

## **Transport Processes in Nature**

### Propagation of Ecological Influences through Environmental Space

This book provides a new and general perspective on how events or conditions in environmental space have influences elsewhere. In the first part of the book, the authors introduce the general question of propagation of ecological influences through environmental space (terrestrial, aquatic, and aerial) and then present a system for its analysis by organization into four components: initiating events or conditions, vectors conducting influences over space, entities that are transported, and the consequences of these propagation processes. Each of these components is rich in variation and logical complexity. Methods for representing environmental heterogeneity and for modeling transport processes are discussed in the context of such propagations. In the second part, properties of eight general transport vectors and examples of transport models in realistic ecological situations are explained. For each of the vectors, a simulation model linked with ArcView<sup>®</sup> geographical information system (GIS) is provided on a CD included with the book (users require access to ArcView<sup>®</sup> GIS software). Although set in an ecological context, the concepts presented will also be of direct relevance to a range of disciplines within the earth and atmospheric sciences.

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William A. Reiners and Kenneth L. Driese

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## Preface

This book evolved from the conjunction of different experiences, world views, and ontologies of people and disciplines. These conjunctions started with the authors. Reiners received a classical plant ecology education in the early 1960s, which was modified over the decades by his involvement with ecosystem ecology, biogeochemistry, landscape ecology, remote sensing, GIS, and earth system science. Driese was formally educated in the early 1980s and 1990s in the broader environmental sciences, which provided him with a stronger background in mathematics and physical science. The authors met in 1987 and have been collaborators since then.

Other conjunctions influenced the way we came to perceive nature. Reiners taught and practiced conventional ecology from the 1960s through the mid-1990s by focusing on single points in space but with changing properties in time. However, this geographically fixed ontology did not satisfactorily accommodate the author's observations of the world around. It provided no "place" for how polluted air transported from the midwestern USA to the mountain ecosystems of New England deposited acidity via cloud droplets, rain, and snow. Nor did it explain how this acidic precipitation then flowed in complicated, spatially distributed ways through canopies, soils, rocks, watersheds, and rivers. It did not satisfactorily account for the fact that these same forests had to be interpreted in terms of the historic New England hurricane of 1938, a disturbance that originated somewhere west of Africa, rolled up the Atlantic coast, and smashed its way into the heart of New England. Similarly, this spatially fixed viewpoint was disconnected from our understanding of how capital and markets in Europe and North America could be expressed as the conversion of rain forests to banana plantations. In Wyoming, we witnessed the extensive forest fires of 1988 in Yellowstone National Park, debris flows in the Teton Range, dispersal of rabid skunks through river valleys, and redistribution of snow by wind in shrub steppes. These phenomena made it obvious to us that many of the



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more important ecological phenomena involved propagation of cause from one locus to give rise to an effect elsewhere; transport and location were not suitably incorporated into conventional ecological thinking. There was a disconnection between point-oriented ecology and important propagations of many kinds. Naturally, we knew that inputs and outputs were recognized as properties of point models, but we came to see that the transport processes themselves were mainly subjects of other disciplines such as hydrology and epidemiology while being just peripheral to mainstream ecological thought.

As we explored the nature of propagations, we found that the sciences explaining transport mechanisms were often mature but dispersed among disciplines such as physical oceanography, geomorphology, and micrometeorology. Consolidating that dispersed information into an ecological viewpoint required many more conjunctions.

This book, then, results from bringing together different ways of seeing and explaining nature. In its simplest form, our goal has been to fuse these conjunctions to achieve a confluence between an ontology based on typical systems treated as homogeneous units (points) and an ontology based on nature as fields of movements and flows through heterogeneous environments. We believe such an ontologic confluence will enrich and empower environmental science in general and ecology in particular.

The contents are divided into two parts. The first provides the philosophical and conceptual grounding for propagation of ecological influences. It also describes how propagations can be abstracted and modeled with spatially distributed modeling tools. Because it is efficient to describe propagations in terms of vectors, fuller descriptions of transport processes are organized by vector in Part II. Each chapter defines and describes the physics and biology of a particular vector, shows how appropriate disciplines have developed methods for modeling the vector, and finally provides a simple model for readers to use. The models illustrate how altering primary variables can vary outcomes of transport processes. The purpose and organization of Part II are more fully explained in Ch. 5.

This book will serve as a primary resource for thoughtful ecologists willing to examine their discipline in a fresh and challenging way. We intend it to facilitate the development of broader and more flexible ways of teaching and practicing ecology. We hope that it will bring geography into more intimate connection with ecology and beyond its present deployment for biogeographic issues. Inasmuch as there are no courses on ecological propagations, this book is not designed as a text; rather we hope it will be a source to be read by individuals or discussed in intimate seminar settings.

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