



## Supplementary Materials for

### **Is ungulate migration culturally transmitted? Evidence of social learning from translocated animals**

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**This PDF file includes:**

Materials and Methods  
Supplementary Text  
Figs. S1 and S2  
Tables S1 to S3  
References

## Supplementary Text:

*Translocation History*— Unregulated hunting and transmission of disease from domestic sheep (*Ovis aries*) to native bighorn sheep (*O. canadensis*) led to the extirpation of bighorn sheep from much of their historical range by the mid-twentieth century (31; Fig. 1). To combat these extirpations, wildlife management and conservation agencies began translocating sheep from robust, extant populations into extirpated areas throughout the historical range of bighorn sheep (32). The genetics of all translocated individuals can be traced to one or more of seven migratory or partially migratory source populations (33-39): (i) Whiskey Basin, WY, USA, (ii) Georgetown, CO, USA, (iii) Missouri River Breaks, MT, USA (iv) Paradise-Perma, MT, USA, (v) Salmon River, ID, USA, (vi) Junction Sheep Range Provincial Park, BC, CA, and (vii) Jasper National Park, AB, CA. We studied eight bighorn sheep populations translocated in Wyoming, Idaho, and South Dakota, USA and four populations that have persisted since the time Europeans first occupied present-day Wyoming and Idaho (hereafter “historical populations”; Table. S1).

The Devils Canyon population was initially established from individuals translocated from Whiskey Basin, WY in 1973. In 2005, individuals from Missouri River Breaks, MT (n=20), and Deschutes, OR (n=20) were added to bighorn sheep (n≈40) persisting from the original 1973 translocation (40). In 2009 and 2010, bighorn sheep were translocated from Devils Canyon, WY (n=12), Hart Mountain, OR (n=20), and John Day River Canyon, OR (n=20) into the Seminoe Mountains (39). The Deschutes, OR and John Day Canyon, OR populations were established via translocation from Hart Mountain, OR, which itself was a translocated population stemming from individuals originating in Junction Sheep Range Provincial Park, BC (41). The Laramie Range population was initially established in 1973 via translocated individuals from Whiskey Basin. In 2007, 30 individuals were translocated to Laramie Range from a population in the

Perma-Paradise area of Montana (42), which is a translocated, but partially migratory, population itself with an uncertain origin (34). Bighorn sheep in the Elk Mountain population of Wyoming and South Dakota were established via translocation of migratory individuals from the mountains surrounding Georgetown, CO (33). Finally, the Lemhi and Beaverhead populations of Idaho were established via multiple translocations occurring from 1976–1989 using individuals from the Lostine River in the Wallowa Mountains of Oregon, which were themselves translocated from Jasper National Park, AB, as well as multiple populations from the Salmon River, ID region and the Whiskey Basin population of Wyoming (38; *Table S1, Fig. 1*).

Moose (*Alces alces*) were not present in the study region when Europeans first settled Jackson Hole, WY, in the mid-nineteenth century (43). Southward expansion of moose from Montana in the late-nineteenth century, however, resulted in what is now considered the Jackson moose population (the greater Grand Teton National Park and Yellowstone National Park area of WY, USA), and the Clearwater and Sand Creek, ID populations by the turn of the twentieth century. By ca. 1930, moose had continued to expand their geographic range southward and began to occupy the area currently delineated as the Sublette population. In 1979, migratory moose from the Jackson population (n=12) and a population in the Uinta mountains of northern Utah (n=12) were translocated into the North Park region of the Medicine Bow mountain range of northern Colorado, USA. In 1987, the burgeoning population of moose in North Park were augmented by a second translocation of individuals (n=12) from Jackson. By ca. 1990, dispersing moose became established in the northern terminus of the Medicine Bow mountain range, and currently are managed as the Snowy Range moose population (44; *Table S1, Fig. 1*).

## **Materials and Methods:**

*Animal capture and handling*— Detailed methods of capture, collar deployment, and translocation are reported elsewhere (33, 39, 40, 42), however, we briefly outline these methods here. Adult (>1 yo) bighorn sheep and moose were captured via either net fired from a helicopter (45, 46), drop net (47), or dart containing a sedative fired from a truck or helicopter (48). Translocated individuals were transported from source populations to release sites using a helicopter or a truck and livestock trailer. Each individual was equipped with a GPS collar (brand and model varied across study areas). All capture and handling methods were approved by the Oregon Department of Fish and Wildlife (49), Idaho Department of Fish and Game Health Laboratory, South Dakota State University Animal Care and Use Committee (Approval Number 12-090A), or the Wyoming Game and Fish Department (Chapter 10–1535 and Chapter 33–750 permits) and followed recommendations of the American Society of Mammalogists (50).

