In just the last decade, scientists have learned a great deal about the critical linkages between natural flow variations and the health of river species and ecosystems. This knowledge will be crucial in guiding society toward better ways of managing water that optimize the long-term provision of ecosystem services while meeting other human water demands. But realizing such improvement will require that water planners and managers do a much better job of incorporating scientific knowledge into their decisions and activities. As we describe in this chapter, the rapidly expanding field of river restoration will only achieve its potential if scientists and engineers work closely together. Some early successes are proving that when their brainpower is fused and directed toward a common purpose, they can find ways to better meet society's water needs while bringing rivers back to life.

THE EVOLUTION OF A NEW RIVER MANAGEMENT PARADIGM

When Donald Tennant stepped into his new job as a fisheries biologist with the U.S. Fish and Wildlife Service in 1956, he soon found himself out of step with many of his fellow Americans: He did not share their unbridled enthusiasm for building dams.

Recovering from the treasury-draining Second World War and emboldened by its outcome, Americans in the 1950s began focusing their attentions on building a strong nation, and investment in public works infrastructure was seen as an essential step. Federal and state highway systems expanded by leaps and bounds. Rural electrification projects brought power to the hinterlands. And nearly two hundred large dams were built each year in the 1950s and 1960s as the United States embarked on a dam-building binge unlike any the world had ever seen. These dams would enable Americans to grow crops in the desert, free western cities from their arid shackles, and protect their homes and livelihoods from the ravages of floods.

But Tennant knew that by depriving rivers of their life-giving waters, these same dams would devastate aquatic life. In 1975, he wrote in the journal *Fisheries*, "Philosophically, it is a crime against nature to rob a stream of that last portion of water so vital to the life forms of the aquatic environment that developed there over eons of time."[4]

Tennant became one of the first scientists to attempt to gauge how much water a river needs. From 1958 to 1975, he systematically collected biological and hydrological data from rivers across the United States, comparing the rivers' biological attributes with their hydrologic condition. On the basis of those observations, he proposed some guidelines for flow protection that became known as the "Tennant Method."[5] To sustain "optimum" biological conditions, Tennant suggested that 60–100 percent of a river's average flow would need to be protected. But to provide "excellent habitat," only 30–50 percent of the flow might be needed. Because it is rather simple and easy to apply, the Tennant Method became one of the most commonly used approaches for defining ecological flow needs in the United States, and it was eventually applied in at least twenty-four other countries.[6]

The Tennant Method came under mounting scrutiny, however, as water managers and dam operators began to equate water left in rivers with water unavailable for other uses, such as irrigating farms, supporting cities, and generating power. Increasingly it became the source of contention in court and regulatory proceedings resulting from new federal legislation, such as the National Environmental Policy Act of 1969, the Endangered Species Act of 1973, and changing policies for the licensing of private hydropower dams. Water managers and dam owners began questioning the scientific assumptions of Tennant's method, inquiring on countless occasions whether fish might do just as well with less water. What would happen with an incremental lowering of the flow requirements, for instance by releasing only 20 percent of a river's natural flow, or only 10 percent? Engineers and economists could readily enumerate the economic worth of each additional meter of water level in a reservoir for hydropower generation, or each additional cubic meter available for irrigation. Why couldn't biologists make similar judgments for fish?

The mounting pressure to justify the biotic worth of flowing water had a profound effect on the evolution of river science in the United States during the 1970s and 1980s. It engendered a new branch of aquatic biology focused on assessing the environmental impact of water development. Hundreds of fish biologists and water resource engineers working primarily for wildlife agencies or environmental consulting firms were swept up into the frenzy of developing new tools and methods to determine how much water should be left in rivers. These tools were needed to inform water negotiations and regulatory proceedings. Eventually these applied scientists became isolated from aquatic research ecologists in universities and other institutions, who continued studying and modeling