

ESF Exploratory Workshop on  
**‘Modelling in Ecology; Does Simple  
Always Equate to General?’**

London (UK), 15-16 September 2011

Convened by:  
**Prof Matthew Evans, Prof Tim Benton  
and Dr Maureen O’Malley**

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**SCIENTIFIC REPORT**

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## 1. Executive summary

The workshop '*Modelling in Ecology; does simple always equate to general?*' was held at Goodenough College, London UK, accommodation was provided in the nearby Goodenough Club. As per the previously announced programme it was held over the 15<sup>th</sup> and 16<sup>th</sup> September 2011, with participants arriving on 14<sup>th</sup> and leaving on 17<sup>th</sup>. There were 14 participants at the meeting, two of the invitees did not arrive. The meeting was held in a medium-sized seminar room; tea, coffee and lunch was provided by the Goodenough College. There was substantial interaction during the breaks. The general atmosphere was vibrant, challenging and collaborative. It was recognised by almost everyone that this was a unique event as it brought together philosophers of science and biologists with an interest in engaging with a common question. The objective of the meeting was to interrogate the way in which ecological modelling is pursued at the moment, to contrast the way modelling is achieved in ecology and systems approaches taken in other areas of biology, to allow consideration of whether change in approaches to ecological modelling are desirable and how to achieve them. The overall conclusion was that there was an established tradition in ecological modelling of assuming that simple models were more general, and that general models were better and more desirable. The consensus conclusion from the meeting was that it was not obvious that simple models were necessarily more general than more complex models, in fact in many instances the converse would be true. It was felt that the emphasis on simple models was detrimental to ecology and that the subject should embrace greater plurality, which means that modelling approaches are adopted that are the best for the purpose for which they are being used. The attendees at the meeting have agreed on a common position which is currently being written into an article for Trends in Ecology and Evolution. The abstract of this paper is pasted at Appendix 1.

## 2. Scientific Content of the Event.

Summaries of presentations:

### **“The state of play” Tim Benton**

An introduction to the issues surrounding modelling in ecology: Tim focussed on the problems created by the ecological modelling community's emphasis on simple models. The talk was illustrated with reference to personally experienced examples of the simple=general=good phenomenon.

### **“An ecologist’s perspective on modelling” Matthew Evans**

A discussion about the history of ecological modelling from the 1960s onwards: Introducing the idea that modelling philosophy was not being thought through when decisions were being made about the modelling approaches to take to a particular problem.

### **“Systems biology and modelling” Darren Wilkinson**

An outline of the systems biology approach to modelling, emphasising the distinction between interpolation (within the range of data) and extrapolation (outside the range of data): A description of some recent developments that allow computationally tractable approaches to fitting nonlinear stochastic models to data.

### **“The view of a naïve field ecologist” Kate Lessells**

Asked the question ‘is a model that is as complex as the real world useful?’ which was answered in the affirmative. Discussed the pragmatic view that models were good if they were useful in solving the problem at which they were pitched. One issue is that all modellers have to grapple with is what to leave out and what to keep in a model.

### **“Pluralism in modelling” Karin Johst**

A talk illustrated by reference to examples from own work, predominantly around the issue of succession: Making a clear argument for pluralism – i.e. the use of multiple approaches, both simple and complex.

### **“Systems biology modelling” Olaf Wolkenhauer**

This talk outlined the argument for the use of theory as the development of frameworks: Illustrated with examples from molecular systems biology.

### **“Individual based models and pattern-orientated modelling” Volker Grimm**

Discussed the issue of over-abstraction – are simple models just too abstract, which raises the question how good are proxies? Similarly the approach in which everything is measured and computed as characterised by the International Biological Programme in the 1960s could be described as naïve realism. We are looking for the Medawar Zone – which maximises pay-off. Pattern-orientated modelling is one approach to finding this zone.

### **“A philosopher of science’s view of the simple=general debate” Michael Weisberg**

If models have are un-instantiated (i.e. the parameters are not given values) then simple models will be less general not more general than complex models (i.e.  $y = ax + bx^2$ , obviously contains  $y = ax$  and so is the more general formulation but is also the less simple of the two formulae).

### **“Complexity – generality tradeoffs in modelling” Rogier de Langhe**

Presented a general discussion of the issues of trade-offs in modelling. Concluding with a general proof for the trade-offs posited by Levins in 1966.

### **“Accuracy and modelling” Tarja Knuuttila**

Suggested that we need to distinguish between conceptual and representational accuracy: Conceptual accuracy being how well statements represent the model and representational accuracy being how well the model represents the world. This distinction is important in understanding the application of models.

