Appendix 4-KK

Ungulate Wildlife Modelling Meeting - January 2020

TERRESTRIAL WILDLIFE VC UPDATE

Crown Mountain Coking Coal Project

Objectives

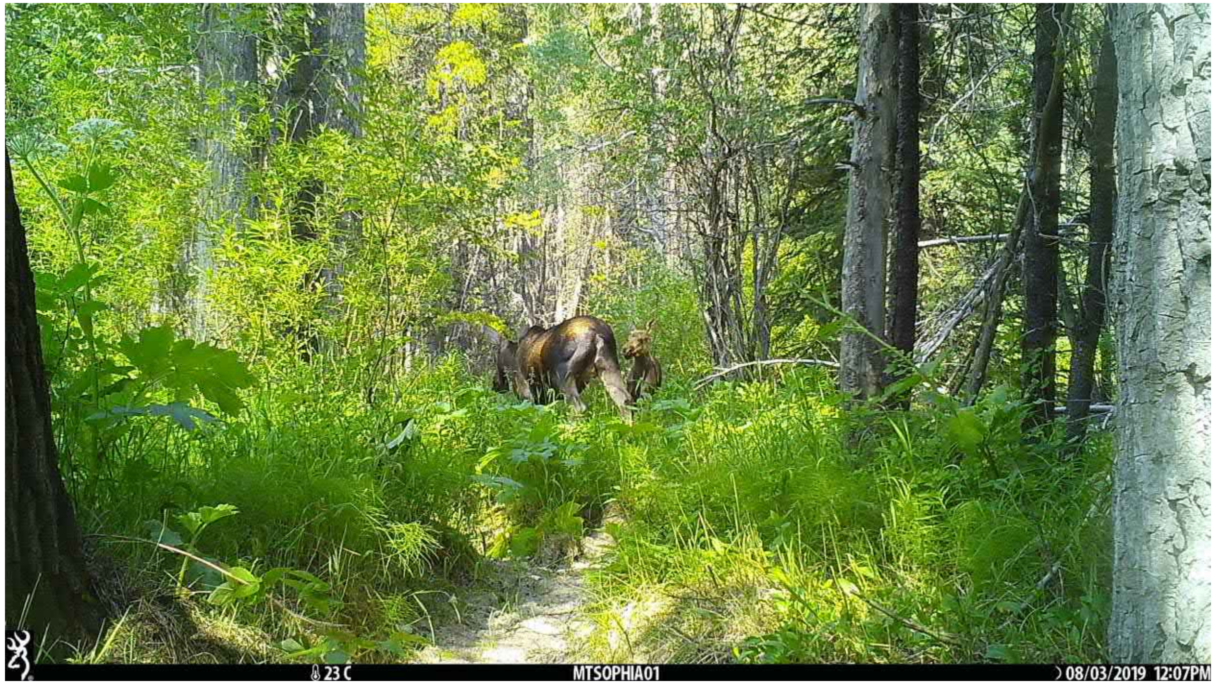
To provide species-specific quantitative measures of species

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

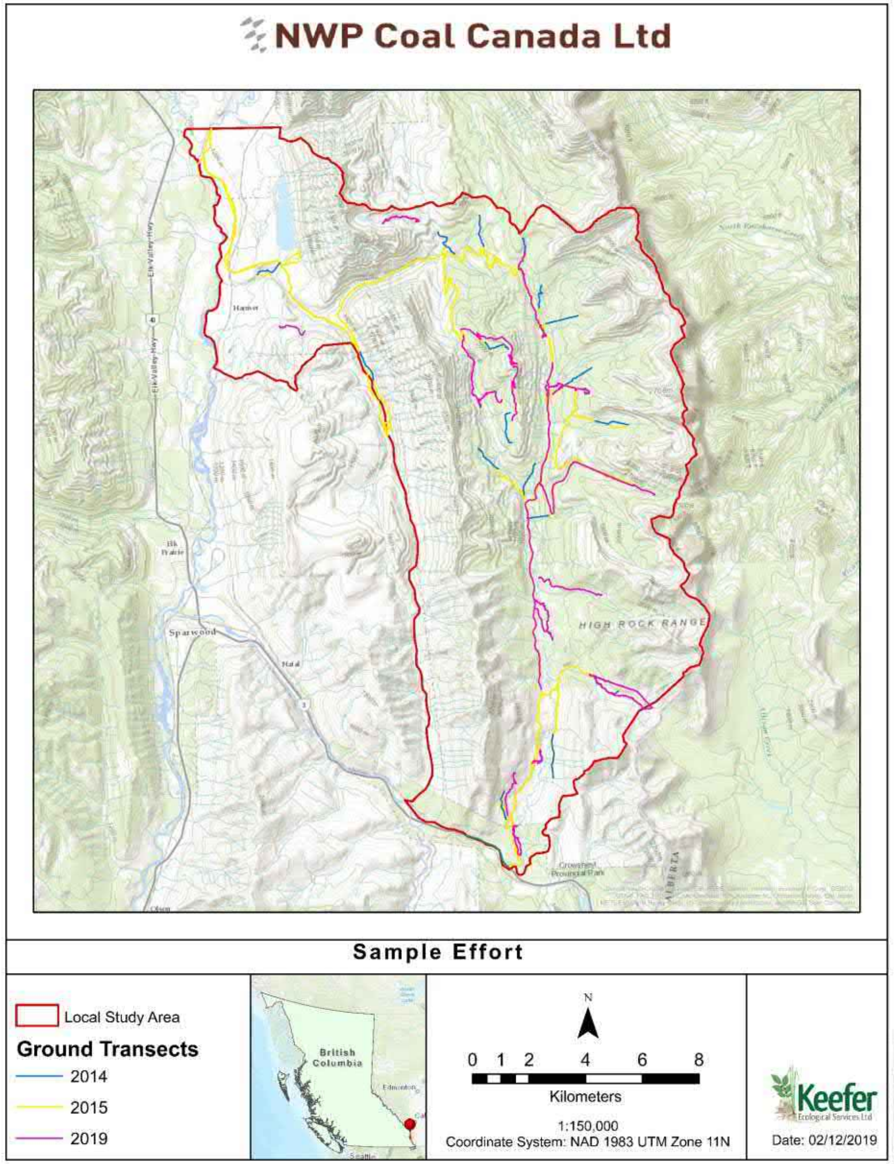
- Baselines that future change can be measured against
- Identification of high quality habitats
- Information necessary for informed land-use planning and identification of species/area specific mitigation strategies

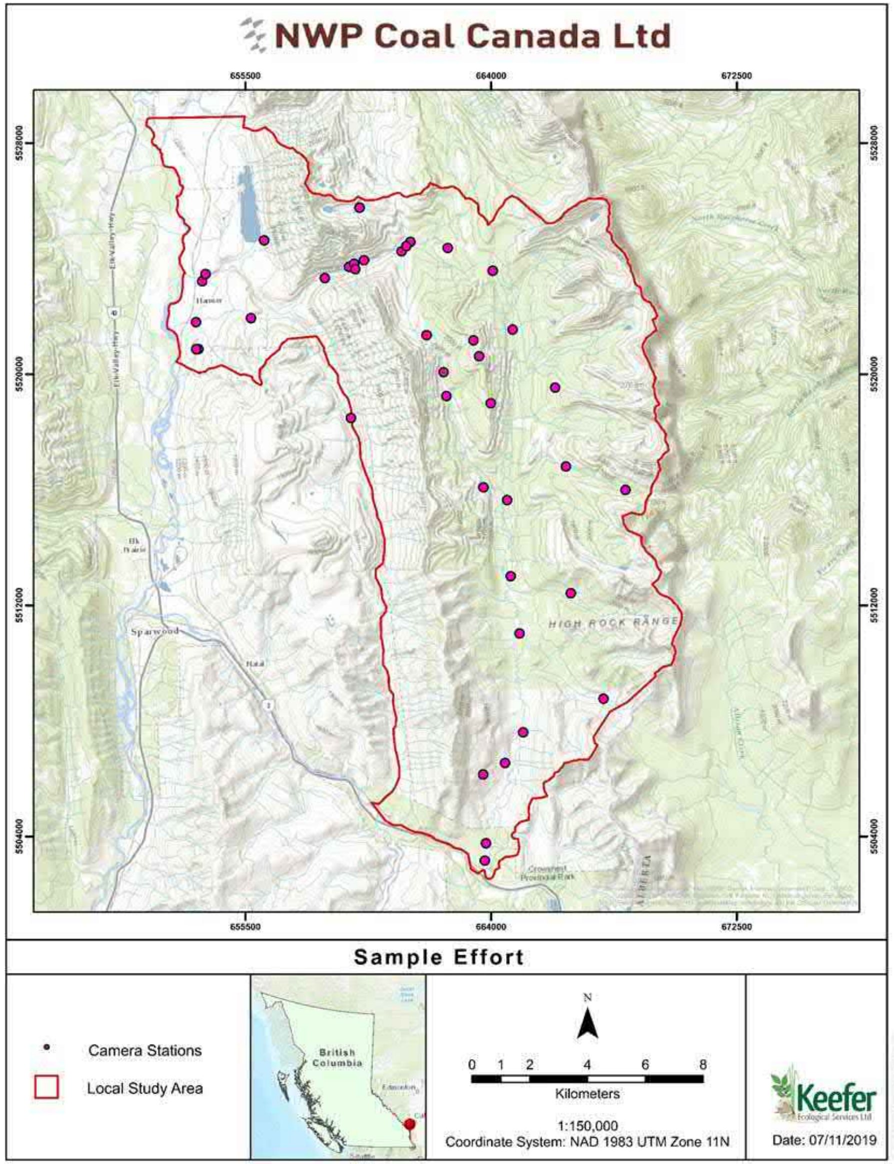
Model Assumptions

- Model assumes that changes to species occurrence over the sampling duration were random (e.g., there was no landscape changes resulting in permanent vacancy or colonization of grid cells)
- Species are not falsely identified
- Detections between sites and surveys are independent
- Heterogeneity in occupancy and detection are accounted for with covariates



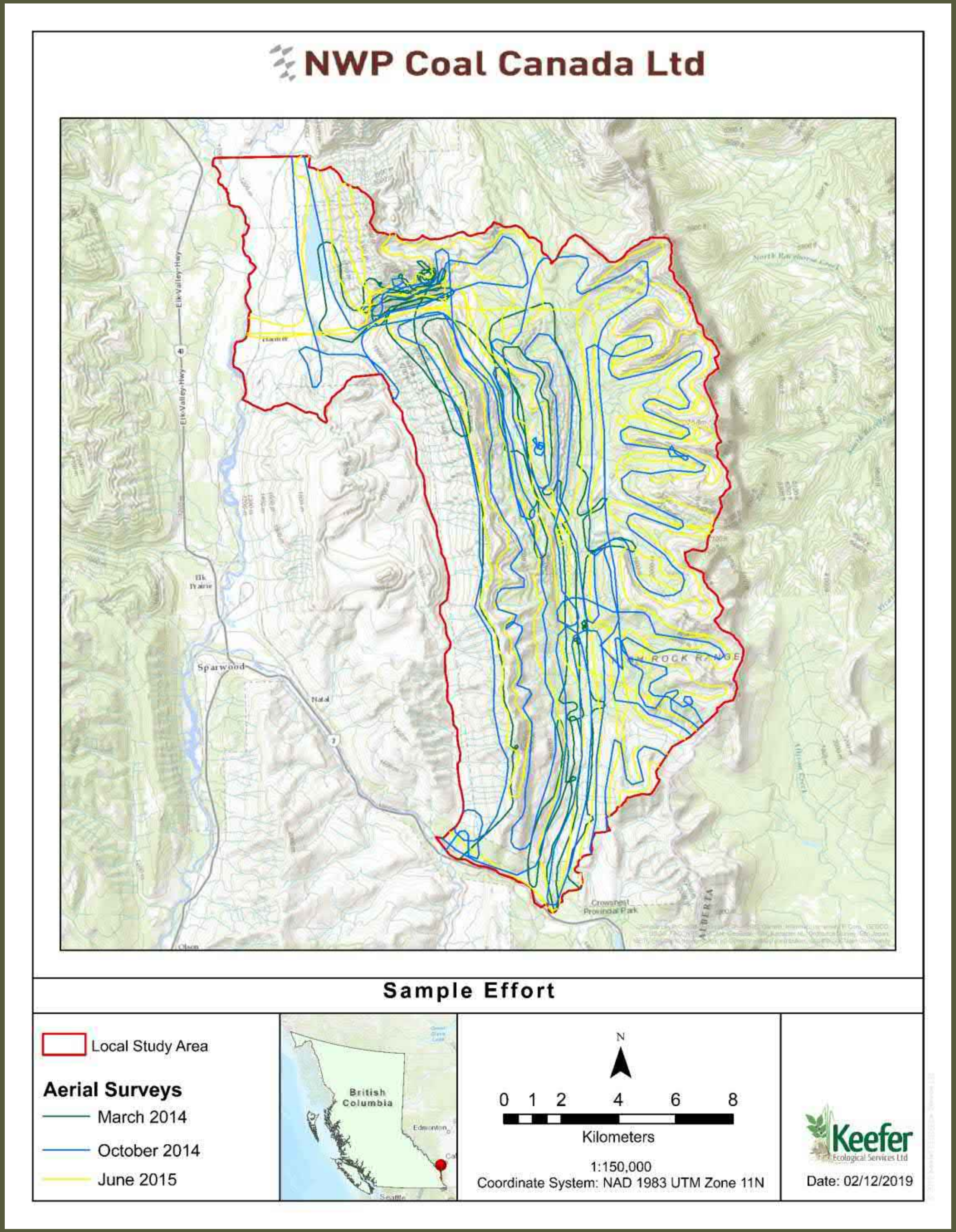
MOOSE MODEL DEVELOPMENT





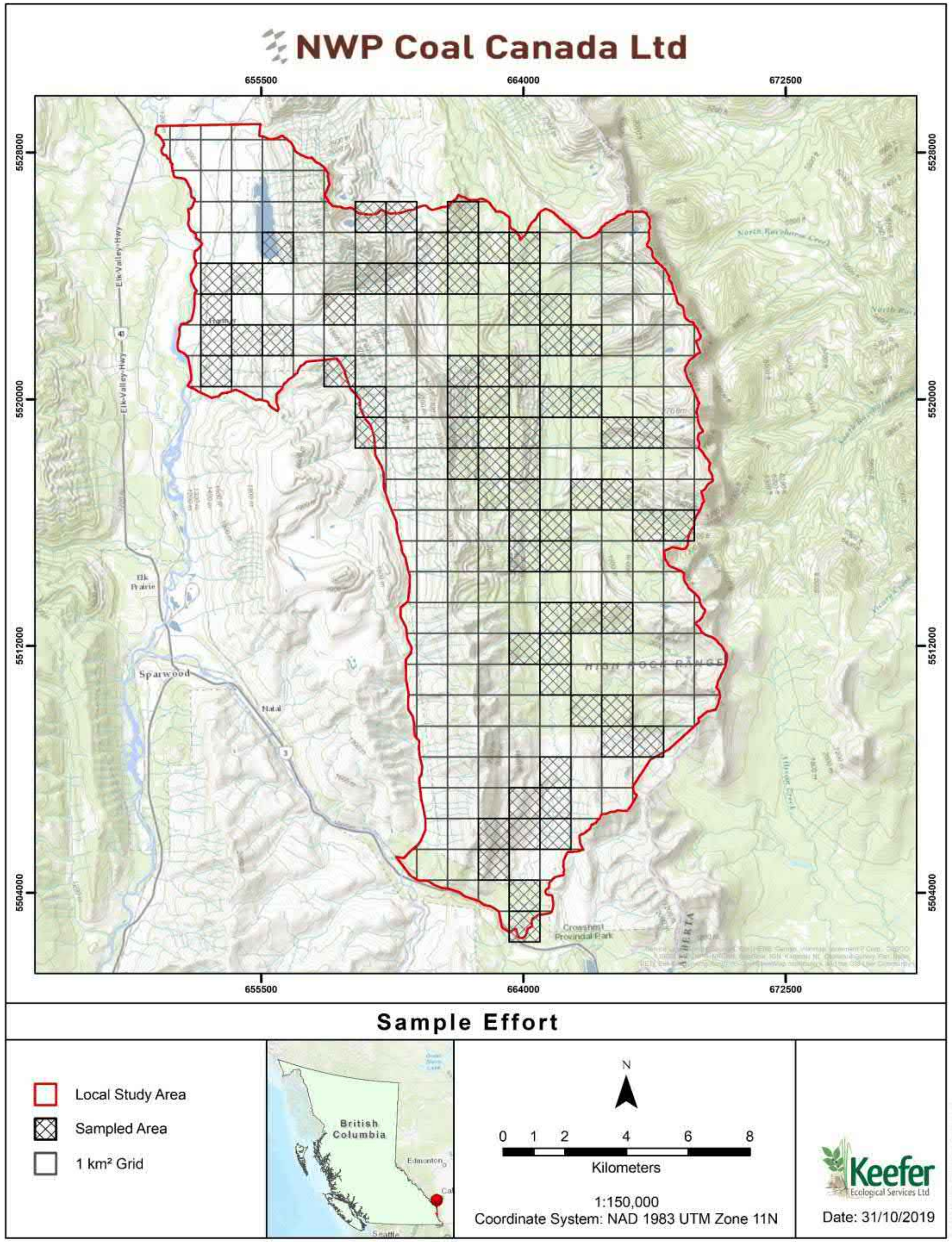
Sample Effort

- ▶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



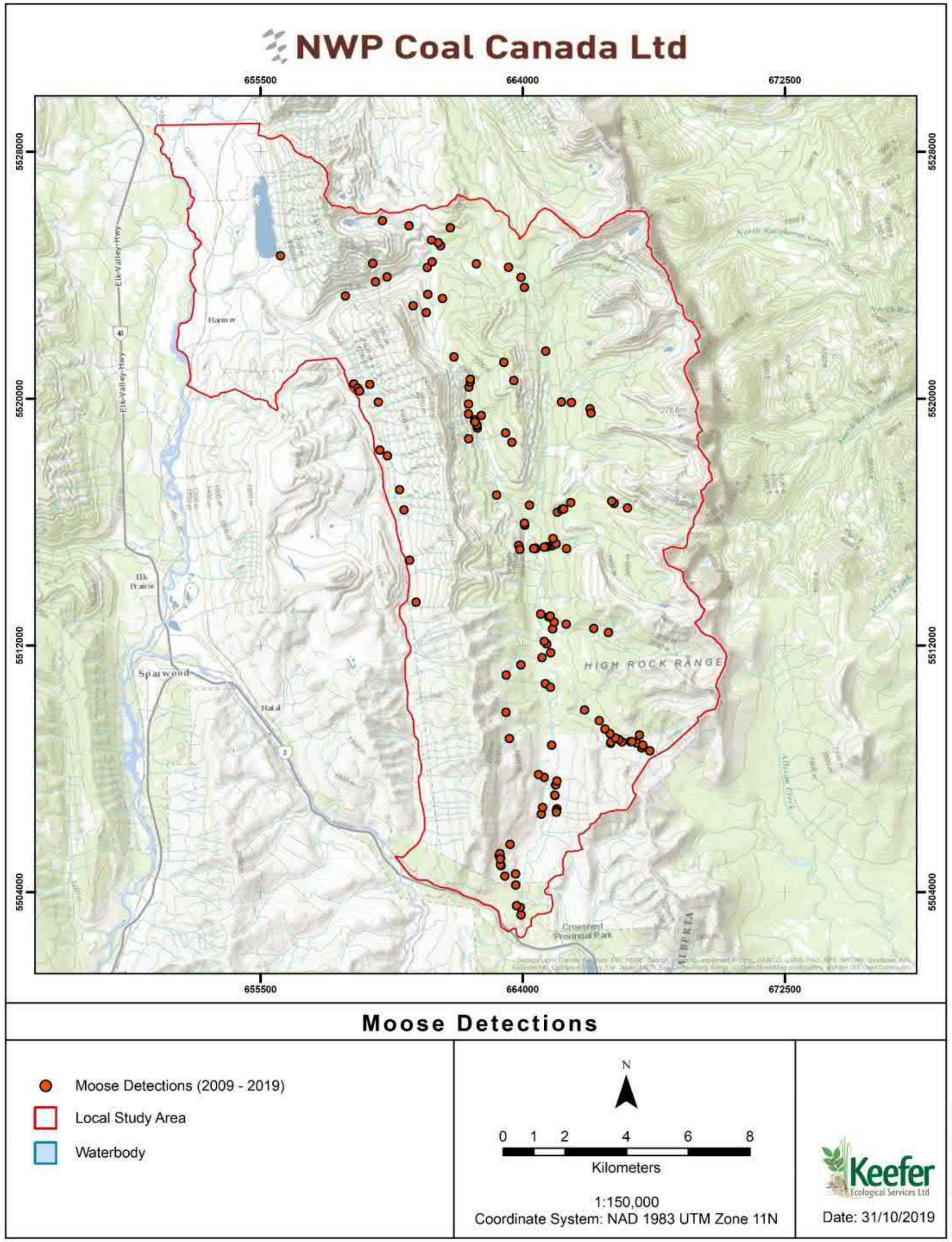
Sample Effort

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

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

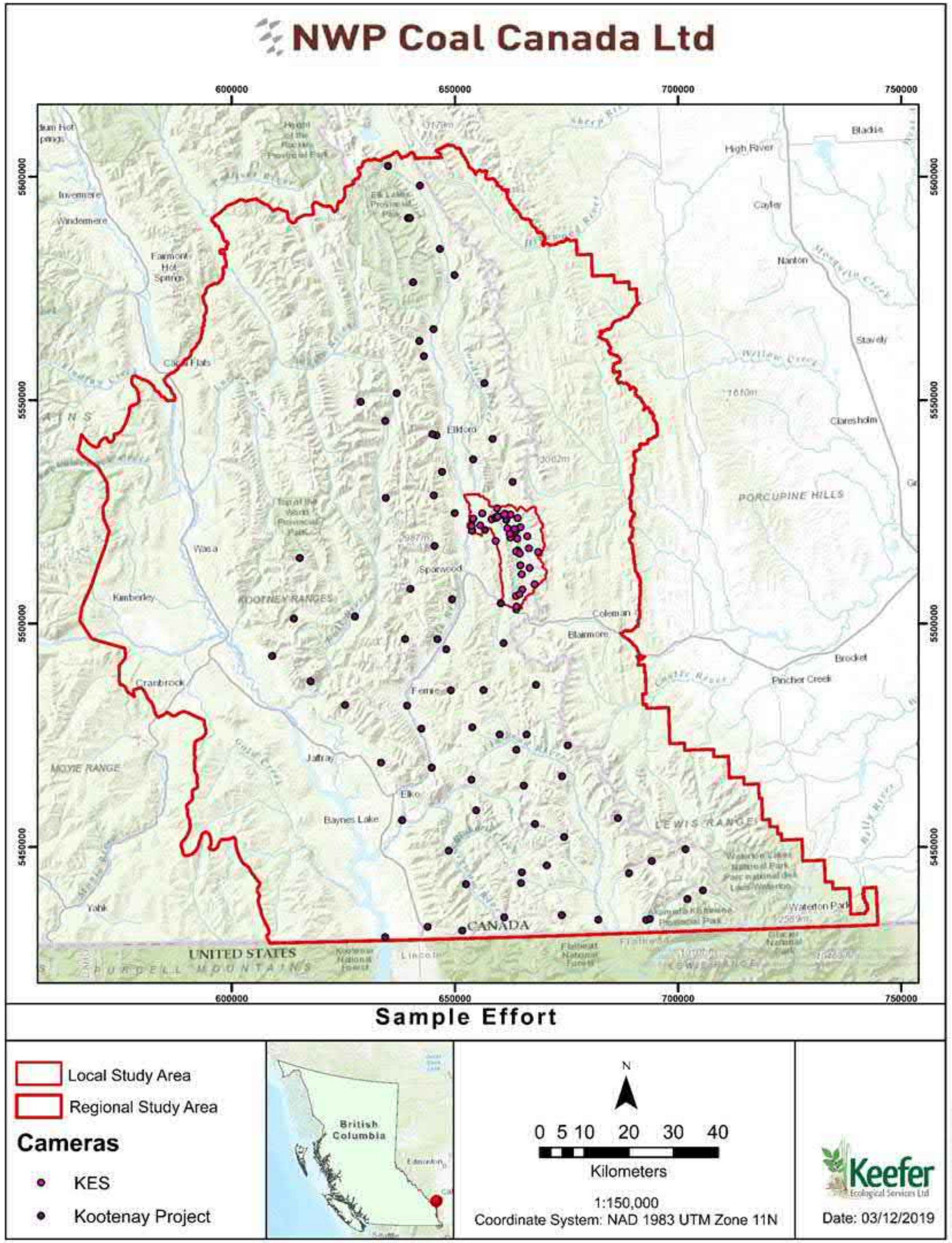
▶Sampling was conducted across a gradient of landscape features and habitat characteristics:

