Ecography

ECOG-04714
McColl-Gausden, S. C., Bennett, L. T., Duff, T. J., Cawson, J. G. and Penman, T. D. 2019. Climatic and edaphic gradients predict variation in wildland-fuel hazard in south-eastern Australia. – Ecography doi: 10.1111/ecog.04714

Supplementary material

Appendix 1

Table A1. A description of the key attributes for assessing fuel hazard in each stratum and examples of all fuel hazard levels for each fuel hazard stratum (Hines, et al. 2010)

Response variable	Key attributes for assessing hazard	Example of low fuel hazard (rating '1')	Example of moderate fuel hazard (rating '2')	Example of high fuel hazard (rating '3')	Example of very high fuel hazard (rating '4')	Example of extreme fuel hazard (rating '5')
Surface fuel hazard	1. Horizontal connectivity 2. Surface litter cover 3. Litter-bed depth	1. Litter poorly interconnected. Large areas of bare soil or rock. More soil than litter. Soil surface readily visible through litter bed. 2. <60% 3. Very thin litter layer <10 mm	1. Litter well connected. Some areas of bare soil or rock. Soil surface occasionally visible through litter bed 2. 60-80% 3. Thin litter layer 10-25 mm	1. Litter well connected. Little bare soil. 2. 80-90% 3. Established litter with layers of leaves ranging from freshly fallen to decomposing. 20–30 mm	1. Litter completely connected. 2. >90% 3. Thick litter layer 25–45 mm	1. Litter completely connected. 2. >95% 3. Very thick layer of litter >35 mm
Near-surface fuel hazard	1. Plant cover 2. % dead 3. Horizontal connectivity	1. <10% 2. <10% 3. Near-surface fuel is absent or virtually absent.	1. 10-20% 2. <20% 3. Gaps many times the size of fuel patches.	1. 20-40% 2. >20% 3. Gaps between fuel patches are greater than the size of fuel patches. Starting to obscure logs and rocks.	1. 40-60% 2. >30% 3. Fuel patches are equal to or larger than the gaps between the fuel patches.	1. >60% 2. >50% 3. Very small gaps between fuel patches. Logs and rocks obscured.
Elevated fuel hazard	1. Plant cover 2. % dead 3. Vertical continuity 4. Vegetation density 5. Thickness of fuel pieces	1. <20% 2. <20% 3. NA 4. Easy to walk in any direction without needing to choose a path between shrubs 5. NA	1. 20-30% 2. <20% 3. Most of the fine fuel is at the top of the layer. 4. Easy to choose a path through but brush against vegetation occasionally. 5. NA	1. 30-50% 2. <20% 3. Most of the fine fuel is at the top of the layer. 4. Moderately easy to choose a path through, but brush against vegetation most of the time. 5. NA	1. 50-80% 2. 20-30% 3. Continuous fine fuel from the bottom to the top of the layer. 4. Need to carefully select path through. 5. Mostly less than 1–2 mm thick.	1. >700% 2. >30% 3. Continuous fine fuel from the bottom to the top of the layer 4. Very difficult to select a path through. Need to push through vegetation. 5. Large amounts of fuel
Bark fuel hazard	1. How bark is attached 2. Quantity of combustible bark	Low fuel hazard does not occur in forests with at least 10% of trees with fine fibrous bark (stringybarks) or in forests dominated by trees with ribbon or candle bark	1. Bark tightly held. Requires substantial effort to break off bark by hand. 2. Very little combustible bark. Entire trunk almost completely black or charred.	1. Bark is mostly tightly held with a few pieces loosely attached. 2. Limited amount of combustible bark. 50–90% of trunk charred. Most of the bark is charred, especially on the lower part of the trunk.	1. Many pieces of bark loosely held. Deep fissures present in bark. 2. Large amounts of combustible bark. 10–50% of trunk charred. Upper parts of the tree may not be charred at all.	1. Outer bark on trees is weakly attached. Light hand pressure will break off large wads of bark. Deep fissures present in bark. 2. Huge amounts of combustible bark.

