2021 SURVEY OF BONNEVILLE CUTTHROAT TROUT IN THE UPPER SEVIER RIVER DRAINAGE, UTAH

Michael J. Hadley
UDWR Regional Aquatics Biologist

Michael E. Golden
Dixie National Forest Fisheries Biologist

James E. Whelan
Fishlake National Forest Fisheries Biologist

Jens H. Swensen
Fishlake National Forest Fisheries Biologist

Publication Number 22-02

Utah Department of Natural Resources
Division of Wildlife Resources
1594 West North Temple Suite 2110
Salt Lake City, Utah 84114

Justin Shirley
Director

March 2022

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The Bonneville Cutthroat Trout (*Oncorhynchus clarkii utah*) (BCT) is one of only three formally recognized subspecies of trout native to Utah. BCT were widely distributed across the Bonneville Basin prior to major European settlement of the area in the mid-1800s (Behnke 1992); however, as with other subspecies of Cutthroat Trout throughout the Intermountain West, over-exploitation, habitat alteration, and introduction of nonnative trout caused large-scale losses of this native fish throughout the next 100 years (Duff 1988, Kershner 1995). Active management of BCT began in southern Utah after the Endangered Species Act was passed in 1973 (Hepworth et al. 2002). By the 1990s, cooperative interagency efforts to conserve, protect, and expand populations of BCT led to the development of a formal management strategy for the state of Utah (Lentsch et al. 1997), as well as a strategy and agreement for range-wide conservation in the states of Utah, Idaho, Nevada, and Wyoming (Lentsch et al. 2000). The range-wide conservation strategy and agreement was most recently updated in 2018 (BCT Conservation Team 2019). BCT conservation was identified as a primary objective for the upper Sevier River drainage (Hydrologic Unit Code [HUC] 16030001) by the Utah Division of Wildlife Resources (DWR) (Ottenbacher and Hepworth 2003). BCT conservation efforts in the Southern Bonneville Geographic Management Unit (GMU), which encompasses the southern portion of the Bonneville Basin, are coordinated and completed by a cooperative interagency team, with representatives from DWR, Fishlake National Forest (FNF), Dixie National Forest (DNF), Bureau of Land Management (BLM), U. S. Fish and Wildlife Service (USFWS), and Trout Unlimited (TU). This team acts as a subset of the range-wide BCT Conservation Team.

A principal component of native Cutthroat Trout management is the monitoring of populations to evaluate their current status, assess trends in population dynamics and the factors that influence them, evaluate past population and land management actions, and help guide future actions. Range-wide status reviews of BCT were completed in 2001 (USFWS 2001), 2005 (May and Albeke 2005), 2010, and 2015 (Paul Burnett, personal comm.). BCT in the upper Sevier River drainage were previously surveyed in 2001-2002 (Hepworth et al. 2003), 2008 (Hadley et al. 2010), and 2014 (Hadley et al. 2015). This report presents results of surveys of BCT in the upper Sevier River drainage conducted in 2021, as well as comparisons with results from previous surveys.

STUDY AREA

The Sevier River is found within the eastern Great Basin, draining a large portion of central and southern Utah. Much of the main stem of the Sevier River was once inundated by prehistoric Lake Bonneville, with the mountainous tributaries feeding the lake. After the desiccation of the lake some 10,000 years ago, Cutthroat Trout persisted in suitable cold water habitats. The upper Sevier River drainage is located in southwestern Utah (Figure 1) and is comprised of the Sevier River and all its tributaries upstream of the Piute Reservoir dam, excluding the East Fork Sevier River (which is its own HUC). The perennial tributaries of the upper Sevier River drain the east slope of the Markagunt Plateau, west slopes of the Paunsaugunt Plateau and southern Sevier Plateau (Mount Dutton), as well as the southeast slope of the Tushar Mountains. Most of the BCT-bearing streams in the drainage are found in the DNF, while one stream lies in the FNF. In addition, the lower reaches of several of the streams cross lands administered by BLM. Tributaries are frequently diverted in their lower reaches for irrigation, and are typically connected to the Sevier River only seasonally.

