

APPENDIX P

TERRESTRIAL RESOURCES TECHNICAL SUPPORT DOCUMENTS

- P-1 Baseline Terrestrial Report
- P-2.1 GHD Category 2 and Category 3 Updated Modelling Report (Ferrit 2024)
- P-2.2 Resource Selection Probability Modelling of Calving Areas using Recent Satellite Telemetry Data (Minnow 2024)**
- P-2.3 Resource Selection Probability Modelling of Calving Areas Using GHD Spring & Summer and MECP Category 1 Areas (Ferrit 2024)
- P-2.4 Report on Caribou Sustainability Metrics for the Springpole Project Current and Future Condition Scenarios with Assessments at LSA and RSA Scales (Ferrit 2024)

Technical Memorandum

Date: September 5, 2024

To: Megan Hazell and Al Arsenault, WSP

From: Jeff Row, Minnow Environmental Inc.

Cc: Kim Connors, Minnow Environmental Inc.

RE: Caribou Calving Habitat Surrounding the Springpole Proposed Development and Across Three Caribou Ranges

Background and Objectives

The overall objective of this project was to model the expected distribution of caribou calving habitat in the vicinity of the open pit mine development by First Mining Gold (hereafter Springpole Gold Project) and across three caribou ranges (Churchill, Berens, and Kinloch) in Northern Ontario. Specifically, Minnow Environmental Inc. (Minnow) was retained to use radio telemetry data from female caribou during the calving season (May and June) with natural and disturbance spatial covariates, to 1) develop and validate a Resource Selection Function (RSF) model to predict the locations of female caribou and use as a surrogate for calving habitat suitability, and 2) predict calving habitat suitability across the three caribou ranges in Northern Ontario.

Methods

Caribou Locations and Movement

Caribou locational data were provided by WSP and consisted of locational data collected every eight hours throughout the calving period (May 1st to June 30th, 2023) from 50 individual female caribou. Using these data, probable calving locations were identified as the 3-day minimum average distances between daily locations. Three-day minimums were calculated by creating a daily locational dataset that included the first location in each day, calculating the successive distances between each of the daily caribou locations, and subsequently calculating 3-day rolling averages using the successive location distances over the previous three days. Daily successive movement distances were also summarized for all individuals and used to derive

spatial covariates at relevant spatial scales and to buffer distances used in the conditional logistic regression models described below.

Locations were generally clustered in space. Thus, to reduce spatial autocorrelation in any resulting models, spatially independent daily locations were derived using a clustering approach to thin the dataset to only retain successive locations that were spaced greater than 1.69 km. This distance represented the mean of the 75th percentile of daily movement distances for individual females over the calving period (Table 1; Figure 1) and would remove any strongly clustered locations. The clustering proceeded such that locations were joined hierarchically starting with locations separated by the smallest spatial distance to those with the largest spatial distance. The threshold of 1.69 km was used to partition the clusters into groups and retain groups of locations spaced below that threshold distance together. One random location was selected within each cluster, resulting in a final “thinned” dataset of locations. This thinned dataset was used in all subsequent modelling steps.

Covariate Development

Landcover covariates were derived from raw GIS data contained in the Ontario Land Cover Compilation v 2.0 for four forest cover categories (coniferous forest, deciduous forest, mixed forest, open forest), wetlands, peatlands, and open water (Table 2; Land Information Ontario 2019). In addition to the natural landcover variables, covariates were derived from the Land Information Ontario Fire Disturbance Area (Land Information Ontario 2022) and anthropogenic disturbance was derived from a combination of the Environment Canada caribou disturbance footprint (Environment and Climate Change Canada 2018) and disturbance layers derived by WSP from the Churchill (Table 2). Point source disturbances and mining lease patents were not included in the anthropogenic disturbances and any linear disturbance features (polylines) were buffered by 500 m and converted to polygons. Fire disturbance data were split into three temporal categories: fire disturbance within the last 20 years (Fire A: 2000 to 2021), fire disturbance between 1980 and 2000 (Fire B), and fire disturbance between 1960 and 1980 (Fire C). All landcover and disturbance GIS data (hereafter referred to as ‘landscape variables’) were initially resampled to binary raster layers (i.e., presence or absence) with a resolution of 45 m² and used to develop model covariates.

Spatial covariates were developed from the binary raster layers to quantify 1) the proportional coverage of each respective landscape variable within defined window sizes, and 2) the distance to the presence of a respective landscape variable. In both cases, the covariates were derived at two spatial scales: 1) 1.69 km which was equal to the 75th percentile of daily movement distances for each individual caribou and the thinning distance used between successive locations (den_1), and 2) 3.78 km which was equal to the 75th percentile of daily



movement distances plus 1.5 x the interquartile range (den_2) to capture larger-scale spatial patterns. Covariates with proportional densities for each spatial extent were derived using a moving window to convert each raster cell into the associated proportional density and resulted in a covariate ranging between 0 (no presence within the moving window) and 1 (all presence cells with the moving window).

Increasing distances from a landscape variable well beyond the movement rates of individual caribou are not likely meaningful to the selection of habitat for an individual on any given day. Thus, to capture a non-linear relationship between occurrence and distance to a landscape variable an exponential decay function $e(-d/\alpha)$ was used to summarize the distance to each presence cell (Fedy et al. 2014; Nielsen et al. 2009). In the decay function equation, d is the distance in metres from the centre of each pixel to the landscape class, and α is the strength of the decay. This transformation also scaled each variable to between 0 and 1 (as with proportional coverage) with 1 being the highest value for the landscape feature (i.e., 0 km distance to the feature) and 0 at farther distances beyond the threshold. Two values were used for α , 0.34 km (decay_1) and 0.74 km (decay_2), which resulted in maximum thresholds of 1.69 km and 3.78 km where the values reached 0 and no longer decreased in importance. Combining the two moving windows (densities) and two decay function transformations led to a total of four covariates for each landscape variable (Figure 2).

Model Development

Resource Selection Function (RSF, Manly et al. 2002) models were developed using a mixed conditional logistic regression model to characterize more local behaviour and habitat selection (Hosmer and Lemeshow 2000). For each caribou location, five random locations were generated within a defined buffer to quantify habitat availability surrounding each location. The buffer size was set to 12.6 km, which was the average of the maximum daily distance travelled by caribou and represented the potential maximum movement distance of a caribou on a given day. This approach ensured that the RSF model was premised on habitat availability of where the caribou could have gone based on observed movement potential, which provided for an ecologically relevant definition of availability (Boulanger et al. 2012; Compton et al. 2002; Johnson & Russell 2014; Row and Blouin-Demers 2006). Because we included multiple locations for each individual, a random effects term for the individual was also included in the model.

Covariate selection through univariate analysis

The most appropriate spatial scale and transformation for each landscape variable were identified by comparing the four univariate models (two density and two decay function scales



discussed above) for each landscape variable amongst each other using corrected Akaike Information Criterion (AICc). The univariate comparison was conducted using 10 replicates with each iteration using a different set of random locations within the defined buffer distance (12.6 km). The top selected transformation was the model that was selected most for the 10 replicates and was used in the subsequent multivariate analysis.

Multivariate model comparison

Using the top selected spatial scale for each landscape variable, multivariate models using all possible combinations of individual landscape variables were compared with some exceptions. Given their importance in projecting habitat and quantifying potential mine influence (i.e., they would be changed during the proposed development), four landcover variables were included in all model comparisons: coniferous forest, wetland, peatland, open water, and anthropogenic disturbance. Consistent with the univariate analyses all models included random intercepts for individual and were compared amongst each other using AICc.

Multivariate model validation and classification

The top multivariate model was spatially predicted and validated using a 'five-fold' cross validation approach and the Boyce index (as implemented in Hirzel et al. 2006). The Boyce Index quantifies how the spatial predictions for observed presence locations deviates from random observations across the selection gradient (i.e., measures of presence locations fall within higher predicted habitat, Boyce 2002 and Hirzel et al. 2006). The index boundaries are -1 to +1, with positive values suggesting that presences are generally found within habitat with higher predictions, values close to zero suggesting the model is not different from a randomly generated model, and -1 suggesting locations fall within lower quality prediction areas. Here, the cross-validation folds were derived by dividing individual caribou into five equally sized folds where each fold contained a different set of caribou. The total number of locations for each fold varied slightly depending on the number of locations that were retained in the thinned data set for the selected caribou. Subsequently, the analysis iteratively fit the top fitting model to a training set consisting of four of the folds and used the remaining fold as a "testing" dataset to calculate the Boyce Index. The cross-validation was set-up using customized scripts in R (R Core Team 2023) and the Boyce Index was calculated using the *ecospat.boyce* function in the *ecospat* package. The function calculates the predicted-to-expected ratio by determining the number of observed locations with predicted values in that suitability class to the expected number locations if they were randomly distributed among the suitability classes. Thus, if the ratio increases with suitability then observed locations are found disproportionately within areas predicted to have higher suitability. The index was calculated using a moving window classification and spearman correlations.



Similarly, the Boyce Index was calculated from historical caribou locations provided by WSP (2010 to 2015) distributed across the study area. The historical locations were first filtered to only include female individuals that were located in May and June. Individuals that were located within forest that had been burned in the last 20 years were removed because the current forest cover is not reflective of what was present on the landscape when the caribou was located. In many cases, there were multiple locations from the same individual and thus a resampling procedure was used to validate the model with the historical data. Specifically, for each replicate, one location was randomly chosen for each individual and the Boyce Index was calculated. To be consistent with the cross-validation approach using the modelling data, five replicates were run in total and a mean spearman correlation coefficient was calculated for each replicate.

The final RSF model was classified into four categories using the percentiles of the RSF values for the thinned caribou locations:

- Unsuitable: Less than the 5th percentile (i.e., less than 5 percent of thinned caribou locations with RSF values in this range);
- Marginal: Greater than the 5th percentile, but below the 10th percentile;
- Suitable: Between the 10th percentile and the 50th percentile; and
- Optimal: Greater than the 50th percentile.

A binary habitat layer was also developed comparing the full set of used locations to randomly generated *pseudo* absence locations across the modelled area (polygon representing a 12.6 km buffer around caribou locations) and selecting the optimal threshold by determining the value that maximizes the sensitivity (highest true positive rate) and locations and specificity (highest true negative rate).

Results

Caribou Locations and Movement

Two individual caribou had less than 30 daily locations over the two-month calving period and were removed from the movement and modelling analyses. This resulted in a final dataset of 48 female caribou that were located (Table 1; Figure 1).

Model Development

The spatial scale and type of covariate (density or decay) varied for each of the landscape variables (Table 3). Coniferous forest (Density 2), Deciduous Forest (Decay 2) and Fire B (Den 2) were summarized at the larger spatial scale (3.78 km) with all other selected variables summarized at the smaller spatial scale (1.69 km; Table 3). For most landscape



variables the choice of scale and transformation was clear with a majority of the replicates selecting the same location (coniferous forest, Fire A, B and C, mixed forest, water, wetland, and peatland). For anthropogenic disturbance, deciduous forest, and open forest there was some ambiguity (Table 3). In these cases, the Δ AIC was low between the models and choosing one transformation over another would likely have little impact on the final model results.

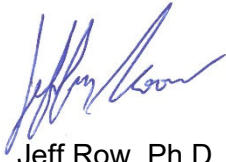
The top selected multivariate model using the selected transformations, contained nine covariates with only Fire B and open forest being excluded in the top model (Table 4). Considering all models with a Δ AIC of less than 10, model coefficients were relatively stable (i.e., same direction and magnitude). The model coefficient for mixed forest had a large standard error relative to the other variables. A model with this variable excluded (i.e., Model 20) had a low Δ AIC of 2.6 and this model performed similarly to the top model in the validation steps and, thus Model 20 was retained as the final selected model (Table 4). The coefficients for this model suggested an avoidance of anthropogenic disturbance, deciduous forest, and fire disturbance, as well as open water and a positive selection for coniferous forest and both wetland categories (wetland and peatland; Figure 3).

Caribou locations were generally found within high suitability calving habitat as suggested by the spatial predictions of the top model (Figure 4). This was confirmed using the five-fold cross-validation and with the historical data validation (Figure 5). The Boyce Index for each of the folds in the cross validation ranged from 0.93 to 0.96 with a mean of 0.95. The results were similar for the historical validation which also had a mean Boyce Index of 0.95 (Figure 5). RSF values were categorized into unsuitable (<0.37), marginal (≥ 0.37 and < 0.44), suitable (>0.53 and <0.60) and optimal (> 0.60) based on the percentile values of used locations. The threshold for maximizing sensitivity and specificity was 0.52 and very similar to the value separating suitable and optimal habitat from unsuitable and marginal.

Summary and Discussion

Generally, female caribou demonstrated a preference to be closer to coniferous forest and wetlands and an avoidance of open water and deciduous forest, and anthropogenic and fire disturbance. Validation of the predicted suitability map generally demonstrated that the radio-telemetry locations and historical caribou locations were found in areas predicted to have higher suitability. Although the model was predicted across three caribou ranges, higher confidence should be placed in the area surrounding the telemetry data (12.6 km buffer) which was used to build the model.



Minnow Environmental Inc.

Jeff Row, Ph.D.

Senior Biostatistician

References

- Boulanger, J., K.G. Poole, A. Gunn and J. Wierchowski. 2012. Estimating the zone of influence of industrial developments on wildlife: A migratory caribou *Rangifer tarandus groenlandicus* and diamond mine case study. *Wild. Biol.* 18(2): 164-179.
- Boyce, M.S., P.R. Vernier, S.E. Nielsen and F.K.A. Schmiegelow. 2002. Evaluating resource selection functions. *Ecol. Mod.* 157(2-3): 281-300.
- Compton, B.W., J.M. Rhymer and M. McCollough. 2002. Habitat selection by wood turtles (*Clemmys insculpta*): An application of paired logistic regression. *Ecol.* 83(3): 833-843.
- ECCC (Environment and Climate Change Canada). 2018. Anthropogenic disturbance footprint within boreal caribou ranges across Canada—As interpreted from 2015 Landsat satellite imagery [online]. Available from [https://data-donnees.az.ec.gc.ca/data/species/developplans/anthropogenic-disturbance-footprint-within-boreal-caribou-ranges-across-canada-as-interpreted-from-2008-2010-Landsat-satellite-imagery-Updated-to-2012-range-boundaries\)/?lang=en](https://data-donnees.az.ec.gc.ca/data/species/developplans/anthropogenic-disturbance-footprint-within-boreal-caribou-ranges-across-canada-as-interpreted-from-2008-2010-Landsat-satellite-imagery-Updated-to-2012-range-boundaries)/?lang=en) [accessed 2022]
- Fedy, B.C., K.E. Doherty, C.L. Aldridge, M. O'Donnell, J.L. Beck, B. Bedrosian, D. Gummer, M.J. Holloran, G.D. Johnson, N.W. Kaczor, C.P. Kirol, C.A. Mandich, D. Marshall, G. McKee, C. Olson, A.C. Pratt, C.C. Swanson and B.L. Walker. 2014. Habitat prioritization across large landscapes, multiple seasons, and novel areas: An example using greater sage-grouse in Wyoming. *Wild. Mono.* 190: 1–39.
- Hirzel, A.H., G. Le Lay, V. Helfer, C. Randin and A. Guisan. 2006. Evaluating the ability of habitat suitability models to predict species presences. *Ecol. Mod.* 199(2): 142-152.
- Hosmer, D.W., S. Lemeshow and R.X. Sturdivant. 2000. *Applied Logistic Regression*. Wiley, New York, N.Y.
- Johnson, C.J. and D.E. Russell. 2014. Long-term distribution responses of a migratory caribou herd to human disturbance. *Biol. Cons.* 177: 52-63.
- Land Information Ontario. 2019. Ontario Land Cover Compilation v.2.0 [online]. Available from: <https://www.arcgis.com/home/item.html?id=7aa998fdf100434da27a41f1c637382c> [accessed May 2023].
- Land Information Ontario. 2022. Fire Disturbance Area [online]. Available from: <https://geohub.lio.gov.on.ca/datasets/lio::fire-disturbance-area/about> [May 2023].
- Manly, B.F.J., L.L. McDonald, D. Thomas, T.L. McDonald and W.P. Erickson. 2002. *Resource Selection by Animals: Statistical Design and Analysis for Field Studies*. Second Edition. Kluwer Academic, Boston, M.A.



- Nielsen S.E., D.L. Haughland, E. Bayne and J. Schieck. 2009. Capacity of large-scale, long-term biodiversity monitoring programmes to detect trends in species prevalence. *Biod. Cons.* 18: 2961–2978.
- Nielsen, S.E., J. Cranston and G.B. Stenhouse. 2009. Identification of priority areas for grizzly bear conservation and recovery in Alberta, Canada. *J. Cons. Plan.* 5(9): 38-60.
- Row, J. R. and G. Blouin-Demers. 2006. Thermal quality influences habitat selection at multiple spatial scales in milksnakes. *Ecosci.* 13(4): 443-450.



