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Fundamentals of Ecological Modelling

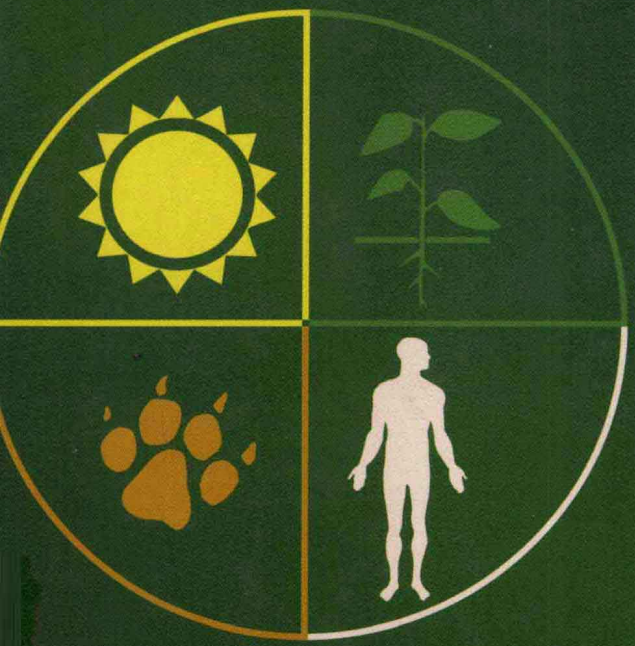
Applications in Environmental Management and Research (Fourth Edition)

生态建模原理

在环境管理和研究中的应用

（原著第四版）

Sven Erik Jørgensen, Brian D. Fath



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应用于环境管理和研究中的生态建模原理

本书《前言》简明扼要地介绍了本书的内容，笔者将《前言》翻译附后，这里就不重复介绍了。

本书主编 Jørgensen 教授是一位国际著名的德高望重的科学家，他的研究和著作推动了国际生态模型和系统生态学的发展。我国系统生态学领域的学者对 Jørgensen 教授并不陌生，1987 年 10 月，他应邀来南京讲学，并连续 3 年考察和指导了太湖流域淀山湖的富营养化研究，与我国学者共同预言，太湖如不认真治理，20 年内将出现重大生态问题，不幸言中了 2007 年的太湖蓝藻爆发事件。近三年，他作为华东师范大学 111 引智项目的国际首席专家，每年在华举办讲习班，并同时关注长江口的湿地生态研究，手把手地指导年轻学者发展了长江口生态工程物种的动态结构模型，取得了重大成果。

国内于 1990 年翻译出版了本书第一版的修订版（《生态模型法原理》，S. E. Jørgenesn 著，陆健健、周玉丽译，张利权校，上海翻译出版公司，1990），那是依据 1986 年本书第一版出版后，Jørgensen 通过 1987 年在华的教育和科研实践，于 1988 年出版的修订版翻译出版的。2008 年本书第三版作为高等教育出版社“生态学名著译丛”之一翻译出版（《生态模型基础》，S. E. Jørgensen，G. Bendoricchio 著，何文珊、陆健健、张修峰译，高等教育出版社，2008）。这次原文影印出版第四版，适用于高校和研究单位的研究生教材，也是从事生态学和环境工作的工程技术人员和管理工作者的重要业务参考书，相信会进一步推动我国的系统生态学研究和生态文明建设实践。

陆健健

2011 年 9 月 18 日

于华东师范大学

作 者 简 介

约恩森（Sven Eric Jørgensen）博士，哥本哈根大学的名誉教授，致力于系统生态学、生态模型和生态工程等方面的研究，已出版专著 66 部，发表论文 350 余篇。约恩森博士已担任《国际生态模型和系统生态学杂志》（International Journal on Ecological Modelling and System Ecology）主编 34 年；他同时还担任《生态学百科全书》（Encyclopendia of Ecology）的主编。他获得了若干重大奖项（普里戈金奖（The Prigoine Award）、帕斯卡奖（The Pascal Medal），中国科学院爱因斯坦讲席教授等），包括极负盛誉的斯德哥尔摩水科学大奖。约恩森博士是哥伦比亚大学、葡萄牙和坦桑尼亚首都达累斯萨拉姆大学的荣誉博士，欧洲科学院院士，以及国际生态模型学会（ISEM）的主席。

