Landscape Ecol (2007) 22:317–318
DOI 10.1007/s10980-006-9008-z

BOOK REVIEW

Individual-based Modeling and Ecology: V. Grimm and S. F. Railsback

Princeton series in theoretical and computational biology, Princeton University Press. 2005. 428pp. Hardcover, ISBN 0-691-09665-1, Paper, ISBN 0-691-09666-X

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Received: 7 April 2006 / Accepted: 21 April 2006 / Published online: 10 June 2006

This book explores the field of individual-based ecological modeling. Individual-based ecology (IBE) is described as the ecology from the perspective of individual organisms and their behavior. Questions addressed by IBE include, e.g., how do system-level patterns of distribution and abundance emerge from interactions of individuals with each other and with their environment? What is the significance of local interactions to dynamics of plant abundance and distribution? What are individual-level processes that explain abundance and distribution at the community and ecosystem level? IBE, like ecology in general, attempts to explain distribution and abundance patterns, however, goes about it in a different way from general ecology. The main difference is that one performs system analysis across levels of organisation by searching for individual behavior to explain system-level dynamics and complexities.

The development of individual-based models requires a sophisticated level of software knowledge which few ecologists are prepared for by their academic training. This book establishes an effective and coherent conceptual and technical framework for individual-based modeling with the objective to develop and illustrate an approach for addressing how individual behaviors and system dynamics emerge from lower-level traits. With the framework, the authors help finding answers to questions e.g., which dynamics in a system should be emergent versus imposed. The framework of individual-based modeling is illustrated with numerous examples. The book is structured into four parts that are divided into a total of twelve chapters.

The introductory part of the book is entitled ''Modeling'' and provides a general summary of the field with three chapters. Guidance is provided for the whole modeling process ranging from the fundamental understanding of models to specific design heuristics. The main purpose of models in science are question-driven descriptions, explanations, and predictions of systems. Modeling is an iterative process during which several tasks are performed, some of them repeatedly. Such tasks include (a) formulation of the question, (b) assembly of hypotheses for processes and structures, (c) choice of essential scales, state variables, processes, and parameters, (d) model implementation, (e) analysis, testing, and revision of the model, (f) communication of the model and its results. This chapter fills an important gap in modeling literature because it specifically addresses the process of modeling, an often neglected subject in the education of environmental scientists.

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The second part of the book, entitled ''Individual-based Ecology'' introduces the topic of IBE in detail with three chapters. In individual-based ecology, the basic assumption is that system-level properties arise from individual-level interactions with each other and their environment. Thus, IBE strives to understand how patterns emerge from the adaptive traits of individuals, and not to simplify empirical complexity. IBE is conducted by interdisciplinary teams trained in simulation modeling, complex systems science, software engineering, and biology.

IBE provides four qualities: testability, generality (developing of theories that apply to wide ranges of conditions), integration across ecological levels, and applicability to real-world ecological management problems.

This part of the book also provides a conceptual framework for designing individual-based models (IBM). The concept can be summarised with a checklist which helps to organize the design of IBMs and may provide a common terminology or framework to communicate models. The conceptual design checklist consists of 10 items: Emergence, adaptation, fitness, prediction, interaction, sensing, stochasticity, collectives, scheduling, and observation. The idea of individual-based models is illustrated with various examples.

The third part of the book is entitled the ''Engine Room'' where technical and software issues are discussed in four chapters. Here, concepts and the technical formulation of individual-based models are introduced. Of primary concern is the efficient reduction of real and perceived uncertainty of the IBM and to provide a consistent and smooth flow of ideas from the IBM's conceptual design through the formulation to its software. One of the objectives of this section is to illustrate links between the model's conceptual design and its translation into a complete, working model. Also of major relevance is to understand that the way we formulate a model—translate a conceptual model into a written description—largely determines the efficiency of the model. Various software-related issues are discussed: software design and platforms, software terminology and concepts, as well as means to test software.

Also of relevance is the analysis of individual-based models. With model analysis, the authors refer to the model's behavior and to learn about the system that the model represents. Objectives typically include verification of the software, finding appropriate model parameters, etc. Altering elements of the model structure, traits of individual biotic units, management practices, etc. helps understanding the model itself and the dynamics of the system under investigation. Model analysis turns modeling into a cycle—indicating whether and how a model needs to be changed before it can be used to solve problems. This part of the book also provides examples of how to communicate a model, how to efficiently describe a model, and how to visualize communication of executable models.

The fourth and final part of the book provides conclusion and presents visions for individual-based modeling.

The book is suited for a broad variety of environmental scientists interested in modeling. On the one hand, an in-depth treatment of individual-based models is provided which makes the book suitable for beginners in modeling. On the other hand, the book challenges traditional ecology with approaches and concepts from complex systems research which makes the book very interesting for advanced modelers. I personally found that the book very successfully linked various ''universes'' ranging from fundamental concepts in ecology and complex systems research to hands-on technical and recipe-like suggestions on how to build a model, illustrated with numerous, well-chosen examples.