Ecography

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Cabral, J. S., Valente, L. and Hartig, F. 2016. Mechanistic simulation models in macroecology and biogeography: state-of-art and prospects. – Ecography doi: 10.1111/ecog.02480

Supplementary material

Supplementary material Appendix 1

Table A1. Selected studies employing mechanistic simulation models in macroecology and biogeography. We adopt a broad definition of macroecology and focus on mechanistic simulation models that investigate spatiotemporal patterns of individuals, populations, species, communities, and assemblages. Our review purposefully encompasses a wider diversity of processes, from physiology, demography, dispersal, biotic interactions, to micro- and macro-evolutionary processes, as well as natural and human-induced drivers. Our goal was to broadly identify the range of processes modelled as well as process-combinations that remain unexplored. We therefore did not add publications to the list in Appendix 1 if we identified them as similar in terms of processes and model properties to other publications already included. For each study, we indicate the main ecological and evolutionary processes modelled, the natural and human drivers considered, and key model properties. The rows highlighted in grey at the bottom of the table present the same information for the classic ecological theories mentioned in the main text (see main text for abbreviations). Ecological processes in the table are physiological (Physio), demographic (Demo), spatial-related processes, such as individual's movement and dispersal (Disp), non-trophic (Non-Trophic), and trophic (Trophic) interactions. Evolutionary processes include micro- (Micro) and macroevolutionary (Macro). Natural drivers comprise spatial variability or heterogeneity (SpatVar), temporal variability (TimeVar), disturbances or perturbations (Disturb), geomorphological (Geo), climate change (CC), and direct human impacts (Direct). Note that what we refer to ecological process types have evolutionary aspects as well (see Fig. 2 on the main text). Among the model properties, we classified the model as spatially implicit vs. explicit; stochastic vs. deterministic; neutral vs. niche-based; according to the ecological level of focus; and according to whether the model considers intraspecific variation. Note that, in principle, niche-based models could also be applied in a way that they are effectively neutral (very wide or equal niches), and that some stochastic models may include deterministic variants. In such cases, we classify the models still in terms of their most complex variant (e.g. stochastic or niche-based). For the ecological level of focus, we considered only the highest level for the model proposed by Harfoot et al. (2014), which focuses on population for eutotrophs and individuals for heterotrophs.

Model	**Processes**							**Drivers**						**Properties**				
	Ecological					**Evolutionary**		**Natural**				**Human**						
Reference	**Physio**	**Demo**	**Disp**	**Non-Trophic**	**Trophic**	**Micro**	**Macro**	**Spat Var**	**Time Var**	**Disturb**	**Geo**	**CC**	**Direct**	**Spatially Explicit/ Implicit**	**Stochastic/ Deterministic**	**Neutral / Niche**	**Focus Ecological Level**	**Intraspecifc Variation**
Anderson et al. 2009		yes	yes					yes				yes		explicit	stochastic	niche	population	none
Bell 2001		yes	yes	yes										explicit	stochastic	neutral	individual	none
Bell 2005		yes	yes	yes				yes						explicit	stochastic	niche	individual	none
Best et al. 2007		yes	yes					yes				yes		explicit	stochastic	niche	population	none
Binzer et al. 2016	yes	yes			yes									implicit	stochastic	niche	population	none
Bocedi et al. 2014		yes	yes			yes		yes	yes			yes	yes	explicit	stochastic	niche	individual	yes
Boeye et al. 2014		yes	yes	yes				yes						explicit	stochastic	niche	individual	none
Bohn et al. 2011		yes		yes						yes				implicit	stochastic	niche	population	none
Borregaard et al. 2015		yes	yes	yes			yes				yes			implicit	deterministic	niche	community	none
Botta-Dukát and Czúcz 2016	yes	yes	yes	yes				yes						implicit	stochastic	niche	individual	none
Bourne et al. 2014		yes	yes			yes		yes	yes			yes		explicit	stochastic	niche	individual	yes
Brooker et al. 2007		yes	yes	yes				yes				yes		explicit	stochastic	niche	individual	none
Buckley 2008	yes	yes			yes				yes			yes		implicit	stochastic	niche	individual	none
Buckley et al. 2015	yes								yes			yes		implicit	stochastic	niche	individual	none
Cabral et al. 2011		yes	yes					yes		yes			yes	explicit	stochastic	niche	population	none