*Assessment of Migratory Behavior*— We operationally defined migration as movement between distinct seasonal ranges (22, 51) and considered multiple round trips between winter and summer ranges within a year as indicative of non-migratory behavior (52). To distinguish migratory behavior from non-migratory behaviors (i.e., residency, nomadism, dispersal), we calculated the net squared displacement (NSD) in daily movements of individual bighorn sheep and moose from January 1 to December 31 (22,51,52). We inspected the NSD plots for clear patterns of movement that mirrored a double logistic curve, which represent movement away from a winter range in spring followed by a movement back to winter range in fall (i.e., migration; see 22,51,52). If an individual left its winter range in spring but did not return by December 31, we inspected the NSD plot for the following year and overlaid GPS collar locations onto topographic maps in ArcMap (Environmental Systems Research Institute, Redlands, CA) to

determine if the individual returned to its winter range during mid-winter (e.g., January or February). As deep snow-adapted animals, moose often migrated back to their winter range in January or February, especially in years with below-average snow accumulation, making our multi-year assessment of NSD plots an important step in determining migratory status. A common migratory behavior observed in bighorn sheep is to winter on wind-blown ridges at mid or high-elevation, quickly move downhill in spring to forage on newly emergent vegetation at lower elevations, then track emerging high-quality forage up through mid or high-elevation winter ranges throughout the calendar months of summer (53-55). Therefore, we categorized this behavior as migratory even though it resulted in individuals returning to winter ranges at some point during the summer calendar months.

*Measuring Forage Quality*– For ungulates, forage quality is highest when plants are in an intermediate phenological state (i.e., when plants are midway through green-up) because this stage of growth offers an optimal balance between digestibility and biomass (16, 17). In our study area, both bighorn sheep and moose select forage in an intermediate phenological state (1). Therefore, we computed the date at which forage reached an intermediate phenological state across space and time by calculating the Instantaneous Rate of Green-up (IRG), a metric derived from a time series of the Normalized Difference Vegetation Index raster grids (NDVI; MODIS product MOD09Q1; 250-m spatial resolution, 8-day temporal resolution) (56). Following the protocol of Merkle *et al.* (1) and Bischof *et al.* (56), we fit a double logistic function to the annual NDVI profile of each 250m x 250m pixel and estimated the date of peak IRG as the first derivative of the fitted double logistic function.

*Accounting for Differences in Plant Phenological Gradients Among Landscapes*—Genetics, learning, and local differences in patterns of plant phenology (i.e., environment) represent three, non-mutually exclusive, hypotheses as to why some populations are migratory and other populations are resident. To address the importance of local landscape characteristics on migratory propensity, we assessed patterns of plant phenology among the landscapes occupied by different populations (57, 58). We quantified gradients in plant phenology by calculating the semivariance in the date of peak IRG across distance lags within each landscape (57, 58). Landscapes in which patterns of phenology progress as a green wave (i.e. green-up which progresses sequentially across the landscape) should facilitate green-wave surfing and favor migration (18, 59). A perfect green wave, in which the date of peak IRG becomes later with greater distance lags (across the entire landscape), would result in a semi-variogram that continues to increase in semi-variance as the distance lag increases (Fig. S1 A). No change in semivariance across distance lags would indicate the absence of a green wave (Fig. S1 B). An asymptotic curve in the semi-variogram represents a green wave that is continuous across only a portion of the landscape (Fig. S1 C). Thus, we used the maximum semivariance (excluding the last  $\frac{1}{4}$  of each semi-variogram; 60) to determine the duration of green-up across the landscape (i.e., magnitude of green wave), and the distance lag of the peak semivariance to represent the distance over which the green wave travelled (Fig S1).

To define each population-specific landscape, we first mapped population boundaries and calculated the size of each population's space-use by computing the 99% minimum convex polygon (MCP; 61) surrounding each population's GPS locations. To standardize the delineation of each landscape, we created a circular buffer (defined as the radius of the maximum area of species-specific population ranges) around the centroid of each MCP (58). The area for each

landscape was 828 km<sup>2</sup> for sheep populations and 3409 km<sup>2</sup> for moose populations. To ensure we measured the size and strength of the phenological gradients available to bighorn sheep and moose, we masked date of peak IRG by a species-specific habitat map (e.g., Fig. S1 D; see *Species-specific habitat delineation* below). Due to computational constraints, we resampled each landscape raster containing the date of peak IRG from a pixel size 250 m<sup>2</sup> to 500 m<sup>2</sup> before calculating the semi-variogram for each landscape and year in which we collar data existed. We found no relationship between migratory propensity of a population and the magnitude of green waves (Fig. S1 G) or the distance the green wave travelled (Fig. S1 H), indicating that landscape characteristics alone cannot explain the presence or absence of migration amongst these populations.

