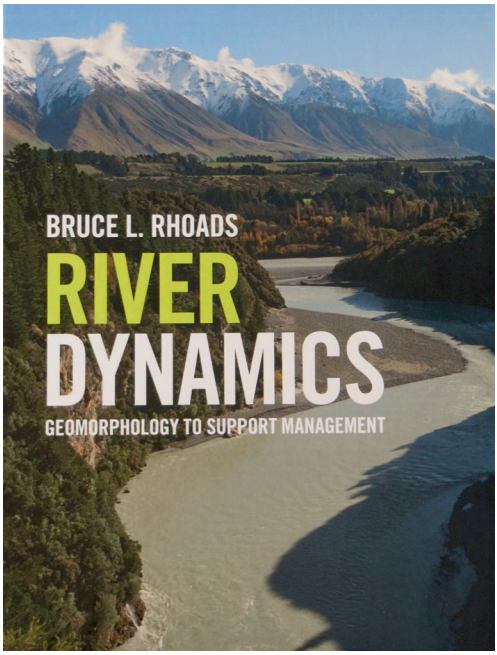
BOOK REVIEW SECTION

Rhoads, B.L.: River Dynamics: Geomorphology to Support Management. Cambridge, Cambridge University Press. 2020. 515 p.

Fluvial processes first began to dominate gomorphological literature during the period of quantitative revolution in the 1970s. The British Geomorphological Research Group estimated that the share of 'studies of fluvial character' in Great Britain jumped from 18 per cent in 1963 and to 27.7 per cent in 1975 (Gregory, K.J. 1978). The trend was similar in the United States too, where seminal papers on channel types appeared at that time. A repeated survey (Piégay, H. *et al*. 2015) found that among 7331 papers published in the five leading journals of the discipline over the period 1987 to 2009, 1717 (23%) were in fluvial geomorphology. An internet search by the author of the book reviewed here estimates a 100-fold increase in topics of fluvial geomorphology since 1980. This is another testimonial to rivers, beyond their geomorphological significance, being important components of the landscape, vital for the existence of both humans and ecosystems. The present book is a good example of the interrelationship between environmental issues and fluvial processes. The book relies on a huge number of sources, the References section consists of 73 pages! (Of course, with the customary bias in favour of United States and British sources.)



The author, Bruce L. Rhoads, professor of geography at the University of Illinois, belongs to the Midwestern school of fluvial geomorphologists, particularly of the one which was led by his recently deceased PhD supervisor, Professor William L. Graf, specialized in river investigations in desert environments. He authored and edited important textbooks with Colin E. Thorn (Rhoad, B.L. and Thorn, C.E. 1996). His research later focused on river confluences to which a separate chapter (number 12) is devoted in this book.

In the Introduction he briefly summarizes the history of fluvial geomorphology. He attempts to reconcile theories of equilibrium, geomorphological effectiveness (magnitude and frequency), landscape sensitivity and resilience – although claims that these concepts are rather difficult to test scientifically. Stability and change are governed by thresholds and the behaviour of the fluvial system is often non-linear. Examples are cited for the interpetation of general concepts in the environmental context (distinguishing between arid/semiarid and humid temperate environments).

Following the conventional structure of textbooks on the subject, Chapter 2 is concerned with overland flow processes in drainage basins. Like elsewhere, some basic processes are succinctly and clearly defined. The reader does not feel the need for a separate Glossary of terms at the end of the book. The detailed index helps the reader find these definitions. Rills and gullies are treated as landforms distinct in origin. (Although, as throughout the book, mostly US studies are cited, a single reference is also made to investigations on valley heads in the Polish Carpathians.)

