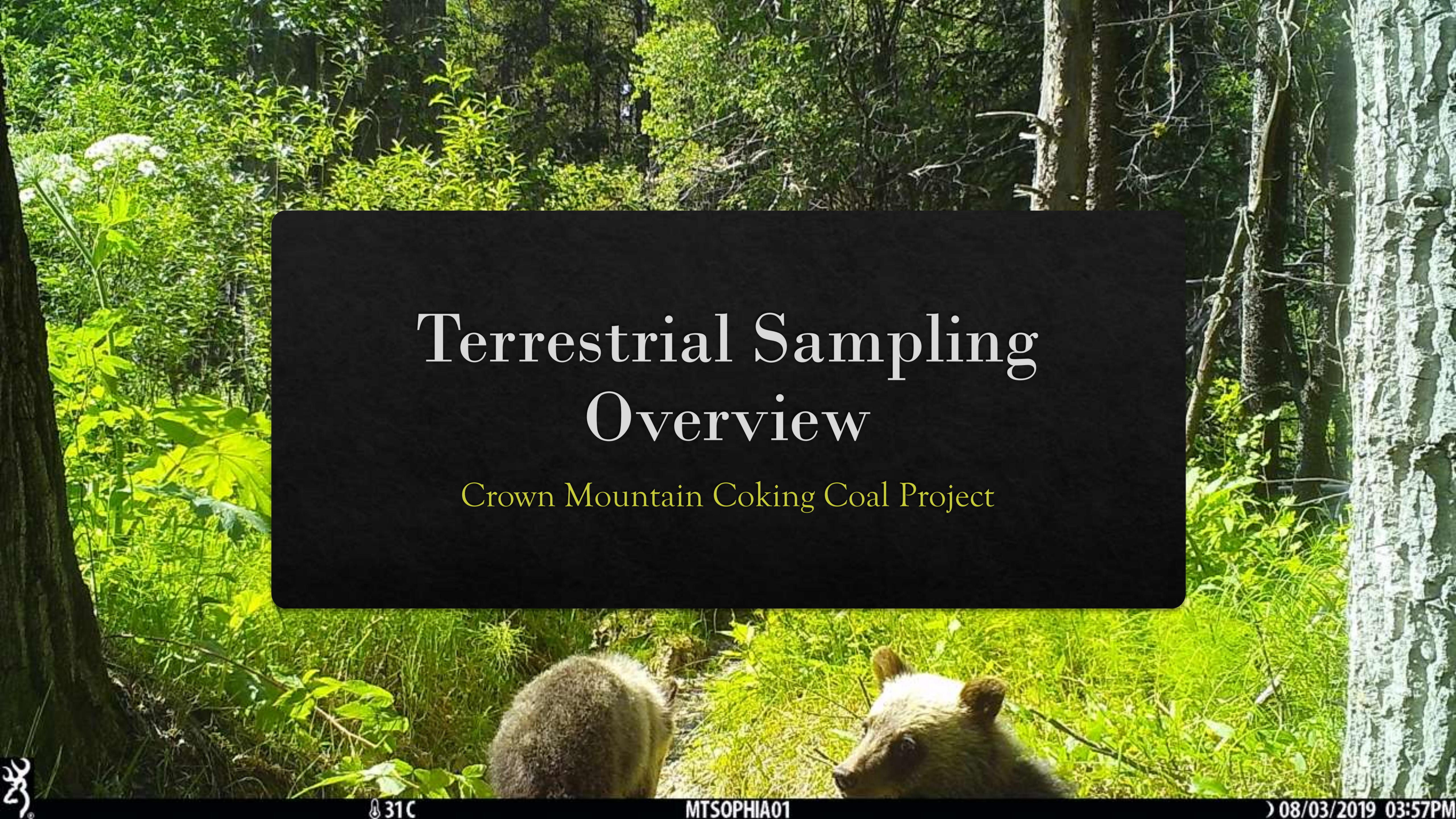
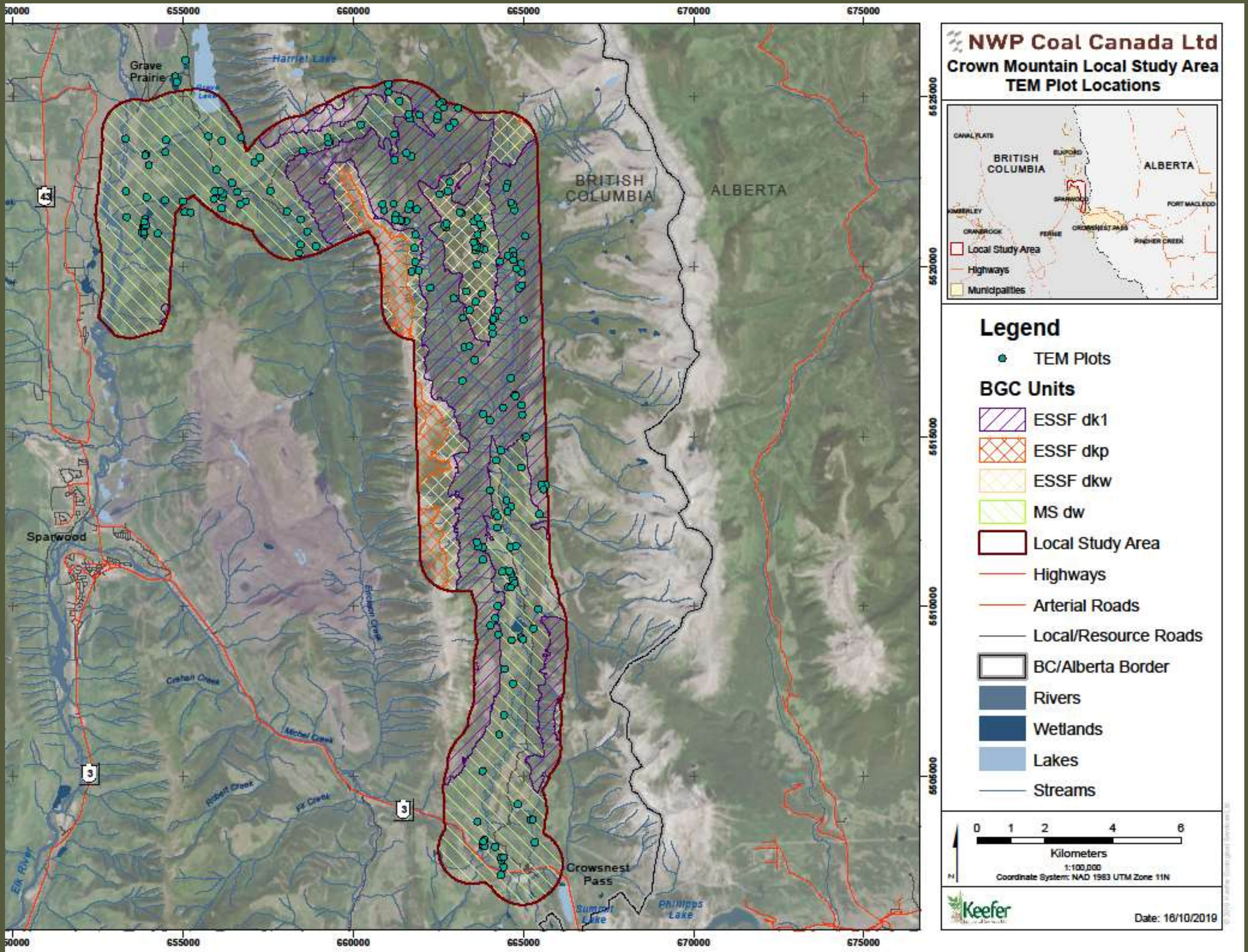
Appendix 4-JJ

Wildlife Modelling Meeting - December 2019

Terrestrial Sampling Overview

Crown Mountain Coking Coal Project





- Soils: 276 plots
- Terrain: 214 plots
- TEM: 209 plots
- CWD: 70 plots

Wildlife

- 560 km Transects (2014-2019)
- 3 Flights (2014-2015)
- 41 Camera sites (2014-2019)
    - 7,500 nights of data