Table A2. List of predictor variables considered for inclusion in Random Forest models. Bolded variables were included in the models, whereas non-bolded variables were excluded due to strong correlation (Pearson's r > |0.80|)) with a bolded variable as indicated in the final column.

Variable (abbreviation in brackets)	Value range	5^{th}- 95^{th} quantile	Mean	Unit	Correlation
Annual Mean Temperature (bio1)	3.1-20.0	14.4-19.0	16.0	°C	
Max Temperature of Warmest Month (bio5)	15.4- 35.7	23.8-34.5	30.5	°C	
Annual Precipitation (bio12)	169-1886	496-1097	687	mm	+bio18, -BDW
Precipitation of Warmest Quarter (bio18)	25-363	40-225	104	mm	
Precipitation of the Coldest Quarter (bio19)	30-677	152-379	225	mm	-BDW
Soil bulk density (BDW)	0.60-1.58	1.09-1.48	1.37	g/cm^3	
Soil clay content (CLY)	3.7-60.0	11.7-40.5	22.9	%	
Soil organic carbon (SOC)	0.48-14.71	2.33-8.12	4.46	%	-bio1, -BDW
Soil pH $CaCl_2$ (pH)	3.73-8.37	4.52-7.33	6.06		
Time since fire (TSF)	1-100 (maximum set at 100)	2-99	43	years	