FIGURES

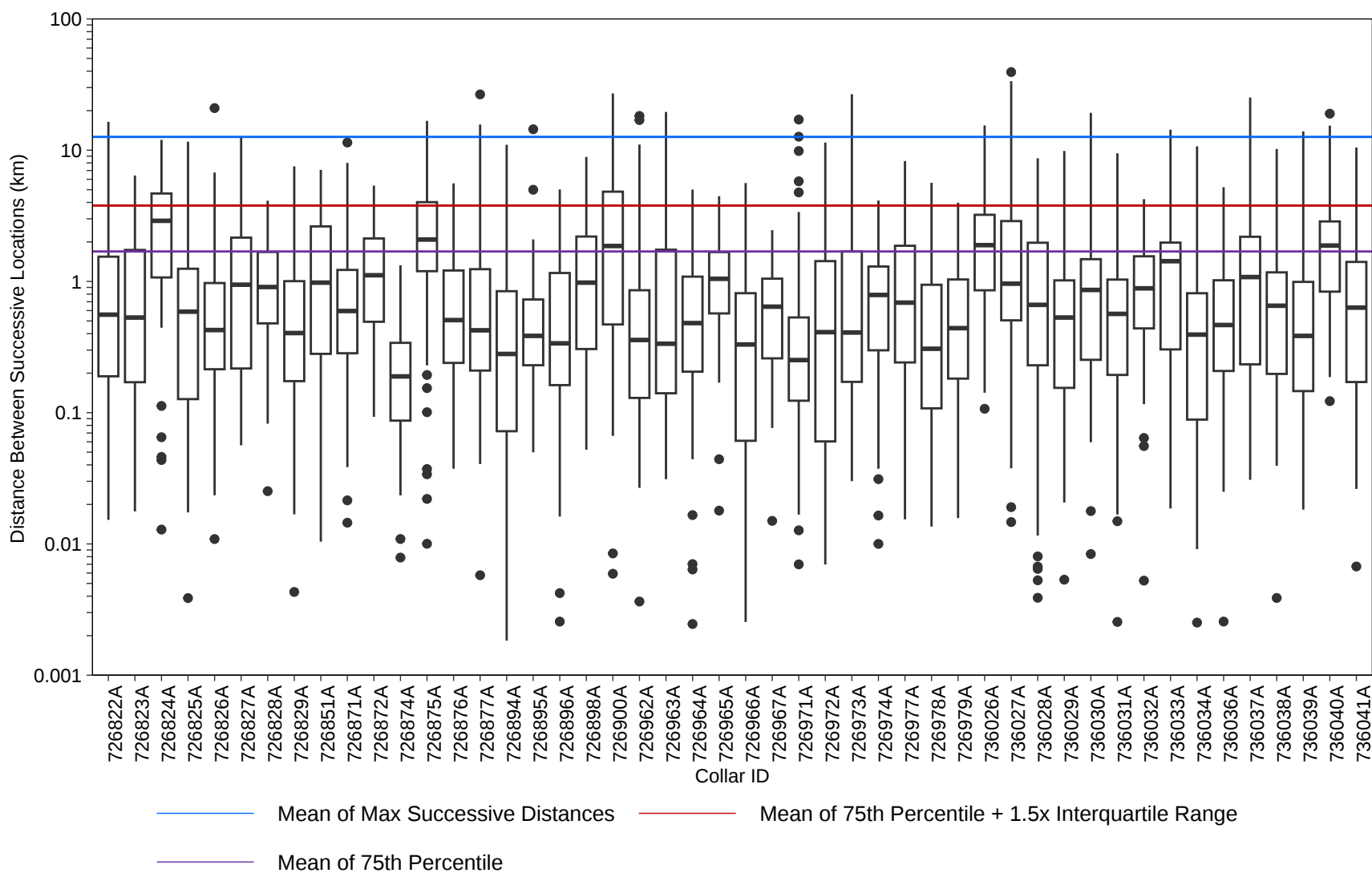


Figure 1: Successive Distances Travelled by Female Caribou in Churchill, Berens, and Kinloch Caribou Ranges, 2023

Notes: Summary statistics were calculated using the entire dataset after filtering out suspected mortalities (individuals with fewer than 30 days worth of movement data recorded).

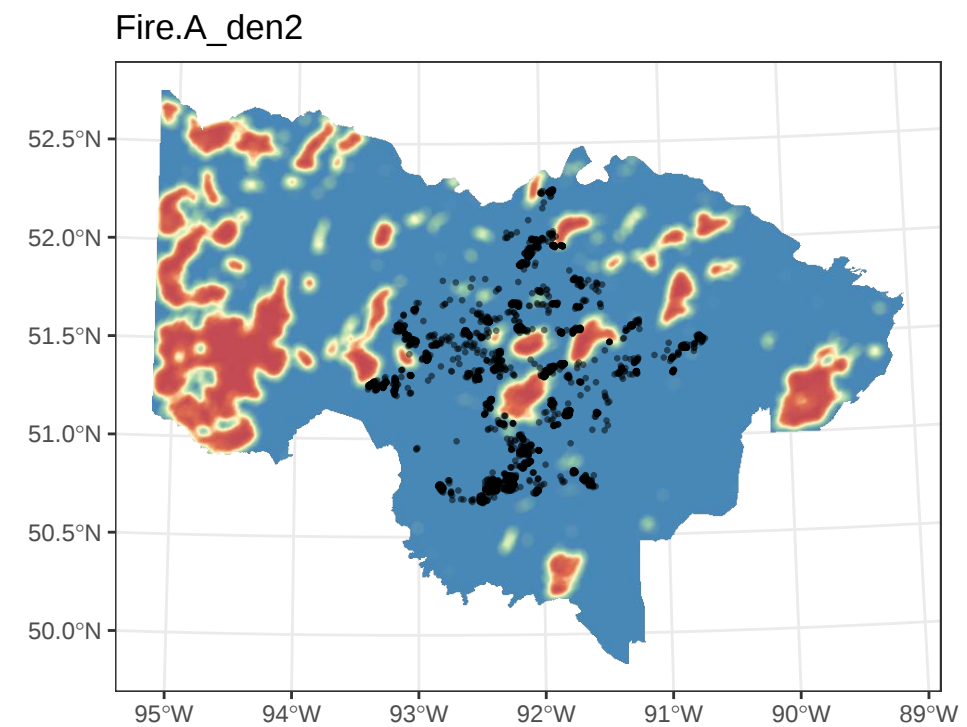
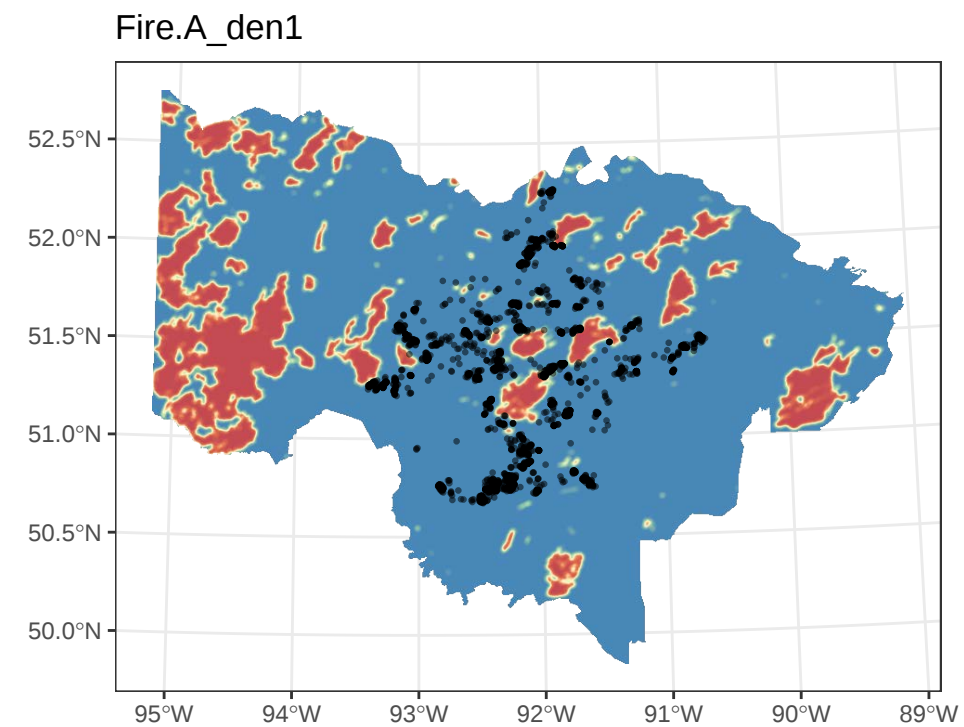
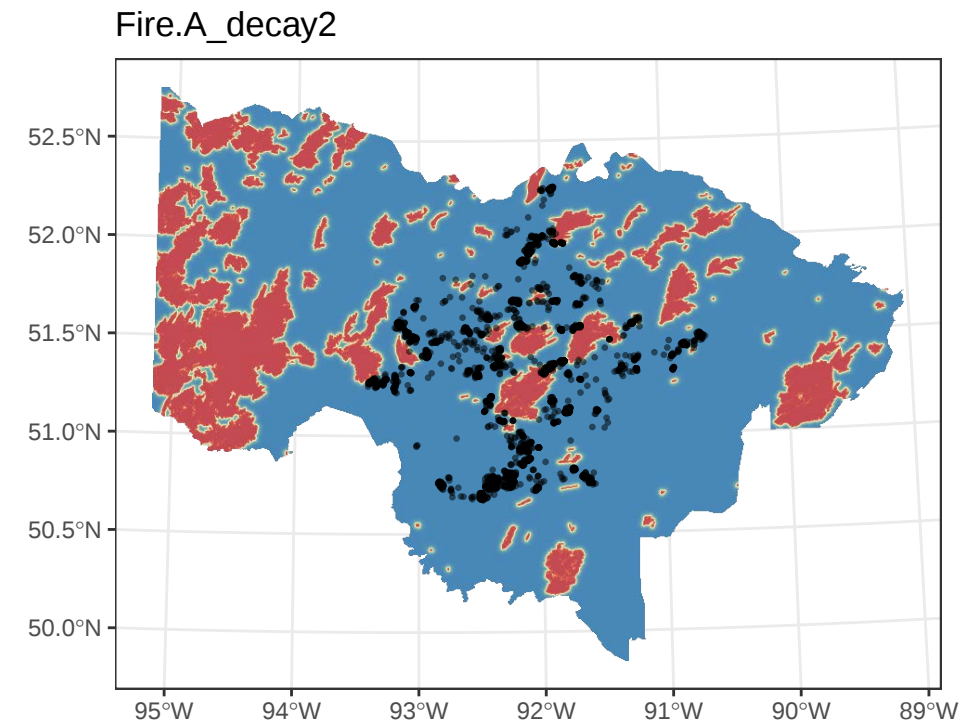
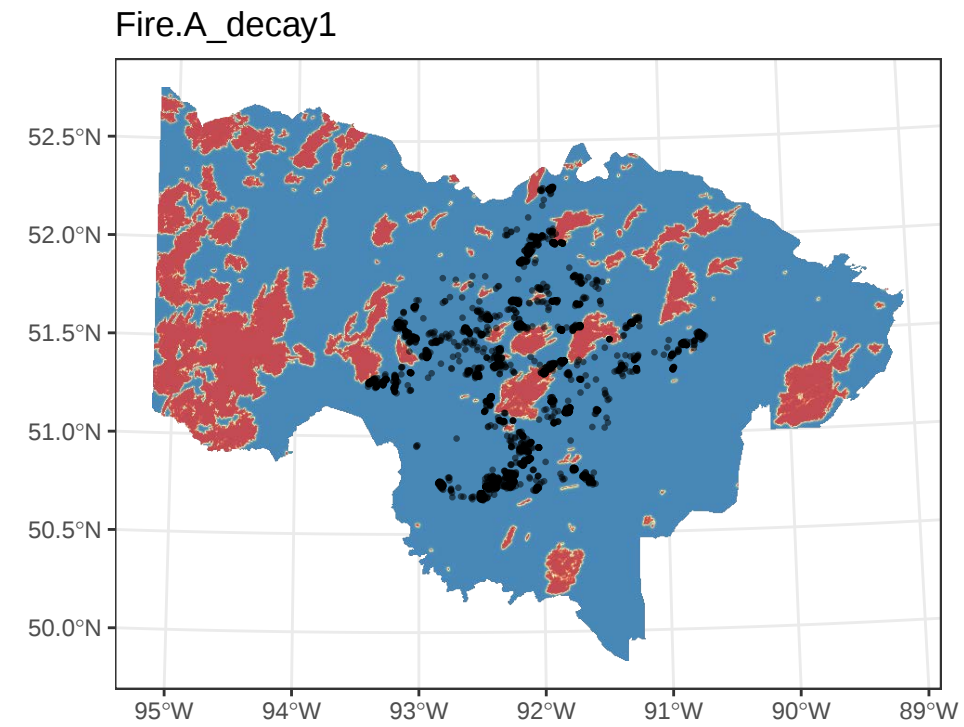


Figure 2: Spatial Distribution of Covariates Used to Model Caribou Calving Habitat Across the Churchill, Berens, and Kinloch Caribou Ranges, 2023

Notes: See Table 2 for description of landscapes variables. Black points represent caribou locations. Landscape variables were summarized with moving windows and decay functions at two spatial scales (1.69 km: den_1 and decay_1; 3.77 km: den_2 and decay_2). See methods for details on the derivation of covariates.

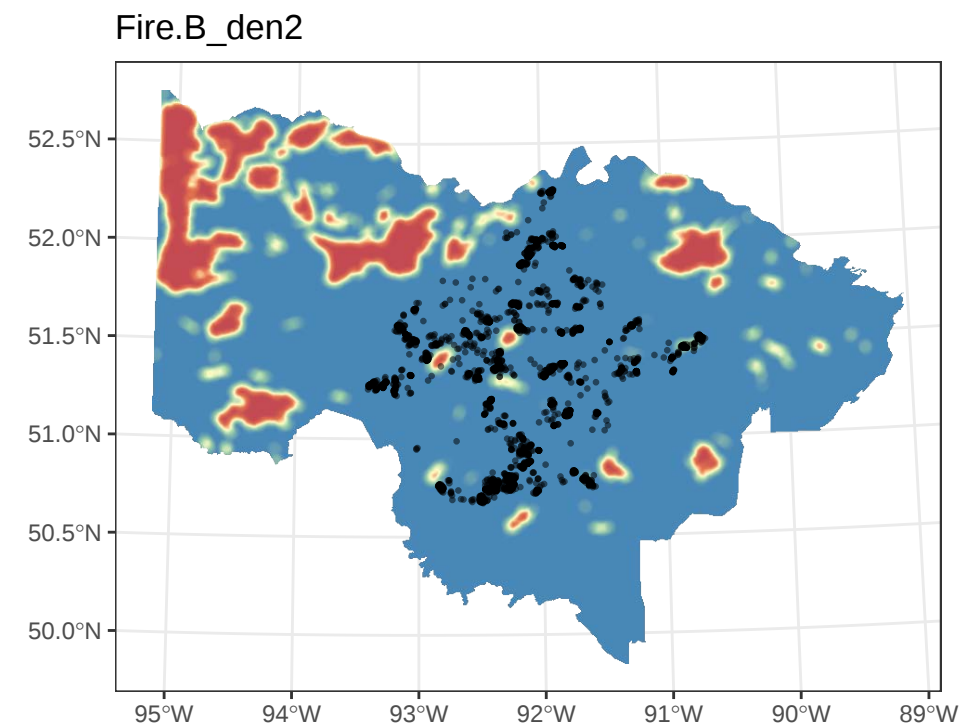
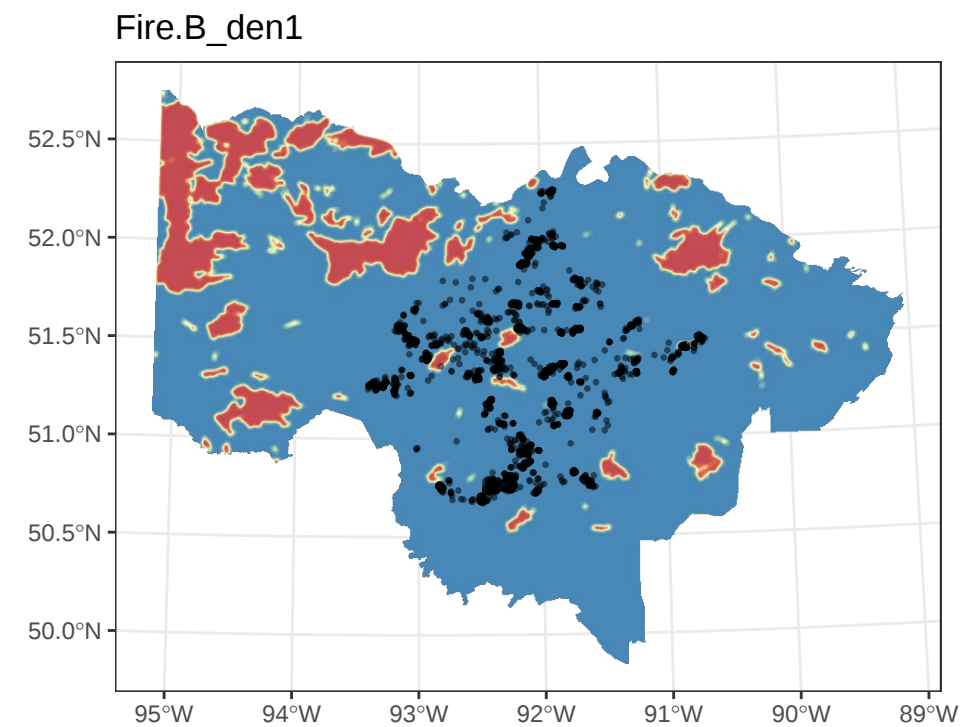
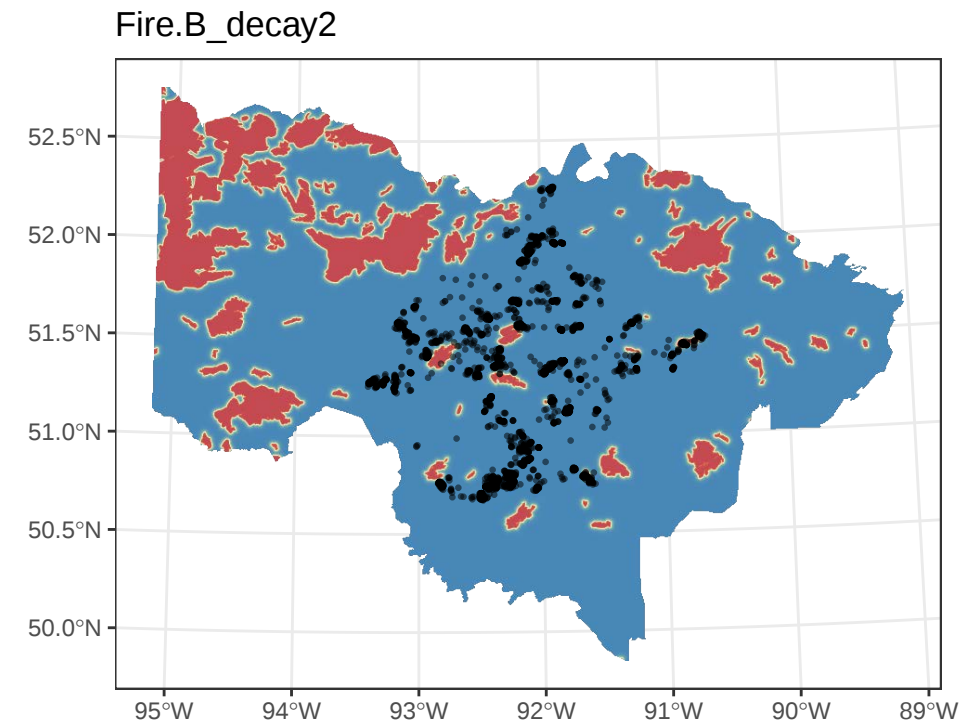
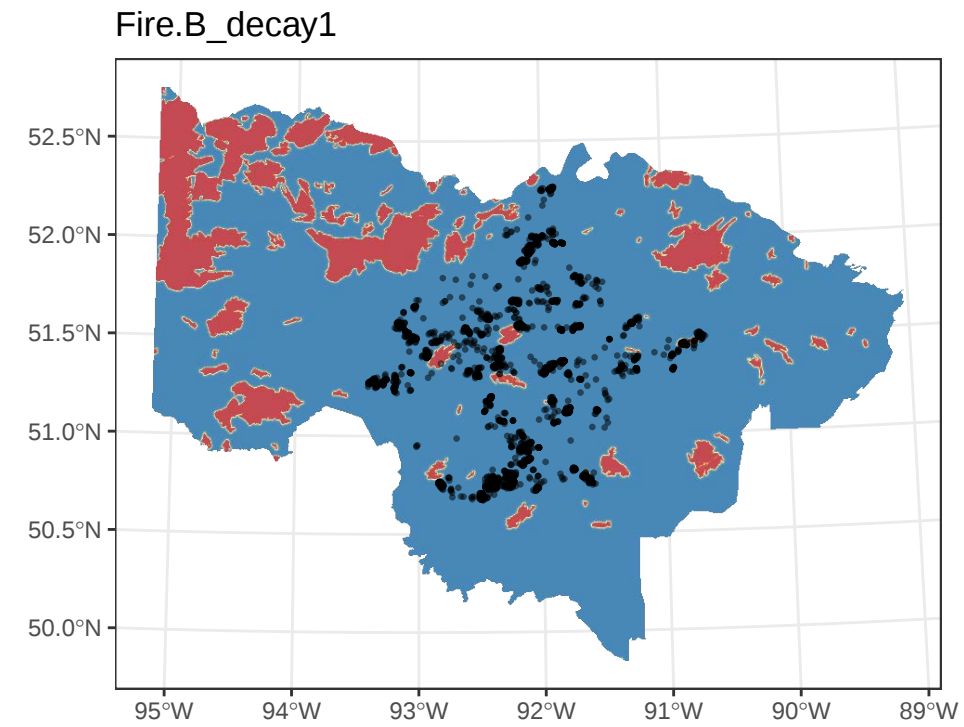


