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Wildlife Research

Supplementary Material

Seasonal and daily activity of non-native sambar deer in and around high-elevation peatlands, south-eastern Australia

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Table S1. Spatial and temporal variables used to model sambar deer activity in Alpine National Park, Victoria, south-eastern Australia.

Variable name (abbreviation)	Units	Description	Resolution	Source and access date	Reference
Spatial covariates					
Elevation	Metres above sea level (m)	The digital elevation model (DEM) is constructed from source data of various resolutions, accuracies and ages to produce an improved DEM containing increased detail in localised areas.	100 metres by 100 metres	http://services.land.vic.gov.au/SpatialDatamart/ Vicmap Elevation DEM 10m 28/10/2020	Department of Environment, Land, Water & Planning ANZVI0803003582
Slope	Degrees	The slope for each cell of the DEM was computed according to Horn (1981), using the eight neighbouring cells. The calculation was done using the function terrain from the R-package raster (v3.1-5).	100 metres by 100 metres	http://services.land.vic.gov.au/SpatialDatamart/ Vicmap Elevation DEM 10m 28/10/2020	Horn, B.K.P., 1981. Hill shading and the reflectance map. Proceedings of the IEEE 69:14-47
Aspect	Degrees	The aspect for each cell of the DEM was computed according to Horn (1981), using the eight neighbouring cells. The calculation was done using the function terrain from the R-package raster (v3.1-5).	100 metres by 100 metres	http://services.land.vic.gov.au/SpatialDatamart/ Vicmap Elevation DEM 10m 28/10/2020	Horn, B.K.P., 1981. Hill shading and the reflectance map. Proceedings of the IEEE 69:14-47

Terrain ruggedness	Index (1 to 40)	TRI (Terrain Ruggedness Index) is the mean of the absolute differences between the value of a cell and the value of its 8 surrounding cells. The calculation was done using the function terrain from the R-package raster (v3.1-5).	100 metres by 100 metres	http://services.land.vic.gov.au/SpatialDatamart/ Vicmap Elevation DEM 10m 28/10/2020	Wilson, M.F.J., O'Connell, B., Brown, C., Guinan, J.C., Grehan, A.J., 2007. Multiscale terrain analysis of multibeam bathymetry data for habitat mapping on the continental slope. Marine Geodesy 30: 3-35.
Distance to water	Metres	This layer is part of Vicmap Hydro and contains line features delineating hydrological features. Includes channels, rivers, streams & connectors. The shortest distance between camera traps locations and linear features was calculated with the function dist2Line from the R-package geosphere (v1.5-10).	GIS line features	http://services.land.vic.gov.au/SpatialDatamart/ Watercourse Network 1:25,000 - Vicmap Hydro 26/10/2020	Department of Environment, Land, Water & Planning ANZVI0803002490
Distance to road	Metres	Vicmap Transport: Road network represents the transport network of the state of Victoria and is made up of line features. The following transport features are fundamental to this data set series: freeway, highway, arterial, 2wd, 4wd, bicycle and walking tracks. The shortest distance between camera traps locations and linear features was calculated with the function dist2Line from the R-	GIS line features	http://services.land.vic.gov.au/SpatialDatamart/ Vicmap Transport: Road network 28/10/2020	Department of Environment, Land, Water & Planning ANZVI0803002441