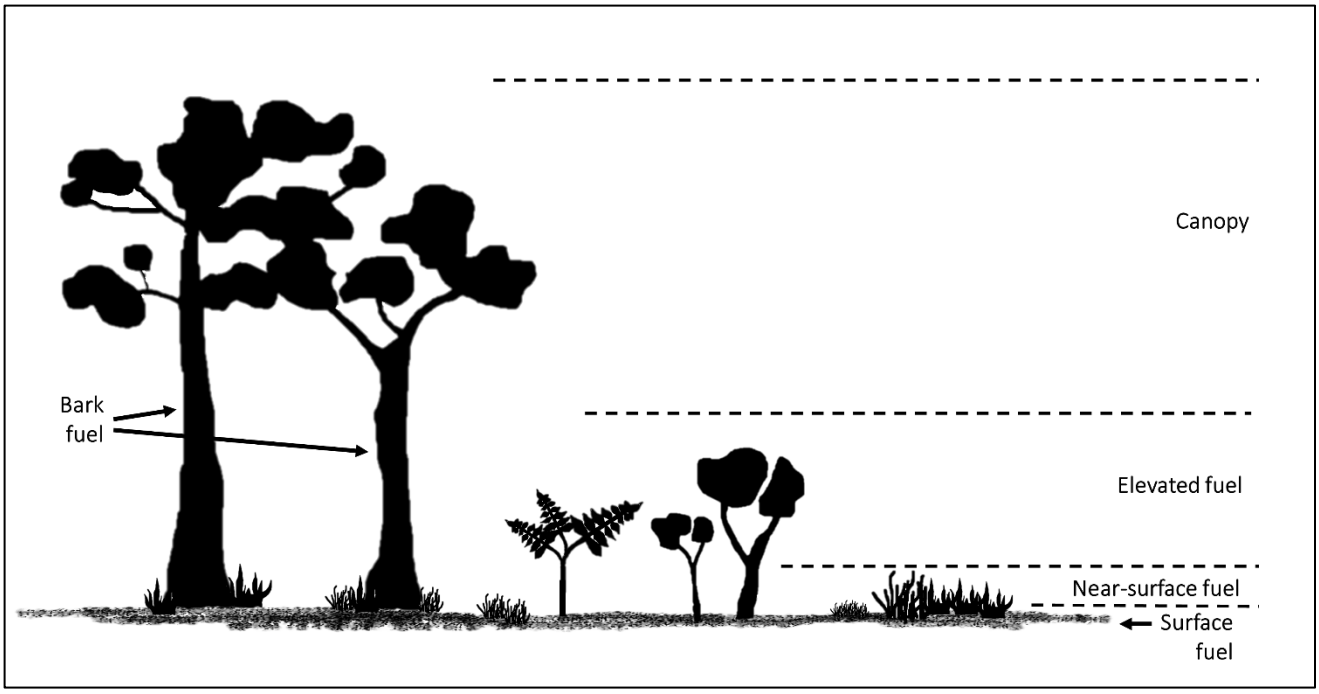

Figure A1. Fuel strata based on the vertical position within the vegetation profile. Surface fuels are leaves, twigs, bark and other fine fuel lying on the ground. Near-surface fuels are live and dead fuels connected to the ground but not lying on it and less than one meter in height. Elevated fuels are generally upright in orientation, have a clear gap between them and the surface fuels and are between one and five meters tall. Bark fuels are the bark on tree stems and branches from the ground and including the canopy. Figure adapted from Hines, et al. (2010).

