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Electronic Supplementary Materials

This file contains additional Information on Methods and Results:

4

1- Tracking data

2- Detailed description of the variables used to estimate habitat suitability models (table S1).

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3- The relative contribution of the assessed environmental variables to the daily habitat suitability models (figure S1).

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4- Information on microsatellite loci used for caribou and diversity statistics (table S2).

5- Correlation among predictive distances (figure S2).

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6- Landscape genetic method validation (figures S3 & S4).

7- Causal modelling (table S3 and figure S5).

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8- Landscape genetic results validation (figures S6 & S7).

9- Additional references.

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16 **1-Tracking data**

18 To fit the models, we used the locations of 296 caribou (53 males and 243 females) of the Rivière-
George herd between 1986 and 2012 and 233 caribou (71 males and 162 females) of the Rivière-
aux-Feuilles herd between 1991 and 2012 fitted with ARGOS satellite-tracking collars (Telonics,
20 ARGOS platform, Mesa, Arizona, USA) (Table 1). Most females were captured on the calving
grounds at sites separated by several kilometres (*e.g.*, range for 2007 to 2009 (mean (SE)):
22 Rivière-George: 21 (3) km; Rivière-aux-Feuilles: 83 (12) km), therefore we considered individuals
to be independent because capture sites within a given year were spread over several thousands of
24 km² and representative of the area used by the entire herd. Males were mainly captured on winter
areas. All captures used a net-gun fired from a helicopter and physical contention, a standard
26 procedure for ungulates [1]. Anaesthetics were never used during captures, which followed
guidelines from the Canadian Council on animal Care. On average, we followed 44 females (SE ±
28 5) each year and females were monitored on average for 2.0 years (SE ± 0.1) with some
individuals followed for up to 10 years. Locations were usually collected every 5 days (65.7% of the
30 database) but frequency ranged from one location every day (1.3%) up to one per 7 days (0.9%).
We filtered the data using a similar algorithm as Austin et al. [2] to eliminate aberrant locations:
32 we selected the most accurate location for a given transmission period based on signal quality and
we excluded locations leading to movements higher than 50 kilometres per day [3].

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2- Detailed description of the variables used to estimate habitat suitability models

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Table S1. Description of the variables used to estimate habitat suitability models for caribou in

38 Quebec and Labrador.

Variable	Description
Elevation	Elevation determined from a global digital elevation model (DEM)
Snow	Surface covered by snow [500m]; available every 8 days ¹
NDVI	Normalized difference vegetation index (1km); available every 10 days ²
Precipitation	Average monthly precipitation (mm) [1km] ³
Temperature	Average monthly maximum temperature (°C * 10) [1km] ³
Open area	Disturbed areas (Burnt area, urban or built-up) [400m] ⁴
Water	Water bodies (rivers and lakes) [400m] ⁴
Lichen	Subpolar needleleaved evergreen forest open canopy - lichen understory [400m] ⁴
Grassland	Temperate, subpolar or polar grassland, with sparse shrub or tree layers [400m] ⁴
Shrubland	Temperate or subpolar shrubland (Broadleaved evergreen, broadleaved deciduous and/or needleleaved evergreen shrublands) [400m] ⁴
Closed Forest	Temperate or subpolar closed forest (Broadleaved evergreen, broadleaved deciduous and/or needleleaved evergreen closed forests) [400m] ⁴
Open Forest	Temperate or subpolar open forest (Broadleaved evergreen, broadleaved deciduous and/or needleleaved evergreen open forests) [400m] ⁴

40 *Note:* Distances in brackets denote the initial resolution at which the variable was acquired

¹ MODIS satellite images [National Snow and Ice Data Center, Boulder, Colorado; <http://nsidc.org/>; 4].