Before embarking on issues of river hydrology, author inserted a chapter (no 3) on global sediment dynamics, emphasizing the leading role of rivers in global sediment flux to oceans and, consequently, in the denudation of drainage basins and continents. The limitations of the sediment delivery approach are correctly assessed. The application of cosmogenic radionuclides measurements as an alternative approach to the estimation of denudation rates and the significance of sediment tracing techniques are presented at the end of the chapter. It is interesting how laboratory experiment refined the classic model of drainage network extension and reduction and how these drainage network evolution models can be developed to landscape evolution models. Now the processing of world-wide databases allows new conclusions on the factors influencing sediment transport. For instance, it becomes evident from a series of diagrams (Figures 3.5 to 3.11)

that sediment yield from a drainage basin is not a direct function of precipitation, runoff or basin area.

Relying on classic and more recent achievements in physics (fluid mechanics, open-channel hydraulics, boundary layer theory etc.), Chapter 4 summarizes the basics of flow dynamics. Although it is central among the topics of the book, it is strictly kept within limits. Even at this level of detail it is rather demanding for the reader – if he is not a mathematician or physicist.

Further fundamental processes and more physics (e.g. explanations and equations of forces like gravity, lift and drag, acting on a particle on the riverbed) come in Chapter 5 (on sediment transport). Here we get a series of precise definitions of processes. (Perhaps the only exception is the classification of channel bars, which would have been necessary to understand the explanation of meandering and braiding. This would have deserved some paragraphs in the chapter on sediment transport.) Compared to previous textbooks we encounter novel topics here, like the analysis of entrainment thresholds and particle size and pivotal angle relationships examined for sand-bed and gravel-bed rivers. Also armouring on gravel beds is seldom detailed in a book of similar content, while here the reader gets a fuller analysis based on both flume and field experiments as well as various bedload transport models. It is pointed out that, although models have been set up to predict fractional transport rates, those for sediment mixtures are yet to be tested for a diversity of conditions. Since the 1980s tracer studies support these models and help establish a virtual velocity for the particles moved in the river. The final part of Chapter 5 is concerned with the geomorphological implications of bedload transport, i.e. how it affects channel morphology and the other way round. (Of course, this topic will turn up in later chapters, too.) Author's conclusion is that "it is the absolute magnitude of spatial gradients in bed-material transport that govern channel change". (Spatial gradients refer to current direction and the direction perpendicular to it.) To estimate sediment transport from surveying changes in channel parameters is even more problematic as yet and needs further research.

Chapter 6 is devoted to the assessment of a fundamental concept of 20th-century fluvial geomorphology, the magnitude and frequency of hydrological events. Is the theory still valid in the 21st century? After defining the interrelated basic terms necessary to study this issue (graded river, channel-formative event, dominant, bankfull and effective discharge), an excellent compilation in Table 6.2 summarizes the efforts to determine effective discharge values in all continents (with the notable exception of Africa). Author finally integrates the previous theories into the concept of geomorphic effectiveness. Although equilibrium thinking survives in geomorphology, he claims that "equilibrium state is a philosophical stance" rather than a testable hypothesis. Non-linearity is also manifest in the fact that it is difficult to find a strong relationship between flood discharge and flood power (geomorphic work). Important refinements in the magnitude-frequency theory include the growing emphasis on the duration of events with high flood power which, above a threshold, can be particularly influential in channel changes as well as on antecedent conditions of formative events.

Chapter 7 answers the question whether anything new can be said about channel geometry. By all means, the difference between at-a-station and downstream hydraulic geometry is well explained and more data can be used to validate the classic equations. When downstream channel geometry is mentioned in a simplified sense, it seems necessary to introduce the algorithms of rational regime analysis, which is used for testing various hypotheses in river hydraulics. Naturally, this approach also has its limitations, which are detailed in several following chapters.

In Chapter 8 issues of channel planform, which is often identified subjectively, are treated. This is another topic which is studied excessively in fluvial geomorphological literature. The parameters applied to distinguish between meandering and braided channels (channel slope, width/depth ratio, media particle size, bank stability) are revisited in the light of recent investigations and a range of charts are presented where the two basic planform types appear distinct from each other (Figures 8.3 to 8.9). (Somewhat surprisingly, straight channels are regarded the most problematic.) The classification of multichannel (anabranching) rivers according to stream power seems to remain unsolved (anastomosing, wandering gravel-bed channels).