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



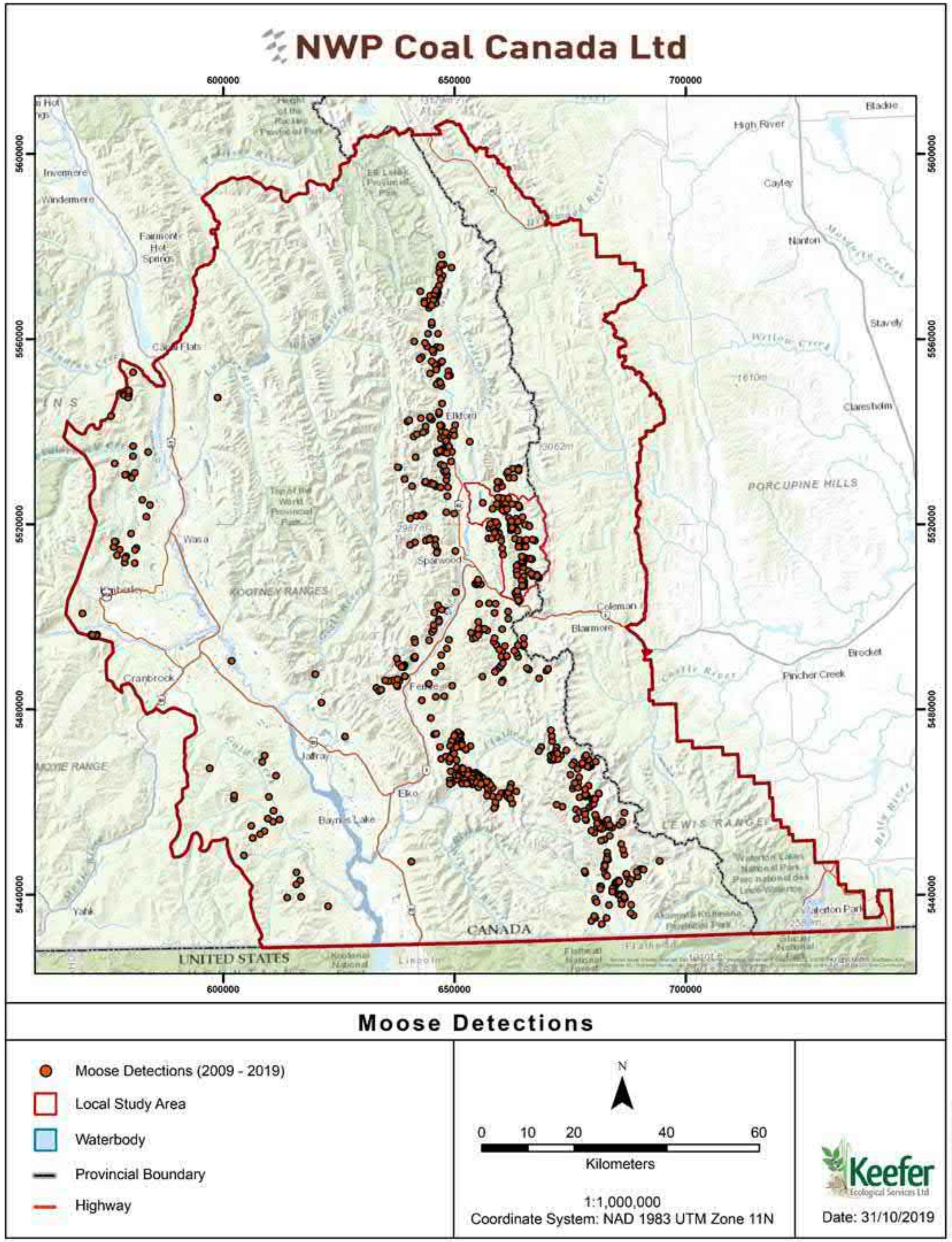
Sample Size

- 177 Moose detections in Local Study Area



Sample Size

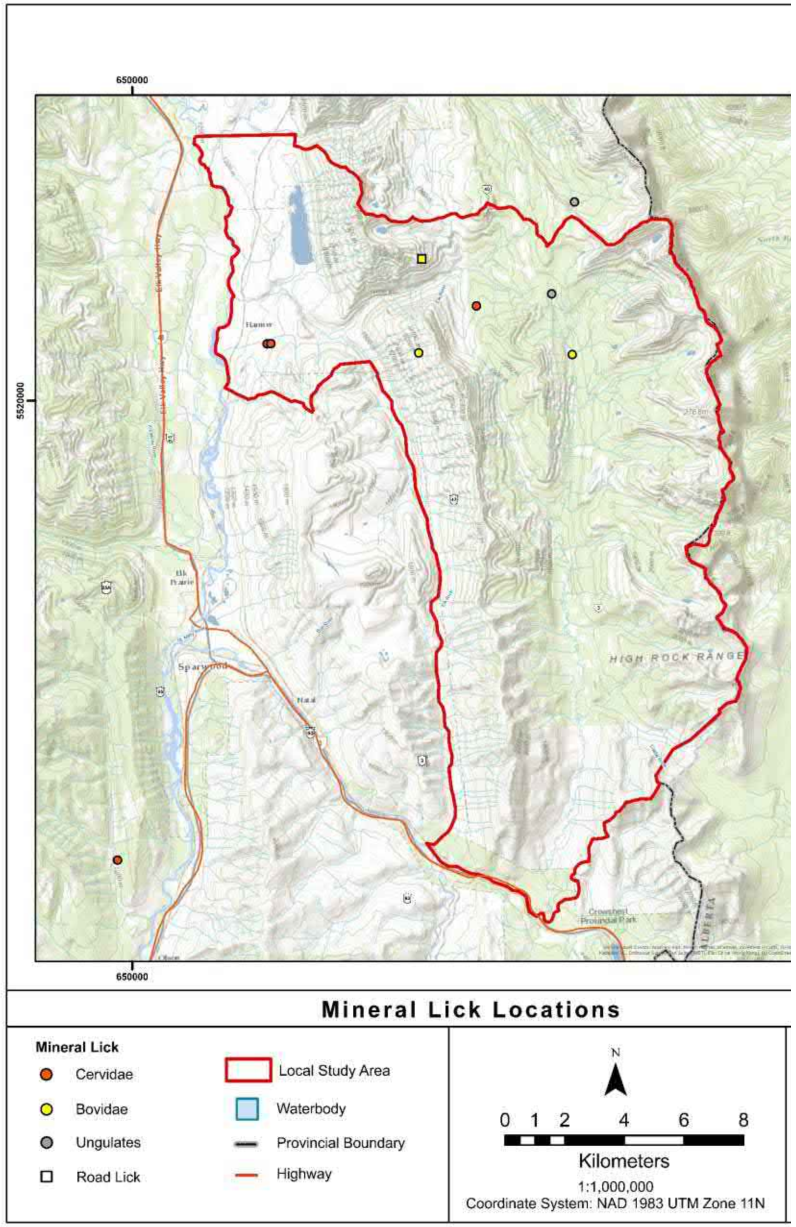
- 1191 Moose detections in RSA
- Inform model site estimates and species-habitat relationships.

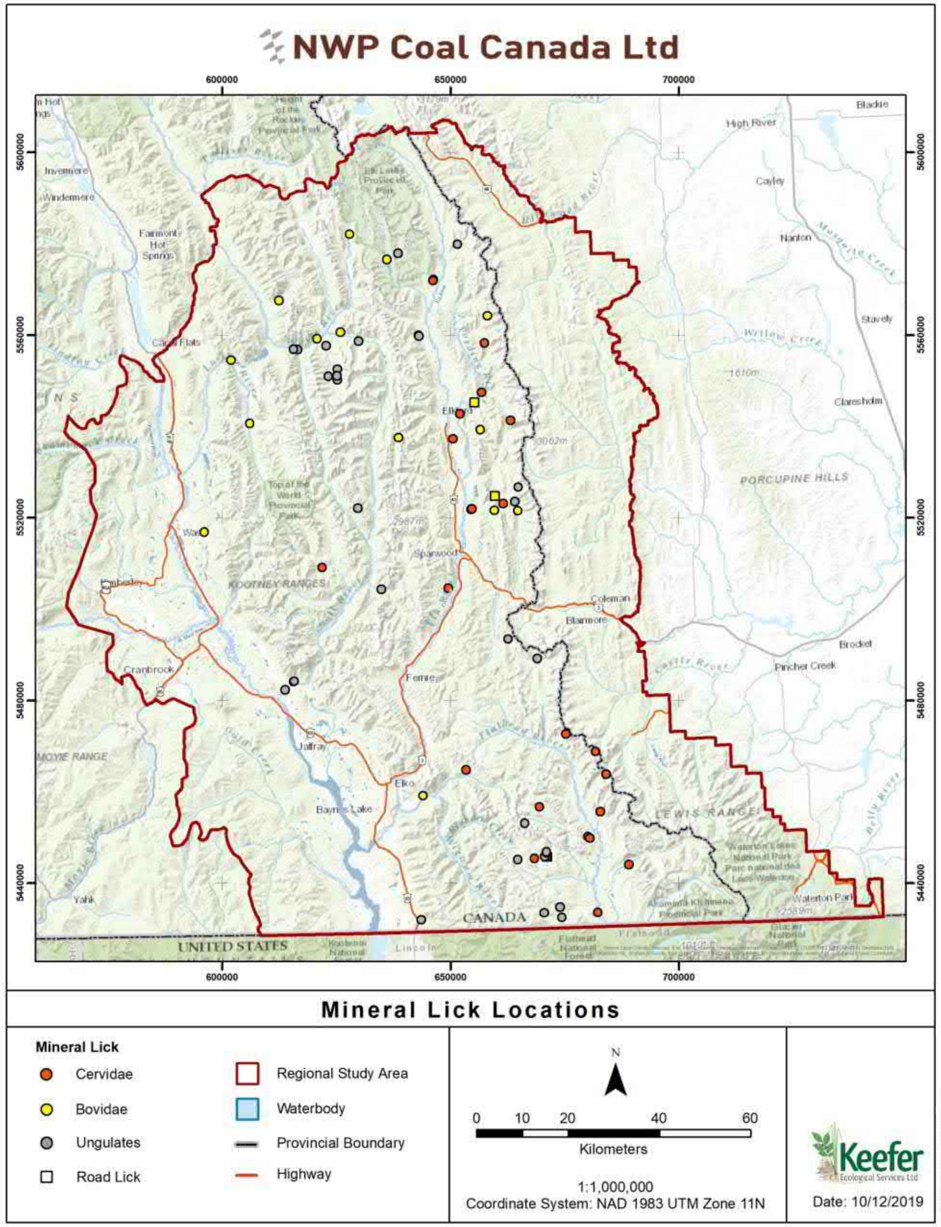


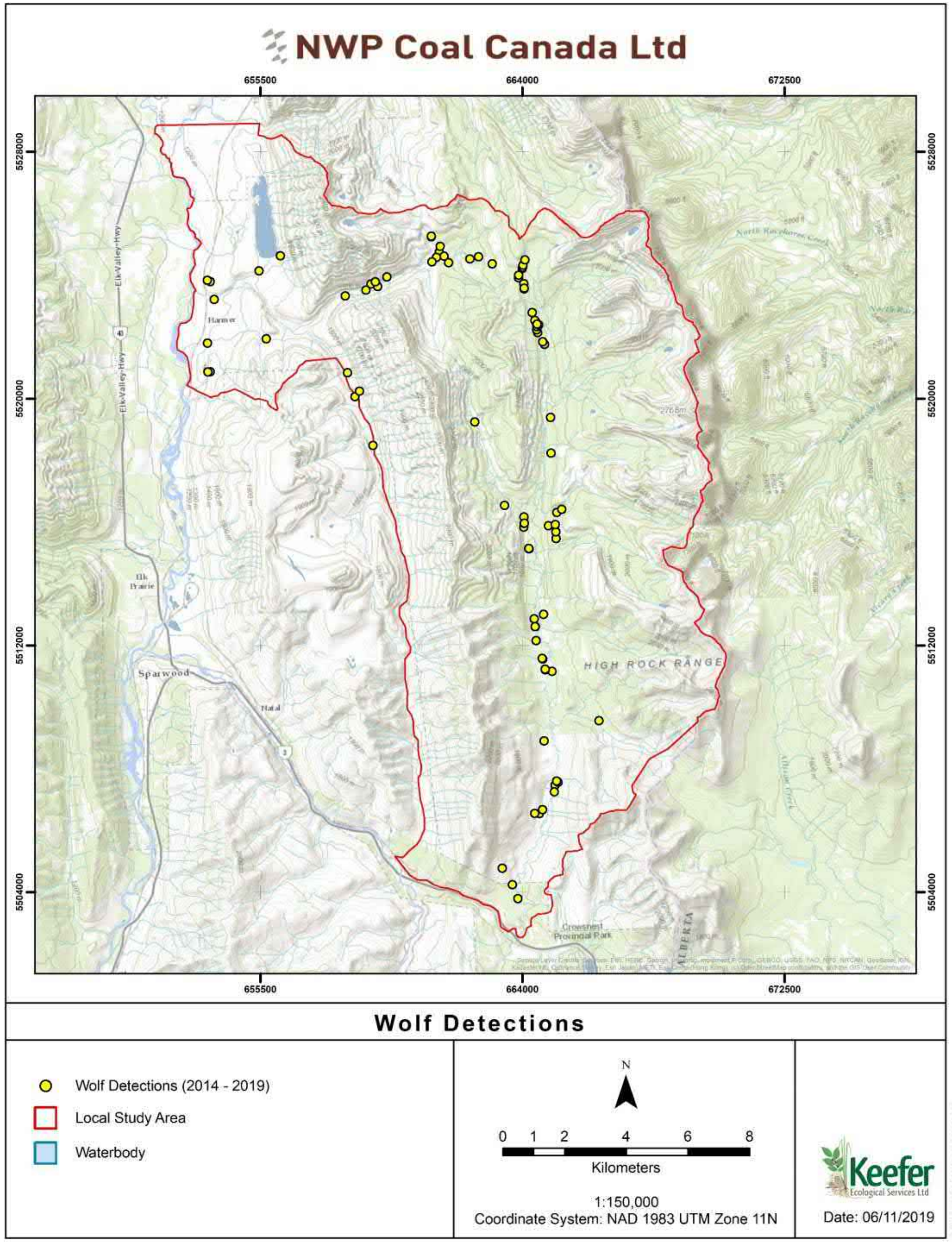
Model Validation

- 1,043 Government aerial detections in Regional Study Area

Mineral Licks







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: 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.

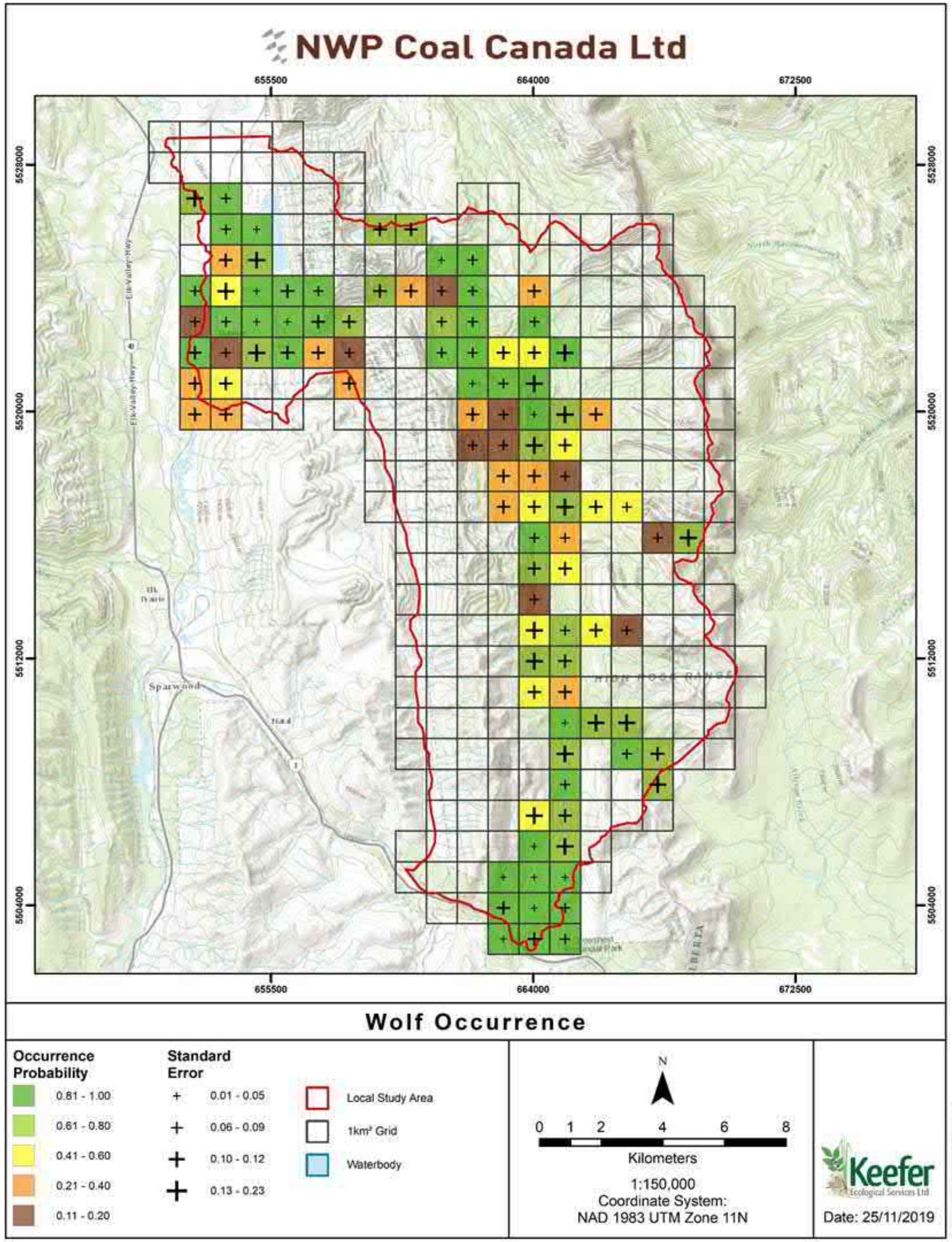
Variable	∑w	β	SE
Mid Seral Forest	0.929	**0.950**	**0.382**
Elevation	0.718	**-1.390**	**0.501**
Primary and Secondary Roads	0.272	**1.671**	**0.822**

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.

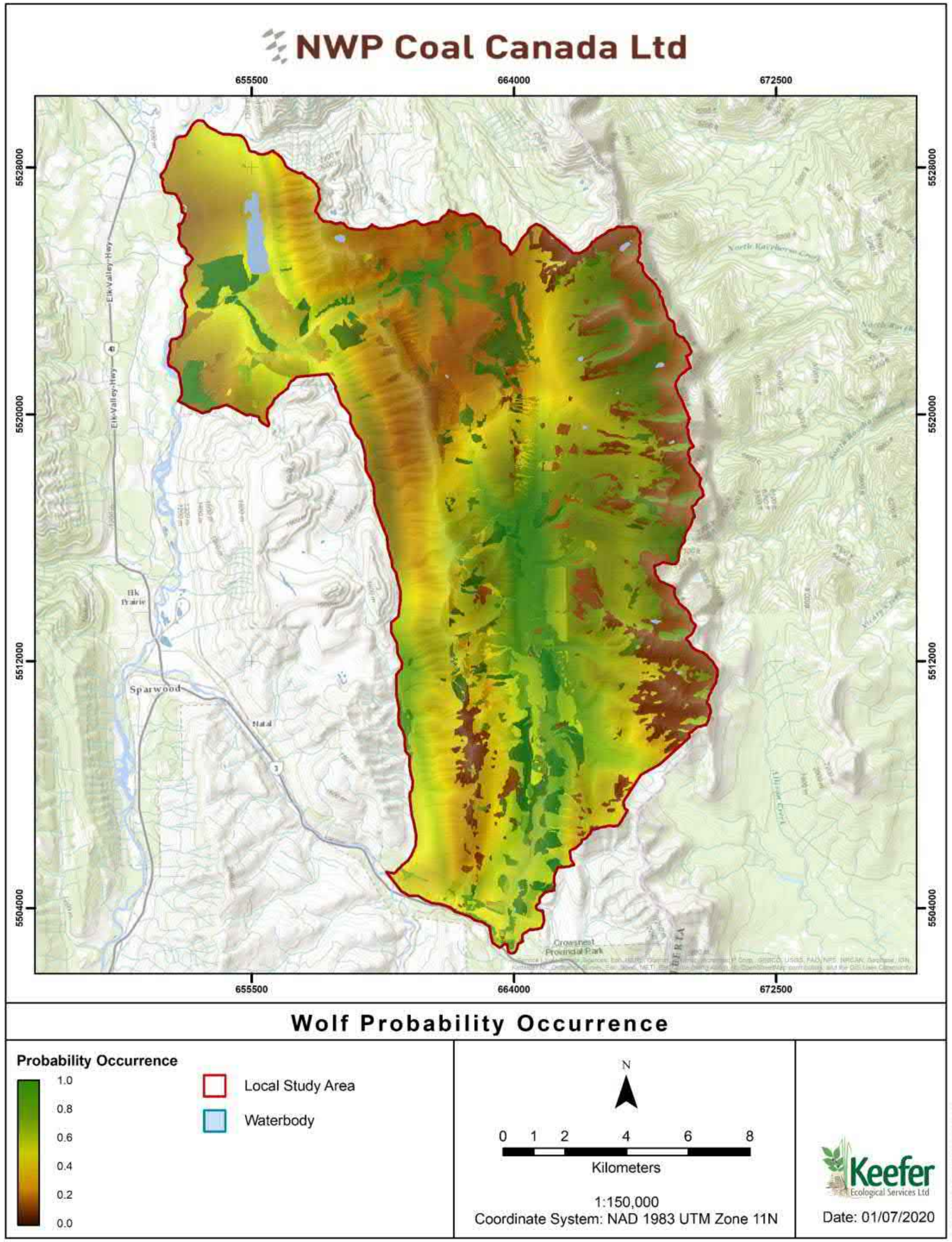


Site-specific Baseline Estimates

- 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(A,CT)	1487.81	0.00	0.9910	4	1479.81
p(.)	1530.17	42.36	0.0000	2	1526.17

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.