HISTORY

Restorations

Discoveries of remnant BCT populations in the East Fork Sevier, Beaver, and Virgin river drainages during the 1970s and 1980s prompted DWR staff to seek out opportunities to expand and replicate these populations in other suitable habitats throughout southern Utah. Nonnative trout were removed by piscicide treatment from Threemile Creek and its tributaries, Delong Creek and Indian Hollow, in the upper Sevier River drainage during the early 1990s and BCT from Birch Creek in the Beaver River drainage were introduced in 1994. This source population was one of the first three BCT remnants discovered in southern Utah, confirmed repeatedly through meristic (Behnke 1976, Hickman 1978, Thron and Miller 2002) and genetic analyses (Klar 1978, Ohlhorst 1991, Shiozawa et al. 1993, Evans and Shiozawa 2004).

Birch Creek (upper Sevier River drainage; not to be confused with the stream of the same name in the Beaver River drainage) on the southeast slope of the Tushar Mountains was treated with rotenone after post-fire flooding from the 1996 Pole Creek fire was believed to have extirpated nonnative trout. This one-time rotenone treatment in 2001 confirmed that Birch Creek was fishless. BCT fingerlings produced from the Manning Meadow Reservoir brood were stocked in Birch Creek in 2001, following the rotenone treatment. The Manning Meadow brood was

founded by mixing BCT from Birch Creek (Beaver River drainage), Water Canyon (Virgin River drainage) (Behnke 1976, Klar 1978, Thompson 1987), and Reservoir Canyon (Virgin River drainage) (Behnke 1976, Thompson 1987, Shiozawa and Evans 1994).

Left Fork Sanford Creek on Mount Dutton was stocked experimentally in 1999 with BCT transferred from Deep Creek in the East Fork Sevier River drainage. The 2002 survey (Hepworth et al. 2003) found that BCT had established in Left Fork Sanford Creek; however, the Sanford fire burned through the upper reaches of the stream later that summer. Flooding following thunderstorms in late summer 2003 led to the extirpation of BCT and extensive degradation of habitat in Left Fork Sanford Creek (Hadley et al. 2010). Observations made in 2011 determined that habitat had likely recovered sufficiently to sustain trout, but confirmed that BCT had not persisted after the Sanford fire (Golden 2012). Despite the loss of this population, early conservation efforts succeeded in restoring BCT to 21.4 km (13.3 miles) of stream habitat in the upper Sevier River drainage by the mid-2000s (Table 1).

Remnant

Prior to 2012, no remnant populations of BCT had been identified in the upper Sevier River drainage. A small population of Cutthroat Trout was known to inhabit the upper reaches of Mammoth Creek, however it was assumed that these fish had undergone hybridization due to a long history of stocking nonnative Rainbow Trout (*O. mykiss*) in Mammoth Creek, as well as in two lakes in the drainage. Genetic analysis of samples collected in 2012 revealed that the Cutthroat Trout were BCT with only 2% introgression from Yellowstone Cutthroat Trout (*O. c. bouvieri*) (YCT) and no evidence of Rainbow Trout hybridization (Evans et al. 2013). The Cutthroat Trout brood used by the state of Utah for sport fish stocking for many years contained YCT genes. Records show that Cutthroat Trout were stocked fourteen times in Mammoth Creek from 1940 to 1979. Additional Cutthroat Trout stocking events occurred in tributary Castle Creek (1953), Lowder Pond (1952), and Dead Lake (1952). In contrast, Rainbow Trout were stocked almost annually in the Mammoth Creek drainage since at least 1940 – and likely earlier than this. In light of this extensive stocking history, the genetic results for Mammoth Creek BCT were unexpected. At 98% genetic purity, this population qualified for conservation status and became the first and only known BCT remnant in the upper Sevier River drainage.

Cutthroat Trout were also observed in Mammoth Creek tributary Reed Valley Creek, which is isolated from Mammoth Creek by subterranean flow down a steep gradient at the canyon rim.

