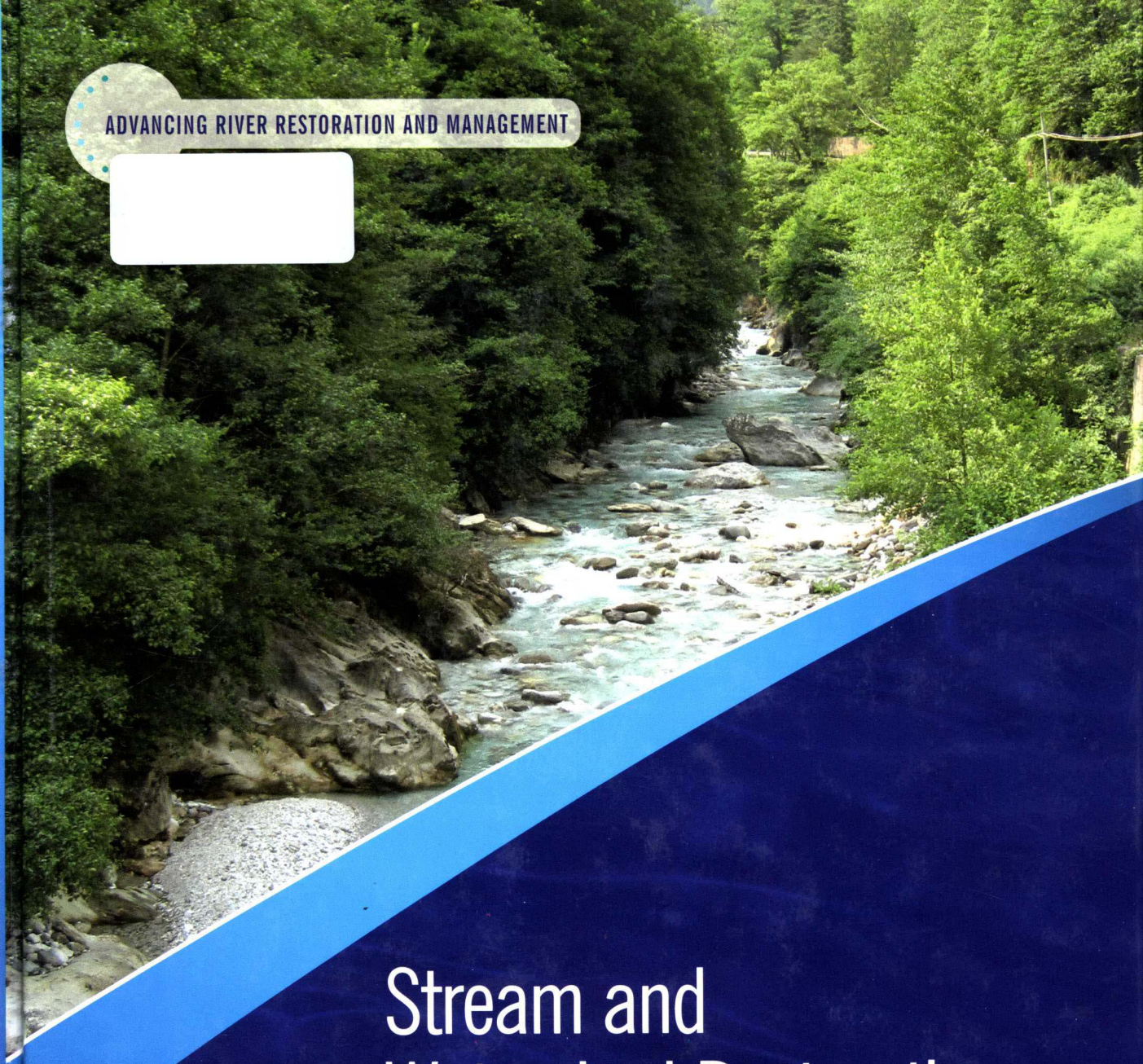

ADVANCING RIVER RESTORATION AND MANAGEMENT

Stream and Watershed Restoration

A Guide to Restoring Riverine Processes and Habitats

Edited by Philip Roni and Tim Beechie

free companion website

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A Guide to Restoring Riverine Processes and Habitats

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ADVANCING RIVER RESTORATION AND MANAGEMENT

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Foreword

Our technical and engineering capacity increased tremendously in the last century, allowing us to manipulate rivers to meet demands for electricity, construction, navigation, and human safety. In this period of intense development, we strongly regulated rivers and damaged them. We were able to address a large number of human needs, thus improving human well-being. Other needs were compromised however, and river channel reactions to our actions have had more negative consequences than were ever anticipated.