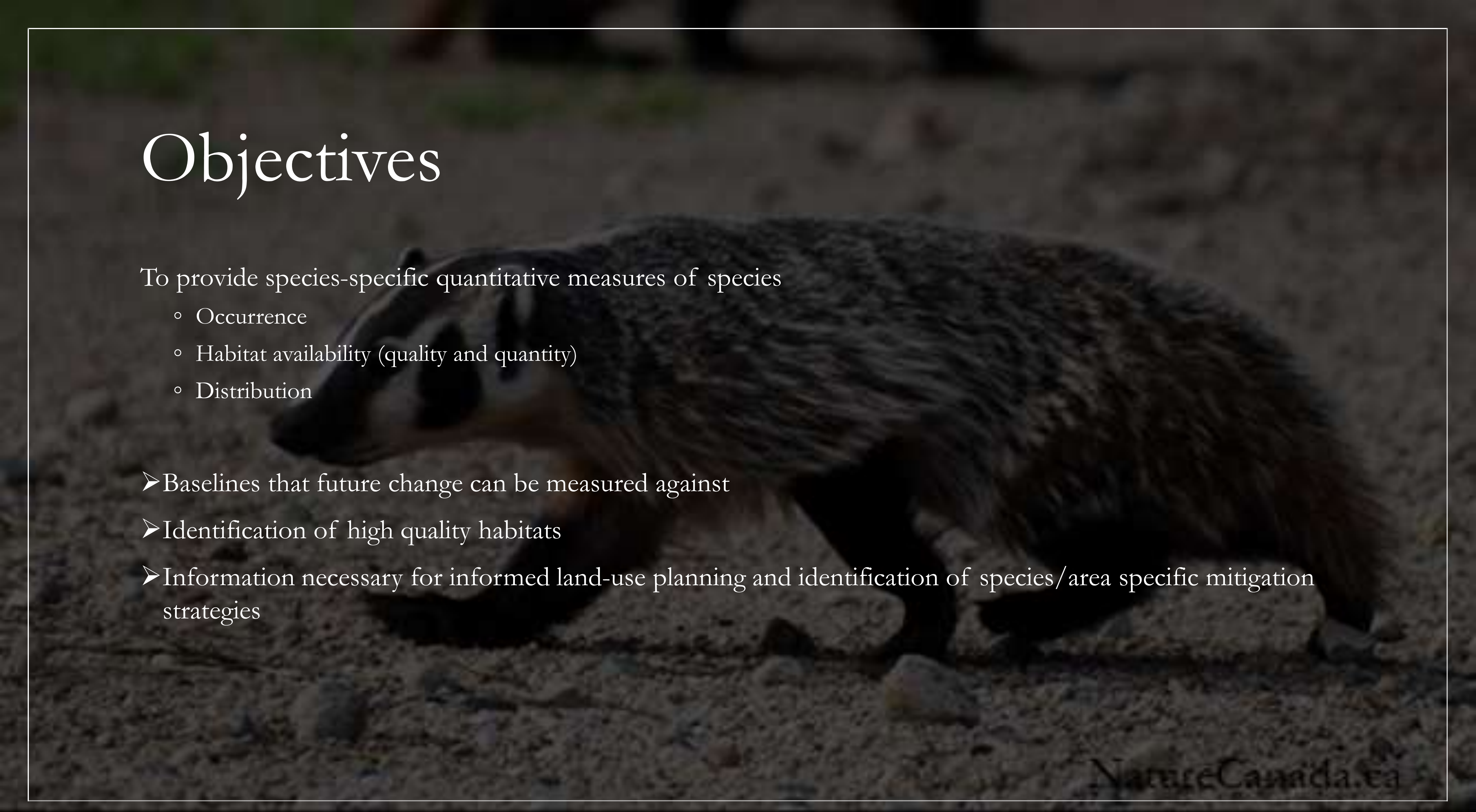
Overview

- Listed Plants
- Fish - Lotic
- Birds & Amphibians – Dillon
- CEMF- Project Rep

TERRESTRIAL WILDLIFE VC UPDATE

Crown Mountain Coking Coal Project

MOOSE MODEL DEVELOPMENT



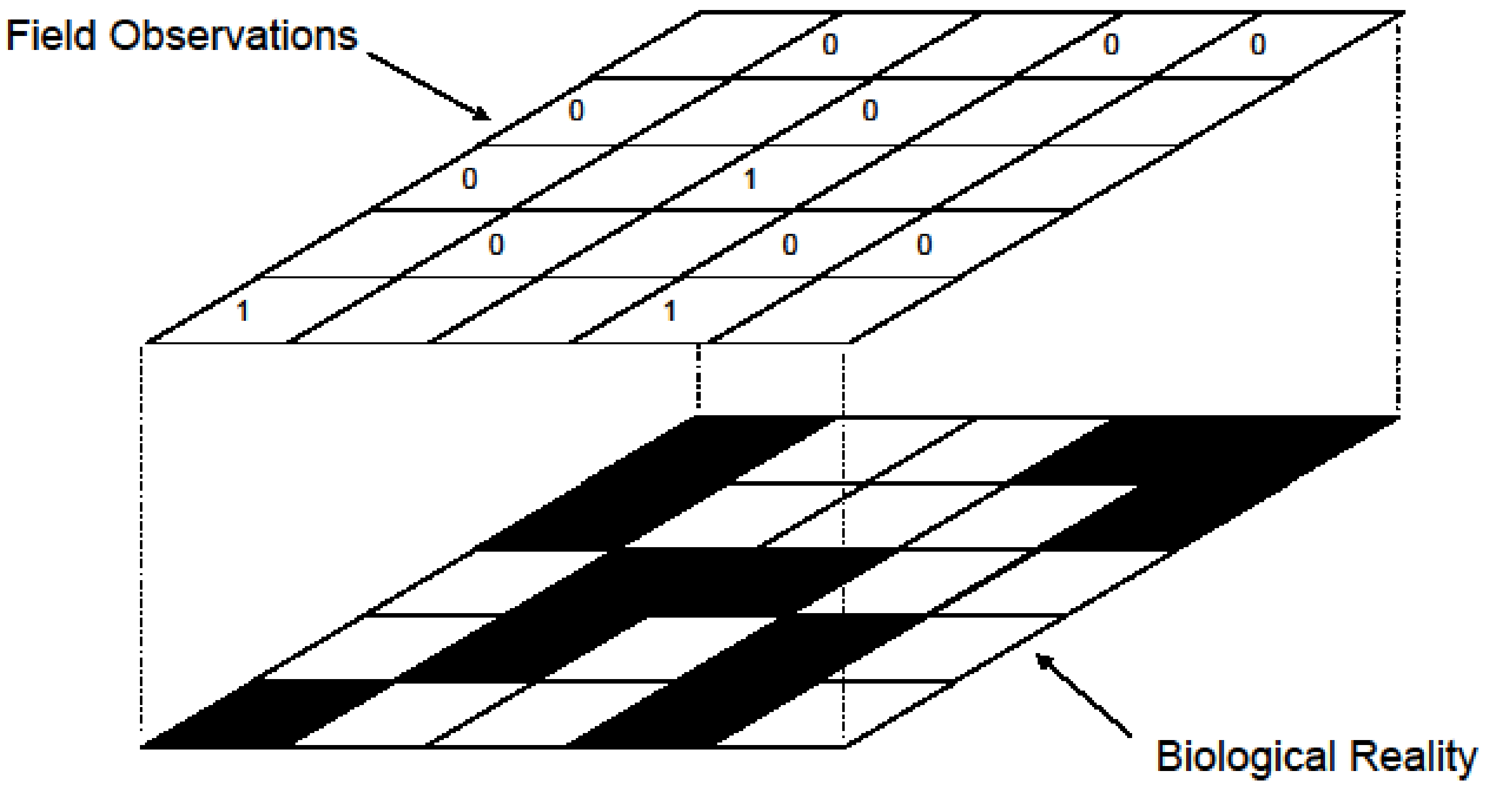
Objectives

To provide species-specific quantitative measures of species

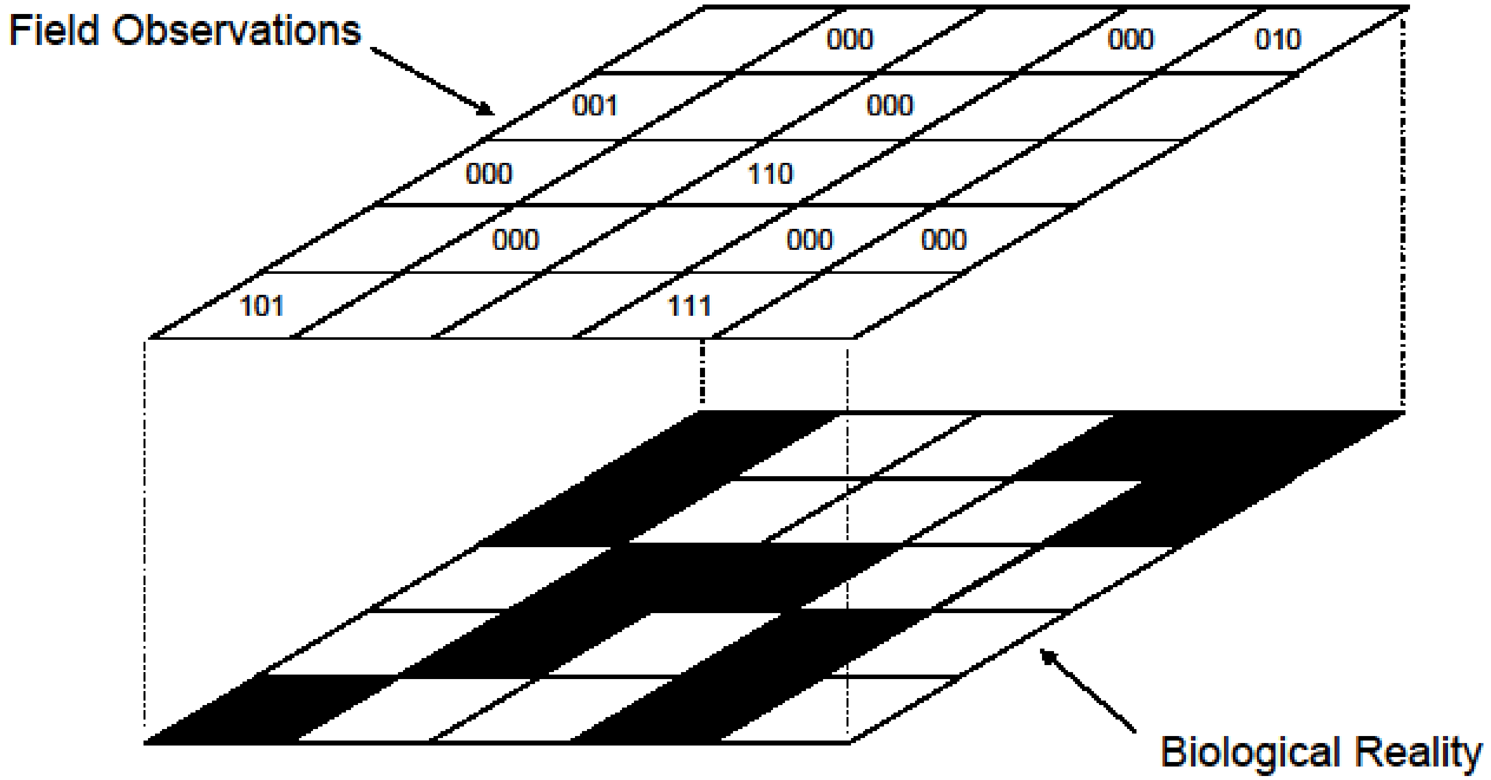
- Occurrence
- Habitat availability (quality and quantity)
- Distribution

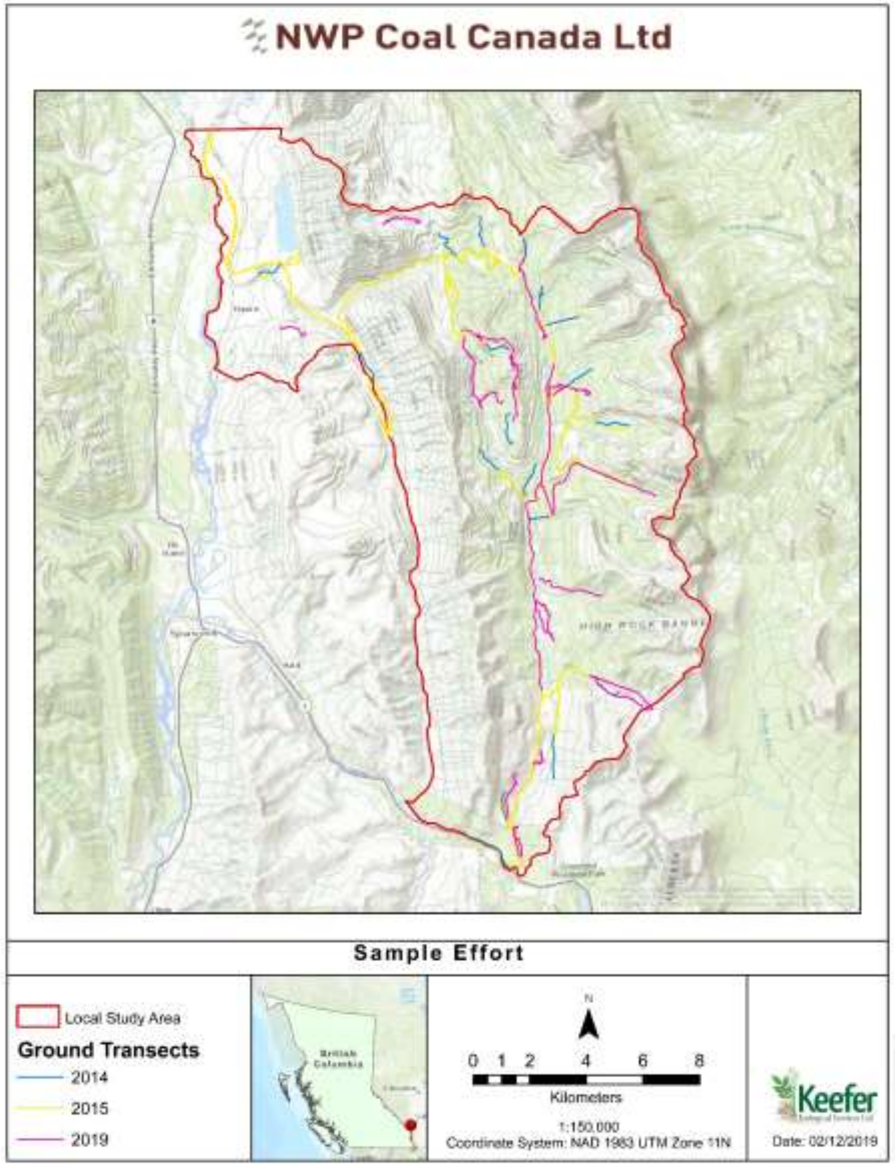
- ➢Baselines that future change can be measured against
- ➢Identification of high quality habitats
- ➢Information necessary for informed land-use planning and identification of species/area specific mitigation strategies

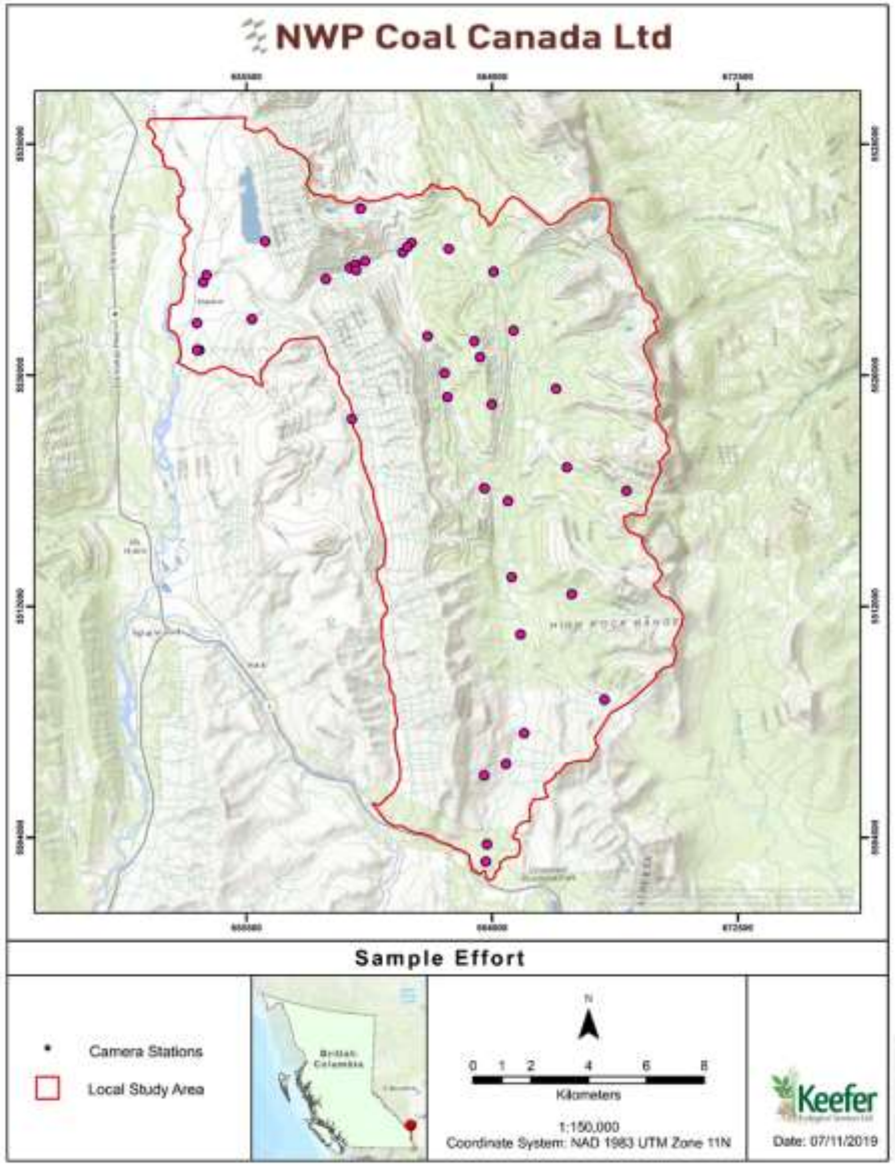
"Concept: Single Surveys Often Fail to Accurately Represent Biological Reality... Problems Occur when Non-detection ≠ Absence..."