Although nonnative Brook Trout (*Salvelinus fontinalis*) were also present in the creek, no historic stocking records existed for Reed Valley Creek, and it was hypothesized that these Cutthroat Trout may also be BCT. However, genetic analysis observed a majority of Colorado River Cutthroat Trout (*O. c. pleuriticus*) (CRCT) alleles in the Reed Valley population, with some introgression by YCT (Evans and Shiozawa 2014a, b). Although genetic analysis was never performed on the old "Strawberry" brood used by the state of Utah to produce Cutthroat Trout for most of the 1900s, results from streams in southeast Utah believed to be founded from this brood showed similar allele ratios to that seen in Reed Valley Creek (Evans and Shiozawa 2005). These results indicated the likelihood of undocumented stocking of both Cutthroat and Brook Trout in Reed Valley Creek. Further review of DWR records and consultation with retired conservation officer Norm McKey shed more light on the fish history of Reed Valley. In decades past, a number of beaver ponds were found in Reed Valley. McKey requested stocking of these ponds in order to satisfy angling demand from a nearby Boy Scout camp. (This was also the impetus for stocking Dead and Porcupine lakes to the north.) Because neither Reed Valley Creek nor the beaver ponds were included in the state's waterbody database at the time, the stockings of Brook and nonnative Cutthroat Trout were likely attributed to Mammoth Creek. Since that time the beaver ponds disappeared and the scout camp was discontinued, leaving Reed Valley Creek as an overlooked and nearly forgotten fishery.

At the time of their discovery, it was estimated that the Mammoth Creek remnant BCT were confined to just 4.9 km (3.0 mi) of stream. Unlike many remnant southern Utah Cutthroat Trout populations which were discovered in isolated headwaters, the Mammoth Creek population was found more than 9 km (6 mi) below the headwaters, in the reach between Mammoth Spring and the confluence with Castle Creek. Brook Trout were abundant throughout the upper Mammoth Creek drainage, while Brown Trout (*Salmo trutta*) were also present in the headwaters. Fingerling Brook and "catchable" (10-inch) Rainbow Trout were still being stocked in Mammoth Creek just below Mammoth Spring to support sport fishing. The fact that BCT still persisted despite the threat of competition or hybridization from nonnative trout, in addition to infection by whirling disease since the early 1990s, was quite unexpected based on past experience with similar scenarios. DWR staff soon began efforts to conserve the remnant BCT by converting stocking near Mammoth Spring to triploid (i.e. sterile) Brook and Rainbow Trout. Later, stocking of Brook Trout was canceled and the Rainbow Trout quota was converted to sterile, hybrid tiger trout.

Shortly after the confirmation of remnant BCT in Mammoth Creek, the Southern Bonneville GMU team formulated plans to preserve and restore BCT throughout the Mammoth Creek drainage upstream of Mammoth Spring. In addition to Mammoth Creek itself, this area includes five tributary streams, three public lakes, and four private lakes/ponds. Nonnative trout removal efforts commenced with piscicide treatments in 2015 and first focused on tributaries: Lowder Creek (2015, 2016), Castle Creek (2015, 2016, 2018), Reed Valley Creek (2019, 2020), and John L Flat Creek (2019, 2020). BCT fingerlings produced by the Manning Meadow brood were stocked in Castle and Lowder creeks in 2017. Nonnative trout were removed from Meadow Lake Creek and Mammoth Creek in 2020 and 2021.

Brian Head Fire

The Brian Head fire ignited in Parowan Canyon (Escalante Desert drainage) on the west slope of the Markagunt Plateau in mid-June 2017. The fire spread rapidly to the east and north through dense, dry timber, eventually burning more than 71,000 acres in the Escalante Desert and upper Sevier River drainages (Fig. 2). The fire burned more than 11,000 acres at high severity and almost 32,000 acres at moderate severity. Portions of thirteen 6th field HUC watersheds were burned and the range of combined moderate to high severity burning in those watersheds varied from 1% to 55% of the total watershed area (Table 2). Post-fire flooding during the 2017 monsoon season caused significant channel and habitat damage in multiple streams. Debris flows occurred in several higher gradient streams and streams with highly erodible soils (Bunker Creek, Center Creek, Clear Creek, Deer Creek, Delong Creek, Little Creek, Parowan Creek, Red Creek). Fish populations were extirpated or significantly reduced in these streams, as well as several others that experienced mainly ash flows and depositional events (Butler Creek, Haycock Creek, Ipson Creek, Indian Hollow, Threemile Creek).

