Characterizing Gene Flow of Non-native Brook Trout to Aid Colorado's Largest Native Cutthroat Trout Restoration Project

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▼ SYNOPSIS

Multiple organizations are undertaking a large-scale restoration project for Colorado's state fish, the greenback cutthroat trout, in the upper Cache la Poudre River. Our study uses microsatellite genetic markers to understand gene flow and spatial population structure of non-native brook trout, a root cause of native trout declines in Colorado. Our results will guide brook trout removal and greenback cutthroat trout reintroduction efforts in the project area.

The Poudre Headwaters Project

Trout have high cultural, ecological, and economic importance around the world, and native trout conservation is an increasingly popular concept. The state of Colorado once harbored six distinct lineages, or subspecies, of native cutthroat trout, each occupying a substantial portion of a major river basin. Unfortunately, this biodiversity has been diminished due to human impacts, and cutthroat trout are often relegated to isolated headwater streams. In addition, demand for recreational fishing has led to widespread trout stocking, which began in Colorado more than 100 years ago. Through this process, non-native trout have been introduced to many waters, and the competition with non-native trout is a key reason for the decline of native cutthroat trout populations.

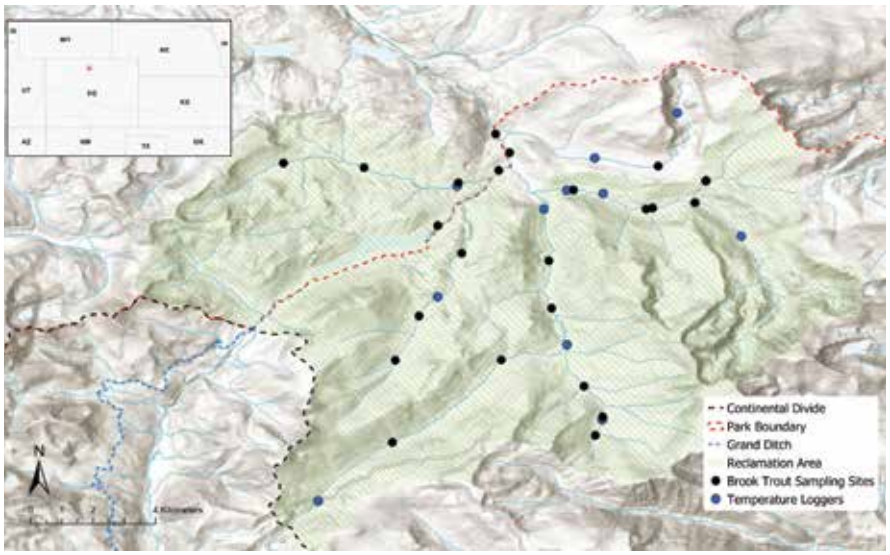

Figure 1. Brook trout study area located in the upper Cache la Poudre River. Image credit: Audrey Harris.

Greenback cutthroat trout (*Oncorhynchus clarkii stomias;* GBCT), the state fish of Colorado, were once declared extinct and are currently listed as threatened under the Endangered Species Act. In 2012, a study using genetics of wild populations and museum specimens found that only a single population of GBCT persisted, stocked outside their native range in the Arkansas River basin (Metcalf et al. 2012). Recovery efforts have intensified since then, with several projects underway to reintroduce GBCT to streams in their native range, the South Platte River basin. Currently, U.S. Forest Service, National Park Service, U.S. Fish and Wildlife Service, Colorado Parks and Wildlife, and Trout Unlimited are working collaboratively to restore GBCT to 37 miles of a continuous stream network in the headwaters of the Cache la Poudre River near Long Draw Reservoir (Figure 1). The Poudre Headwaters Project is the largest native trout restoration effort in Colorado to date and will result in a fivefold increase of GBCT habitat in their entire native range. The recla-

Figure 2. Corral Creek, one of the study sites in the upper Poudre River Basin. Photo by Yoichiro Kanno.

mation area is highly protected—it lies within Arapaho and Roosevelt National Forests and Rocky Mountain National Park. However, the reclamation area is currently dominated by non-native brook trout (*Salvelinus fontinalis*).

Modern approaches for native cutthroat trout conservation center on isolating populations in headwater streams by removing non-native fish and constructing permanent barriers at the downstream boundary of the reclamation area. However, because the Poudre Headwaters Project reclamation area is so large, biologists plan to install a series of additional temporary barriers that will allow them to remove non-native brook trout sequentially by stream. After all brook trout have been removed, GBCT will be reintroduced with an anticipation that they will occupy and move throughout the stream network. This large-scale restoration effort will take place over the next 15 years and provide a safe haven for Colorado's state fish.

