LATE WINTER HABITAT SELECTION BY SHEEP IN THE DAWSON REGION

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Summary

- Access to suitable late winter habitat is important for Dall's sheep. I evaluated late winter habitat selection by sheep in the Dawson region using resource selection functions (RSFs), which I built using sheep survey data collected 12–15 March 2009.

- These RSFs incorporated information on habitat types available to sheep, and those habitat types that sheep were observed using, and calculated relative probabilities of use by sheep for the entire study area.

- Of the candidate models, the best-supported model showed that sheep selected for areas with high elevation, high convexity, high ruggedness and a southerly aspect, and selected against areas distant from escape terrain and with northerly aspects.

- This model accurately predicted late winter habitat selection by sheep in the Dawson region.

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Introduction

In late winter, Dall's sheep require access to exposed slopes for feeding. Areas where wind and/or solar radiation expose alpine vegetation in late winter are of critical importance to Dall's sheep, as they allow sheep easy access to low-growing forage (Walker et al. 2007). Where snow accumulates, the energetic costs of removing snow overwhelms the benefit gained from the vegetation beneath. Such late winter feeding areas typically comprise only a small percentage of the sheep's annual range, and access to late winter habitat is presumed to be a limiting factor for Dall's sheep (Barichello et al. 1987, Walker et al. 2007). Identification and protection of late winter habitat is thought to be critical to maintaining sheep populations.

Methods and Results

Data collection

From 12 to 15 March 2009, Environment Yukon Species Program staff performed helicopter surveys of the western Ogilvie Mountains and south Nahoni Range. Staff recorded photos and locations of sheep or sheep tracks. Surveys were a combination of transects between randomly chosen locations, and of searches guided by a local outfitter familiar with sheep habitat in the northern Dawson region. Survey efforts resulted in 201 locations for individual sheep, sheep groups, or sheep tracks.

Habitat modeling: resource selection functions

I created models for late winter habitat selection by Dall's sheep in the Dawson region using resource selection functions (RSFs; Manly et al. 2002). Briefly, RSFs use characteristics of samples of used and available resource units to provide values for resource units that are proportional to their probability of their being used by the study organism.

Variable selection

In this case, I built candidate RSFs using ecogeographical variables from 201 sheep locations (considered to be 'used' locations) and 1000 'available' locations seeded at random within the study area. The ecogeographical variables I used were derived from a 30 m resolution digital elevation model (DEM), and were related to topography and aspect. To incorporate spatial error inherent in sheep locations and the DEM, and to better characterize variables affecting site selection by sheep, I calculated variables from a 200 m radius buffer surrounding each 'used' and 'available' location. I examined all variable pairs for correlation before continuing with model-building, segregating pairs with Pearson's r >0.70.

Elevation_Max = maximum elevation (m) within a 200 m radius buffer of each pixel

Curvature_Max = maximum curvature value (as calculated as the second derivative of the 30 m DEM) within a 200 m radius buffer of each pixel

Escape_Mean = mean distance to 'escape terrain', defined as areas where slope > 27˚ (*sensu* DeCesare and Pletscher 2006), within a 200 m radius buffer of each pixel

Rugged_Mean = mean ruggedness, measured as the dispersion of vectors orthogonal to the 30 m DEM surface, within a 200 m radius buffer of each pixel

North = sum of 30 m pixels with an aspect between 315˚ – 45˚ within a 200m radius buffer of each pixel

South = sum of 30m pixels with an aspect between 135˚ – 225˚ within a 200m radius buffer of each pixel

Model construction

Candidate RSFs took the exponential form:

$$w(x) = \exp(\beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 \ldots + \beta_i x_i)$$

Where x_i is the value of the i^{th} ecogeographical variable for each considered resource unit, and β_i is the coefficient value assigned to the i^{th} ecogeographical variable for each considered resource unit. Covariate values were estimated using logistic regression (Manly et al. 2002).

I evaluated 7 candidate RSFs, each considering a different combination of ecogeographical variables as the best predictor of late winter habitat use by sheep. I developed the form of candidate RSFs *a priori* as ecologically meaningful hypotheses concerning late winter habitat selection by sheep, thereby avoiding the temptation to engage in "fishing" for a highly predictive (but ecologically uninformative) RSF structure.

