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Supplementary material

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Appendix 1: Description of GIS-based spatial landscape covariates

To address our research questions we used a suite of geographic information system (GIS) raster data sets characterizing habitat that caribou and moose used (Table A1). We used a digital elevation model (DEM) to estimate elevation (m) and slope (degrees). Vegetation was characterized by 13 categorical landcover layers, which were calculated on the basis of landcover type (10 classes; e.g., Upland Trees, Shrubs, Snow/Ice), forest canopy closure and tree species composition. These three layers were produced with Landsat 5 and 7 Thematic Mapper sensors (McDermid et al. 2005). Closed conifer was used as the reference category in habitat use models and thus always subsumed into the intercept. Alpine landcover types were delineated by estimating tree line, which was modeled through a curvilinear relationship between latitude and tree line along the north-south study area gradient following Paulsen and Körner (2001). Two landcover types, burns and clear-cuts, were produced based on combined data from British Columbia (BC) Ministry of Forests and Range Data Models (British Columbia Ministry of Sustainable Resource Management 2010), British Columbia Forest Vegetation Composite Polygons and Rank 1 data (British Columbia Ministry of Sustainable Resource Management 2009), data from the Foothills Research Institute Grizzly Bear Program (FRIGBP) and the Alberta Sustainable Resource Development.

Normalized Differential Vegetation Index (NDVI) can be used as an index of vegetation productivity (greenness) to characterize green forage biomass (Hebblewhite et al. 2008, Pettorelli et al. 2005). We estimated NDVI during the growing season using 16-day composites derived from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS, MOD13Q1; Huete et al. 2002). Hebblewhite et al. (2008) estimated the mean growing season from 3 May (Julian day 123) to 9 October (Julian day 282) near Banff National Park. Because the growing season decreases with increasing latitude, we estimated average NDVI based on these growing season dates, but used the

closest day after 3 May and before 1 October (Julian day 129 and 273) at a 250 m resolution for which MODIS data were available for our calculations. Percent snow cover was estimated from 8-day composites of maximum snow extent maps at a 500m resolution produced by MODIS satellites (MOD10A2; Hall et al. 2000). The number of days snow occupied a cell was divided by the number of days in the seasonal period to derive spatial models of percent snow cover. Season start and end dates were the same as for logistic regression models (i.e. summer = 16 May – 16 October, winter = 17 October – 15 May). For all habitat use analyses we calculated NDVI and snow cover values by using the layer of the corresponding year of the GPS locations. Spatial predictions were made using average NDVI and seasonal percent snow layers for winters 2007, 2008 and 2009 and for summers 2008 and 2009.

Besides forest harvesting impacts, human disturbance was further estimated from a variety of vector geodatabases of roads, seismic exploration lines, railways, pipelines and human trails (Alberta Sustainable Resource Developement –Resource Information Management Branch and digitized 2004 Satellite Personal Tracker (SPOT) imagery and 1:250 000 National Topographic System (NTS) maps). We calculated density layers for roads and linear features (km/ km^2) in the Spatial Analyst extension for ArcGIS® Desktop 9.3.1 software.

Table A1. Description of covariates used in redundancy analyses and to determine differences in habitat use between moose and woodland caribou (data collected 2007 – 2010) in west-central Alberta and east-central British Columbia, Canada.

Covariate	Type	Resolution	Covariate Description
Human/Natural Disturbance			
Road Density	Continuous	30	Road density calculated for each cell (km/ km^2) in a 1 km radius based on a composite roads data layer.
Line Density	Continuous	30	Density of seismic exploration lines, hiking trails, railways and pipelines for each cell (km/ km^2) in a 1 km radius based on a composite linear features data layer.
Cut-block	Categorical	30	Cut-blocks <60 years old.
Burn	Categorical	30	Burns <60 years old.
Cut-block density	Continuous	30	Density of cut-blocks (%area/100) within a 3km radius.
Topography			
Elevation	Continuous	30	Elevation in meters.
Slope	Continuous	30	Percent slope (0-89°).

Aspect	Continuous	30	S-N and W-E indices (-1 – 1)
		Other Variables	
Closed conifer	Categorical	30	Closed conifer forest with ≥ 50% canopy closure and ≥ 70% coniferous. Reference category.

Table A1. continued

Open conifer	Categorical	30	Open conifer forest ≤ 50% canopy closure and ≥ 70% coniferous.
Mixed forest	Categorical	30	Mixed forest ≥ 30%, but < 70% coniferous.
Deciduous	Categorical	30	Deciduous dominated forest < 30% coniferous.
Herbaceous	Categorical	30	Grasslands below tree-line.
Herbaceous Alpine	Categorical	30	Grasslands above tree-line.
Barren	Categorical	30	Barren ground below tree-line.
Barren Alpine	Categorical	30	Barren ground above tree-line.
Muskeg	Categorical	30	Treed and herbaceous wetlands at all elevations.
Shrub Alpine	Categorical	30	Shrub communities above tree-line.
Shrub Alpine	Categorica	30	Shrub communities below tree-line.

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Water	Categorica l	30	Water at all elevations.
Glacier	Categorica l	30	Permanent ice.
NDVI (Normalized Vegetation Index)	Continuou s	250	Mean of NDVI in non-forested habitats for growing season (-1 − 1).
Snow (s/w)	Continuou s	500	Seasonal average a raster cell has been covered by snow estimated for summer (16 May–16 October) and winter (17 October–15 May).

References

British Columbia Ministry of Sustainable Resource Management. 2009. Vegetation Resource Inventry - Forest Vegetation Composite Polygons and Rank 1 Layer. Resources Inventory Committee. BCGOV FOR Forest Analysis and Inventory Branch, Victoria, British Columbia, Canada. Accessed 05/20/2010. Available at: http://www.for.gov.bc.ca/hts/vridata/standards/index.html

British Columbia Ministry of Sustainable Resource Management. 2010. RESULTS - Openings. Resources Inventory Committee. BCGOV FOR FS Division Forest Practices Branch. Accessed: 05/20/2010. Available at: http://www.for.gov.bc.ca/his/datadmin/models/models.htm#models

Hall, D. K., Riggs, G. A. and Salomonson, V. V. 2000. MODIS/Terra snow cover 8-day L3. Global 500m Grid V03, February 2000 to February 2002. - National Snow and Ice Data Center. Digital media.

Hebblewhite, M., Merrill, E. and McDermid, G. 2008. A multi-scale test of the forage maturation hypothesis in a partially migratory ungulate population. - Ecol. Monogr. 78: 141-166.

Huete, A., Didan, K., Miura, T., Rodriguez, E. P., Gao, X. and Ferreira, L. G. 2002. Overview of the radiometric and biophysical performance of the MODIS vegetation indices. - Remote Sens. Environ. 83: 195-213.

McDermid, G. J., Franklin, S. E. and LeDrew, E. F. 2005. Remote sensing for large-area habitat mapping. - Prog. Phys. Geog. 29: 449-474.

Paulsen, J. and Körner, C. 2001. GIS-analysis of tree-line elevation in the Swiss Alps suggests no exposure effect. - J. Veg. Sci. 12: 817-824.

Pettorelli, N., Vik, J. O., Mysterud, A., Gaillard, J. M., Tucker, C. J. and Stenseth, N. C. 2005. Using the satellite-derived NDVI to assess ecological responses to environmental change. - Trends in Ecol. Evol. 20: 503-510.