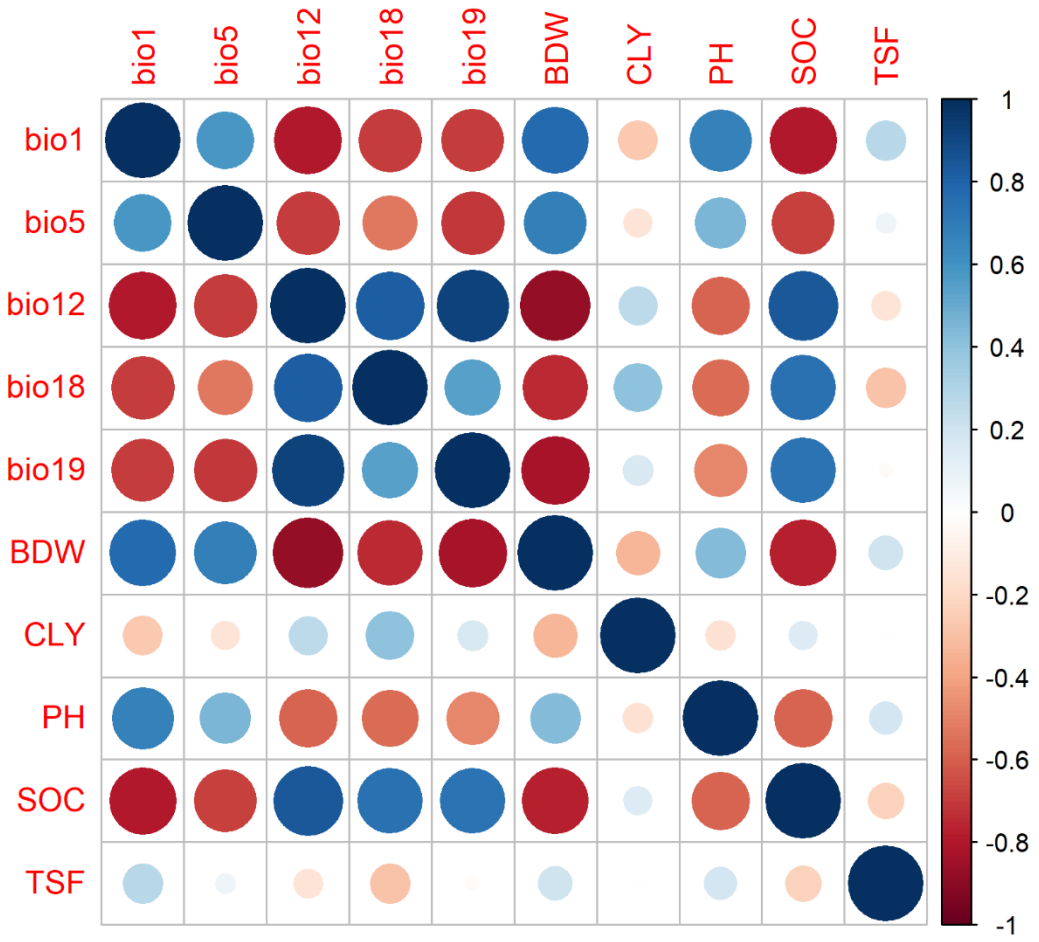

Figure A2. Correlation matrix of all possible predictor variables. Positive correlations are displayed in blue and negative correlations in red. Colour intensity and the size of the circle are proportional to the correlation coefficients.

Table A3. Range of environmental variables and characteristics of the contrasting regions of Murray Sunset National Park and East Gippsland

Environmental characteristics	Murray Sunset National Park			East Gippsland		
Major vegetation groups DELWP 2019	**Murray mallee bioregion:** The vegetation is dominated by East/West-Dune Mallee with some Chenopod Mallee and Shallow-Sand Mallee			**East Gippsland lowlands bioregion**: The vegetation is dominated by Lowland Forest with Damp Forest and Shrubby Dry Forest ecosystems interspersed throughout the foothills; Banksia Woodland and Riparian Scrub Complex		
Dominant fire adaptive traits Cheal 2010	Typically, mallee vegetation is topkilled by fire and basally resprouts following fire			Combination of resprouting shrubs and trees, with some obligate seeding shrubs		
Variable	Min-max	5^{th} -95^{th} quantiles	Mean	Min-max	5^{th} -95^{th} quantiles	Mean
Annual Mean Temperature °C (**bio1**)	16.0-16.9	16.3-16.7	16.5	8.2-15.1	10.6-14.6	13.3
Max Temperature of Warmest Month °C (**bio5**)	31.8-32.6	32.0-32.4	32.2	19.9-25.0	22.3-24.4	23.5
Precipitation of Warmest Quarter mm (**bio18**) (min-max)	56-68	57-66	61	186-250	193-224	204
Soil bulk density g/cm^3 (**BDW**)	1.37-1.51	1.41-1.46	1.44	0.76-1.34	0.92-1.22	1.12
Soil clay content % (**CLY**) (mean)	6.1-29.6	9.7-17.6	13.5	5.1-40.4	10.3-19.5	14.4
Soil pH $CaCl_2$ (**pH**)	6.54-7.93	7.00-7.37	7.20	4.04-5.05	4.29-4.61	4.44