Project Rationale

We aim to provide crucial scientific support for the Poudre Headwaters Project by evaluating brook trout spatial population structure in the reclamation area. Genetic data inform the spatial extent of trout movement, and when combined with environmental data, can help us understand which environmental variables (e.g., temperature) may facilitate or impede movement.

Analyzing brook trout spatial population structure will support the Poudre Headwaters Project in two distinct ways. First, understanding how individuals move between streams in the reclamation area will provide key scientific guidance for brook trout removal efforts. Second, identifying barriers and environmental drivers of spatial structure will likely inform GBCT reintroduction efforts in the coming years. Understanding how the riverscape influences connectivity and population persistence will allow biologists to release fish in key stretches of habitat that ensure the highest probability of reintroduction success. In this sense, our project uses a non-native trout as a surrogate for understanding spatial ecology of a native trout.

Methods

In the summer of 2019, we collected 1,391 brook trout tissue samples from 20 sites on nine different streams in the reclamation area (Figure 2). We used backpack electrofishing units to capture fish (Figure 3) and collected tissues non-lethally for genetic analysis (Figure 4). We also installed in-stream temperature loggers throughout the reclamation area to measure spatial thermal patterns. Tissue samples are analyzed for 12 microsatellite genetic markers. A subsample of 796 individuals was selected for genetic analysis, which began in fall 2019 but has been delayed due to COVID-19. Once genetic analysis is complete, the spatial population structure will be evaluated.

Results and Conclusions

Preliminary analyses of genotype data show that brook trout are spatially structured in the reclamation area, meaning that each stream often harbors a unique group of individuals that exhibit some gene flow with nearby populations. Essentially, we can cluster individuals by stream based on genetic signatures, but we also see evidence of trout movement between streams. This has important implications for brook trout removal—for instance, if we see that certain streams are source populations to provide immigrants to other streams, biologists may choose to prioritize the source populations for removal.

In the future, we will use a riverscape genetics framework to understand how

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environmental variables influence brook trout gene flow and movement. Understanding the influence of various environmental factors on trout movement in the reclamation area will be integral to ensure GBCT reintroduction success. Our preliminary analyses using a non-native trout demonstrate that trout occupy and move within a large headwater stream network, a promising sign for re-establishing a robust GBCT population in the upper Poudre River.

Next Steps and Future Research

Our work with brook trout spatial population structure has led to another important research question regarding the Poudre Headwaters Project. We aim to use genetic markers to study movement of cutthroat trout through the Grand Ditch located across the Continental Divide, a transbasin water diversion structure located at the upstream boundary of the reclamation area (Figure 1).

Transbasin water diversions connect previously isolated watersheds and may result in unintended hybridization of aquatic organisms. Because isolation from non-native trout is an integral part of successful restoration projects and a different sub-species of cutthroat occupies the opposite side of the Continental Divide, understanding how transbasin diversions influence fish movement has significant implications for GBCT reintroduction in the study area. This work is particularly relevant in Colorado, where there are more than 44 transbasin diversions and a large emphasis on native trout restoration.

Impacts and Partnerships

Balancing water supply and conservation is critically important in Colorado, where there is a significant and growing demand for water with implications for biodiversity and ecosystem protection. As anthropogenic impacts— non-native species introduction, water management, and climate change—continue to confine trout populations to headwater stream networks, understanding environmental drivers of population persistence and spatial structure in a riverscape is critical to conserving and restoring native trout.

The Poudre Headwaters Project is the largest native cutthroat trout reclamation project in Colorado's history and will help preserve an important legacy of cutthroat trout biodiversity. Throughout this project, we have forged strong relationships with the Rocky Mountain Flycasters Chapter of Trout Unlimited, U.S. Forest Service, National Parks Service, U.S. Fish and Wildlife Service, and U.S. Geological Survey. This research has been supported by a Water Faculty Fellow grant from the Colorado Water Center, as well as the National Fish and Wildlife Foundation, U.S. Forest Service, and Trout Unlimited.

Figure 3. Research team collecting brook trout by using backpack electrofishing units and dip nets. Photo by Kate Hansen.

Figure 3. Audrey Harris (middle) processes brook trout and collects fin clips for genetic analysis, along with Dr. Kurt Fausch (left). Photo by Yoichiro Kanno.