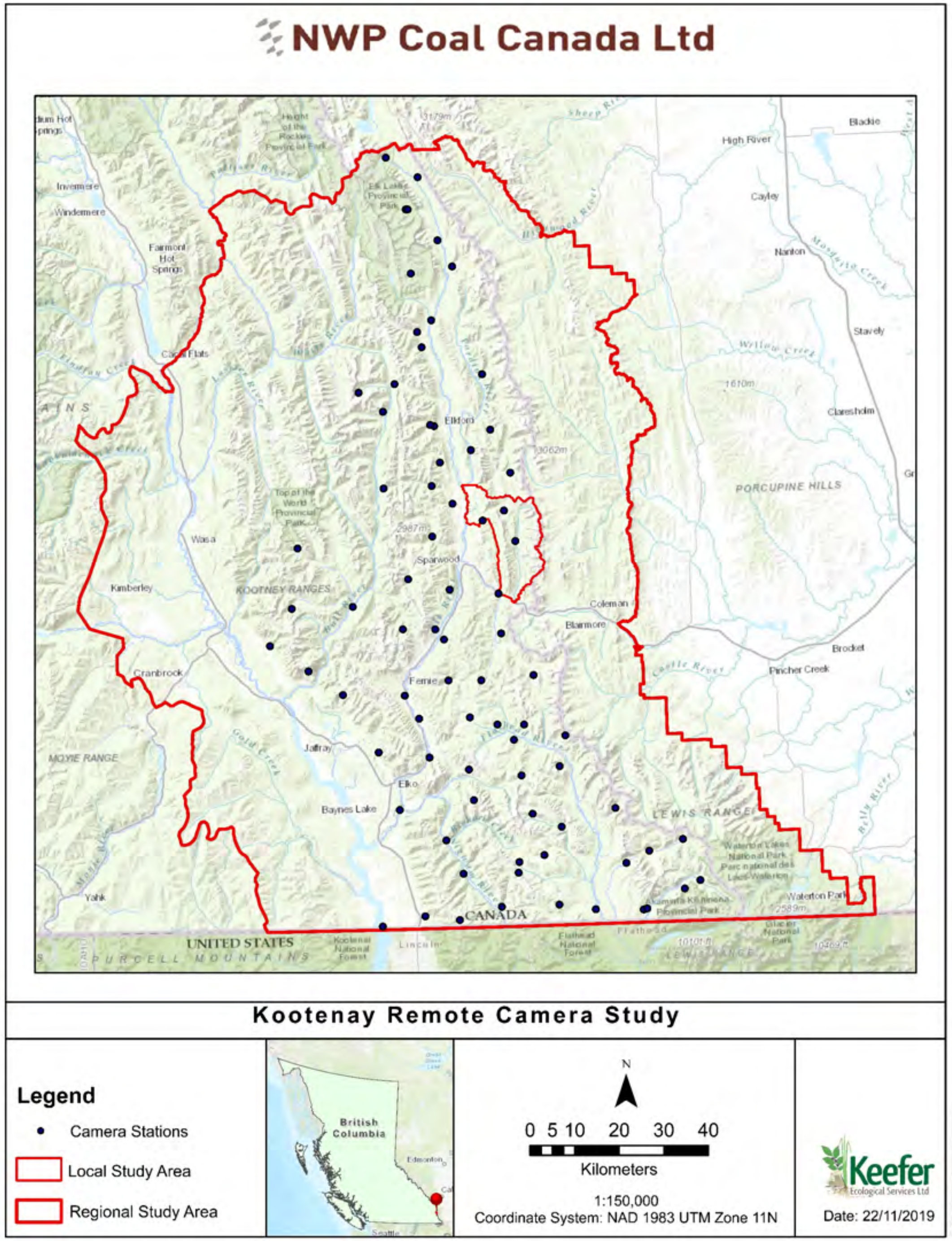
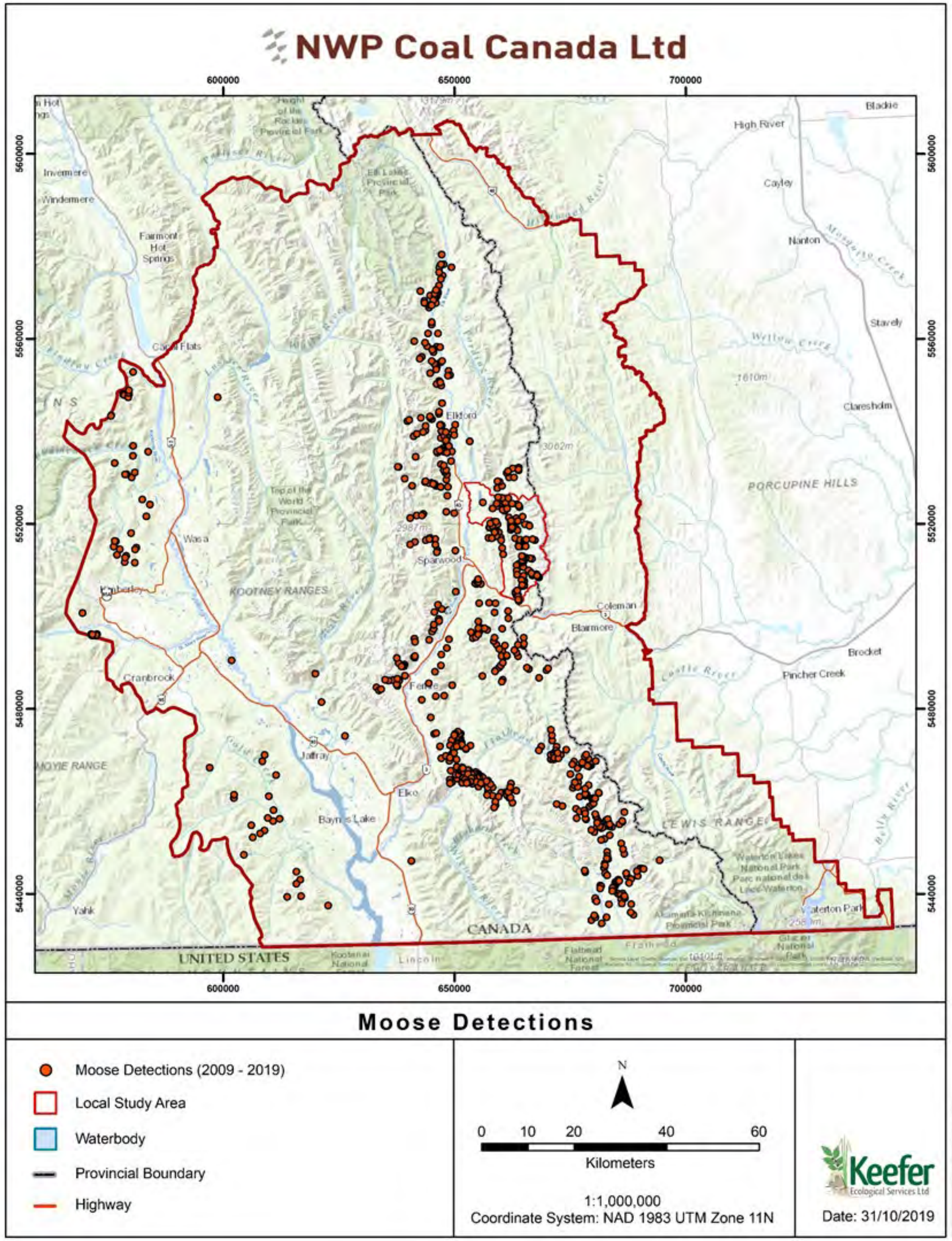
5528000
5520000
5512000
5504000
Elk Valley Hwy
Sparwood
Natal
Elk Prairie
Crowsnest Provincial Park
ALBERTA
Spring/Summer Moose Occurrence Probability
Probability Occurrence
1.0
0.8
0.6
0.4
0.2
0.0
Local Study Area
Waterbody
N
0 1 2 4 6 8
Kilometers
1:150,000
Coordinate System: NAD 1983 UTM Zone 11N
Keefer Ecological Services Ltd
Date: 25/11/2019