"...Multiple surveys, in conjunction with OM, can account for detectability (false absences)..."

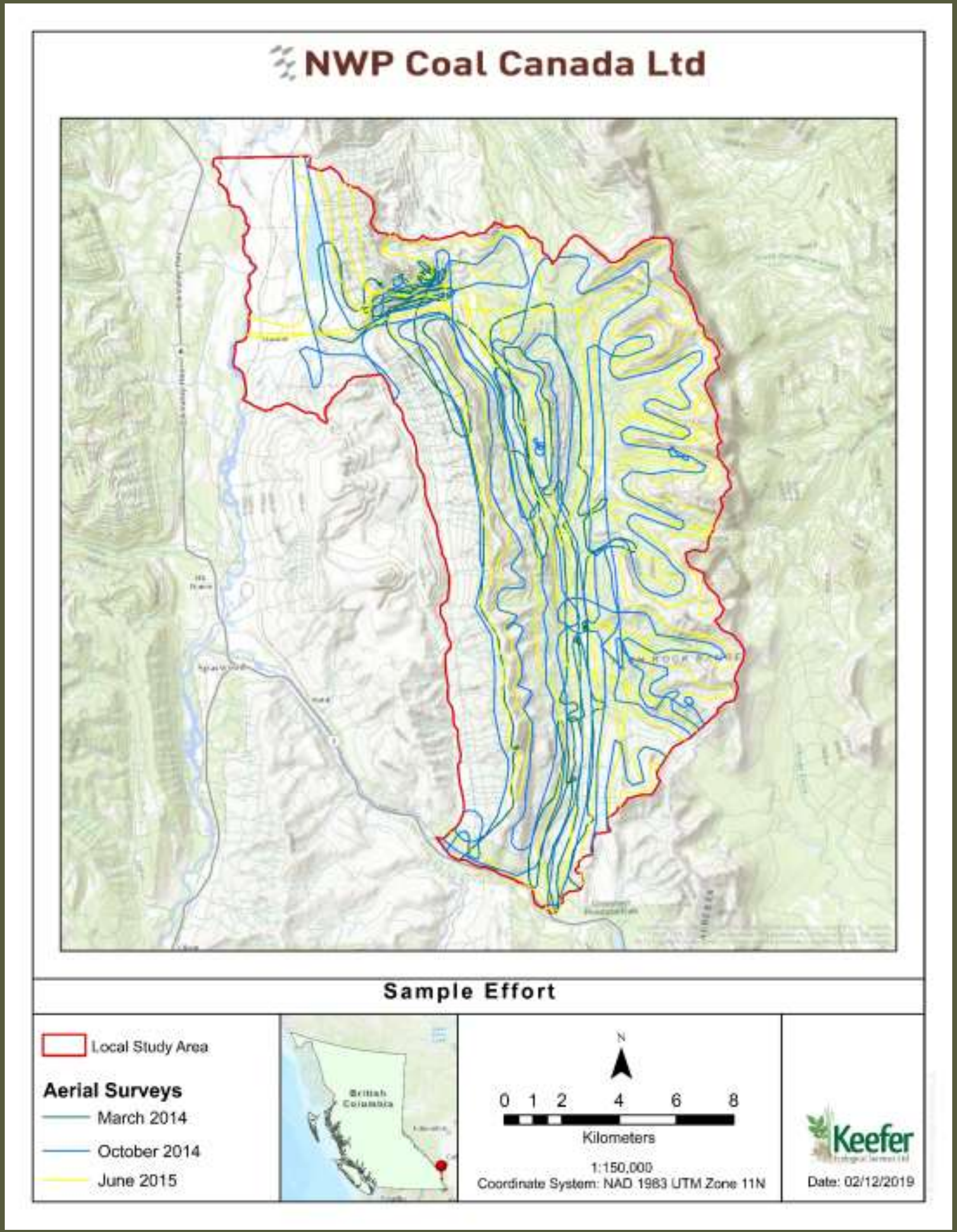






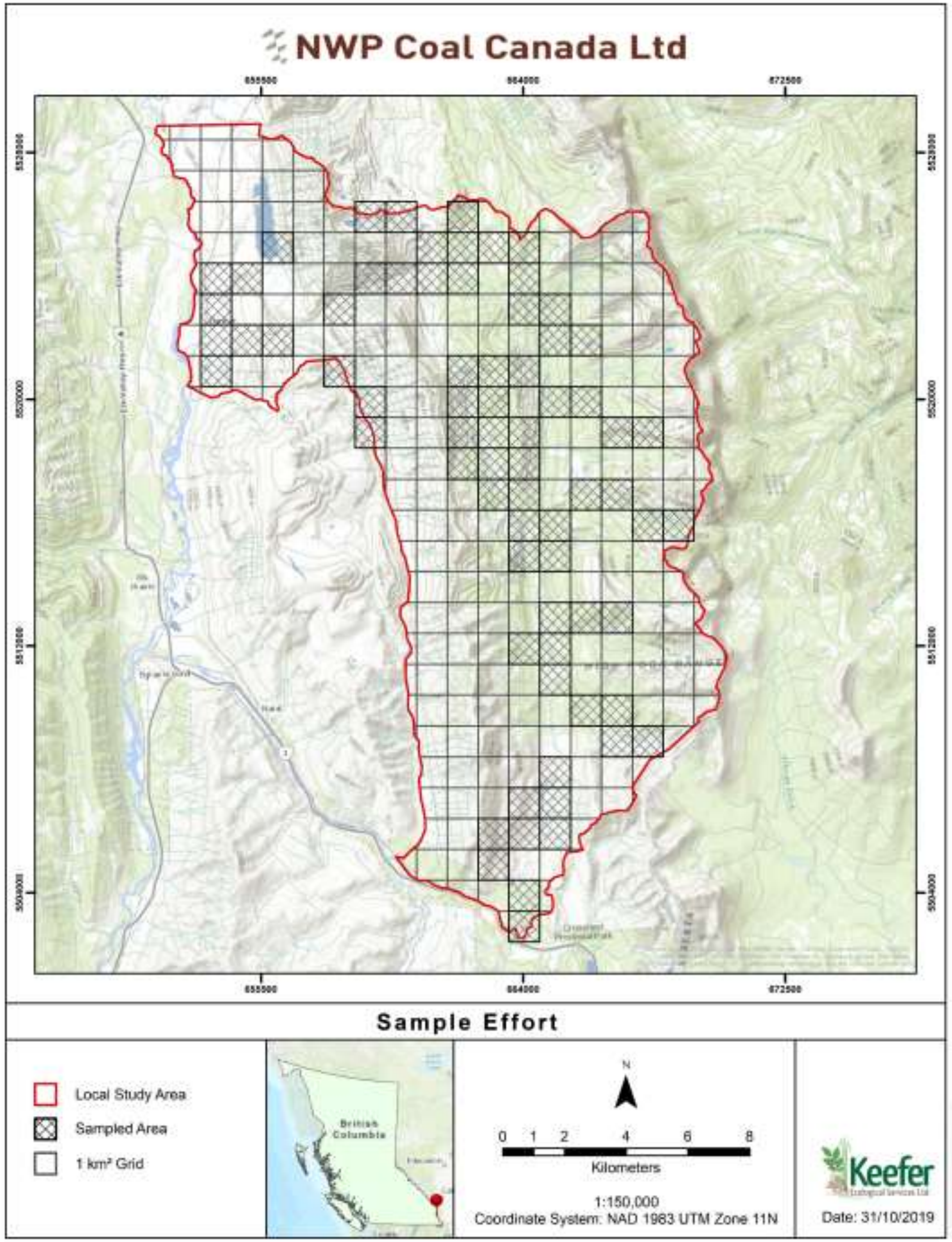
Sample Effort

- ▶557 km transects
  - 220 (2014)
  - 262 (2015)
  - 74 km (2019)
- ▶41 remote camera stations (2014-2019)



