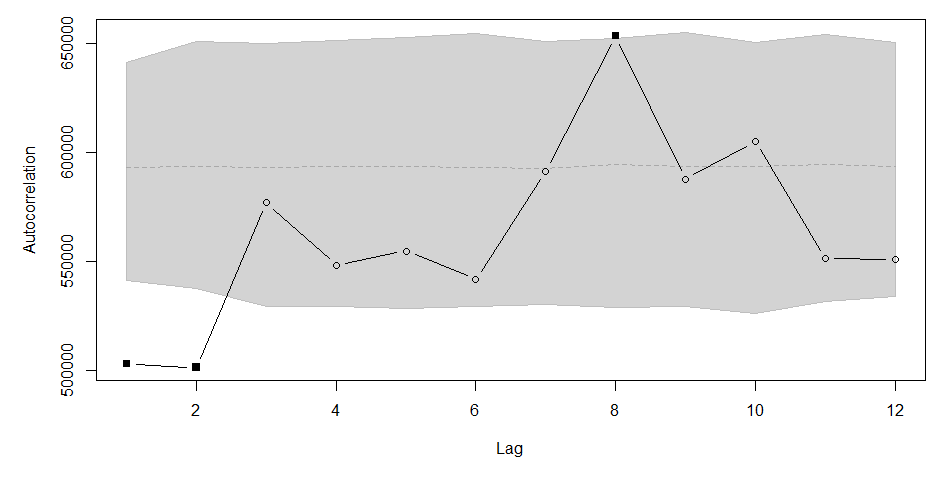
Attacked from two fronts: interactive effects of anthropogenic and biotic disturbances generate complex movement patterns

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**Table S1**. Thresholds of meteorological conditions at which oestrid (a) and mosquito (b) activity occurs, according to different studies.

|  |  |  |
| --- | --- | --- |
| (a) Oestrid activity |  |  |
| Source | Maximum  wind speed (m/s) | Minimum temperature (°C) |
| Hagemoen and Reimers (2002) | 12 | 6.9 |
| Colman (2000) | - | 13 |
| Mörschel (1996) | 11 | 10 |
| Anderson et al. (1994) | 6-8 | 10 |
| Helle et al. (1992) | - | 16-24 |
| Helle and Tarvainen (1984) | - | 13-17 |
| Helle and Aspi (1984) | - | 15 |
| Kelsall (1975) | 8-9 | 13-15 |
| White et al. (1975) | - | 13 |
| **MEAN** | 9.6 | 13 |
|  |  |  |
|  |  |  |
|  |  |  |
| (b) Mosquito activity |  |  |
| Source | Maximum  wind speed (m/s) | Temperature range  (°C) |
| Hagemoen and Reimers (2002) | 5-7.5 | t < 16 |
| Anderson et al. (2001) | - | t > 7 |
| Nixon and Russell (1990) | 6 | 7 < t < 18 |
| Russell et al. (1993) | 6 | t > 7 |
| White et al. (1975) | - | t > 7 |
| **MEAN** | 6.12 | 7 < t < 17 |



**Figure S1**. Correlogram showing temporal autocorrelation (y-axis) in the movement rates of a sample reindeer followed through a GPS collar in 2010 in the Udtja reindeer-herding district in northern Sweden. Filled squares indicate temporal autocorrelation with the reference value, i.e. lag = 0. The plot was created following Dray et al. (2010) and is the output of the *acfdist.ltraj* function available in the R package “adehabitatLT” (Calenge, 2006). We repeated the same assessment for all reindeer and years.



**Figure S2**. Circadian patterns in mean reindeer movement rates. The thick, horizontal line inside each boxplot represents the movement rate median for each hour of the day, averaged across individuals, while the white dots represent the mean. The panels refer to: A) all reindeer followed in 2010; B) all reindeer followed in 2011 starting on July 12 at midnight; C) all reindeer followed in 2011 starting on July 12 at 1 am; D) all reindeer followed in 2012 starting on July 12 at midnight; and E) all reindeer followed in 2012 starting on July 12 at 1 am.

