

RIVERS IN THE LANDSCAPE

Science and Management

Ellen Wohl

*Department of Geosciences,
Colorado State University, Colorado, USA*




Rivers in the Landscape: Science and Management offers a comprehensive and accessible overview of the current state of knowledge for river process and form, taking a holistic approach to the subject with coverage of integrated river science and management in practice.

The processes and forms present in channelized surface flow—rivers—are systematically explored in this book to

- emphasize the connectivity between rivers and the greater landscape by explicitly considering the interactions between rivers and tectonics, climate, biota, and human activities;
- provide a concise summary of the current state of knowledge for physical process and form in rivers;
- reflect the diversity of river environments, from mountainous, headwater channels to large, lowland, floodplain rivers and from the arctic to the tropics;
- reflect the diverse methods that scientists use to characterize and understand river process and form, including remote sensing, field measurements, physical experiments, and numerical simulations;
- reflect the increasing emphasis on quantification in fluvial geomorphology and the study of Earth surfaces in general;
- provide both an introduction to the classic, foundational papers on each topic, and a guide to the latest, particularly insightful and integrative references.

Aimed at advanced undergraduate students, graduate students, and professionals looking for a concise summary of physical aspects of rivers, this book emphasizes general principles and conceptual models, as well as concrete examples of each topic drawn from the extensive literature on river process and form.

 Also available
as an e-book

This book is accompanied by a companion website:
www.wiley.com/go/wohl/riverslandscape



WILEY Blackwell
www.wiley.com/wiley-blackwell

ISBN 978-1-118-41489-7



9 781118 414897

Contents

Acknowledgements

ix

About the Companion Website

xi

Chapter 1 Introduction

1

1.1 Connectivity and inequality

1

1.2 Six degrees of connection

3

1.3 Rivers as integrators

6

1.4 Organization of this volume

7

1.5 Understanding rivers

9

1.5.1 The Colorado Front Range

9

1.6 Only connect

19

Chapter 2 Creating channels and channel networks

21

2.1 Generating water, solutes, and sediment

21

2.1.1 Generating water

21

2.1.2 Generating sediment and solutes

22

2.2 Getting water, solutes, and sediment downslope to channels

23

2.2.1 Downslope pathways of water

23

2.2.2 Downslope movement of sediment

29

2.2.3 Processes and patterns of water chemistry entering channels

32

2.2.4 Influence of the riparian zone on fluxes into channels

32

2.3 Channel initiation

34

2.4 Extension and development of the drainage network

37

2.4.1 Morphometric indices and scaling laws

37

2.4.2 Optimality

40

2.5 Spatial differentiation within drainage basins

41

2.6 Summary

43

Channel processes I

45

Chapter 3 Water dynamics

47

3.1 Hydraulics

47

3.1.1 Flow classification

48

3.1.2 Energy, flow state, and hydraulic jumps

51

3.1.3 Uniform flow equations and flow resistance

53

3.1.4 Velocity and turbulence

60

3.1.5 Measures of energy exerted against the channel boundaries

65

3.2	Hydrology	67
3.2.1	Measuring, indirectly estimating, and modeling discharge	67
3.2.2	Flood frequency analysis	71
3.2.3	Hydrographs	73
3.2.4	Other parameters used to characterize discharge	75
3.2.5	Hyporheic exchange and hydrology	77
3.2.6	River hydrology in cold regions	77
3.2.7	Human influences on hydrology	78
3.3	Summary	79

Channel processes II

81

Chapter 4 Fluvial sediment dynamics

4.1	The channel bed and initiation of motion	84
4.1.1	Bed sediment characterization	84
4.1.2	Entrainment of non-cohesive sediment	85
4.1.3	Erosion of cohesive beds	89
4.2	Sediment transport	91
4.2.1	Dissolved load	91
4.2.2	Suspended load	94
4.2.3	Bed load	98
4.3	Bedforms	104
4.3.1	Readily mobile bedforms	105
4.3.2	Infrequently mobile bedforms	108
4.3.3	Bedforms in cohesive sediments	115
4.4	In-channel depositional processes	115
4.5	Bank stability and erosion	117
4.6	Sediment budgets	120
4.7	Summary	124

Chapter 5 Channel forms

5.1	Cross-sectional geometry	125
5.1.1	Bankfull, dominant, and effective discharge	125
5.1.2	Width to depth ratio	127
5.1.3	Hydraulic geometry	128
5.1.4	Lane's balance	130
5.1.5	Complex response	132
5.1.6	Channel evolution models	133
5.2	Channel planform	133
5.2.1	Straight channels	135
5.2.2	Meandering channels	136
5.2.3	Wandering channels	139
5.2.4	Braided channels	139
5.2.5	Anabranching channels	142

5.2.6	Compound channels	143
5.2.7	Karst channels	144
5.2.8	Continuum concept	144
5.2.9	River metamorphosis	146
5.3	Confluences	147
5.4	River gradient	149
5.4.1	Longitudinal profile	151
5.4.2	Stream gradient index	153
5.4.3	Knickpoints	154
5.5	Adjustment of channel form	156
5.5.1	Extremal hypotheses of channel adjustment	157
5.5.2	Geomorphic effects of floods	157
5.6	Downstream trends	160
5.6.1	Grain size	160
5.6.2	Instream wood	161
5.7	Summary	163
Chapter 6	Extra-channel environments	165
6.1	Floodplains	165
6.1.1	Depositional processes and floodplain stratigraphy	167
6.1.2	Erosional processes and floodplain turnover times	172
6.1.3	Downstream trends in floodplain form and process	174
6.1.4	Classification of floodplains	175
6.2	Terraces	175
6.2.1	Terrace classifications	176
6.2.2	Mechanisms of terrace formation and preservation	176
6.2.3	Terraces as paleoprofiles and paleoenvironmental indicators	179
6.3	Alluvial Fans	181
6.3.1	Erosional and depositional processes	182
6.3.2	Fan geometry and stratigraphy	183
6.4	Deltas	185
6.4.1	Processes of erosion and deposition	186
6.4.2	Delta morphology and stratigraphy	187
6.4.3	Paleoenvironmental records	190
6.4.4	Deltas in the Anthropocene	191
6.5	Estuaries	192
6.6	Summary	194
Chapter 7	Humans and rivers	197
7.1	Indirect impacts	198
7.1.1	Climate change	198
7.1.2	Altered land cover	200
7.2	Direct impacts	205
7.2.1	Flow regulation	205
7.2.2	Altered channel form and connectivity	208

7.3	River management in an environmental context	215
7.3.1	Reference conditions	215
7.3.2	Restoration	217
7.3.3	Instream, channel maintenance, and environmental flows	221
7.4	River health	223
7.5	Summary	224
Chapter 8	Rivers in the landscape	225
8.1	Rivers and topography	225
8.1.1	Tectonic influences on river geometry	226
8.1.2	Effects of river incision on tectonics	228
8.1.3	Indicators of relations between rivers and landscape evolution	228
8.1.4	Tectonics, topography, and large rivers	229
8.2	Geomorphic process domains	230
8.3	Connectivity	232
8.4	Climatic signatures	234
8.4.1	High latitudes	234
8.4.2	Low latitudes	235
8.4.3	Warm drylands	236
8.5	Rivers with a history	237
8.5.1	Upper South Platte River drainage, Colorado, USA	240
8.5.2	Upper Rio Chagres, Panama	242
8.5.3	Mackenzie River drainage, Canada	244
8.5.4	Oregon Coast Range, USA	246
8.5.5	Yuma Wash, Arizona, USA	248
8.6	The greater context	250
References		255
Index		311