### **“Idealisation” Martina Metz**

There are two ways to simplify a model – through omission (abstraction) or through distortion (idealisation). Idealisation needs to be justified and can be used to isolate a factor of interest. We also need to distinguish between logical prediction and temporal prediction by which means we respectively either test theory or make statements about the future. This talk also gave insights into modelling from a social science perspective.

### **“A perspective on modelling” Steve Orzack**

What counts is how well a model predicts. We should compare models to each other – so one model is more (or less) general than another model, in other words these concepts are relative not absolute.

### **3. Assessment of the results, contribution to the future direction of the field, outcome**

The workshop was extremely successful by bringing together two groups of people who do not normally engage with each other – ecologists and philosophers of science, this was a productive exchange that resulted in a lot of interesting discussion and new insights on both sides. There was substantial discussion at the end of each session that explored the issues under consideration – in particular the notions that a) ecology was dominated by an acceptance that simple = general = good; and b) was it reasonable to regard either simple or complex models as more general than the other. The conclusion was that it did seem that ecology was dominated by the simple = general = good notion, probably as a result of this view being promulgated by many of the subject's pioneers. The discussion about whether simple models were more (or less) general than complex models was at times heated and there remained disagreements, but the final agreement was that there was no justification for saying that simple models were necessarily more general than complex models. In fact the majority were convinced that there were good reasons to suggest that the reverse was more likely and with a minority suggesting that actually there was no justification in expecting either simple or complex models to be more general than the other. Sufficient agreement was reached to allow the formulation of an article which is aimed at Trends in Ecology and Evolution to which everyone at the meeting was prepared to put their names. The meeting agreed a process by which this article would be prepared and it has been drafted by a core group (O'Malley, Weisberg, Orzack, Evans, Grimm and Johst) and has been sent to all participants at the meeting for comment.

At the encouragement of the ESF representative (Constantin Doukas) sometime was spent considering funding, all participants declared an interest in pursuing funding if suitable opportunities arose. However, the ESF Research Network Programme has been suspended, which we would have immediately pursued and would have been supported by Doukas. It was constantly noted how unusual this workshop had been, containing as it did philosophers of science, systems biologist and ecologist – many of the people at the workshop had never been exposed to the views of people in the other communities. In the view of the philosophers the meeting was unique. In the interests of pursuing the interaction we are exploring the option of applying for an ESF research conference for 2014.



## Friday, 16<sup>th</sup> September 2011

### 09.00-12.30 Morning Session

09.00-09.30 "A philosopher of science's view of the simple=general debate"  
Michael Weisberg

"A perspective on modelling"

09.30-10.00 "Complexity – generality tradeoffs in modelling"  
Rogier de Langhe

10.00-10.30 Time taken up by Rogier's talk over-running

10.30-11.00 *Coffee / Tea Break*

11.00-11.30 "Accuracy and modelling"  
Tarja Knuuttila

11.30-12.00 "Idealisation"  
Martina Metz

12.00-12.30 "A perspective on modelling"  
Steve Orzack

12.30-14.00 *Lunch*

### 14.00-15.30 Afternoon Session

Discussion to consider opportunities for following up the issues raised in the meeting, agreeing a position statement that everyone could sign.

15.30-16.00 *Coffee / tea break*

16.00-16.30 **Summing up and agreeing drafting process for paper**  
Maureen O'Mally & Matthew Evans

16.30 *End of Workshop*

19.00 *Dinner: Cigala – not paid by ESF*

## Saturday, 17<sup>th</sup> September 2011

**Departure**

## 5. Final list of participants

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## 6. Statistical information on participants

	UK	Germany	The Netherlands	France	Switzerland	Finland	Norway	Denmark	Spain	Belgium	USA
% by country	0.31	0.23	0.08	0.00	0.08	0.08	0.00	0.00	0.00	0.08	0.15
% female	0.38										

Data on age were not collected.

### ***Are simple ecological models more general?***

Proposal prepared by working group on behalf of the 14 participants at the ESF-funded meeting, *Modelling in ecology: does simple always equate to general?*

Tim Benton (Leeds)

Matthew R. Evans (Queen Mary, London)

Volker Grimm (Helmholtz Center for Environmental Research — UFZ, Leipzig)

Karin Johst (Helmholtz Center for Environmental Research — UFZ, Leipzig)

Maureen A. O'Malley (Sydney, Australia)

Steven Orzack (Fresh Pond Research Institute)

Michael Weisberg (Pennsylvania)

Proponents of simplicity in ecological models have argued that simple models are more likely to yield general conclusions (e.g., [<sup>i</sup>, <sup>ii</sup>, <sup>iii</sup>]). Many ecologists have taken this to mean that only simple models are valuable, since only simple models can attain generality [<sup>iv</sup>].