One of the longest of chapters, number 9, focuses on the causes and styles of meandering – another classic topic of river research. Flow oscillation and riverbed/bank instability are in the centre of theories of meander initiation. However, both theories have limitations related to the starting phase of the process, the development of alternating bar units. A difficulty of meandering river mechanism lies in the scarcity of validation of numerous laboratory experiments with field studies. Since the morphology of the individual meanders is controlled by riffle-pool sequences, the latter are described in detail – although their mathematical description is not yet possible. Neither the velocity (and shear) reversal nor the secondary flow theory provide a full and universal explanation to the maintenance of riffle-pool sequences and their contribution to curvature development. The further evolution and migration of meanders depends on sediment transport, shifting of bars, to a large extent and considerable knowledge has accumulated on these processes. Also bank erosion mechanisms are intensively investigated in connection with meander migration, lateral shifts and cutoffs included. (The reviewer would have liked to read more about the role of vegetation in bank erosion.) The development of compound meanders is a particularly intriguing issue. There is some field evidence but no

theory concerning them. Similarly to other chapters, the final part summarizes the results of computer-modelling of meander evolution.

It is equally (or even more) challenging to give a short and clear answer to the question how braided channels are formed (in Chapter 10). A similarity to meandering is that most researchers agree on the role of bars in the initiation of a braided channel. The differences are presented in Figure 9.3 and 10.2. By now a wide range of laboratory experiments support theories which are based on a critical width/depth ratio to be reached. Also here an equilibrium theory is difficult to build since rapid local morphological alterations of the channel starkly contrast with long periods of overall adjustment. The concept of confluence-diffluence is used to explain bar development in braided channels. Bifurcations are due to deposition in some cases and to erosion in some others, creating seemingly minor differences in bed elevation, which, however, generate asymmetrical and dynamic conditions in the channel. Here we learn more of the role of vegetation.

Chapter 11 tackles anabranching channels, a channel planform type least studied of all so far. The morphological similarity of channels of this type masks a great variety of formative processes, basically bar stabilization into islands. Variations in channel slope, bank resistance and the density of vegetation are examined as factors producing different types of anabranching. The differences are marked among continents (Australia, Africa, South-America), but less clearly pointed out between wandering gravel-bed and anastomosing channels.

Chapter 12 is about one of author's favourite research topics: river confluences. The confluence hydrodynamic zone is interpreted as a special geomorphic environment, where helical and secondary flows are significantly modified. Sediment transport, tributary-mouth and bank-attached bar formation is largely controlled by junction angle. Proper attention is also paid to the consequences of mixing of waters with different character. All these aspects make Chapter 12 one of the most original and valuable in the book.

The study of river longitudinal profiles in Chapter 13 displays perhaps less novelty, but is equally relevant to the understanding of river dynamics. Explaining downstream fining and selective sorting of bedload, profile adjustment, knickpoint retreat etc., the chapter is useful for bachelor students, too. (This statement also applies to the introductory parts of most chapters.) This chapter summarizes the hypotheses and accumulated results on the formation of step-pool structures. The mathematical expression of their physical background is unfortunately still missing.