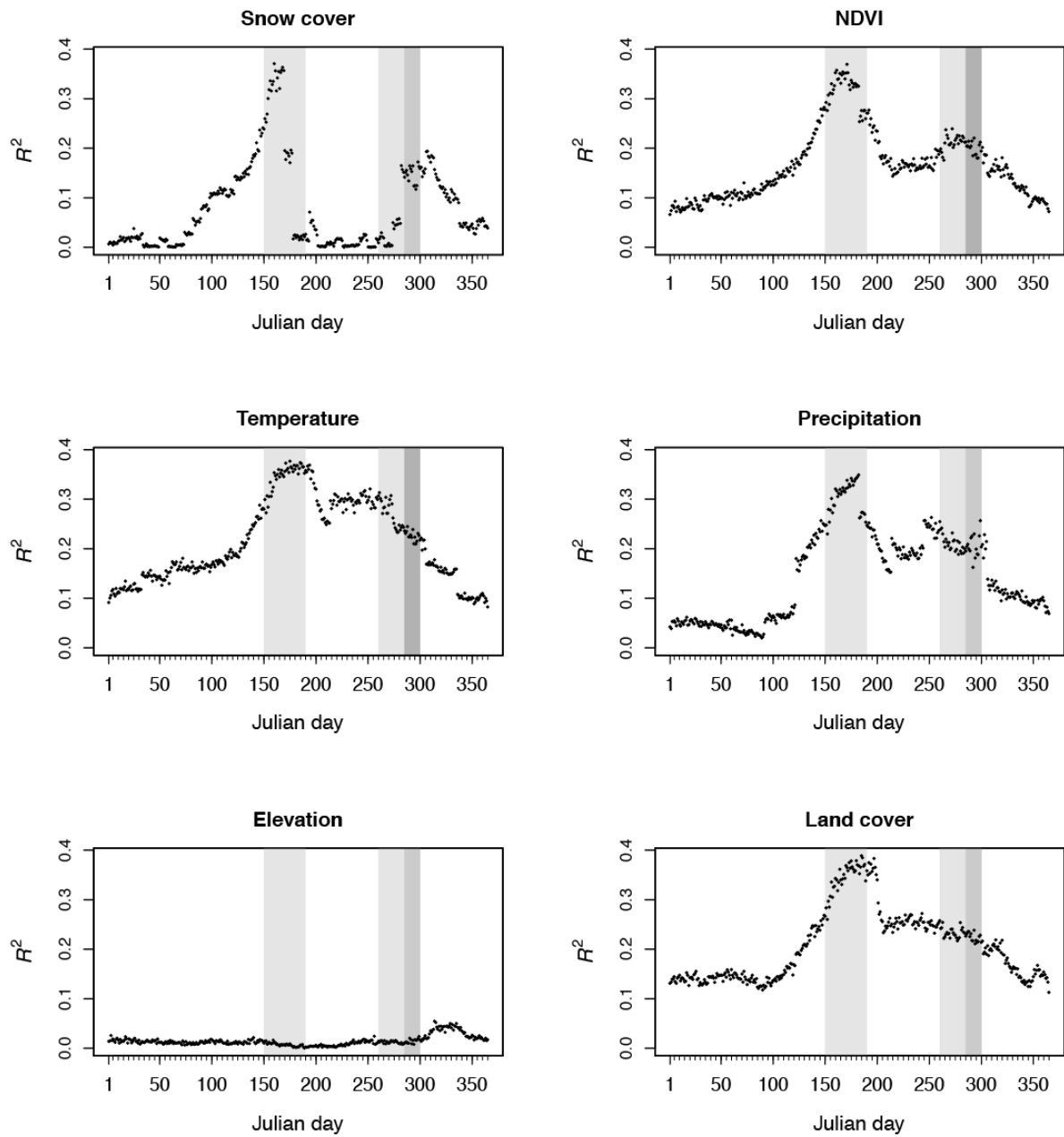
42 ² NDVI data acquired by the National Oceanic and Atmospheric Administration Advanced Very High Resolution Radiometer (NOAA-AVHRR) satellite series [5] and processed by the Canada Centre for Remote Sensing (CCRS,