- 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 Elk Valley, BC (2014-2019; number of sites = 229). Habitat components considered are proximity to primary roads (PRD), old forests (OF), proximity to tertiary rivers (TRV), elevation (EL), avalanche chutes (AV), and shrub containing habitat (SH). Models with AICc w >0.95 are shown, and the model that assumes occurrence is constant Ψ (.) is shown for comparison. Moose detectability varies with survey method (camera-trap, transect or aerial).

Model	AICc	ΔAICc	w	k	-2LL	Ψ (SE)
Ψ (PRD,OF,TRV,EL,AV),p(CT,A)	1093.50	0.00	0.299	9	1074.68	0.43 (0.09)
Ψ (PRD,OF,TRV,EL),p(CT,A)	1094.32	0.82	0.199	8	1077.67	0.44 (0.09)
Ψ (PRD,OF,TRV,EL,SH),p(CT,A)	1095.54	1.95	0.113	9	1076.63	0.44 (0.10)
Ψ (PRD,TRV,EL),p(CT,A)	1095.89	2.04	0.108	7	1081.03	0.45 (0.08)
Ψ (PRD,TRV,EL,AV),p(CT,A)	1096.88	2.39	0.091	8	1079.24	0.44 (0.09)
Ψ (PRD,TRV,EL,SH),p(CT,A)	1097.99	3.38	0.055	8	1080.23	0.45 (0.09)
Ψ (PRD,OF,SH,EL),p(CT,A)	1098.07	4.49	0.032	8	1081.34	0.45 (0.10)
Ψ (PRD,OF,EL),p(CT,A)	1099.18	4.57	0.031	7	1083.56	0.46 (0.09)
Ψ (PRD,EL),p(CT,A)	1099.25	5.68	0.018	6	1086.80	0.46 (0.08)
Ψ (PRD,OF,TRV,SH,AV),p(CT,A)	1099.41	5.75	0.017	9	1080.43	0.49 (0.11)
Ψ (.),p(CT,A)	1108.29	14.79	0.000	8	1100.11	0.58 (0.06)
Model Average						**0.44 (0.09)**

Results

- Moose used approximately 44% of the sites surveyed during fall/winter.
- 39% higher than naïve estimate (0.2707)

Fall/Winter: Habitat Variables

Table#. Habitat variables influencing Moose occurrence during fall/winter (Sept 22-March 22) in the Elk Valley, 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 = 229). The β-coefficient is the strength and direction (±) of influence.

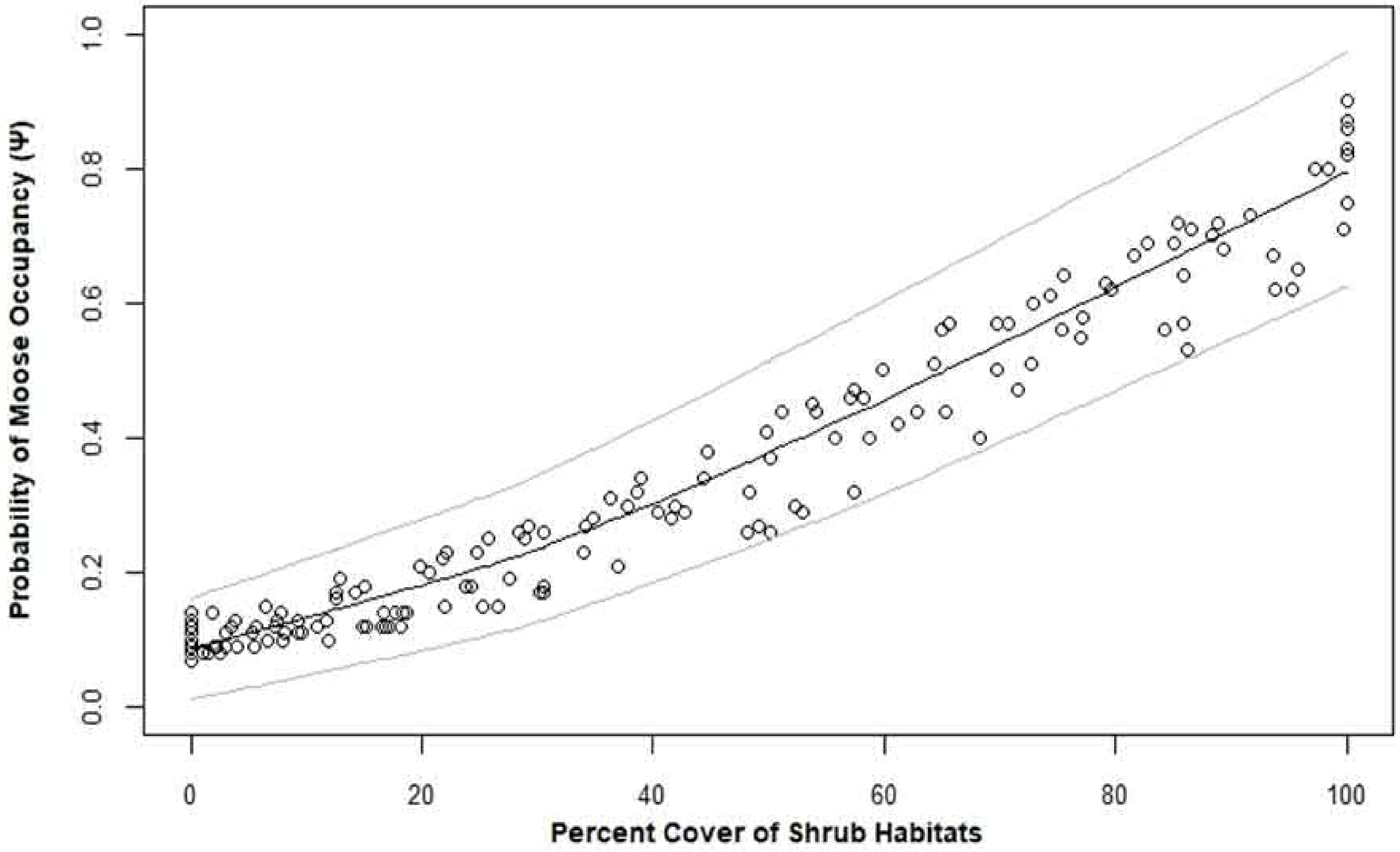
Variable	∑w	β	SE
Primary Roads	0.96	**-1.069**	**0.349**
Elevation	0.94	**-1.117**	**0.377**
Tertiary Rivers	0.88	**0.616**	**0.301**
Old Forest	0.69	**0.527**	**0.242**
Avalanche Chutes	0.41	-0.600	0.370
Shrub Containing Habitats	0.22	**0.554**	**0.228**

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

Results

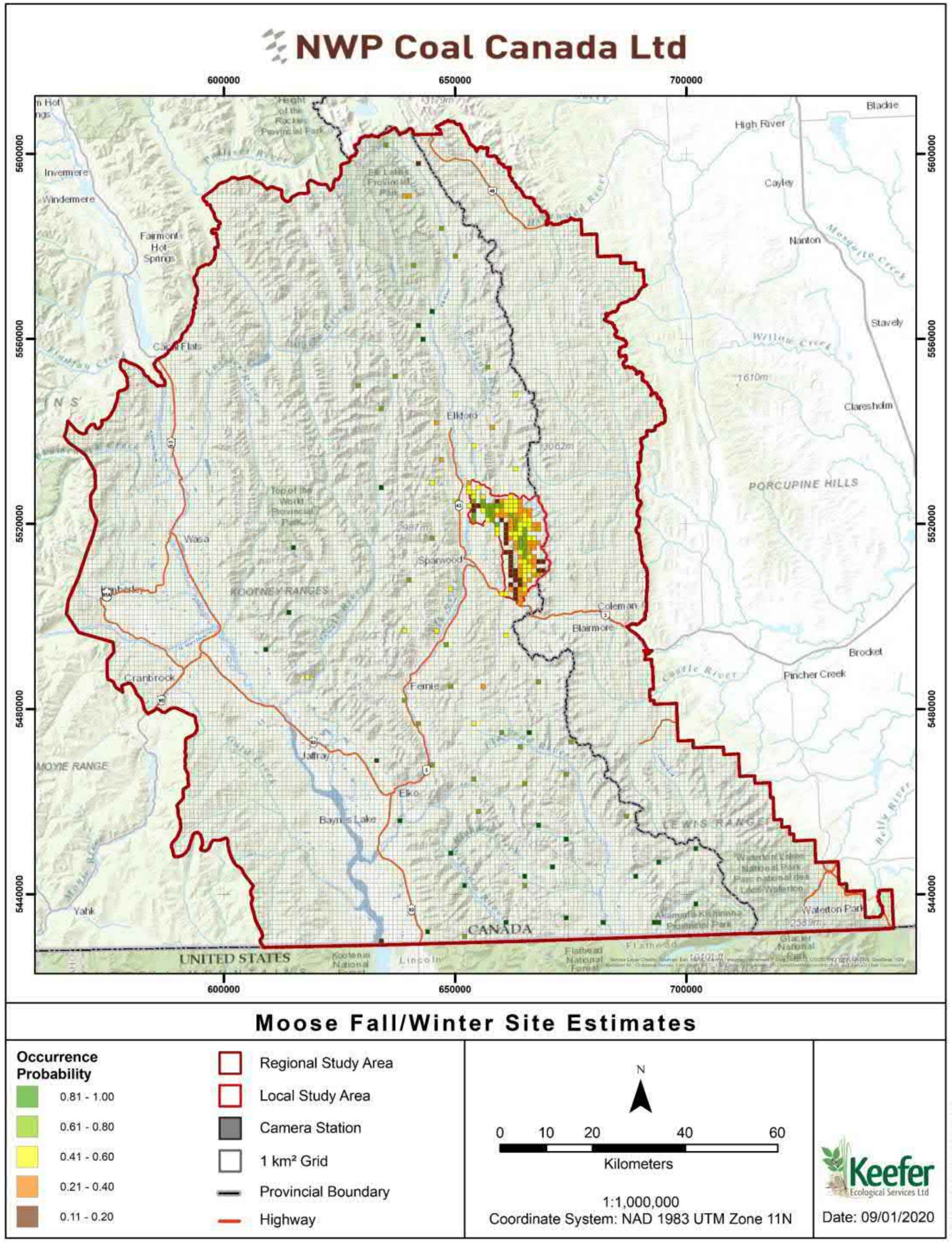
Most important predictors of Moose occurrence:

- Selection for browse containing habitats and old forests
- Positive association with tertiary rivers
- Negative association with roads and elevation



Results

- Percent cover of shrub habitats was positively associated with moose habitat use during fall/winter

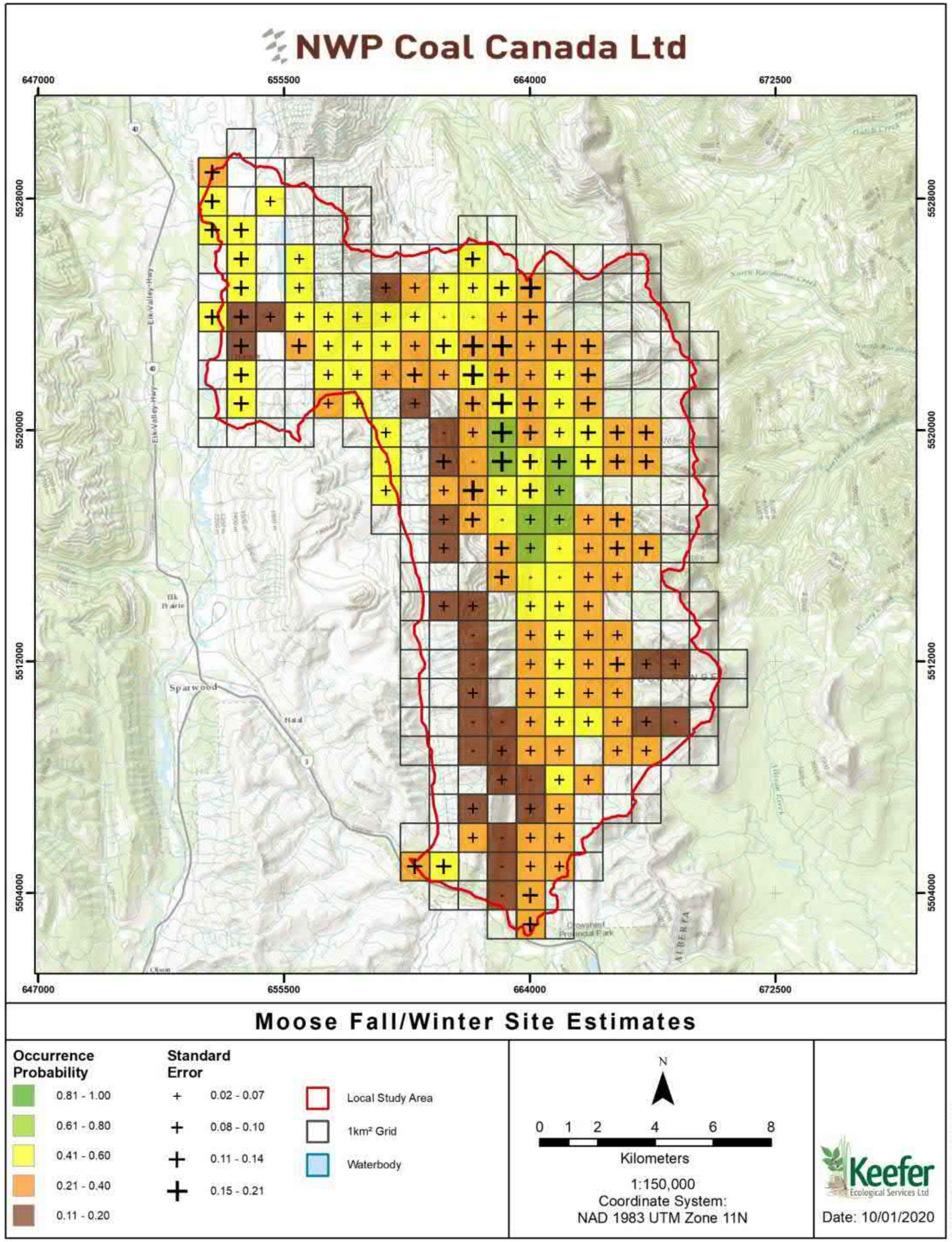


Site-specific Baseline Estimates

- Mean probability of habitat use:

  0.44 (SE = 0.09)

- Moose used approximately 44% of the sites surveyed during fall/winter
- Strong selection for shrub containing habitats, old forests and tertiary rivers
- General avoidance of sites with greater elevation and proximity to primary roads



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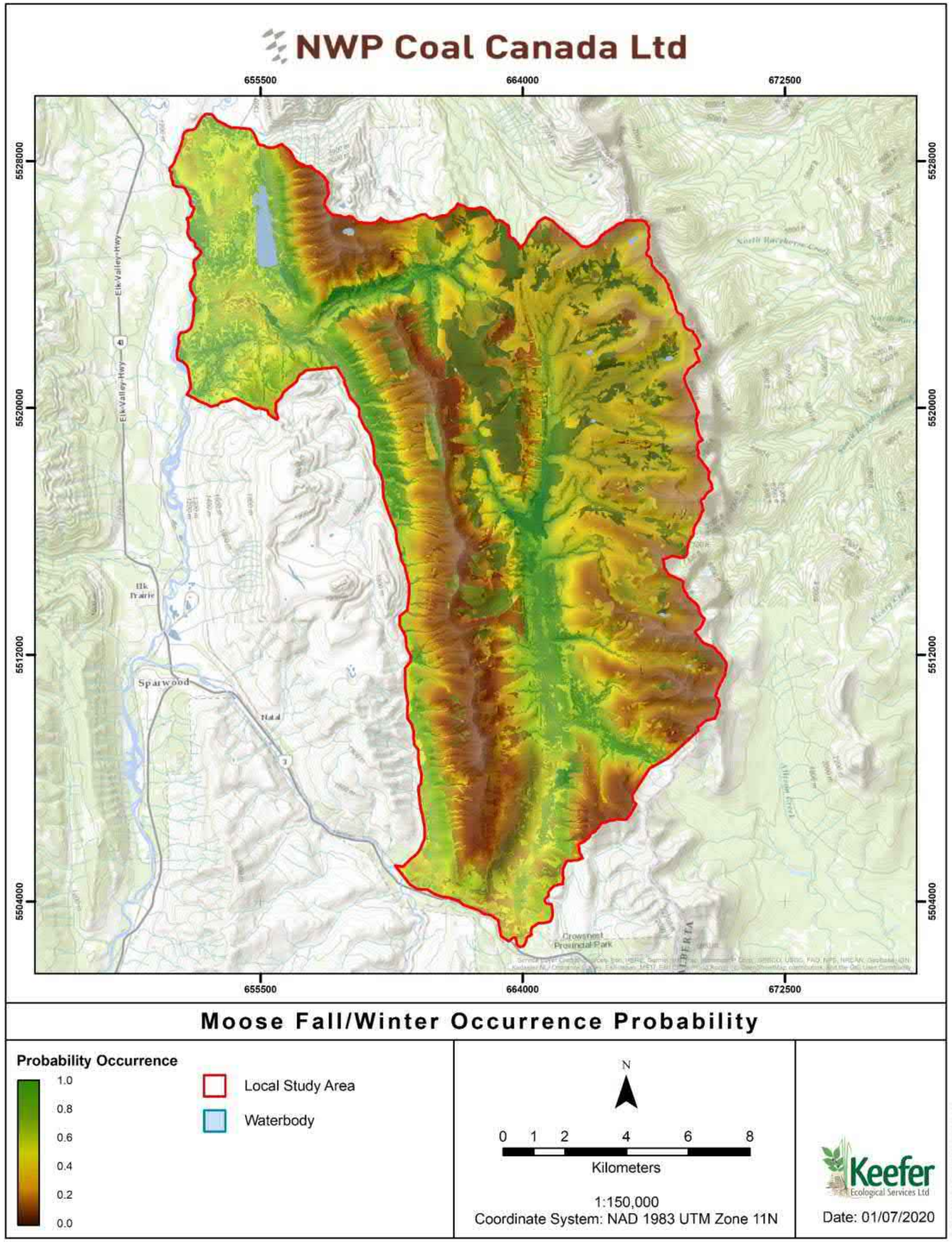
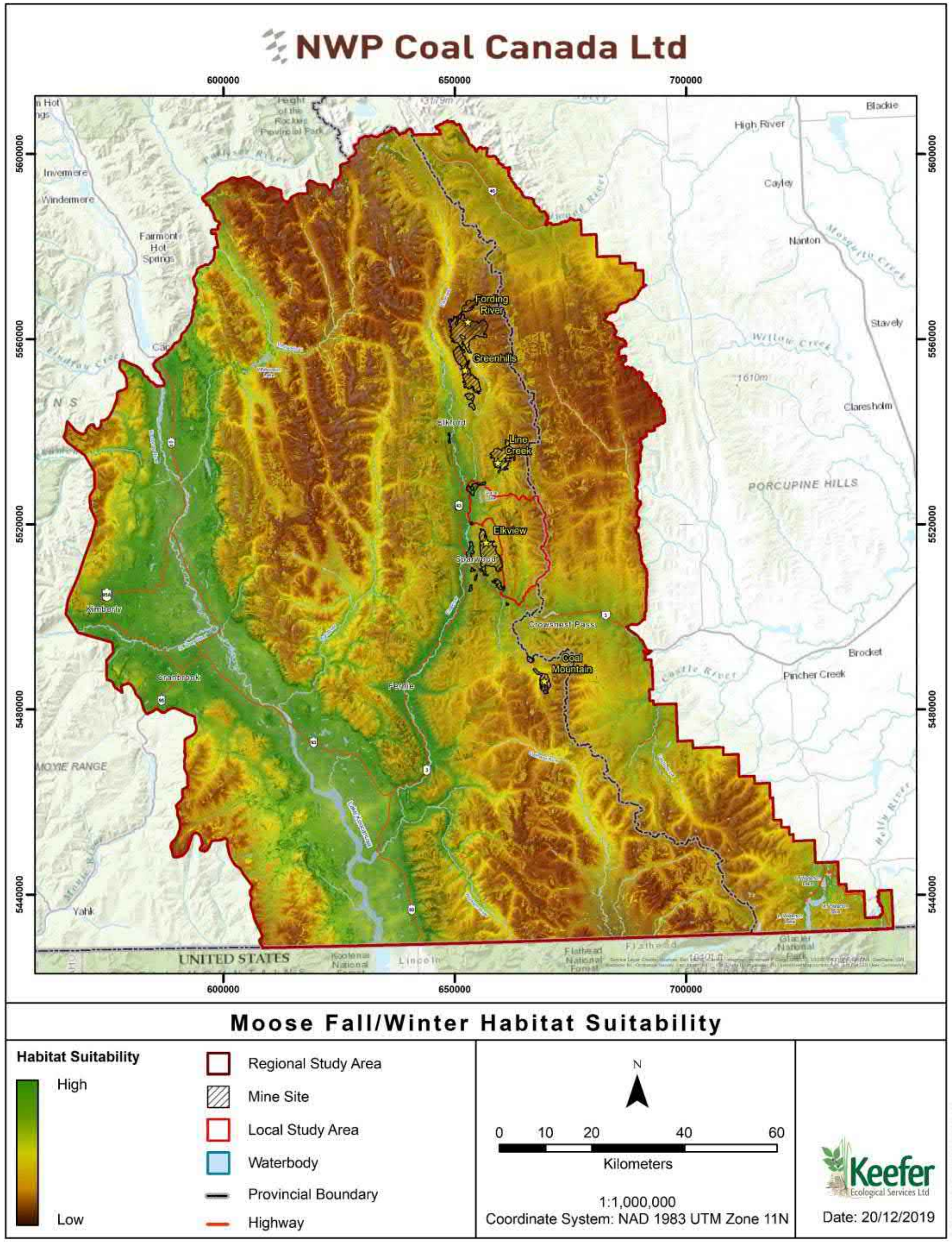


Moose Habitat Occupancy (fall-winter)

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

- Primary Roads
- Elevation
- Tertiary Rivers
- Old Forests
- Avalanche chutes
- Shrub containing habitat