Sample Effort

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



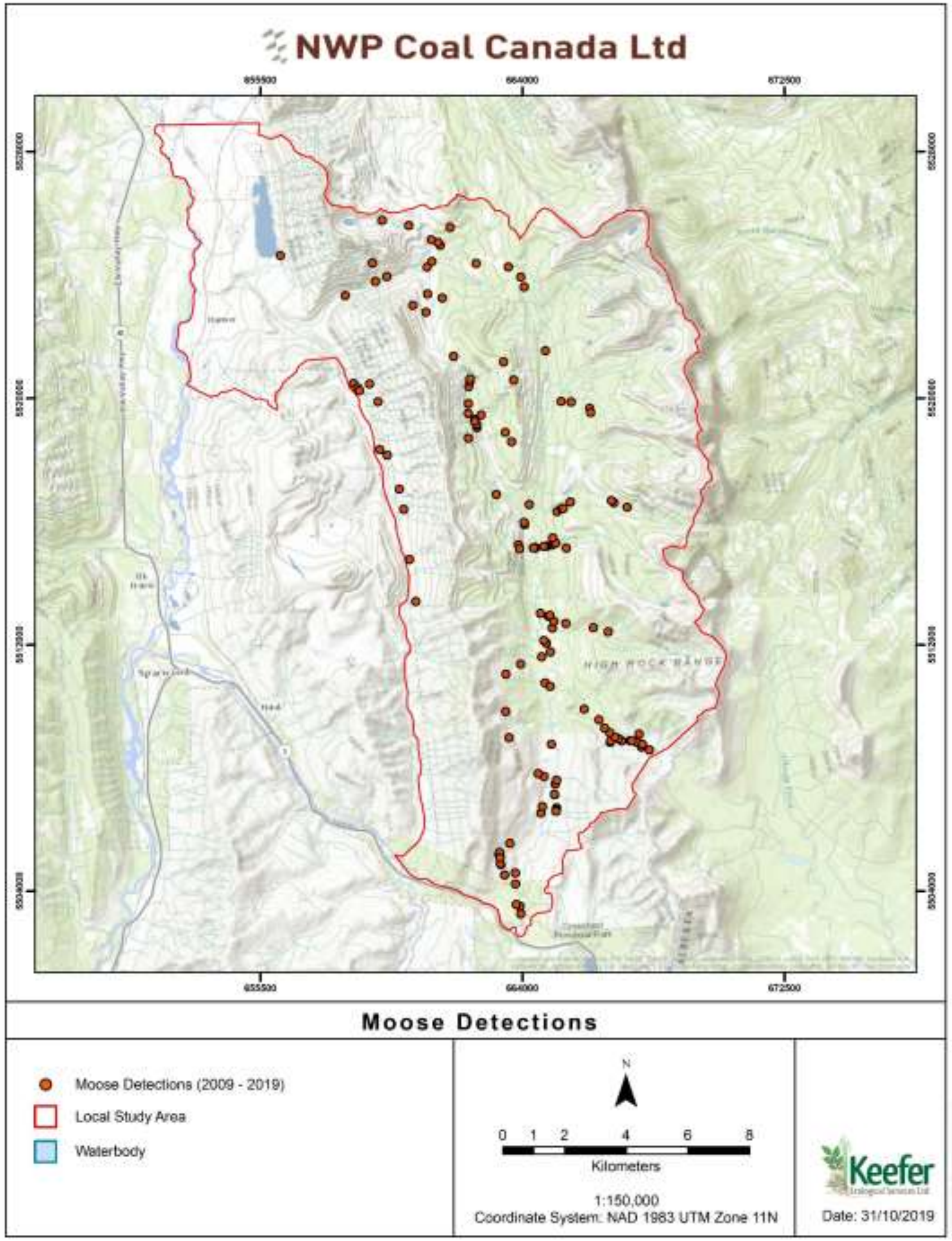
Sample Effort

- ▶72 grid cells including:
  - ▶Camera stations
  - ▶Ground transects

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

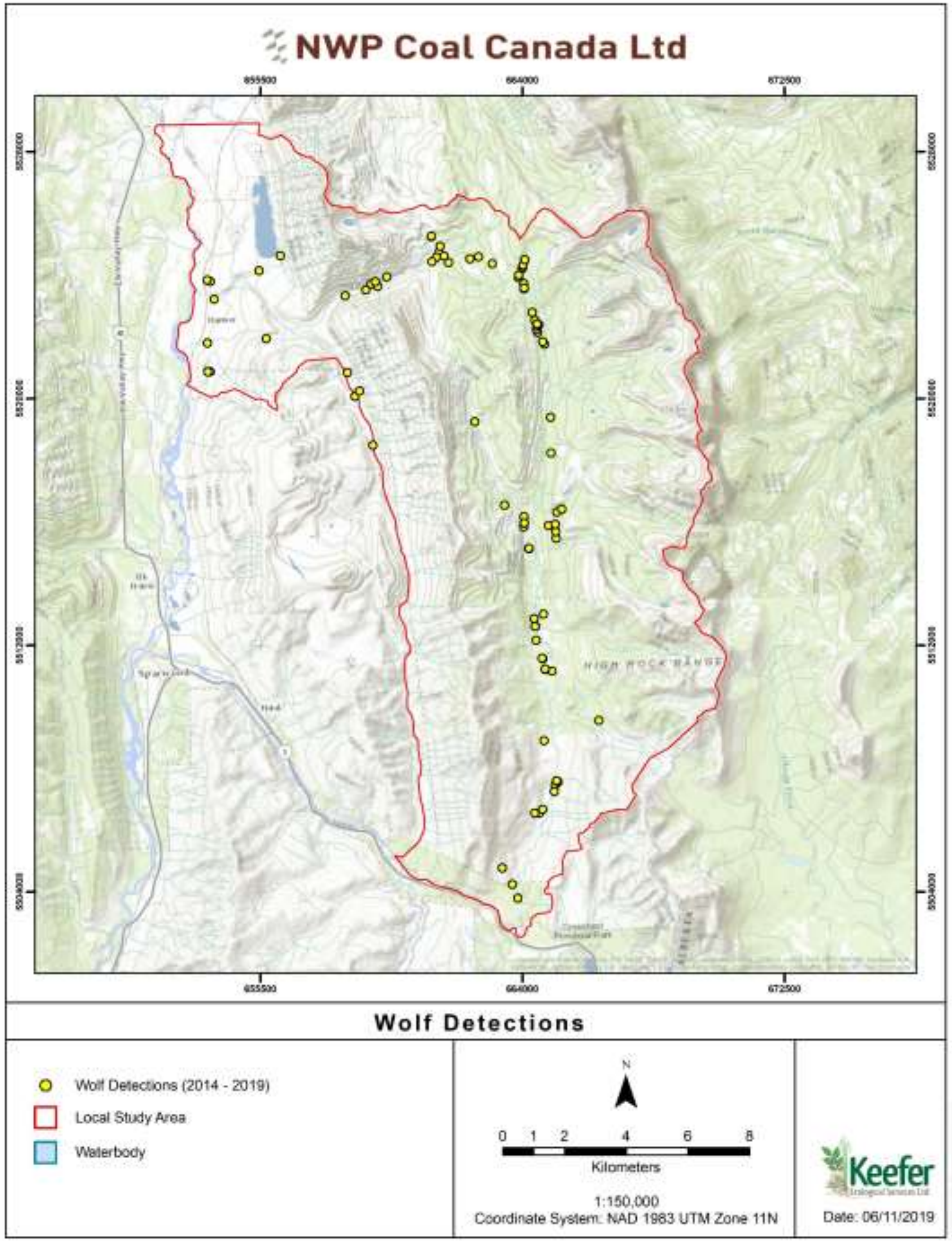
▶Sampling was conducted across a gradient of landscape features and habitat characteristics:

- BEC zones
- proximity to roads, rivers, Alberta border and project footprint



Sample Size

- 177 Moose detections in Local Study Area



Sample Size

- 132 Wolf detections (2014-2019)
- Mean pack size = 4

Habitat Variable Development: Moose

HABITAT COMPONENT	RELATION TO MOOSE FITNESS (+/-)
Rivers and streams	Facilitation of movement (+), and conditions favouring browse (+)
Conifer & Broadleaf forests	Cover from predators (+), thermoregulation (+), browse (+)
Roads	Facilitation of movement (+), facilitation of predator movement (-), risk of mortality (-)
Elevation	Proxy for snow depth (-)
Shrubs	Nutritious forage (+)
Cutblocks	Forage with high nutritional content (+)
Riparian & Wetlands	Forage with high nutritional content (+)
Seepage points	Influence energetic condition by providing essential minerals (+)
Predator (Wolf)	Predation risk (-)

Habitat Variable Development: Wolf

HABITAT COMPONENT	RELATION TO WOLF FITNESS (+/-)
Rivers and streams	Facilitation of movement (+), and conditions favouring vegetation foraged by prey (+)
Roads	Facilitation of movement (+), disturbance/persecution (-)
Elevation	Conditions suitable for dens and movement (i.e., snow cover) (+)
Canopy Closure	Cover for insulation and shade (+), protection of young (+), conditions suitable for dens and movement (+)
Seral Stage	Cover for insulation and shade, protection of young (+), conditions suitable for dens and movement (+)
Rocks/Rubble	Conditions not suitable for prey capture (-)
Terrain Ruggedness	Conditions not suitable for prey capture (-)
Urban areas	Risk of mortality and disturbance (-)

Habitat Variable Development: Data Sources

Covariate	Original map classes (descriptions)	Unit of Measure	Data Source
Shrub (browse) containing habitat	TEM site series: MSdw: Ws03, Ws04, Ws07, Ws, Fl, Fl04, Rl, Fm02, Vs, Gb04, Gb, Xv, Vs, 102, 103, 104, 110, 111 ESSFdk1: Gb, Gb20, Vs, Xv, 102,110, 111 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

Habitat Variable Development: Data Sources

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 and Streams	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
Slope	British Columbia Alberta		
Terrain curvature	British Columbia Alberta		
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: Wolves

Wolf: Survey Covariates

Table #. Summary of model selection procedure for factors influencing Wolf detectability (p) in the Crown Mountain, BC. Factors considered are: survey method (M), baited camera stations (B), season (S), proximity to rivers (RV) and roads (RD).

Model	AICc	ΔAICc	w	k	-2LL
p (RD)	560.92	0.00	0.8438	3	554.66
p (SN)	564.78	3.86	0.1225	3	558.52
p (M)	569.00	8.08	0.0148	2	564.87
p (B)	569.22	8.30	0.0133	3	562.96
p (RV)	570.95	10.03	0.0056	3	564.69

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.

- Wolf detectability varied with proximity to roads and season

Wolf: Model Selection

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	ΔAICc	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)

Results

- Wolves used approximately 64% of the sites surveyed

Wolf: Habitat Variables

Table#. Habitat variables influencing Wolf occurrence 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 Wolf occurrence at a (1 km^2) site (n = 98). The β-coefficient is the strength and direction (±) of influence.

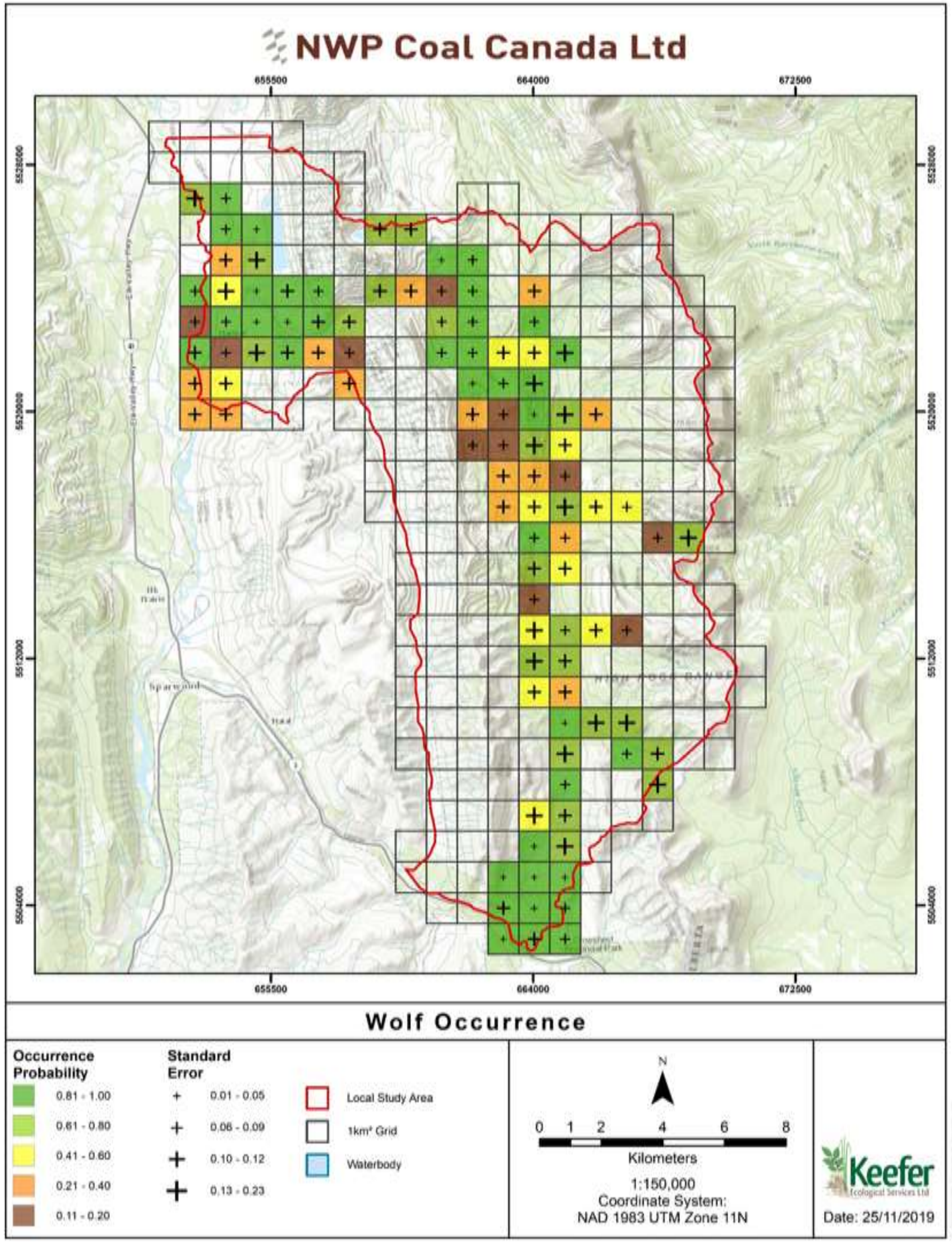
Variable	∑w	β	SE
Mid Seral Forest	0.929	**0.950**	**0.382**
Elevation	0.718	**-1.390**	**0.501**
Primary and Secondary Roads	0.272	**1.671**	**0.822**

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

Results

Most important predictors of Wolf occurrence:

- Strong selection for low elevation habitats, primary and secondary roads and mid-seral forest.