44 Department of Natural Resources Canada, Ottawa, Ont.)

³ WorldClim Version 1.4 [6]

46 ⁴ Determined from landcover layer [GlobeCover 2009 [Global Land Cover Map]; 7]

48 **3- The relative contribution of the assessed environmental variables to the daily habitat suitable models**



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52 **Figure S1.** The relative contribution of the assessed environmental variables to the daily habitat
54 suitability models. Grey boxes delimit the calving period (Julian days 155-190) and the rutting
56 period (Julian days 260-300) for forest-dwelling caribou [8] and migratory caribou [3]. Dark-grey
boxes show the rutting peak for migratory caribou [Julian days 285-300; 3].

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4- Information on microsatellite loci used for caribou and diversity statistics

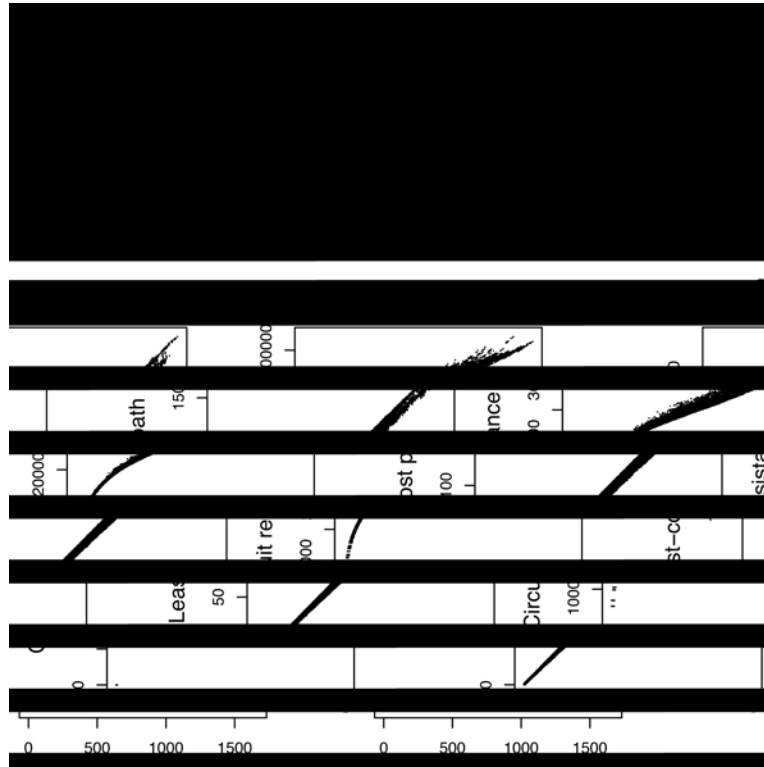
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Table S2. Information on microsatellite loci used for caribou and diversity statistics. Observed heterozygosity (H_O), expected heterozygosity (H_E), and Weir & Cockerham's inbreeding coefficient (F_{IS}) are reported.

Locus	H_O	H_E	F_{IS}
BL42	0.72	0.75	0.022
BM4513	0.69	0.91	0.254
BM6506	0.69	0.69	-0.014
BMS178	0.74	0.81	0.068
BMS745	0.64	0.67	0.070
FCB193	0.77	0.77	0.034
NVHRT1	0.49	0.57	0.167
NVHRT3	0.59	0.76	0.269
OheQ	0.71	0.71	0.018
Rt1	0.76	0.75	0.018
Rt24	0.64	0.68	0.033
Rt27	0.56	0.67	0.198
Rt5	0.60	0.74	0.210
Rt6	0.65	0.67	0.042
Rt7	0.75	0.76	0.075
Rt9s	0.70	0.72	-0.025