Figure 2: Spatial Distribution of Covariates Used to Model Caribou Calving Habitat Across the Churchill, Berens, and Kinloch Caribou Ranges, 2023

Notes: See Table 2 for description of landscapes variables. Black points represent caribou locations. Landscape variables were summarized with moving windows and decay functions at two spatial scales (1.69 km: den_1 and decay_1; 3.77 km: den_2 and decay_2). See methods for details on the derivation of covariates.

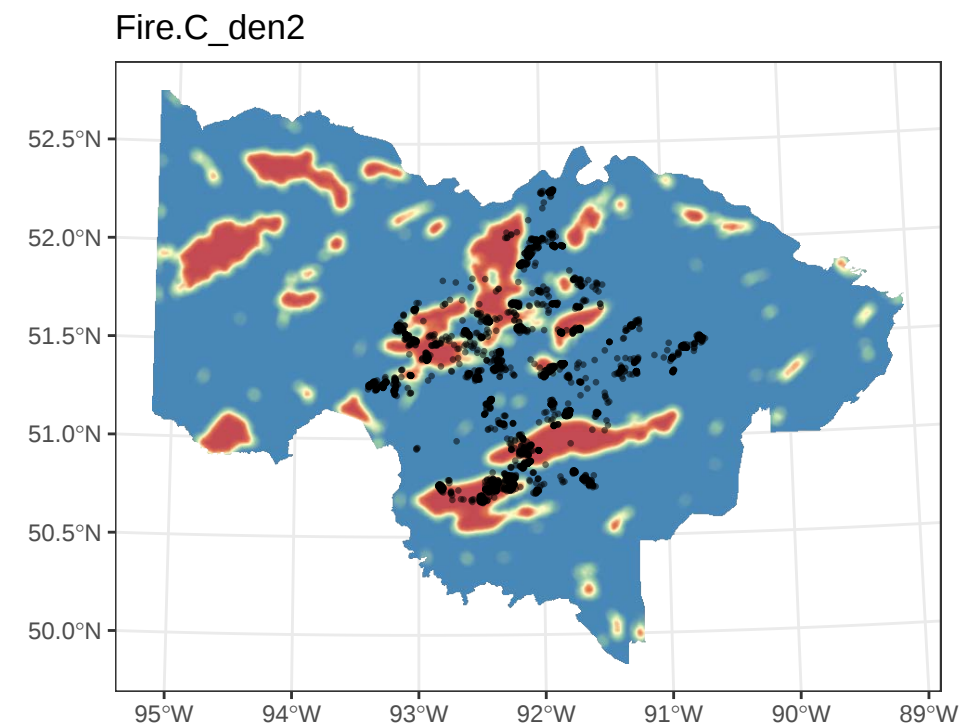
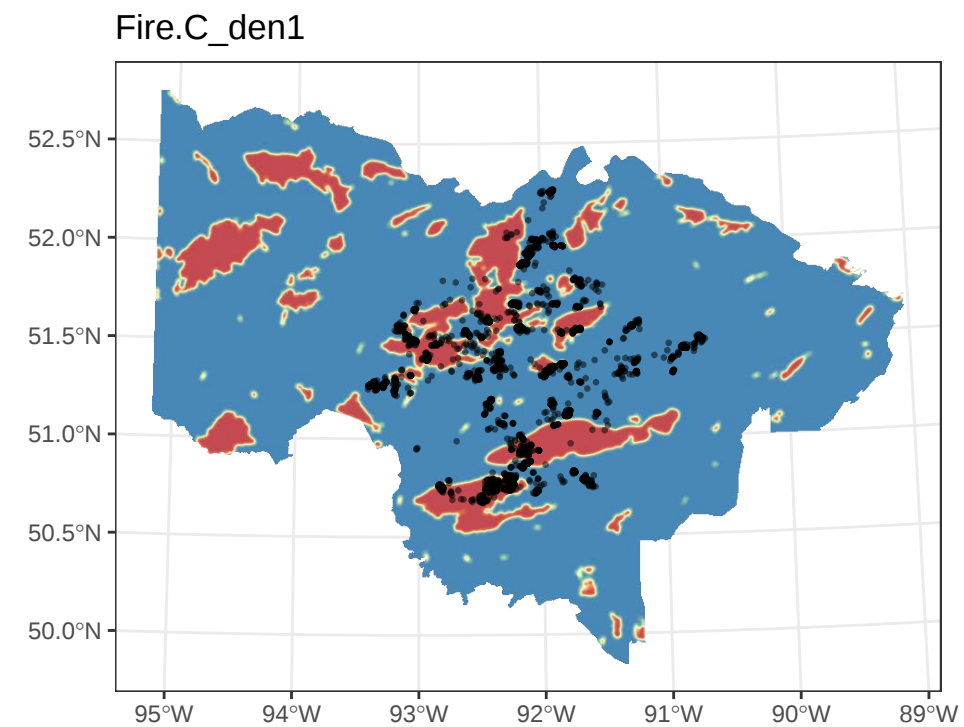
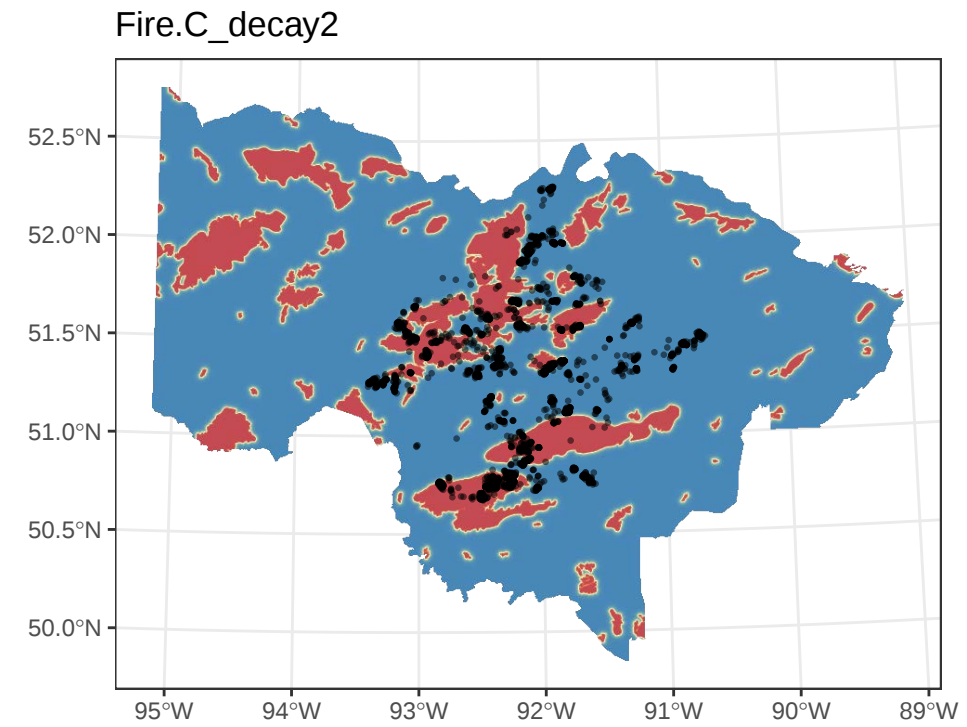
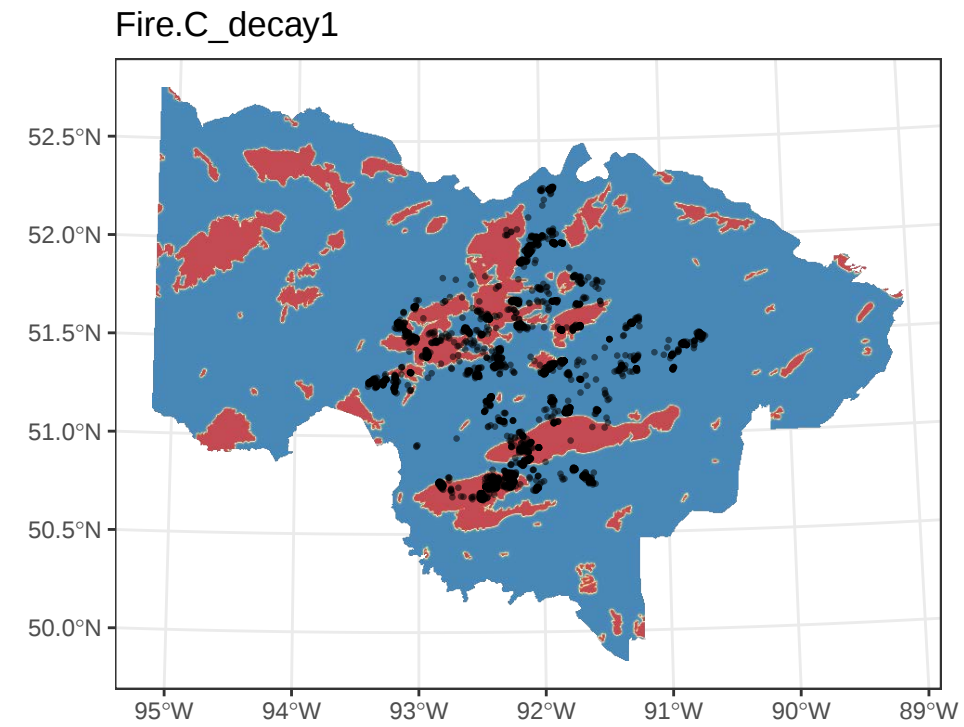


Figure 2: Spatial Distribution of Covariates Used to Model Caribou Calving Habitat Across the Churchill, Berens, and Kinloch Caribou Ranges, 2023

Notes: See Table 2 for description of landscapes variables. Black points represent caribou locations. Landscape variables were summarized with moving windows and decay functions at two spatial scales (1.69 km: den_1 and decay_1; 3.77 km: den_2 and decay_2). See methods for details on the derivation of covariates.

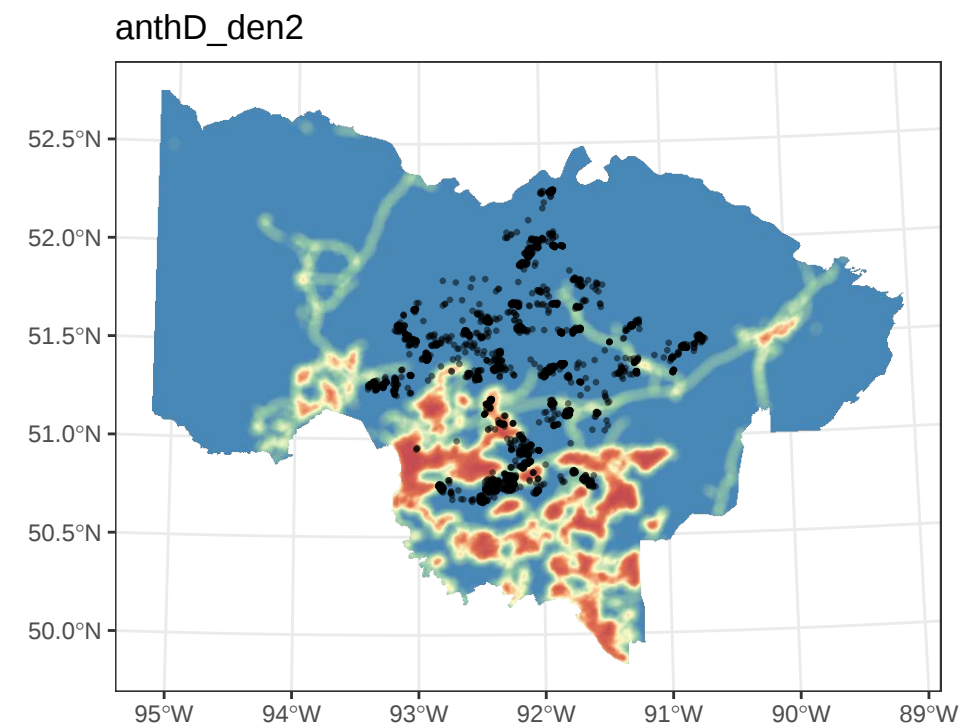
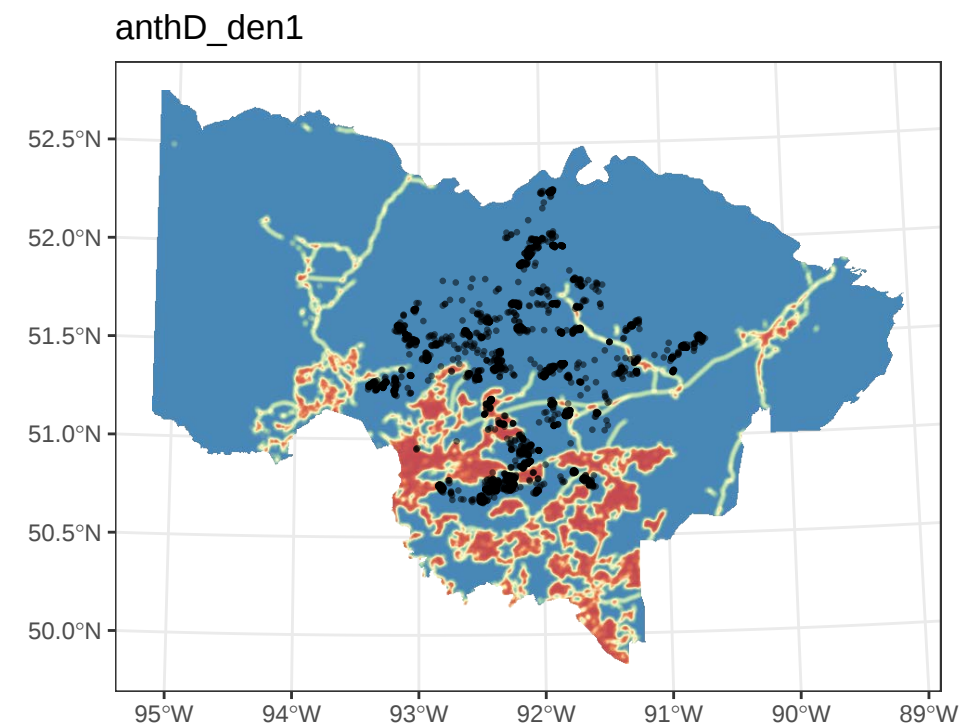
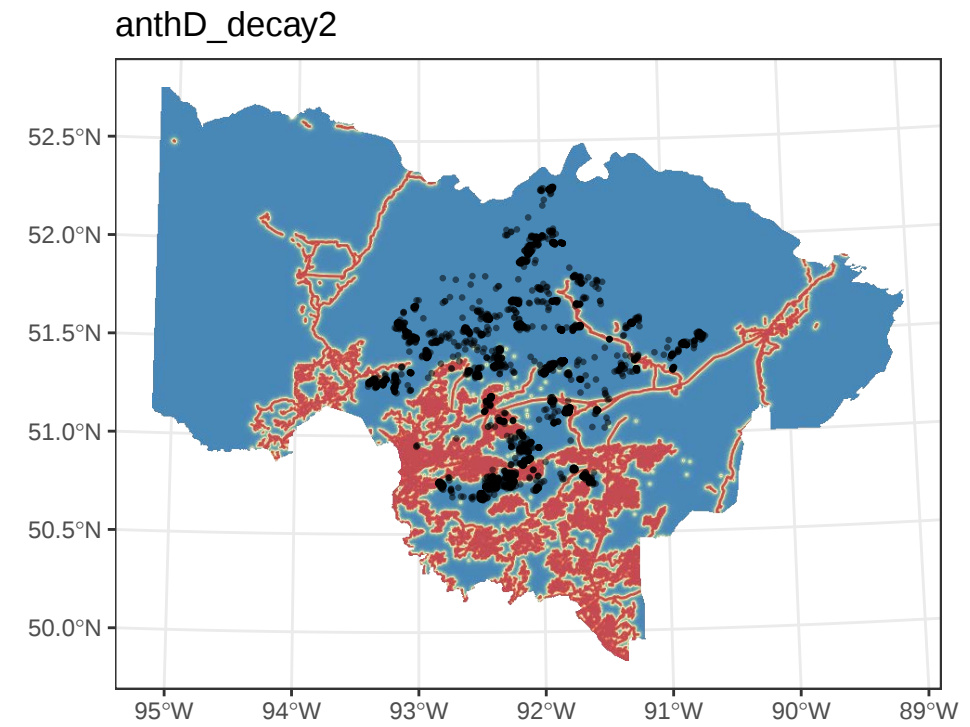
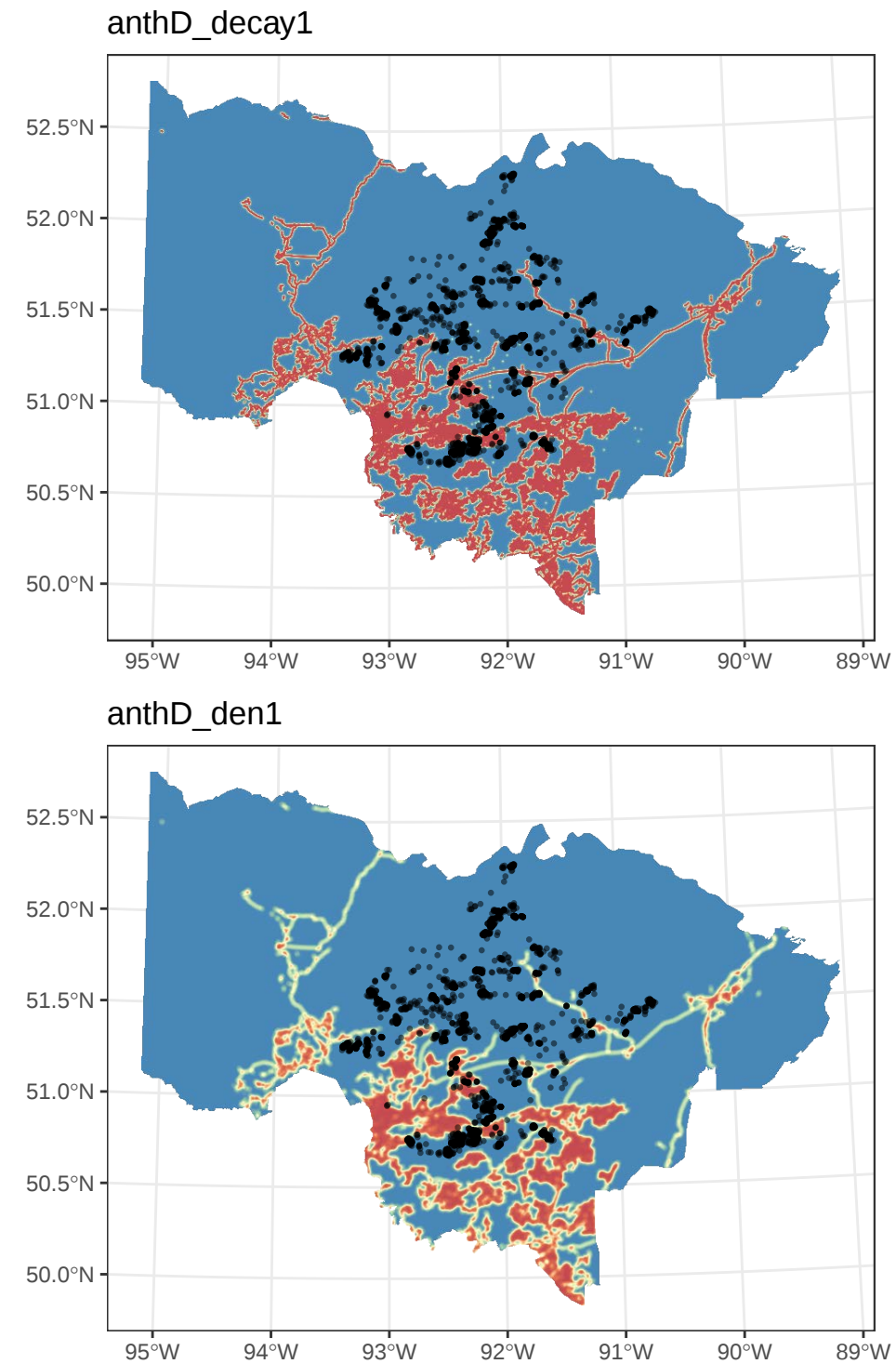