NEXT STEPS:
Moose RSA Habitat Suitability & Model Validation

To be integrated into data set

- 1191 Moose detections



NEXT STEPS: Moose RSA Habitat Suitability & Model Validation

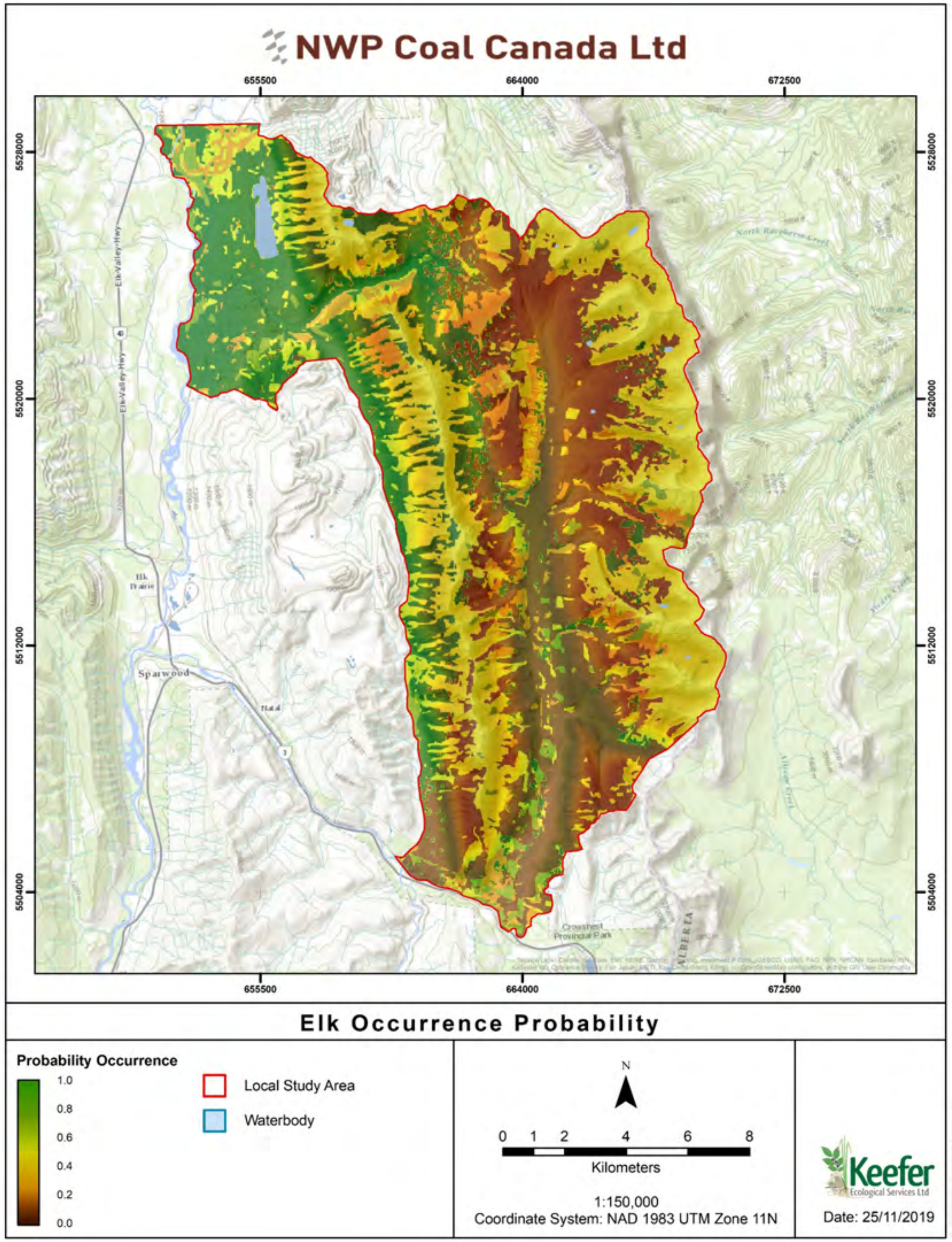
- 1,043 Government aerial detections in Regional Study Area

