

ADDENDUM 4

MAXENT MODELS

OF

CHAPTER 6

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Maxent models can be written as an equation based on the λ -values and values of k_1 and k_2 associated with the λ -values. The value of k_1 and k_2 have a different meaning depending on the feature (see table A4.1). With these values the logistic output of the Maxent model can be calculated for each grid cell.

In Table A4.2 the λ -values and values of k_1 and k_2 are given for the final threshold models of Chapter 6.

For each grid cell the value of the environmental variables is known and the feature function $f(x)$ can be calculated (Table A4.1 and A4.2). When all the feature functions are calculated for a single grid cell, these functions are summed:

$$S = \sum_{i=1}^n f_n(x) - L$$

with n the number of features, and L being the Linear Prediction Normalizer (LPN in Table A4.2).

$$q_\lambda(x) = \frac{e^S}{Z_\lambda}$$

with Z_λ the Density Normalizer (DN in Table A4.2).

This is the raw data output which is then logistic-scaled to give the final output of the model.

$$L_{output} = \frac{q_\lambda(x) \cdot e^{entropy}}{1 + q_\lambda(x) \cdot e^{entropy}}$$

The value of *entropy* can be found in Table A4.2.

To compute the complete output map, this should be repeated for each grid cell.

Linear	$f(x) = \lambda \cdot \frac{x - k_1}{k_2 - k_1}$	k_1 and k_2 are the minimum and maximum value of the variable
Quadratic	$f(x) = \lambda \cdot \frac{x^2 - k_1}{k_2 - k_1}$	k_1 and k_2 are the minimum and maximum value of the squared variable
Product feature	$f(x, y) = \lambda \cdot \frac{x \cdot y - k_1}{k_2 - k_1}$	k_1 and k_2 are the minimum and maximum value of the product of the two variables
Forward hinge	if $x < k_1$ then $f(x) = 0$ else $f(x) = \lambda \cdot \frac{x - k_1}{k_2 - k_1}$	k_1 = hinge k_2 is the maximum value of the variable
Reverse hinge	if $x < k_2$ then $f(x) = \lambda \cdot \frac{k_2 - x}{k_2 - k_1}$ else $f(x) = 0$	k_2 = hinge k_1 is the minimum
Threshold	if $x < \text{threshold}$ then $f(x) = 0$ else $f(x) = \lambda$	k_1 and k_2 represent the outcome of the threshold test: 0 if true and 1 if false.

Table A4.1. Application of λ , k_1 and k_2 for each feature.

	variable	feature	λ	k_1	k_2			
<i>Daptonema tenuispiculum</i>	Tavg	linear	4.85	0.98	24.06			
		LPN	4.85					
		DN	337.34					
		entropy	8.02					
<i>Dichromadora cucullata</i>	Tavg^2	quadratic	-70.62	2.85	579.12			
		Cavg*Dept	product			17.99	-15.32	353.94
		Cavg*Tavg	product			-100.46	4.20	337.08
		Cmin*D50x	product			5.98	0.89	2039.59
		LPN	7.27					
		DN	779.14					
		entropy	8.48					
<i>Enoploides spiculohamatus</i>	Cmax	linear	3.44	4.89	38.83			
		LPN	3.44					
		DN	1133.01					
		entropy	8.80					
<i>Onyx perfectus</i>	Cavg	linear	-6.08	1.98	17.84			
		quadratic	-25.53			3.93	318.16	
		D50x^2	quadratic			1.76	16.15	363174.99
		Dept^2	quadratic			-14.97	0.00	2484.22
		`Cavg	reverse hinge			2.25	1.98	4.35
		`Cmax	reverse hinge			-2.90	4.89	10.15
		`Dept	reverse hinge			0.14	-1.00	9.24
		`Dept	reverse hinge			0.17	-1.00	9.29
		`Dept	reverse hinge			0.11	-1.00	9.52
		`Tavg	reverse hinge			-2.93	1.69	7.53
		`Tmin	reverse hinge			-0.38	0.32	0.86
		`Tmin	reverse hinge			-4.47	0.32	1.06
		`Tmin	reverse hinge			1.07	0.32	1.90
		`Tmin	reverse hinge			0.55	0.32	1.97
		`Tmin	reverse hinge			0.42	0.32	2.82
		`Tmin	reverse hinge			0.61	0.32	2.91
		'Cmax	forward hinge			0.74	28.02	38.83
		'Cmax	forward hinge			0.30	28.15	38.83
			LPN			-0.64		
			DN			167.44		
	entropy	7.61						

	variable	feature	λ	k_1	k_2
<i>Sabatieria celtica</i>	Cmin	linear	7.12	0.04	13.69
	Tavg	linear	4.03	0.98	24.07
	Tmax	linear	1.28	2.42	65.74
	Cavg ²	quadratic	-1.85	1.72	383.22
	Cmin ²	quadratic	-4.02	0.00	187.50
	Tavg ²	quadratic	-2.98	0.96	579.17
	Tmax ²	quadratic	1.67	5.87	4321.48
		LPN	4.18		
		DN	610.23		
	entropy	8.90			
<i>Sabatieria punctata</i>	Cmax	linear	1.35	4.89	38.83
	Tmax	linear	3.00	3.03	55.95
	D50x ²	quadratic	-5.34	16.15	363174.99
	D50x*Tmax	product	1.06	123.91	15593.29
	(18.02<Tmax)	threshold	1.11	0.00	1.00
	(28.06<Tmax)	threshold	0.11	0.00	1.00
	(19.55<Cmax)	threshold	0.31	0.00	1.00
	(304.28<D50x)	threshold	-0.32	0.00	1.00
	(36.48<Tmax)	threshold	-0.83	0.00	1.00
	(2.02<Cmin)	threshold	-0.42	0.00	1.00
	(0.11<Cmin)	threshold	-0.30	0.00	1.00
	(28.56<Tmax)	threshold	0.04	0.00	1.00
	(35.13<Cmax)	threshold	-0.22	0.00	1.00
		LPN	4.59		
		DN	390.95		
		entropy	7.50		

Table A4.2. Model parameters of the threshold models of the six nematode species modelled in Chapter 6.