Figure 2: Spatial Distribution of Covariates Used to Model Caribou Calving Habitat Across the Churchill, Berens, and Kinloch Caribou Ranges, 2023

Notes: See Table 2 for description of landscapes variables. Black points represent caribou locations. Landscape variables were summarized with moving windows and decay functions at two spatial scales (1.69 km: den_1 and decay_1; 3.77 km: den_2 and decay_2). See methods for details on the derivation of covariates.

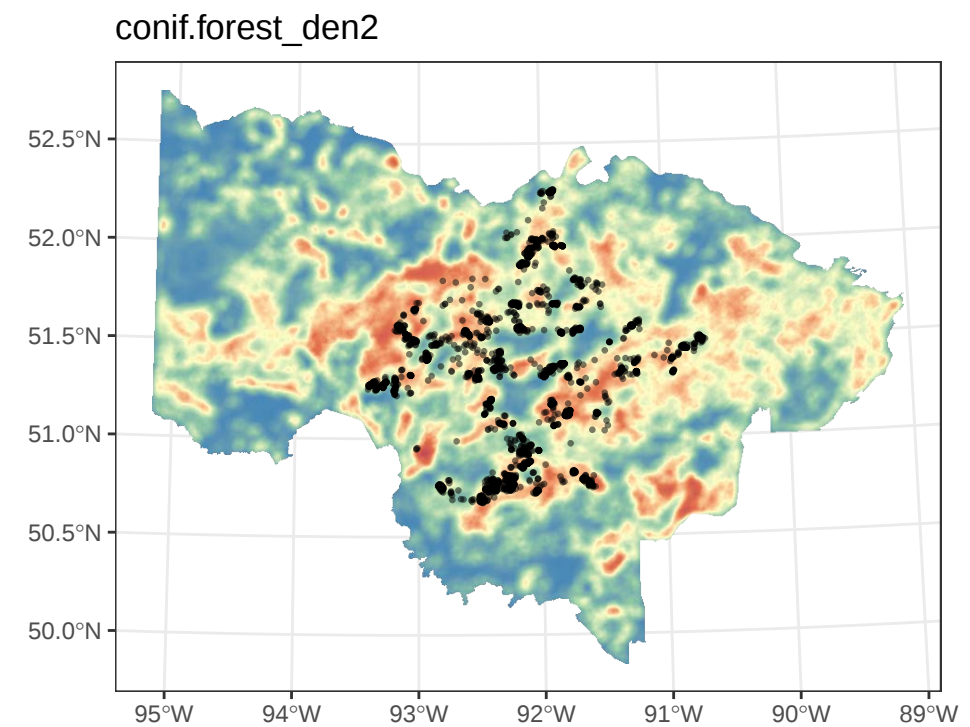
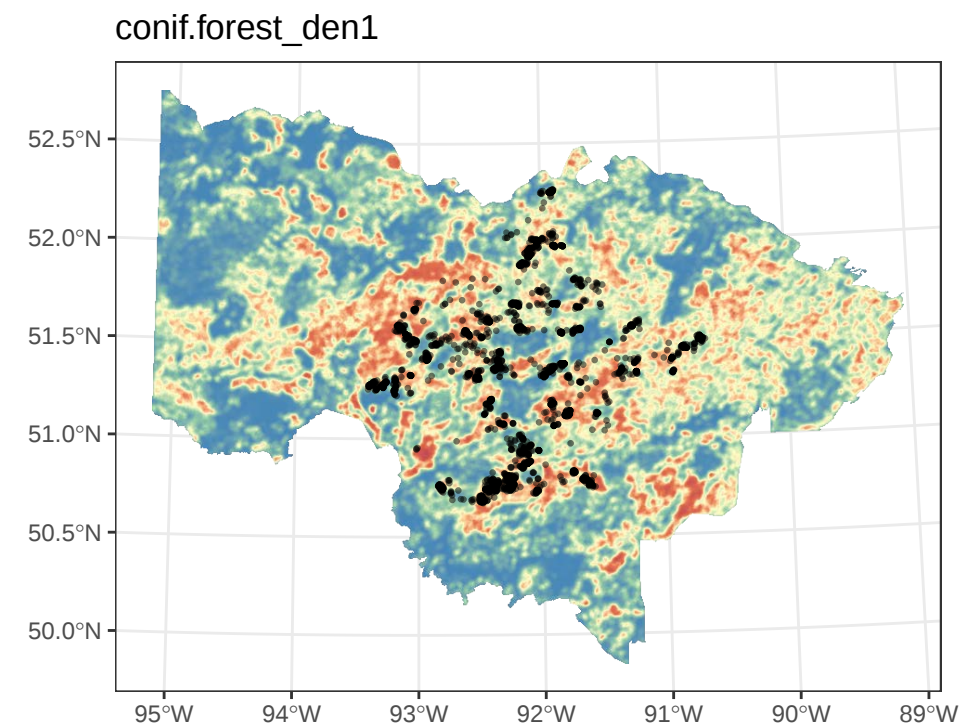
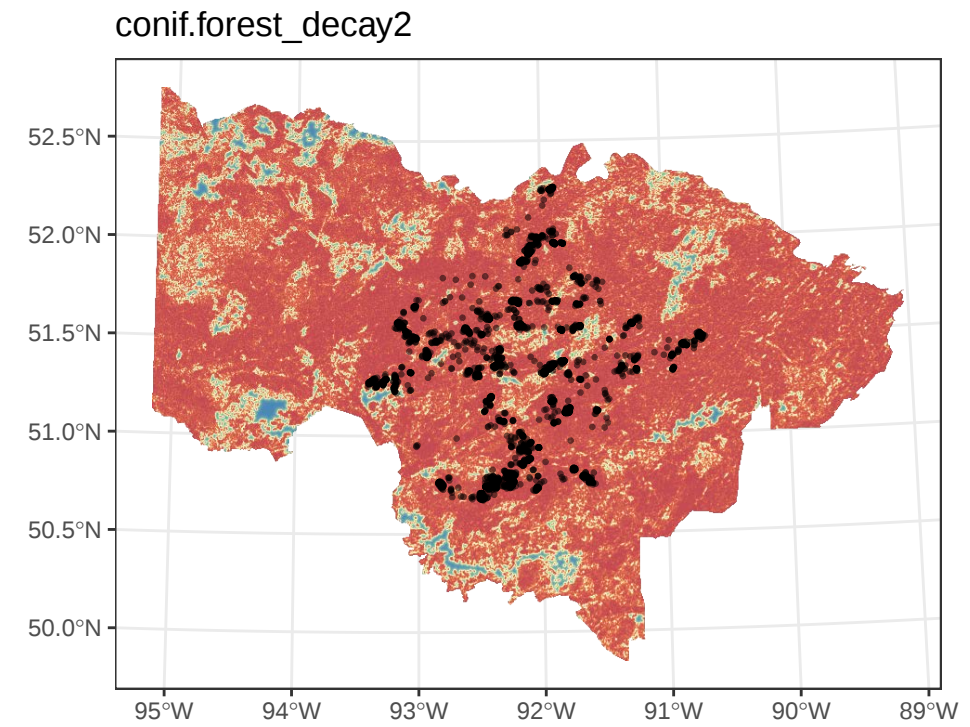
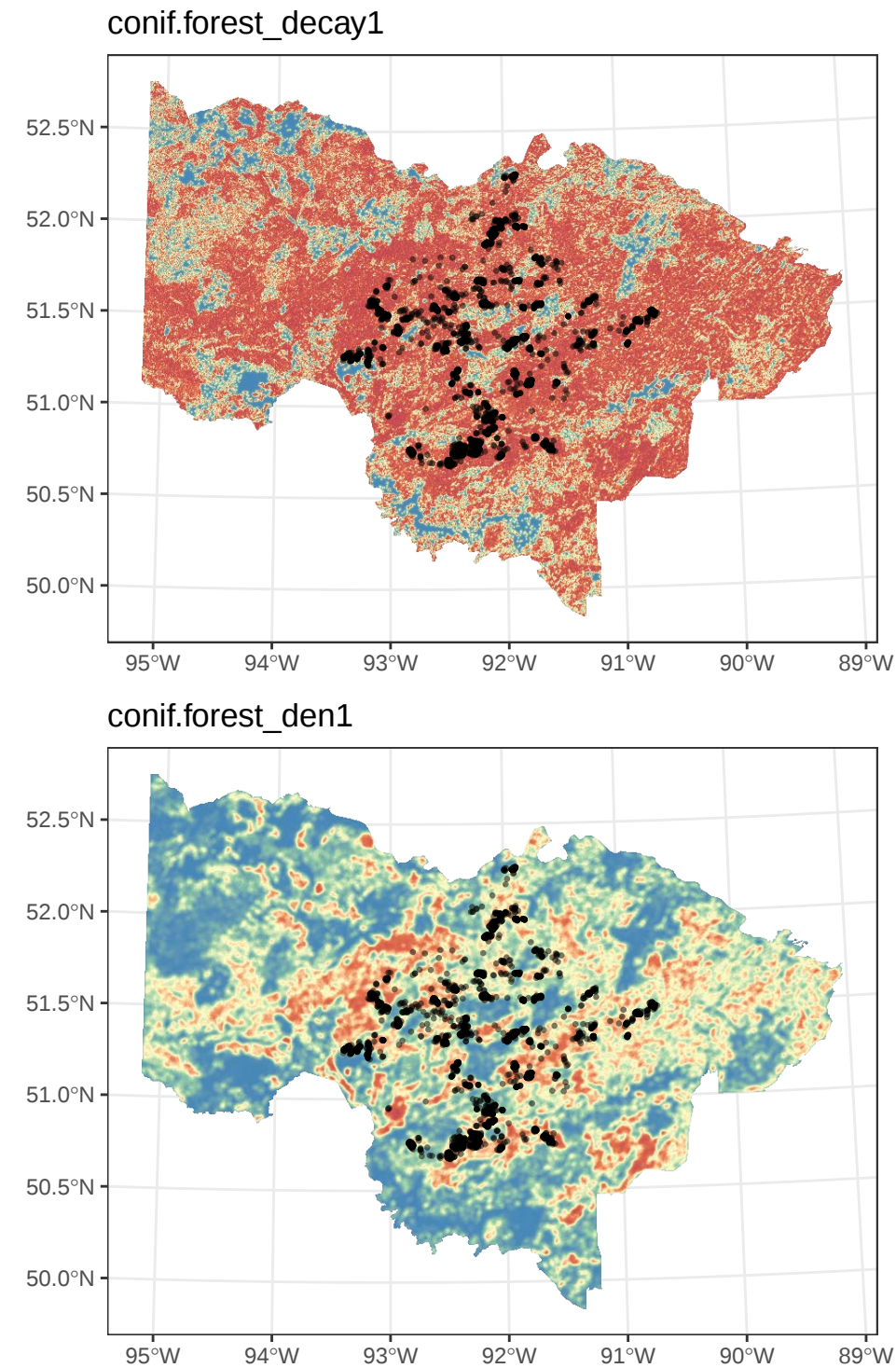


Figure 2: Spatial Distribution of Covariates Used to Model Caribou Calving Habitat Across the Churchill, Berens, and Kinloch Caribou Ranges, 2023

Notes: See Table 2 for description of landscapes variables. Black points represent caribou locations. Landscape variables were summarized with moving windows and decay functions at two spatial scales (1.69 km: den_1 and decay_1; 3.77 km: den_2 and decay_2). See methods for details on the derivation of covariates.

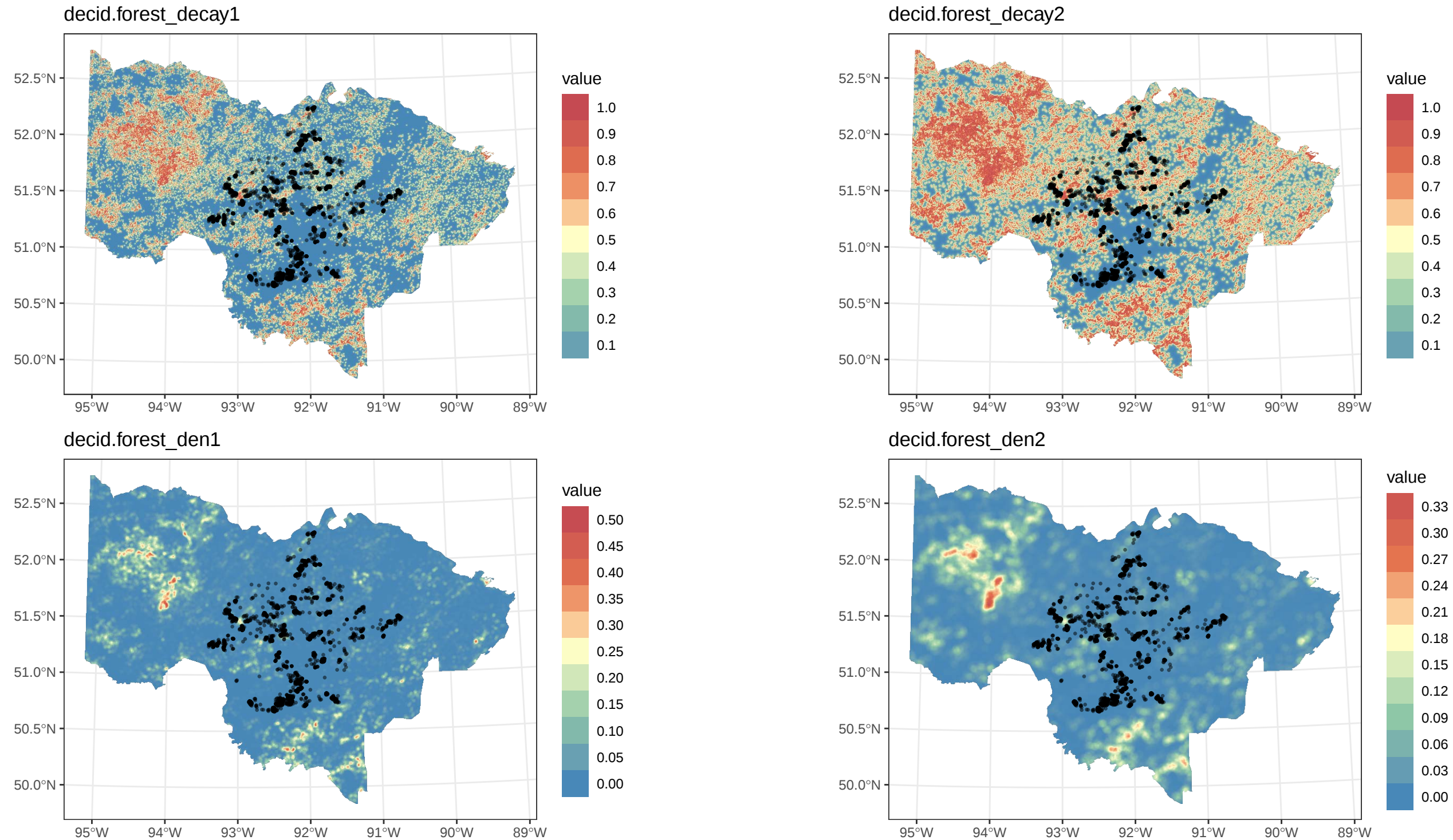


Figure 2: Spatial Distribution of Covariates Used to Model Caribou Calving Habitat Across the Churchill, Berens, and Kinloch Caribou Ranges, 2023

Notes: See Table 2 for description of landscapes variables. Black points represent caribou locations. Landscape variables were summarized with moving windows and decay functions at two spatial scales (1.69 km: den_1 and decay_1; 3.77 km: den_2 and decay_2). See methods for details on the derivation of covariates.