法思（Brian D. Fash）博士是美国马里兰州陶森大学（Towson University）生物科学系副教授，国际应用系统分析协会（拉克森堡，奥地利）动态系统项目的研究人员，在各类期刊上发表论文、报告和研究著作近 100 篇。2007 年 6 月，法思博士与约恩森博士共同撰写了其第一部著作《新生态学》（A New Ecology），2008 年，他们又共同编撰了生态学百科全书的 5 卷内容。自 2009 年 1 月起，法思博士开始担任《生态学模型》杂志的主编。他在美国陶森开设了生态系统生态学、环境生物学、网络及人类生态学与可持续发展等课程，还分别在中国、克罗地亚、丹麦、法国、德国和葡萄牙开设了短期课程。法思博士现任巴尔的摩国家环境质量委员会主席。

（陆健健　译）

前　言

这是“生态建模原理”（Fundamentals of Ecological Modelling）的第四版，我们为之取了一个较长的名字：“生态建模原理：在环境管理和研究中的应用”。这么做是为了强调应用在环境管理和生态研究中的一些模型，尤其是本书中涉及的一些模型例证。

本书2001年第三版的共同作者Giuseppe Bendoricchio已于2005年去世，我们借此次再版表达对他的怀念，并纪念其在20世纪80～90年代期间对生态模型发展做出的杰出贡献。

本书的第一、二版（分别于1986和1994年出版）着重于学科基础——4个在30～40年里占该领域主要地位的模型类型：（1）生物地球化学动态模型，（2）种群动态模型，（3）生态毒理模型，及（4）生物地球化学稳态与能量模型。这两版让我们对生态模型有了一个初步的全面理解。Bendoricchio为第三版带来了新的内容，聚焦于生态模型中相关生态过程的数学公式。第三版中，生态过程一章包括了118页，而今天相同的内容可能需要200页了，在2008年秋出版的《生态学百科全书》（Encyclopendia of Ecology）中对此做了较好的阐述。

在第四版中，以之前列出的四个模型类型作为基础，扩展到最新开发的一些模型，包括空间模型、结构动态模型及基于个体的模型。这七个类型的模型各不相同，在模型开发过程中需要考虑的内容也有所不同，因此我们认为对于一本最新的教科书而言，为这七个模型类型的每个模型的开发专设一章非常重要。纵观全书内容，案例主要来自于环境管理和研究相关模型应用的文献。本书内容安排如下：

第一章：生态模型导论，提供一个全面的介绍并引入本书后续内容。

第二章：模型概念，介绍一些主要的模型要素，包括框图模型要素（状态变量），关联模型要素（用流程和数学公式来描绘生物学、化学及物理学过程），控制模型要素（参数，常数），以及推动系统的强制函数。本章还会介绍建模过程，从概念模型到验证、校准、证实和灵敏度分析。

第三章：不同类型模型应该或能够被应用的综述。

第四章：调整和确定模型，对使用模型过程进行简短介绍，从而在综合跨学科的项目中引导研究问题和促进利益相关者参与。

第五章：种群动态模型，包括Lotka-Volterra模型在种群增长及两个或多个种群间的相互作用中的应用，以及其他更现实的捕食—被捕食模型和寄生模型。案例包括渔业和收获模型、异质种群动态模型和传染病模型。