*Evaluating Green-Wave Surfing Knowledge*— The frequency with which collars recorded GPS locations was based on the objectives of each study and varied from 1–24h. Therefore, we standardized the fix rate of each GPS collar by subsampling to one location per day (the least-frequent fix rate in our data set). We determined the temporal window within which green-wave surfing (i.e., the ability to track green waves of plant phenology) would be assessed by first extracting the date of peak IRG for all collar locations within each population, then calculating the start of spring as the 2.5% quantile, and the end of spring as the 97.5% quantile of the Julian days that IRG peaked [*sensu* (23)]. The daily green-wave surfing ability of each individual was then computed as the absolute difference (in days) between the date individuals used a given IRG cell and the date peak IRG occurred in that same cell ("Days-From-Peak"; 23). We then calculated a surfing ability score for each individual as the median Days-From-Peak the individual experienced between our estimated start and end of spring.

560           Because the green waves of some landscapes may be easier to track than others (23),  
561 directly comparing the surfing ability of individuals in different environments does not provide a  
562 robust estimate of knowledge possessed about local patterns of phenology. To quantify the  
563 amount of knowledge individuals and, by extension, populations possessed about local  
564 phenology, we assessed the degree to which observed green-wave surfing differed from two  
565 simulated foragers: (i) an omniscient forager with complete knowledge of local patterns in plant  
566 phenology, and (ii) a naïve forager with no knowledge of local patterns in plant phenology. Both  
567 naïve and omniscient foragers were forced to move within species-specific habitat (see *Species-*  
568 *Specific Habitat Delineation* below) and were limited by the distance (step length) they could  
569 move in a day. Daily step lengths were identified separately for bighorn sheep and moose by  
570 calculating the 99% quantile (to remove outliers) of daily step lengths occurring during the  
571 spring period (moose=6049 m, bighorn sheep=6453 m). We simulated omniscient foraging by  
572 allowing simulated foragers to choose the IRG cell within its step-length radius that was closest  
573 to date in which its step occurred. If more than one cell possessed a peak IRG date that was  
574 equally close to the date in which the simulated forager's step occurred, the simulated forager  
575 chose the IRG cell closest to its current position. We simulated naïve foraging by allowing  
576 simulated foragers to make daily steps determined by randomly sampling (with replacement)  
577 from uniform distributions of turning angles and step lengths (i.e., a random walk). As with  
578 simulations of omniscient foragers, the movements of naïve foragers were constrained to occur  
579 within species-specific habitats and maximum daily step lengths. Because the simulated surfing  
580 ability of naïve foragers varied among iterations, we simulated 100 random walks per collared  
581 individual (*sensu* 62). For each of the 456 GPS collared (n=706 animal years) bighorn sheep and  
582 moose (hereafter, "empirical foragers"), the distribution of surfing ability across all 100



simulated random walks was not normally distributed (Shapiro-Wilk test), so we considered the median surfing ability of all 100 random walks as the surfing ability for each naïve forager. Each simulated individual began foraging at the same location and date as its paired empirical forager (i.e., a collared sheep or moose). To measure the amount of information each individual possessed about local patterns of plant phenology, we calculated an index of surfing knowledge as follows:

$$\text{Eq. 1.} \quad 1 - \frac{\text{abs}(\text{omniscient} - \text{empirical})}{\text{abs}(\text{omniscient} - \text{naïve})}$$

By comparing the surfing ability of collared individuals with those of the simulated omniscient and naïve individuals, the index of surfing knowledge not only accounts for different patterns of phenology in each landscape, but also provides a measure of how proficient individuals are at surfing relative to the surfing opportunity provided by the local environment (Fig. S1).

*Species-Specific Habitat Delineation*— To ensure that the simulated movements of omniscient and naïve foragers were realistic (in the sense that a simulated forager did not use locations on the landscape that a real moose or sheep would not), we delineated species-specific habitat across the study region by using resource selection functions (63). GPS collar locations from historical populations more accurately reflect migratory behavior and optimal habitat selection than the locations of recently translocated individuals who had less time to acquire information about their environment. Therefore, we parameterized resource selection functions using only the GPS locations of individuals from historical populations along with a suite of habitat and topographic variables known to be important to bighorn sheep and moose in the region (55, 64, 65; Table S2).