**Table S2**. Occurrence of oestrid and mosquito harassment from July 12 to September 10, 2010-2012 in the Udtja reindeer herding community.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Presence | Absence | Exclusive presence | Total |
| OHI | 3298 | 15973 | 1006 | 19271 |
| MHI | 4298 | 14973 | 5 | 19271 |

NOTE: Insect harassment was estimated using the Insect Harassment Indices (IHIs) described in the Methods section of the main manuscript. Data refer to the number of records (corresponding to the two-hour intervals of the GPS data) in which the IHIs were >0 (presence) or =0 (absence). “Exclusive presence” refers to the case in which an insect group was present (IHI > 0), while the other was absent (IHI=0). OHI = Oestrid Harassment Index. MHI = Mosquito Harassment Index.

**Table S3**. Model performance of two sets of regression models aimed to verify whether reindeer left the Vidsel Test Range, northern Sweden, while military exercises occurred in summers 2010-2012.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Predictor | Model | Random term | Correlation | df | AIC | Δ AIC | wi |
| Vehicle | GLS.M1.cor1 |  | √ | 6 | 20474.69 | 0.00 | 0.73 |
|  | GLMM.M1.cor1 | √ | √ | 7 | 20476.69 | 2.00 | 0.27 |
|  | GLMM.M1 | √ |  | 6 | 23286.69 | 2812.00 | 0.00 |
|  | GLMM.M3 | √ |  | 7 | 23288.69 | 2814.00 | 0.00 |
|  | GLMM.M2 | √ |  | 6 | 24110.93 | 3636.24 | 0.00 |
|  | GLS.M1 |  |  | 5 | 24242.77 | 3768.08 | 0.00 |
| Aircraft | GLS.Ma.cor1 | √ | √ | 6 | 20459.97 | 0.00 | 0.73 |
|  | GLMM.Ma.cor1 | √ |  | 7 | 20461.97 | 2.00 | 0.27 |
|  | GLMM.Ma | √ |  | 6 | 23266.18 | 2806.21 | 0.00 |
|  | GLMM.Mb |  |  | 6 | 24101.70 | 3641.73 | 0.00 |
|  | GLS.Ma |  |  | 5 | 24231.58 | 3771.61 | 0.00 |

NOTES: The response variable in all models was the daily average Euclidean distance (in meters) between each reindeer and the three activity points (E, Q and T). The predictor variable was a categorical variable describing the occurrence of military exercises performed either with vehicles or with aircrafts, computed as the sum of the occurrence of military exercises at the three activity points. Models GLS.M1 and GLS.Ma were Generalized Least Squares (GLS) models. Models GLS.M1.cor1 and GLS.Ma.cor1 were also GLS models, but included an autoregressive correlation structure of the residuals AR1. Models GLMM.M1.cor1, GLMM.M1, GLMM.Ma.cor1, and GLMM.Ma were generalized linear mixed models (GLMM) with reindeer ID as a random intercept term. In addition, models GLMM.M1.cor1 and GLMM.Ma.cor1 contained an autoregressive correlation structure of the residuals AR1. Models GLMM.M2 and GLMM.Mb included year as a random intercept term. Model GLMM.M3 included reindeer ID/year as nested random terms. A similar model could not be run for military activities performed with aircraft because of overparameterization. df = degrees of freedom; AIC = Akaike Information Criterion; Δ AIC = difference in AIC compared to the best-fit model; wi = Akaike weights.