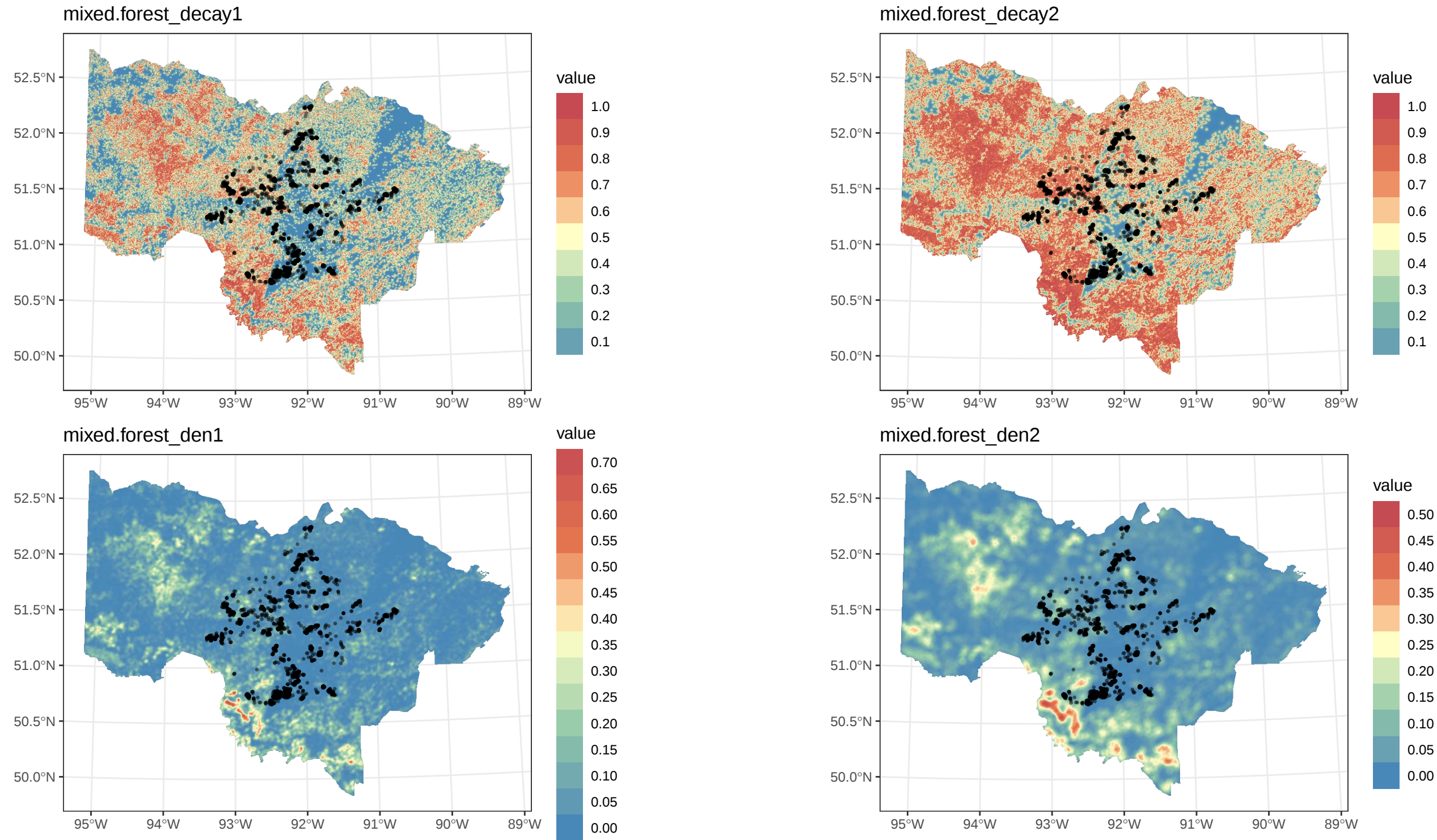


Figure 2: Spatial Distribution of Covariates Used to Model Caribou Calving Habitat Across the Churchill, Berens, and Kinloch Caribou Ranges, 2023

Notes: See Table 2 for description of landscapes variables. Black points represent caribou locations. Landscape variables were summarized with moving windows and decay functions at two spatial scales (1.69 km: den_1 and decay_1; 3.77 km: den_2 and decay_2). See methods for details on the derivation of covariates.

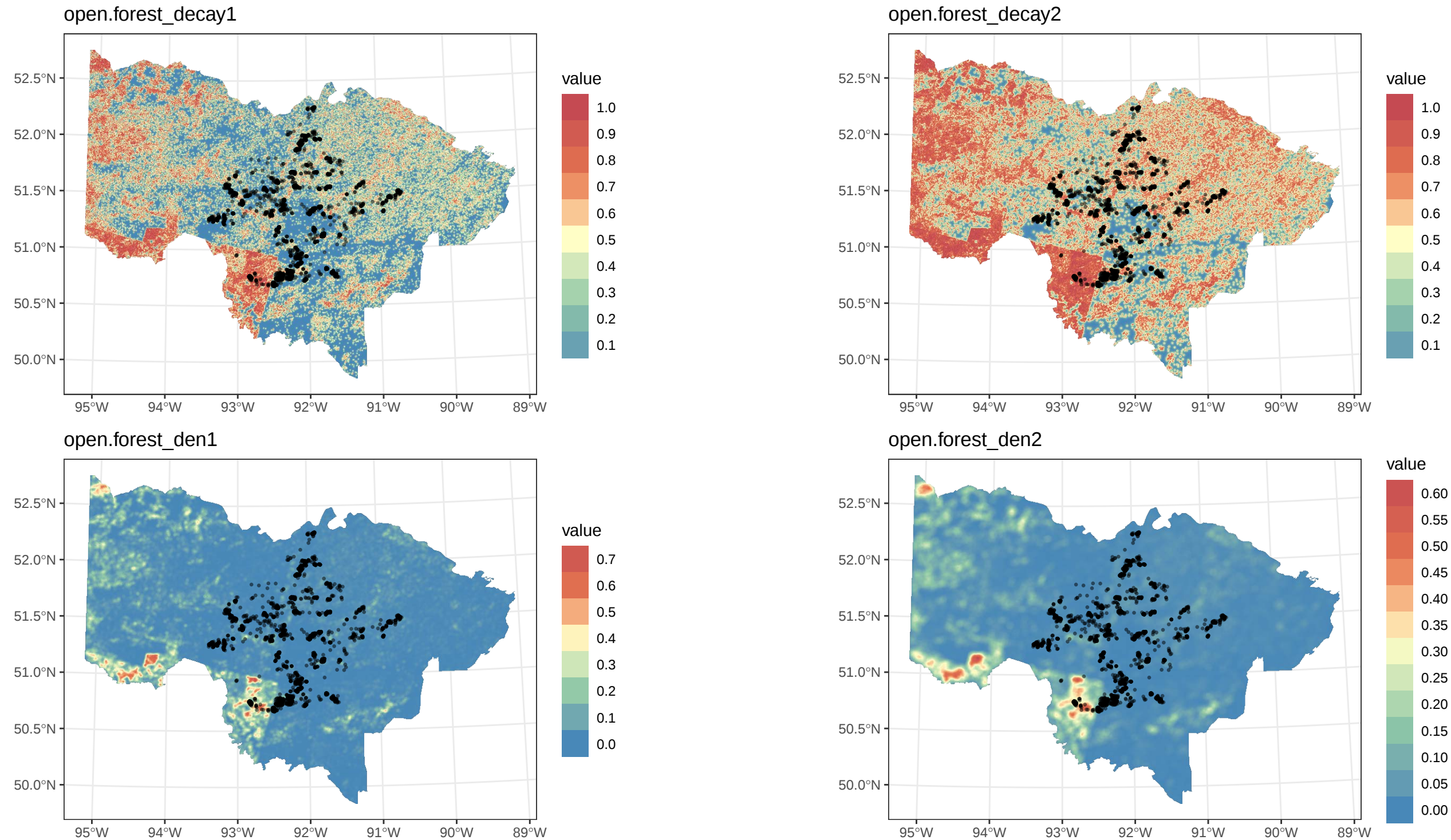


Figure 2: Spatial Distribution of Covariates Used to Model Caribou Calving Habitat Across the Churchill, Berens, and Kinloch Caribou Ranges, 2023

Notes: See Table 2 for description of landscapes variables. Black points represent caribou locations. Landscape variables were summarized with moving windows and decay functions at two spatial scales (1.69 km: den_1 and decay_1; 3.77 km: den_2 and decay_2). See methods for details on the derivation of covariates.

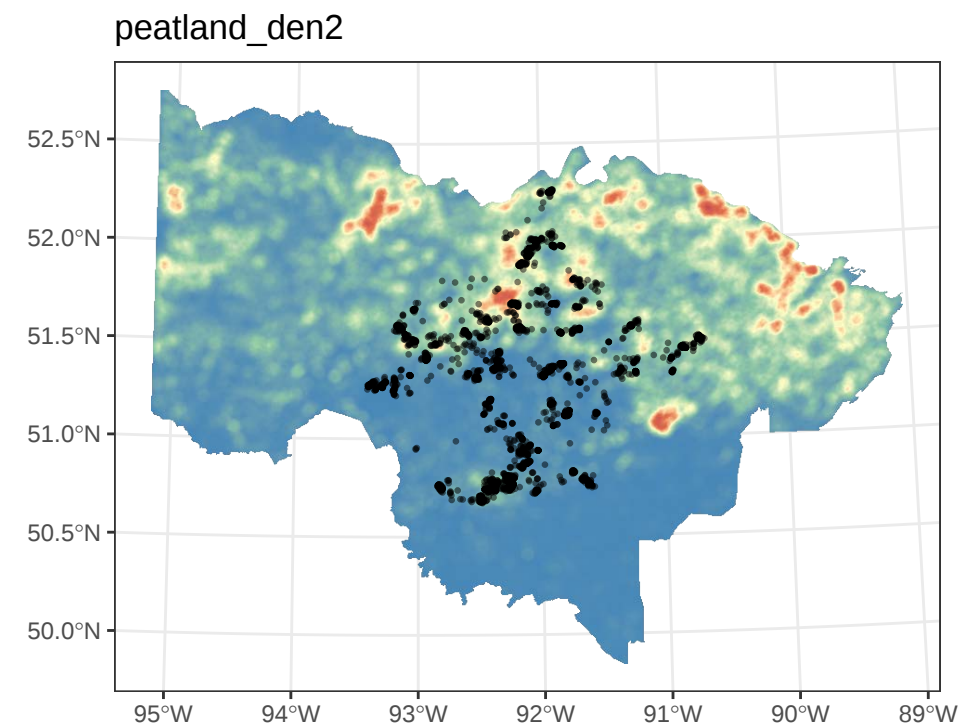
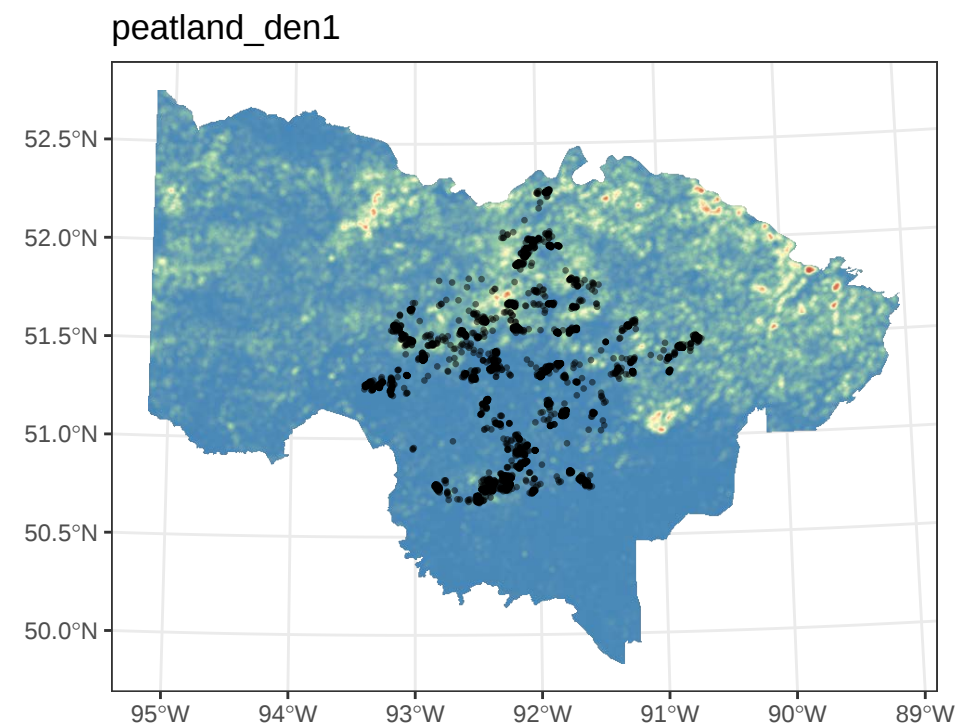
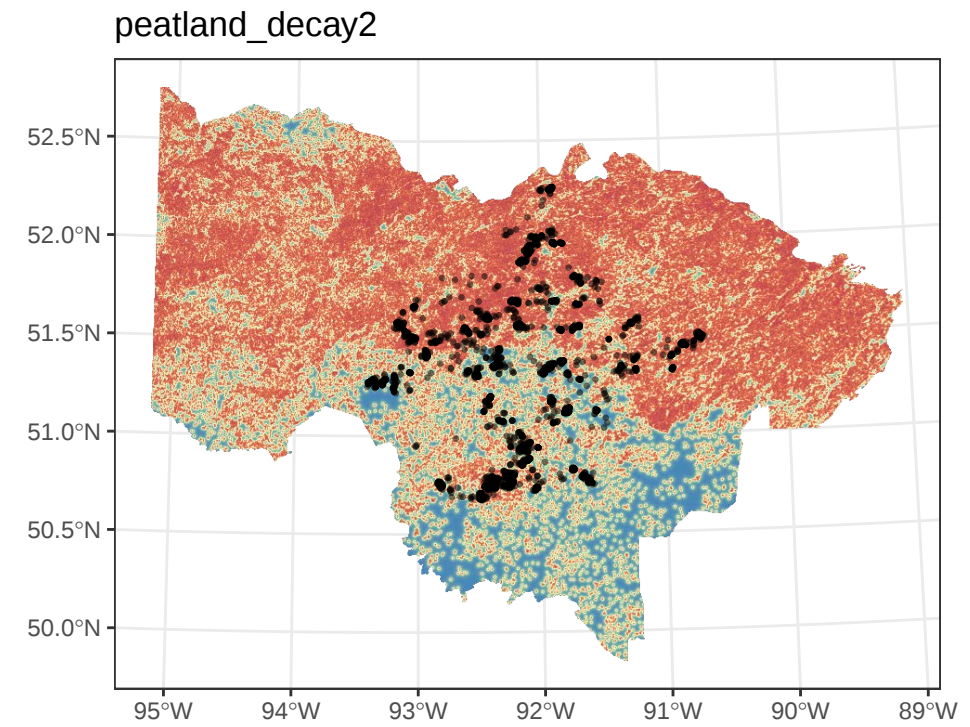
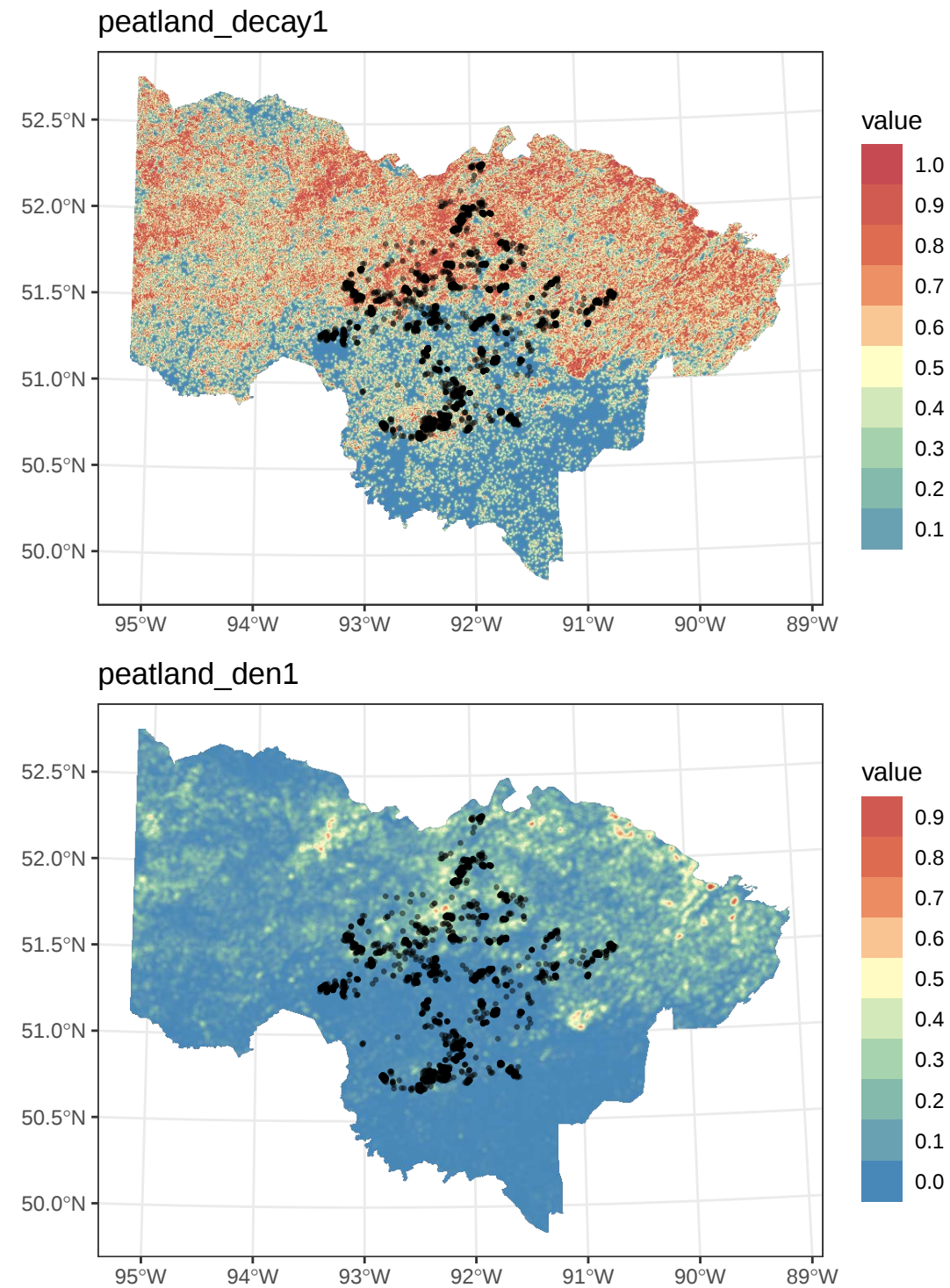


Figure 2: Spatial Distribution of Covariates Used to Model Caribou Calving Habitat Across the Churchill, Berens, and Kinloch Caribou Ranges, 2023

Notes: See Table 2 for description of landscapes variables. Black points represent caribou locations. Landscape variables were summarized with moving windows and decay functions at two spatial scales (1.69 km: den_1 and decay_1; 3.77 km: den_2 and decay_2). See methods for details on the derivation of covariates.

