



To learn more about the Bear Creek greenback cutthroat trout, watch an interview with CPW Senior Aquatic Biologist Doug Krieger at the following link: [Bit.ly/bcgreenback](https://bit.ly/bcgreenback)

Piecing Together the Past

Using DNA to resolve the heritage of our state fish

By Dr. Kevin Rogers



The cutthroat trout in Bear Creek are the only remaining fish that share the genetic fingerprint with specimens collected in the late 1800s from across the South Platte Basin (approximate collection locations shown with yellow stars).



© KEVIN ROGERS/CPW

Several years ago, researchers at the University of Colorado (CU) in Boulder created quite a stir when they published a paper in the journal *Molecular Ecology* suggesting that half of the greenback cutthroat trout populations in the state were actually Colorado River cutthroat trout, native to the Western Slope. 🌀 The resulting media coverage focused on how biologists could possibly have confused Colorado River with greenback cutthroat trout, but indeed the two were always difficult to separate. In fact, experienced taxonomists reported major overlap in visual characteristics between the two, and even the world's foremost salmonid expert, Robert Behnke, Ph.D., maintained they could not clearly be separated. 🌀 This news received both national and international media coverage, in part because the story of the greenback cutthroat trout was held as one of the shining stars of the Endangered Species Act (ESA).

AN ELUSIVE TRAIL

The greenback was thought to be extinct by 1937, but several relict populations were discovered and used in a recovery effort that spanned three decades. The species was downlisted to "threatened" status in 1978, and the Greenback Recovery Team was approaching the goal of having the 20 self-sustaining populations necessary to remove the greenback from the ESA list. The new assertion that most of these populations were not greenback, but rather Colorado River cutthroat trout, dealt a significant blow to recovery efforts.

The desire to clearly distinguish Colorado's native cutthroats spawned extensive genetic testing in the mid-'90s with the hope of finding molecular markers that would make the distinction clear. Unable to identify any, the recovery team had to continue to rely on existing science to guide management decisions. Ultimately, geographic location was used to assign native trout to either subspecies.

A clearer picture of native trout taxonomy in Colorado began to emerge when the team at CU suggested that — in fact — good molecular markers were apparent, but they were being masked by a jumbled distribution of the fish.

They proposed that stocking in the early part of the 20th century was responsible for the presence of Colorado River cutthroats in Eastern Slope waters. They also identi-

Trappers Lake with the Colorado Parks and Wildlife cabin and the Cabin Creek weir in the foreground where the bulk of fertilized eggs were produced and sent to state hatcheries.





Otto Peterson and crew prepare to strip eggs from a large female trout on the Grand Mesa in the early 1900s.

© PHOTO COURTESY OF BETTY KENDRICK

The scale of production of wild trout native to Colorado was dramatically underappreciated until the U.S. Fish and Wildlife Service's Chris Kennedy dug up everything he could about the production of native trout in Colorado.

In addition to his regular duties as a fish biologist, Kennedy spent five years scouring the state in search of information about the stocking of "blackspotted" or "natives" as they used to be called, by state, federal and private hatcheries in Colorado's past.

He stitched together a history that includes a minimum estimate of native cutthroat trout produced in the state and released back into its waters from 1872-1951. Kennedy scanned state and federal fish commissioner reports, state archives, records from agencies around the country, and local newspaper archives to compile a comprehensive cutthroat trout stocking database for the state.



Outlet weir at Trappers Lake used to collect spawning cutthroat trout.

While Colorado Parks and Wildlife (CPW) has a robust digital stocking database that covers activities back to 1952, what was produced by the hatchery system before then was much less clear.

Initial efforts producing cutthroat trout appear to have started with private residents, around the same time as movement of trout between waters was first documented, in 1873. Then, two men named Cushman and Barrett collected trout in Bear Creek and "brought over one hundred live ones, which were placed in Green Lake. . . . In a few summers our favorite lake will be stocked to repletion with delicious trout, and they will become as cheap and common as potatoes." (Colorado Miner, July 8, 1873). Actions soon escalated rapidly to include state and federal efforts to establish trout fishing opportunities for the public good by the late 1880s.

Some of Kennedy's research results are startling. He discovered that, in a 12-year

period from 1914-1925, the state fish commission not only produced at least 26 million trout from Trappers and Marvine lakes, but stocked them in virtually every county that could support trout in the state.