		package geosphere (v1.5-10).			
Distance to peatland	Metres	The shortest distance between camera traps locations and edges of polygon features were calculated with the function dist2Line from the R-package geosphere (v1.5-10).	GIS polygon feature	MCAS-S Datapack for Alpine Bogs of the Australian Alps Bioregion. https://cloudstor.aarnet.edu.au/plus/s/7ed8381ad59f8f9def9e877d6cf08b0e	Magierowski RH and Wild A (2014) MCAS-S Datapack for Alpine Bogs of the Australian Alps Bioregion. University of Tasmania.
Woody vegetation cover	Probability	Gives the probability that the landcover at each 25 by 25 m pixel is 'woody vegetation' across the years 2015-2019 (see White et. al 2020). The raster was then resampled to a 100 m grid and through pixel averaging and converted to an integer scale (where 100 equals a probability of 1).	100 metres by 100 metres	Data provided by Arthur Rylah Institute for Environmental Research, Department of Environment, Land, Water and Planning.	White, M., Griffioen, P. and Newell, G. (2020). Multi-temporal Native Vegetation Extent for Victoria. Arthur Rylah Institute for Environmental Research Technical Report No 311. Department of Environment, Land, Water and Planning.
Herbaceous vegetation cover	Probability	Gives the probability that the landcover at each 25 by 25 m pixel is 'woody vegetation' across the years 2015-2019 (see White et. al 2020). The raster was then resampled to a 100 m grid and through pixel averaging and converted to an integer scale (where 100 equals a probability of 1).	100 metres by 100 metres	Data provided by Arthur Rylah Institute for Environmental Research, Department of Environment, Land, Water and Planning.	White, M., Griffioen, P. and Newell, G. (2020). Multi-temporal Native Vegetation Extent for Victoria. Arthur Rylah Institute for Environmental Research Technical Report No 311. Department of Environment, Land, Water and Planning.

Time series covariates					
Minimum temperature	Degree Celsius	Daily Minimum Temperature Climate Data Bureau of Meteorology station number: 83084 Station name: FALLS CREEK Latitude: -36.87 Longitude: 147.28 Height of station: 1765m	0.1 C	http://www.bom.gov.au/climate/cdo/about/about-airtemp-data.shtml 24/11/2020	Product code: IDCJAC0011 reference: 68857798
Maximum temperature	Degree Celsius	Daily Maximum Temperature Climate Data Bureau of Meteorology station number: 83084 Station name: FALLS CREEK Latitude: -36.87 Longitude: 147.28 Height of station: 1765m	0.1 C	http://www.bom.gov.au/climate/cdo/about/about-airtemp-data.shtml 24/11/2020	Product code: IDCJAC0010 reference: 68857730
Snow depth	Centimetres	Snow depth Falls Creek Snow depth using data collected each morning by on-mountain staff. The measuring of natural snow depths is done at three locations (1. 1635 m, 3° North; 2.	1 cm	https://discover.data.vic.gov.au/dataset/victorian-alpine-resorts-daily-snow-depth-records-falls-creek 24/11/2020	Department of Environment, Land, Water & Planning

		1636 m 118˚ South-east; 3. 1673 m, 203˚ South-west). From these locations an average overall depth is ascertained. The snow reporting service ceases when resort operations cease. Falls creek ski resort is located less than 5km from the study area.			

Table S2a. Matrix of Pearson's correlation coefficients for each pair of spatial covariates used to model sambar deer activity in Alpine National Park, Victoria, south-eastern Australia. Grey = identity; orange = high correlation, i.e., $|r| > 0.70$.

	Elevation	Slope	Aspect	Terrain ruggedness	Woody vegetation	Herbaceous vegetation	Distance to watercourses	Distance to roads	Distance to peatlands
Elevation	1.000	-0.405	0.321	-0.411	-0.447	0.416	-0.064	-0.016	-0.921
Slope		1.000	-0.480	0.985	0.374	-0.397	-0.128	0.336	0.401
Aspect			1.000	-0.476	-0.150	0.149	-0.023	-0.273	-0.373
Terrain ruggedness				1.000	0.357	-0.371	-0.147	0.355	0.412
Woody vegetation					1.000	-0.966	-0.054	0.324	0.300
Herbaceous vegetation						1.000	0.041	-0.325	-0.293
Distance to watercourses							1.000	-0.047	0.113
Distance to roads								1.000	0.011
Distance to peatlands									1.000

Table S2b. Matrix of Pearson's correlation coefficients for each pair of temporal covariates used to model sambar deer activity in Alpine National Park, Victoria, south-eastern Australia. Grey = identity; orange = high correlation, i.e., $|r| > 0.70$.

	Min temperature	Max temperature	Snow depth
Min temperature	1.000	0.997	-0.701
Max temperature		1.000	-0.659
Snow depth			1.000

Table S3. Posterior distribution of model parameters for sambar deer activity in Alpine National Park, Victoria, south-eastern Australia. lHDI and uHDI represent the lower and upper limits of the 95% credible intervals, *R* is the Gelman-Rubin diagnostic and ESS is the estimated sample size.