Model	Processes							Drivers						Properties				
	Ecological					Evolutionary		Natural				Human						
Reference	**Physio**	**Demo**	**Disp**	**Non-Trophic**	**Trophic**	**Micro**	**Macro**	**Spat Var**	**Time Var**	**Disturb**	**Geo**	**CC**	**Direct**	**Spatially Explicit/ Implicit**	**Stochastic/ Deterministic**	**Neutral / Niche**	**Focus Ecological Level**	**Intraspecifc Variation**
Cabral and Kreft 2012	yes	yes	yes	yes				yes						explicit	stochastic	niche	population	none
Cabral and Schurr 2010		yes	yes					yes		yes				explicit	stochastic	niche	population	none
Cazelles et al. 2016		yes	yes	yes	yes									implicit	stochastic	niche	species	none
Cheung et al. 2009		yes	yes					yes				yes		explicit	stochastic	niche	population	none
Cheung et al. 2011	yes	yes	yes		yes			yes				yes		explicit	stochastic	niche	population	none
Chuine and Beaubien 2001	yes	yes							yes					implicit	stochastic	niche	individual	none
Cobben et al. 2012	yes	yes	yes			yes		yes				yes		explicit	stochastic	niche	individual	yes
Colwell and Rangel 2010			yes				yes	yes	yes					explicit	stochastic	niche	species	none
de Aguiar et al. 2009		yes	yes			yes								explicit	stochastic	neutral	individual	none
Dislich et al. 2010	yes	yes	yes	yes						yes				explicit	stochastic	niche	individual	none
dos Santos et al. 2011		yes	yes	yes						yes				explicit	stochastic	niche	individual	none
Fordham et al. 2013	yes	yes	yes					yes				yes	yes	explicit	stochastic	niche	population	none
García-Valdés et al. 2013	yes	yes	yes					yes				yes		explicit	stochastic	niche	population	none
García-Valdés et al. 2015	yes	yes	yes					yes				yes	yes	explicit	stochastic	niche	population	none
Goldberg et al. 2011		yes	yes				yes	yes						explicit	stochastic	niche	species	none
Gravel et al. 2011		yes	yes		yes									implicit	stochastic	niche	community	none
Gutiérrez et al. 2016	yes	yes		yes										implicit	stochastic	niche	individual	none
Harfoot et al. 2014	yes	yes	yes	yes	yes			yes	yes					explicit	stochastic	niche	population	none
Hartig et al. 2014		yes		yes			yes							implicit	stochastic	niche	Individual	none
Hickler et al. 2012	yes	yes		yes				yes				yes		implicit	stochastic	niche	population	none
Higgins and Cain 2002		yes	yes	yes				yes		yes				explicit	stochastic	niche	population	none

Model	Processes							Drivers						Properties				
	Ecological					Evolutionary		Natural				Human						
Reference	**Physio**	**Demo**	**Disp**	**Non-Trophic**	**Trophic**	**Micro**	**Macro**	**Spat Var**	**Time Var**	**Disturb**	**Geo**	**CC**	**Direct**	**Spatially Explicit/ Implicit**	**Stochastic/ Deterministic**	**Neutral / Niche**	**Focus Ecological Level**	**Intraspecifc Variation**
Higgins et al. 2012	yes													implicit	stochastic	niche	individual	none
Higgins and Scheiter 2012	yes	yes		yes					yes	yes		yes		implicit	stochastic	niche	individual	none
Hortal et al. 2009		yes	yes	yes				yes						implicit	stochastic	niche	individual	none
Jabot 2010		yes	yes	yes				yes						implicit	stochastic	niche	individual	none
Kearney 2012	yes								yes					implicit	stochastic	niche	individual	none
Kearney et al. 2008	yes		yes						yes			yes		implicit	stochastic	niche	individual	none
Kearney et al. 2009	yes		yes			yes			yes			yes		implicit	stochastic	niche	individual	none
Keith et al. 2008		yes	yes					yes		yes		yes		explicit	stochastic	niche	population	none
Krug et al. 2010		yes	yes					yes		yes			yes	explicit	stochastic	niche	population	none
Kubisch et al. 2011		yes	yes			yes		yes	yes					explicit	stochastic	niche	individual	yes
Kubisch et al. 2013		yes	yes	yes		yes		yes	yes			yes		explicit	stochastic	niche	individual	yes
Kubisch et al. 2014		yes	yes	yes	yes	yes		yes	yes					explicit	stochastic	niche	individual	yes
Kuparinen et al. 2007		yes	yes					yes	yes				yes	explicit	stochastic	niche	individual	none
Kuparinen et al. 2010	yes	yes	yes			yes		yes				yes		explicit	stochastic	niche	individual	yes
Kuparinen et al. 2012		yes	yes			yes								implicit	stochastic	niche	individual	yes
Lawson et al. 2010		yes	yes					yes		yes		yes		explicit	stochastic	niche	population	none
Lin et al. 2012	yes	yes		yes										explicit	stochastic	niche	individual	none
Lin et al. 2013	yes	yes		yes										explicit	stochastic	niche	individual	none
May et al. 2015		yes	yes	yes			yes							explicit	stochastic	neutral	individual	none
Midgley et al. 2010		yes	yes	yes				yes		yes		yes	yes	explicit	stochastic	niche	population	none
Mokany et al. 2012		yes	yes					yes	yes			yes	yes	explicit	stochastic	neutral	community	none