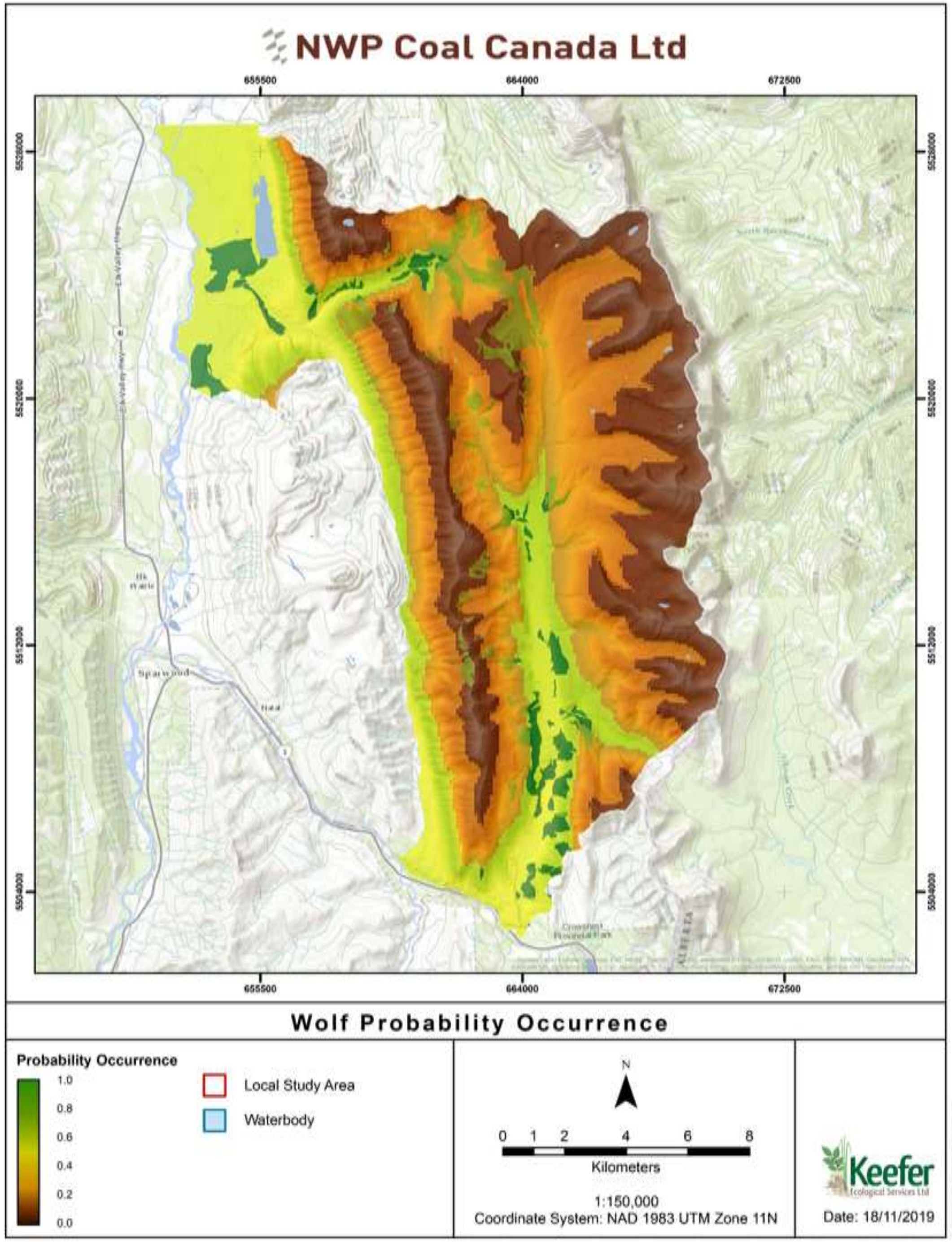


Site-specific Baseline Estimates

- Mean probability of habitat use:

  0.64 (SE = 0.09)

- Wolves used approximately 64% of the sites surveyed
- Strong selection for low elevation habitats, primary and secondary roads and mid-seral forest.



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

Fall/Winter: Survey Covariates

Table #. Model selection procedure showing factors influencing Moose detectability (p) during fall-winter in the Crown Mountain, BC (2014-2019). Factors considered are: (16 day) camera-trap, (1 km) transect (CT) and 1.5 km aerial (A) surveys. Models with 557 (1 Km) transect surveys, 41 (8 day) camera surveys, 874 (1.5 km) aerial surveys of 194 (1 km^2) grid cells. Number of sites = 156.

Model	AICc	ΔAICc	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 (C,T)	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.

- Fall/winter Moose detectability varied with survey method

Fall/Winter: Model Selection

Table #. Model selection procedure for factors influencing Moose site occupancy (Ψ) during fall-winter in the Crown Mountain, BC (2014-2019; number of sites = 229). Habitat components considered are elevation (E), 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 (SH,PRV)	236.31	0.00	0.2226	6	223.75	0.28 (0.10)
Ψ (SH)	236.85	0.54	0.1699	5	226.45	0.32 (0.10)
Ψ (SH,WL)	237.96	1.65	0.0975	6	225.40	0.28 (0.11)
Ψ (SH,PRV,PRD)	238.27	1.96	0.0835	7	223.51	0.28 (0.12)
Ψ (SH,MSF)	238.30	1.99	0.0823	6	225.74	0.33 (0.12)
Ψ (SH,PRV,OMF)	238.51	2.20	0.0741	7	223.75	0.28 (0.12)
Ψ (SH,PR)	238.80	2.49	0.0641	6	226.24	0.33 (0.12)
Ψ (SH,SRD)	238.91	2.60	0.0607	6	226.35	0.32 (0.12)
Ψ (SH,OMF)	238.93	2.62	0.0601	6	226.37	0.33 (0.12)
Ψ (SH,PRD)	238.01	2.70	0.0577	6	226.45	0.32 (0.12)
Ψ (SH,PRV)	242.06	5.75	0.0126	6	229.50	0.32 (0.12)
Ψ (PRV)	242.52	6.21	0.0100	5	232.12	0.32 (0.12)
Ψ (.)	243.89	7.58	0.0500	4	235.63	0.42 (0.11)
Model Average						**0.30 (0.11)**

Results

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

Fall/Winter: Habitat Variables

Table#. Habitat variables influencing Moose occurrence during fall/winter (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 = 156). The β-coefficient is the strength and direction (±) of influence.

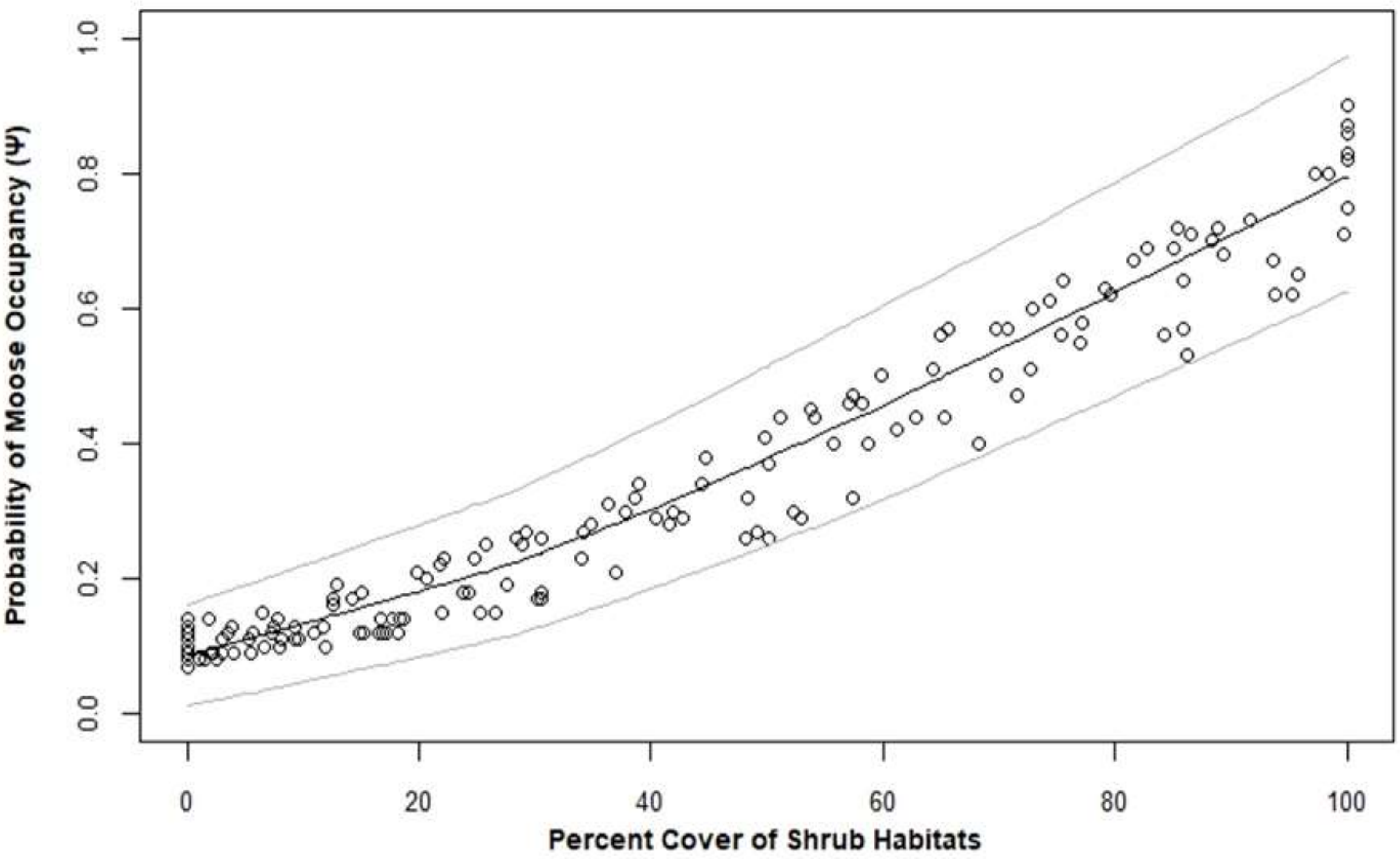
Variable	∑w	β	SE
Shrub Containing Habitats	0.97	**1.076**	**0.406**
Primary and Secondary Rivers	0.38	**0.858**	**0.501**
Primary Roads	0.14	-0.214	0.129
Old and Mature Forests	0.13	0.674	0.465
Wetlands	0.10	0.440	0.384
Mid Seral Forest	0.08	-0.314	0.306
Predator Occurrence	0.06	-0.939	0.059
Secondary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

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

Results

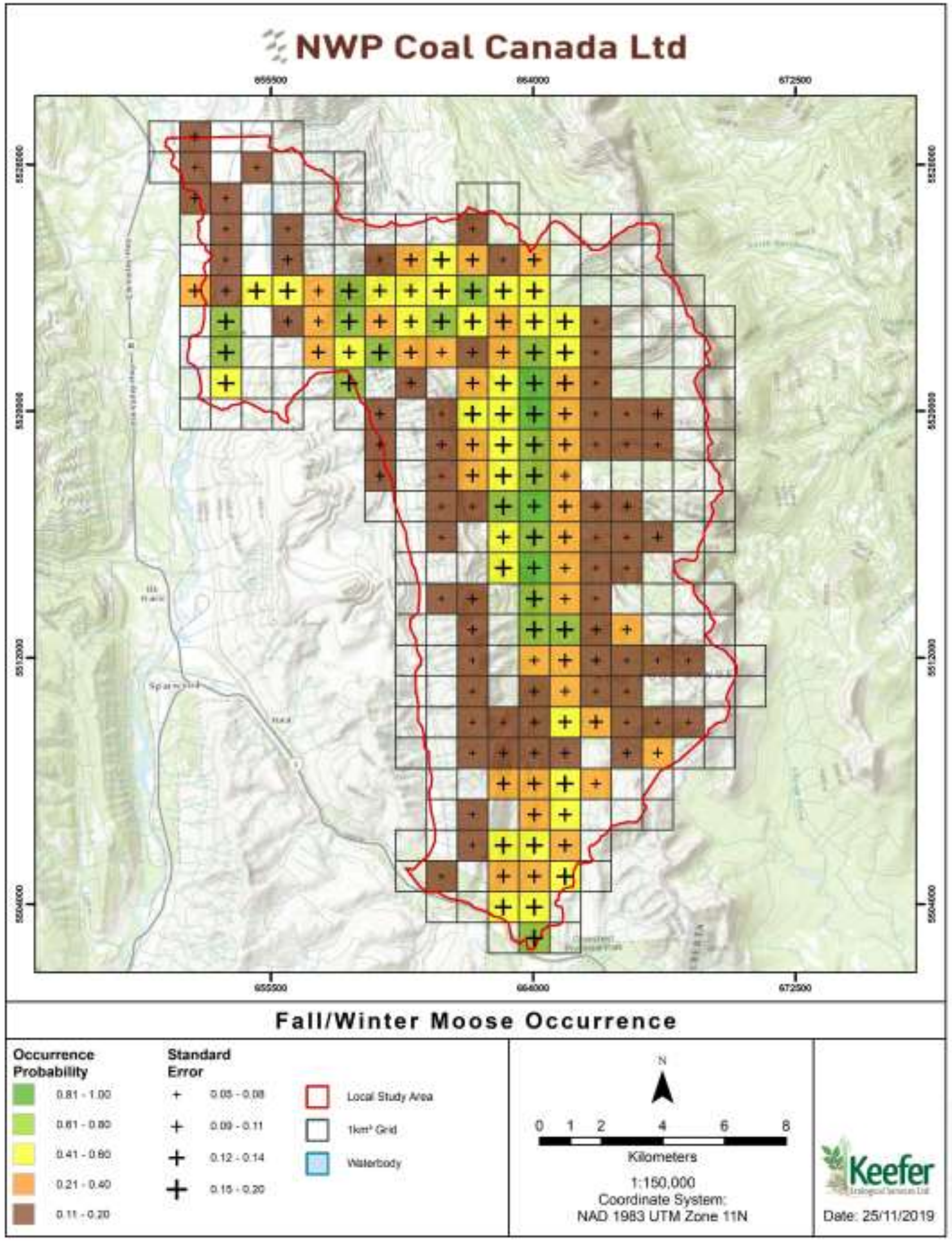
Most important predictors of Moose occurrence:

- Strong selection for browse containing habitats and primary and secondary rivers
- Positive association with old and mature forests and wetlands
- Negative association with roads and predator occurrence.



