A NANFA CONSERVATION RESEARCH GRANT REPORT

A Rule Made to be Broken: Research and Education in Rocky Mountain National Park

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For four years during graduate school, I obtained a permit to conduct fisheries research in Rocky Mountain National Park in Colorado. The permit always stipulated, "Research shall be conducted out of the sight and sound of park visitors." I never understood the reason for this rule. Perhaps visitors might consider my research methods harsh. (Certainly the fish—captured by electrofishing and regurgitating their gut contents for the benefit of science—would think so.) Perhaps seeing a researcher at work, deep in the backcountry, would interfere with a visitor's nature experience. A reason for the provision was never given, so I can only guess.

I must admit, though, that every now and then park visitors did happen to see and hear my research. Even miles from a trail-head, camouflaged in green and brown waders, it was hard for me to hide from every one of the three million people who visit the park each year. The "out of sound" part of the rule was especially hard to obey. My battery-powered backpack electro-fisher emitted a steady, high-pitched *eeeee* when the electricity was flowing. For someone who had hiked miles into the wilder-ness, this distinctly unnatural sound required investigation.

One day I was working with three undergraduate assis-tants at the Roaring River, in the headwaters of the South Platte drainage (Fig. 1). We had just finished an electrofishing pass when a man and his eight-year-old son caught us, red-handed, with about 50 glistening greenback cutthroat trout (*Oncorhynchus clarkii stomias*, Fig. 2). Spying our impressive catch, they asked what we were doing.

I told them that I was a graduate student at the University of Colorado, and that I was studying how non-native brook trout (*Salvelinus fontinalis*, Fig. 3) affect native cutthroat trout. I pointed to the bucket and explained:

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"These fish are greenback cutthroat trout, a subspecies that occurs in the headwaters of the South Platte and Arkansas Rivers and nowhere else in the world. Two hundred years ago, the greenback was isolated from other trout throughout most of its range. During the 19th century, European settlers brought rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and brook trout to Colorado. The settlers introduced these non-native species to 'improve' native fisheries. The introduced species spread quickly, and soon dominated in streams and lakes where cut-throat trout had lived alone in the past."

The man sat on a rock, seeming to settle in for a chat, and asked the question that inevitably follows my mini-history lesson on greenback cutthroat trout.

"Why do the other species do better than the cutthroat trout?"

"Well, *that* is the question," I replied. "Brook trout usually are the problem."

"Brook trout," I continued, "are native to eastern North America, and have habitat requirements similar to those of cutthroat trout. Both species survive in cold, steep streams at high elevation. When brook trout invade a cutthroat stream, the brook trout multiply and the cutthroat disappears. But we don't know why the brook trout win and why the cutthroat trout lose."