We entered into a new period of 'sustainable' development in the mid-1990s, recognizing the value of riverscapes and the ecosystem services provided by rivers with little or no regulation. After decades of diking, some countries promote 'more space' or 'room' for rivers and diverse schemes of dike setback have been undertaken, both approaches aiming to protect populations. In urban and suburban areas, riverfronts and corridors are increasingly valued for their potential contribution to the quality of city life. In this context, new questions emerge around environmental ethics and justice, and public actions to mitigate, improve, enhance, restore, and repair the rivers are underway.

Repairing rivers is becoming a real challenge in different parts of the world, and varying strategies are proposed by decision makers to promote this new objective. In Europe, we must reach a good ecological status for our rivers by 2015. This effort is often associated with actions on the physical conditions: so-called hydromorphological measures.

River restoration is a newly emerging practical science based on the principles of engineering ecology. It is still a work in progress. We need to learn a lot, partly from our previous errors. We have passed the 'we did it' step, where the fact of doing was already an achievement in itself. Now we are climbing the 'we did this and it was successful' step. We are realizing more humbly that restoration is not so easy. We need to experiment, try, and innovate in a domain where uncertainty is high and patience is required; nature does not react obligingly to our requirements. After almost two decades of river restoration some scientists are now deeply involved in this new domain, becoming restoration specialists and providing feedback to the scientific community and practitioners. Good practice guidelines are therefore needed to allow us to move forward and improve decision-making procedures, techniques, and *savoir faire*.

What is the problem? Why is it degraded? These may seem basic questions, but their answers allow us to know whether we act on the disease or its symptoms. Rivers are not only water canals but also complex corridors with water and other features. Riparian vegetation is completely integrated within this environment, contributing to its good health. Flooding, erosion, and sediment deposition are the engines of this natural infrastructure. A good repair is based on a good diagnosis.

Where should we repair? When thinking about restoration, it is important to look at the big picture. The regional level is strategic here because it allows consideration of the different geographical contexts that control river functioning. Restoration measures can be valuable in a given regional context but not in another. Considering this level is therefore critical for improving the success of restoration. The regional level is also appropriate for policy making to plan and target actions. At this level we can prioritize where restoration would be most beneficial. Where is the most damage? Where would restoration most clearly satisfy needs?

What should we do when we repair? How can we design a restoration project? We need to consider geographical complexity; rivers have different sensitivities to change and can react differently to our actions. This can be helpful at times, but it may also have counter effects if we do not properly appreciate these properties. We also need to consider different timescales; sustainable solutions for very active and reactive rivers will be different from other cases, and self-restoration may take time to propagate its effect downstream. Process-based thinking provides a framework for preventing unexpected river responses. When we play with nature, there are rules we must know. Monitoring is also needed because we do not know enough: we must better define and characterize

what we call a restoration success. How should we do this? What can we learn from previous experiences? How can we capture this valuable feedback? All these are questions to be answered in the near future.

Restoration is a management action and a socioeconomic challenge. It aims to provide benefits for society. Such action is therefore conducted in a collective framework and there is a need to reconsider why we are acting. Working not only with nature but also with society has become necessary. Public participation is important because these approaches are new, not always intuitive and sometimes contradictory to historical practices. Discussing conflicting aspects in order to understand different viewpoints opens ways to co-construct a river's future. Environmental education is equally a means for preparing society, especially younger generations, to develop with nature. Cost-effective pragmatic measures should be a goal shared by all participants.

All these questions are addressed in this very valuable contribution by a team of authors known internationally for their competence in the field of river restoration. Their motivation is to transfer their knowledge and help society answer this new challenge. Opportunistic restoration must give way to a more strategic framework for prioritizing, designing and implementing actions in an iterative way. The questions are complex. The authors' response here is interdisciplinary, crossing examples and experiences from North America and Europe where pioneer experiences provide discussion material. This book is a very well-illustrated and exemplified update step. It comprehensively summarizes previous results, then moves on to promote principles, strategies, methods, and techniques to improve our practices and answer social demands for a better environment.

Hervé Piégay,
Research Director at the Centre National de la
Recherche Scientifique, Lyon, France

Series Foreword

Advancing River Restoration and Management

The field of river restoration and management has evolved enormously in recent decades, driven largely by increased recognition of the ecological values, river functions, and ecosystem services. Many conventional river management techniques, emphasizing hard structural controls, have proven difficult to maintain over time, resulting in sometimes spectacular failures, and often degraded river environment. More sustainable results are likely from a holistic framework, which requires viewing the 'problem' at a larger catchment scale and involves the application of tools from diverse fields. Success often hinges on understanding the sometimes complex interactions among physical, ecological and social processes.

Thus, effective river restoration and management requires nurturing the interdisciplinary conversation, testing and refining our scientific theories, reducing uncertainties, designing future scenarios for evaluating the best options, and better understanding the divide between nature and culture that conditions human actions. It also implies that scientists better communicate with managers and practitioners, so that new insights from research can guide management, and so that results from implemented projects can in turn, inform research directions.