To delineate species-specific habitat across the study region we quantified 2<sup>nd</sup> order resource selection (66) using a classic use vs. availability design (63). In contrast to the more common analyses of 3<sup>rd</sup> order habitat selection, where used (observed) locations are compared to available (random) locations within a home range to infer fine-scale habitat selection, a 2<sup>nd</sup> order analysis of habitat selection compares used locations to available location across a much larger (landscape) scale to infer more broad scale selection of habitats associated with placement of the home range (63). Therefore, we sampled a random location across the entire study area for every observed GPS location because we our goal was to identify species-specific habitat use rather than individual selection for specific habitat characteristics. After extracting covariate values to both used and available locations, we centered and scaled covariates prior to fitting generalized mixed-effect models (GLMM; 67). We used forward step-wise model selection and Akaike's Information Criterion (AIC) to identify the most parsimonious resource selection function (68). We further evaluated model fit for each species by performing a K-folds cross validation (k=10, repeated 100 times; 69). K-folds cross validation indicated that our models performed well (bighorn sheep  $r_s=0.87\pm0.03$ , moose  $r_s=0.88\pm0.02$ ). We considered species-specific habitat to be any raster cell with a probability-of-use value above the 50<sup>th</sup> quantile of the distribution of selection probabilities (i.e., high probability of use areas; 70).

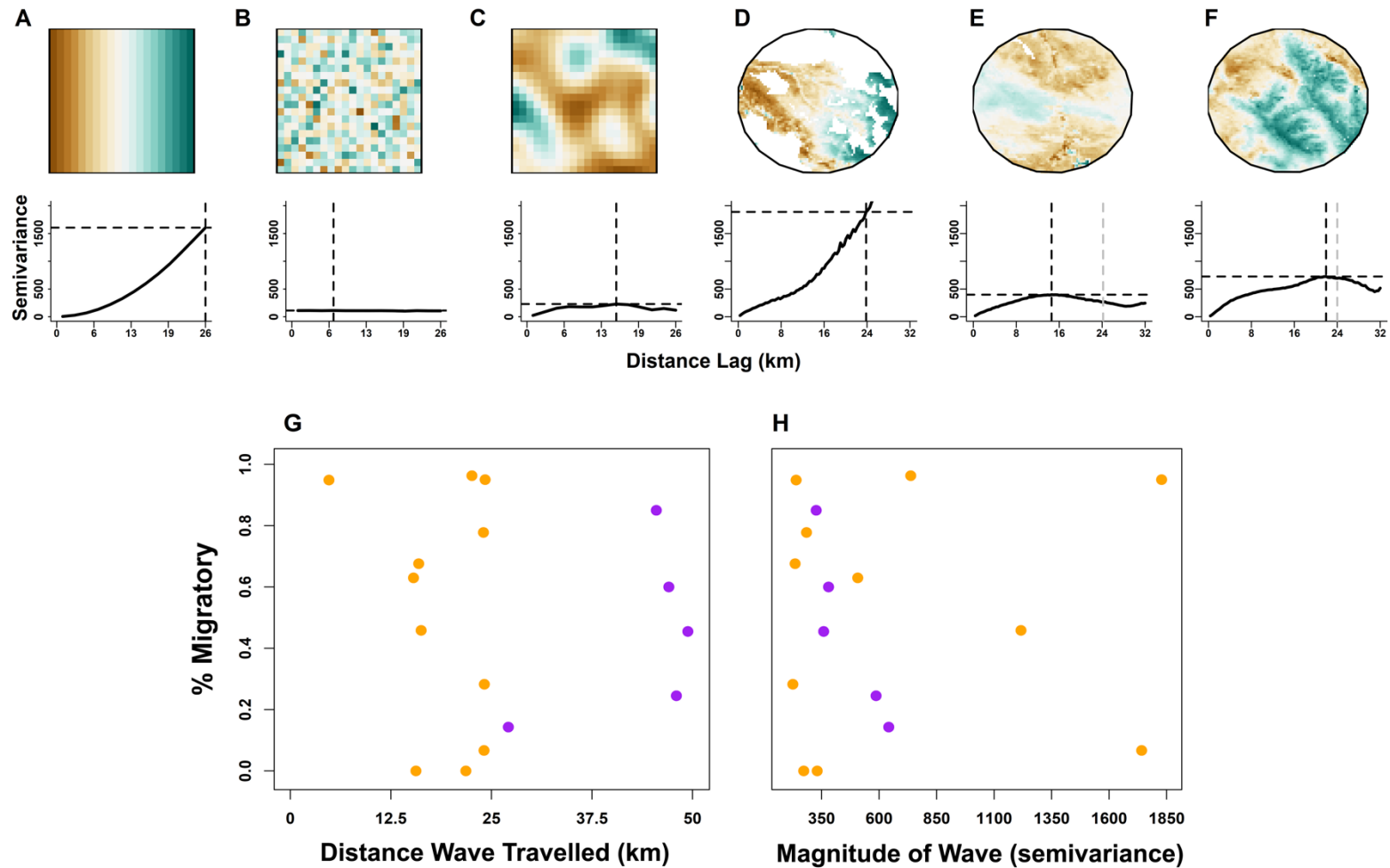
*Statistical Assessment of Social Learning and Culture*— We used GLMs and GLMMs to quantify the effect of opportunity for cultural transmission (time in years) had on surfing knowledge (Fig. 3A), the influence of surfing knowledge on migratory propensity (Fig. 3B), and the influence of time on migratory propensity (Fig. 3C). We fit models with and without random intercepts, random slopes, and random intercepts and slopes with species (moose and bighorn sheep) as the

random effect. We estimated model parameters using maximum likelihood and compared models using likelihood ratio tests (71). Mixed effect models indicated that sheep and moose had similar intercepts and slopes in all models ( $P > 0.5$  for all log likelihood ratios). All models were statistically significant (all  $P < 0.01$ ). All analyses and simulations were performed in Program R (72).