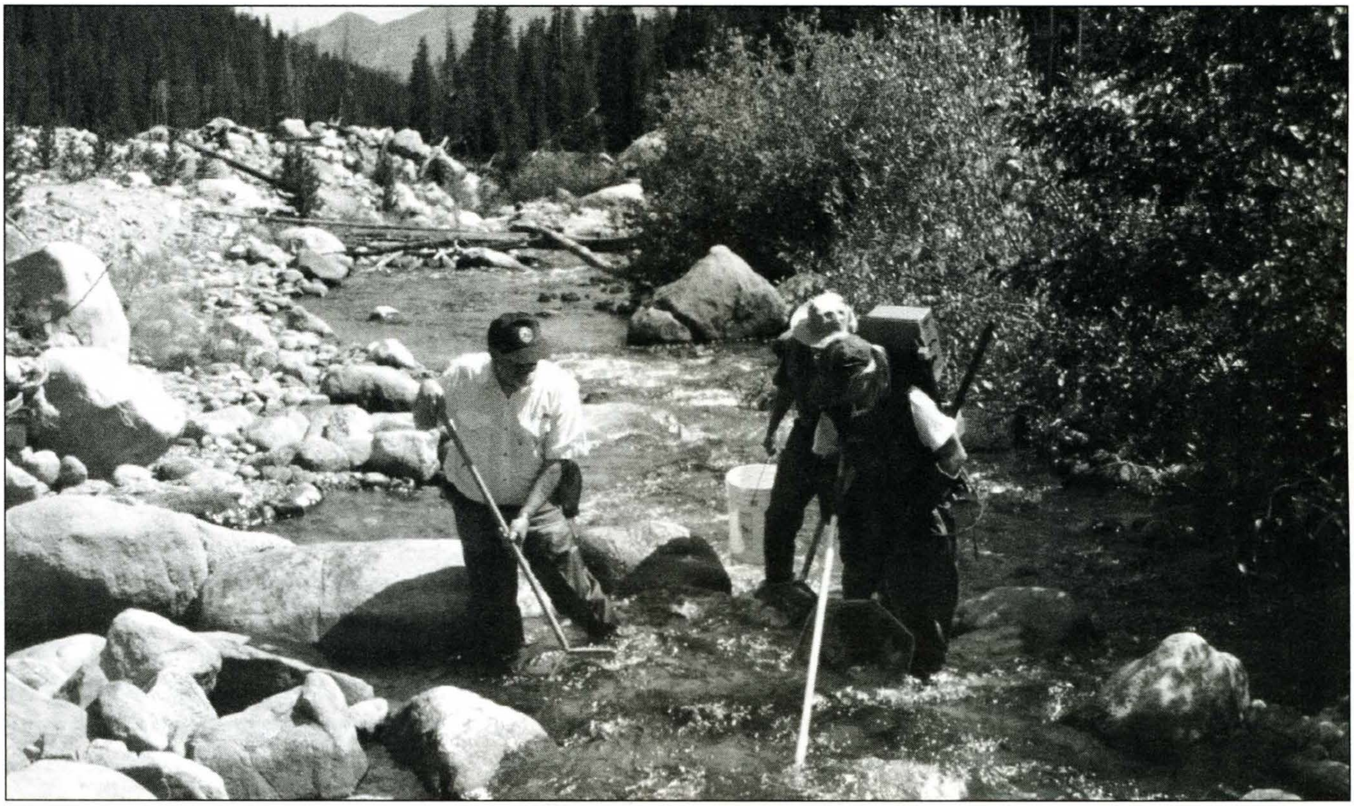

Fig. 1.
The author and assistants electrofishing at Roaring River, Rocky Mountain National Park, Colorado. Photo: Chris Kennedy.

I paused, poured the fish from the bucket into a mesh bag, cinched it shut, and submerged it in calm water at the stream's edge. Then I perched onto a rock of my own. I decided to provide more background.

"In 1973, the greenback cutthroat trout had declined to such low numbers that it was listed as endangered under the Endangered Species Act. By 1978, its numbers had increased, and it was reclassified as threatened, which is its current status. The approach to recovery has been to raise the greenback in hatcheries, and then introduce them to areas where they can establish self-sustaining populations. Restoration sites typically are headwaters that are isolated from non-native fish by barriers such as waterfalls or dams. If non-natives are present at the restoration site, they are removed using chemicals that are toxic to fish before the greenbacks are reintroduced. But often this approach does not work perfectly. In some areas, a few brook trout survive the chemical treatment and reproduce. In other areas, brook trout swim upstream past barriers that were thought to exclude them."

Earlier, on their steep hike up the Roaring River valley, the man and his son had frequently stopped to rest. During these breaks, they peered into the incised riverbed and saw a quarter-mile of steep cascades and falls.

"The cascades and falls are a natural barrier to brook trout," I told them, and then added: "I think you picked a good place to hike. The Roaring River is one place where greenback cutthroat trout thrive."

I took a fish from the mesh bag. The specimen was large for a greenback, about 11 inches long. I showed the boy and his dad the dark, oval spots concentrated near its tail, and the red slash under its throat. It was August, and this fish had a bright orange blush to its belly and opercles, a remnant of its spawning about six weeks earlier. With ample encouragement from his dad and me, the boy stroked the tiny, smooth scales just below its dorsal fin, and then giggled as he wiped his hands on his shirt. They continued on their hike, and my crew and I continued with our work.