Results

- Shrubs were the greatest determining factor of moose habitat use during fall/winter

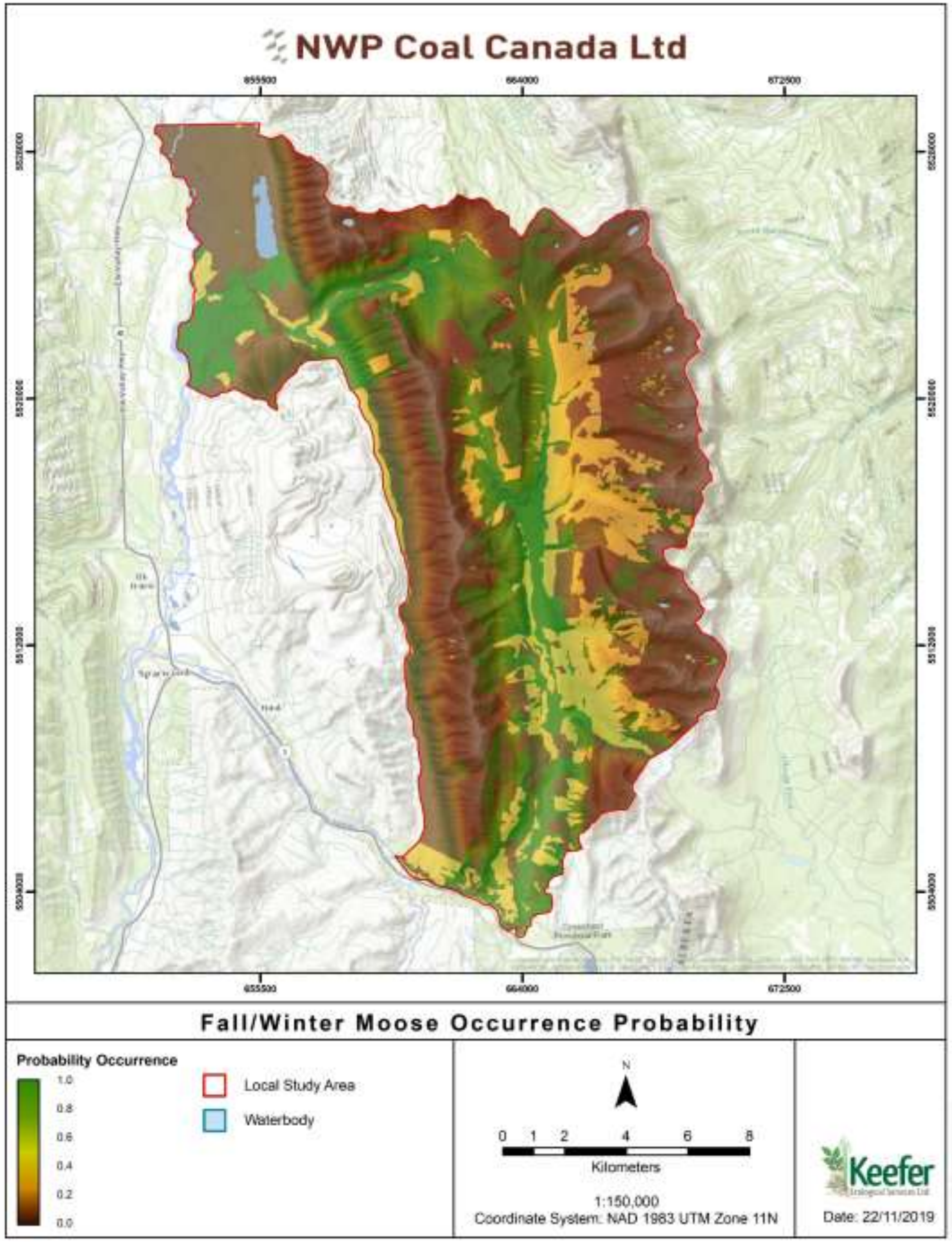


Site-specific Baseline Estimates

- Mean probability of habitat use:

  0.30 (SE = 0.11)

- Moose used approximately 30% of the sites surveyed during fall/winter
- Strong selection for shrub containing habitats and primary and secondary rivers
- Positively associated with wetlands and old and mature forest patches
- General avoidance of sites with greater predator (wolf) occurrence and roads



Moose Habitat Occupancy (fall-winter)

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

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

Spring/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, 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

Spring/Summer: Model Selection

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 (WL), 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)

Results

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

Spring/Summer: Habitat Variables

Table #. Habitat variables influencing Moose occurrence during spring/summer (March 23-Sept 21) 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 = 156). The β-coefficient is the strength and direction (±) of influence.

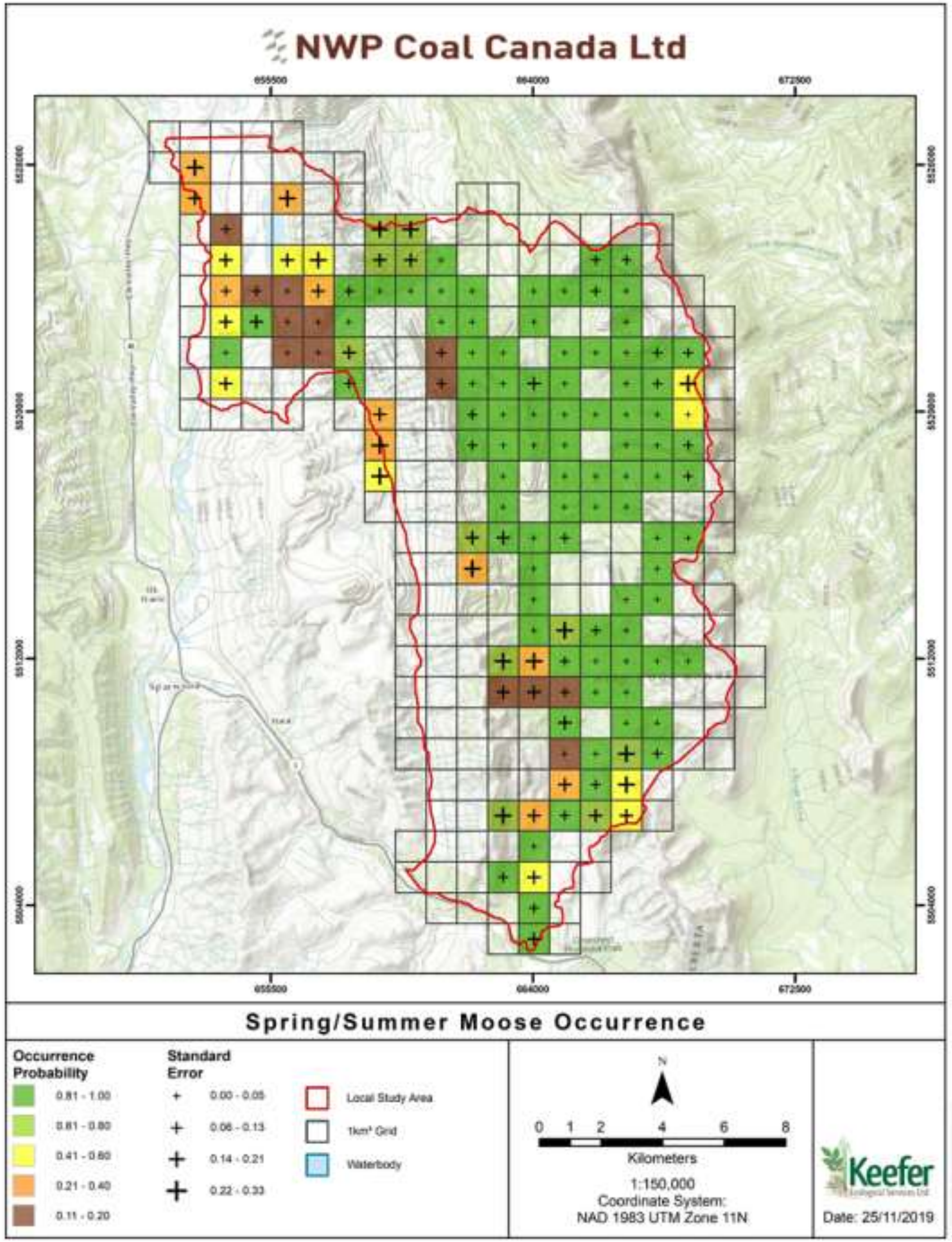
Variable	∑w	β	SE
Old Mature Forest	0.96	**3.483**	**1.174**
Early Seral Forest	0.80	**-2.622**	**1.295**
Tertiary Rivers	0.37	**2.742**	**1.202**
Secondary Roads	0.37	2.442	1.503
Wetlands	0.37	1.291	0.724
Primary Roads	0.34	2.539	1.348

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

Results

Most important predictors of Moose occurrence:

- Strong positive association with Old Mature forests & Tertiary rivers
- Negative association with Early Seral forests.
- Positive association with wetlands and roads



Site-specific Baseline Estimates

- Mean probability of habitat use:

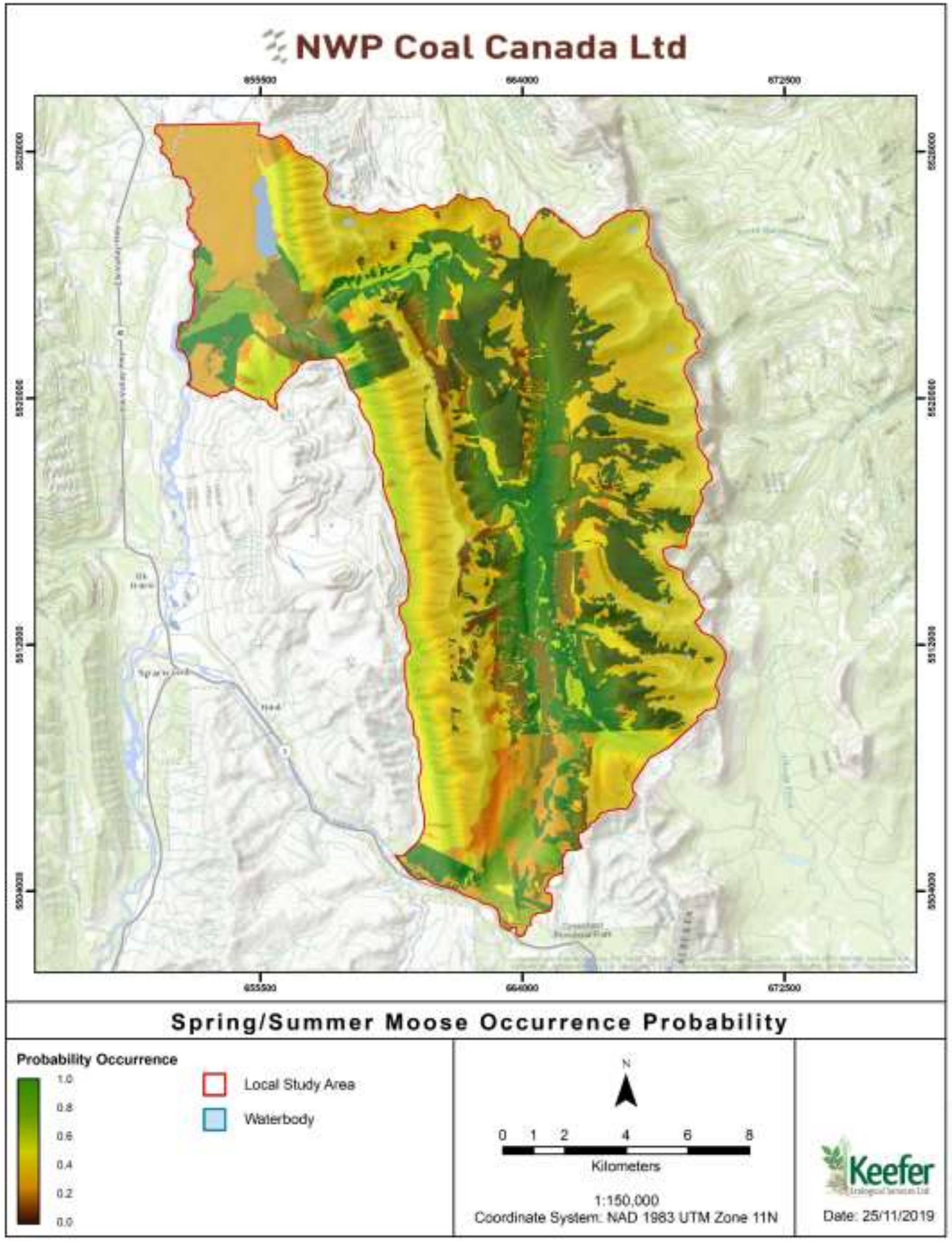
  0.77 (SE = 0.08)