The series provides a forum for 'integrative sciences' to improve rivers. It highlights innovative approaches, from the underlying science, concepts, methodologies, new technologies, and new practices, to help managers and scientists alike improve our understanding of river processes, and to inform our efforts to better steward and restore our fluvial resources for more harmonious coexistence of humans with their fluvial environment.

G. Mathias Kondolf,
University of California, Berkeley

Hervé Piégay
University of Lyon, CNRS

Preface

This book was borne out of the clear need for a comprehensive resource for developing stream and watershed restoration programs at regional (provincial), watershed, reach, and project scales. Many restoration efforts have failed to meet their objectives because they have not adequately addressed the root cause of habitat degradation, or because they do not recognize the role that watershed and riverine processes play in determining the outcome of restoration actions. Over our many years of experience in watershed research, we have repeatedly seen the need for a systematic process-based approach to planning, prioritizing, designing, and evaluating habitat restoration programs and projects. In the chapters that follow, we strive to meet this need. This book is a synthesis of our previous efforts on restoration that have been published as manuscripts, books, and technical reports, as well as our experience teaching practitioners and students in workshops and university courses. We focus primarily on restoration of physical processes and habitat and draw heavily from our experiences in North America and Europe, the continents where considerable habitat restoration and research has occurred. However, the principles and methods covered in this volume are applicable to stream, river, and watershed restoration anywhere in the world and useful for programs that focus on improving degraded water quality and reducing contaminants.

This book is intended as a guide for practitioners, an instructional manual for educators and students, and a general reference for those interested or active in the field of aquatic and restoration ecology. It is organized in a stepwise fashion covering the key aspects of aquatic restoration including: assessing watershed and riverine processes and conditions; identifying restoration opportunities; choosing appropriate restoration techniques; prioritizing restoration actions; and monitoring and implementation. For the educator and student, it is set up so that each chapter can be covered as a section of a course on stream and watershed restoration. Ideally, an instructor will use our text along with data from a local watershed to create realistic and relevant assignments and exercises for the students. For those new to restoration, we recommend reading through most of the chapters in the order presented before embarking on a project. For the experienced restoration practitioner or those with a general interest in the topic, we recommend reading the introduction and watershed processes chapters (1 and 2) and then the remaining chapters in the order that most suits your needs and interests.

This book would not have been possible without the assistance of numerous individuals and organizations. First, our employer the Northwest Fisheries Science Center and current and former supervisors John Ferguson, Tracy Collier, and Doug Dey deserve special thanks for allowing us to pursue and work on this project. We would also like to thank all those who assisted us by reviewing chapters including: Peter Kiffney, John Klochak, Keith Hendry, Mason Bryant, Tom O'Brien, Matt Hudson, Jennifer Steger, Lauren Senkry, Erik Michelson, Martin O'Grady, Sarah Miller, Chris James, Robin Jenkinson, Pauliina Louhi, Ray White, Martin Janes, Jenny Mant, Mary Raines, and Dana Warren. Karrie Hanson, Ed Quimby, Bert Tarrant and JoAnne Butzerin provided much-needed assistance with technical editing. We thank Su Kim, Clemens Trautwein and Hiroo Imaki for assistance in developing figures and numerous individuals for providing photos of restoration used in one or more chapters. Finally, we would like to thank all those who have and continue to dedicate their lives to environmental restoration. We hope that this book will serve you well in your challenge to protect and restore streams, rivers, and watersheds.

Philip Roni and Tim Beechie
June 2012

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Companion website

This book has a companion website:

www.wiley.com/go/roni/streamrestoration

with Figures and Tables from the book

1 Introduction to Restoration: Key Steps for Designing Effective Programs and Projects

Philip Roni & Tim Beechie
Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration, USA

1.1 Introduction

The restoration of streams, rivers, and watersheds has become a growth industry in North America and Europe in the 21st century, with an estimated $1 billion spent annually in the United States alone (Bernhardt *et al.* 2005). This comes with a growing appreciation from the general public of the importance of water, watersheds, and natural places not only for their wildlife and fisheries, but also for social, cultural, economic, and spiritual reasons. With this increased emphasis on restoration has come the need for new techniques and guidance for assessing stream and watershed conditions, identifying factors degrading aquatic habitats, selecting appropriate restoration actions, and monitoring and evaluating restoration actions at appropriate scales. All these require detailed consideration of not only the latest scientific information but also regulations and socioeconomic constraints at local, regional, and national levels. Thus the challenges facing watershed restoration in the 21st century are multifaceted, including both technical and non-technical issues.