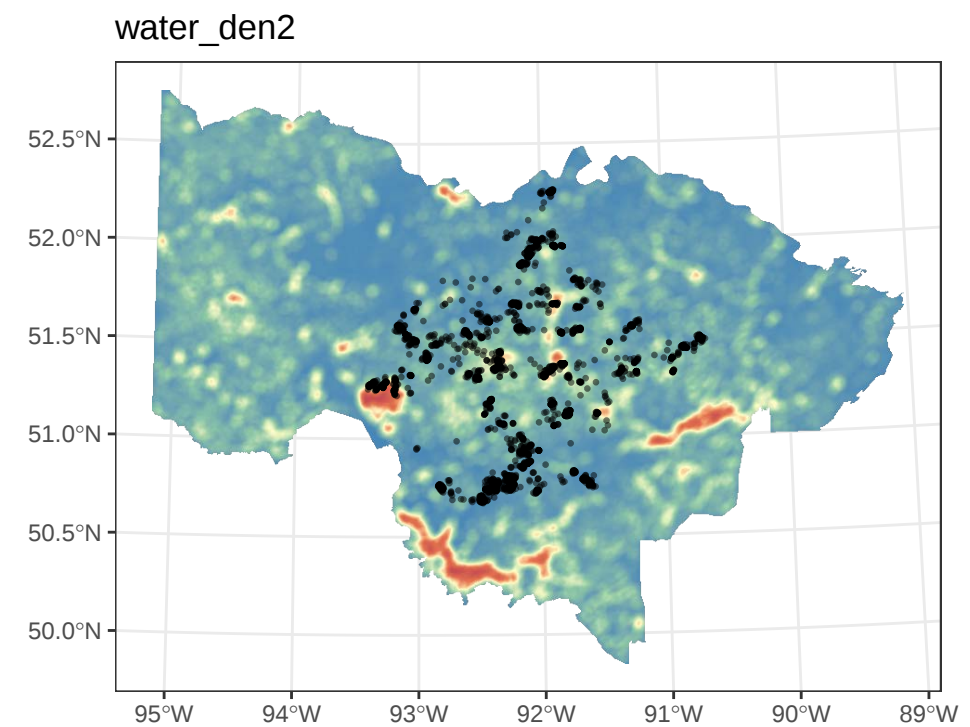
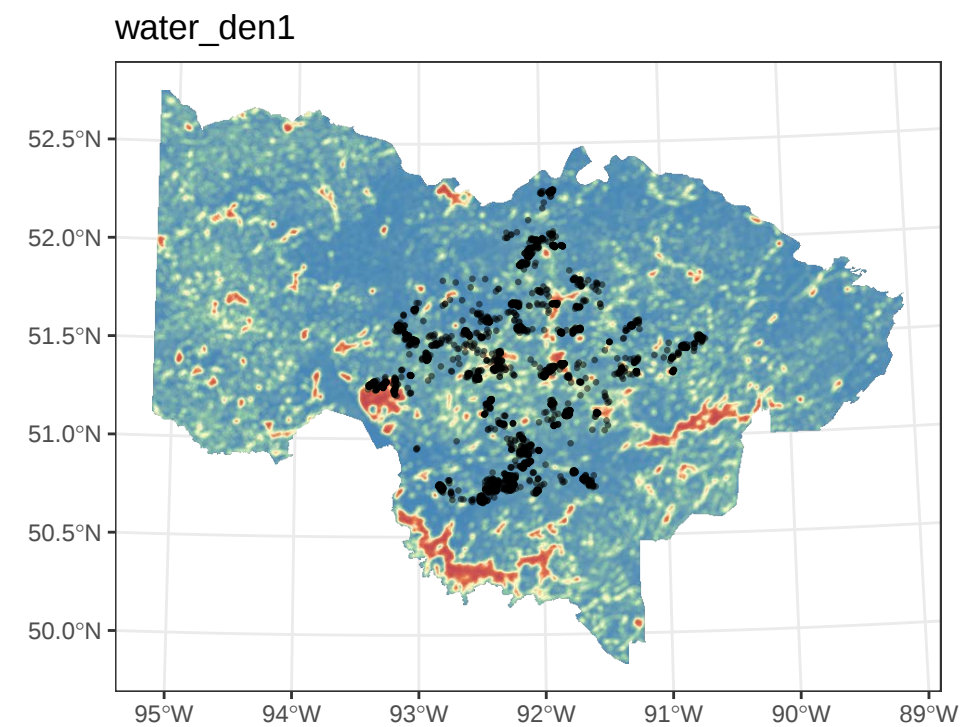
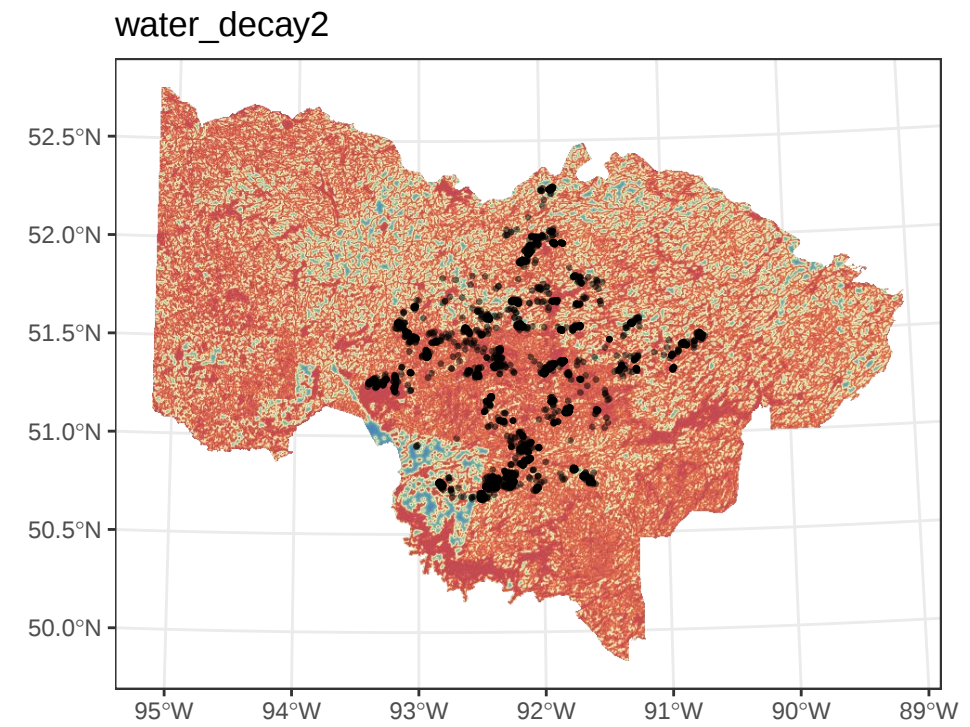
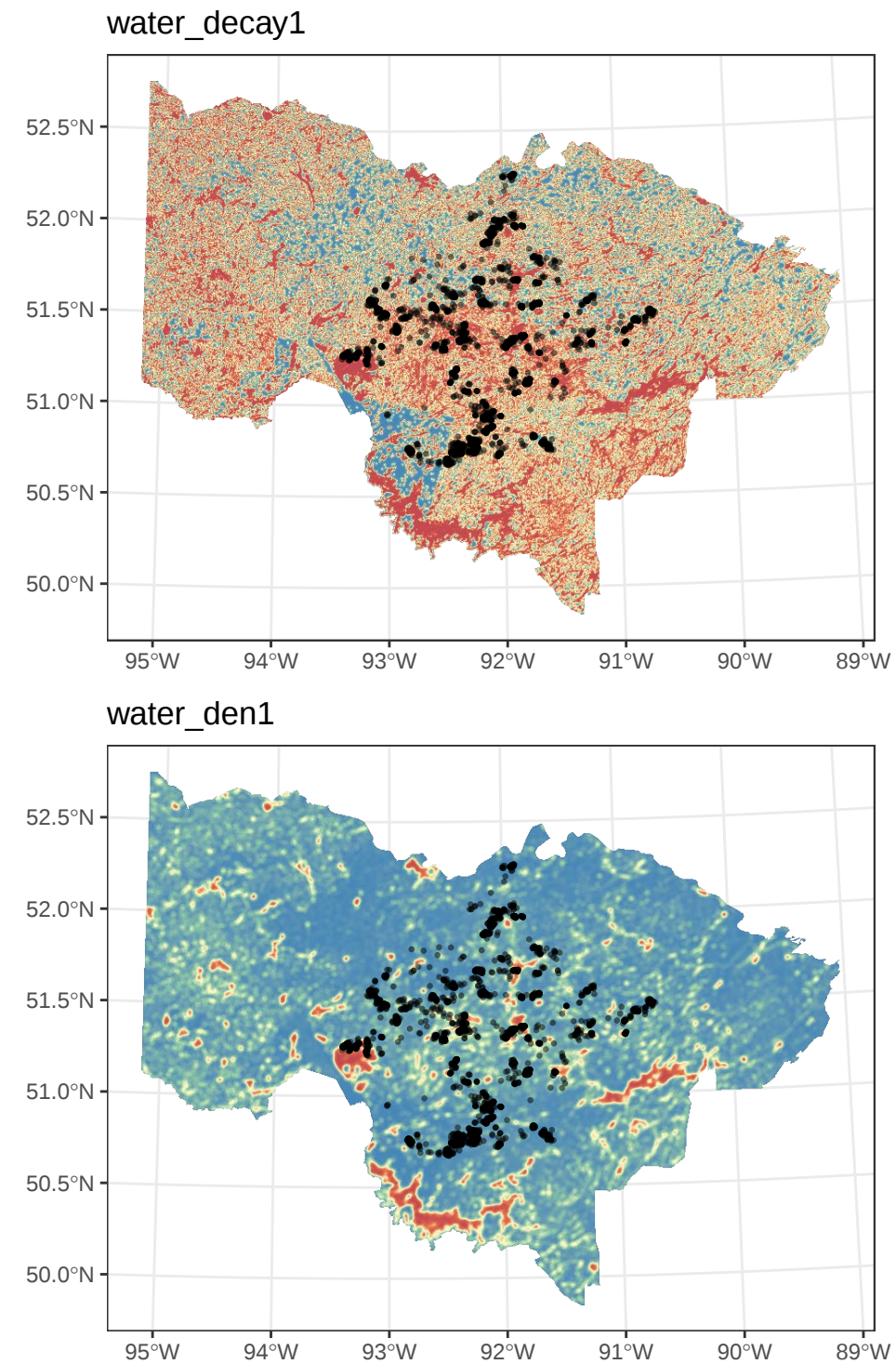


Figure 2: Spatial Distribution of Covariates Used to Model Caribou Calving Habitat Across the Churchill, Berens, and Kinloch Caribou Ranges, 2023

Notes: See Table 2 for description of landscapes variables. Black points represent caribou locations. Landscape variables were summarized with moving windows and decay functions at two spatial scales (1.69 km: den_1 and decay_1; 3.77 km: den_2 and decay_2). See methods for details on the derivation of covariates.

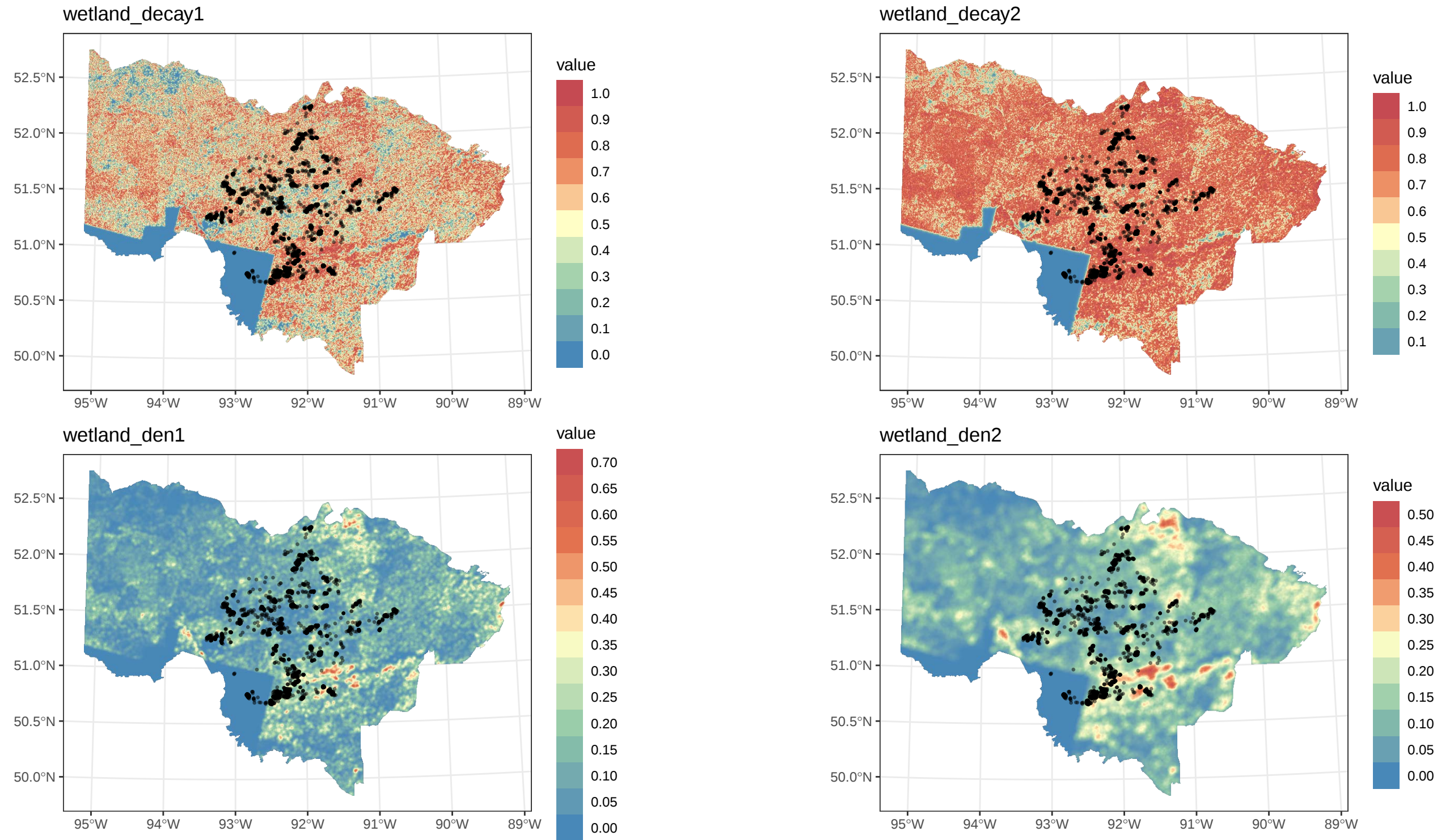


Figure 2: Spatial Distribution of Covariates Used to Model Caribou Calving Habitat Across the Churchill, Berens, and Kinloch Caribou Ranges, 2023

Notes: See Table 2 for description of landscapes variables. Black points represent caribou locations. Landscape variables were summarized with moving windows and decay functions at two spatial scales (1.69 km: den_1 and decay_1; 3.77 km: den_2 and decay_2). See methods for details on the derivation of covariates.