While the state busied itself producing eggs in these areas at the headwaters of the White River, federal fish culturists were obtaining eggs from several lakes on the Grand Mesa — through an agreement with a British gentleman who owned a hatchery and numerous lakes there.

William Raddiffe, who purchased the property in 1896, took offense when Delta County locals considered it their right to descend on his lakes each spring to seine and snag — even dynamite — his spawning runs of cutthroat trout to secure fish for the year. To curb this behavior, he hired game wardens to patrol the grounds. A confrontation at Island Lake resulted in one game warden shooting several locals, killing one of them. The incensed community sent a lynch mob to Alexander Lake to get even, burning Raddiffe's buildings to the ground. Fearing for his life, Raddiffe returned to England, then received restitution from the U.S. government for his losses.

Though Raddiffe was gone, fish culturists at the new Federal hatchery near Leadville continued to take spawn from those same lakes. With good records from that operation, they produced 29 million eggs during an 11-year period from 1899-1909. Like the state-led operation at Trappers Lake, these fish were distributed around Colorado in streams that could support them.

These two wild spawn operations alone provide a clear mechanism for how cutthroat trout strains — native to the Colorado and Yampa River basins — found their way east of the Continental Divide. It appears that descendants of these efforts remain up and down Colorado's Front Range, persisting in waters where barriers to migration have protected them from invasion by non-native brook, brown and rainbow trout.



U.S. Fish and Wildlife Service fisheries biologist Chris Kennedy. © Kevin Rogers/CPW

fied an alleged greenback population west of the Continental Divide.

Also at this time, biologists with Colorado Parks and Wildlife (CPW) partnered with Pisces Molecular, in Boulder, to develop another molecular test. It also suggested a genetic basis for differences between Colorado's native trout. Major survey efforts

of cutthroat populations on the Western Slope also identified many more of these "greenback" populations using this test.

By 2010, more than 50 populations of "greenback" were discovered west of the Divide, casting doubt on the notion that fish with this genetic fingerprint were actually native to the Eastern Slope.

STOCKING WAS PERVERSIVE

Researchers suggested stocking played a role in the distribution of cutthroat trout because their DNA indicated populations on opposite ends of the state were often more closely related than those in neighboring drainages — a phenomenon not seen in distributions of other native fish species.

Although biologists recognized that trout stocking was an integral part of Colorado's past, it was clear that a more thorough understanding of what actually went on in the early 1900s was needed.

Enter Chris Kennedy — biologist and fish genealogist for the U.S. Fish and Wildlife Service (see sidebar). Kennedy's sleuthing skills and passion for digging through old archives revealed valuable findings. Specifically, he was able to recreate a stocking history that the records at the time only hinted at.

Indeed, stocking was pervasive.

Although wild spawn operations took place in a number of waters around Colorado, the primary egg source for the state in the early years was Trappers Lake, at the headwaters of the White River.

Biologists began taking eggs from there in 1903, sending 750,000 to the hatchery in Steamboat Springs that year. In 1908, they took a record 10 million eggs out of Trappers and neighboring Marvine Lakes — even using those eggs to establish a brood source for native cutthroat trout on the south slope of Pikes Peak that produced many more.

They stopped taking eggs from Trappers Lake after a population crash in 1938 then started again after World War II, when hybridizing trout species were introduced into the lake. By then, spawning runs in the headwaters of the White River had likely produced more than 80 million fertilized pure cutthroat trout eggs for hatcheries around the state.

Federal fish culturists based out of the Leadville National Fish Hatchery were not idle during that time either, collecting large numbers of fertilized eggs from native cutthroat trout on the Grand Mesa. Despite it being a rather spartan operation, they were able to produce as many as 7 million fish a year from that facility. These fish were scattered widely around the state as well.

A LEGACY IS TRACED

The stocking records made it clear that, to get a firm understanding of the distribution of native cutthroat trout in Colorado, specimens housed in museums that had been collected prior to the bulk of stocking activities needed to be examined.

Fortunately, trout have long held the interest of naturalists and, in fact, there are fairly extensive collections in museums around the country, collected by notable individuals like David Starr Jordan, Louis Agassiz, Ferdinand Hayden and others who had a hand in exploring the West.

Although some of these specimens are more than 150 years old and have very degraded DNA, the CU team was able to use cutting-edge molecular methods — both here in Colorado and at the Australian Center for Ancient DNA — to piece together fragments long enough to classify these specimens into different groups.