Displacement of Cutthroat Trout by Brook Trout

The greenback is not unique in its vulnerability to brook trout. Thirteen inland subspecies of cutthroat trout occur in the western U.S., and most are displaced readily by brook

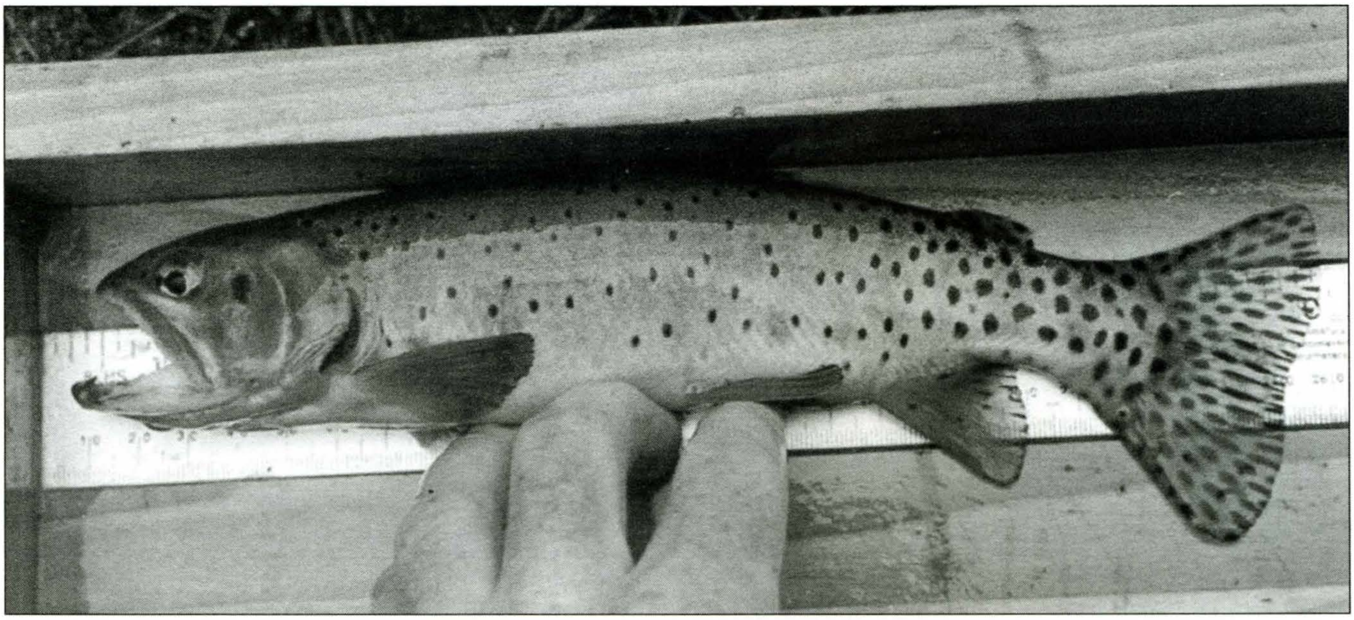

Fig. 2.
Greenback cutthroat trout (*Oncorhynchus clarkii stomias*). Photo: Chris Kennedy.

trout (Behnke, 2002). The mechanisms for displacement, however, are not clearly defined.

Possible interactions between brook trout and cutthroat trout include competition, predation, and transmission of disease or parasites (reviewed by Dunham et al., 2002; McGrath, 2004). Disease surveys indicate that past declines in greenback cutthroat trout cannot be attributed to disease or parasites (USFWS, unpublished data). Predation of brook trout on cutthroat trout is plausible, but few studies of predation have been done, and the results have varied. Competition for resources usually is cited as the reason for displacement of cutthroat trout by brook trout. But there have been few, if any, rigorous tests of competition between cutthroat trout and brook trout under natural conditions.

Studying the Feeding Ecology of Greenback Cutthroat Trout and Brook Trout

While investigating competition and predation as possible mechanisms by which brook trout displace cutthroat trout, I also studied the feeding, or trophic, roles of the native and non-native trouts in the foodweb. Defining trophic roles helps to determine if brook trout function the same as cutthroat trout in the stream ecosystem.

During 2000-2002, I surveyed 10 stream sites in the Rocky Mountains. Eight sites were within the South Platte drainage in Rocky Mountain National Park, which is a critical refuge for greenback cutthroat trout. Two additional sites were in the headwaters of the Arkansas River. Research areas contained 1) cutthroat trout only, 2) brook trout only, 3) both species, or 4) both species with subsequent removal of brook trout. No other fish species were present.

I conducted surveys of habitat and trout populations in the streams. Most of my research was focused on defining the feeding ecology of the two species. I collected gut contents from fish using a technique called gastric lavage, or "stomach washing." I built a lavage kit with a syringe and flexible tubing that could be inserted down a fish's throat to flush the gut with water (Fig. 4). Back at the laboratory, I measured the amount of food in gut contents, and I identified the foods selected by the two species.

