AGU BOOKSHELF

Stream Restoration in Dynamic Fluvial Systems: Scientific Approaches, Analyses, and Tools

In the United States the average annual investment in river restoration programs is approximately $1 billion. Despite this burgeoning industry, the National Water Quality Inventory, which tracks the health of the nation's rivers, has shown no serious improvement in cumulative river health since the early 1990s. In the AGU monograph Stream Restoration in Dynamic Fluvial Systems: Scientific Approaches, Analyses, and Tools, *editors Andrew Simon, Sean J. Bennett, and Janine M. Castro pull together the latest evidence-based understanding of stream restoration practices, with an aim of guiding the further development of the field and helping to right its apparently unsuccessful course. In this interview,* Eos *talks to Sean J. Bennett, University of Buffalo, about the culture, practice, and promise of restoring rivers.*

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Eos: *What are the primary forces that lead to river degradation, such that rivers need to be restored?*

Bennett: Many of the restoration projects in the United States today are centered on the Chesapeake Bay region, the Pacific Northwest, the upper Mississippi, and the lower Mississippi. In general, anthropogenic activities, such as land use change or changing land management practices, are the primary causes of stream degradation and water quality and ecological impairment.

One can envision the conversion of forested, pasture, or fallow land into an urban center. When this happens, it markedly changes the hydrologic characteristics of the watershed. This usually results in shorter but stronger flows following precipitation, increased rates of erosion, bank destabilization, and the inundation of riverbank vegetation. And, of course, it tends to increase the levels of nutrients or contaminants flowing into the water from urban runoff. All these factors then affect not only the function and form of a river but also the water quality and ecological factors. A lot of restoration projects within urban areas are, in fact, trying to address the deficiencies within these stream systems in hopes of improving them or making them more natural. As we look toward the future, these issues will become much more important because of increasing population and the rising demand for water and water resources.

Eos: *The focus of river restoration and management has changed substantially in the past few decades. What is the modern goal of most river restoration projects, and how does that differ from historical motivations?*

Bennett: I teach a course in stream restoration, and I often ask my students what the difference is between river engineering from 10–20 years ago, or even longer, and river restoration projects today. I think the primary issue that differentiates river engineering from river restoration is the emphasis that is placed on ecosystem services. Federal and environmental agencies have been actively engaged in improving channel stability and water conveyance and addressing flood issues for decades. But now there is a much greater emphasis placed on ecological attributes.

There was an approach that was taken within federal agencies 40, 50, even 60 years ago to simply make channels stable and navigable and to convey water as efficiently as possible from upstream to downstream. Doing this may have created instabilities within the system that actually resulted in the erosion that then caused the current degraded rivers. There is now an enormous societal expectation to have streams that are naturalized, that provide aesthetic and recreational value, and that provide ecosystem services that have a positive impact both locally and within the watershed. I think our knowledge of streams is much more holistic today than it was 50 years ago, and there has no doubt been a fundamental shift in how we view rivers and river management.

Eos: *What are the tools of the river restoration trade? What are the steps involved in taking a river from a straight, smooth, largely life-free channel to a healthy, diverse, thriving ecosystem?*

Bennett: I think one of the key aspects of transforming a stream within an urban environment, for example, is to increase the complexity of the stream corridor. Oftentimes in urban corridors the river channels have been straightened, their wood has been removed, their bed topography has been smoothed, and their side slopes have been laden with concrete. In some respects the rivers have been turned into trapezoidal channels with very little complexity. If you want to improve the ecological indices, whether it's fish and wildlife diversity, carbon storage rates, or otherwise, then you need to add complexity back into that system. That complexity could be through the construction of shallow, gravel-filled riffles, for example, which we discuss in the edited volume. It could be the introduction of weirs or vanes of some sort that induce wandering or meandering of the streamflow, the creation of deep pools that provide habitat and refuge for fish, or the introduction of riverbank vegetation to shade the river and provide the necessary carbon litter to the stream system. So there are a variety of ways that one can naturalize a river within an urban environment. Natural rivers are complex. They have complex bed topography, complex flow patterns, and a diverse ecology.