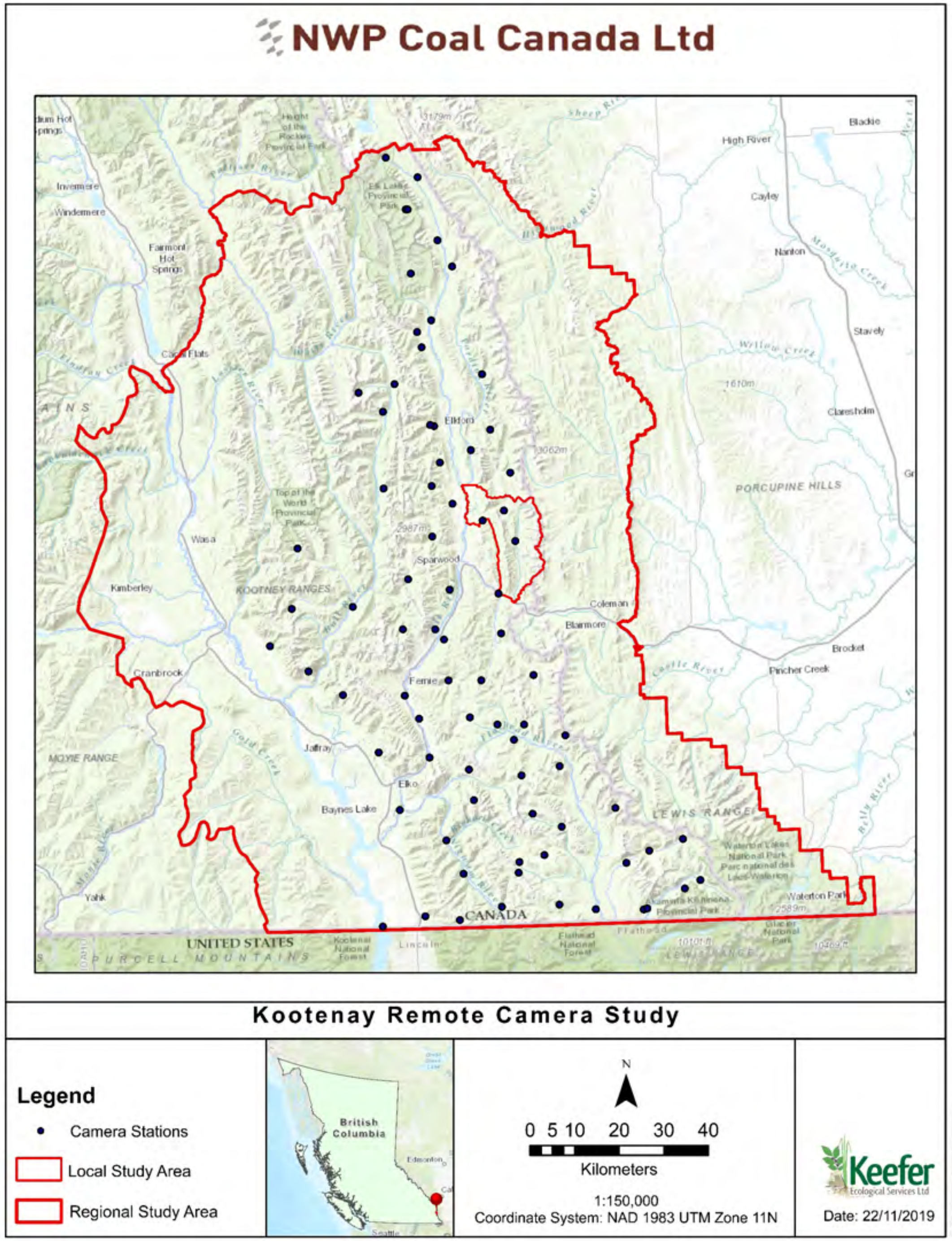
Elk


-1 C
TRAILCAM15
11/07/2017 03:51PM


-13 C
TRAILCAM14
11/04/2017 10:26AM

Habitat Suitability