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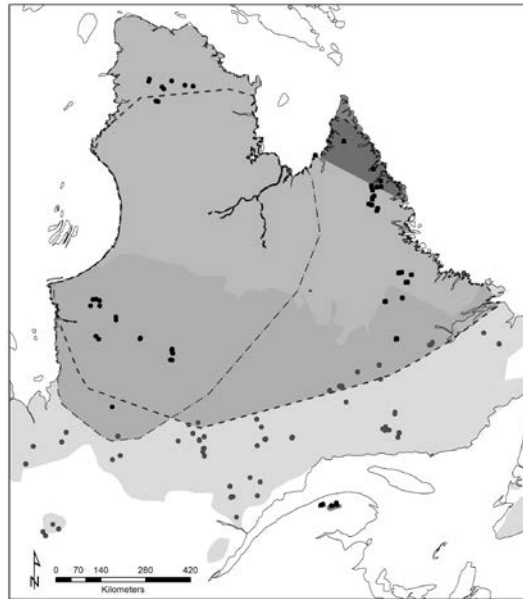
64 5- Correlation among predictive distances



66 **Figure S2.** Relationship among the three different predictive distances, *i.e.*, Geodesic distances (in
68 km), Least-cost path and circuit resistance estimated among caribou pairs for the Julian Day 300.

68 The upper right inset shows the Pearson's correlation coefficient among pair of distances.

6- Landscape genetic method validation



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Figure S3. Landscape genetic method validation. Map of sample locations of caribou, showing
74 migratory caribou for which we had both genetic and tracking information and used for method
validation (see Methods). Grey squares: Rivières-aux-Feuilles migratory herd; grey dots: Rivière-
76 George migratory herd; black squares: forest-dwelling caribou; black triangles: mountain caribou.
The annual ranges of migratory herd are delineated by dotted and dashed contour lines for
78 Rivières-aux-Feuilles and Rivière-George herds, respectively.

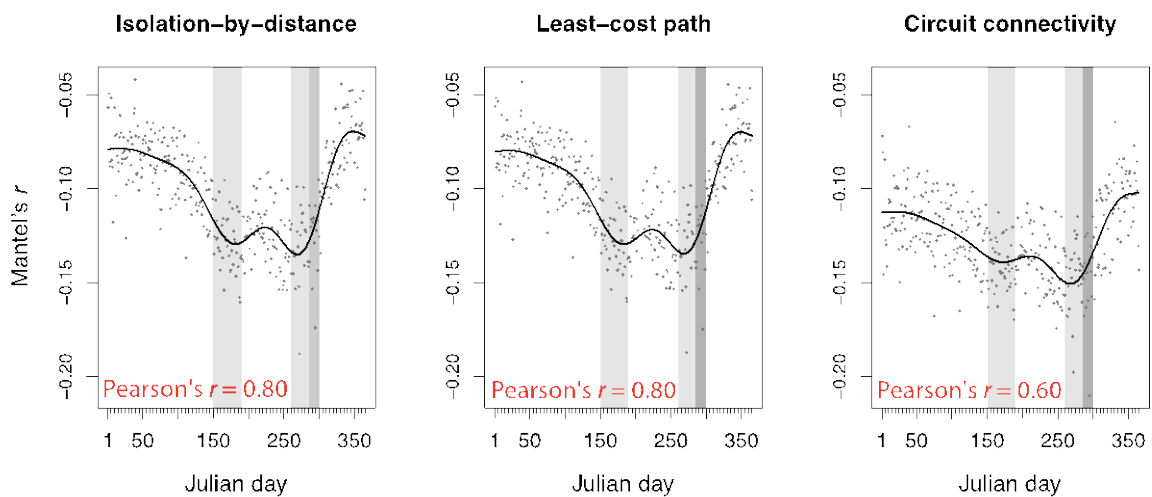


Figure S4. Landscape genetic method validation. Temporal changes in correlation coefficient
 84 (Mantel's r) of genetic relatedness (Lynch and Ritland [9] relationship coefficient) against Geodesic
 geographic distance (IBD); least-cost path; and circuit resistance, for which we had both genetic
 86 and location information for migratory caribou (see Methods). Pearson's correlation coefficient
 between the daily Mantel's r correlations obtained for the models based on the whole dataset and
 88 the data subset is indicated. Grey boxes delimit the calving period (Julian days 155-190) and the
 rut period (Julian days 260-300) for forest-dwelling caribou [8] and migratory caribou [3]. Dark-
 90 grey boxes show the rutting peak for migratory caribou (Julian days 285-300; [3]).

