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over two competing algorithms – MaxEnt (maximum $\hspace{0.2cm}$ $\hspace{0.2cm}$ (maximum $\hspace{0.2cm}$

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models that are based on genetic data.

SPECIES DISTRIBUTION MODELS

of a species, and thus how much additional \mathbf{A} should be included in the statistical analysis. On the one hand, including lots of absence data may tend to lead to over-fitting of climatic variables and simply demonstrate that \mathbf{y}_i temperate species are unlikely to occur in tropical are unlikely to occur in tropical areas $\mathcal{L}_\mathbf{z}$ (2007) . $-D$ by the many $\frac{1}{2}$ $\begin{array}{ccc}\n\mathbb{B} & 8 & , 2007. \\
\hline\n\end{array}$ $\begin{array}{ccc}\n\mathbb{B} & \mathbb{B} & \mathbb{B} \\
\hline\n\end{array}$ (H & , 2000), $(H \& 0, 2000),$ ited dispersal (Fenster et al., 2003), philopatry (Weatherme $\& 1, 1, 2)$ expressed as $A = B \&$ (2007) have shown, models of spatial variation in abundance shown, models of spatial variation in abundance $f(x)$ of N A lation can obtain $f(x) = f(x)$ and $f(x) = f(x)$ and $f(x) = f(x)$ are statistically independent of one another. \overrightarrow{f} the other hand, many climate models do forecast \overrightarrow{f} strong changes in abiotic variables over the next century, $\begin{array}{cc} \downarrow \qquad \qquad \downarrow \qquad$ et al., 2012), $f \rightarrow$
f f (et al., abundant evidence from the fossil record f record f record ℓ record ℓ record ℓ 2013). Some effort show \mathbf{f} spatially varied sampling to encompass some of the potential of the conditions that arise for example $f(x)$ for example $f(x)$ is made about sampling models showld certainly models showld certainly models showld certainly $\frac{1}{2}$ explore the consequences of including versus excluding versus exclud absence data or training data that are collected beyond the current range boundaries of a species f and (x_1, x_2, \ldots, x_n) A , 2014).

MODELLING SPECIES RANGE LIMITS WITH GENETICALLY DISTINCT CLUSTERS

Although a variety of methods can be used to estimate the used to estimate p species of species occurrence with simple presence with simple presence ℓ absence data, we favour a \mathbf{f}_{max} and a logit link function \mathcal{R}_{eff} (MeCullagh \mathcal{R}_{eff} , 1989). model properly captures the variance structure of properly f and f $\mathbf A$ information can criterion criterion criterion (AI) for a variety of \mathbf{f} mial predictor variables, and allows for f spatial of spatial order f autocorrelation $\qquad \qquad$ et al. (2009) for since \mathbf{A} and individual generations \mathbf{A} and \mathbf{A} and \mathbf{A} and \mathbf{A} (2007) use since $\int f$ and $\int f$ allelic frequencies at marker loci and environmental variables. The second environmental variables. This kind of model could be applied separately to each \mathbf{f} genetic cluster, raising the interesting possibility that different possibility that different possibility of \mathbf{ff} entr clusters may be best fit with different sets of predictors \mathbf{f} variables. The prediction for each of the m clusters is Pkj, the probability that cluster k is present in location j. To forecast range shifts under changes under changes $\mathbf f$ becomes sites of prediction sites $\mathbf f$ can be expanded beyond the original set of sites where the sit data were collected.

individual and sex-specific variation in recombination. American Journal of Human Genetics, $63, 61-6$. $-B \rightarrow \cdots$, $-p-B \rightarrow \cdots$ P^{max} , \leftarrow degree H , \rightarrow \leftarrow H , \rightarrow \leftarrow H $\begin{array}{lllllll} \text{,} & \text{,} &$ \ldots , \ldots , \mathbb{E} , \ldots , \mathbb{E} (2011) $f \quad f$ \star Science, 334, 652–655. Burrows, M.T., Schoeman, D.S., Richardson, A.J. et al. (2014) $\qquad \qquad - \qquad \qquad$ f $\frac{1}{2}$ ested by climate velocity. Nature, 507, 492. $\mathcal{D} \rightarrow \mathbb{B}$. $\mathcal{D} \rightarrow \mathbb{B}$, $\mathcal{D} \rightarrow \mathbb{B}$ $-B$ \cdots $, -A$, \cdots $, -A$, \cdots $, -D$ H , H $e_1, e_2, \ldots, e_{n-1}$ $e_3, e_4, \ldots, e_{n-1}$ $e_4, e_5, \ldots, e_{n-1}$ $\frac{1}{\sqrt{2}}$ contrast $\frac{1}{\sqrt{2}}$ contrast of Climate, 19, 2122–2143.

 κ , κ , κ , κ (2012) Patterns of neutral diversity of neutral diversity of neutral diversity of neutral diversity of κ under general models of selections of selections, $\mathbf f$ selections, $\mathbf f$ 205–240.