The study proved that genetically distinct cutthroat trout lineages could be found in

virtually every major drainage basin in Colorado. Two distinct lineages of Colorado River cutthroat trout were found on the west side of the Divide — one called the White and Yampa rivers home, the other centered around the Grand Mesa. Both lineages are established on both sides of the Continental Divide today, likely as a result of long-bygone stocking efforts originating from eggs taken from Trappers Lake and the Grand Mesa Lakes.

The study also showed a third lineage was historically found on the western side of the Divide, native to the San Juan basin. Unfortunately, CPW biologists have not been able to find any descendants of that lineage in current cutthroat trout populations.

A GIANT GOES MISSING

Museum specimens of the extinct yellowfin cutthroat trout were also easily distinguished by their DNA. It appears that this regal fish, routinely topping the scales at more than 10 pounds, did indeed go extinct shortly after it was discovered. Twin Lakes fish surveys in 1902 and 1903 failed to find any remaining individuals.

Many hoped that since fertilized eggs were taken from Twin Lakes, that they may have become established elsewhere — even as far away as France. Unfortunately, despite extensive testing, no descendants of this fish living today have been found.

The museum data challenges the long-held belief that the yellowfin were native to just Twin Lakes, as early taxonomists had suggested. Rather, data tells us they could be found up and down the Arkansas River basin.

GREENBACKS: AN ACCIDENTAL PRESERVATION

The most intriguing news from the study centers on the greenback cutthroat trout — Colorado's state fish.

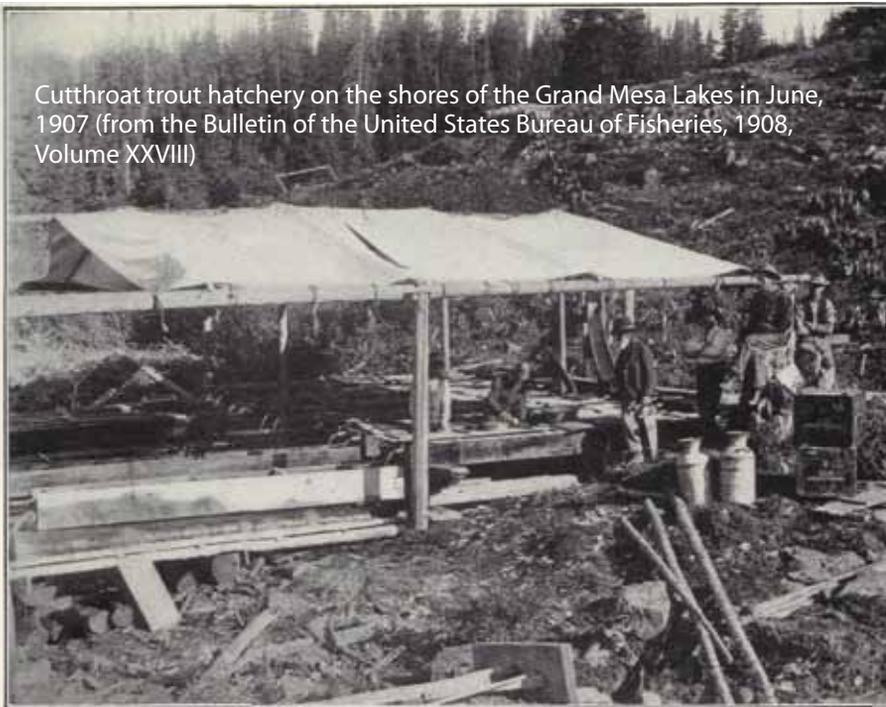
The “type specimens” — those used by E. D. Cope to describe the subspecies in 1871 — are not greenbacks at all, but rather Rio Grande cutthroat trout (*see Hammond sidebar*).

A future president of Stanford University, David Starr Jordan, was the first to coin the term “greenback” to describe these fish. It's clear in his 1891 writings that he intended the name to apply to “trout of the Platte” — thought to have gone extinct in 1937.

While the greenback cutthroat trout appeared to have been rediscovered in 1969 in a few small streams isolated from non-native trout, only the fish in Bear Creek share the genetic fingerprint of those collected across the South Platte basin in the late 1800s, prior to large-scale stocking activities.