A modern geomorphological book could not be complete without a treatment of floodplain dynamics (Chapter 14). Overbank flow is acknowledged as essential a fluvial process as channel flow. The multifarious ecosystem services of floodplains are enumerated to underline the importance of their study. When describing deposition features, point bars and scroll bars are distinguished, the origin of ridge-and-swale topography is explained – both by deposition and erosion. Among the controls of overbank sedimentation author presents the role of suspended sediment concentration in the river on several examples. Further interesting issues are touched upon: How advective suspended sediment transport during floods producing bank-top and crevasse splays influences levee morphology? How backloading contributes to levee building? It is observed that, in addition to deposition (including the infilling of abandoned channels created by neck and chute cutoffs), erosional processes like floodplain stripping and avulsions, hardly mentioned in previous literature, also shape floodplains. Floodplain typology is based on stream power, river mechanism (planform types) and the cohesion of banks. Although the level of knowledge is far from being equal for them, Figures 14.21, 14.22, 14.24 and 14.26 allow a good visual comparison of alluvial architecture among floodplains associated with the main planform types.

Chapter 15 means to describe human impact on rivers, a theme absolutely necessary to understand the actual conditions of rivers in the 21st century. Full books have been written on the numerous indirect and direct influences exerted by human society which have completely changed the life of rivers for good. First the impacts of agriculture, then forestry and mining and finally those of urban development are investigated. Fifteen years ago a standard British undergraduate textbook about human impact on the environment (Goudie, A.S. 2006, 178–183) only mentioned river straightening, establishing of meander cutoffs and some artificial channels as deliberate interventions into fluvial systems along with alterations of sediment budget (through land use transformation) and dam and reservoir building as non-deliberate interventions. Naturally, the Rhoads book also deals with these issues, but also reflects that in the meantime the significance of further human impacts have been recognized: e.g. as agriculture involves the reduction of infiltration into the soil and of flow resistance over hillslopes, inducing rill and gully erosion, thus creating new paths for runoff. Examples of responses of rivers to land conversions and accelerated soil erosion are cited from many parts of the world. Peak discharges can also be increased by clear cutting, logging and establishing logging roads. Mining can raise sediment load considerably. Construction sites are localities where soil erosion can reach dangerous dimensions, while runoff from developed sealed surfaces often leads to destructive flash floods. The geomorphological consequences of the sediment deficite resulting from dam construction as well as planform responses to channelization are detailed based on recent reseach. Among the more indirect impacts, those of climate change take the first place. However, the interrelationships are so

complicated that it is extremely difficult to predict how climate change will influence rivers, both in the short and long term.

The management tasks springing from all previous chapters are overviewed in Chapter 16. It is made clear that rivers are not simply natural resources to explit and natural hazards to mitigate, but also valuable ecological and aesthetic objects to conserve. They are not to be appreciated for their stability, but for their dynamic properties which are also of high value. The knowledge on the dynamic geomorphology of rivers and floodplains has to be incorporated into river restoration, stream naturalization and mitigation projects. To this purpose, two widely applied approaches are available: the Rosgen method and the River Styles framework. Their benefits and drawbacks are investigated. One of the last questions raised in the book is how dam removal affects rivers. Author warns of hurried action without the careful consideration of both short- and long-term impacts on river dynamics.

The book was not written for engineers. Therefore, appendices are attached to it to present power functions used in fluvial geomorphology and some sedimentological and hydrological basics.

A great merit of the book is a balanced combination of theoretical basics (BSc-level knowledge) with information on practical research problems. The rich illustrations form an integral part of the work. For a large part they are simple graphics which introduce fundamental phenomena (like Figure 6.22, which presents complex river response to base level change in a particularly clear manner), while others display measurement data from case studies in a uniform and easily interpretable format.

The most unusual feature of the book is the titles of subchapters: they are consistently formulated as special questions. The review could agree with this since it makes end-of-the chapter questions (common in textbooks) superfluous, but it is only justified if the subchapter raises a particular problem, e.g. 2.6.3 Where do channels begin? In many other cases this practice leads to changing easily palatable titles to monstrously overcomplicated ones, e.g. 7.1 How is channel geometry related to the three-dimensionality of river form?

For Hungarian master students the book may not prove an easy reading. For researchers in geomorphology, hydrology and practical experts of river management with a firm basis of scientific English, however, this is the best handbook available, an indispensable companion in their everyday work.

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