- $H \, A, \, S, \, R, \, R, \, H \, H$ genetic structure in an expanding of $\mathcal{L}_{\mathcal{A}}$ population. Molecular Ecology, $19, 45, -471$. $H \longrightarrow A$., $-\gamma$, $-\gamma$, γ , γ , β , H , \ldots , $-\gamma$ m_1 , m_2 , m_3 , m_4 , m_5 , m_6 , m_7 , m_8 , m_7 , m_8 $-\mathbf{B}$, \mathbf{A} ra- (2011) **A** bidopsis thaliana general sections of $\frac{334}{3}$, 3-6. $H \longrightarrow \rightarrow \rightarrow$ A cherman, B beerling, H been H been assumed by H been assumed by B O., Hsu, S.L., Parmesan, C., Rockstrom, J., Rohling, E.J., S \rightarrow S \rightarrow S \rightarrow \mathbf{f} , \rightarrow \rightarrow \rightarrow \rightarrow \rightarrow \rightarrow $\begin{array}{cc} \text{S} & \text{S} \\ \text{S} & \text{S} \end{array}$, $\begin{array}{cc} \text{S} & \text{S} \\ \text{S} & \text{S} \end{array}$, $\begin{array}{cc} \text{S} & \text{S} \\ \text{S} & \text{S} \end{array}$ ous climate change \mathbf{r} required reduction of carbon emission of \mathbf{f} sions to protect young people, future generations and \mathbf{r} $PLOS ONE, 8, 164.$ $H \t, I. 8 \t, (2000)$ $\overline{}$ f fragmented landscape. Nature, 404, 755– 75. $H \t, A., \t, .& , \t, .& , \t, .& (2014) A$ cies in \mathcal{A} range limits with limits write \mathcal{A} review \mathcal{A} f transplant experiments beyond the range of f the American Naturalist, 183, 157–173. H , . & , . (2013) If f - $\frac{1}{2}$ \leftarrow Ecography, 36, 64–67. $H \nvert f \nvert , \nvert f$. \mathcal{L} (200) A - $f\{f\}$. The American Naturalist, 173, 57 $-$ 5. Hernandez, P.A., Graham, C.H., Master, L.L. & Albert, D.L. (2006) ff f on performance of different species distribution modeling f different species distribution modeling f . Ecography, 29, 773-7 5. $\overline{\mathcal{F}}$, \cdots (171) \mathbf{f} . The Wilson Bulletin, 83 , $215-236$. Jay, F., Manel, S., Alvarez, N., Durand, E.Y., Thuiller, W., Holderegger, R., Taberlet, P. & Francois, O. (2012) Fore $c_{\rm c}$ in population $\mathbf f$. Molecular Ecology, $21, 2354 - 236$. $\neg \rightarrow \neg \neg B, A, -\n\overline{B}, \dots, -\n\overline{D}, \dots$ \therefore \therefore $\&$ \therefore (2007) A $\qquad \qquad \Rightarrow$ (A) for selection for selection: towards a landscape genomics approach to adaptation. Molecular Ecology, 16 , 3 55– 3 6. κ , κ , $\frac{1}{\epsilon}$, $\frac{1}{\epsilon}$ (2010) increases fitness during a biological invasion. Journal of Evolutionary Biology, 23, 1720–1731. λ , $\&$, λ (200) A meta-analysis of . PLoS ONE, 3, 4010. \mathcal{L} , \mathcal{L} and \mathcal{L} are significant in \mathcal{L} $\mathbf f$ **local generic differentiation in plants.** Annual Review of Ecology and Systematics, 27, 237–277. $\sum_{\nu_1,\ldots,\nu_k} \frac{1}{\nu_k} \mathbb{E}_{\nu_1,\ldots,\nu_k} \mathbb{E}_{\nu_1,\ldots,\nu_k} \mathbb{E}_{\nu_1,\ldots,\nu_k} \mathbb{E}_{\nu_1,\ldots,\nu_k} \mathbb{E}_{\nu_1,\ldots,\nu_k} \mathbb{E}_{\nu_1,\ldots,\nu_k}$ $-\frac{8}{x}$ A \rightarrow $\frac{1}{x}$ $-\frac{1}{x}$ (200)
	- . Nature, 462, 1052-

, $\frac{1}{2}$, ...& , ... (2006) -
Figure 1 - Ecological Modelling, 190, 231–25. Genetics, 155, 45– 5.
 $\frac{8}{3}$, $\frac{1}{1}$, (200)

f Science, 321, 6. (2013) R: a language and environment for statistical computing. , and \mathcal{L} , \mathcal{L} , \mathcal{L} , \mathcal{L} , \mathcal{L} , \mathcal{L} Maxent f . Journal of Biogeography, $41, 62$ – 643.

 $\frac{1}{2}$, $\frac{1}{2}$ Molecular Ecology, 16, 3 73-3 2.

 \rightarrow A. & \rightarrow D., ... (200) Hierarchical modeling
and inference in ecology: the analysis of data from popula-

tions, metapopulations and communities. $887/7331$ (5.5 10)-(\pounds (\pounds) / 2D50(1 50 1. $83/412/8017$ 45) $J_1=12.52.0107053$ ($J_1=12.52.0107053$) $J_2=12.52.0107053$