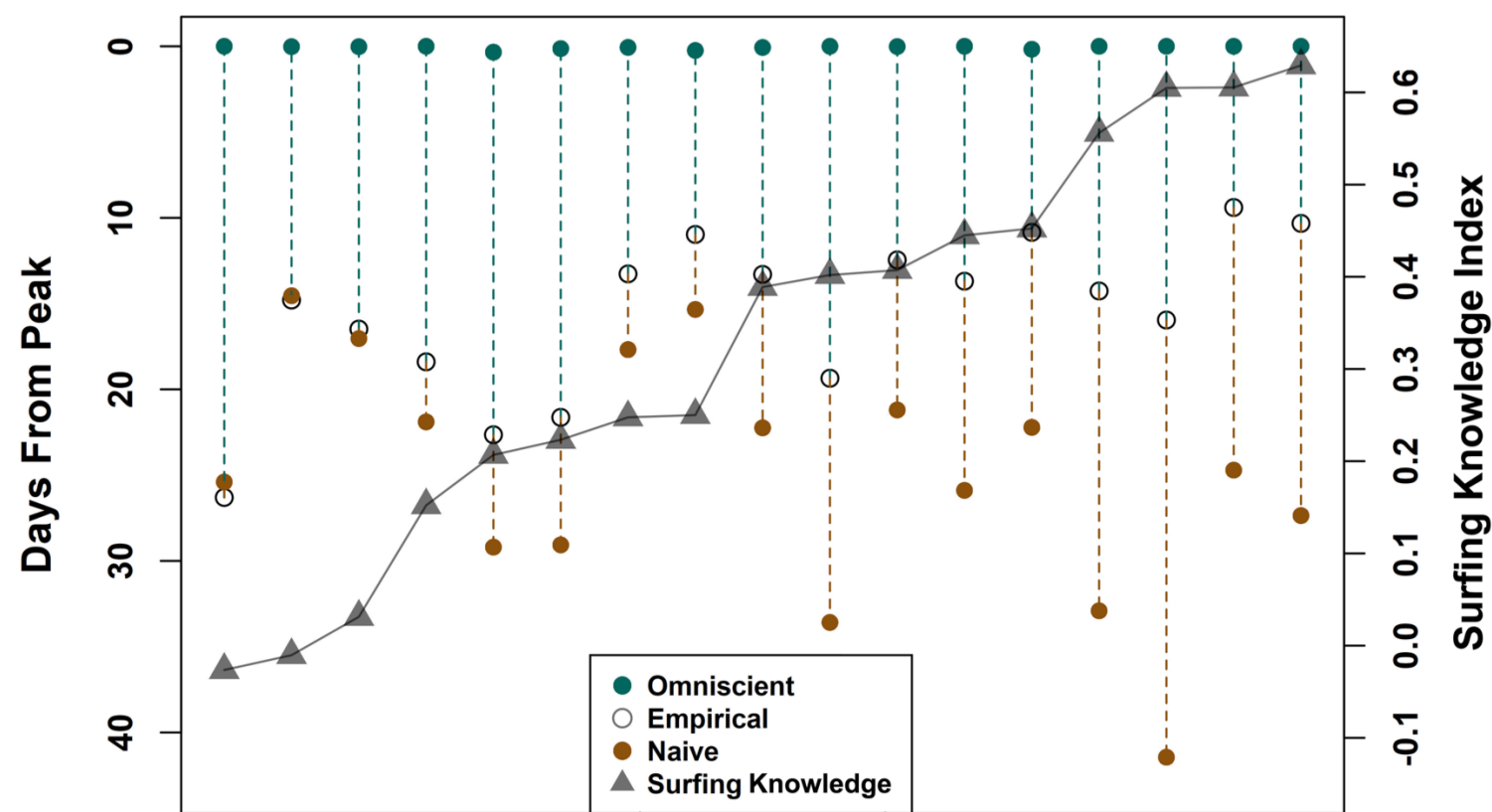
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**Fig. S1. Illustration of how landscape suitability for migration was measured.** Simulated (A) perfect green wave (i.e., phenological gradient), (B) heterogeneous landscape with no green wave, and (C) landscape intermediate to A and B, as well as observed green waves in (D) Devils Canyon, (E) Seminoe, and (F) Jackson. Brown pixels represent areas where the date of peak forage quality occurred early, whereas green pixels represent relatively late peaks in forage quality. X-axis represents the distance travelled by green waves (distance lag in km) and y-axis represents magnitude of the green wave (semivariance). Dashed lines illustrate maximum semivariance (horizontal), maximum distance lag (vertical), and the  $\frac{3}{4}$  cutoff (grey) used to eliminate ‘edge’ effects. No relationship was found between migratory propensity and the (G) distance green waves travelled or (H) the magnitude of green waves available to all 17 populations of bighorn sheep (orange) and moose (purple), indicating that landscape characteristics alone cannot explain the presence or absence of migration.