92 **7- Causal modelling**

94 Causal modelling analyses based on partial Mantel tests showed that all variables explained a
 96 significant part of genetic relatedness among individuals (table S3). The respective influences of
 barriers and distance, however, significantly changed over time. While after controlling for distance
 98 (Isolation-by-Distance; IBD) and barriers (Isolation by Barrier; IBB), the circuit resistance models
 always showed a significant negative relationship to relatedness (table S3), the effect of distance
 and barrier on genetic relatedness either switched from negative to positive (*i.e.*, $r > 0$) when the
 circuit resistance model was controlled for, or was non-significant in 34% and 16% of the IBD and
 100 IBB models, respectively (table S3 and figure S3). In particular, IBD and IBB models were not
 significant during the calving and rut periods, once circuit resistance models were controlled for.

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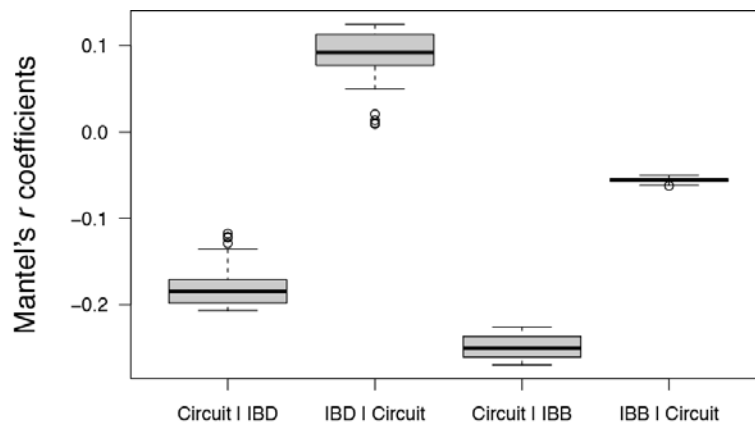
Table S3. Partial Mantel tests used in the causal modelling framework to assess the degree of
 104 association between each genetic distance matrix and four cost distance matrices, representing the
 two null models (Isolation by Distance, Isolation by Barrier), and the two correct landscape
 106 resistance models. The expected outcomes are for the situation where the landscape resistance
 model is a true driver of the observed genetic differentiation.

Test number	Variable			Expected Outcome	Results*	mean \pm sd Mantel' <i>r</i>
	Dependent	Independent	Covariates			
#1	Genetic	Circuit	IBD	Significant	100.00	-0.18 \pm 0.02
#2	Genetic	IBD	Circuit	Not significant	100.00	0.09 \pm 0.02
#3	Genetic	Circuit	IBD IBB	Significant	100.00	-0.18 \pm 0.02
4	Genetic	IBD	Circuit IBB	Not significant	84.4	-0.09 \pm 0.02

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- Percentage of significant tests out of 365 Mantel tests.

