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# River Restoration in the Twenty-First Century: Data and Experiential Knowledge to Inform Future Efforts

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## Abstract

Despite some highly visible projects that have resulted in environmental benefits, recent efforts to quantify the number and distribution of river restoration projects revealed a paucity of written records documenting restoration outcomes. Improving restoration designs and setting watershed priorities rely on collecting and making accessible this critical information. Information within the unpublished notes of restoration project managers is useful but rarely documents ecological improvements. This special section of *Restoration Ecology* is devoted to the current state of knowledge on river restoration. We provide an overview of the section's articles, reflecting on lessons learned, which have implications for the implementation, legal, and financing frameworks for restoration. Our reflections are informed by two databases developed under the auspices of the National River Restoration Science Synthesis project and by extensive inter-

actions with those who fund, implement, and permit restoration. Requiring measurable ecological success criteria, comprehensive watershed plans, and tracking of when and where restoration projects are implemented are critical to improving the health of U.S. waters. Documenting that a project was put in the ground and stayed intact cannot be equated with ecological improvements. However, because significant ecological improvements can come with well-designed and -implemented stream and river restorations, a small investment in documenting the factors contributing to success will lead to very large returns in the health of our nation's waterways. Even projects that may appear to be failures initially can be turned into success stories by applying the knowledge gained from monitoring the project in an adaptive restoration approach.

Key words: mitigation, monitoring, restoration, rivers, streams.

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## Introduction

At the time of writing this article, most of the land in the United States was no longer in its native state of vegetation and the rate of conversion of land to urban or exurban development was at an all time high (Irwin et al. 2007). By 2030, the United Nations Population Division estimates that 85% of the U.S. population will live within urban areas (UNPD 2003). Much of the land that has not yet been urbanized is or has recently been in agricultural use (Allan 2004; Moore & Palmer 2005). Thus, whether we are referring to regions that were once home to boreal forests, vast prairies, or mountainous highlands, human impacts on ecosystems are now so pervasive that few landscapes can be considered "pristine."

As low-lying points, streams and rivers integrate the effects of these changes to the landscape. Of the 5.3

million km of rivers in the coterminous United States, about 79% are affected by human activities and another 19% drowned by reservoirs, leaving only 2% relatively unimpacted river kilometers (Abell et al. 2000; Graf 2001; Wohl et al. 2007). The vast majority (>70%) of the riparian forests along U.S. rivers and streams have been lost (Innis et al. 2000; Wohl et al. 2007), and more than one-third of the rivers are officially listed as impaired or polluted (EPA 2000). Further, the flood storage capacity of rivers has decreased markedly; water shortages are common throughout the United States; and the diversity of native aquatic wildlife is decreasing (Doppelt et al. 1993; Ricciardi & Rasmussen 1999; EPA 2000).

Thus, it is easy to understand why stream restoration is important. When rivers and streams are degraded, many of the ecosystem services that are so important to society are lost (Baron et al. 2002). Restoration is an attempt to recoup some of these losses and to do so in more aesthetically pleasing ways and at lower costs than through technological fixes such as waste treatment plants (Palmer et al. 2004). As the National River Restoration Science Synthesis (NRRSS) working group has previously shown, river restoration has increased exponentially in the United States (Fig. 1) largely in response to a greater awareness of the unhealthy state of our

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