

River Dynamics

Rivers are important agents of change that shape the Earth's surface and evolve through time in response to fluctuations in climate and other environmental conditions. They are fundamental in landscape development and essential for water supply, irrigation, and transportation. This book provides a comprehensive overview of the geomorphological processes that shape rivers and that produce change in the form of rivers. It explores how the dynamics of rivers are being affected by anthropogenic change, including climate change, dam construction, and modification of rivers for flood control and land drainage. It discusses how concern about environmental degradation of rivers has led to the emergence of management strategies to restore and naturalize these systems, and how river management techniques work best when coordinated with the natural dynamics of rivers. This textbook provides an excellent resource for students, researchers, and professionals in fluvial geomorphology, hydrology, river science, and environmental policy.

Bruce L. Rhoads is Professor of Geography and Geographic Information Science at the University of Illinois, Urbana-Champaign. He has been actively engaged in research on river dynamics for over 35 years. He has been a Guggenheim fellow and has received awards for research excellence and a distinguished research career from the American Association of Geographers. He is a fellow of the American Association of Geographers and the American Association for the Advancement of Science.

“*River Dynamics* represents a comprehensive and concise overview of contemporary knowledge of river process and form. The text is thoroughly illustrated with relevant photographs, drawings, and graphs, and the referencing is thorough and up to date. Rhoads is skilled at providing clear explanations of complex phenomena and the book includes just enough historical perspective to allow the reader to understand the background for contemporary conceptualizations of rivers. The book starts with a thorough discussion of basic information on river process and form, and then discusses river management in a manner that effectively integrates basic and applied science. This book will provide an engaging textbook for advanced undergraduate and graduate courses, and a resource for river-management professionals.”

Ellen Wohl, *Colorado State University*

“This is a superb textbook on fluvial geomorphology – the book we have long been waiting for in this field. It provides a clear framework for understanding and is written in such a way, with the headings posed as questions, that we can immediately identify the key issues and content of each section. It provides detailed analysis and information on all the main topics in fluvial geomorphology, as well as a few not usually covered well. It can be used at various levels of information, from the main principles and concepts to detailed analysis of, for example, hydraulics and processes. It provides a rich source of information for undergraduates, for more specialist courses, and for fluvial management. I shall immediately recommend it as the main text for my own taught course in fluvial geomorphology. It has a copious reference list, with an excellent balance between classic references that provided the foundation of our subject and the more recent research developments, allowing the reader to appreciate how ideas and knowledge have developed to our present state of understanding, while also highlighting ongoing debates and questions. It is clearly illustrated with numerous figures to complement the explanations. It provides a firm scientific basis for sustainable management of rivers and catchments that builds on a thorough understanding of principles, processes, and dynamics.”

Janet Hooke, *University of Liverpool*

“Bruce Rhoads draws on his unique experience to comprehensively review concepts in river dynamics. This book will be of great benefit to students, scientists, and managers of rivers by blending field and laboratory studies with theory and application.”

Marwan Hassan, *University of British Columbia*



River Dynamics

Geomorphology to Support Management

Bruce L. Rhoads

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Preface

*Flow river flow, past the shady trees,
Go river go, go to the sea
Flow to the sea*
“Ballad of Easy Rider,” The Byrds, 1969

I have always been fascinated by flowing water. At a very young age, I remember wading into small streams near my home in eastern Pennsylvania to catch salamanders and assemble piles of rocks and sticks in vain efforts to stem the flow. Along with my sisters and cousins, I went fishing in my grandfather’s jon boat on the local creek. Rather foolishly (in hindsight), we would row the boat right up to the face of the local abandoned mill dam and walk across its crest to feel the rush of cascading water across our feet. Only later, when I became aware that these dams are drowning machines, did I realize how dangerous this was.

When I went to college, I found that I could combine my love of science with my interest in flowing water to pursue the scientific study of rivers. As I became aware of how important rivers are in shaping landscapes on our planet, and just how unusual flowing water is on the surface of most planets, my fascination with the dynamics of rivers grew. I still remember clearly the excitement accompanying my personal discovery that I wanted to become a river scientist. Somewhat ironically, my PhD research examined dryland mountain streams in Arizona, where, despite several years of intensive field work, I never saw water flowing in the streams I studied.

