Preface

May God us keep from single vision and Newton sleep.

WILLIAM BLAKE, 1802

Ecological Processes Handbook presents an overview of a large number of processes that take place in ecosystems. The processes are in most cases quantified as mathematical equations that have found wide use in the application of ecology in environmental management. The past 50 years—since Rachel Carson's book *A Silent Spring*—ecology has found an increasing use in environmental management. A number of ecological subdisciplines have been developed to facilitate the application of ecological considerations to solve environmental problems: ecological modeling, ecological engineering, ecological economics, application of ecological indicators and ecological services, ecotoxicology, and ecological informatics. These ecological subdisciplines all demand a quantification of ecological processes. These subdisciplines form a bridge between ecology and environmental management.

Ecological models consist of five components: state variables to describe the state of the ecosystems; forcing functions to describe the impacts on the ecosystems; ecological process equations; coefficients in these equations, so-called ecological modeling parameters; and physical and chemical constants. Ecological process equations are, therefore, an indispensable part of ecological models. Ecological engineering covers ecological restoration and the use of natural or constructed ecosystems to solve environmental problems. All these applications of ecological engineering require quantification and therefore the use of mathematical equations for the description of the focal ecological processes. Applications of ecological indicators and the assessment of the ecological services offered by ecosystems imply most often a quantification, which often must be based on mathematical equations of ecologically significant processes. Ecotoxicology is about the harmful effects of toxic substances in ecosystems, which entails a quantification of the processes in which the toxic substances participate in the ecosystems, and it is indispensable to assess the distribution of toxic substances in the ecosystems. All uses of ecological informatics are rooted in quantifications including quantifications of ecological processes. All in all, like a real bridge requires the use of iron and concrete, the virtual bridge from ecology to environmental management requires mathematical equations of ecological processes. In addition, a quantitative understanding of ecological processes is crucial for the basic ecological science, particularly of course for systems ecology that has focus on how ecosystems are working as (very effective) systems. We have, therefore, found that there was an urgent need for a comprehensive

quantitative overview of ecological processes and we do hope that this book is able to meet this need.

The core material for this text comes from lecture handouts circulated in the last decade during the courses of "Modelling and Control of Environmental Systems" and "Environmental Impact Assessment" for master students of the curricula in environmental engineering, as well as during several seminars on the broad topics of ecological processes and systems ecology held in various international academic contexts.

The book consists of five sections. The first section presents some basic knowledge about ecosystems physics and may be considered an introduction to systems ecology. In this section, after introducing the fundamental concepts of classical and far-from-equilibrium systems thermodynamics, systems ecology is discussed with the perspective of information and systems theory. Here, the indicators emergy, exergy, and ascendency, commonly used to derive goal functions in ecological modeling, are presented. By defining these indicators on the common ground of thermodynamics of far-from-equilibrium systems, it is shown how all the goal functions proposed ultimately rely on the very generalization of the second principle of thermodynamics as proposed by Ilya Prigogine.

Sections II through V present the ecological processes and their mathematical formulation, focusing, respectively, on physical, chemical, biological/ecological, and landscape processes. The appendix shows how it is possible to make fast quantifications of several chemical processes simultaneously by graphical methods. Use of models is of course also possible, but the graphical methods are in most cases faster, providing results with a sufficiently accurate standard deviation as required. Therefore, it was chosen to include these methods in the handbook. This book contains many illustrations providing exemplifying quantifications. The examples demonstrate how the indicators and ecological process equations presented could be applied directly in the above-mentioned ecological subdisciplines.

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