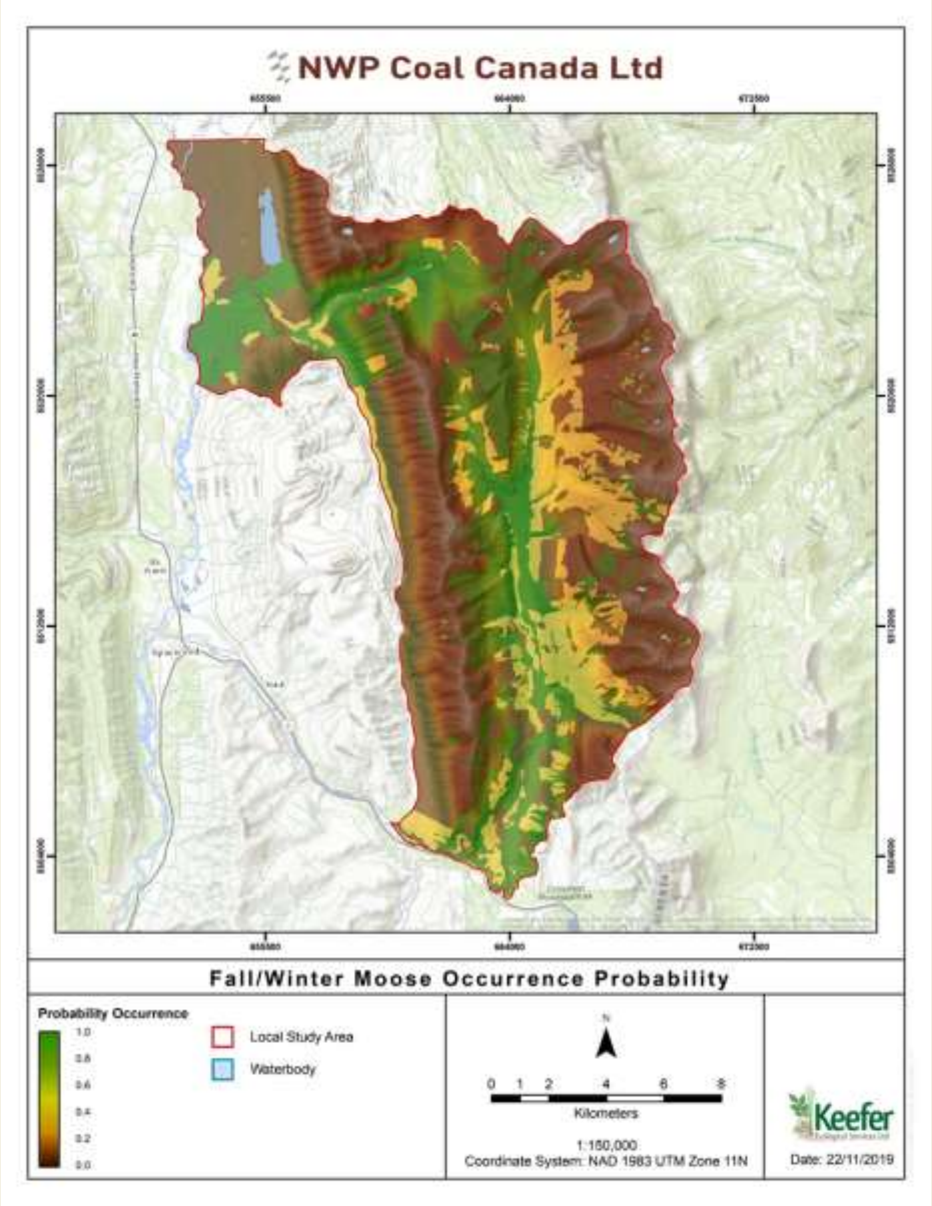
- Moose used approximately 77% of the sites surveyed during spring/summer
- Strong selection for old and mature forest patches and tertiary rivers
- Association with wetlands and roads
- Avoidance of early seral forest patches

Moose Habitat Suitability (spring/summer)

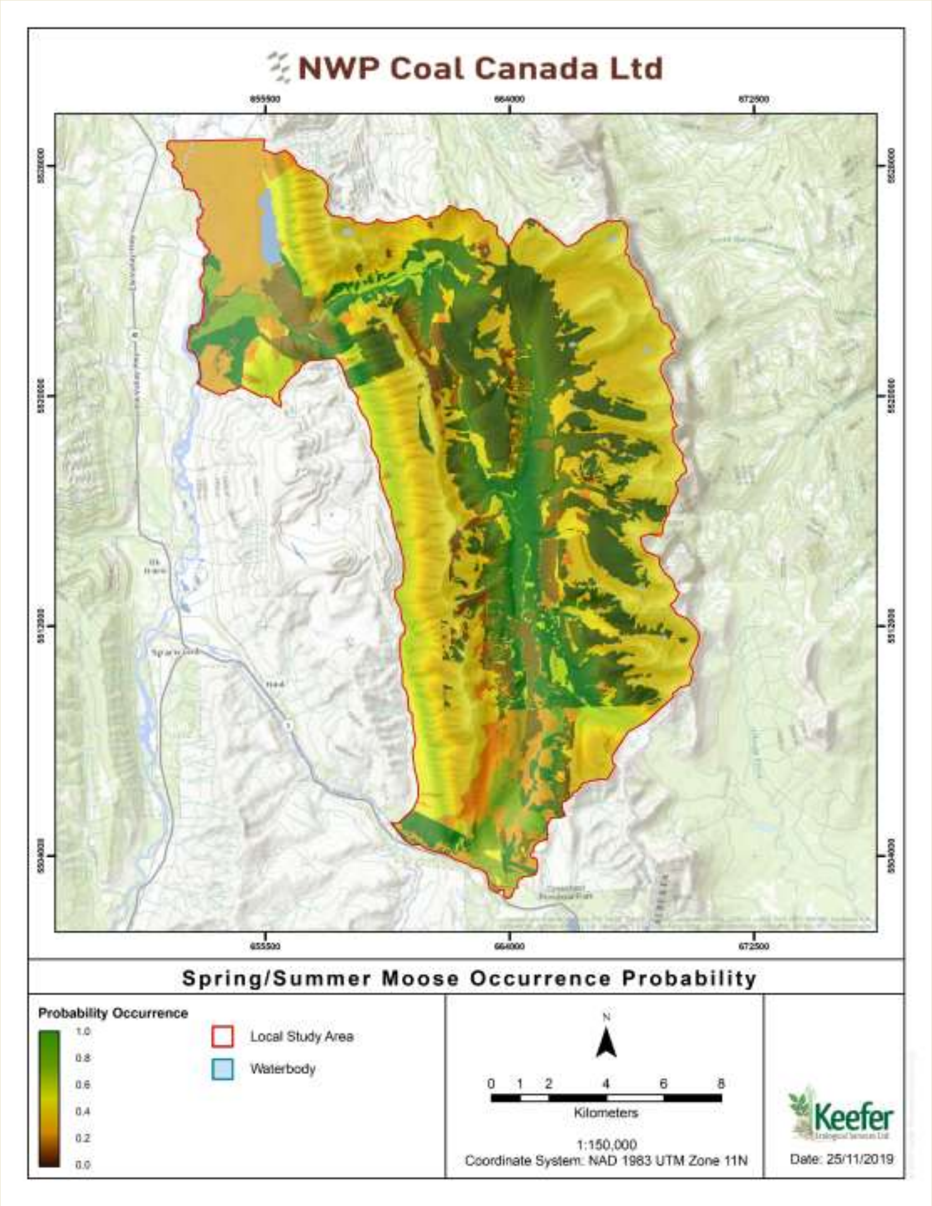
Habitat suitability model based on resulting regression equation from weighted model averaged estimates considering:

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

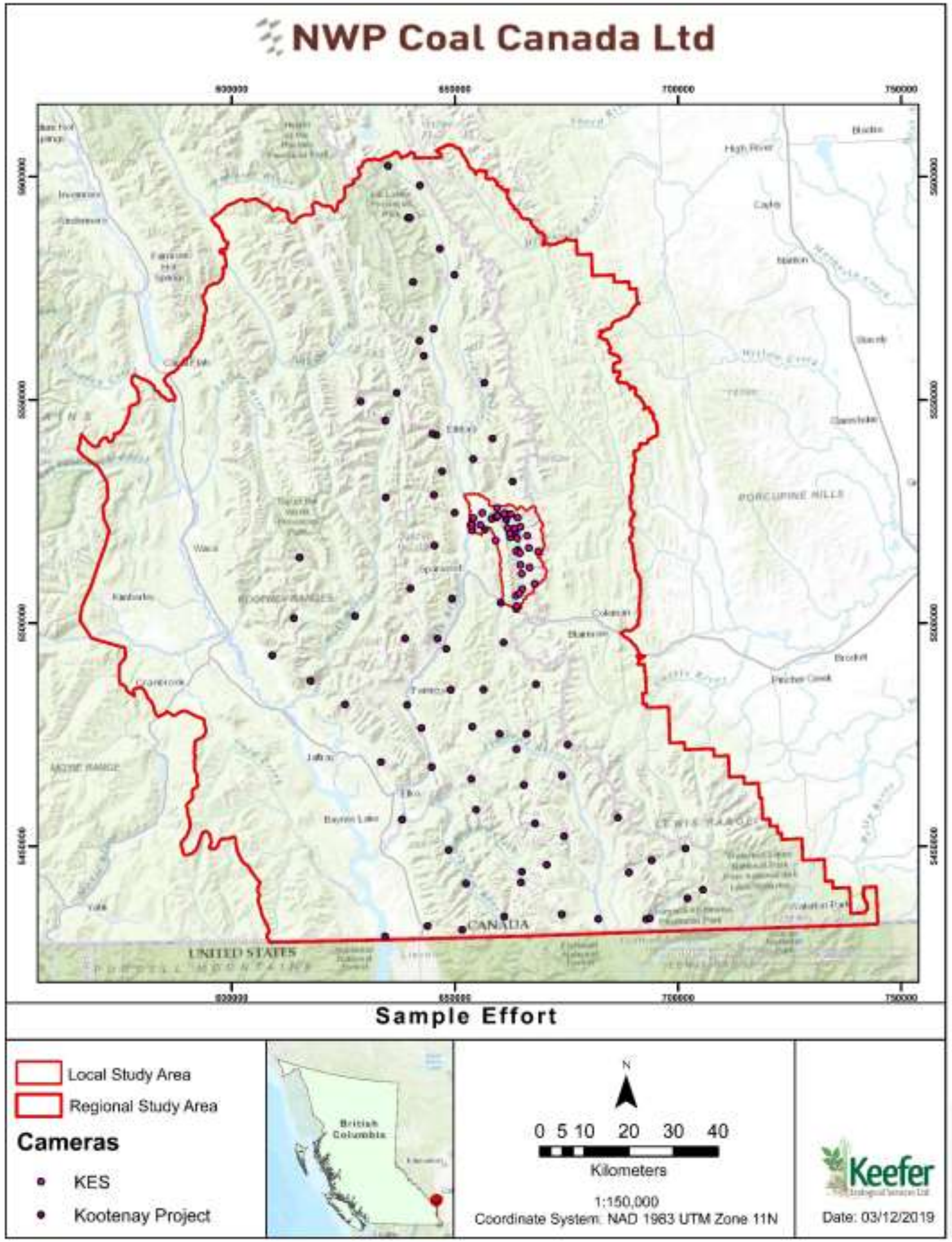




Fall/Winter Overall Occurrence/Habitat use = 0.30 (0.11)