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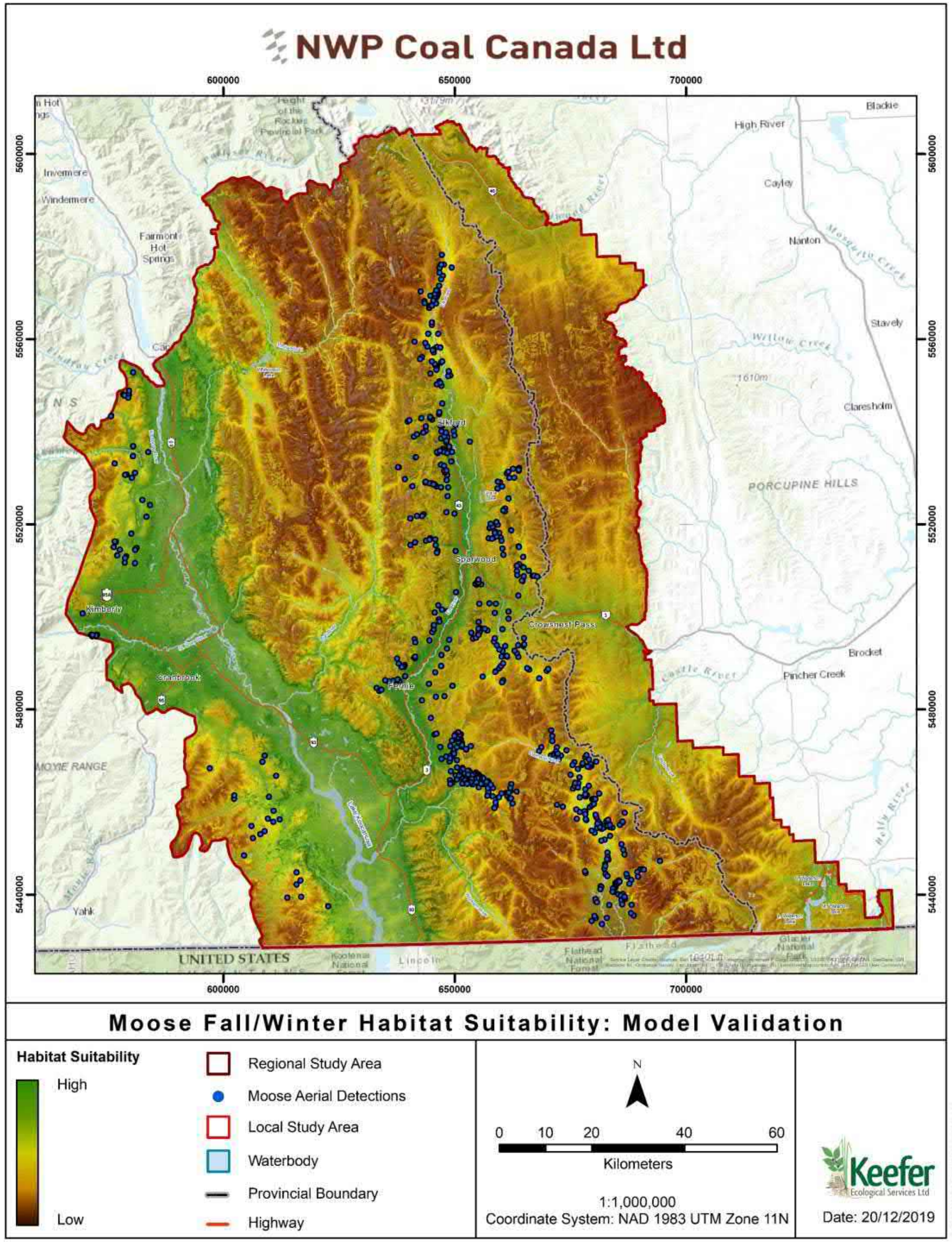
- Shrub containing habitat

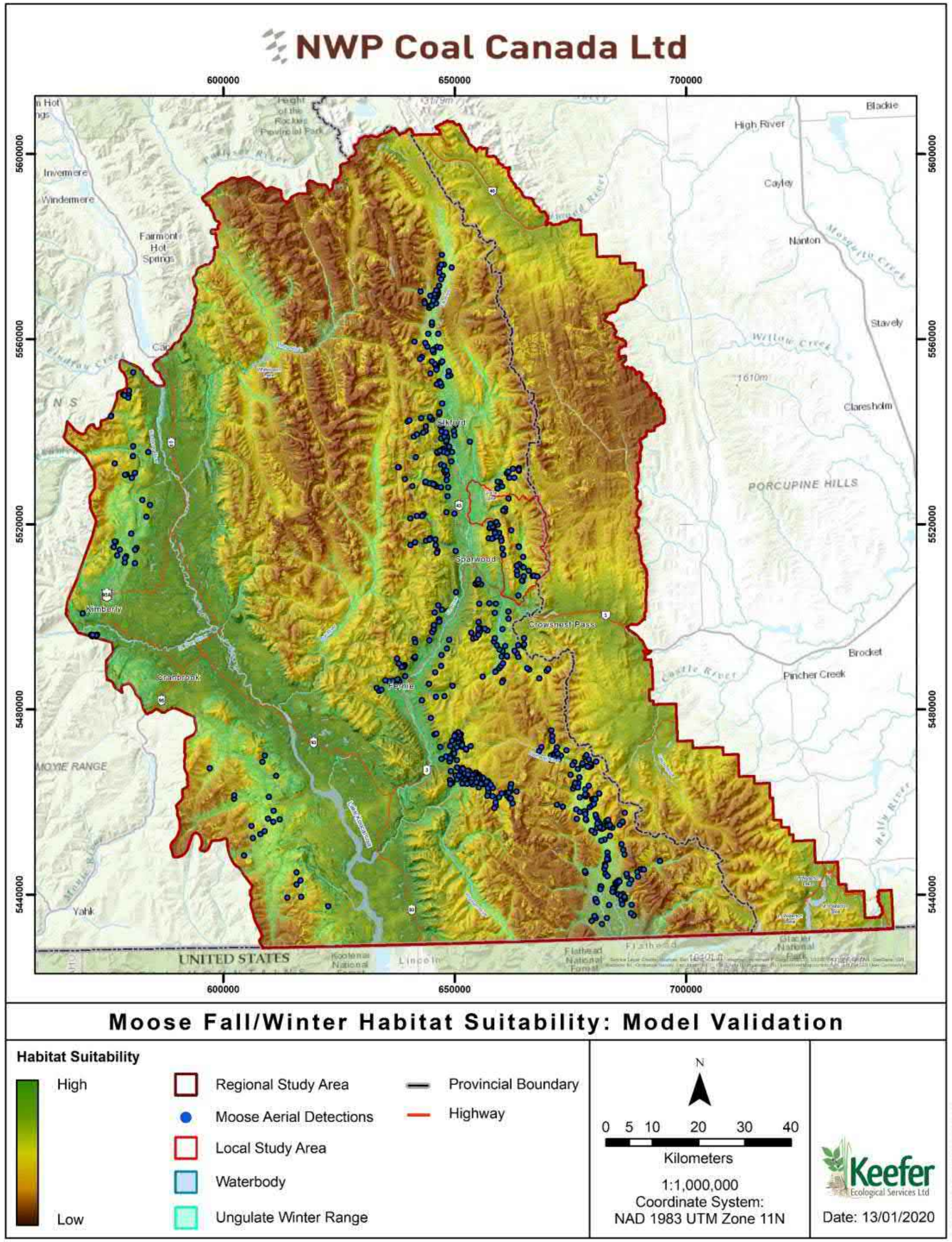


Moose Habitat Occupancy (fall-winter): Model Validation

Predicted probability of habitat use by Moose in RSA during fall/winter, overlaid with 701 Moose government aerial survey detections

The mean predicted probability of habitat use for all government aerial survey detections was 0.611.

Moose Habitat Occupancy (fall-winter): Model Validation



- Ungulate Winter Ranges

Spring/Summer: Model Selection

Table #. Model selection procedure for factors influencing Moose site occupancy (Ψ) at a 1 km site (n = 211) during spring-summer (2014-2019) in the Elk Valley, BC. Habitat components considered are: elevation (EL), primary roads (PRD), cervid mineral licks (CML), early seral forests (ESF), tertiary rivers (TRV), old forests (OF), mid seral forests (MSF), avalanche chutes (AV), and wetlands (WL). Models with AICc w >0.95 are shown, and the model that assumes occurrence is constant Ψ (.) is shown for comparison. Moose detectability varies with survey method (camera-trap, transect or aerial).

Model	AICc	ΔAICc	w	k	-2LL	Ψ (SE)
Ψ (EL,PRD,CML,ESF),p(CT,A)	1473.29	0.00	0.274	8	1456.58	0.73 (0.08)
Ψ (CML,TRV,PRD,EL,ESF),p(CT,A)	1473.44	0.15	0.254	9	1454.54	0.73 (0.09)
Ψ (EL,PRD,CML,OF),p(CT,A)	1475.98	2.69	0.071	8	1459.27	0.75 (0.08)
Ψ (EL,PRD,CML,MSF),p(CT,A)	1476.01	2.72	0.070	8	1459.30	0.74 (0.09)
Ψ (EL,PRD,CML),p(CT,A)	1476.07	2.78	0.068	7	1461.52	0.75 (0.08)
Ψ (CML,TRV,PRD,EL),p(CT,A)	1476.41	3.12	0.058	8	1459.70	0.74 (0.08)
Ψ (CML,TRV,PRD),p(CT,A)	1477.63	4.34	0.031	7	1463.08	0.71 (0.08)
Ψ (CML,PRD,EL,AV),p(CT,A)	1477.93	4.64	0.027	8	1461.22	0.75 (0.08)
Ψ (CML,TRV,EL,ESF),p(CT,A)	1477.96	4.67	0.027	8	1461.25	0.75 (0.08)
Ψ (CML,EL,PRD,WL),p(CT,A)	1477.98	4.69	0.026	8	1461.27	0.75 (0.08)
Ψ (CML,TRV,PRD,EL,WL),p(CT,A)	1478.35	5.06	0.022	9	1459.45	0.74 (0.09)
Ψ (CML,TRV,EL),p(CT,A)	1479.34	5.79	0.015	7	1464.53	0.76 (0.07)
Ψ (EL,PRD,ESF),p(CT,A)	1479.99	6.05	0.013	7	1464.79	0.73 (0.08)
Ψ (.),p(CT,A)	1488.00	14.71	0.000	4	1479.81	0.73 (0.05)
Model Average						**0.74 (0.08)**

Results

- Moose used approximately 74% of the sites surveyed during spring/summer.
- 46% higher than naïve estimate (0.398)

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 = 211). The β-coefficient is the strength and direction (±) of influence.

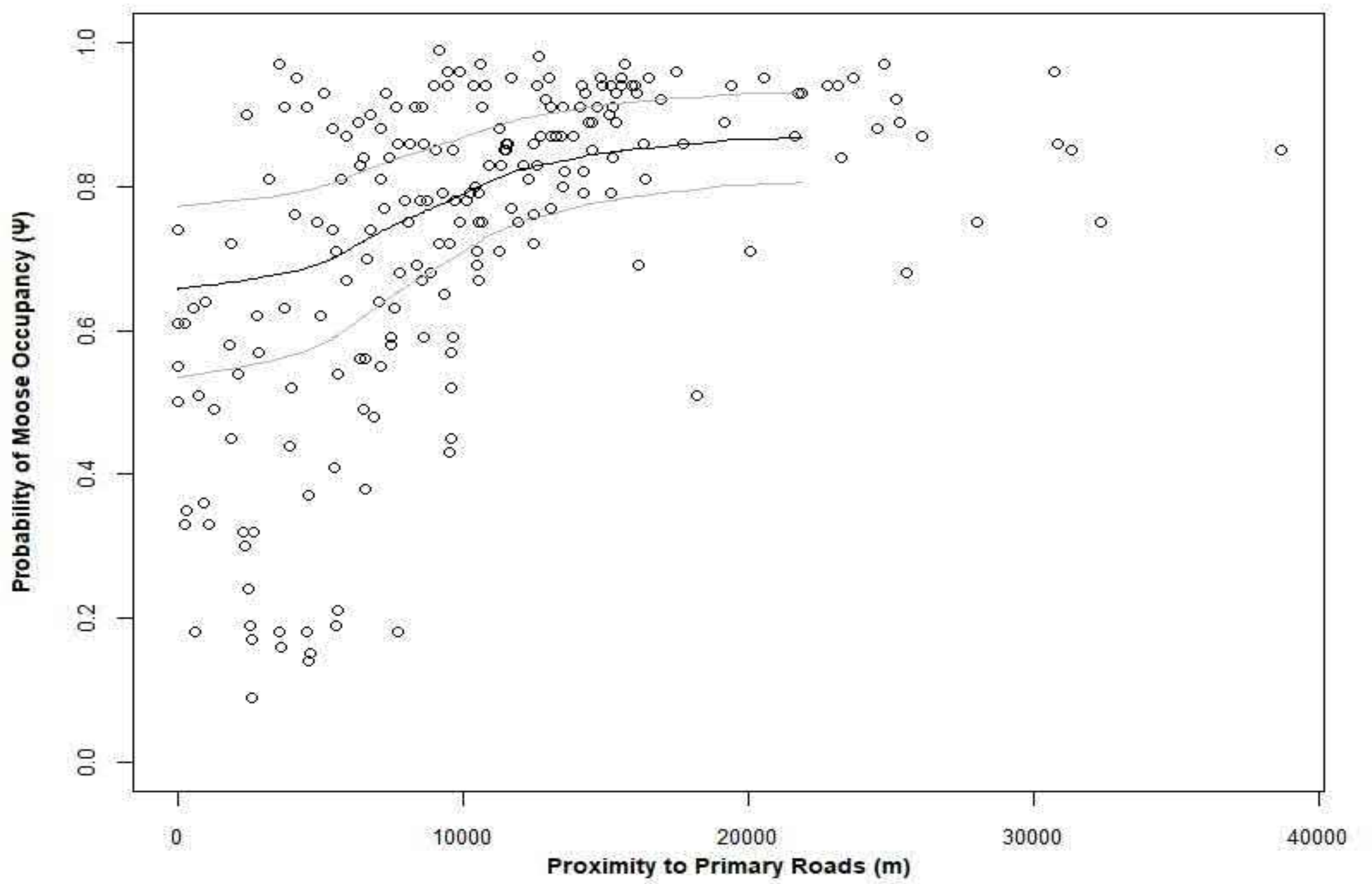
Variable	∑w	β	SE
Mineral Licks	0.94	**0.766**	**0.308**
Elevation	0.94	**0.819**	**0.371**
Primary Roads	0.92	**-0.724**	**0.295**
Early Seral Forest	0.57	**-0.629**	**0.274**
Tertiary Rivers	0.41	0.487	0.351
Mid Seral Forest	0.07	0.461	0.347
Old Forest	0.07	0.549	0.383
Wetlands	0.05	**0.139**	**0.056**
Avalanche Chutes	0.03	0.182	0.063

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

Results

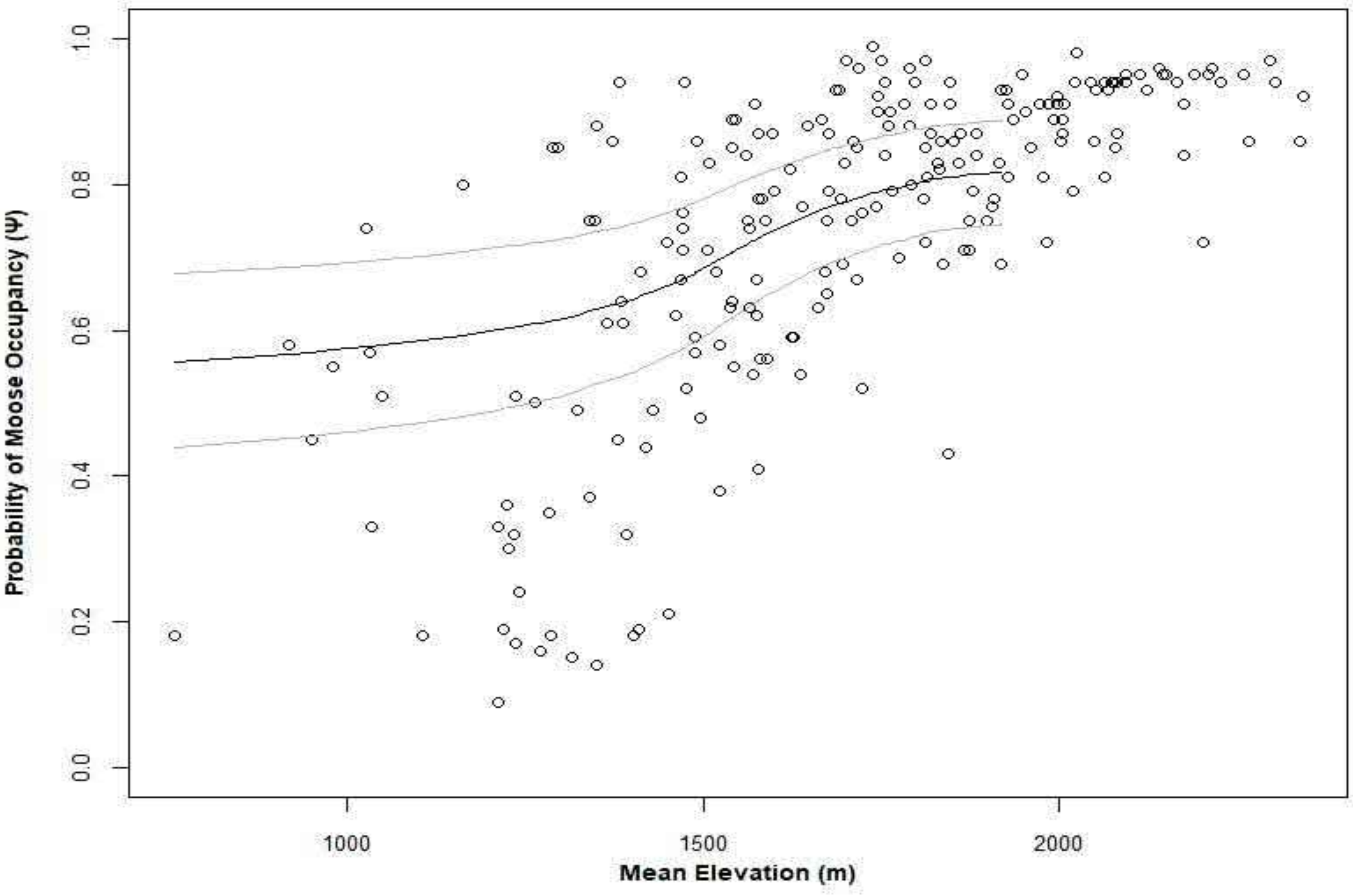
Most important predictors of Moose occurrence:

- Strong positive association with mineral licks and elevation
- Negative association with Early Seral forests and proximity to roads



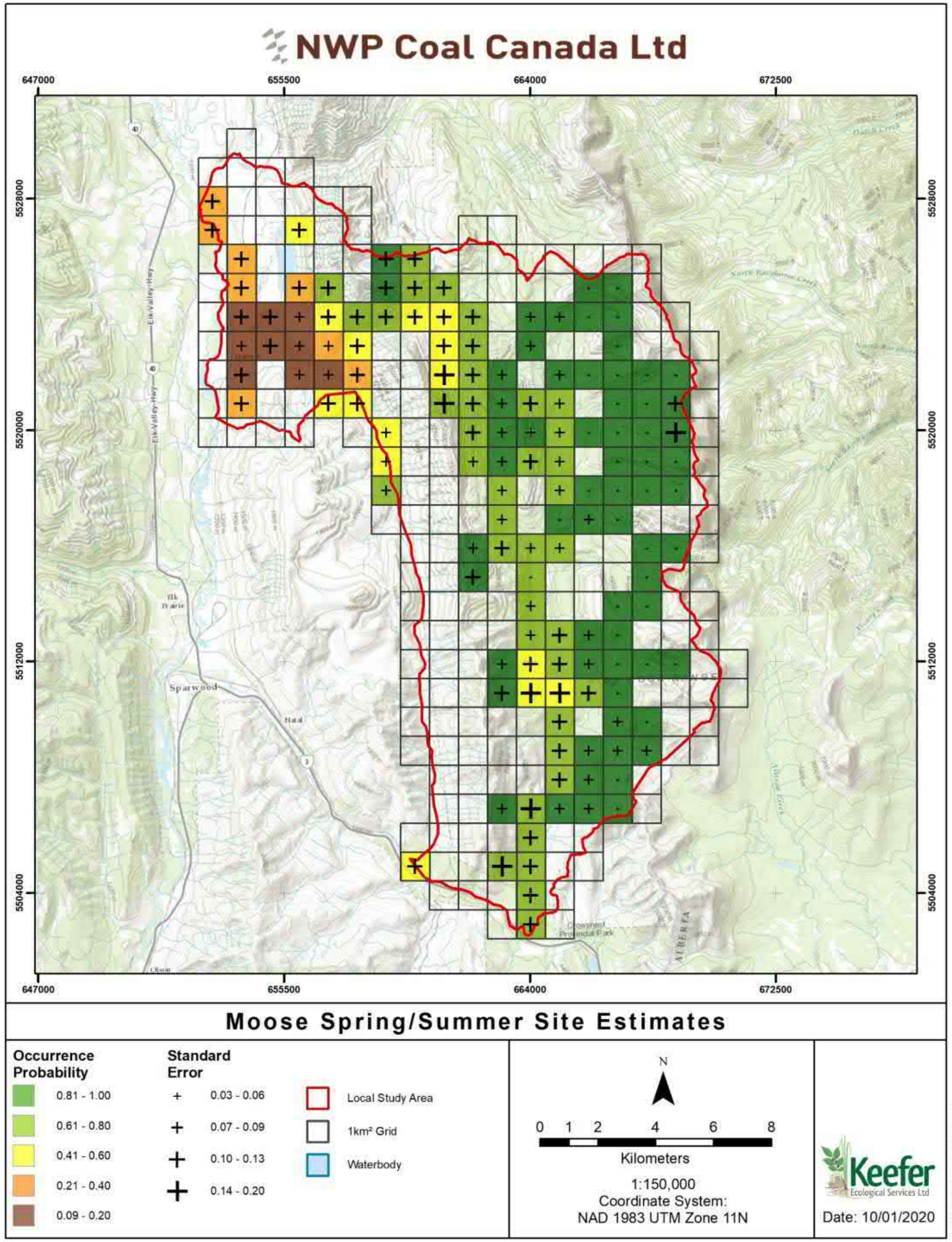
Results

- Proximity to primary roads were negatively associated with moose habitat use during spring/summer



Results

- Elevation was a positive indicator of Moose habitat use during spring/summer

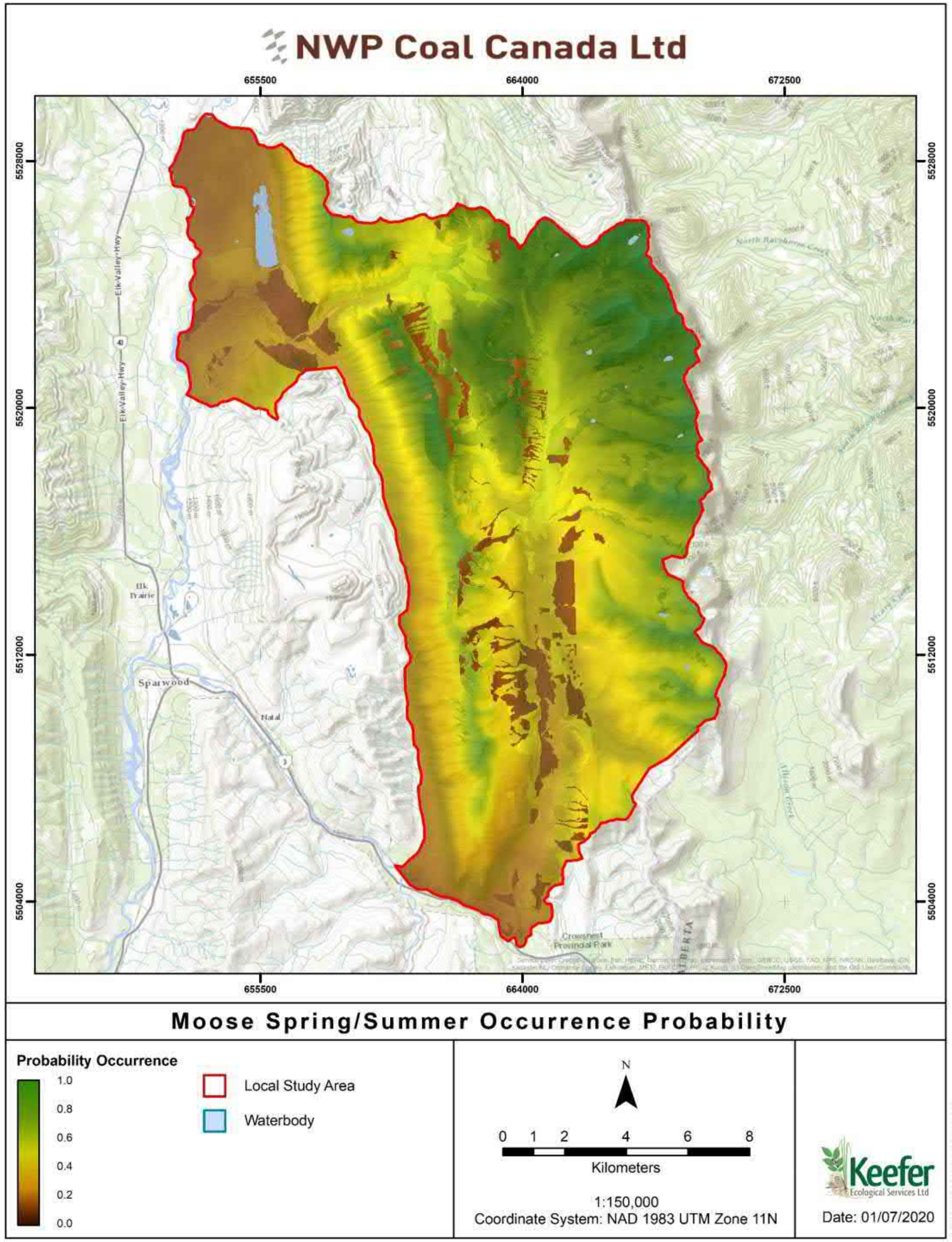


Site-specific Baseline Estimates

- Mean probability of habitat use:

  0.74 (SE = 0.08)

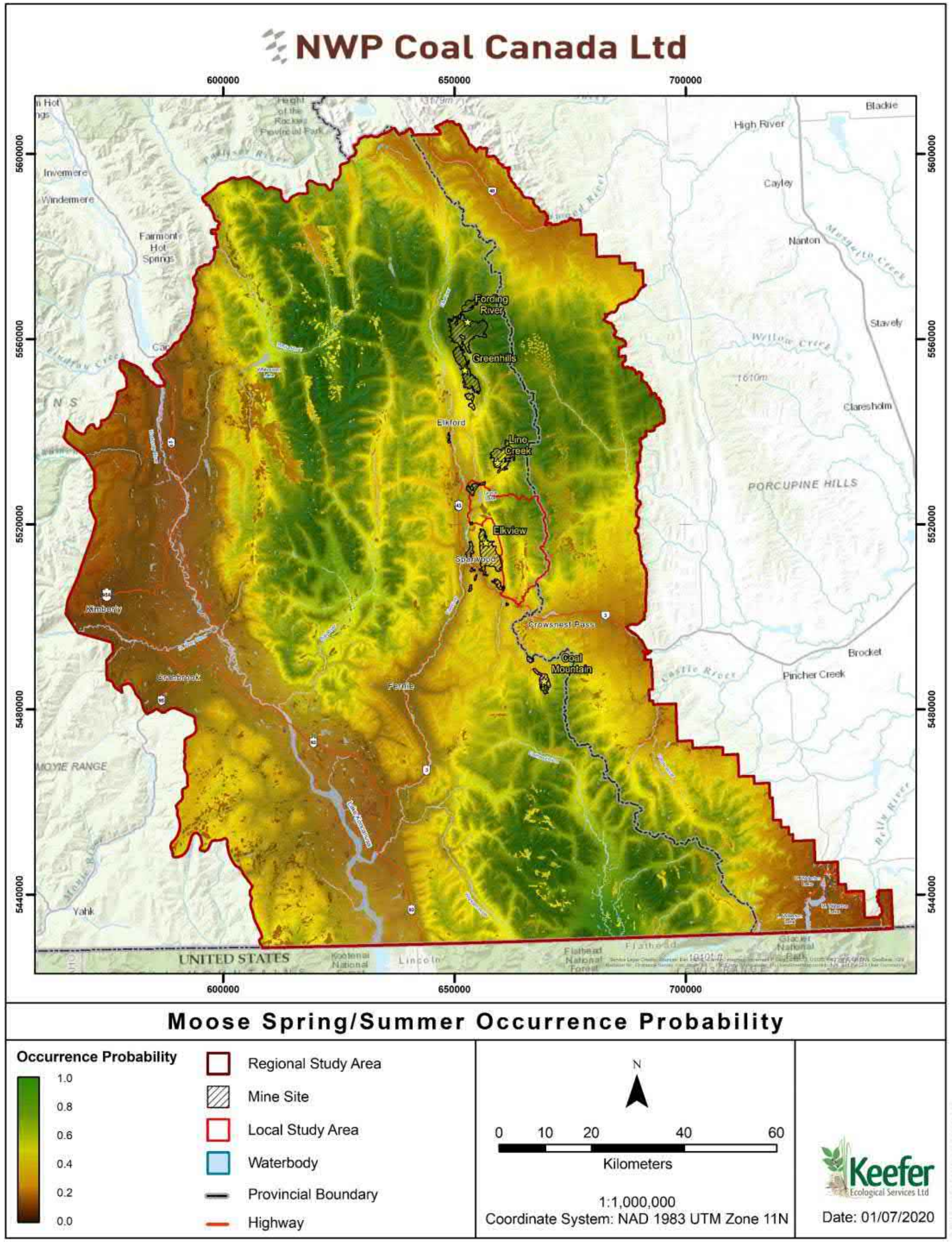
- Moose used approximately 74% of the sites surveyed during spring/summer
- Strong selection for mineral licks and low elevations
- Association with wetlands
- Avoidance of early seral forest patches and primary roads



Moose Habitat Suitability (spring/summer)

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

- Mineral Licks
- Early Seral Forest
- Mid Seral Forest
- Old Forest
- Elevation
- Primary Roads
- Tertiary Rivers
- Wetlands
- Avalanche chutes



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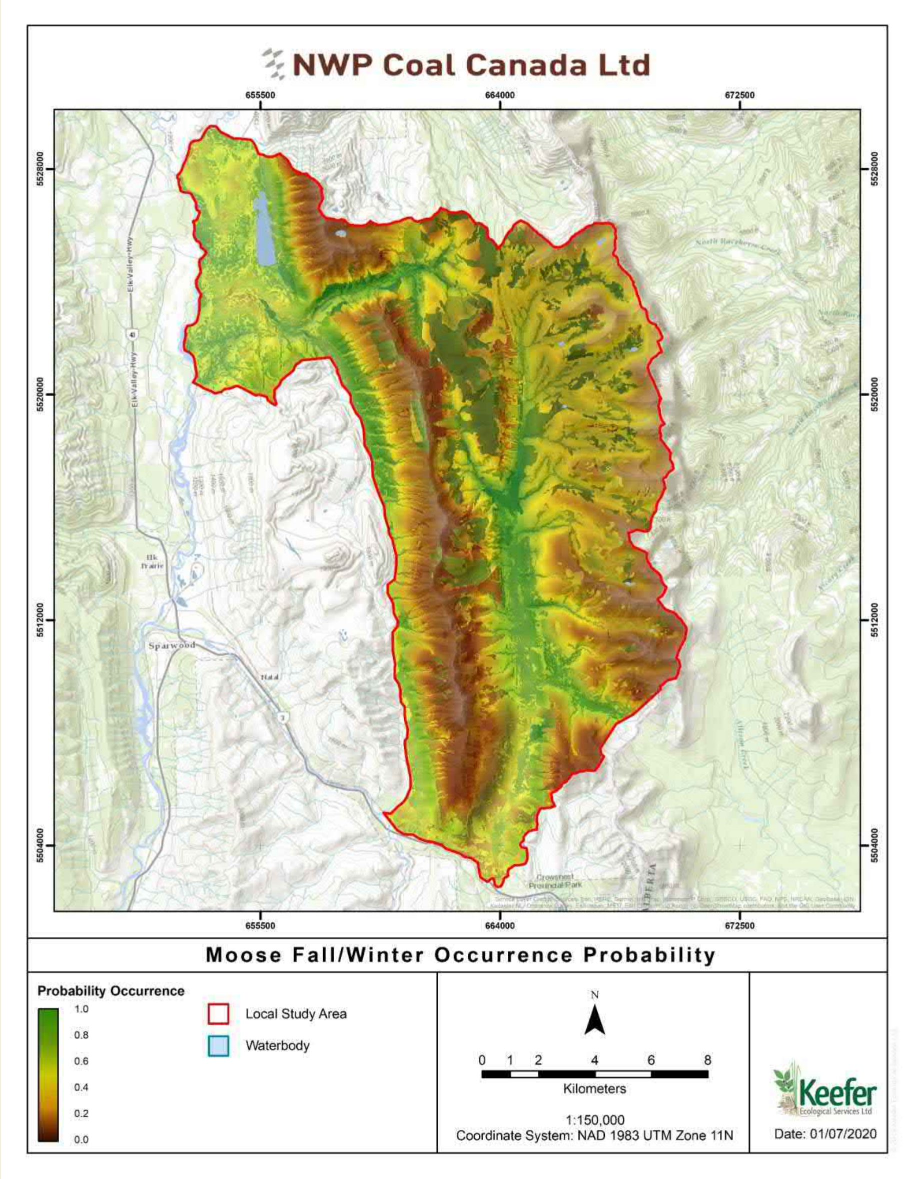
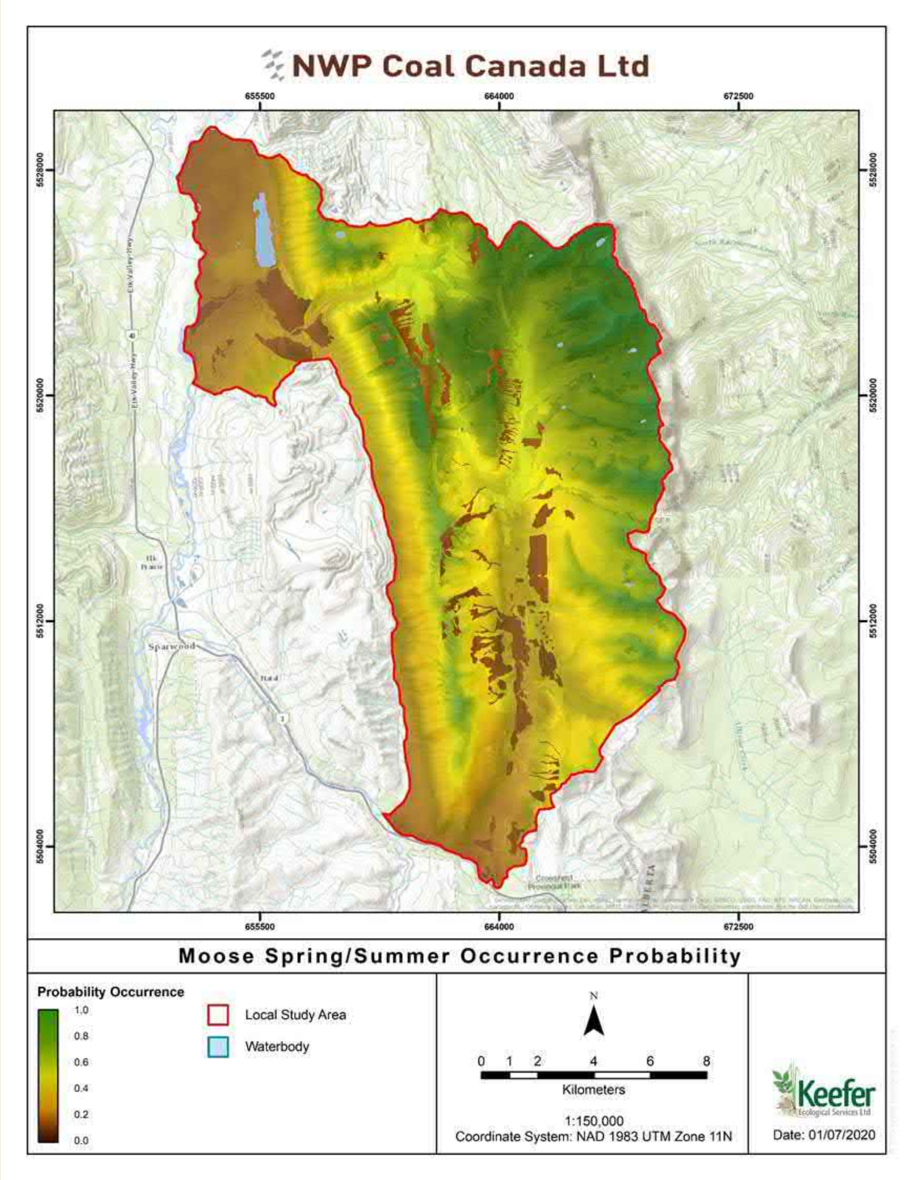


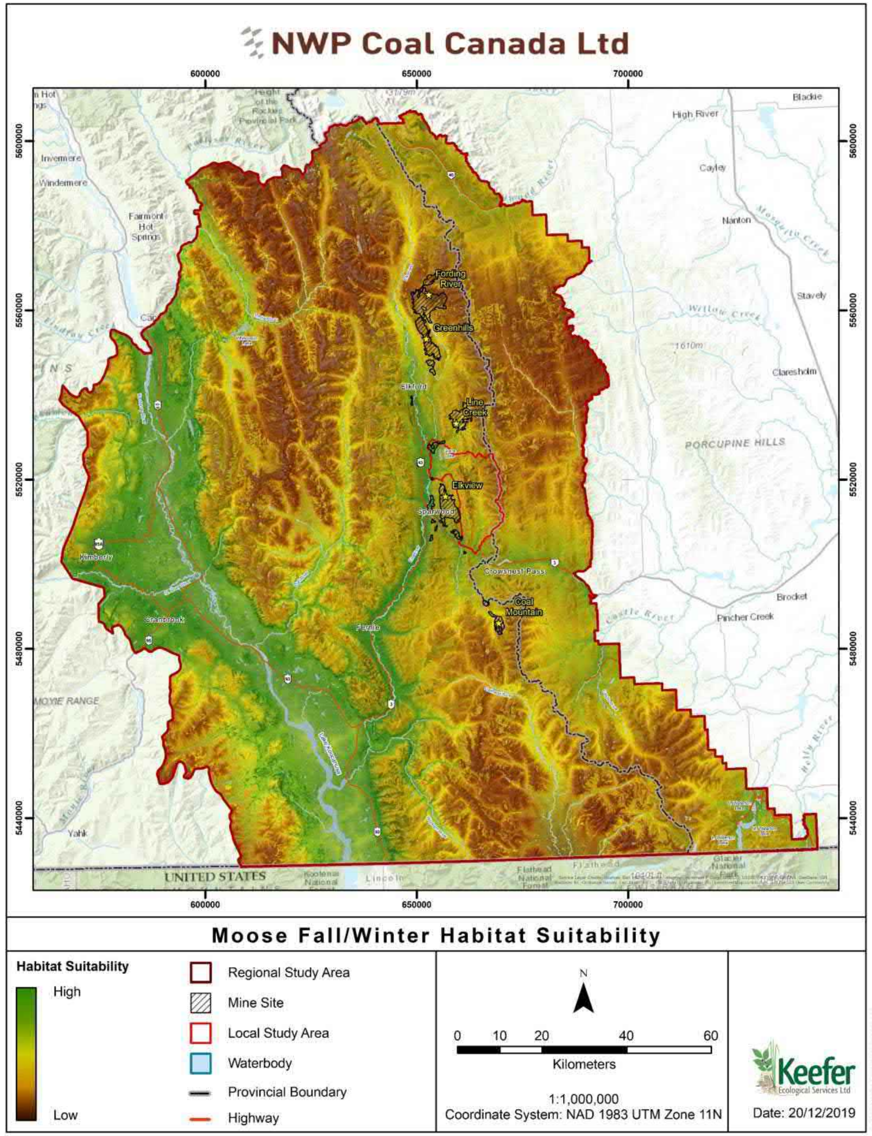
- Primary roads (β= -1.07)
- Elevation (β=-1.12)
- Tertiary rivers (β=0.62)



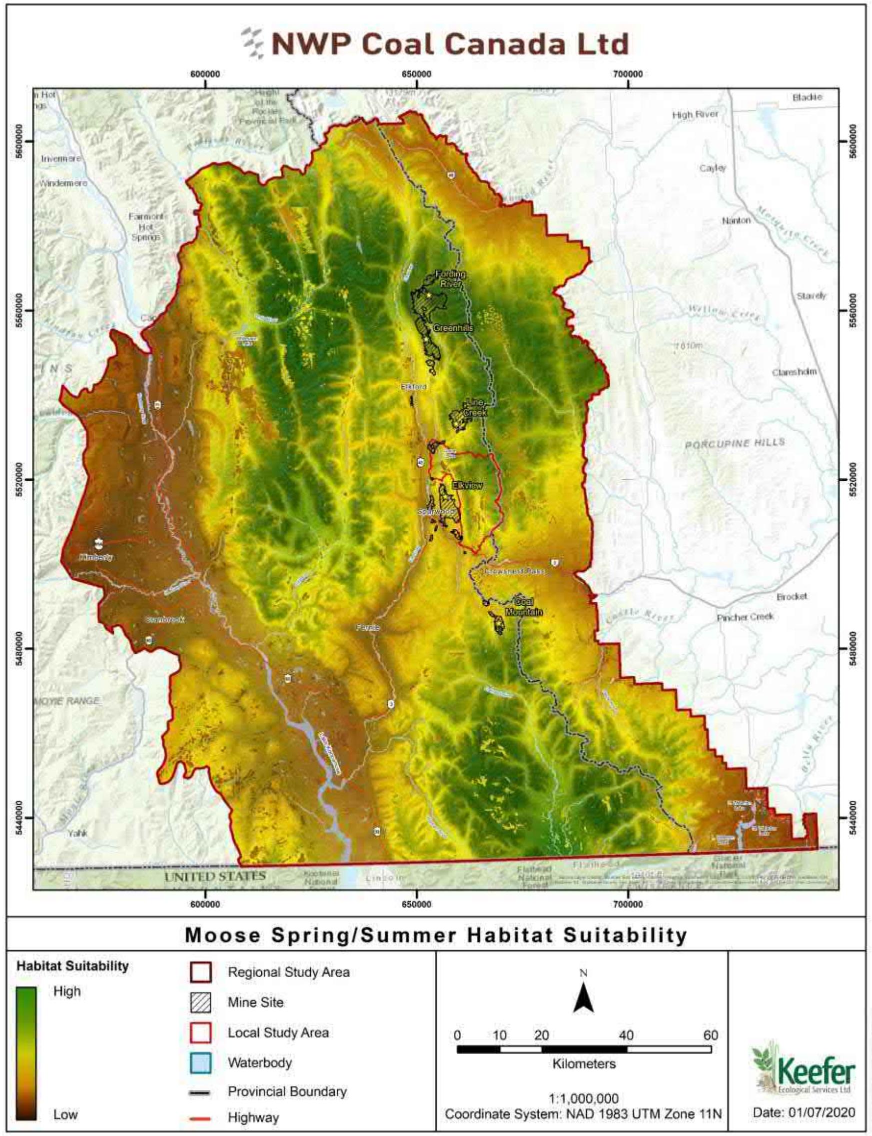
- Mineral licks (β= 0.77)
- Elevation (β=0.82)
- Primary roads (β= -0.72)
- Early Seral Forest (β= -0.63)

Fall/Winter Overall Occurrence/Habitat use = 0.44 (0.09)

Spring/Summer Overall Occurrence/Habitat use = 0.74 (0.08)



- Primary roads (β= -1.07)
- Elevation (β=-1.12)
- Tertiary rivers (β=0.62)

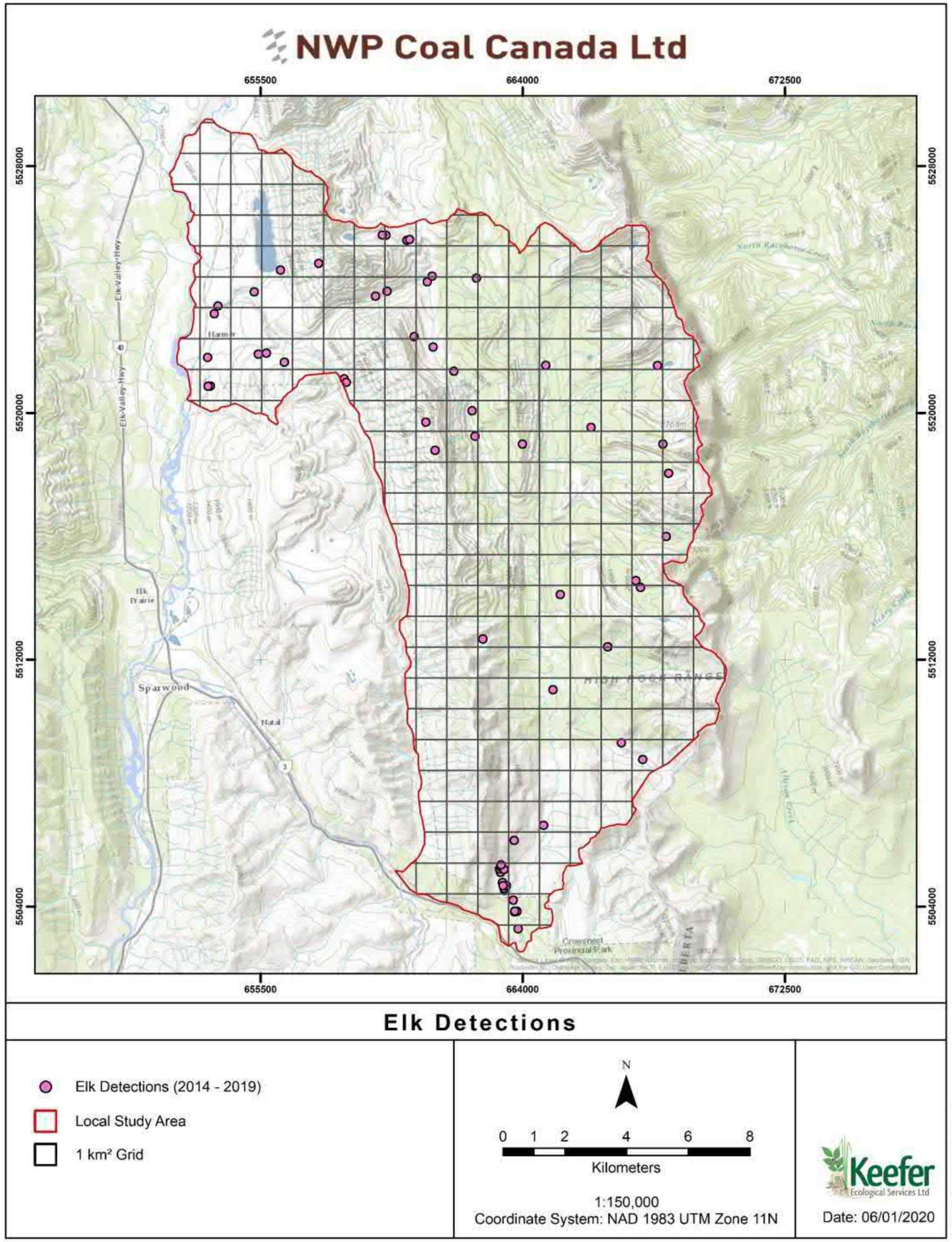


- Mineral licks (β= 0.77)
- Elevation (β=0.82)
- Primary roads (β= -0.72)
- Early Seral Forest (β= -0.63)

Fall/Winter Overall Occurrence/Habitat use = 0.44 (0.09)

Spring/Summer Overall Occurrence/Habitat use = 0.74 (0.08)

ELK



- 339 Elk Detections

Fall/Winter: Survey Covariates

Table #. Model selection procedure showing factors influencing Elk 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 = 229.

Model	AICc	ΔAICc	w	k	-2LL
p (CT,A)	881.60	0.00	1.00	4	873.42
p (CT)	902.41	20.81	0.00	3	896.30
p (.)	972.35	90.75	0.00	2	968.30

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 Elk detectability varied with survey method

Fall/Winter: Model Selection

Table #. Model selection procedure for factors influencing Elk site occupancy (Ψ) during fall-winter (2014-2019) in the in the Elk Valley, BC. Habitat components considered are elevation (EL), predator occurrence (PD), proximity to build up areas (BU), grasslands (GR), proximity for primary rivers (PRV) and proximity to tertiary rivers (TRV). Elk detectability varies with season and survey method (camera trap and aerial surveys). For simplicity, only models that emerged with support (ΔAICc <7) are shown. The model that assumes that occurrence is constant Ψ (.) is shown for comparison.