Global

Elevation_Max + *Curvature_Max* + *Escape_Mean* + *Rugged_Mean* + *North* + *South*

Feeding Site Driven

Elevation_Max + *Curvature_Max* + *North* + *South*

Escape Terrain Driven

Elevation_Max + *Escape_Mean* + *Rugged_Mean*

Terrain Driven

Elevation_Max + *Curvature_Max* + *Escape_Mean* + *Rugged_Mean*

Aspect Driven

Elevation_Max + *North* + *South*

Ruggedness Driven

Elevation_Max + *Rugged_Mean*

Ruggedness and Aspect Driven

Elevation_Max + *Rugged_Mean* + *North* + *South*

Model selection

I evaluated the 7 candidate RSFs using Akaike's Information Criterion, which weighs a model's capacity for self-prediction against model complexity (Burnham and Anderson 2002). The Global model was ranked most parsimonious, and took the form:

$$w(x) = \exp(0.001*Elevation\_Max + 0.365*Curvature\_Max - 0.005*Escape\_Mean + 6.394*Rugged\_Mean - 0.005*North + 0.004*South)$$

Model interpretation

Positive coefficient values for *Elevation_Max*, *Curvature_Max*, *Rugged_Mean* and *South* in the Global model demonstrate a tendency for sheep to select for resource units with high values for these ecogeographical variables during late winter. Sheep selected for areas of high elevation in close proximity of highly convex and rugged topography, with a preference for southerly aspects. Negative coefficients for *Escape_Mean* and *North* denote selection against areas distant from escape terrain (slopes >27˚) and areas with a northerly aspect. These results are unsurprising given their similarity to habitat selection patterns observed in other sheep populations.

Without a measure for snow depth, the observed selection for convex topography may relate to selection for ridges, which are often windswept and relatively free of snow. Selection for southerly aspects (and against northerly aspects) may also relate to snow depth, with south-facing slopes receiving more solar radiation, and consequently accumulating less snow. This selection pattern may also reflect patterns in vegetation growth, with more forage available on sunnier slopes. Sheep may also be gaining a thermal advantage from selecting for southerly aspects. Selection for rugged topography, and against areas distant from escape terrain likely relates to predation risk management by sheep.

Model validation

I assessed the predictive performance of the Global model using k-fold cross-validation (Boyce et al. 2002). I randomly assigned “used” and “available” locations into 5 data subsets of equal size. I then used each data subset as a validation sample for RSFs trained using data from the remaining four subsets. I classed resulting RSF values derived from the validation data subset into 10 ranked bins, each containing roughly $1/10^{th}$ of the pixel RSF values within the entire study area. For used locations in each data subset in turn, I calculated RSF values using RSFs built from the remaining 4 subsets. I then binned used locations for each subset according to their predicted RSF value. I adjusted bin frequencies by dividing them by the actual area of the study area contained within each bin. A positive, significant Spearman Rank Correlation between bin rank and area-adjusted frequency rank denotes a model with good predictive performance.

Bin rank and area-adjusted frequency rank for both the individual data subsets (Figures 1 and 2) and mean values showed positive and strongly significant Spearman Rank Correlations. The Global model is a good predictor of habitat use by sheep within the study area.