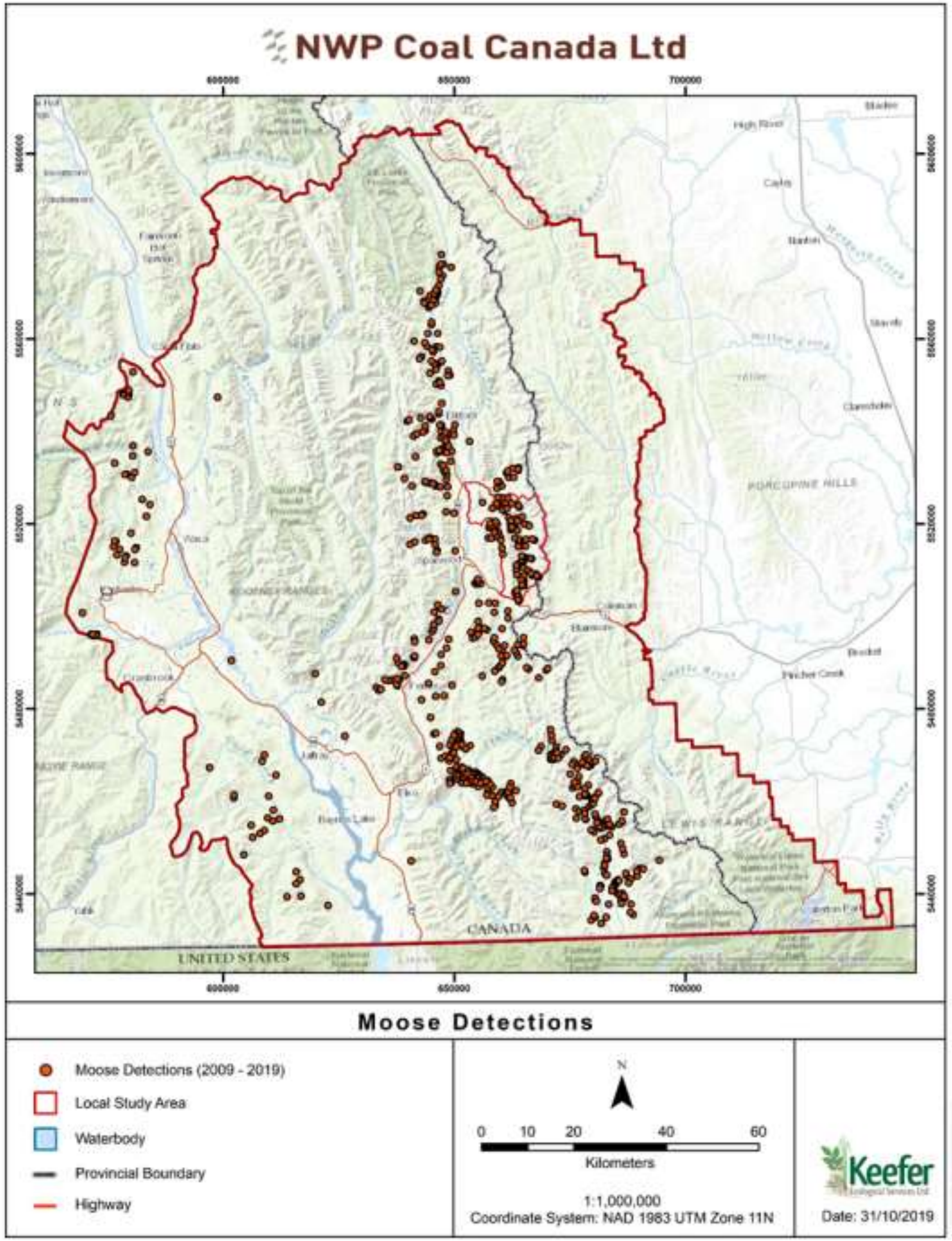


Spring/Summer Overall Occurrence/Habitat use = 0.77 (0.08)



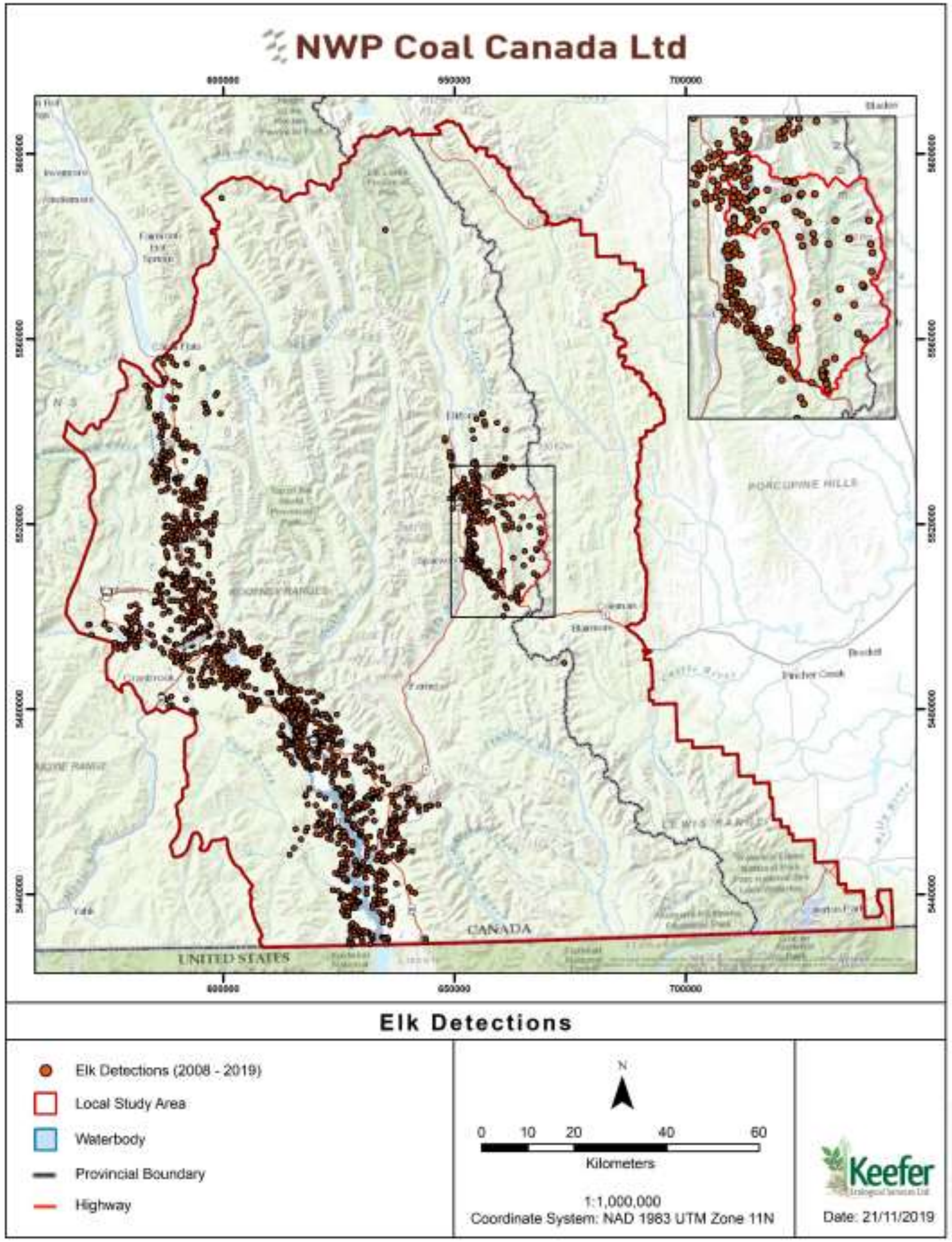
NEXT STEPS:
Moose RSA Habitat Model

- 1191 Moose detections to be integrated into data set.
- Inform model site estimates and species-habitat relationships.

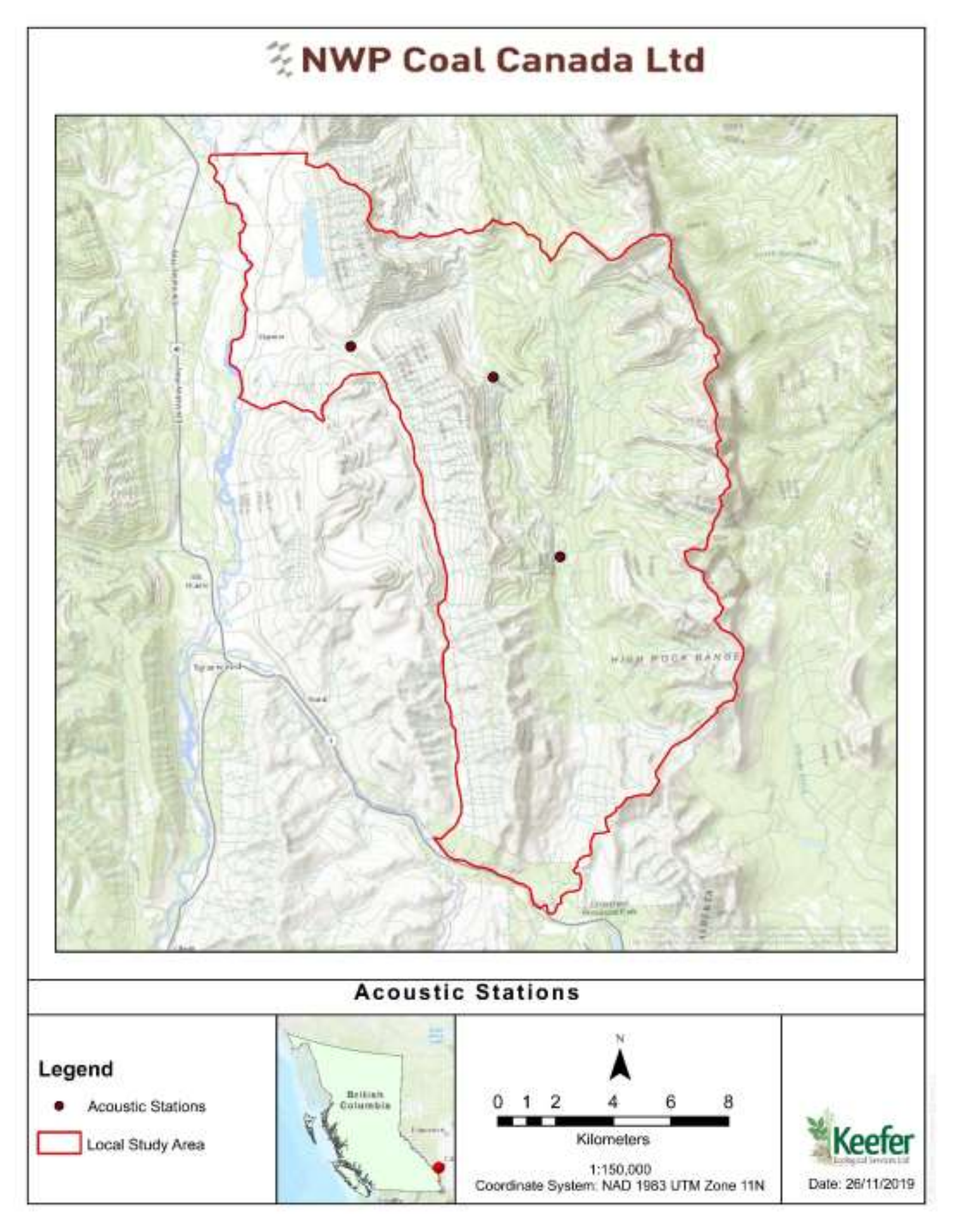


NEXT STEPS: Moose RSA Habitat Model Validation

- 1,043 Government aerial detections in Regional Study Area



NEXT STEPS:
ELK RSA Habitat Model Validation



Bat winter monitoring

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