Model	Processes							Drivers						Properties				
	Ecological					Evolutionary		Natural				Human						
Reference	Physio	Demo	Disp	Non-Trophic	Trophic	Micro	Macro	Spat Var	Time Var	Disturb	Geo	CC	Direct	Spatially Explicit/ Implicit	Stochastic/ Deterministic	Neutral / Niche	Focus Ecological Level	Intraspecifc Variation
Morin et al. 2008	yes	yes	yes					yes	yes			yes		explicit	stochastic	niche	individual	none
Münkemüller et al. 2012		yes	yes	yes				yes						explicit	stochastic	niche	individual	none
Münkemüller and Gallien 2015		yes		yes			yes						yes	implicit	stochastic	niche	individual	none
Pagel and Schurr 2012	yes	yes	yes					yes	yes			yes		explicit	stochastic	niche	population	none
Pigot et al. 2010		yes	yes				yes							explicit	stochastic	neutral	species	none
Pigot and Etienne 2015		yes	yes	yes			yes							implicit	stochastic	neutral	community	none
Rangel and Diniz-Filho 2005a		yes	yes	yes						yes				explicit	stochastic	neutral	community	none
Rangel and Diniz-Filho 2005b			yes				yes	yes						explicit	stochastic	niche	species	none
Rangel et al. 2007			yes				yes	yes	yes					explicit	stochastic	niche	species	none
Regan et al. 2012		yes	yes					yes	yes	yes		yes	yes	explicit	stochastic	niche	population	none
Reu et al. 2011	yes													implicit	stochastic	niche	individual	none
Rosindell and Cornell 2007		yes	yes	yes			yes							explicit	stochastic	neutral	individual	none
Rosindell and Harmon 2013		yes	yes	yes										implicit	stochastic	neutral	individual	none
Sarmento Cabral et al. 2013		yes	yes					yes		yes		yes	yes	explicit	stochastic	niche	population	none
Scheiter and Higgins 2009	yes	yes		yes					yes	yes		yes		implicit	stochastic	niche	individual	none
Schiffers et al. 2013		yes	yes			yes		yes				yes		explicit	stochastic	niche	individual	yes
Smith and Lundholm 2010		yes	yes	yes				yes						explicit	stochastic	niche	individual	none
Smolik et al. 2010			yes					yes					yes	explicit	stochastic	niche	population	none
Sukumaran et al. 2015		yes	yes		yes		yes	yes					yes	explicit	stochastic	niche	species	none
Swab et al. 2015		yes	yes					yes				yes		explicit	stochastic	niche	population	none
Tello and Stevens 2012		yes	yes				yes							explicit	stochastic	neutral	species	none

Model	Processes							Drivers						Properties				
	Ecological					Evolutionary		Natural				Human						
Reference	Physio	Demo	Disp	Non-Trophic	Trophic	Micro	Macro	Spat Var	Time Var	Disturb	Geo	CC	Direct	Spatially Explicit/ Implicit	Stochastic/ Deterministic	Neutral / Niche	Focus Ecological Level	Intraspecifc Variation
Travis 2003		yes	yes					yes		yes		yes	yes	explicit	stochastic	niche	population	none
Travis and Dytham 2002		yes	yes				yes						yes	explicit	stochastic	niche	population	yes
Travis et al. 2005		yes	yes	yes				yes						explicit	stochastic	niche	individual	none
Travis et al. 2006		yes	yes	yes				yes						explicit	stochastic	niche	individual	none
Travis et al. 2009		yes	yes			yes							yes	explicit	stochastic	niche	population	none
Triantis et al. 2015		yes	yes	yes			yes							implicit	deterministic	neutral	community	none
Valente et al. 2014		yes	yes	yes			yes				yes			implicit	stochastic	neutral	community	none
Valente et al. 2015		yes	yes	yes			yes							implicit	stochastic	neutral	community	none
Zinck et al. 2010		yes								yes				explicit	stochastic	niche	individual	none
Zurell et al. 2012		yes	yes					yes	yes			yes		explicit	stochastic	niche	individual	yes
DEB	yes	yes												implicit	deterministic	niche	individual	none
ETIB		yes	yes	yes			yes							explicit	stochastic	neutral	community	none
GDM		yes	yes	yes			yes	yes			yes			explicit	stochastic	niche	community	none
Metapopulation		yes	yes					yes	yes	yes				implicit	stochastic	neutral	population	none
MTE	yes	yes				yes	yes	yes						implicit	deterministic	niche	individual	none
Niche	yes	yes	yes	yes		yes		yes						explicit	stochastic	niche	species	none
UNTB		yes	yes	yes			yes							implicit	stochastic	neutral	individual	none

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