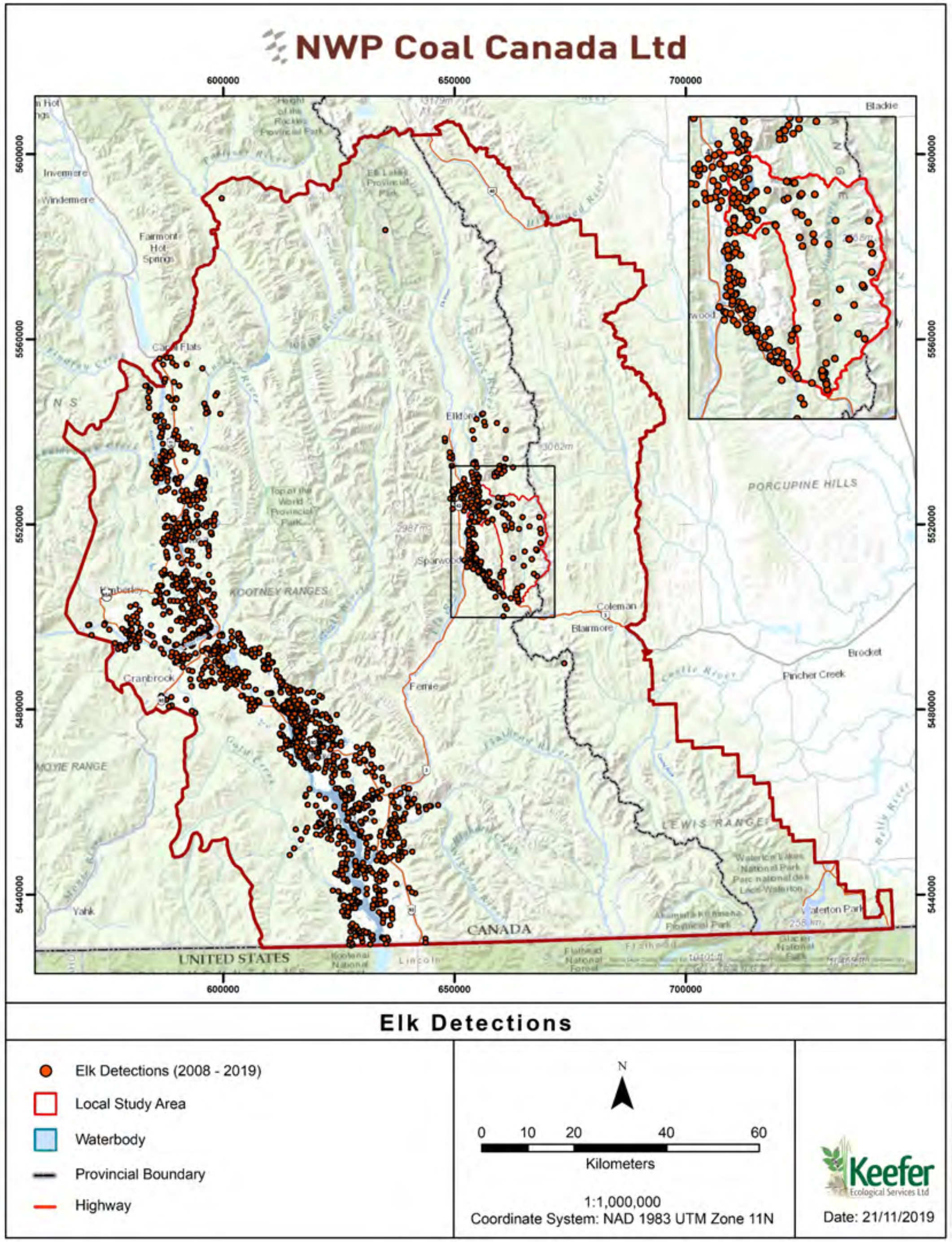




NEXT STEPS:
Elk RSA Habitat Suitability & Model Validation

To be integrated into data set:

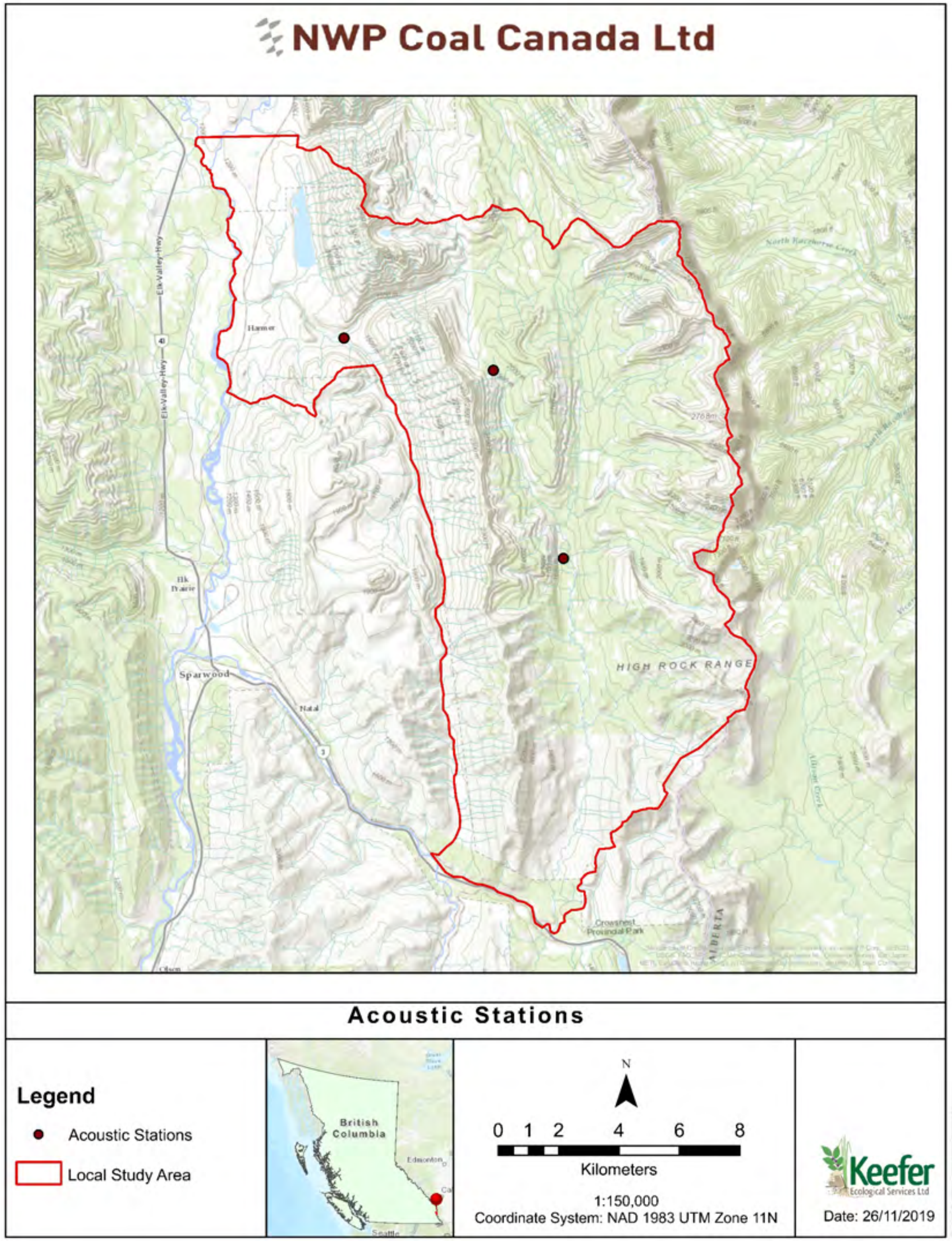
- 1639 Elk detections



NEXT STEPS:
Moose RSA Habitat Suitability & Model Validation

To be integrated into data set

- 1639 Elk detections



Bat Acoustic Devices

- Acoustic devices installed to improve understanding of winter habitat use in LSA.
- Three devices installed on October 21-22, 2019