778 **Fig. S2. Heuristic demonstration of how surfing knowledge was calculated.** The phenology tracking (surfing) abilities of simulated  
 779 omniscient (black circles), simulated naïve (red circles), and empirical (open circles) bighorn sheep and moose were used to calculate  
 780 an index of mean surfing knowledge (green triangles). Population-level (n=17) means are plotted to illustrate the appropriateness of  
 781 our surfing knowledge index for quantifying how well observed populations were able to track high-quality forage relative to  
 782 simulated individuals in real landscapes. Graphically, equation 1 and the surfing knowledge index represents how close to  
 783 omniscience (complete knowledge of forage quality distribution on their landscape) or naïveté (no knowledge of forage quality  
 784 distribution on their landscape) empirical individuals, and hence populations, surfed green waves. Therefore, the surfing knowledge  
 785 index simultaneously controls for local variation in the distribution of high-quality forage and represents how much information  
 786 individuals and populations have about distribution of high-quality forage on their landscapes.  
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**Table S1. Data illustrating study design of translocation experiment.** For convenience in plotting and analyzing the effect of time on the migratory propensity of bighorn sheep, we use ca 1800 as year of establishment because these populations have persisted since the time European Americans settled western North America (31). Moose were not present in WY and ID when European-American settlers first arrived, but were rather first observed around the turn of the twentieth century (43). Population age is either (i) the difference between the year a population was established and the year in which GPS collars were deployed on individuals or (ii) zero if collars were deployed at the time of translocation. Double crosses (‡) reflect populations where GPS-collared bighorn sheep were translocated into previously extirpated landscapes where small populations of bighorn sheep (<200 individuals) had been established approximately three decades prior. Sample size (n) refers to the number of animal years (i.e., total number of years individuals were monitored). Source populations of each translocation and bibliographical references describing the migratory behavior of each source population are provided.

Species	Population	Pop. Type	Pop. Age	(n)	Source Population(s)	References
<i>Ovis canadensis</i>	East Fork Salmon R.	historical	216	51	–	–
<i>Ovis canadensis</i>	Whiskey Basin	historical	212	44	–	–
<i>Ovis canadensis</i>	Jackson	historical	211	43	–	–
<i>Ovis canadensis</i>	Grand Teton	historical	209	43	–	–
<i>Alces alces</i>	Clearwater	historical	111	29	–	–
<i>Alces alces</i>	Jackson	historical	108	67	–	–
<i>Alces alces</i>	Sublette	historical	82	119	–	–
<i>Alces alces</i>	Sand Creek	historical	82	14	–	–
<i>Ovis canadensis</i>	N. Beaverhead Range	translocated	35	18	Salmon River, ID; Jasper National Park, AB	Idaho Fish and Game Department (38)
<i>Ovis canadensis</i>	S. Beaverhead Range	translocated	35	10	Salmon River, ID	Idaho Fish and Game Department (38)
<i>Ovis canadensis</i>	N. Lemhi Range	translocated	32	45	Salmon River, ID; Jasper National Park, AB	Idaho Fish and Game Department (38)
<i>Ovis canadensis</i>	S. Lemhi Range	translocated	30	25	Whiskey Basin, WY	Idaho Fish and Game Department (38)
<i>Alces alces</i>	Snowy Range	translocated	20	57	Jackson, WY	Brimeyer and Thomas (44)
<i>Ovis canadensis</i>	Elk Mountain	translocated	8	10	Georgetown, CO	Parr (33), Colorado Parks and Wildlife (35)
<i>Ovis canadensis</i>	Devils Canyon	translocated	0	44	Whiskey Basin, WY; Junction Sheep Range Provincial Park, BC; Missouri River Breaks, MT	Hickey (36), Sugden (37), Kauffman et al. (40)
<i>Ovis canadensis</i>	Laramie Range	translocated	0 <sup>‡</sup>	42	Whiskey Basin, WY; Paradise-Perma, MT	Beyer (34)
<i>Ovis canadensis</i>	Seminole Range	translocated	0 <sup>‡</sup>	45	Junction Sheep Range Provincial Park, BC; Devils Canyon, WY	Clapp (39)