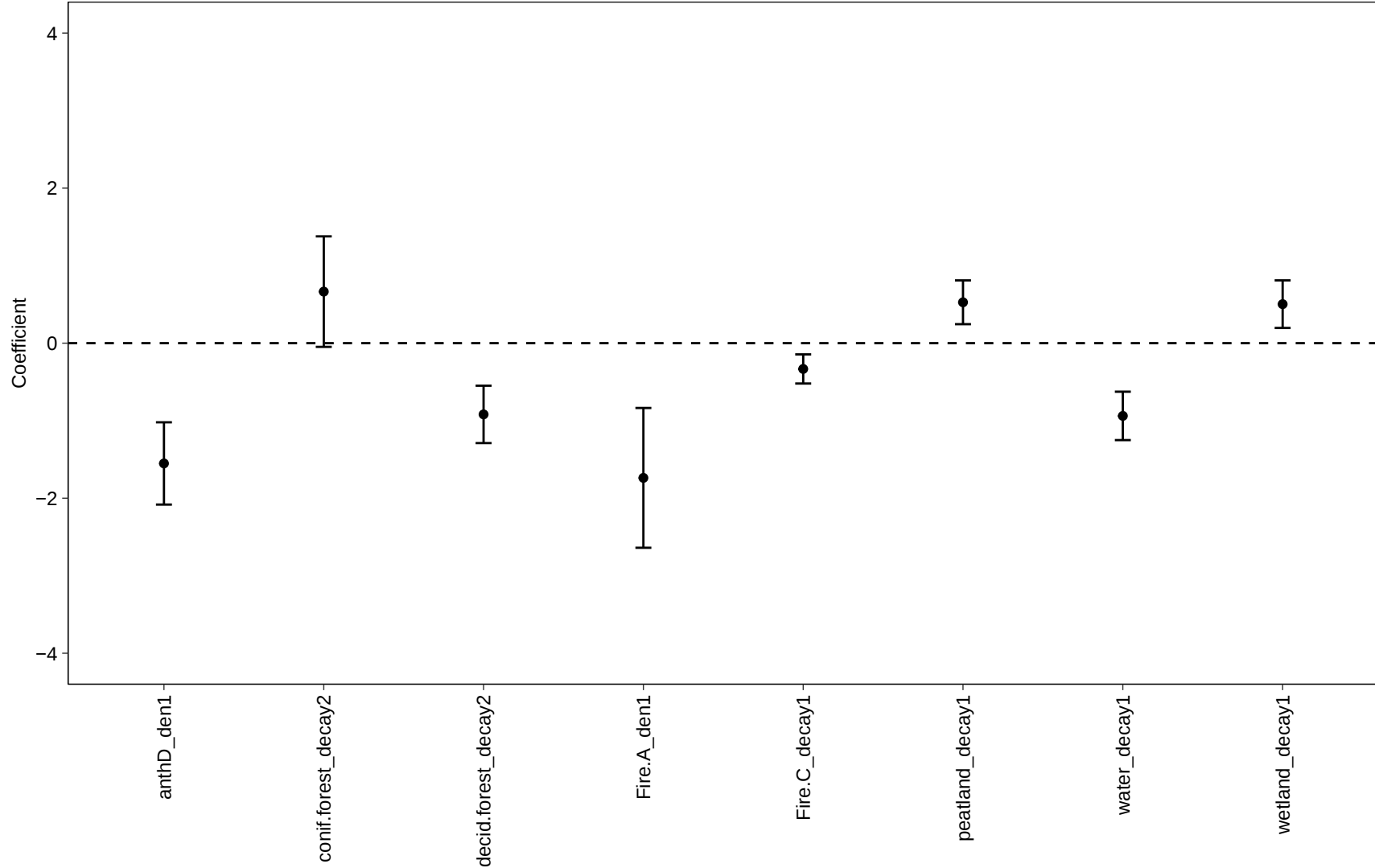


Figure 3: Coefficients of Conditional Multivariate Model Used to Predict Caribou Calving Habitat Across Churchill, Berens, and Kinloch Caribou Ranges, 2023

Notes: See Table 1 for description of landscape variables. Coefficients derived from Resource Selection Function (RSF, Manly et al. 2002) models using mixed conditional logistic regression to characterize local behaviour and habitat selection of calving females (Hosmer & Lemeshow 2000).

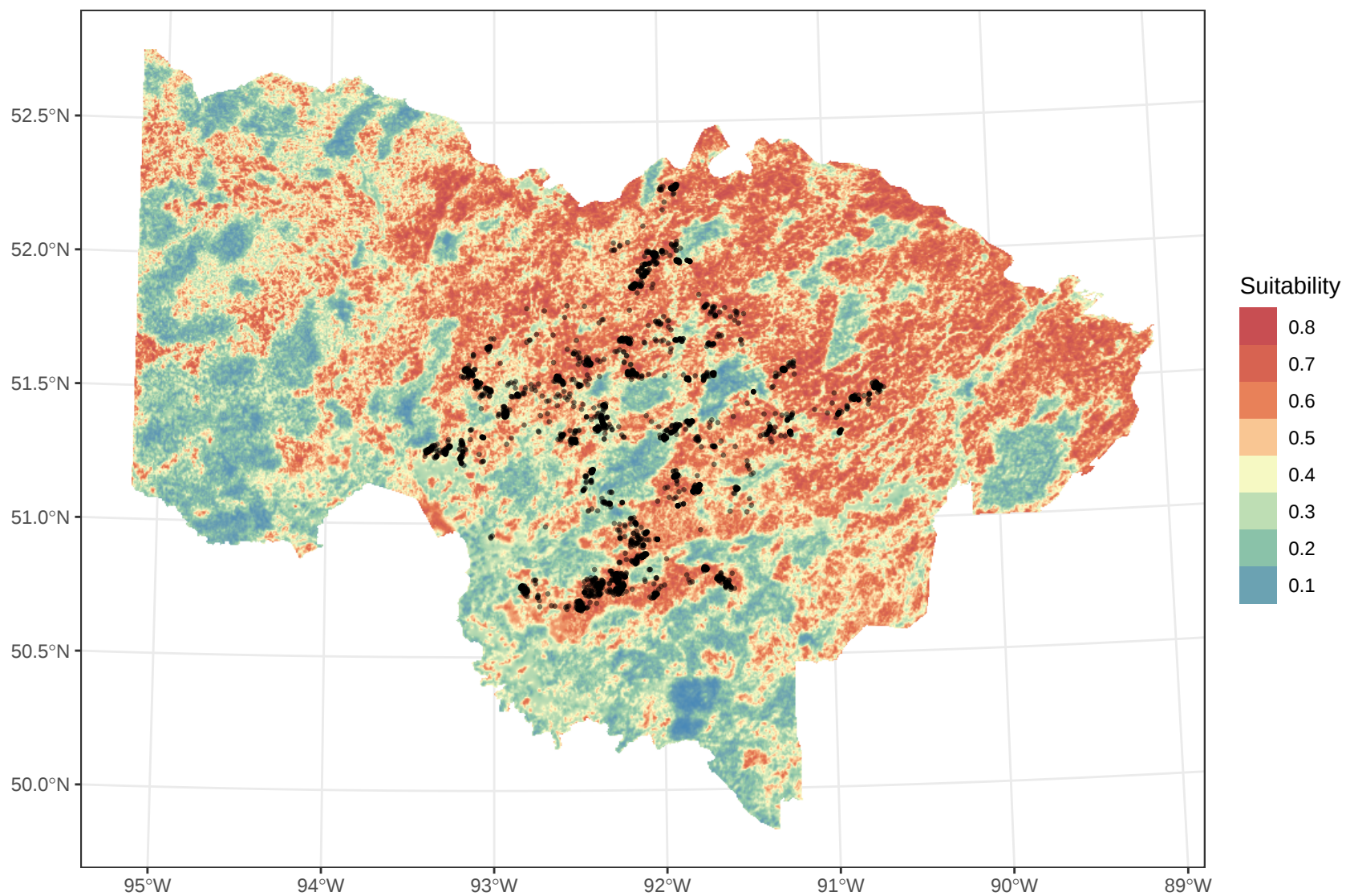


Figure 4: Predicted Caribou Calving Habitat Across Churchill, Berens, and Kinloch Caribou Ranges, 2023

Notes: Black points represent female caribou locations used in modelling calving habitat.

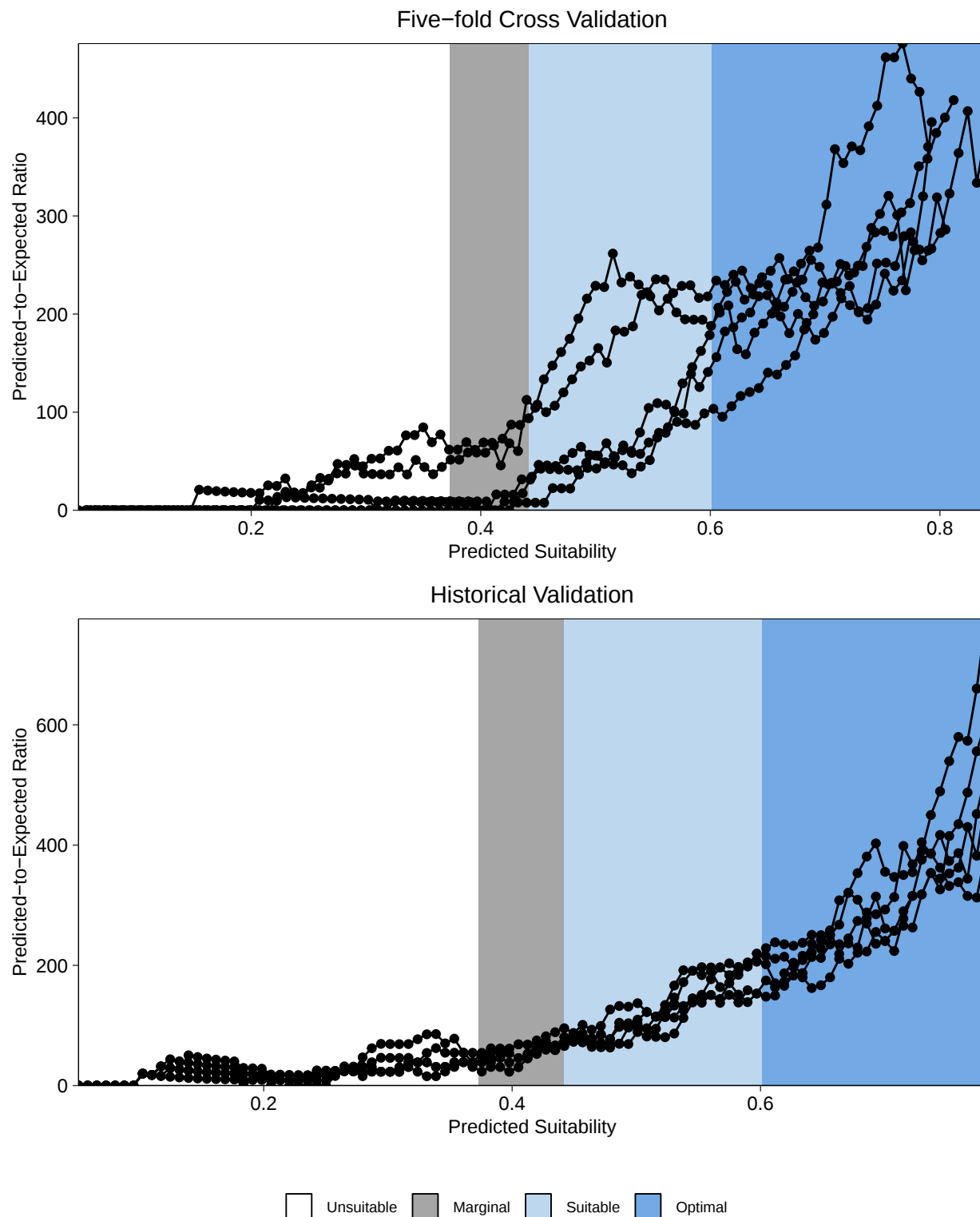


Figure 5: Validation of Caribou Calving Habitat Model Across Churchill, Berens, and Kinloch Caribou Ranges, 2023

Notes: Model validation calculated using the Boyce Index. Predicted suitability was categorized into unsuitable (<0.37), marginal (≥ 0.37 and < 0.44), suitable (>0.53 and <0.60) and optimal (> 0.60) based on the percentile values of used locations as described in the methods.

TABLES

Table 1: Summary of Successive Daily Movements for Female Caribou from May and June, 2023

Caribou Collar ID	Number of Days of Movement Data	Median Successive Distance (km)	Maximum Successive Distance (km)	75th Percentile of Successive Distances (km)	Interquartile Range (km)	1.5x Interquartile Range + 75th Percentile (km)
726822A	61	0.622	16.4	1.59	2.09	3.68
726823A	60	0.675	6.42	1.98	2.71	4.69
726824A	61	2.90	12.0	4.51	5.19	9.71
726825A	60	0.588	15.5	1.34	1.82	3.16
726826A	61	0.465	21.6	1.05	1.25	2.30
726827A	61	0.970	17.7	2.23	3.01	5.24
726828A	61	0.876	4.12	1.61	1.70	3.30
726829A	61	0.429	7.53	1.03	1.28	2.31
726851A	61	0.996	7.97	2.81	3.75	6.56
726871A	61	0.586	11.4	1.19	1.40	2.59
726872A	59	1.11	5.37	2.19	2.52	4.71
726874A	59	0.189	1.33	0.332	0.369	0.701
726875A	59	1.95	16.7	3.98	4.31	8.29
726876A	61	0.508	8.47	1.23	1.47	2.70
726877A	61	0.408	26.6	1.16	1.40	2.57
726894A	61	0.280	11.0	0.890	1.23	2.12
726895A	61	0.392	14.8	0.890	0.981	1.87
726896A	60	0.337	5.02	1.09	1.39	2.48
726898A	61	0.979	12.4	2.29	2.97	5.26
726900A	61	1.71	27.0	4.54	6.08	10.6
726962A	59	0.365	18.2	1.01	1.31	2.32
726963A	44	0.355	19.6	1.80	2.48	4.27
726964A	61	0.521	12.8	1.38	1.75	3.13
726965A	61	1.06	4.46	1.71	1.69	3.40
726966A	60	0.343	5.62	0.846	1.17	2.01
726967A	59	0.644	2.46	1.05	1.15	2.21
726971A	61	0.252	17.1	0.504	0.575	1.08
726972A	61	0.460	11.4	1.58	2.26	3.84
726973A	61	0.422	26.7	1.41	1.83	3.24
726974A	61	0.812	4.13	1.35	1.58	2.93
726977A	60	0.717	8.26	1.87	2.43	4.31
726978A	60	0.368	5.64	1.06	1.40	2.45
726979A	60	0.465	4.69	1.06	1.31	2.37
736026A	59	1.86	15.4	3.08	3.38	6.46
736027A	59	0.941	39.4	2.84	3.54	6.38
736028A	61	0.663	8.69	1.81	2.36	4.17
736029A	59	0.531	9.86	1.07	1.37	2.45
736030A	61	0.875	19.3	2.04	2.69	4.74
736031A	61	0.566	9.46	1.02	1.24	2.26
736032A	59	0.886	4.50	1.57	1.67	3.24
736033A	61	1.47	14.3	2.16	2.65	4.80
736034A	59	0.405	10.7	0.829	1.10	1.93
736036A	61	0.491	5.22	1.03	1.23	2.26
736037A	61	1.08	25.2	2.12	2.83	4.94
736038A	61	0.610	10.2	1.12	1.38	2.50
736039A	61	0.402	13.9	1.48	2.00	3.48
736040A	61	1.84	19.0	2.86	2.98	5.84
736041A	61	0.652	10.5	1.60	2.12	3.72
Dataset Average	60	0.771	12.6	1.69	2.09	3.78

Notes: Two suspected mortalities (categorized as individuals with fewer than 30 days of movement) were filtered out of the data set. Distances are shown in kilometres (km). Successive distance = the distance an individual travels in a 24 hour span.

Table 2: Summary of Geographic Information System (GIS) Data Used to Derive Model Covariates to Describe Caribou Calving Habitat, 2023

Source	Name	Description	Percent Coverage	
			Study Area	Modelled Area
Land Information Ontario: Ontario Land Cover Compilation v 2.0	conif.forest	OLC code 15: Predominately coniferous tree cover that is typically closed and tall (greater than 10 metres in height and 60% closure). May also include open tall (greater than 10 metres in height and between 25 and 60% closure) and low (less than 10 metres in height and greater than 25% closure) communities. Upland coniferous tree species make up greater than 75% of canopy closure.	30 %	38 %
	decid.forest	OLC code 13: Predominately deciduous tree cover that is typically closed and tall (greater than 10 metres in height and 60% closure). May also include open tall (greater than 10 metres in height and between 25 and 60% closure) and low (less than 10 metres in height and greater than 25% closure) communities. Upland deciduous tree species make up greater than 75% of canopy closure.	2.5 %	1.0 %
	mixed.forest	OLC code 14: A mixture of deciduous and coniferous tree cover that is typically closed and tall (greater than 10 metres in height and 60% closure). May also include open tall (greater than 10 metres in height and between 25 and 60% closure) and low (less than 10 metres in height and greater than 25% closure) communities. Upland deciduous and coniferous tree species are present and make up less than 75% of canopy closure.	5.7 %	4.2 %
	open.forest	OLC code 11: A patchy or sparse forest canopy composed of coniferous or deciduous species. Treed sites with tall and/or low treed canopy closure between 10 and 25%.	4.5 %	3.6 %
	peatland	OLC codes 7 and 8: Open (< 10 % tree cover) and treed (>10 % tree cover) fens and bogs.	9.1 %	8.7 %
	wetland	OLC codes 5 and 6: Open (< 10 % tree cover) and treed (>10 % tree cover) marshes and swamps.	11 %	12 %
	water	OLC codes 1 and 2: Open and turbid water.	16 %	16 %
Anthropogenic Disturbance from Environment and Climate Change Canada 2018 and provided by WSP for the Churchill range	anthD	Anthropogenic disturbance: Buffered polyline disturbance by 500 m and removed point source disturbance. Combined two data sources such that a disturbance in either source would be a disturbance in the final layer.	11 %	13 %
Land Information Ontario: Fire Disturbance Area Version 3	Fire.A	Fire Disturbance from 2000 to 2021.	15 %	7.4 %
	Fire.B	Fire Disturbance between 1980 and 2000.	12 %	2.2 %
	Fire.C	Fire Disturbance between 1960 and 1980.	14 %	24 %

Notes: Study area included the extent of the OLC data converge clipped to 3 caribou ranges: Churchill, Barrens, and Kinloch and modelled area represents the caribou locations buffered by 12.6 km (the average of the maximum daily distance travelled by caribou).