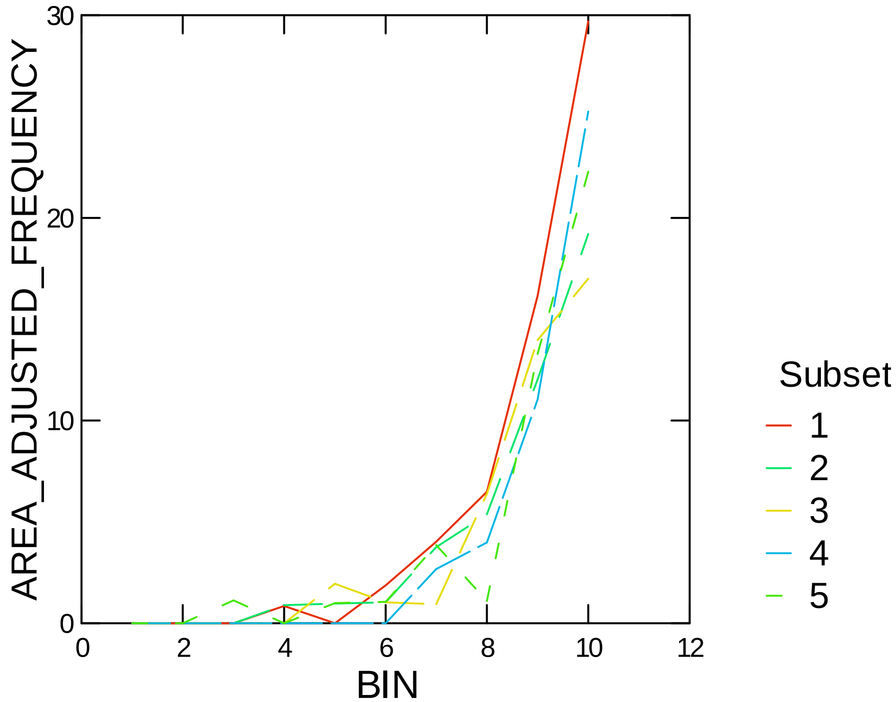

Figure 1. Individual area-adjusted frequencies of sheep locations (divided at random into 5 equal data subsets) within 10 ranked RSF value bins.

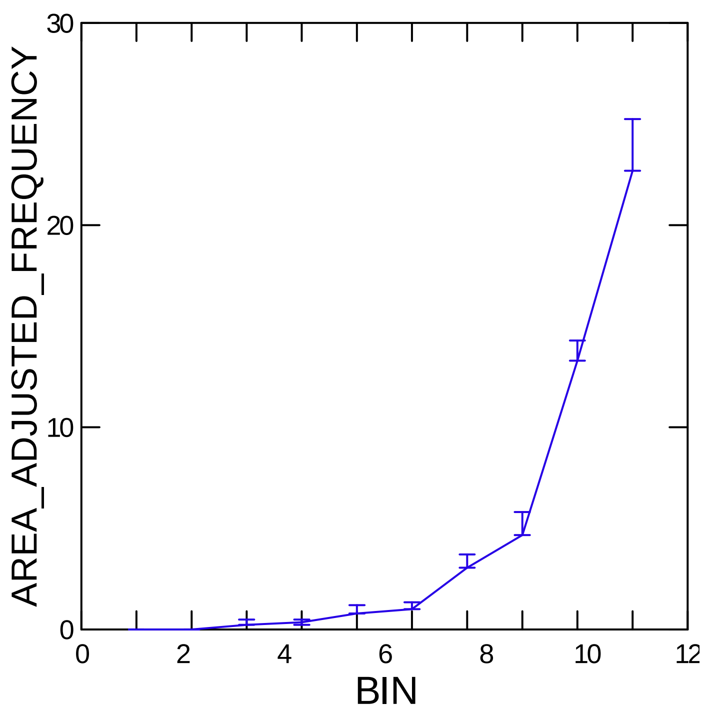

Figure 2. Mean (±SE) area-adjusted frequency of sheep locations (as determined individually for 5 randomly-selected data folds) within 10 ranked RSF value bins. Spearman rank correlation for the mean data = 0.912, p<0.0001.

Extrapolation of the model to the entire Dawson Planning Region

I then applied the sheep winter habitat RSF, determined within the study area, to the whole Dawson Planning Region (Figure 3). The predictive performance of the RSF outside of the study area used to build it is not quantifiable without sheep locations for validation. Extrapolation of the model beyond the study area, however, provides an "educated guess", with an unknowable error term, on the relative probability of use of other areas in the Dawson Planning Region by sheep in late winter.

As the predicted relative probabilities of use south of the Yukon River and Klondike Highway were negligible, only the northern Dawson Planning Region is shown.