2 **Table S2. Parameters used to build resource selection functions.** Parameter names match those presented in Table S3. All parameters were  
 3 derived from 30m resolution raster data. For all discrete parameters, we calculated “distance to” (in meters) and “focal” (sum of the number cells  
 4 within a 1km circular moving window) parameters in ArcGIS (Environmental Systems Research Institute, Redlands, CA). Data references are both  
 5 the raster data sources as well as the ArcGIS and Program R tools used to derive metrics from the data. Parameter references are literature from  
 6 which the important parameters were identified. Species “BS” refers to bighorn sheep and “M” refers to moose. Asterisks indicate variables that were  
 7 excluded from final RSF models through the model selection procedure.  
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Parameter	Data Type	Data Reference	Parameter Reference	Species
<i>Topographic</i>				
Escape Terrain	Discrete	National Elevation Dataset (74)	Sappington et al. (73)	BS
Topographic Roughness*	Continuous	National Elevation Dataset (74), Evans (75)	Sappington et al. (73)	BS
Elevation	Continuous	National Elevation Dataset (74)	Baigas (65), Becker (64), Courtemanch et al. (55)	BS, M
Linear Aspect	Continuous	National Elevation Dataset (74), Evans et al. (76)	Baigas (65), Becker (64), Courtemanch et al. (55)	BS, M
Slope	Continuous	National Elevation Dataset (74), ESRI	Baigas (65), Becker (64), Courtemanch et al. (55)	BS, M
Slope <sup>2</sup>	Continuous	National Elevation Dataset (74), ESRI	Baigas (65)	M
Compound Topographic Index	Continuous	National Elevation Dataset (74), Evans et al. (76)	sensu Becker (64)	M
Topographic Position Index*	Continuous	National Elevation Dataset (74), Evans (75)	sensu Courtemanch et al. (55), Valdez and Krausman (31)	BS
Heat Load Index	Continuous	National Elevation Dataset (74), Evans et al. (76)	Monteith et al. (77)	M
<i>Habitat</i>				
Willow	Discrete	National Land Cover Database (78)	Baigas et al. (65), Becker (64), Valdez and Krausman (31)	BS, M
Wetland	Discrete	National Land Cover Database (78)	Baigas et al. (65), Becker (64), Valdez and Krausman (31)	BS, M
Shrub	Discrete	National Land Cover Database (78)	Baigas et al. (65), Becker (64), Valdez and Krausman (31)	BS, M
Grass	Discrete	National Land Cover Database (78)	Baigas et al. (65), Becker (64), Courtemanch et al. (55)	BS, M
Conifer Forest	Discrete	National Land Cover Database (78)	Baigas et al. (65), Becker (64), Courtemanch et al. (55)	BS, M
Deciduous Forest	Discrete	National Land Cover Database (78)	Baigas et al. (65), Becker (64), Courtemanch et al. (55)	BS, M
Mixed Deciduous-Conifer Forest	Discrete	National Land Cover Database (78)	Baigas et al. (65), Becker (64), Courtemanch et al. (55)	BS, M
All Forest	Discrete	National Land Cover Database (78)	Baigas et al. (65), Becker (64), Courtemanch et al. (55)	BS, M



0 **Table S3. (A) Bighorn sheep and (B) moose resource selection functions.** All variables were centered and scaled prior to model fitting, meaning  
1 parameter estimates ( $\beta$  coefficients) reflect relative effect sizes.

2 **A**

Sheep RSF Models	Intercept	Escape Terrain Distance	Grass Distance	Wetland Distance	Forest Focal	Shrub Distance	Willow Distance	Escape Terrain Focal	Grass Focal	Shrub Focal	DF	LogLik	AICc	Delta	Weight
Model 9	-7.58	-18.72	-3.22	-2.04	0.34	-1.29	-1.24	0.74	1.50	1.14	11	-3663.32	7348.65	0.00	1.00
Model 8	-7.44	-18.62	-3.19	-1.97	-0.64	-1.81	-1.20	0.66	0.63	-	10	-3704.81	7429.64	80.99	0.00
Model 7	-7.50	-18.53	-4.16	-1.94	-0.96	-1.34	-1.09	0.73	-	-	9	-3772.59	7563.19	214.54	0.00
Model 6	-9.17	-23.82	-4.48	-1.84	-0.91	-1.10	-1.01	-	-	-	8	-3913.72	7843.45	494.80	0.00
Model 5	-8.90	-22.90	-4.50	-2.64	-0.86	-1.22	-	-	-	-	7	-4060.27	8134.55	785.90	0.00
Model 4	-8.38	-22.07	-4.31	-2.69	-0.91	-	-	-	-	-	6	-4257.70	8527.41	1178.76	0.00
Model 3	-8.44	-19.63	-6.68	-2.81	-	-	-	-	-	-	5	-4589.90	9189.81	1841.16	0.00
Model 2	-7.78	-18.98	-7.02	-	-	-	-	-	-	-	4	-5431.03	10870.07	3521.42	0.00
Model 1	-6.60	-20.61	-	-	-	-	-	-	-	-	3	-7846.09	15698.18	8349.53	0.00
Intercept	0.00	-	-	-	-	-	-	-	-	-	2	-13449.83	26903.66	19555.01	0.00