Eos: *What are the big open questions and the areas that need the most work?*

Bennett: I think the biggest challenge that stream restoration practitioners face today is developing tools that allow them to assess their stream restoration design before it is actually implemented. So, for example, it would be useful to have a numerical model that can effectively interpret how watershed-scale drivers of river processes relate to the

The heavily channelized Los Angeles River demonstrates the extent of river engineering practices. Stream restoration scientists work to return heavily degraded waterways to a more natural state.

varying water quality and ecological indices while simultaneously fitting all of this within a context of economic valuation. To me, that is going to be the greatest challenge in the near future, because we cannot afford to experiment on the landscape.

Eos: *A common issue discussed in the book is that the enthusiasm to restore streams has, in practice, outpaced the scientific understanding of the field. What effect has this had on the outcomes of restoration attempts?*

Bennett: There is no doubt that the practice of stream restoration has outpaced the research. Now, I hope that when you read this book, or thumb through its pages, you do not get the message that stream restoration at the present time is unsuccessful. I think the key message that we would like to communicate is that it is an evolving science, and we are exploring what works and what doesn't work. The field right now is a beautifully dynamic, amorphous system that is expanding and exploring every facet of the stream restoration problem.

But on that note, I think that the rates of success or failure of stream restoration projects remain difficult to gauge. This uncertainty primarily stems from the fact that the practitioners, who are really driving and developing these projects, tend not to communicate their results to the broader scientific community. A few of the key questions that we've tried to communicate in this volume are, What are successful restoration projects, and how we can measure their success and assess their sustainability and resiliency over time?

Eos: *The stream restoration community is a diverse mix of public and private researchers and practitioners, and there seem to be strained relationships at times between the varying groups. As you explain in the book, what is the source of this tension? How might it be resolved?*

Bennett: There is tension in the field, but it's a healthy tension. It is a tension that is really rooted in the different perspectives that the practitioners and researchers have. Practitioners are often seeking resolution to a problem that is posed to them by their clients. So a client might say, "We have a problem with our stream: Banks are failing, we have poor ecological indices, and we want to improve fish habitat." A practitioner will then recommend solutions to those problems within the imposed financial and time constraints. Researchers, on the other hand, who are often comparably free of those same constraints, use a diverse line of inquiry to seek answers to the underlying scientific questions, such as determining how river restoration practices affect ecologic indices over longer time and space scales, or improving the analytic basis of restoration practices and design. So I think a lot of the tension that occurs within the scientific community between practitioners and researchers is really about their ultimate motivations; a practitioner is providing a very much needed service to his or her client and to society, whereas researchers want to explore the scientific and philosophical foundations of these sorts of practices.

But in some instances I think there can also be a communication gap. Sometimes practitioners are trying to develop tools, technologies, and approaches that they can then market to other clientele, so I don't know if it is necessarily in their best interest to share with the broader community how they go about designing their restoration projects. However, I don't want to pick on practitioners. What we've tried to do in this volume is invite some of the leading practitioners to share with the broader community their approaches and their design criteria for restoration projects, an effort we were very successful in doing. Our volume has a very nice mix of practitioner perspectives, as well as scientific perspectives.

Eos: *The text goes into detail in describing some methods and best practices of river restoration, rather than focusing exclusively on concepts, mechanisms, or theories. Who is the intended audience of your book?*

Bennett: We hoped, in particular, to connect with young researchers. That really is the ultimate audience for this book. We want to share our experiences, our thought processes, and our scientific results with the younger audience so that they can assimilate this information and improve upon it. Our book is simply a stepping stone in this process.

That being said, I think there are chapters on some of the new and exciting avenues of research in stream restoration that even experienced researchers would be interested in reading. These include examining the exchange of fluids within the stream channel and within the near-surface, or hyporheic, zone. I think many researchers would be very interested to know the design criteria for pool and riffle sequences that are discussed in the book, and I think researchers are very interested to know what models and tools are currently available and actively being used to address restoration activities and projects. So I think this book will be exciting to both the seasoned veteran and the young investigator.

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—Colin Schultz, Writer