Parameters	Mean	Median	Mode	lHDI	uHDI	SD	*R*	ESS
Dispersion	0.563	0.562	0.574	0.523	0.604	0.021	1.000	267910
Fixed effects								
Intercept	-0.785	-0.783	-1.022	-1.267	-0.312	0.243	1.006	1651
Snow : females	-0.011	-0.011	-0.010	-0.015	-0.006	0.002	1.002	8237
Snow : males	-0.011	-0.011	-0.011	-0.015	-0.006	0.002	1.002	8221
Males	0.460	0.460	0.444	0.365	0.554	0.048	1.001	16039
Non-treatment area	0.331	0.330	0.413	0.082	0.585	0.129	1.003	2328
Year : non-treatment	0.065	0.065	0.101	0.010	0.121	0.028	1.003	5308
Year : treatment	-0.141	-0.141	-0.145	-0.202	-0.081	0.031	1.000	10982
Distance to watercourses	0.001	0.001	0.001	0.000	0.001	0.000	1.000	101525
Distance to roads	0.000	0.000	0.000	-0.001	0.000	0.000	1.000	58338
Distance to peatlands	0.000	0.000	0.000	0.000	0.000	0.000	1.000	46413
Woody vegetation cover	0.028	0.028	0.027	0.024	0.031	0.002	1.000	66702
Easterly aspect	0.294	0.294	0.289	0.205	0.383	0.045	1.000	110472
Northerly aspect	0.129	0.129	0.128	0.051	0.207	0.040	1.000	162928
Slope	-0.087	-0.087	-0.089	-0.099	-0.074	0.006	1.000	124150
Random effect of month								
January	-0.006	-0.006	-0.102	-0.306	0.291	0.150	1.001	9565
February	-0.142	-0.141	-0.139	-0.443	0.154	0.150	1.001	9443
March	0.137	0.136	0.119	-0.159	0.435	0.150	1.001	9381
April	-0.059	-0.059	-0.131	-0.359	0.236	0.150	1.001	8478
May	0.021	0.021	0.116	-0.277	0.315	0.149	1.001	8694
June	0.008	0.009	-0.142	-0.261	0.276	0.136	1.001	9253
July	-0.233	-0.232	-0.273	-0.535	0.066	0.152	1.001	10778
August	-0.626	-0.620	-1.011	-1.091	-0.193	0.227	1.001	10352
September	0.441	0.435	0.303	-0.052	0.969	0.257	1.001	8720
October	0.442	0.439	0.482	0.153	0.748	0.151	1.001	10071
November	-0.055	-0.054	-0.126	-0.350	0.236	0.148	1.001	8837
December	0.064	0.064	0.121	-0.232	0.361	0.149	1.002	8466

Table S4a. Model output for monthly diel activity of sambar deer in Alpine National Park, Victoria, south-eastern Australia.

Parametric coefficients	**Estimate**	**SE**	***T***	***P***
(Intercept)	-3.34	0.03	-112.73	
Males	0.01	0.04	0.14	0.89

Smooth terms	**EDF**	**Ref EDF**	***F***	***P***
s(hour): females-juveniles	13.77	18	27.44	<0.01
s(hour): males	14.83	18	47.47	<0.01
s(month): females-juveniles	0.00	8	0.00	0.80
s(month): males	0.00	8	0.00	1.00
ti(month, hour): females-juveniles	77.52	144	1.68	<0.01
ti(month, hour): males	82.79	144	2.50	<0.01

Table S4b. Model check for monthly diel activity of sambar deer in Alpine National Park, Victoria, south-eastern Australia.

Smooth terms	***K'***	***EDF***	***K***	***P***
s(hour): females-juveniles	18.00	13.80	0.91	0.59
s(hour): males	18.00	14.80	0.91	0.59
s(month): females-juveniles	8.00	0.00	0.92	0.88
s(month): males	8.00	0.00	0.92	0.79
ti(month, hour): females-juveniles	144.00	77.50	0.92	0.73
ti(month, hour): males	144.00	82.80	0.92	0.80