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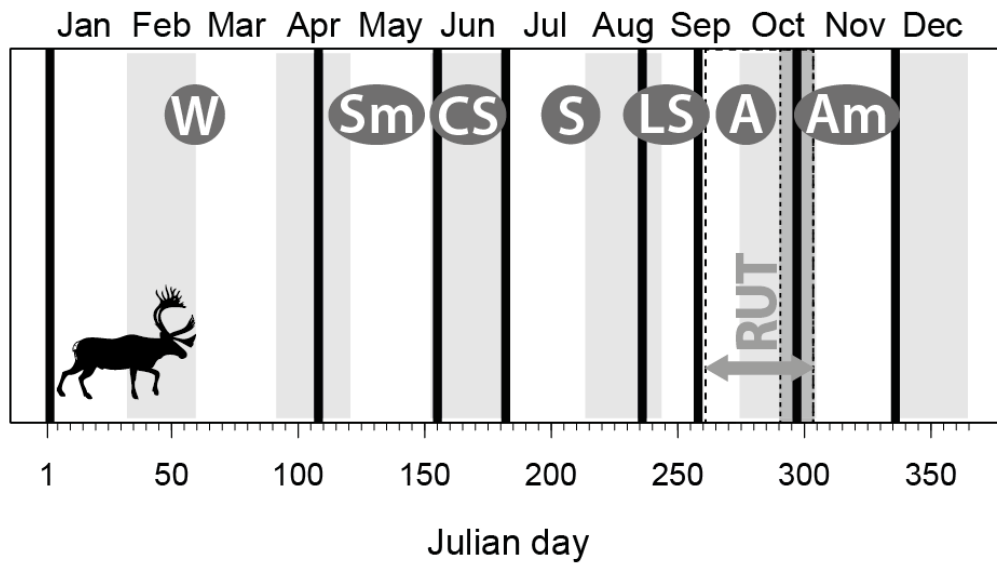
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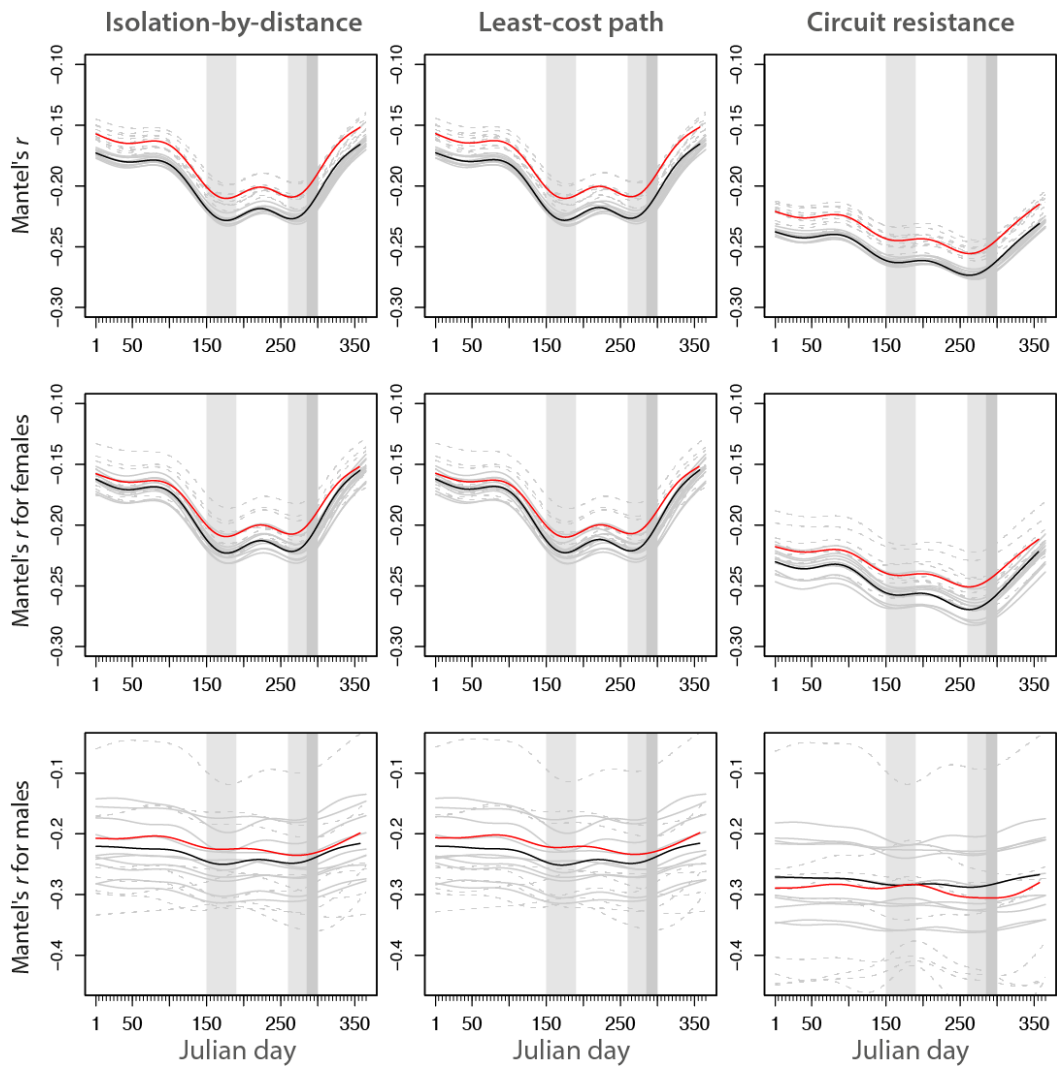
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Figure S5. The relative Mantel' r coefficients estimated by partial Mantel tests from the correlation of genetic *versus* geographic distances between pairs of caribou, once alternative distances were controlled for (indicated by |). Geodesic distance (IBD), Circuit theory resistance distance (Circuit) and geographic Barrier (IBB), respectively. The solid line in each box shows the median of the Mantel' r coefficients distribution, the box shows the 25% and 75% quantiles, and the whiskers show the full range of the coefficients.