Model	AICc	ΔAICc	w	k	-2LL	Ψ (SE)
Ψ(EL,PD),p(CT,A)	**840.04**	**0.00**	**0.347**	**6**	**827.66**	**0.48 (0.08)**
Ψ (BU,EL,PD,GR),p(CT,A)	840.38	0.34	0.293	8	823.73	0.52 (0.11)
Ψ (BU,EL,PD,PRV),p(CT,A)	842.63	2.59	0.095	8	825.98	0.53 (0.12)
Ψ (BU,TRV,EL,PD),p(CT,A)	842.92	2.88	0.082	8	826.27	0.51 (0.10)
Ψ (BU,EL,GR),p(CT,A)	843.73	3.69	0.055	7	829.22	0.52 (0.10)
Ψ (EL,GR),p(CT,A)	845.14	5.10	0.027	6	832.76	0.47 (0.07)
Ψ (BU,EL),p(CT,A)	845.17	5.13	0.027	6	832.79	0.50 (0.09)
Ψ (BU,TRV,EL,GR),p(CT,A)	845.59	5.55	0.027	8	828.94	0.52 (0.10)
Ψ (BU,EL,PRV,GR),p(CT,A)	845.67	5.63	0.021	8	829.02	0.53 (0.11)
Ψ (.), p(CT,A)	881.60	41.56	0.000	4	873.42	0.57 (0.06)
Model Average						**0.50 (0.10)**

Results

- Elk used approximately 50% of the sites surveyed during spring/summer.
- 58% higher than naïve estimate (0.21)

Fall/winter: Habitat Variables

Table#. Habitat variables influencing Elk occurrence in the Elk Valley, 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 Elk occurrence at a (1 km^2) site (n = 229). The β-coefficient is the strength and direction (±) of influence.

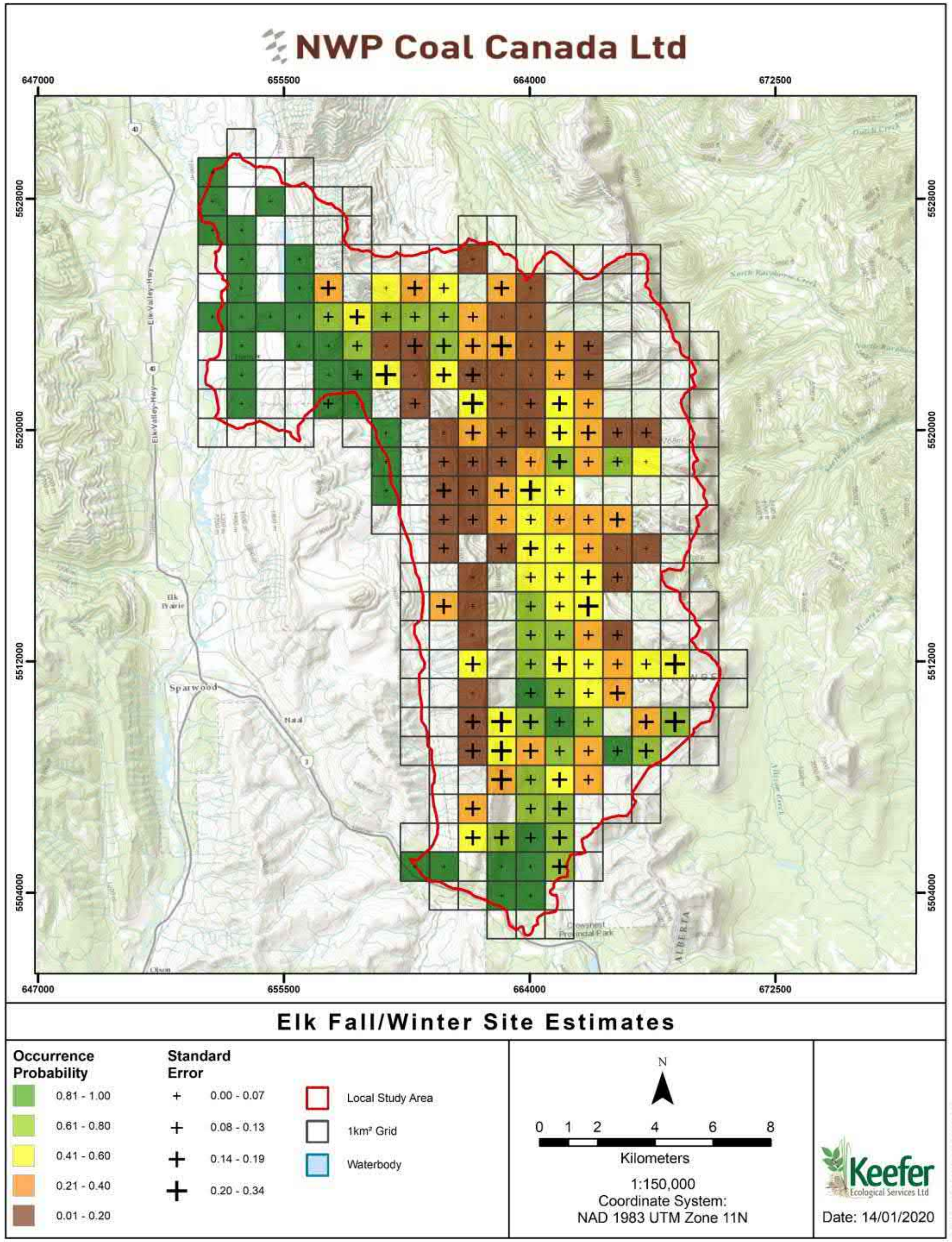
Variable	∑w	β	SE
Elevation	**0.97**	**-2.815**	**0.849**
Wolf Occurrence	0.82	**-1.305**	**0.558**
Built-Up Areas	0.59	**0.576**	**0.286**
Grasslands	0.42	**6.534**	**2.861**
Primary Rivers	0.12	**0.715**	**0.245**
Tertiary Rivers	0.10	-1.486	0.804

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

Results

Most important predictors of Elk occurrence:

- Strong avoidance of high elevations, predator activity and tertiary rivers
- Positive association with built-up areas and primary rivers
- Strong selection for grasslands

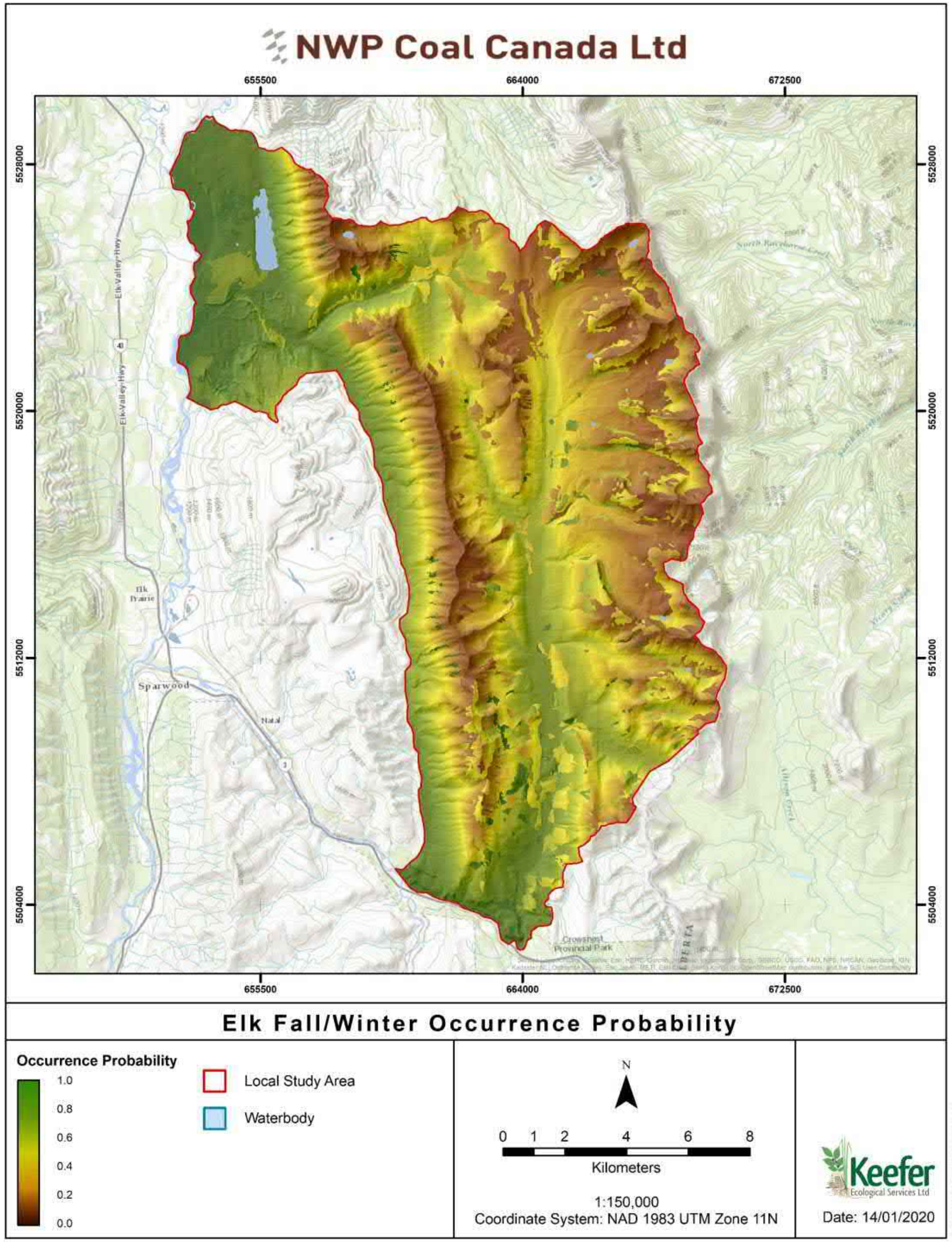


Site-specific Baseline Estimates

- Mean probability of habitat use:

  0.50 (SE = 0.09)

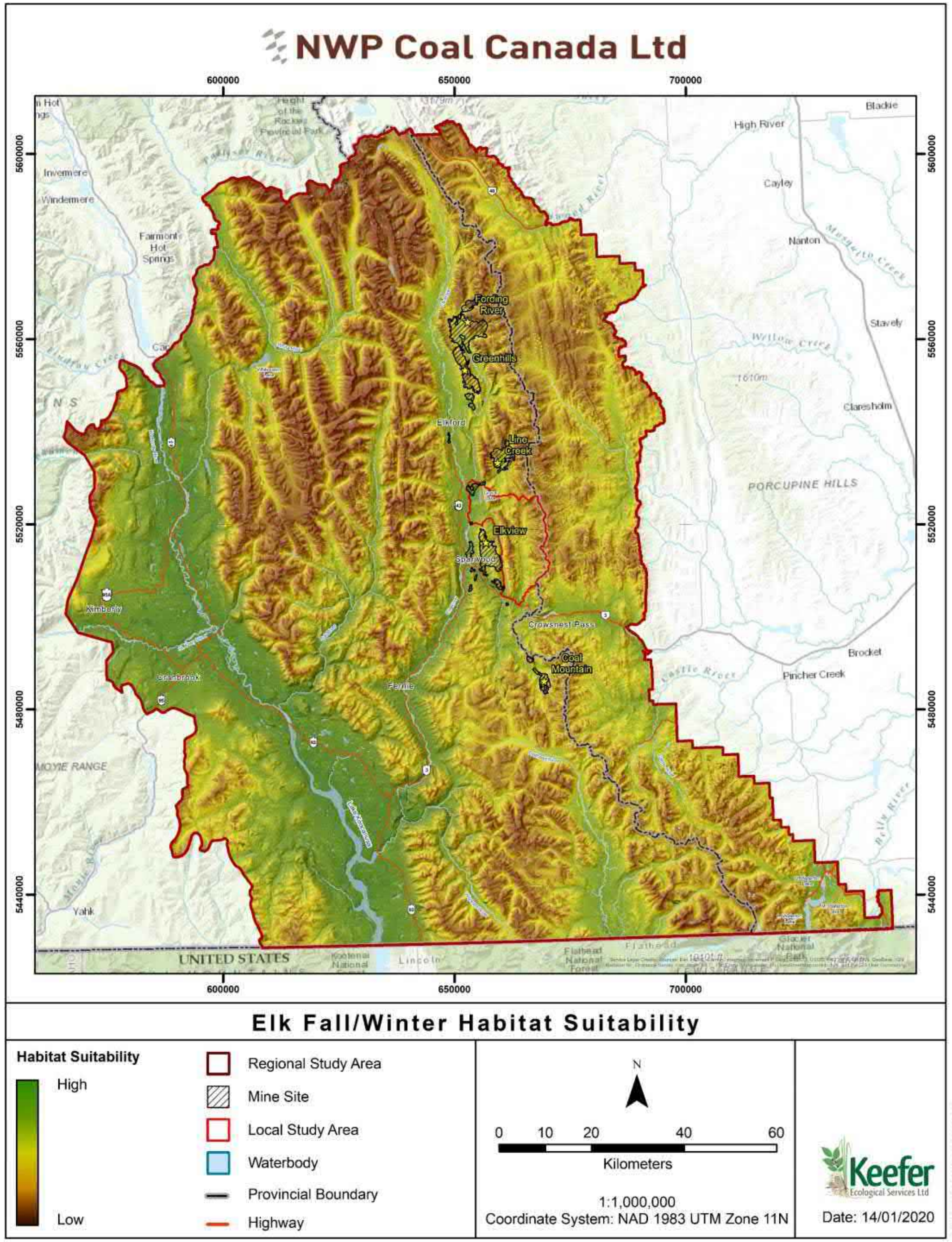
- Elk used approximately 50% of the sites surveyed during fall/winter
- Strong selection for grasslands, tertiary rivers and built-up areas
- Avoidance of high elevation, predator occurrence and primary rivers



Elk Habitat Suitability (fall/winter)

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

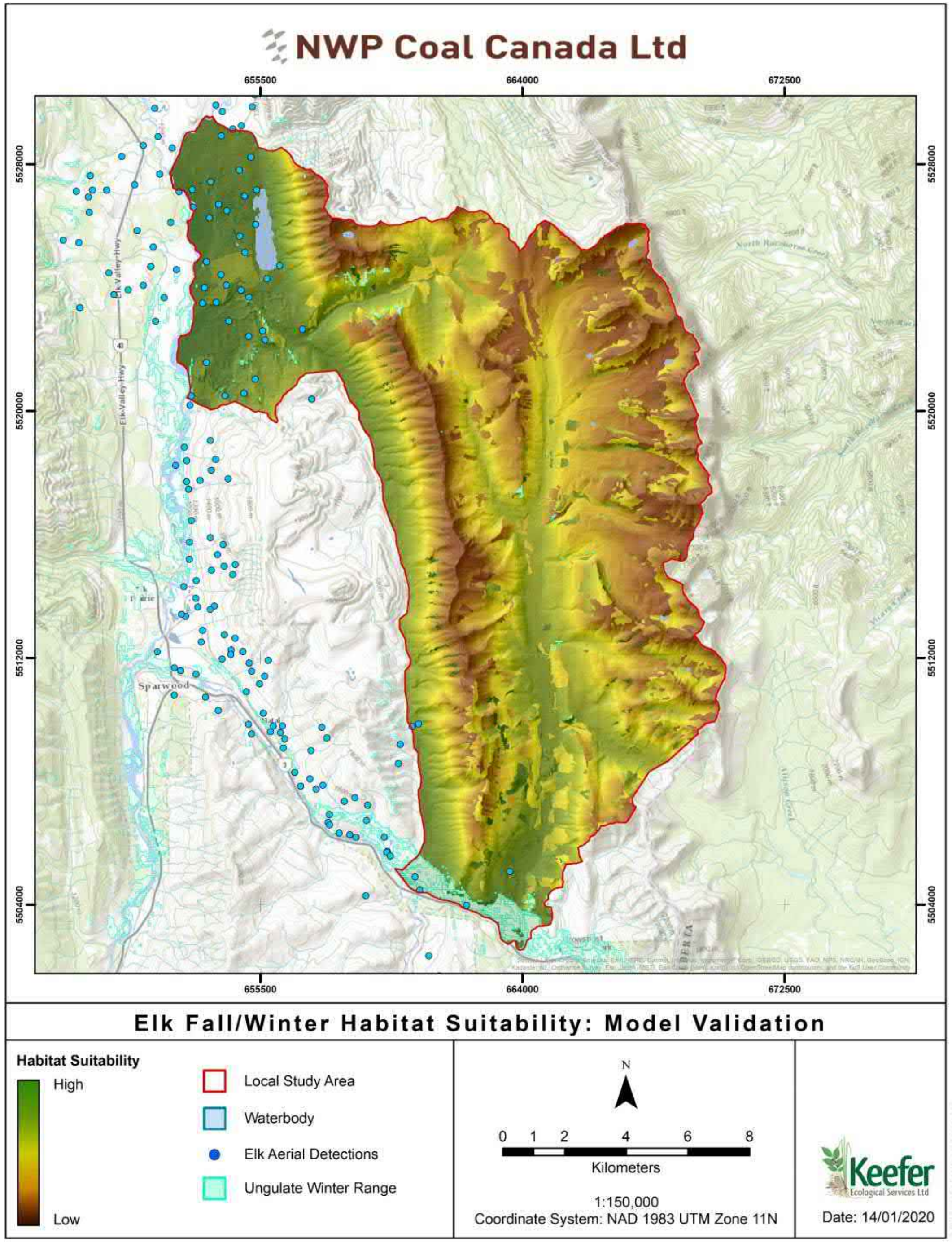
- Elevation
- Predator occurrence
- Built-up areas
- Grasslands
- Primary rivers
- Tertiary rivers



Elk Habitat Suitability (fall/winter)

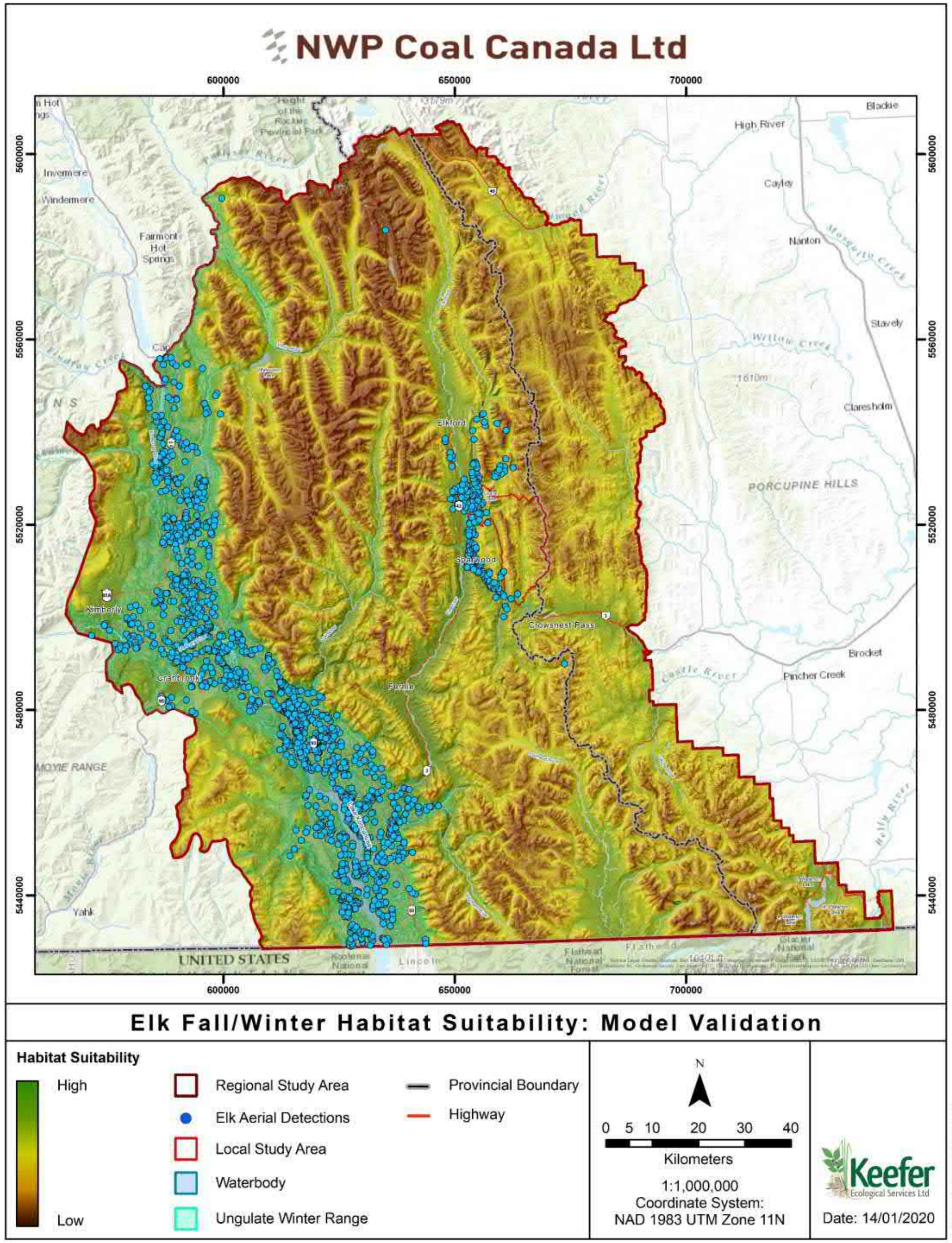
Habitat suitability model based on resulting regression equation from weighted model averaged estimates considering:

- Elevation
- Predator occurrence
- Built-up areas
- Grasslands
- Primary rivers
- Tertiary rivers



Elk Habitat Suitability (fall/winter):Model Validation

- Ungulate Winter Ranges & Aerial detections



Elk Habitat Suitability (fall/winter):Model Validation

▶Ungulate Winter Ranges & Aerial detections

The mean predicted probability of habitat use for all government aerial survey detections was 0.652.

Spring/Summer: Model Selection

Table #. Model selection procedure for factors influencing Elk site occupancy (Ψ) during fall-winter (2014-2019) in the in the Elk Valley, BC. Habitat components considered are predator occurrence (PD), NDVegetation Index (NDVI), proximity to mines (MN), cutblocks and fires (CBFR), Mid seral stage forest (MSF), open canopy grassland (OCG), and elevation (EL). Elk detectability varies with season and survey method (camera trap and aerial surveys). For simplicity, only models that emerged with support (ΔAICc <7) are shown. The model that assumes that occurrence is constant Ψ (.) is shown for comparison. Number of sites = 215.