In addition, I used stable isotope studies, a newer technique, to describe the feeding ecology of fish. Using a surgical instrument designed for humans, I took tissue samples from fish. I measured the chemical composition of carbon and nitrogen isotopes in the fish tissue. I also measured isotopes in algae and terrestrial leaves, which form the base of the stream foodweb. By comparing the isotopic composition of fish and plants, I could compare the positions of cutthroat trout and brook trout in the foodweb.

Gut content and stable isotope analyses provide different yet complementary information about the feeding ecology of fishes. Gut contents cover a snapshot of time and give information about the amount and type of foods eaten. Stable

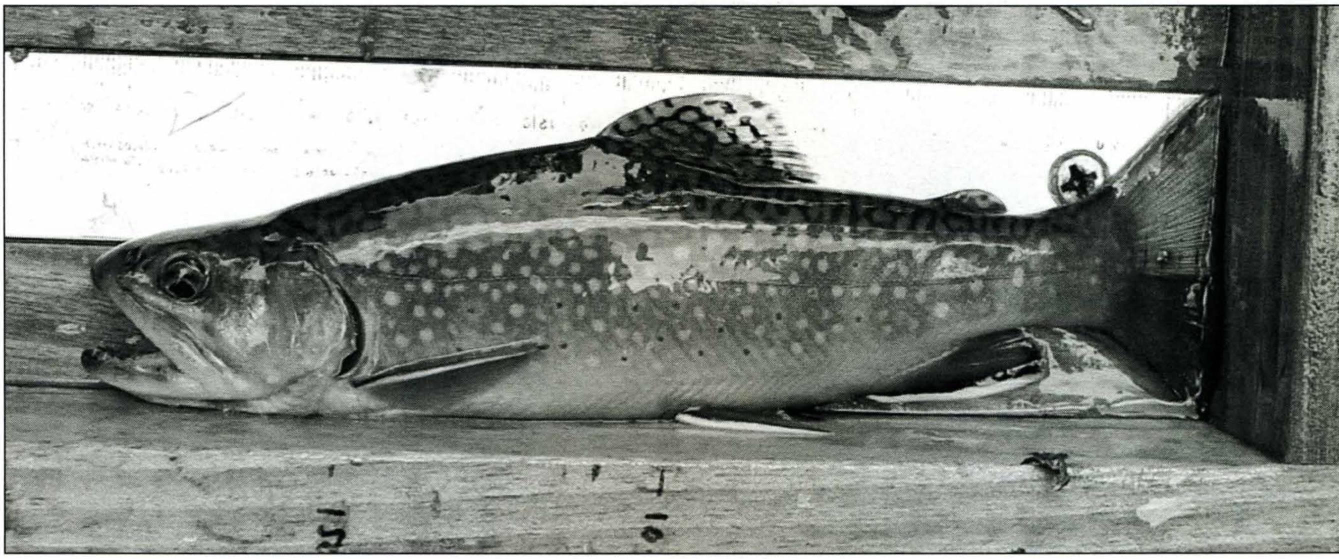

Fig. 3.
Brook trout (*Salvelinus fontinalis*). Photo: Chris Kennedy.

isotopes integrate information over a longer time and provide larger scale information about the cycles of nutrients through ecosystems.

Finding the Answer

Peering through a microscope at partially digested bugs in fish vomit is not a glamorous job. Always eager to talk about my research, I discovered that most people are not interested in hearing about this aspect of my work. Their reaction usually included some combination of "Eew!" and "Gross!" Fishermen, of course, are an exception. They can talk trout guts for hours.

One day I was at Ouzel Creek, a wood-choked stream in the southeast corner of Rocky Mountain National Park, with my research crew. We had finished our first electrofishing pass. I sent the crew to start the second pass while I finished weighing and measuring the fish captured on the first.

As I grabbed hold of an eight-inch brook trout, I glanced at it and blurted to myself, "No way!" A mouse's tail was hanging out of its mouth. I had heard that brown trout will eat rodents, but would not have believed it for a little brook trout. I couldn't resist. I tugged at the tail until out popped the mouse.

Right then, I noticed a fisherman nearby and I motioned for him to come over. I said to him, "I thought you might like to see this." I held up the mouse in one hand and the trout in the other hand.

"No way!" he exclaimed.