122 **Figure S6.** Landscape genetic method validation. Schematic representation of the biological
 124 seasons for migratory caribou in Québec/Labrador. The vertical black lines indicate the seasonal
 126 periods independently defined on the base on the rate of travel (First Passage Time analysis; M. Le
 128 Corre, C. Dussault and S.D. Côté, unpublished data). Legends: W winter, Sm spring migration, CS
 calving season, LS late summer, A autumn, Am autumn migration. The dashed-lines delimited the
 overlapping rut period for boreal forest caribou [8] and migratory caribou [3]. Dark-grey box
 shows the rutting peak for migratory caribou [3].



132 **Figure S7.** Landscape genetic models validation. Temporal changes in correlation coefficient
 134 (Mantel's r) of genetic relatedness (Lynch and Ritland [9] relationship coefficient) against Geodesic
 136 geographic distance (IBD); least-cost path; and circuit resistance, obtained using a repeated split
 138 sampling approach in which models were calibrated over 70% of the data (n [total]=336,
 140 n [female]=281 and n [male]=55; black line=average over 10 replicates) and evaluated over the
 remaining 30% (n [total]=144, n [female]=129 and n [male]=15; red line=average over 10
 replicates). Grey boxes delimit the calving period (Julian days 155-190) and the rut period (Julian
 days 260-300) for forest-dwelling caribou [8] and migratory caribou [3]. Dark-grey boxes show the
 rutting peak for migratory caribou (Julian days 285-300; [3])

144 **Table S4.** Repeated split sampling testing the effect of the distances (*i.e.*, geodesic distance, least
 146 cost-path or circuit connectivity) and the seasons (see figure S6) on the Mantel's r coefficients. ρ
 corresponds to Spearman correlation coefficient between values predicted by the training data set
 148 and values observed in the testing data set, average \pm se over 10 repeats obtained using a
 repeated split sampling approach in which models were calibrated over 70% of the data
 (n[total]=336, n[female]=281 and n[male]=55) and evaluated over the remaining 30%
 (n[total]=144, n[female]=129 and n[male]=15); and R^2 the proportion of variance explained by
 150 the training models.

Model		Whole data		Male		Female	
		ρ	R^2	ρ	R^2	ρ	R^2
#1	~Distance + Season	0.95 \pm 0.01	0.92	0.53 \pm 0.09	0.83	0.94 \pm 0.02	0.92
#2	~Distance	0.70 \pm 0.01	0.63	0.52 \pm 0.05	0.63	0.69 \pm 0.04	0.63
#3	~Season	0.48 \pm 0.02	0.29	0.16 \pm 0.06	0.19	0.48 \pm 0.05	0.29

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