Table 3: Univariate Model Selection for Identifying Female Caribou Locations in a Conditional Logistic Regression Model, 2023

Habitat Type	Univariate Model	Number of Times Model was Selected	Rep 1		Rep 2		Rep 3		Rep 4		Rep 5		Rep 6		Rep 7		Rep 8		Rep 9		Rep 10	
			Coefficient	Δ AIC	Coefficient	Δ AIC	Coefficient	Δ AIC	Coefficient	Δ AIC	Coefficient	Δ AIC	Coefficient	Δ AIC	Coefficient	Δ AIC	Coefficient	Δ AIC	Coefficient	Δ AIC	Coefficient	Δ AIC
Anthropogenic Disturbance	Decay Model 1	2	-0.888	1.39	-0.855	1.36	-1.03	1.57	-0.889	1.11	-1.00	0	-0.992	1.07	-1.01	0	-0.977	1.04	-0.953	2.94	-0.992	0.837
	Decay Model 2	3	-0.840	0	-0.778	1.92	-0.936	2.22	-0.815	1.46	-0.904	1.49	-0.925	0	-0.920	0.638	-0.908	0	-0.866	3.97	-0.916	0.892
	Density Model 1	5	-1.23	0.230	-1.16	0	-1.42	0	-1.20	0	-1.34	0.599	-1.34	0.622	-1.35	0.911	-1.34	0.0415	-1.32	0	-1.34	0
	Density Model 2	0	-1.20	6.13	-1.18	3.95	-1.39	8.21	-1.23	4.05	-1.31	8.25	-1.34	6.80	-1.34	7.78	-1.36	5.08	-1.35	4.79	-1.34	6.59
Coniferous Forest	Decay Model 1	0	0.844	2.45	0.862	2.57	0.894	2.74	0.911	2.81	0.913	4.19	0.915	2.29	0.831	3.09	0.976	1.06	0.982	1.16	0.796	2.32
	Decay Model 2	8	1.49	0	1.51	0	1.57	0	1.59	0	1.60	0.995	1.59	0	1.46	0.543	1.68	0	1.68	0	1.41	0
	Density Model 1	1	0.984	7.74	1.14	3.67	1.04	8.73	1.25	1.62	1.34	0	0.980	10.4	1.19	0.408	1.00	11.3	1.28	1.70	0.998	4.80
	Density Model 2	1	1.36	5.32	1.44	3.84	1.43	6.44	1.58	2.14	1.63	2.71	1.37	7.24	1.53	0	1.36	9.76	1.56	3.29	1.34	3.04
Deciduous Forest	Decay Model 1	4	-1.02	2.16	-0.979	0.525	-0.997	0.0241	-1.02	0.171	-0.992	0	-1.14	0	-1.14	0	-0.994	0.901	-1.08	0	-1.10	0.208
	Decay Model 2	6	-0.760	0	-0.703	0	-0.709	0	-0.727	0	-0.670	1.50	-0.795	0.762	-0.797	0.773	-0.730	0	-0.745	0.883	-0.779	0
	Density Model 1	0	-6.90	11.5	-6.50	9.81	-6.88	8.51	-7.11	8.69	-7.27	8.01	-7.76	11.7	-8.20	11.1	-6.96	9.79	-7.02	12.0	-7.40	11.1
	Density Model 2	0	-6.91	13.8	-5.88	12.6	-6.29	12.2	-6.78	12.3	-6.16	12.5	-6.73	17.4	-8.07	15.0	-6.92	12.3	-5.74	16.3	-6.94	14.9
Fire Class A (2000 to 2021)	Decay Model 1	0	-0.981	9.99	-0.914	10.4	-1.07	9.04	-1.09	9.99	-0.992	9.15	-1.07	11.6	-0.967	11.0	-1.01	10.3	-1.01	9.24	-0.937	10.5
	Decay Model 2	0	-0.894	9.64	-0.822	10.4	-0.936	10.1	-0.925	12.2	-0.879	9.45	-0.962	11.8	-0.850	11.8	-0.905	10.5	-0.885	9.89	-0.840	10.6
	Density Model 1	10	-1.92	0	-1.82	0	-1.97	0	-2.01	0	-1.92	0	-2.03	0	-1.90	0	-1.95	0	-1.96	0	-1.86	0
	Density Model 2	0	-1.70	6.84	-1.66	5.00	-1.75	7.80	-1.77	8.66	-1.67	6.60	-1.83	7.26	-1.70	6.15	-1.79	5.43	-1.68	8.23	-1.70	5.18
Fire Class B (1980 to 2000)	Decay Model 1	0	-0.230	4.56	-0.332	4.47	-0.0915	3.70	-0.508	3.52	-0.575	5.69	-0.400	5.46	-0.372	5.24	-0.147	2.29	-0.293	4.84	-0.474	4.48
	Decay Model 2	0	-0.214	4.52	-0.353	4.00	-0.0923	3.68	-0.381	4.37	-0.500	6.01	-0.332	5.76	-0.310	5.50	-0.0906	2.41	-0.279	4.73	-0.405	4.76
	Density Model 1	0	-0.655	3.20	-0.757	3.26	-0.517	2.51	-0.981	1.36	-1.14	2.91	-0.920	2.89	-0.804	3.48	-0.520	1.25	-0.744	3.05	-0.959	2.38
	Density Model 2	10	-1.42	0	-1.55	0	-1.22	0	-1.44	0	-1.82	0	-1.58	0	-1.55	0	-0.965	0	-1.39	0	-1.56	0
Fire Class C (1960 to 1980)	Decay Model 1	6	-0.0790	0	-0.106	0	-0.0553	0	-0.0159	0.114	-0.0757	0	-0.0182	0.499	-0.0560	0	-0.0878	0	-0.0714	0.0900	-0.0598	0.0942
	Decay Model 2	2	-0.0742	0.104	-0.0998	0.175	-0.0516	0.0553	-0.0259	0.0678	-0.0733	0.0582	-0.0126	0.519	-0.0521	0.0580	-0.0852	0.0735	-0.0779	0	-0.0672	0
	Density Model 1	0	-0.0438	0.540	-0.0544	1.02	-0.0227	0.306	0.0238	0.0870	-0.0493	0.424	0.0349	0.417	-0.00768	0.358	-0.0476	0.679	-0.0330	0.581	-0.00246	0.513
	Density Model 2	2	-0.00215	0.730	-0.0184	1.29	0.0197	0.327	0.0422	0	-0.0159	0.646	0.0819	0	0.0383	0.247	0.00134	0.904	-0.00163	0.688	0.0256	0.461
Mixed Forest	Decay Model 1	0	-0.478	12.2	-0.470	12.6	-0.505	11.6	-0.526	7.74	-0.535	8.82	-0.571	9.70	-0.573	11.5	-0.541	6.91	-0.520	11.3	-0.578	4.01
	Decay Model 2	0	-0.486	11.4	-0.483	11.6	-0.503	11.2	-0.499	8.31	-0.490	10.3	-0.551	9.86	-0.535	12.9	-0.510	7.69	-0.487	12.2	-0.563	4.17
	Density Model 1	9	-5.36	0	-5.25	0	-5.40	0	-5.09	0	-5.28	0	-5.49	0	-5.69	0	-5.04	0	-5.34	0	-4.86	0.184
	Density Model 2	1	-6.11	1.69	-5.78	2.84	-6.20	0.992	-5.62	2.09	-5.75	2.72	-5.97	3.01	-6.04	5.11	-5.57	2.28	-5.97	2.03	-5.80	0
Open Forest	Decay Model 1	5	0.238	0	0.250	0.431	0.246	0	0.145	1.24	0.210	0.365	0.227	0	0.197	0	0.262	0.0780	0.240	0	0.112	0.724
	Decay Model 2	2	0.217	0.623	0.278	0	0.233	0.485	0.123	1.56	0.199	0.754	0.209	0.514	0.203	0.0193	0.276	0	0.223	0.517	0.0921	0.946
	Density Model 1	0	-0.630	1.69	-0.603	2.50	-0.639	1.83	-0.780	0.759	-0.802	0.891	-0.737	1.08	-0.454	1.36	-0.473	2.84	-0.608	1.79	-0.620	0.471
	Density Model 2	3	-1.01	0.723	-0.916	1.84	-0.972	1.10	-1.09	0	-1.17	0	-1.07	0.289	-0.812	0.668	-0.904	1.91	-0.978	0.839	-0.870	0
Peatland	Decay Model 1	10	0.873	0	0.894	0	0.921	0	0.866	0	0.874	0	0.859	0	0.924	0	0.753	0	0.815	0	0.878	0
	Decay Model 2	0	0.985	9.85	0.989	11.1	1.03	11.4	0.977	9.31	0.961	11.0	0.992	7.93	1.01	12.8	0.846	7.23	0.920	8.22	0.959	11.4
	Density Model 1	0	1.90	24.9	1.63	30.7	1.80	30.3	1.62	29.0	1.73	26.9	2.03	20.9	1.88	28.7	1.40	22.1	1.56	25.5	1.81	25.6
	Density Model 2	0	1.36	39.6	1.27	41.0	1.27	44.7	1.01	41.5	1.33	38.8	1.55	36.8	1.36	43	0.867	31.7	1.13	35.7	1.22	39.8
Water	Decay Model 1	10	-1.15	0	-1.11	0	-1.10	0	-1.18	0	-1.18	0	-1.11	0	-1.19	0	-1.12	0	-1.05	0	-1.21	0
	Decay Model 2	0	-1.31	16.6	-1.23	17.4	-1.22	16.9	-1.40	12.8	-1.33	16.0	-1.28	14.5	-1.36	16.9	-1.27	16.0	-1.15	16.2	-1.41	15.4
	Density Model 1	0	-0.570	59.0	-0.441	56.8	-0.459	55.5	-0.643	58	-0.565	59.7	-0.331	56.5	-0.520	63.6	-0.404	57.7	-0.468	50.2	-0.406	66.2
	Density Model 2	0	-0.0200	63.4	0.00558	59.4	0.0660	58.2	-0.124	63.2	0.00834	64.0	0.114	57.8	0.0309	67.1	0.175	59.6	0.134	52.9	0.233	67.8
Wetland	Decay Model 1	9	0.778	0	0.614	0.619	0.717	0	0.747	0	0.810	0	0.698	0	0.749	0	0.667	0	0.715	0	0.605	0
	Decay Model 2	1	0.995	2.67	0.829	0	0.957	0.206	0.987	1.01	1.06	1.84	0.908	1.29	0.962	2.40	0.886	0.629	0.944	0.691	0.788	0.810
	Density Model 1	0	1.47	16.1	1.25	10.0	1.43	13.6	1.61	12.6	1.45	18.9	1.46	10.9	1.35	15.7	1.29	11.9	1.55	11.1	1.36	7.28
	Density Model 2	0	1.56	19.3	1.54	10.2	1.42	17.2	1.75	15.5	1.63	21.1	1.67	12.7	1.37	18.8	1.28	15.0	1.61	14.7	1.34	10.7

Δ AIC value = 0, indicating the best model for the replicate.

boldThe model that was selected the most for a given habitat type.

Notes: AIC = Akaike Information Criterion

Table 4: Multivariate Model Selection for Identifying Female Caribou Locations in a Conditional Logistic Regression Model, 2023

Model	AIC	Δ AIC	Coefficients										
			Anthropogenic Disturbance - Density 1	Coniferous Forest - Decay 2	Deciduous Forest - Decay 2	Fire A - Density 1	Fire B - Density 2	Fire C - Decay 1	Mixed Forest - Density 1	Open Forest - Decay 1	Peatland - Decay 1	Water - Decay 1	Wetland - Decay 1
Model 42	1,938	0	-1.53	0.630	-0.730	-1.81	-	-0.301	-2.89	-	0.504	-0.957	0.420
Model 55	1,939	0.62	-1.55	0.627	-0.738	-1.80	-	-0.300	-2.96	0.176	0.488	-0.946	0.449
Model 51	1,940	1.5	-1.53	0.578	-0.721	-1.81	-0.488	-0.302	-2.91	-	0.500	-0.960	0.411
Model 57	1,940	2.1	-1.56	0.571	-0.728	-1.81	-0.519	-0.302	-2.98	0.180	0.483	-0.949	0.440
Model 20	1,941	2.6	-1.55	0.665	-0.919	-1.74	-	-0.333	-	-	0.527	-0.938	0.503
Model 43	1,942	3.4	-1.57	0.665	-0.928	-1.73	-	-0.333	-	0.162	0.514	-0.927	0.534
Model 36	1,942	4.2	-1.55	0.617	-0.911	-1.74	-0.460	-0.334	-	-	0.524	-0.941	0.496
Model 52	1,943	4.9	-1.57	0.614	-0.919	-1.74	-0.486	-0.336	-	0.165	0.510	-0.930	0.527
Model 23	1,946	7.9	-1.43	0.694	-0.605	-1.71	-	-	-3.51	-	0.460	-0.952	0.383
Model 45	1,947	8.4	-1.45	0.693	-0.612	-1.71	-	-	-3.59	0.179	0.444	-0.941	0.415
Model 39	1,948	9.5	-1.43	0.647	-0.597	-1.72	-0.430	-	-3.53	-	0.456	-0.955	0.375
Model 54	1,948	10	-1.46	0.643	-0.603	-1.71	-0.455	-	-3.61	0.182	0.440	-0.944	0.407
Model 21	1,949	11	-1.44	0.689	-	-1.83	-	-0.235	-5.13	-	0.443	-0.980	0.393
Model 44	1,950	12	-1.46	0.686	-	-1.83	-	-0.234	-5.19	0.156	0.427	-0.971	0.417
Model 37	1,950	12	-1.45	0.619	-	-1.84	-0.638	-0.239	-5.11	-	0.440	-0.984	0.382
Model 3	1,951	13	-1.44	0.745	-0.823	-1.61	-	-	-	-	0.485	-0.926	0.492
Model 53	1,951	13	-1.47	0.611	-	-1.83	-0.671	-0.237	-5.17	0.162	0.422	-0.975	0.405
Model 24	1,952	14	-1.46	0.748	-0.830	-1.61	-	-	-	0.158	0.472	-0.915	0.525
Model 17	1,953	15	-1.44	0.706	-0.816	-1.62	-0.379	-	-	-	0.482	-0.928	0.486
Model 4	1,954	15	-1.38	0.734	-	-1.76	-	-	-5.31	-	0.414	-0.973	0.365
Model 40	1,954	16	-1.46	0.707	-0.822	-1.61	-0.397	-	-	0.160	0.469	-0.917	0.519
Model 25	1,954	16	-1.40	0.732	-	-1.75	-	-	-5.37	0.163	0.398	-0.964	0.392
Model 18	1,955	17	-1.38	0.672	-	-1.76	-0.567	-	-5.30	-	0.411	-0.975	0.355
Model 41	1,956	17	-1.40	0.667	-	-1.76	-0.597	-	-5.36	0.168	0.393	-0.967	0.381
Model 32	1,960	22	-1.48	0.957	-0.747	-	-	-0.260	-2.25	-	0.544	-0.955	0.498
Model 50	1,960	22	-1.51	0.949	-0.756	-	-	-0.259	-2.32	0.186	0.526	-0.945	0.528
Model 10	1,961	22	-1.50	0.967	-0.895	-	-	-0.287	-	-	0.561	-0.942	0.559
Model 33	1,961	23	-1.52	0.961	-0.905	-	-	-0.287	-	0.174	0.546	-0.931	0.591
Model 46	1,962	23	-1.48	0.920	-0.739	-	-0.396	-0.261	-2.26	-	0.542	-0.957	0.491
Model 56	1,962	24	-1.51	0.908	-0.747	-	-0.427	-0.260	-2.34	0.189	0.523	-0.947	0.522
Model 26	1,962	24	-1.50	0.931	-0.887	-	-0.381	-0.288	-	-	0.559	-0.944	0.553
Model 47	1,963	25	-1.52	0.922	-0.897	-	-0.409	-0.289	-	0.177	0.543	-0.933	0.585
Model 2	1,965	26	-1.44	0.804	-	-1.69	-	-0.265	-	-	0.462	-0.963	0.538
Model 13	1,965	27	-1.40	0.991	-0.641	-	-	-	-2.83	-	0.504	-0.951	0.462
Model 35	1,966	27	-1.42	0.985	-0.649	-	-	-	-2.91	0.189	0.486	-0.941	0.495
Model 16	1,966	27	-1.44	0.731	-	-1.70	-0.695	-0.269	-	-	0.458	-0.966	0.526
Model 22	1,966	28	-1.46	0.805	-	-1.69	-	-0.264	-	0.130	0.450	-0.955	0.561
Model 38	1,967	29	-1.46	0.728	-	-1.70	-0.723	-0.269	-	0.137	0.445	-0.958	0.550
Model 29	1,967	29	-1.40	0.958	-0.634	-	-0.352	-	-2.84	-	0.501	-0.953	0.456
Model 49	1,967	29	-1.42	0.948	-0.641	-	-0.378	-	-2.93	0.192	0.483	-0.943	0.489
Model 14	1,969	30	-1.43	1.01	-0.826	-	-	-	-	0.172	0.506	-0.921	0.578
Model 7	1,970	32	-1.41	0.978	-0.810	-	-0.321	-	-	-	0.519	-0.933	0.538
Model 30	1,970	32	-1.43	0.973	-0.819	-	-0.341	-	-	0.174	0.504	-0.922	0.573
Model 11	1,972	33	-1.40	1.03	-	-	-	-0.194	-4.51	-	0.481	-0.976	0.470
Model 5	1,972	34	-1.38	0.860	-	-1.60	-	-	-	0.132	0.418	-0.942	0.551
Model 1	1,972	34	-1.36	0.796	-	-1.61	-0.600	-	-	-	0.426	-0.952	0.515
Model 34	1,972	34	-1.42	1.02	-	-	-	-0.192	-4.57	0.164	0.464	-0.969	0.495
Model 27	1,973	35	-1.40	0.969	-	-	-0.568	-0.197	-4.48	-	0.479	-0.978	0.461
Model 19	1,973	35	-1.38	0.796	-	-1.60	-0.622	-	-	0.137	0.414	-0.944	0.542
Model 48	1,974	35	-1.42	0.957	-	-	-0.602	-0.195	-4.54	0.169	0.461	-0.971	0.485
Model 15	1,975	36	-1.36	1.04	-	-	-	-	-4.76	0.171	0.438	-0.964	0.472
Model 8	1,975	37	-1.34	0.996	-	-	-0.511	-	-4.68	-	0.453	-0.972	0.436
Model 31	1,976	38	-1.37	0.985	-	-	-0.543	-	-4.75	0.175	0.435	-0.965	0.463
Model 12	1,984	46	-1.42	1.08	-	-	-	-0.224	-	0.139	0.480	-0.956	0.612
Model 6	1,984	46	-1.40	1.02	-	-	-0.639	-0.229	-	-	0.491	-0.965	0.577
Model 28	1,986	47	-1.42	1.02	-	-	-0.668	-0.228	-	0.146	0.477	-0.957	0.602
Model 9	1,989	51	-1.35	1.05	-	-	-0.588	-	-	0.147	0.448	-0.946	0.591

Final Selected Model.

Notes: AIC = Akaike Information Criterion.