第六章：稳态模型，讨论Chemostat模型，Ecopath软件以及生态网络分析。

第七章：生物地球化学动态模型的应用，从最初的Streeter-Phelps模型到目前复杂的富营养化模型。

第八章：生态毒理模型，提供了多种生态毒理模型的详尽试验及它们在风险评估和环境管理中的应用。

第九章：基于个体的模型，讨论该模型作为一个工具来获取个体在环境中所具备的自发特性和个体特征的历史及起源。

第十章：结构动态模型，列举了21个案例，对模型参数进行变化和调节以达到高等级目的功能（典型的热力学）。

第十一章：空间模型，涵盖了具有理解和管理系统十分重要的空间特征模型。

作为一本教科书，第四版的每一章节都有许多具体模型例证及其运用。前面的版本已经广泛地被作为教科书用于生态建模课程中，笔者寄希望于本版本能够成为目前生态建模课程中一本优秀的基础教材。

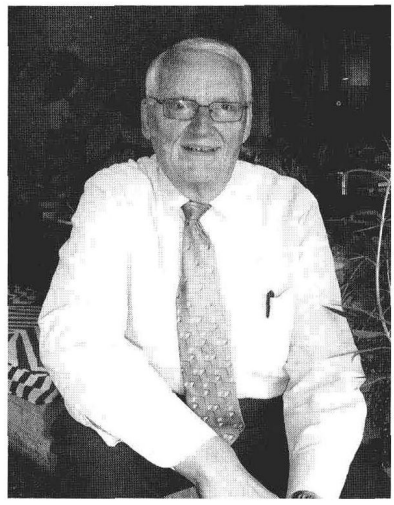
Sven Erik Jørgensen
丹麦　哥本哈根

Brian D. Fath
奥地利　拉克森堡

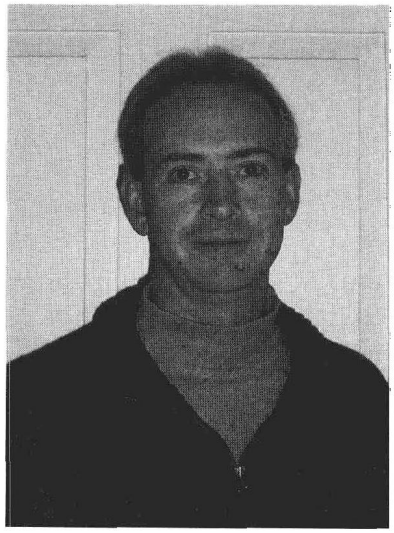
2010年7月

（陆健健　译）

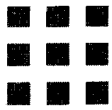
Author Biography



Dr. Jørgensen is Professor Emeritus at the University of Copenhagen and specializes in systems ecology, ecological modelling, and ecological engineering. Dr. Jørgensen has published 66 books and more than 350 papers. He has served as Editor-In-Chief of *Ecological Modelling: International Journal on Ecological Modelling and Systems Ecology* for 34 years. He is also editor-in-chief of *Encyclopedia of Ecology*. He has received several prizes (The Prigoine Award, The Pascal Medal, The Einstein Profesorship of Chinese Academy of Sciences) and the very prestigious Stockholm Water Prize. He is honorable doctor of Coimbra University, Portugal and Dar es Salaam University, Tanzania. He is an elected member of the European Academy of Sciences. He is president of ISEM (International Society of Ecological Modelling).



Dr. Fath is an Associate Professor in the Department of Biological Sciences at Towson University (Maryland, USA) and is a research scholar in the Dynamic Systems Program at the International Institute for Applied Systems Analysis (Laxenburg, Austria). He has published almost 100 journal articles, reports, and book chapters. Dr. Faith first book, *A New Ecology*, was published with S.E. Jørgensen in June 2007 and in 2008 they co-edited a 5-volume Encyclopedia of Ecology. Dr. Fath has been Editor-in-Chief of the journal *Ecological Modelling* since January 2009. He teaches regular courses in ecosystem ecology, environmental biology, networks, and human ecology and sustainability at Towson and has given short courses in China, Croatia, Denmark, France, Germany, and Portugal. Dr. Fath is currently the chair of the Baltimore County Commission on Environmental Quality.