Affectionately called “weird” Bear Creek because the fish look a little odd, with spots on the belly and large parr marks, even on adults, the DNA obtained from this population was analyzed in 2002.

Despite showing no evidence of hybridization with rainbow trout or Yellowstone cutthroat trout, they were not included in the greenback broodstock or recovery efforts because they just didn't look quite right. These descendants of the South Platte natives are actually found in the Arkansas basin, above several large waterfalls that have protected them from invasion by other trout species.



Cutthroat trout hatchery on the shores of the Grand Mesa Lakes in June, 1907 (from the Bulletin of the United States Bureau of Fisheries, 1908, Volume XXVIII)



Historically, native cutthroat trout could be found in streams allocated among eight major drainage basins (colored areas) in Colorado. The traditional view (left) was that all five drainages west of the Continental Divide were home to Colorado River cutthroat trout, while greenback cutthroat trout lived in the South Platte and Arkansas basins, and the headwaters of the Rio Grande contained its own namesake. This study suggests that outside of the Colorado/Gunnison/Dolores complex, each major basin supported its own distinct lineage.

FROM THE BULLETIN OF THE UNITED STATES BUREAU OF FISHERIES, 1908, VOLUME XXVIII

MAPS BY GRANT WILCOX

This stream was likely fishless historically. But in 1873, J. C. Jones (who homesteaded 160 acres in the headwater area) — in hopes of establishing a hotel to take advantage of tourist traffic traveling up Bear Creek to the summit of Pikes Peak — may have also been culturing trout. In 1882, a visitor related that Jones “strode back to the work of digging big stones out of his fish pond.”

Only two hatcheries were producing natives at that time — one on Trout Creek in the South Platte basin north of Woodland Park, and a facility in Colorado Springs, owned by Col. George De La Vergne, who reportedly collected his broodstock “in the mountains.”

The closest, most easily accessible wild trout population to both De La Vergne and Jones would have been the same Trout Creek. While the true greenback cutthroat trout may have indeed gone extinct across its native range in 1937, these early propagation efforts seem to have inadvertently preserved the legacy of our state fish in another drainage.

THE ROAD AHEAD

While this work will certainly make the U.S. Fish and Wildlife Service reevaluate the greenback cutthroat trout recovery program goals and objectives, it is important to recognize that past recovery efforts were not in vain.

A large part of those efforts involved developing and protecting secure habitats where cutthroat trout can persist without being invaded by non-native salmonids that displace or hybridize with them.

Thanks to the work of dozens of dedicated biologists, there are now many more populations of native cutthroat trout than when the program started. Their efforts helped secure the pieces of our cutthroat legacy while classification uncertainties were sorted out. Now, the job remains to continue protecting and securing the genetic diversity bestowed on us for future generations. 🐟

Dr. Kevin Rogers is an aquatic research scientist for Colorado Parks and Wildlife, specializing in cutthroat trout.



© KEVIN ROGERS/CPW

Fishing through History

There I was. . . floating in my belly boat on South Delaney Butte Lake, when I got a call from an exasperated Jessica Metcalf. As one of the leaders of the University of Colorado research effort, she had spent the weekend working on DNA from greenback cutthroat trout “type” specimens.

Historically significant, these were the specimens gathered by Army surgeon William Hammond, stationed at Fort Riley, Kan. In 1856, he sent them to the Academy of Natural Sciences in Philadelphia. In 1871, Edwin Cope used these same specimens to define what an “*O. c. stomias*” (greenback cutthroat trout) was.

Though degraded over time, Metcalf pieced together the DNA sequence of a mitochondrial gene used to identify the different cutthroat trout subspecies. Her exasperation? Rather than greenback cutthroat trout, the genetic fingerprint looked like that of a Rio Grande cutthroat trout instead.

Given her unexpected results, I set out to find more about these collections. What I discovered was a fascinating tale of life in the West, prior to the Civil War, decades before Colorado became a state.

MYSTERIOUS ORIGINS

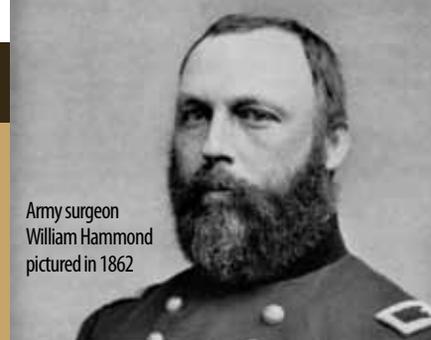
As a former student of salmonid expert, Robert Behnke, I remember him regaling us with stories of the mystery surrounding these greenback specimens.