**Table S4**. Model performance of four sets of regression models aimed to test the effects of military exercises performed at the Vidsel Test Range, northern Sweden, and insect harassment on reindeer movement rates in summer 2010-2012.

| Focus variables a | Model b | Random term | Variance structure | Correlation | df | AIC | Δ AIC | wi |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| OHI + *Vehi\_ALL* | GLS.var.year.cor |  | √ | √ | 28 | 274762.5 | 0.0 | 1.00 |
|  | GLS.var.year |  | √ |  | 26 | 274961.2 | 198.7 | 0.00 |
|  | GLS.var.month |  | √ |  | 26 | 274997.5 | 235.0 | 0.00 |
|  | GLS |  |  |  | 24 | 275089.3 | 326.8 | 0.00 |
|  | GLMM.id | √ |  |  | 25 | 275091.3 | 328.8 | 0.00 |
|  | GLMM.year | √ |  |  | 25 | 275091.3 | 328.8 | 0.00 |
|  | GLMM.id.year | √ |  |  | 26 | 275093.3 | 330.8 | 0.00 |
| OHI + *Air\_ALL* | GLS.var.year.cor |  | √ | √ | 28 | 274760.5 | 0.0 | 1.00 |
|  | GLS.var.year |  | √ |  | 26 | 274960.6 | 200.1 | 0.00 |
|  | GLS.var.month |  | √ |  | 26 | 274997.1 | 236.6 | 0.00 |
|  | GLS |  |  |  | 24 | 275088.8 | 328.3 | 0.00 |
|  | GLMM.id | √ |  |  | 25 | 275090.8 | 330.3 | 0.00 |
|  | GLMM.year | √ |  |  | 25 | 275090.8 | 330.3 | 0.00 |
|  | GLMM.id.year | √ |  |  | 26 | 275092.8 | 332.3 | 0.00 |
| MHI + *Vehi\_ALL* | GLS.var.year.cor |  | √ | √ | 28 | 274706.4 | 0.0 | 1.00 |
|  | GLS.var.year |  | √ |  | 26 | 274892.2 | 185.8 | 0.00 |
|  | GLS.var.month |  | √ |  | 26 | 274930.0 | 223.6 | 0.00 |
|  | GLS |  |  |  | 24 | 275020.7 | 314.3 | 0.00 |
|  | GLMM.id | √ |  |  | 25 | 275022.7 | 316.3 | 0.00 |
|  | GLMM.year | √ |  |  | 25 | 275022.7 | 316.3 | 0.00 |
|  | GLMM.id.year | √ |  |  | 26 | 275024.7 | 318.3 | 0.00 |
| MHI + *Air\_ALL* | GLS.var.year.cor |  | √ | √ | 28 | 274702.5 | 0.0 | 1.00 |
|  | GLS.var.year |  | √ |  | 26 | 274888.0 | 185.5 | 0.00 |
|  | GLS.var.month |  | √ |  | 26 | 274926.2 | 223.7 | 0.00 |
|  | GLS |  |  |  | 24 | 275016.7 | 314.2 | 0.00 |
|  | GLMM.id | √ |  |  | 25 | 275018.7 | 316.2 | 0.00 |
|  | GLMM.year | √ |  |  | 25 | 275018.7 | 316.2 | 0.00 |
|  | GLMM.id.year | √ |  |  | 26 | 275020.7 | 318.2 | 0.00 |

a The focus variables were OHI = Oestrid Harassment Index, MHI = Mosquito Harassment Index, and the military exercises variables (either Vehi\_ALL or Air\_ALL). In addition to the focus variables, all models included the following variables: vegetation type, elevation, slope, ruggedness, temperature, NDVI, Area, and distance from roads. The models also included interaction terms 1) between the Insect Harassment Indices (either OHI or MHI) and i) the military exercises variables (either Vehi\_ALL or Air\_ALL), ii) vegetation type, iii) elevation, and iv) distance from roads; and 2) between Area and i) distance from roads and ii) the military exercises variables.

b GLS = Generalized Least Squares model. GLMM = Generalized Linear Mixed-effect Model. The models GLS.var.year.cor were GLS models with year as fixed variance structure and an exponential spatial autocorrelation structure with range = 850, nugget = 0.4 and sill = 1.

NOTES: df = degrees of freedom. AIC = Akaike Information Criterion; Δ AIC = difference in AIC compared to the best-fit model; wi = Akaike weights.

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