accurately mirror the natural environment. The outcomes of these experiments have, in some instances, been surprising. In rare cases, one of two stressors may actually have a subtractive effect, negating the negative effect of the other stressor. For example, in some marine invertebrates, the development of embryos may be slowed by exposure to ocean acidification but accelerated to a normal rate of development by elevated temperature.[4] More commonly, the impacts of multiple stressors are either additive or synergistic.

To picture additivity and synergism, imagine an experiment carried out by fish biologists with three equal-sized groups of Antarctic fish, with one group exposed to a thermal stress (elevated temperature), another to ocean acidification stress (increased seawater acidity), and a third to the two stressors at the same time. In this example, imagine that 10 percent of the fish in the group exposed to elevated temperature die over a month, while 15 percent of the group of fish exposed to increased acidity die over a similar amount of time. If 25 percent of the final group of fish exposed to both increased temperature and increased acidity die over a month's time, then the two stressors have an additive effect on fish survival. If, on the other hand, half the fish die over a month, the two stressors have caused a synergistic effect on fish survival. It is this latter, synergistic example that is of particular concern, as fish weakened by one of the stressors have become more vulnerable to the second stressor. By understanding which environmental stressors have subtractive, additive, or synergistic outcomes, fisheries biologists are better able to develop effective mitigation strategies to promote fish conservation.

Fish habitats are also experiencing increased environmental disturbance. Yet, despite these challenges, promising stories exist of successful efforts to preserve and in some instances restore or even enhance fish habitat. The first story is one of habitat preservation, originating in my hometown of Birmingham, Alabama. The story is testament to the quintessential nature of effective communication and cooperation. The characters include an environmental organization and a state agency in charge of highway construction.

Birmingham's Cahaba River Society (CRS)[5] was established in 1988 as a nonprofit organization to promote and ensure the sustainable health of the Cahaba River, the longest free-flowing river remaining in Alabama. One of the unique attributes of the CRS is that over the years members of the board of directors have increasingly been selected to represent a full spectrum of community stakeholders, including CEOs and executives of land development companies, real estate firms, banks, law firms, and energy companies. Corporate leaders serve alongside freshwater biologists and environmentalists.

Board members of the CRS became concerned when they learned that the Alabama Department of Transportation (ALDOT) planned to build a three-mile section of highway northeast of Birmingham. The short section of highway would establish a foothold for a controversial northern beltway around the city of Birmingham. The fifty-two-mile beltway would ultimately cross all five upper tributaries of the Cahaba River. The construction project, near the town of Pinson, Alabama, would not directly impact the Cahaba River, but the four-land highway, designed to expand to six lanes in the future, would be in close proximity to Self Creek, a tributary that ultimately feeds into the Black Warrior River, a 178-mile river in west-central Alabama. Accordingly, the highway's construction near the creek posed risks to fish habitats, both through sediment deposition and runoff carrying asphalt toxins. The creek and the river it feeds provide habitat for native darters and redeye bass, spotted and largemouth bass, and a host of other aquatic plants, invertebrates, and fish. In large part because of the corporate nature of the CRS board, an objective "best practices" document developed by the board was delivered to ALDOT, rather than a legal challenge to the state transportation agency over the need for an environmentally sound mitigation strategy. What followed was remarkable. The director of ALDOT invited CRS board members to meet with his leadership team and forge a statement outlining collaborative aims to protect Self Creek and its downstream waters. A culture change was under way.

"I couldn't believe what I saw!" exclaimed Randy Haddock, field director for the CRS, describing his reaction to touring the mid-construction phase of ALDOT's highway project near Self Creek. Barry Fagan, the ALDOT environmental compliance engineer, walked Randy and Beth Stewart, executive director of the CRS, over to the edge of one of the detention ponds that had been built by construction workers to mitigate sediment runoff and asphalt pollutants from the banks and road surface of the highway. Randy explained that Barry had proudly shown them a pond that was two to three times larger than a normal detention pond and uniquely shaped to retain the brunt of waterborne sediments at its deep end nearest the highway. Finer sediments settled out as the water slowly moved the length of the pond. Water flowing into the pond first moved across swales—gently sloping, grassy drainage areas—which facilitated absorption of water by the soil. Water draining out of the pond flowed over a water-level spreader, a device that dispersed water across a wide, relatively flat slope, further facilitating soil absorption and sediment settlement before water entered Self Creek.

Randy Haddock explained to me that to accommodate the swales and detention ponds, ALDOT, in an unprecedented action, had purchased additional land prior to highway construction. The state agency had also established an on-site team to monitor runoff near Self Creek during storms and provided a $40,000 bonus to the highway's contractor for each month of road construction completed without a storm-water violation. Randy and Beth were convinced that the aggressive mitigation efforts by ALDOT had significantly enhanced protection of fish habitat in Self Creek and river waters farther downstream. The successful culture change also owed considerable credit to ALDOT's compliance officer, Barry Fagan, who'd become passionate about the development and promotion of what he'd coined ALDOT's "Five Pillars," which include the management of communication, work, water, erosion, and sediment.[6] "ALDOT's previous focus had been only the last two pillars," Barry explained to me over the phone. The adoption of the other three pillars had been essential in convincing the CRS board that aquatic habitat could be protected in concert with highway construction. Should plans to build a northern beltline come to fruition, there's now hope for sustaining water quality and fish habitat in the Cahaba River and its tributaries. I could tell by Barry's tone he was proud of recent invitations from a variety of agencies to speak about his Five Pillars approach to managing road construction in environmentally sensitive areas.

The second story is a cautiously optimistic tale that centers on recent signs of environmental recovery in mountain lakes of the northeastern United States that were ravaged by acid rain in the 1960s and 1970s. First described by Yale and Dartmouth ecologist Herbert Bormann in 1971, acid rain is generated when sulfur dioxide and nitrate oxides, released from industrial smokestacks, combine with ammonia and infiltrate rain droplets. The sulfuric- and nitric acid–laden rain falls to earth and ultimately ends up acidifying creeks and streams that feed lakes. The result is the establishment of chronically low pH "acid lakes." Unfortunately, the mineralogy of soils in the northeastern United States does little to buffer the acidity of lake water. Under acidifying conditions, soils surrounding acid lakes release toxic forms of aluminum and mercury, heavy metals that, in combination with acidity, can be harmful or even deadly to fish and other aquatic organisms. A few species of fish can survive in moderately acidic lakes, while others such as brook trout are sensitive to acidity. Even fish that survive acidic waters often display damaging sublethal effects such as slow growth and small adult body size, factors that reduce the ability of the fish to compete effectively for food and habitat. In some lakes, however, the water becomes so acutely acidic that, no matter how carefully fisheries biologists search, there's not a living fish to be found. The bottleneck that prevents fish from surviving such conditions is often some aspect of their reproductive cycle.

In 1995, the federal government established the Acid Rain Program.[7] The program set limits on major emissions of sulfur dioxide and nitrogen oxides originating primarily from industrial combustion