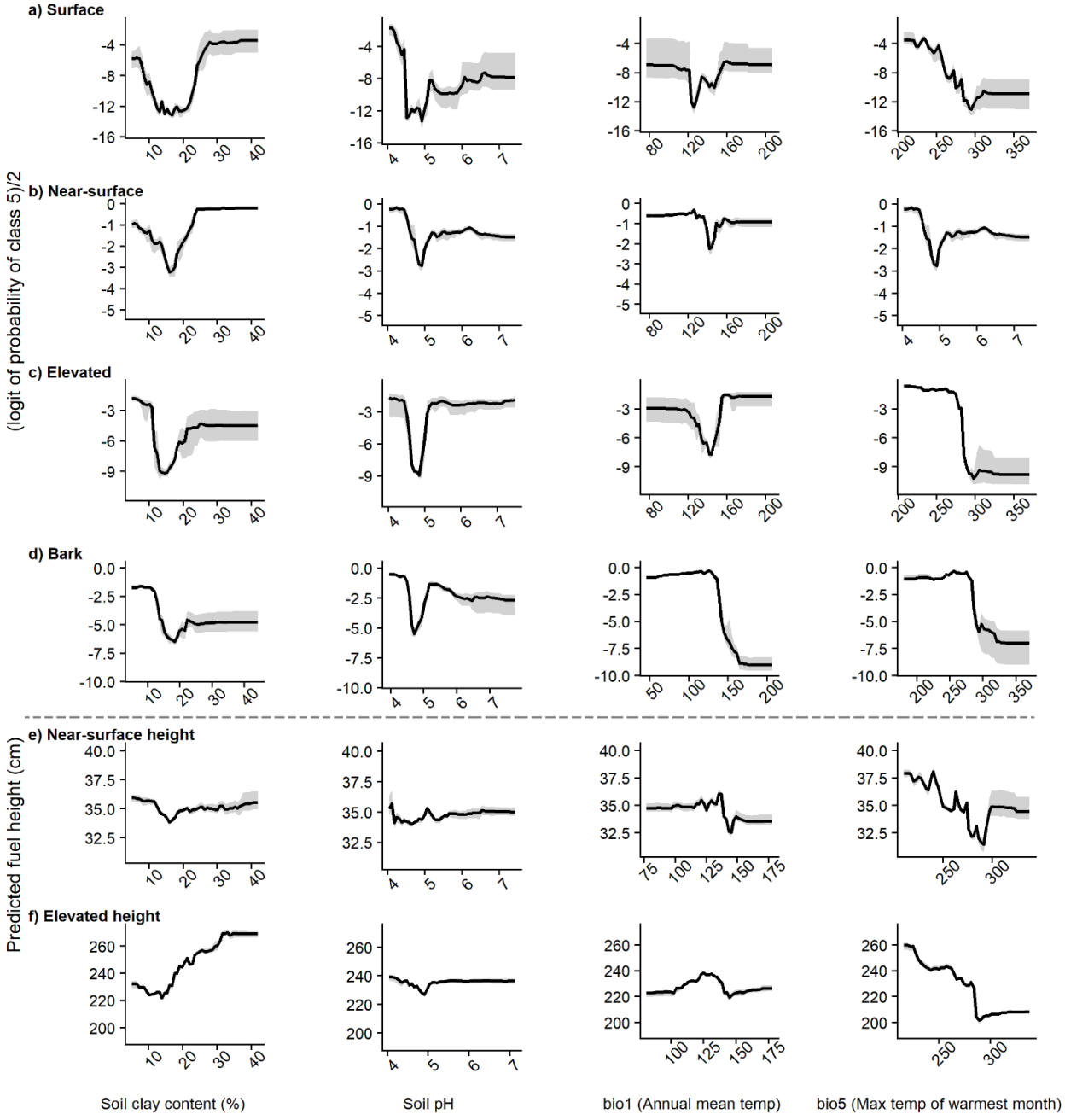

Figure A3. Partial dependence plots for each fuel hazard stratum: a) surface, b) near-surface, c) elevated, d) bark and fuel height e) near-surface height and f) elevated height for the four predictor variables not presented in main article, Clay (%), soil pH, bio 1 (annual mean temperature (°C x 10)), and bio5 (Max temperature of the warmest month (°C x 10). Partial dependence is the dependence of the probability of class 5 (extreme) for fuel hazard strata or predicted fuel height for fuel height strata, on one predictor variable after averaging out the effects of the other predictor variables in the model. See Cutler, et al. (2007) for an explanation of the y-axis metric.

Supplementary reference list

Cheal, D. C. 2010. Growth stages and tolerable fire intervals for Victoria's native vegetation data sets. Fire and adaptive management. - In: D. o. S. a. Environment (ed).
Cutler, D. R., Edwards, T. C., Beard, K. H., Cutle, r. A., Hess, K. T., Gibson, J. and Lawler, J. J. 2007. Random Forests for classification in ecology. - Ecology 88: 2783-2792.
DELWP 2019. Bioregions and EVC benchmarks. - In.
Hines, F., Tolhurst, K. G., Wilson, A. A. and McCarthy, G. J. 2010. Overall fuel hazard assessment guide. - In: Fire and adaptive management. Victorian Government Department of Sustainability and Environment.