As interest in aquatic restoration has increased, several texts have been produced over the last few decades to assist with various aspects of river restoration. Most have focused on habitat improvement techniques specific to trout and salmon (e.g. Hunter 1991; Mills 1991; Hunt 1993; O'Grady 2006) or design considerations for specific techniques (e.g. Brookes & Shields 1996; Slaney & Zoldakis 1997; RRC 2002). A few have provided more comprehensive regional overviews of riverine restoration planning and techniques (Ward *et al.* 1994 in UK; Cowx & Welcomme 1998 in Europe; FISRWG 1998 in USA; CIRF 2006 in Italy). Still others have published overviews of key concepts and principles (e.g. Brierley & Fryirs 2008; Clewell & Aronson 2008). Collectively these publications cover many of the tools, techniques, and concepts needed for restoration planning, but no single book covers the full restoration process from initial assessment to monitoring of results and adaptive management. In this book, we strive to meet the need for a comprehensive guide and educational tool that covers the key steps in this process and provide a text that links watershed assessment and problem identification to identification of appropriate restoration measures, project selection, prioritization, project implementation, and effectiveness monitoring (Figure 1.1). Each of these steps is discussed in detail in subsequent chapters. In addition, we discuss the human dimension and how one can best work with citizens, government bodies, and private companies to develop restoration projects and goals. In this introductory

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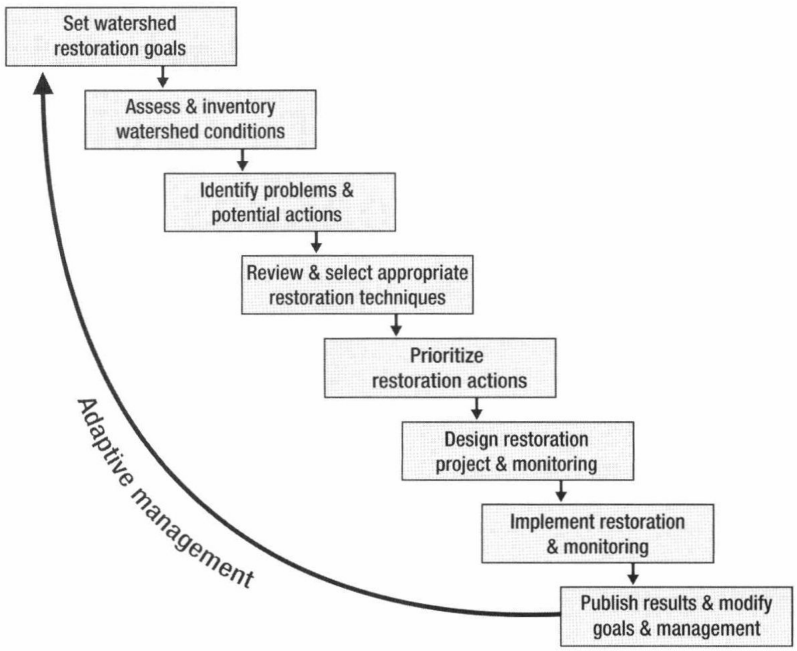

Figure 1.1 Major steps in the restoration process required to develop a comprehensive restoration program and well-designed restoration projects.

chapter we provide important background on the need for restoration, its relatively short history, and the major steps and considerations for planning and implementing restoration actions.

1.2 What is restoration?

Restoration ecology is a relatively young field with considerable confusion over its terminology (Buijse *et al.* 2002; Omerod 2004; Young *et al.* 2005). The terms restoration, rehabilitation, enhancement, improvement, mitigation, reclamation, full and partial restoration, passive and active restoration, and others have been used to describe various activities meant to restore ecological processes or improve aquatic habitats (Table 1.1). These represent a gradient of activities from creating new habitats, to mitigating for lost habitat, to full restoration of ecosystem processes and functions and even protection. In practice, the term restoration is used to refer to any of the above activities. To avoid further confusion over terminology, we therefore use the term in this sense throughout this text. Where appropriate, we distinguish between full restoration, partial restoration and habitat improvement or creation (Table 1.1).

We focus most of our discussion on 'active restoration,' which are restoration efforts that take on the ground action to restore or improve conditions. However, regulations, laws, land-use practices, and other forms of 'passive restoration' that eliminate or prevent human disturbance or impacts to allow recovery of the environment are equally important. For example, most of the improvements in water quality and habitat condition in the USA, Europe, and elsewhere would not have occurred without legislation and regulation. Similarly, habitat protection, while not typically included in definitions of restoration, is a critical watershed conservation and restoration strategy that should not be overlooked. Given the continued pressure on aquatic ecosystems, including a growing human population and climate change, habitat loss will continue and even outpace restoration efforts unless protection of high-quality functioning habitats is a high-priority component of restoration plans. In fact, habitat protection in many cases is a type of passive restoration that allows ecosystems to recover following disturbance. Ultimately, it is much more cost-effective to protect functioning habitats from degradation than it is to try to restore them once they have been damaged.