Though more common than finding a mouse, it was still rare to find prey fish in gut contents. Of approximately 10,000 prey items in the stomachs of 300 fish, I found only four prey fish. Predation did not appear to account for declines in cutthroat trout. Isotope analysis corroborated the results of gut content analysis. If brook trout were more piscivorous than cutthroat trout, then nitrogen isotopes would reflect it. Instead, nitrogen isotopes, too, revealed that the two species occupied the same level in the food chain.

Competition for food also did not appear to be an important mechanism for displacement of cutthroat trout by brook trout. The two species had similar gut fullness and body condition. Greenback cutthroat trout and brook trout both consumed aquatic and terrestrial invertebrates. Surprisingly, greenback cutthroat trout consistently ate a wider variety of prey and more prey items than did brook trout. Both the native and the invasive species had healthy body condition, and there was no indication that food was limiting growth of either species.

Are All Trout Created Equal?

On my last day of fieldwork I found myself at Hidden Valley Creek, my only roadside research site. Once again I was deliberately chatting up my research with a retired couple who was visiting the park. I was giving them my mini-history lesson on greenback cutthroat trout when the man commented, "It seems like an awful lot of time and money to me. A trout is a trout. It doesn't matter if it's an eastern trout or a western trout."

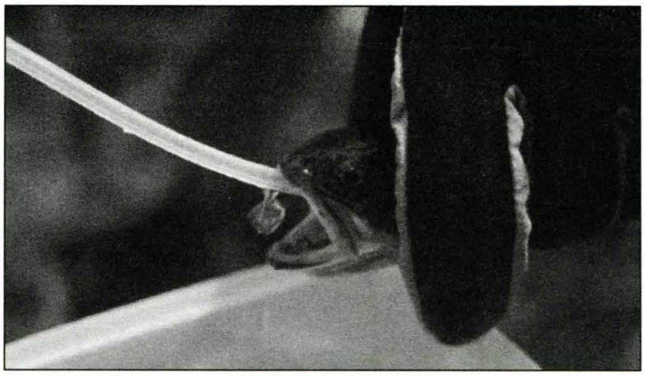

Fig. 4.
Obtaining gut contents from a brook trout. Photo: Chris Kennedy.

"Well, *that* is the question," I replied once again.

"Many people, scientists included," I continued, "think the two species play a similar role in the environment. But I would argue that we don't really know how similar these two species are. This is a question that I am looking at in my research."

I explained the concept of a trophic cascade—that if the two species eat differently, then replacing cutthroat with brook trout could affect the entire aquatic foodweb. The cascade can alter invertebrate and plant communities, and even energy budgets of stream ecosystems.

We also talked about the purpose of the Endangered Species Act—to protect native species for ethical and aesthetic reasons, and also to preserve the functions of native species in their ecosystems.

So how do brook trout displace greenback cutthroat trout? My research does not support the idea that brook trout cause declines in cutthroat trout populations through competition for food or predation. Instead, population surveys suggested that cutthroat trout are lost during their first year of life. Since it's difficult to obtain samples for gut contents and stable isotope analysis from very small fish, I had few data on the feeding ecology of fish during their first year. Specific mechanisms of interaction on young cutthroat trout should be the subject of future investigations.

In the past it has been assumed that cutthroat trout and brook trout function similarly in stream ecosystems. Stable isotope studies supported this idea—the two species had similar levels of carbon and nitrogen isotopes, suggesting that they rely on the same food resources. The gut content analysis, however, told a different story. Both species ate an array of aquatic and terrestrial invertebrates. But greenback cutthroat trout consumed a wider variety of prey than did brook trout, and consumed more of them. According to gut content analysis, the native species had a broader trophic niche than the invasive species. This indicates that invasive brook trout might alter stream communities by altering the aquatic foodweb.

Conclusions

The conservation and management of native species should be based on research, not assumptions. My results challenge a long-standing assumption about the interactions between invasive brook trout and native cutthroat in the interior west. My research also challenges the assumption that brook trout are "functionally equivalent" to greenback cutthroat trout in stream ecosystems.

I admit that I broke the rule. My research was not conducted "out of the sight and sound" of park visitors. But this is one rule that was made to be broken. I believe that, as a scientist, I have two critical responsibilities. The first is to answer important questions in a scientifically rigorous way. The second is to educate. I should communicate my findings, not only to the scientific community, but also to the broader community. Informing policymakers will help to ensure that policy reflects science, and informing the general public will help generate public support of conservation programs.

Acknowledgments

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