Model	AICc	ΔAICc	w	k	-2LL	Ψ (SE)
psi(PD,NDVI,MN),p(CT,A)	1775.41	0.00	0.139	7	1760.87	0.92 (0.05)
psi(NDVI,MSF),p(CT,A)	1775.72	0.31	0.119	6	1763.32	0.93 (0.04)
psi(MSF,NDVI,MN),p(CT,A)	1775.75	0.34	0.117	7	1761.21	0.92 (0.05)
psi(PD,NDVI,CBFR),p(CT,A)	1775.76	0.35	0.117	7	1761.22	0.94 (0.03)
psi(PD,NDVI,OCG),p(CT,A)	1776.29	0.88	0.089	7	1761.75	0.93 (0.05)
psi(NDVI,CBFR),p(CT,A)	1776.68	1.27	0.074	6	1764.28	0.93 (0.03)
psi(PD,NDVI,MSF),p(CT,A)	1777.83	2.42	0.041	7	1763.29	0.93 (0.05
psi(PD,NDVI),p(CT,A)	1777.94	2.53	0.039	6	1765.54	0.93 (0.04)
psi(PD,OCG),p(CT,A)	1778.00	2.59	0.038	6	1765.60	0.92 (0.05)
psi(MSF),p(CT,A)	1778.32	2.91	0.032	5	1768.03	0.91 (0.04)
psi(PD,NDVI,EL),p(CT,A)	1778.41	3.00	0.031	7	1763.87	0.93 (0.05)
psi(OCG,MSF),p(CT,A)	1778.49	3.08	0.030	6	1766.09	0.91 (0.05)
psi(PD),p(CT,A)	1778.61	3.20	0.028	5	1768.32	0.92 (0.04)
psi(NDVI,OCG),p(CT,A)	1779.29	3.88	0.020	6	1766.89	0.91 (0.05)
psi(MSF,CBFR),p(CT,A)	1779.40	3.99	0.019	6	1767.00	0.92 (0.04)
psi(PD,CBFR),p(CT,A)	1779.61	4.20	0.017	6	1767.21	0.93(0.04)
psi(PD,EL),p(CT,A)	1779.64	4.23	0.017	6	1767.24	0.92 (0.05)
Ψ (.), p(CT,A)	1779.71	4.30	0.016	4	1771.52	0.91 (0.04)
Model Average						**0.93 (0.04)**

Results

- Elk used approximately 93% of the sites surveyed during spring/summer.
- 46% higher than naïve estimate (0.502)

Spring/summer: Habitat Variables

Table#. Habitat variables influencing Elk occurrence in the Elk Valley, 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 Elk occurrence at a (1 km^2) site (n = 229). The β-coefficient is the strength and direction (±) of influence.

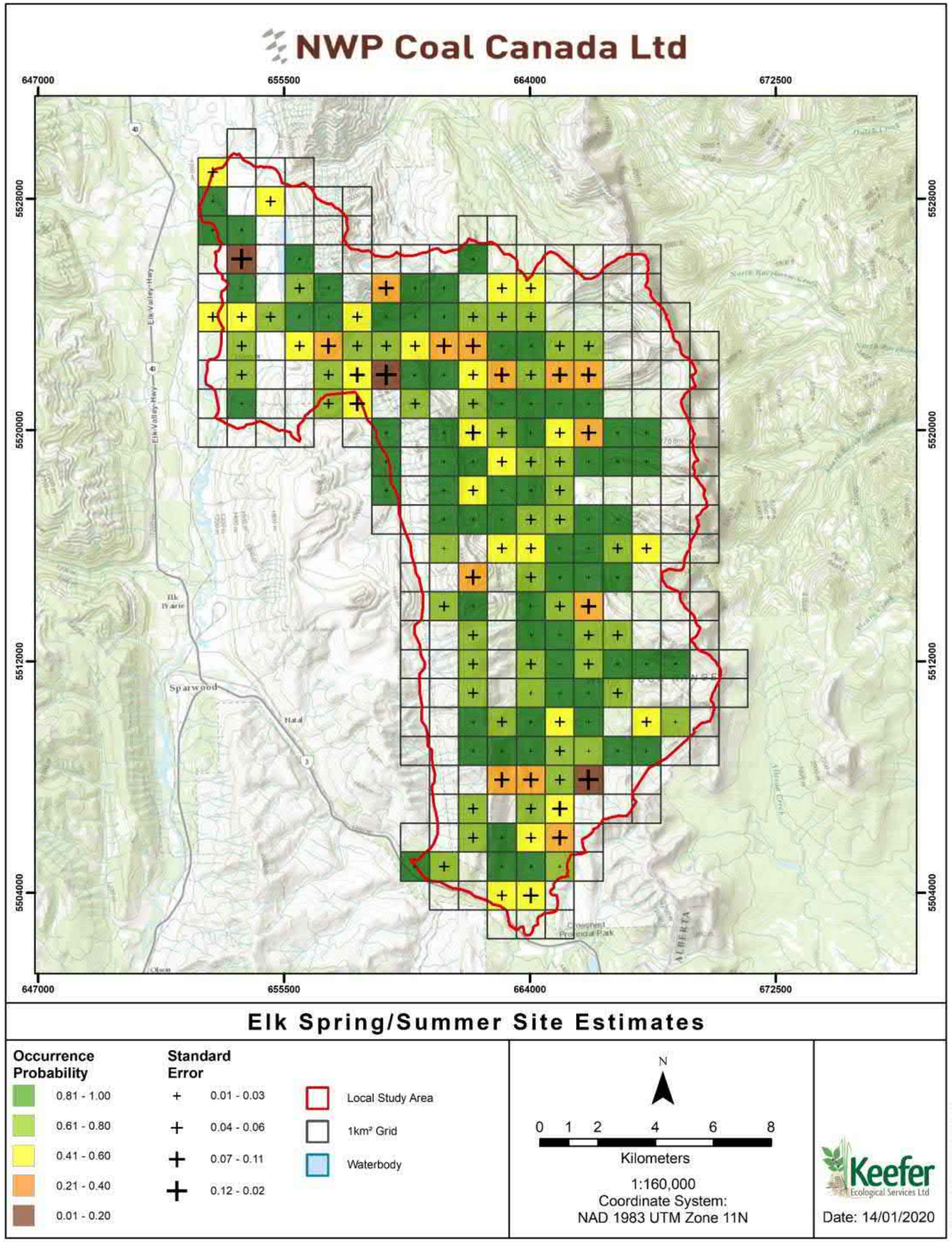
Variable	∑w	β	SE
NDVI	**0.79**	**1.105**	**0.360**
Wolf Occurrence	0.56	**-1.125**	**0.500**
Mid Seral Forest	0.24	**-0.771**	**0.314**
Mines	0.26	0.597	0.462
Grasslands and Crops	0.18	**0.779**	**0.302**
Burns and Cut Blocks	0.23	**1.793**	**0.736**
Elevation	0.05	**-0.508**	**0.219**

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

Results

Most important predictors of Elk occurrence:

- Positive association with NDVI, burns and cutblocks & grasslands and crops
- Strong avoidance of Predator occurrence, mid seral forest and elevation

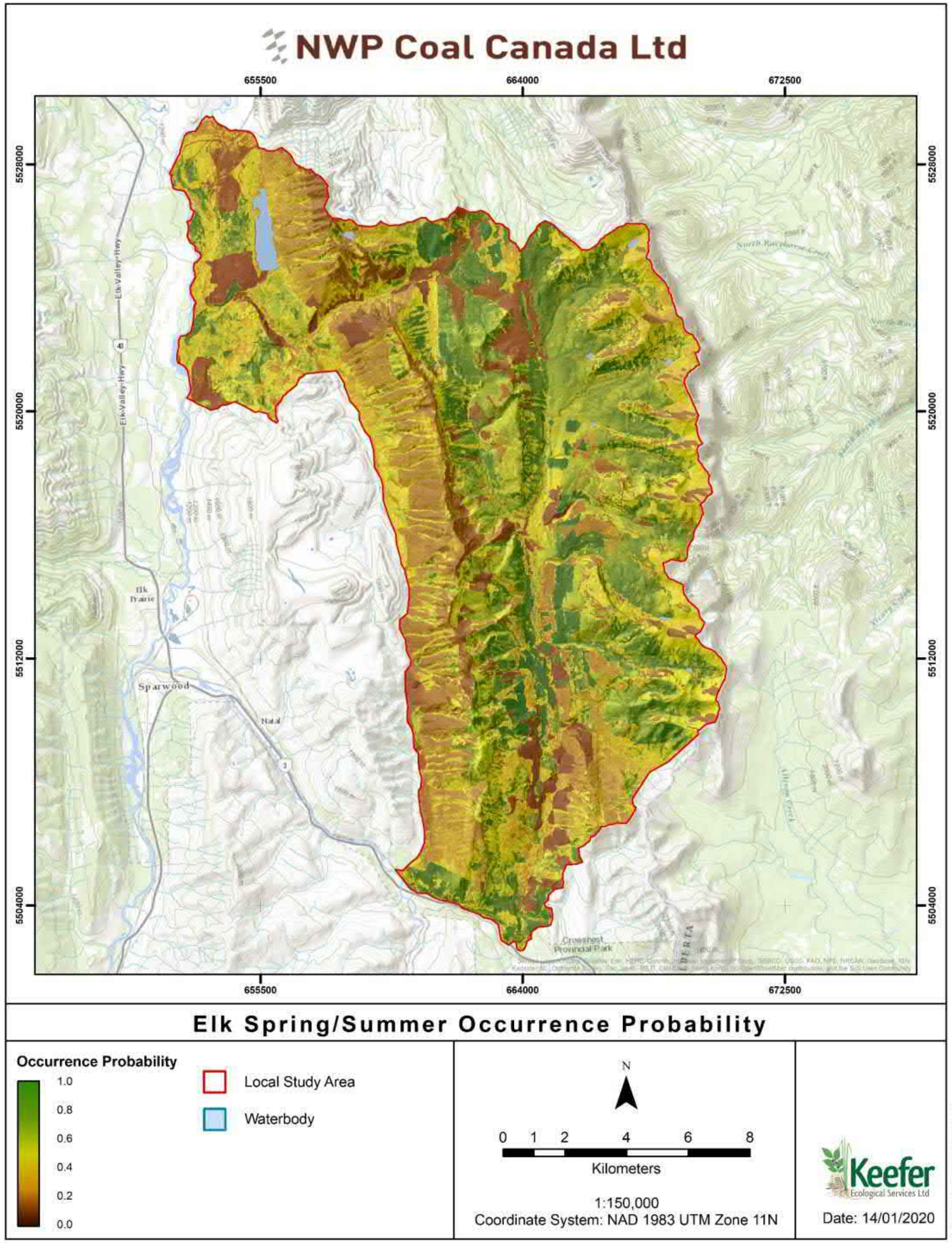


Site-specific Baseline Estimates

- Mean probability of habitat use:

  0.93 (SE = 0.04)

- Elk used approximately 93% of the sites surveyed during spring/summer
- Strong selection for NDVI and burns & cutblocks
- Avoidance of high elevation, predator occurrence and mid seral forests



Elk Habitat Suitability (spring/summer)

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

- NDVI
- Predator occurrence
- Mid seral forest
- Proximity to mines
- Grassland and crops
- Burns and cut blocks
- Elevation


BIGHORN SHEEP
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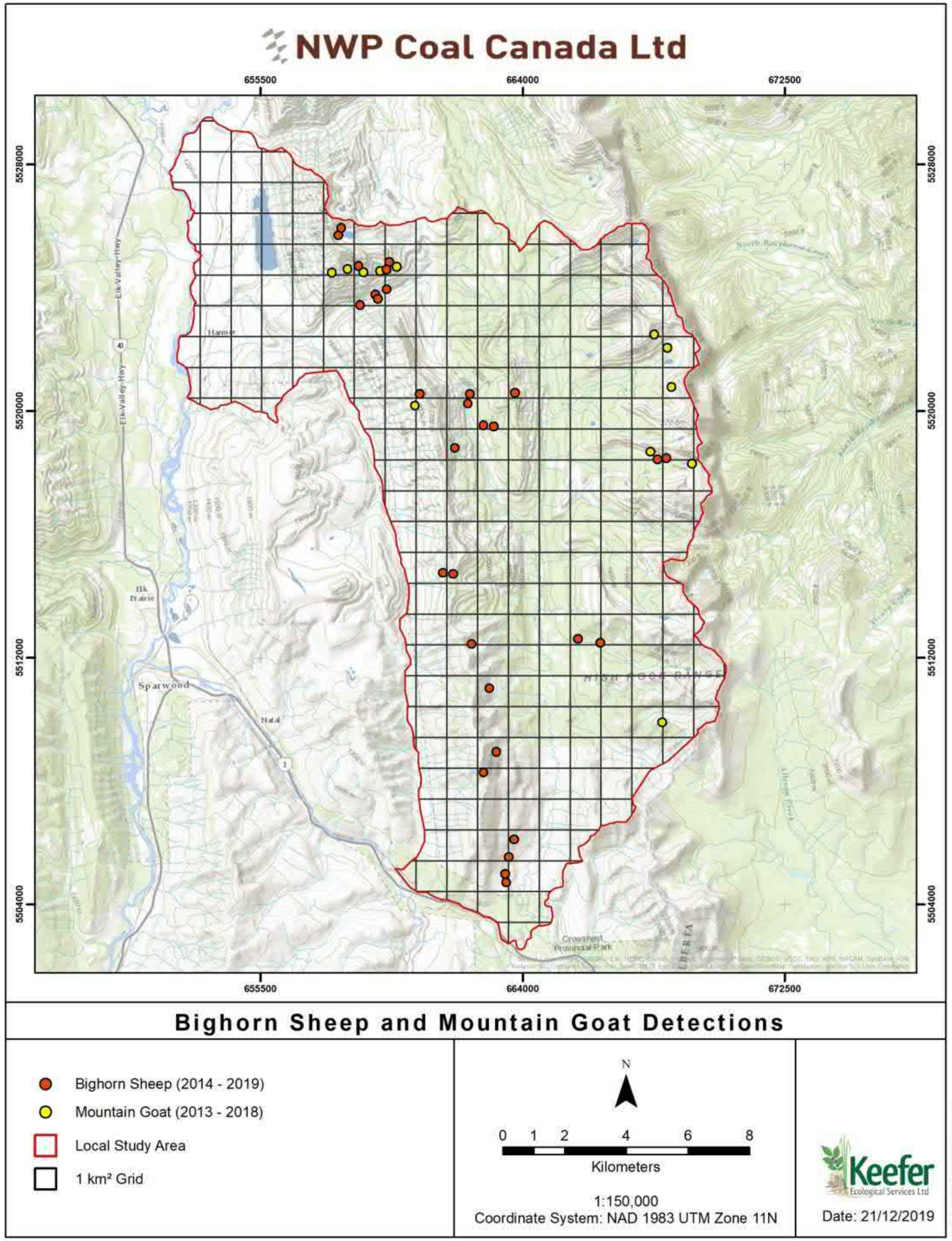
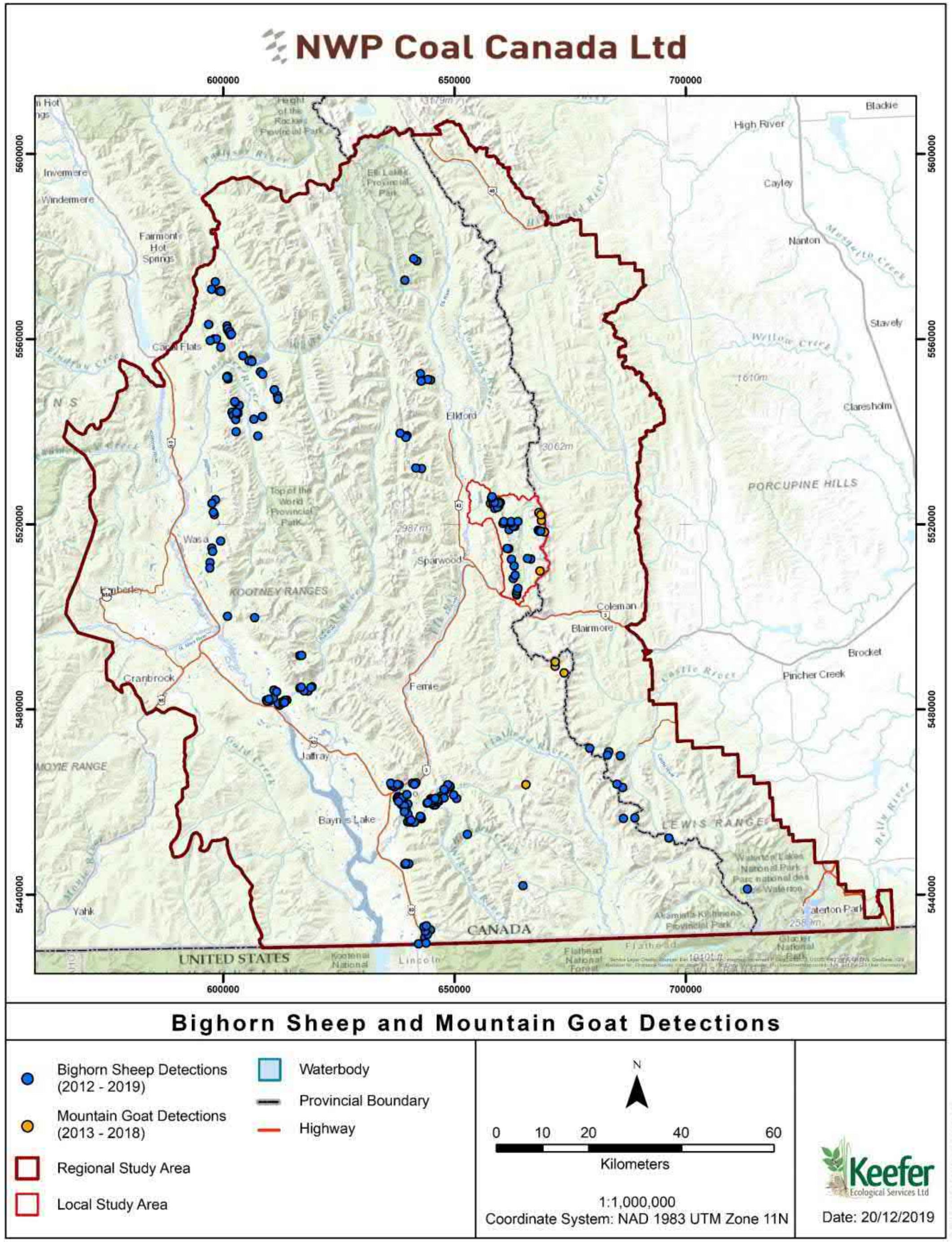


Bighorn Sheep & Mountain Goat Detections

- 110 Bighorn Sheep detections



Bighorn Sheep& Mountain Goat Detections

- 422 Bighorn Sheep detections

Survey Covariates

Table #. Summary of model selection procedure for factors influencing Bighorn Sheep detectability (p) in the Elk Valley, BC. Factors considered are: (32 day) camera-trap and aerial surveys (M) season (SN). The model that assumes that occurrence is constant Ψ (.) is shown for comparison. Number of sites = 253.

Model	AICc	ΔAICc	w	k	-2LL
p (M)	**340.79**	**0.00**	**0.4845**	**3**	**334.69**
p (.)	342.36	1.57	0.2210	2	338.31
p (SN,M)	342.50	1.71	0.2060	4	334.34
p (SN)	344.19	3.40	0.0885	3	338.09

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.

- Bighorn Sheep detectability varied with survey method

Table #. Model selection procedure for factors influencing Bighorn Sheep site occupancy (Ψ) in the in the Elk Valley, BC. Habitat components considered are proximity to escape terrain (ET), solar radiation (SR), proximity to mineral licks (ML), predator occurrence (Wolf, PR), high elevation grass and herbs (FG), avalanche chutes (AV), terrain ruggedness (RU), elevation (EV), terrain ruggedness (RU), proximity to secondary rivers (SRV), old and mature forest (OMF). Models with AICc w >0.95 are shown, and the model that assumes occurrence is constant Ψ (.) is shown for comparison. Bighorn Sheep detectability varies with survey method (camera-trap, transect or aerial).

Model	AICc	ΔAICc	w	k	-2LL	Ψ (SE)
Ψ (ET,SR,ML,PR),p(SN,A)	**301.50**	**0.00**	**0.176**	**8**	**284.91**	**0.20 (0.06)**
Ψ (ET,SR,ML,PR,FG),p(SN,A)	302.06	0.56	0.133	9	283.32	0.20 (0.07)
Ψ (ET,SR,ML),p(SN,A)	302.25	0.75	0.121	7	287.79	0.18 (0.06)
Ψ (ET,SR,ML,FG),p(SN,A)	302.67	1.17	0.098	8	286.08	0.18 (0.06)
Ψ (ET,SR,ML,AV),p(SN,A)	303.18	1.68	0.076	8	286.59	0.18 (0.06)
Ψ (RU,ML,PR),p(SN,A)	305.12	3.62	0.029	7	290.66	0.20 (0.06)
Ψ (ET,SR,FG),p(SN,A)	305.36	3.86	0.026	7	290.90	0.20 (0.06)
Ψ (ET,ML,PR),p(SN,A)	305.37	3.87	0.026	6	290.91	0.17 (0.06)
Ψ (ET,SRV),p(SN,A)	305.47	3.97	0.024	6	293.13	0.17 (0.06)
Ψ (RU,ML),p(SN,A)	305.53	4.03	0.024	8	293.19	0.17 (0.05)
Ψ (ET,ML,SRV,PR),p(SN,A)	305.60	4.10	0.023	6	289.01	0.19 (0.07)
Ψ (RU,PR),p(SN,A)	305.72	4.22	0.021	7	293.38	0.18 (0.06)
Ψ (ET,SRV,ML),p(SN,A)	305.76	4.26	0.021	6	291.30	0.17 (0.06)
Ψ (ET,ML),p(SN,A)	305.99	4.49	0.019	7	293.65	0.15 (0.05)
Ψ (ET,SR,AV),p(SN,A)	306.01	4.51	0.019	7	291.55	0.18 (0.06)
Ψ (ET,SRV,PR),p(SN,A)	306.28	4.78	0.016	7	291.82	0.19 (0.07)
Ψ (ET,SRV,OMF),p(SN,A)	306.29	4.79	0.016	6	291.83	0.17 (0.06)
Ψ (ET,SR),p(SN,A)	306.30	4.80	0.016	8	293.96	0.17 (0.06)
Ψ (ET,SRV,OMF,ML),p(SN,A)	306.45	4.95	0.015	7	289.86	0.16 (0.07)
Ψ (RU,OMF,ML),p(SN,A)	306.59	5.09	0.014	5	292.13	0.16 (0.06)
Ψ (RU),p(SN,A)	306.81	5.31	0.012	8	296.57	0.17 (0.05)
Ψ (ET,ML,PR,FG),p(SN,A)	**306.86**	**5.36**	**0.012**	**7**	**290.27**	**0.19 (0.07)**
Ψ (RU,OMF,ML),p(SN,A)	307.04	5.54	0.011	7	292.58	0.17 (0.06)
Ψ (.)	342.50	41.00	0.000	4	334.34	0.11 (0.02)
Model Average						**0.18 (0.06)**

Model Selection Results

- Bighorn Sheep used approximately 18% of the sites surveyed.
- 63% higher than naïve estimate (0.0672)

Habitat Variables

Table#. Habitat variables influencing Bighorn Sheep occurrence in the Elk Valley, 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 Bighorn Sheep occurrence at a (1 km^2) site (n = 253). The β-coefficient is the strength and direction (±) of influence.