In his writings, he suggests all labels on specimens Hammond collected on the 1856 expedition said “Fort Riley, Kansas.” However, in an 1872 description of greenbacks, the location was listed as “South Platte River, Kansas,” but the South Platte does not enter Kansas, nor could trout persist in any of the warm streams around Fort Riley — even back in 1856.

Behnke surmised they could have been collected on an expedition to chart a wagon road from Fort Riley to Fort Bridger. The officer in command, Lt. Francis T. Bryan, supervised the building of roads in the Kansas and Nebraska territories from 1855 to 1858. That expedition would have encountered the South Platte and could therefore have collected the specimens there and merely shipped them from Fort Riley in 1856. Yet this explanation falls apart when compared with Hammond’s actual field notes at the Academy of Natural Sciences in Philadelphia, which are clearly dated 1857, rather than 1856.

After encountering resistance from Native Americans on the first expedition in 1856, Lt. Bryan had difficulty recruiting laborers to go along on the 1857 expedition. It wasn’t until he guaranteed a military escort and a surgeon would accompany them that he was able to launch the expedition.

Fortunately for cutthroat trout enthusiasts everywhere, Hammond was that surgeon. A diligent naturalist, Hammond took detailed notes of all the specimens of fish, amphibians and insects he collected along the way — so detailed I was able to assign map coordinates to each of the specimens. Plotting those points on a map of the Kansas and Nebraska territories revealed that the 1857 journey went out and back from



Army surgeon
William Hammond
pictured in 1862

PHOTO COURTESY OF THE
NATIONAL MUSEUM OF
HEALTH AND MEDICINE, AFIIP

Fort Riley. It is apparent Hammond never made it anywhere close to the South Platte River. Additionally, his notes suggest that trout were only collected at one location on the journey — “in streams on Pacific slope” of the Continental Divide near Bridger’s Pass “706 miles west of Fort Riley,” which would have been Colorado River cutthroat trout.

RIO GRANDE CONNECTION

A more likely explanation is alluded to in letters Hammond wrote to several esteemed scientists at the academy in Philadelphia. On June 18, 1855, he wrote to Joseph Leidy, “I expect to leave in a few weeks for the plains, having been designated to accompany a topographical party who are ordered to survey a route from this post [Fort Riley] to Santa Fe, New Mexico. I will be absent about two months.”

A year later he followed that letter with another to a beetle aficionado named John LeConte. On Aug. 24, 1856, Hammond wrote “I sent a large box of specimens in Natural History a month since to the Academy. Has it been received yet?”

Perhaps, these samples showed up in Philadelphia in the fall of 1856 and were then simply labeled as Fort Riley, 1856. The most compelling evidence for this explanation comes from museum data. The closest present-day genetic match to Hammond’s greenback cutthroat trout specimens come from the Rio Mora, just outside of Santa Fe.

Though not discussed in his more recent writings, Behnke suspected the type specimens could indeed be Rio Grande cutthroat trout. In a letter to the curator at the academy, dated Jan. 20, 1967, he mentions the specimens had fewer scales than expected “for the native greenback cutthroat trout of the South Platte.” This led him to believe these were not the specimens collected by Hammond, or, if they were, they did not come from the South Platte.

Further curiosities were noted by one of Behnke’s master-degree students who suggested “some populations of Pecos cutthroat trout exhibited a striking similarity to greenback cutthroat trout in their spotting pattern.”

Metcalf’s work seems to have vindicated Behnke’s questions regarding the type specimens, and illustrates another reason why it was so difficult to visually separate greenback cutthroat trout from Colorado’s other native cutthroat trout subspecies.

More specific details from Hammond’s collections and transcriptions of letters to others at the Academy of Natural Sciences at Philadelphia can be found at <http://wildlife.state.co.us/research/aquatic/CutthroatTrout>

This image: Locations of specimens collected by William Hammond on his 1857 expedition to Fort Bridger from Fort Riley with current state boundaries in gray. At left: Leaders of the CU research effort, Dr. Jessica Metcalf and Dr. Andrew Martin prepare samples in the lab.

