Appendix 3: Transformation of explanatory variables into derived variables

Table A3.1. Transformation of explanatory variables (EVs) into derived variables (DV): DV main types (DVMTs) and types (DVTs) relevant for MaxEnt modelling. Transformation is carried out in two steps, of which only the first step, transformation into 'raw' derived variables (rDVs) $\boldsymbol{X}_k'$, is shown in the rightmost column of the table. The proper DVs $\boldsymbol{X}_k$ are obtained by linear ranging of rDVs onto a [0,1] scale. * = DVTs not currently implemented in Maxent software.

DVMT	DVT		Description	Interpretation	Transformation function for rDVs
	Code	Term			
continuous	L	Linear	the continuous EV $\boldsymbol{Z}_j$ itself	models the response to the EV itself	$x_{ik}' = h_L(z_{ij}) = z_{ij}$
continuous	M	monotonous	a monotonous, continuous trans-formation of the continuous EV $\boldsymbol{Z}_j$	models the response to a nonlinear transformation of the EV; the quadratic (Q) variable obtained as the square of $\boldsymbol{Z}_j$ is a special case	$x_{ik} = h_M(z_{ij}) = \mathrm{f}(z_{ij})$ where f is a continuous function
continuous	D*	Deviation	the continuous EV $\boldsymbol{Z}_j$, centred on the mean for observed presence grid cells, raised to the power a	takes the tolerance of the species with respect to the EV explicitly into account by modelling the response to the spread of z_{ij} around the mean value for observed presence grid cells, $\bar{z}_j^*$; the V (variance) variable, which is obtained for $a = 2$, is a special case	$x_{ik}' = h_D(z_{ij}) = \lvert z_{ij} - \bar{z}_j^* \rvert^a$
spline	HF	forward hinge	a continuous EV $\boldsymbol{Z}_j$ transformed to a linear spline of order two	models the response to a piecewise linear spline with one knot (the point z_{0j}) above which $\boldsymbol{X}_k$ is a linear function of $\boldsymbol{Z}_j$ and below which $\boldsymbol{X}_k$ is set equal to 0	$x_{ik}' = h_{HF}(z_{ij}) = \begin{cases} 0 \text{ if } z_{ij} < z_{0j} \\ \frac{z_{ij} - z_{0j}}{\max(z_{ij}) - z_{0j}} \; if\, z_{ij} \geq z_{0j} \end{cases}$
spline	HR	reverse hinge	a continuous EV $\boldsymbol{Z}_j$ transformed to a linear spline of order two	models the response to a piecewise linear spline with one knot (the point z_{0j}) below which $\boldsymbol{X}_k$ is a linear function of $\boldsymbol{Z}_j$ and above which $\boldsymbol{X}_k$ is set equal to 0	$x_{ik}' = h_{HR}(z_{ij}) = \begin{cases} \frac{z_{0j} - z_{ij}}{z_{0j} - \min(z_{ij})} \; if\, z_{ij} \leq z_{0j} \\ 0 \text{ if } z_{ij} > z_{0j} \end{cases}$

DVMT	DVT		Description	Interpretation	Transformation function for rDVs
	Code	Term			
spline	T	Threshold	binary transformation of a continuous EV $\boldsymbol{Z}_j$	piecewise constant spline with one knot (discontinuity point z_{0j}) below which $\boldsymbol{X}_k$ is set equal to 0 and above which $\boldsymbol{X}_k = 1$; models the proportion (frequency) of presence grid cells with $z_{ij} \geq z_{0j}$	$x_{ik}' = h_T(z_{ij}) = \begin{cases} 1 \text{ if } z_{ij} \geq z_{0j} \\ 0 \text{ if } z_{ij} < z_{0j} \end{cases}$
spline	X*	complex spline	a continuous EV $\boldsymbol{Z}_j$ transformed to a linear spline of order three or higher	models a continuous or discontinuous, complex, response to an EV	$x_{ik} = h_M(z_{ij}) = \text{f}(z_{ij})$ where f is a discontinuous spline function of order three or higher
inter-action	P	Product	the product of two continuous EVs $\boldsymbol{Z}_j$ and $\boldsymbol{Z}_v$	models the response to the product of two continuous DVs	$x_{ik}' = h_P(z_{ij}, z_{iv}) = z_{ij} \cdot z_{iv}$
inter-action	O*	covariance	the product of two continuous EVs $\boldsymbol{Z}_j$ and $\boldsymbol{Z}_v$, centered on the respective means for observed presence grid cells	takes the interaction (covariance) between the modelled target's tolerances to two EVs explicitly into account	$x_{ik}' = h_O(z_{ij}, z_{iv}) = (z_{ij} - \bar{z}_j^*) \cdot (z_{iv} - \bar{z}_v^*)$
binary set	B	Binary	m_j binary DVs, one for each factor level u of a categorical EV $\boldsymbol{Z}_j$; each DV expresses if factor level u is recorded in cell i or not	models the proportion (frequency) of presence grid cells for each factor level u	m_j binary DVs, one for each factor level u: $x_{ik} = h_C(z_{ij}) = \begin{cases} 1 \text{ if } z_{ij} = u \\ 0 \text{ if } z_{ij} \neq u \end{cases}$