Preface

This is the fourth edition of *Fundamentals of Ecological Modelling*, and we have given it a longer title: *Fundamentals of Ecological Modelling: Application in Environmental Management and Research.* This was done to emphasize that models, applied in environmental management and ecological research, are particularly considered in the model illustrations included in this book.

Giuseppe Bendoricchio, co-author of the third edition published in 2001, passed away in 2005. We would therefore like to dedicate this book to his memory and his considerable contributions in the 1980s and 1990s to the development of ecological modelling.

The first two editions of this book (published in 1986 and 1994) focused on the roots of the discipline — the four main model types that dominated the field 30-40 years ago: (1) dynamic biogeochemical models, (2) population dynamic models, (3) ecotoxicological models, and (4) steady-state biogeochemical and energy models. Those editions offered the first comprehensive textbook on the topic of ecological modelling. The third edition, with substantial input from Bendoricchio, focused on the mathematical formulations of ecological processes that are included in ecological models. In the third edition, the chapter called Ecological Processes encompasses 118 pages. The same coverage of this topic today would probably require 200 pages, and is better covered in the *Encyclopedia of Ecology*, which was published in the fall of 2008.

This fourth edition uses the four model types previously listed as the foundation and expands the latest model developments in spatial models, structural dynamic models, and individual-based models. As these seven types of models are very different and require different considerations in the model development phase, we found it important for an up-to-date textbook to devote a chapter to the development of each of the seven model types. Throughout the text, the examples given from the literature emphasize the application of models for environmental management and research. Therefore the book is laid out as follows:

Chapter 1: Introduction to Ecological Modelling provides an overview of the topic and sets the stage for the rest of the book.
Chapter 2: Concepts of Modelling covers the main modelling elements of compartments (state variables), connections (flows and the mathematical equations used to represent biological, chemical, and physical processes), controls (parameters, constants), and forcing functions that drive the systems. It

also describes the modelling procedure from conceptual diagram to verification, calibration, validation, and sensitivity analysis.
Chapter 3: An Overview of Different Model Types critiques when each type should or could be applied.
Chapter 4: Mediated or Institutionalized Modelling presents a short introduction to using the modelling process to guide research questions and facilitate stakeholder participation in integrated and interdisciplinary projects.
Chapter 5: Modelling Population Dynamics covers the growth of a population and the interaction of two or more populations using the Lotka-Volterra model, as well as other more realistic predator–prey and parasitism models. Examples include fishery and harvest models, metapopulation dynamics, and infection models.
Chapter 6: Steady-State Models discusses chemostat models, Ecopath software, and ecological network analysis.
Chapter 7: Dynamic Biogeochemical Models are used for many applications starting with the original Streeter-Phelps model up to the current complex eutrophication models.
Chapter 8: Ecotoxicological Models provides a thorough investigation of the various ecotoxicological models and their use in risk assessment and environmental management.
Chapter 9: Individual-based Models discusses the history and rise of individual-based models as a tool to capture the self-motivated and individualistic characteristics individuals have on their environment.
Chapter 10: Structurally Dynamic Models presents 21 examples of where model parameters are variable and adjustable to a higher order goal function (typically thermodynamic).
Chapter 11: Spatial Modelling covers the models that include spatial characteristics that are important to understanding and managing the system.

This fourth edition is maintained as a textbook with many concrete model illustrations and exercises included in each chapter. The previous editions have been widely used as textbooks for past courses in ecological modelling, and it is the hope of the authors that this edition will be an excellent basis for today's ecological modelling courses.

Sven Erik Jørgensen
Copenhagen, Denmark

Brian D. Fath
Laxenburg, Austria

July 2010

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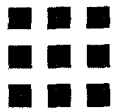
（陆健健 译）



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