Since receiving my PhD in 1986, I have been a professor at the University of Illinois, where I have engaged in basic and applied research on river dynamics. Teaching students has been remarkably rewarding, especially when I see these students become fascinated, as I am, by the dynamics of rivers. Working with graduate students who are passionately interested in rivers has been particularly gratifying. I have been fortunate to have had the opportunity to work with many talented graduate students. It has been fulfilling to see them succeed as professionals in academia, government agencies, and private industry.

Teaching is one of the major motivations behind the writing of this book. Over the past 20 years, the scope of knowledge related to river dynamics has advanced rapidly. In my own teaching at the advanced level, I have found it increasingly difficult to refer students to a concise text that includes the breadth of material I cover in my courses. These students also have diverse backgrounds, ranging from those with extensive coursework in college-level mathematics and science to those with minimal math and science coursework. This diversity necessitates an approach to teaching that allows those with advanced math and science backgrounds to feel challenged, while not overwhelming those without advanced training in math and science. I also feel strongly that the material should not be dumbed down to the extent that it does not include content commensurate with what a student at the advanced level should learn, given the current state of knowledge. This book represents an attempt to capture the balance between depth and breadth, at least as I see it. I have tried to at least touch on most major topics, but my personal predilections show through in that some topics are covered in greater detail than others. I have organized each chapter in the book using headings and subheadings in the form of questions. This approach emphasizes that science proceeds by asking questions and seeking answers to these questions. Not all of the headings represent scientific questions, but many of them do.

Many students are innately attracted to the relevance of river science to environmental issues, particularly human impacts on rivers and efforts to manage rivers in ways that enhance environmental quality. I have examined these types of issues in my own research and, in a world in which the footprint of humans is becoming increasingly large, understand why they are appealing to students. The last two chapters of the book explicitly address these issues, but given the complexity of rivers, I strongly feel that basic understanding of river dynamics, the focus of the majority of the

book, is important for effective management. Attempts to manage rivers based on a rudimentary understanding of their complexity are unlikely to be successful. The title of the book, which includes the phrase “geomorphology to support management,” is meant to emphasize that the book is not directed explicitly at management but is intended to provide information relevant to management. In this sense, I hope the book will be of value to river managers seeking to learn more about how rivers function. Not all aspects of river dynamics, particularly those that occur over long timescales, are relevant to management. Nevertheless, these long-term dynamics are important for understanding how rivers contribute to erosional and depositional processes that shape the surface of the Earth.

The other motivation behind writing this book is largely personal. Throughout my career, I have always thought that someday I would write a book on river dynamics. When actively engaged in research, accomplishing this task is difficult, given constant demands on one’s time. My career as a professor now exceeds 30 years, and the time had come when it was now or never. As a lifelong learner, I have found the task of writing this book to be enormously fulfilling. Early in my career, I discovered that topics I thought I knew thoroughly, I did not know nearly as well as I thought I did once I had to teach those topics to students. Teaching improved my learning. The same discovery has occurred in producing this book. I learned much that was new about topics I thought I knew well. My appreciation of the talents of my fellow river scientists, as well as of the brilliance of their ideas, has deepened greatly through this experience. I have done my best to represent their efforts correctly, but take full responsibility for any omissions, errors, or misrepresentations. I thank those who took the time to read through drafts of chapters, including Mike Church, Tom Dunne, Brett Eaton, Karen Gran, Marwan Hassan, Janet Hooke, Kory Konsoer, and Jonathan Phillips. Your willingness to devote your valuable time on my behalf is greatly appreciated. Thanks also to Allison Goodwell for her help in producing an important figure and to Tanya Shukla for her expert camera work on some of the images in the book.

As a first-generation college student, I am blessed to have parents who emphasized the importance of education, who encouraged me to pursue my interests, whatever they might be (including fluvial geomorphology!), and who contributed to my education financially. Although my father is gone, I have stimulating conversations with my mother on an almost daily basis. At 90-plus years old, she continues to inspire me to maintain a proper perspective on life. I fell short as a teacher in getting my children interested in science and rivers; both pursued career paths more closely akin to that of my wife, a social worker. Jamie and Steven, you are the joy of my life, and I am immensely proud of you both. To my wife, Kathy, I cannot begin to express how much your love and support has meant to me over the years. Without it, this book would not have been possible. You are my rock.