We outline a range of definitions of both simplicity and generality and argue that there are good reasons to believe that simple models are less general than is often claimed. We examine a variety of contemporary ecological models and show how they include many assumptions about the systems they represent and so their complexity is concealed [<sup>v</sup>]. By contrast, complex models often make fewer assumptions about the systems they represent than simple models. We discuss the virtues of simple and complex models and conclude that a plurality of modelling approaches is desirable (e.g., [<sup>vi</sup>, <sup>vii</sup>, <sup>viii</sup>, <sup>ix</sup>, <sup>x</sup>, <sup>xi</sup>, <sup>xii</sup>, <sup>xiii</sup>, <sup>xiv</sup>]). Our central point is that simple models are not necessarily more general than complex models, which suggests that there is no justification for the emphasis on simple models in ecology [<sup>xv</sup>, <sup>xvi</sup>, <sup>xvii</sup>]. However, we do not perceive simple and complex models as competitive but as complementary, and will show how they work together.

The mistaken belief in the greater generality of simple models generates a bias towards such models. Such a bias would be of no concern if the outcome were neutral, but simple models are not well suited on their own to providing answers to most of the problems ecologists are now trying to solve. For example, the prediction of the state of ecosystems subject to environmental change will require relatively complex, process-based models. The time for a change in emphasis in ecological modelling is now.

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<sup>i</sup> Doak, D.F. and Mills, L.S. (1994) A useful role for theory in conservation. *Ecology* 75, 615-626

<sup>ii</sup> Beissinger, S.R. and Westphal, M.I. (1998) On the use of demographic models of population viability in endangered species management. *J. Wildl. Manage.* 62, 821-841

<sup>iii</sup> Pace, M.L. (2003) The utility of simple models in ecosystem science. In *Models in Ecosystem Science* (Canham, C.D., et al., eds.), pp. 49-62, Princeton University Press

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- <sup>iv</sup> Holling, C.S. (1966) The strategy of building models of complex ecological systems. In *Systems Analysis in Ecology* (Watt K.E.F., ed.), pp. 195–214, Academic Press
- <sup>v</sup> Donalson, D.D., and Nisbet, R.M. (1999). Population dynamics and spatial scale: effects of system size on population persistence. *Ecology* 80, 2492-2507
- <sup>vi</sup> Loreau, M., and Holt, R.D. (2004) Spatial flows and the regulation of ecosystems. *Am. Nat.* 163, 606-615
- <sup>vii</sup> Johst, K., *et al.* (2006) Diversity and disturbances in the Antarctic megabenthos: feasible versus theoretical disturbance ranges. *Ecosystems* 9, 1145-1155
- <sup>viii</sup> Chon, T.-S. *et al.* (2009) Individual-based models. In *Handbook of Ecological Modelling and Informatics* (Jørgensen, S.E. *et al.*, eds.), pp. 99-123, WIT Press
- <sup>ix</sup> Dos Santos, F. A. S., *et al.* (2011) Neutral communities may lead to decreasing diversity-disturbance relationships: insights from a generic simulation model. *Ecol. Lett.* 14, 653-660
- <sup>x</sup> Calabrese J.M., *et al.* (2010) The interactive effects of tree-tree establishment competition and fire on savanna structure and dynamics. *Am. Nat.* 175, E44–E65
- <sup>xi</sup> Gilman, S.E., *et al.* (2010). A framework for community interactions under climate change. *Trends Ecol. Evol.* 25, 325-331
- <sup>xii</sup> Goss-Custard, J., *et al.* (2006) Test of a behaviour-based individual-based model: response of shorebird mortality to habitat loss. *Ecol. Appl.* 16, 2215–22
- <sup>xiii</sup> Railsback, S.F., and Grimm, V. (2011) *Agent-Based and Individual-Based Modeling: A Practical Introduction*. Princeton University Press
- <sup>xiv</sup> Stillman, R.A. and Goss-Custard, J.D. (2010). Individual-based ecology of coastal birds. *Biol. Rev.* 85, 413-434
- <sup>xv</sup> DeAngelis, D.L. and Mooij W.M. (2003) In praise of mechanistically rich models. In *Models in Ecosystem Science* (Canham, C.D., *et al.*, eds.), pp. 63-82, Princeton University Press
- <sup>xvi</sup> Jørgensen, S.E., *et al.* (2009) *Handbook of Ecological Modelling and Informatics*. WIT Press
- <sup>xvii</sup> Jopp, F., *et al.* (2011) *Modelling Complex Ecological Dynamics - An Introduction into Ecological Modelling for Students, Teachers, & Scientists*, Springer