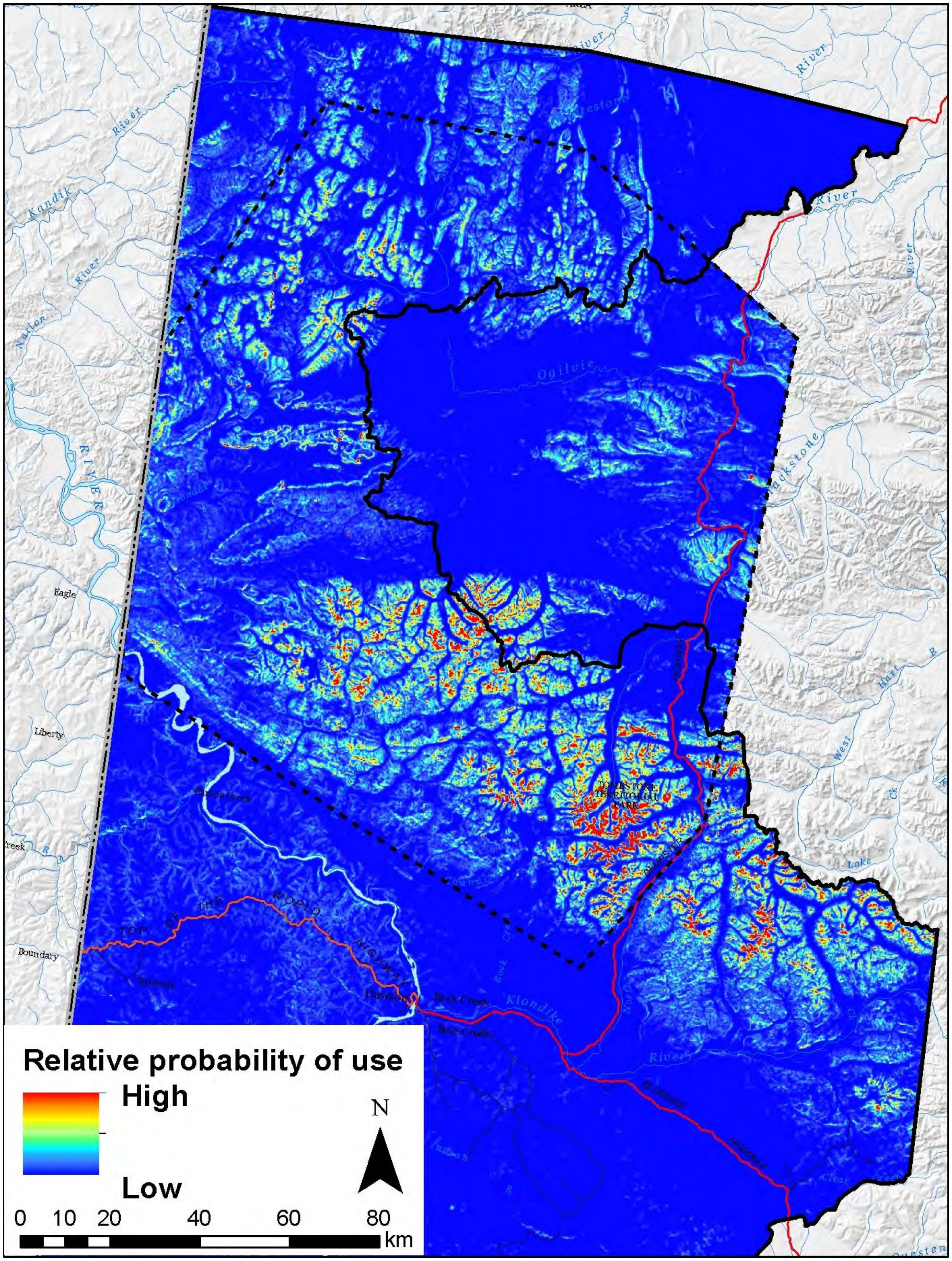

Figure 3. Relative probability of habitat use by Dall's sheep in late winter within the study area (dashed outline) and extrapolated to the larger Dawson Land Use Planning Region (solid outline).

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