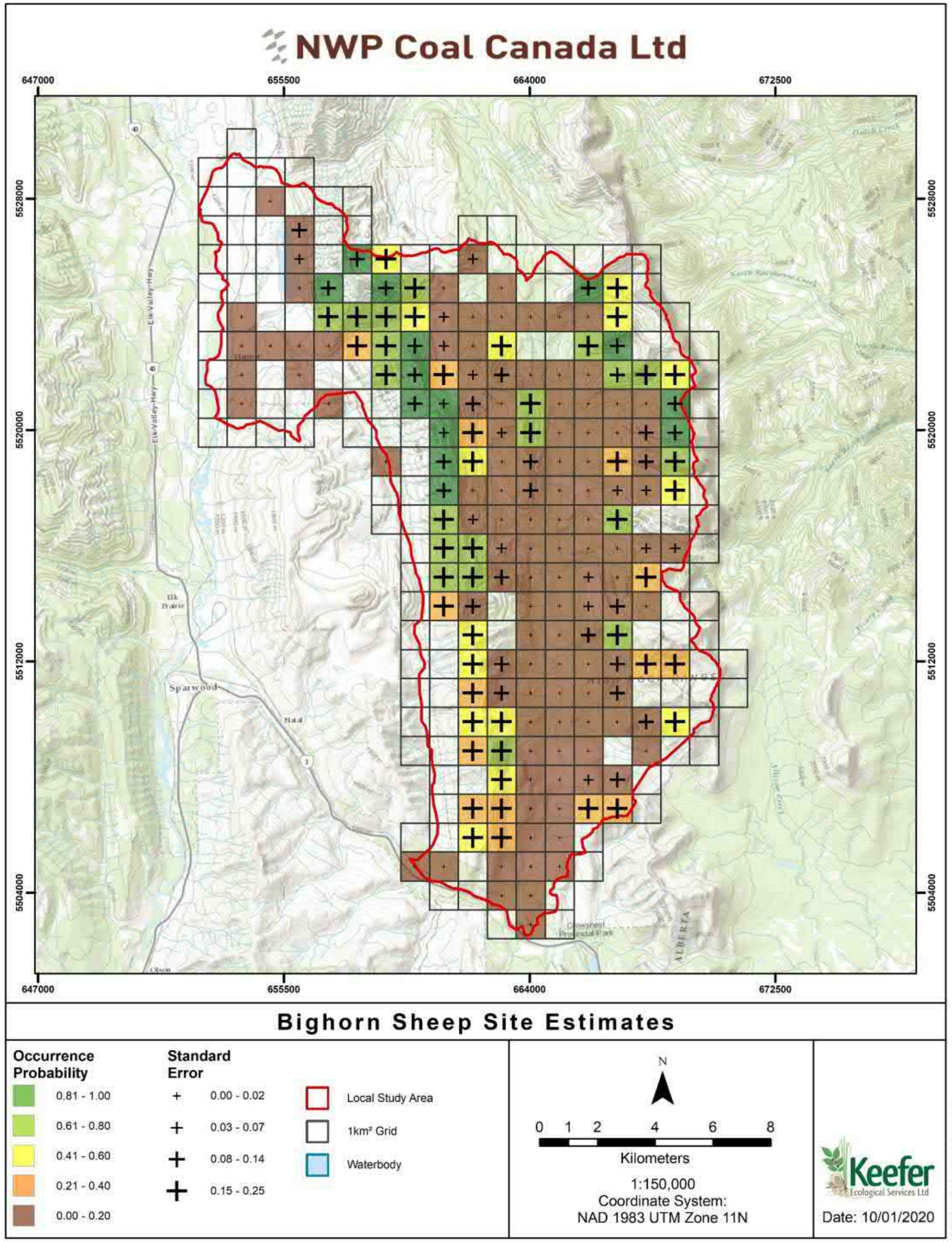
Variable	∑w	β	SE
Escape Terrain	**0.84**	**32.415**	**12.331**
Mineral Licks	0.80	**1.898**	**0.950**
Solar Radiation (May)	0.67	**1.159**	**0.559**
Predator Occurrence	0.44	-7.486	4.966
High Elevation Grass and Herbs	0.27	0.453	0.291
Avalanche Chutes	0.17	0.331	0.324
Secondary Rivers	0.12	-0.998	0.494
Old Mature Forest	0.06	-0.595	0.524

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

Results

Most important predictors of Bighorn Sheep occurrence:

- Strong selection for escape terrain
- Positive association with mineral licks, solar radiation
- Negative association with predator activity, secondary rivers and old mature forests

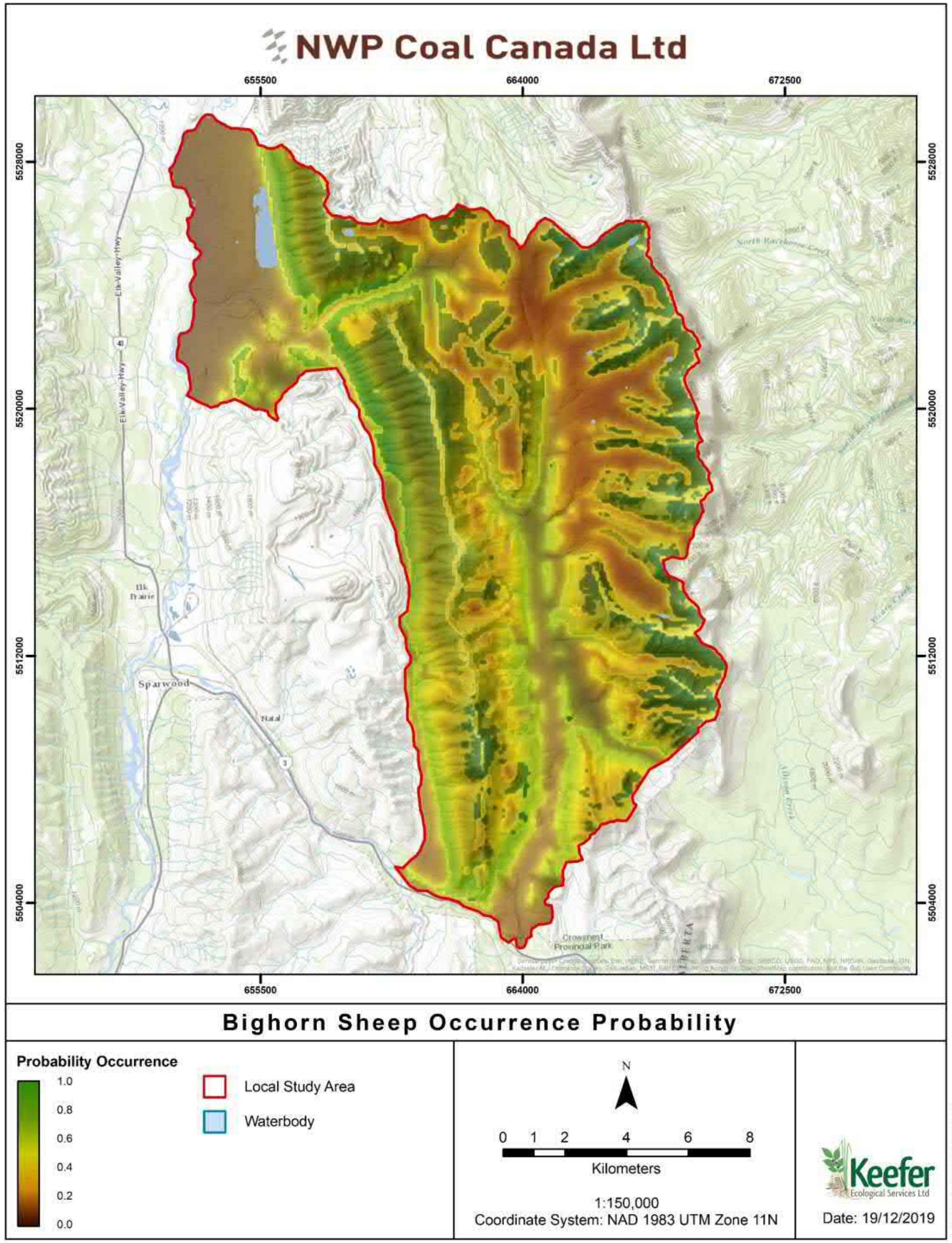


Site-specific Baseline Estimates

- Mean probability of habitat use:

  0.18 (SE = 0.061)

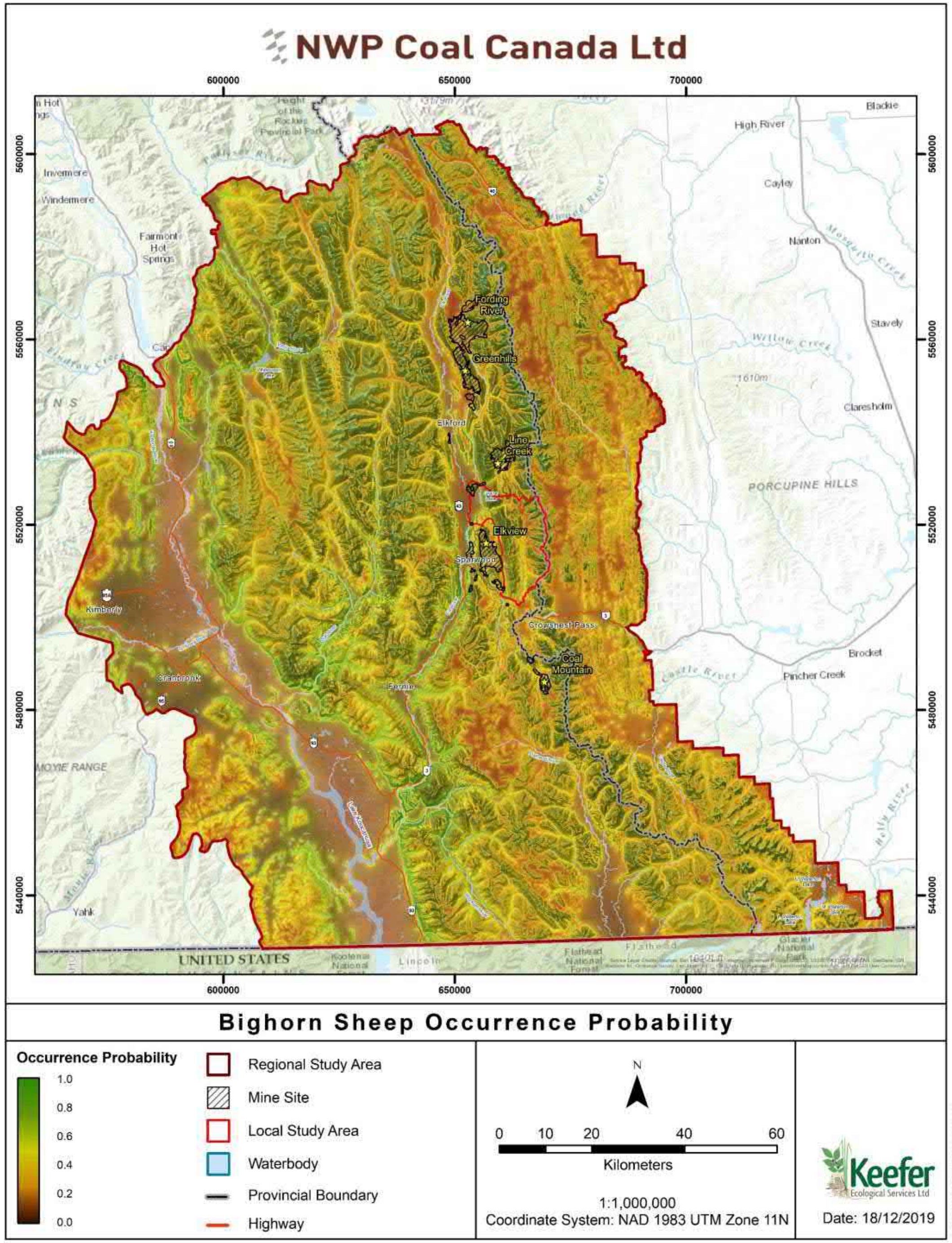
- Bighorn Sheep used approximately 18% of the sites surveyed during spring/summer
- Strong selection for escape terrain and mineral licks
- Avoidance of predators



Bighorn Sheep Habitat Suitability

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

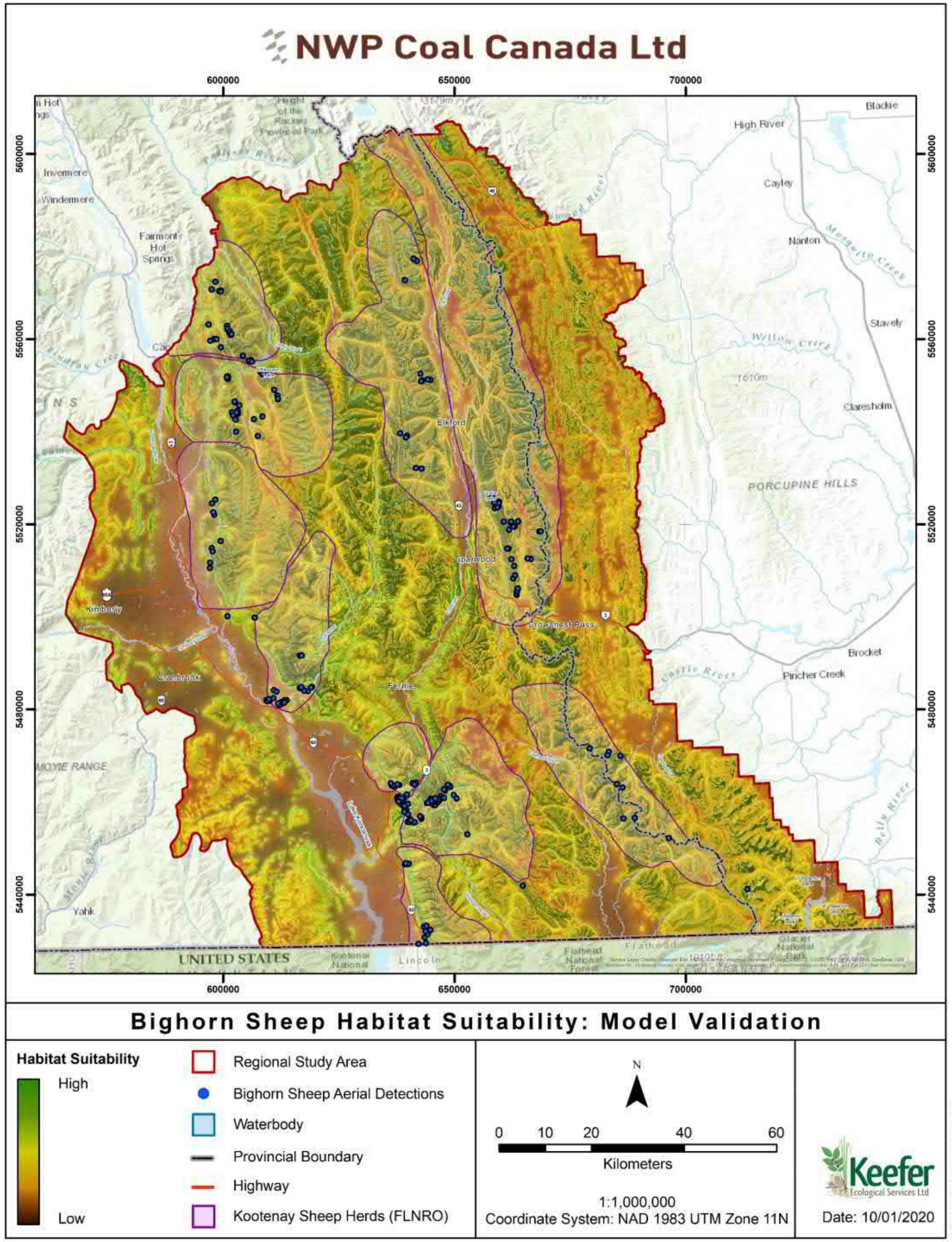
- Escape terrain
- Mineral licks
- Solar radiation (May)
- Predator occurrence
- High elevation grass and herbs
- Avalanche chutes
- Secondary rivers
- Old mature forest



Bighorn Sheep Habitat Suitability

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

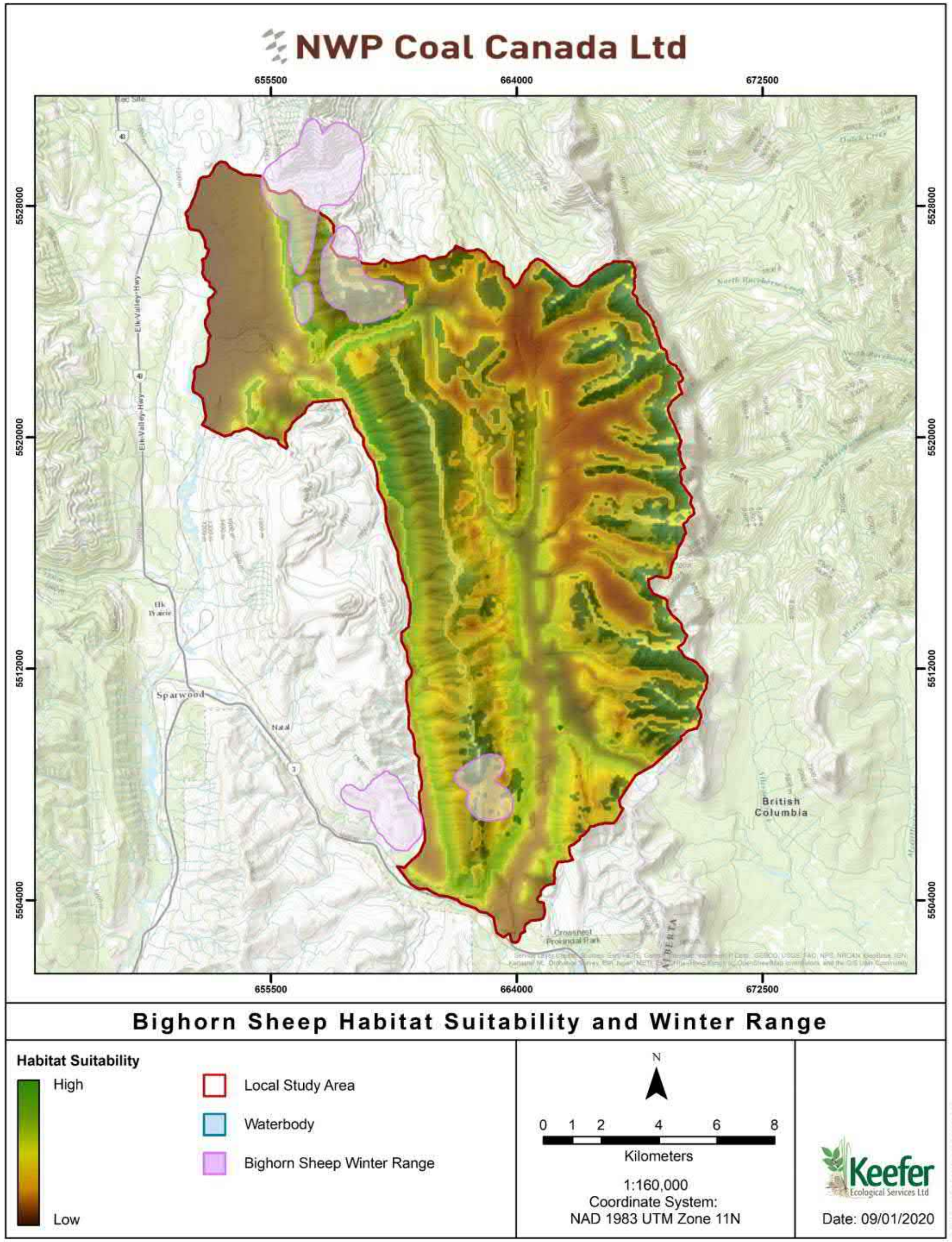
- Escape terrain
- Mineral licks
- Solar radiation (May)
- Predator occurrence
- High elevation grass and herbs
- Avalanche chutes
- Secondary rivers
- Old mature forest



Bighorn Sheep Habitat Suitability- Model Validation

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

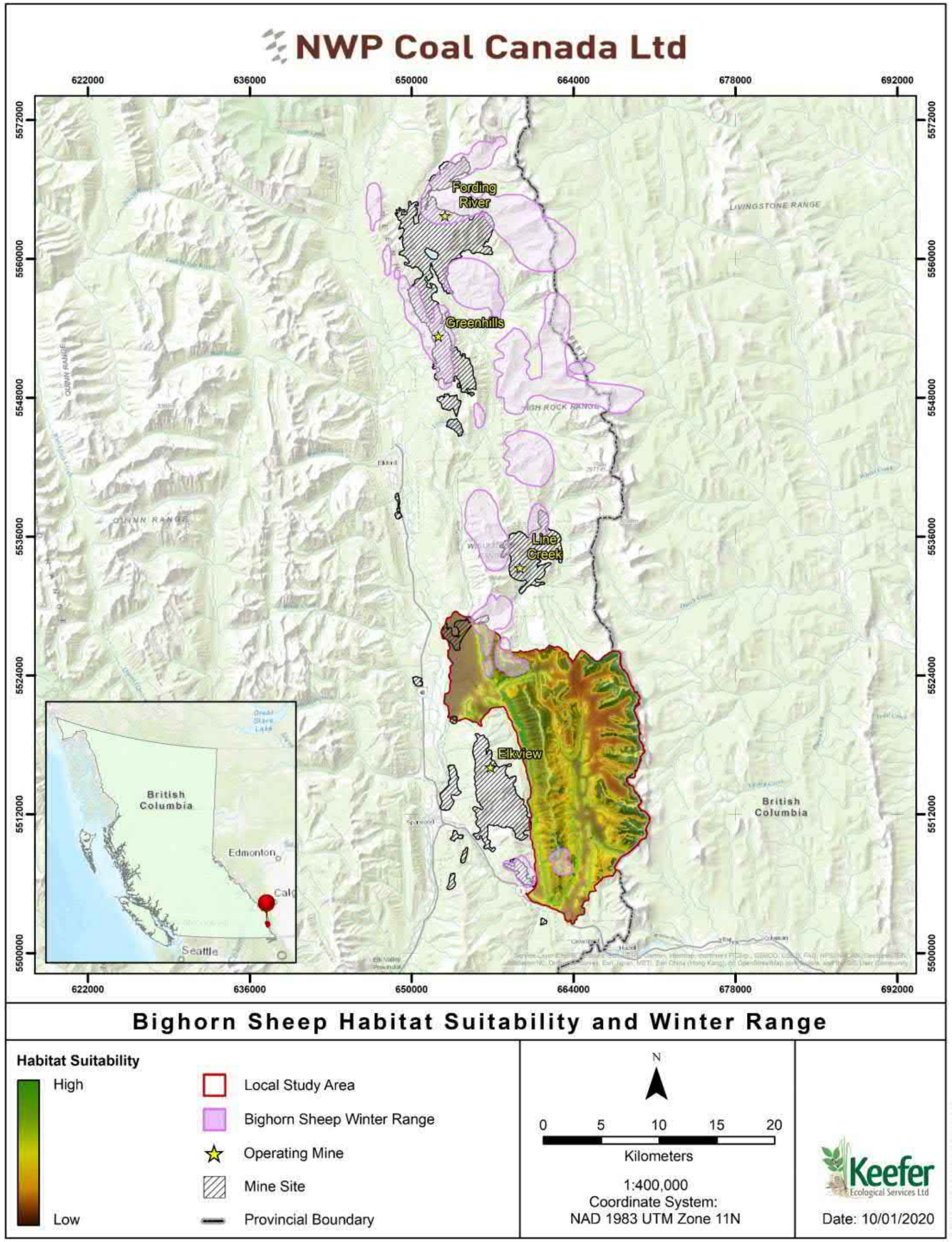
- Escape terrain
- Mineral licks
- Solar radiation (May)
- Predator occurrence
- High elevation grass and herbs
- Avalanche chutes
- Secondary rivers
- Old mature forest



Bighorn Sheep Habitat Suitability- Model Validation

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

- Escape terrain
- Mineral licks
- Solar radiation (May)
- Predator occurrence
- High elevation grass and herbs
- Avalanche chutes
- Secondary rivers
- Old mature forest



Bighorn Sheep Habitat Suitability- Model Validation

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

- Escape terrain
- Mineral licks
- Solar radiation (May)
- Predator occurrence
- High elevation grass and herbs
- Avalanche chutes
- Secondary rivers
- Old mature forest

In progress:

- Mountain Goat
- Snowshoe Hare
- Coarse Woody Debris
- Canada Lynx
- American Marten
- Wolverine