# Supplementary material for:

# Future suitability of habitat in a migratory ungulate under climate change

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**Table S1.** Mean and median of sex-specific migration characteristics for red deer in Norway used in the resource selection functions.

|  |  |  |
| --- | --- | --- |
|  | **Females** | **Males** |
|  | *Mean* | *Median* | *Mean* | *Median* |
| Distance (km) | 17.8 | 14.2 | 25.7 | 20.2 |
| Duration spring migration (days) | 5.4 | 2 | 10.5 | 7 |
| Duration fall migration (days) | 4.3 | 2 | 8.1 | 4 |
| Direction winter to summer range (degrees) | 131 | 107 | 133 | 120 |

**Table S2.** Number of locations (obs), years, individuals (id) and individual ranges used in the resource selection functions for the two seasons (summer and winter) and sexes.

|  |  |  |
| --- | --- | --- |
|  | **Summer** | **Winter** |
|  | *Females* | *Males* | *Females* | *Males* |
| Nobs | 326000 | 178000 | 488000 | 238000 |
| Nyears | 10 | 9 | 11 | 9 |
| Nid | 127 | 62 | 110 | 53 |
| Nrange | 163 | 89 | 244 | 119 |

**Table S3.** Key statistics on selected topography and climate variables in the four counties in Norway comprising the study area.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **County** | **Hordaland** | **Møre og Romsdal** | **Sør-Trøndelag** | **Sogn og Fjordane** |
| Area (km2) | 15 437 | 15 100 | 18 848 | 18 619 |
| Elevation mean (m a.s.l.) | 734 | 598 | 578 | 806 |
| Elevation median (m a.s.l.) | 761 | 517 | 561 | 788 |
| Elevation range (m a.s.l., 5-95%) | 22-1425 | 14-1405 | 42-1235 | 51-1568 |
| Slope mean (degrees) | 13.43 | 16.83 | 7.92 | 17.69 |
| Northness mean (cos(degrees)) | 0.004 | 0.044 | 0.041 | -0.003 |
| Distance to coast mean (km) | 101.6 | 84.6 | 403.1 | 94.2 |
| Temperature mean (July; ºC) | 11.97 | 12.05 | 12.62 | 11.25 |
| SWE1 mean (February; mm) | 366.26 | 238.18 | 153.25 | 355.18 |
| Pasture availability mean (prop) | 0.029 | 0.036 | 0.037 | 0.024 |

1SWE = Snow water equivalent

**Table S4.** Percent change in available red deer habitat in Western Norway from 2005-2014 to year 2100 for 5 different thresholds of habitat suitability (0.1-0.5). Predictions are made for males and females during summer and winter, and under two emission scenarios (medium, RCP4.5 and severe, RCP8.5).

|  |  |  |
| --- | --- | --- |
|  | **Summer** | **Winter** |
|  | *Females* | *Males* | *Females* | *Males* |
| **Threshold** | **RCP4.5** | **RCP8.5** | **RCP4.5** | **RCP8.5** | **RCP4.5** | **RCP8.5** | **RCP4.5** | **RCP8.5** |
| 0.1 | 3.01 | 7.30 | 1.28 | 2.86 | 24.15 | 24.83 | 17.69 | 18.12 |
| 0.2 | 2.52 | 7.27 | 0.80 | 2.06 | 19.81 | 20.14 | 14.48 | 14.69 |
| 0.3 | 2.00 | 6.76 | 0.49 | 1.41 | 17.07 | 17.29 | 12.65 | 12.79 |
| 0.4 | 1.57 | 5.62 | 0.25 | 0.32 | 14.25 | 14.40 | 10.92 | 11.02 |
| 0.5 | 1.32 | 3.74 | 0.00 | -2.64 | 11.17 | 11.26 | 8.96 | 9.02 |

**Table S5.** Niche overlap between present and future habitat suitability, assessed by Schoener’s D, for red deer in Western Norway. Current habitat suitability is estimated for the study period 2005-2014, and future habitat suitability for the year 2100 under moderate (RCP4.5) and severe (RCP8.5) emission.

|  |  |  |
| --- | --- | --- |
|  | **Summer** | **Winter** |
|  | *Current - RCP4.5* | *Current - RCP8.5* | *Current - RCP4.5* | *Current - RCP8.5* |
| Females | 0.981 | 0.958 | 0.889 | 0.887 |
| Males | 0.994 | 0.983 | 0.919 | 0.917 |



**Figure S1.** The distance (km; length of lines) and direction (degrees) migrated between winter and summer ranges for female (red) and male (blue) red deer in Norway from 2005-2015.



**Figure S2.** Monthly temperature (July; top row) and snow water equivalent (February; bottom row) means for Norway during the study period (2005-2014) and in year 2100 under two alternative emission scenarios (medium, RCP4.5 and severe, RCP8.5).



**Figure S3.** Effects of sample size on prediction accuracy estimated as a) AUC and b) Cohen’s Kappa on resource selection functions for red deer in Norway during summer (green) and winter (blue) and for females (circles) and males (triangles). Points show the mean and error bars show the standard deviation.



**Figure S4.** Relative change per pixel in habitat suitability from 2004-2014 to year 2100 for male (dashed lines) and female (solid lines) red deer during winter (blue) and summer (green) under medium (RCP4.5; darker) and severe (RCP8.5; lighter) emission. The smoothed lines are based on generalized additive models with future habitat suitability as response and current habitat suitability as predictor. The horizontal line indicates no change in habitat suitability.