Wildlife Biology

WLB-00290

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Appendix 1

We examined underlying habitat selection during travel to aid model diagnostics of the SSF by conducting a resource selection function (RSF). RSFs are mathematical functions that estimate use proportionally to availability (Manly et al. 2002). We used ArcGIS 10.2 (ESRI 2014) to gather underlying landscape characteristics of wolf use points (GPS locations). All point data and underlying covariate layers were transformed to Universal Transverse Mercator (UTM) Zone 6. UTM zone 6 is appropriate for measuring distances between points in our study region. In order to maintain statistical power, we only chose biologically plausible covariates that we thought could be related to wolf travel paths (Table 1). These landscape characteristics were used as covariates in our RSF and included distance to rivers, distance to waterbodies, and distance to ridgelines. We measured distance to rivers and waterbodies as the distance from a point to the nearest river or waterbody of the high-resolution National Hydrography Dataset at a scale of 1:24 000 (United States Geological Survey 2015). We measured distance to ridges as the distance of points to ridges derived from a 17-m resolution digital elevation model. We used the National Landcover Dataset (NLCD) from 2001 to generate underlying categorical habitat variables. We grouped NLCD into four broader categories based on habitat height. $NLCD_1$ was the water NLCD class, which includes water bodies or rivers greater than 30 × 30 m in width or area. $NLCD_2$ included shrub land cover of medium height. $NLCD_3$ included tall tree classes, and $NLCD_4$ included riparian or wetland classes with short or grassy vegetation. We assumed that some NLCD categories created efficient travel corridors in open habitats (e.g. $NLCD_1$, $NLCD_4$) and some created barriers to travel in tall or medium vegetation-height habitats (e.g. $NLCD_3$, $NLCD_4$) (James 2000).

We analyzed habitat selection by building an RSF model that controlled for variation within each pack. We used a generalized linear mixed-effects model (GLMM) with a logit link and a random intercept for each pack (DeCesare 2012). We assessed model data assumptions and found no evidence of multicollinearity (variance inflation factors of all predictor variables were <2). Our model choice controls for autocorrelation of locations within a pack, and selection by an individual wolf would be expected to be more similar within the pack, than between packs (Hebblewhite and Merrill 2008). Our RSF models compared underlying characteristics at used (1) and random available locations (0). We generated available points within a 95% kernel density estimate (KDE) area (Houle et al. 2010) at a 1-use: 1-available ratio. By utilizing 95% KDE, the analysis focused on the core home range of the wolf (DeCesare 2012, Houle et al. 2010). We utilized a 1:1 ratio for each pack because the number of points for each pack in the dataset ranged significantly (Table 2), and a pooled sample size of 5461 random points should adequately characterize the underlying data (DeCesare 2012, Johnson et al. 2006). We built our RSF model in R using the lme4 package and glmer function (<www.r-project.org>). To help with model stability and convergence, we scaled continuous variables by subtracting the mean and dividing by the standard deviation. NLCD classes were input with 'dummy indicator variables', with $NLCD_1$ being the reference regressor. We based model selection on the corrected Akaike information criterion (AIC_c) (Anderson et al. 1998, Gillies et al. 2006), with the model that best described the data having the lowest AIC_c model score.

We selected our final RSF GLMM model by using the smallest AIC_c and would consider models within two points of the lowest AIC_c. Based on AIC_c our global model achieved the best model fit (Table 3) and converged successfully. In the global model, coefficients of $NLCD_2$, $NLCD_4$, the scaled distance to water, and the scaled distances to ridges were large compared to their standard errors, suggesting that the factors were significant to the model (Table 4). Coefficients of $NLCD_3$ were not significant relative to the reference category. The coefficients of the analysis show very strong selection against $NLCD_2$ and mild selection against $NLCD_4$. A large, negative coefficient for distance to water suggests that as distances from water increase, the probability of selection decreases. To a lesser extent, a smaller, negative coefficient suggests that as distance from ridges increased, selection decreased. The results of the RSF suggest that wolves were selecting strongly against barriers to travel, such as shrub habitat, and strongly for frozen river corridors. The results are consistent with the SSF used in the final analysis.

Referenses

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Table A1. Results of model selection of generalized linear mixed-effects resource selection models for wolves *Canis lupus* in the Yukon Flats, Alaska during the winter of 2009–2010. All models included a random pack intercept. Sample sizes of use and available points were constant for each model (n use = 2385, n available = 5461). We report model structure, number of parameters (k), log likelihood (LL), and AIC corrected for small sample sizes (AIC_c).

Model name	Structure	LL	∆AICc
Global	use.corrected ~ nlcd + dist.water.all.s + dist.ridge.s + (1 | ID)	-4192.9	0
Distance from ridges and land cover classes	use.corrected ~ nlcd + dist.ridge.s +(1 | ID)	-4215.1	42.2
Land cover classes	use.corrected ~ nlcd + (1 | ID)	-4327.7	267.5
Distance from water	use.corrected ~ dist.water.s + (1 | ID)	-4342.9	296
Distance from water and land cover classes	use.corrected ~ nlcd + dist.water.all.s+ (1 | ID)	-4778.6	1163.3
Distance from ridges	use.corrected ~ dist.ridge.s + (1 | ID)	-4780.8	1167.8

Table A2. Coefficient output for best-fit generalized linear mixed-effects model of four National Land Cover Dataset (NLCD) habitat types and two linear variables. Habitat variables and distance to water were computed from locations of collared wolves *Canis lupus* in the Yukon Flats, Alaska in the winter of 2009–2010 The model formula was (use ~ NLCD $_{(4\ levels,\ cat.)}$ + Distance water $_{(scaled,\ cont.)}$ + Distance ridges $_{(scaled,\ cont.)}$ + (1 | ID) $_{(random\ intercept)}$). The p-value (Pr(>|z|), was not significant for $NLCD_3$, and although is not significant for $NLCD_1$, it is not interpretable for the intercept.

	Estimate $_{z\text{-value}}$	Std. Error	z-value	Pr(>|z|)
NLCD $_{1\ (Intercept)}$	-0.3769	0.1593	-2.365	0.018
NLCD $_2$	-2.9609	0.1896	-15.614	<0.0001
NLCD $_3$	0.1437	0.1304	-1.102	0.27
NLCD $_4$	-0.737	0.1529	-4.82	<0.0001
Distance water $_{scaled}$	-0.5161	0.0344	-14.99	<0.0002
Distance ridges $_{scaled}$	-0.14628	0.0273	-5.359	<0.0003