3

4 **B.1**

Moose RSF Models	Intercept	Wetland Distance	Grass Focal	Mixed Forest Distance	Decid. Forest Distance	Wetland Focal	Willow Distance	Shrub Distance	Willow Focal	Conifer Forest Focal	Heat Load Index	Conifer Forest Distance	Mixed Forest Focal	Grass Distance	Slope <sup>2</sup>
Model 16	-3.39	-4.87	-1.84	-7.27	2.43	1.22	-1.71	-0.83	0.67	0.20	0.29	-0.66	-0.23	0.17	-0.12
Model 15	-3.36	-4.85	-1.81	-7.24	2.42	1.24	-1.71	-0.77	0.70	0.26	0.30	-0.66	-0.22	0.17	-0.12
Model 14	-3.36	-4.84	-1.80	-7.25	2.41	1.23	-1.70	-0.78	0.69	0.27	0.29	-0.68	-0.22	0.17	-0.09
Model 13	-3.38	-4.87	-1.83	-7.26	2.40	1.24	-1.71	-0.77	0.69	0.26	0.27	-0.65	-0.22	0.16	-
Model 12	-3.42	-4.80	-1.92	-7.33	2.42	1.25	-1.71	-0.75	0.69	0.25	0.27	-0.65	-0.22	-	-
Model 11	-3.38	-4.87	-1.91	-7.15	2.42	1.25	-1.68	-0.78	0.69	0.26	0.27	-0.65	-	-	-
Model 10	-3.46	-4.90	-1.85	-7.69	2.43	1.29	-1.70	-0.81	0.63	0.37	0.27	-	-	-	-
Model 9	-3.42	-4.83	-1.79	-7.74	2.41	1.29	-1.63	-0.88	0.65	0.40	-	-	-	-	-
Model 8	-3.46	-4.56	-2.04	-8.22	2.56	1.24	-1.71	-0.78	0.53	-	-	-	-	-	-
Model 7	-3.36	-4.47	-2.07	-7.85	2.63	1.43	-2.13	-0.75	-	-	-	-	-	-	-
Model 6	-3.39	-4.80	-1.98	-7.94	2.59	1.41	-1.97	-	-	-	-	-	-	-	-

Model 5	-3.17	-6.30	-1.99	-7.47	2.24	1.55	-	-	-	-	-	-	-	-
Model 4	-3.59	-8.17	-2.12	-5.53	1.94	-	-	-	-	-	-	-	-	-
Model 3	-2.50	-6.72	-2.23	-2.73	-	-	-	-	-	-	-	-	-	-
Model 2	-2.10	-7.18	-2.26	-	-	-	-	-	-	-	-	-	-	-
Model 1	-1.54	-6.71	-	-	-	-	-	-	-	-	-	-	-	-
Intercept	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-

B.2

Moose RSF Models	Compound Topographic Index	Shrub Focal	DF	LogLik	AICc	Delta	Weight
Model 16	-0.10	-0.09	18	-4760.10	9556.22	0.00	0.59
Model 15	-0.09	-	17	-4761.53	9557.08	0.86	0.39
Model 14	-	-	16	-4765.58	9563.19	6.97	0.02
Model 13	-	-	15	-4768.94	9567.91	11.69	0.00
Model 12	-	-	14	-4774.70	9577.42	21.20	0.00
Model 11	-	-	13	-4799.79	9625.60	69.38	0.00
Model 10	-	-	12	-4825.70	9675.41	119.19	0.00
Model 9	-	-	11	-4880.85	9783.72	227.50	0.00
Model 8	-	-	10	-4949.27	9918.56	362.34	0.00
Model 7	-	-	9	-5026.49	10070.99	514.77	0.00
Model 6	-	-	8	-5196.47	10408.95	852.73	0.00
Model 5	-	-	7	-5574.88	11163.77	1607.55	0.00
Model 4	-	-	6	-6108.91	12229.83	2673.61	0.00
Model 3	-	-	5	-6948.51	13907.03	4350.80	0.00
Model 2	-	-	4	-7740.81	15489.62	5933.40	0.00
Model 1	-	-	3	-9766.79	19539.58	9983.36	0.00
Intercept	-	-	2	-15463.42	30930.84	21374.62	0.00

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