Eight percent of the Threemile Creek watershed was burned at high severity during the 2017 Brian Head fire, while 18% was burned at moderate severity. A combination of Burned Area Emergency Response (BAER) and fire rehabilitation treatments (mulch and seeding) were strategically applied to 224 acres of the more than 3,400 acres burned at moderate to high severity in that drainage, though the streams still experienced ash flows and channel altering floods in 2017 and subsequent years. While a portion of Threemile Creek itself was burned over, the primary impacts to the stream came from ash flows from the headwaters of Threemile Creek and Indian Hollow, as well as ash and debris flows from Delong Creek. The immediate impact to Delong

Creek was significant bed load movement and bank erosion (Fig. 3), while Threemile Creek mainly received the deposition of that Delong Creek sediment (Fig. 4). Sampling and other observations in late 2017 indicated that the BCT populations in Delong Creek, Indian Hollow, and Threemile Creek were all extirpated by the floods. Although the fire burned into portions of the Castle Creek and Mammoth Creek drainages, these streams did not experience the same level of flooding observed in other streams, most likely because the watershed area burned at moderate and high severity was relatively low (< 7%). The only immediate impact observed was the burning of about half of the dense willow thicket and beaver dam complex in upper Castle Valley.

In fall 2017, a number of triploid (i.e. sterile) BCT produced at the Manning Meadow brood were stocked into some of the streams impacted by the Brian Head Fire, including Threemile Creek and both of its tributaries. (These fish were originally produced as a means to fill the temporary void in angling opportunity in restoration project streams following nonnative trout removal.) The purpose of the stocking after the Brian Head fire was to aid in monitoring the survival potential in these streams after the initial post-fire flooding had subsided. Repeated visits to the Threemile Creek drainage in the succeeding years found that these fish did not survive and confirmed that the post-fire flooding had eliminated the conservation population in the drainage. The continued elevated flooding off the burned areas, particularly from the steep, rocky basin housing Delong Creek, appeared to be the cause for the failed stocking efforts. The continued flood events increased the erosion, incision, and channel damage in the upper reaches of Threemile Creek downstream of the Delong Creek confluence.

METHODS

Complete population surveys were conducted during 2021 in Birch Creek, Castle Creek, Lowder Creek, Threemile Creek, and its tributaries. Standard protocol for BCT monitoring in the Southern Bonneville GMU calls for surveying all known populations within the selected drainage during a single field season (Hadley et al. 2015). However, the ongoing removal of nonnative trout and restoration of BCT in the Mammoth Creek drainage during 2021 precluded complete surveys in most of those streams, except Castle Creek and Lowder Creek, where BCT had been introduced in 2017. Although informal sampling had previously indicated that BCT were extirpated from Threemile Creek and its tributaries, survey stations were repeated in those streams in 2021 in order to formally document the population status. Fish populations were sampled using backpack electrofishing units (Smith-Root models 12-B, LR-20B, and/or LR-24) (Fig. 5). DWR, DNF, and

FNF personnel conducted surveys when stream conditions allowed for effective sampling. Surveys were generally conducted at a similar time of year as previous surveys (Appendix). A minimum of two stations were electrofished in each second or higher order stream, while at least one station was surveyed in first order tributaries. The target length of each station was 100 m, though the exact length was modified as needed to fit available habitat and allow for effective sampling. Fish populations were sampled in each station using the multiple-pass removal method (Zippin 1958). We attempted to collect all trout except young-of-the-year, though relative abundance of age-0 fish was documented. (In general, young-of-the-year measured less than 70 mm in total length.) Total length (TL) (mm) and weight (g) were recorded for all yearling, sub-adult, and adult trout collected.

Mean wetted stream width (m) was determined by measuring ten random transects within each survey station. Population estimates were calculated by the program MicroFish 3.0 (Demo Version) (Van Deventer 1989). Stream dimensions were combined with population estimates and mean trout weight to calculate trout density (fish/km, fish/hectare) and biomass (kg/ha). Upstream and downstream ranges of BCT were determined in each surveyed stream through electrofishing, ocular observation, or professional judgment. Range limits, stream distances, and barrier locations were documented and/or measured with a global positioning system (GPS) unit, US Geological Survey topographical maps, and ArcGIS® software (by Esri). Reaches currently occupied by BCT were classified as occupied habitat. BCT biomass and distribution were compared to results from previous surveys. Trends were classified as increasing, decreasing, or stable, depending if current values differed by more than 10% from previous surveys (Table 3).

Although Mammoth Creek and three of its tributaries were not formally surveyed in 2021 due to ongoing piscicide treatment, barriers were documented in all of these streams and available habitat was determined through occupation of nonnative trout observed during removal efforts. Remnant BCT were salvaged from Mammoth Creek and returned to the stream following treatments, allowing for a measure of currently occupied habitat.

RESULTS

Survey results were compiled by stream, with tables listing BCT abundance and biomass at specific stations, along with maps showing the distribution of native trout (Appendix). Appreciable numbers of BCT were observed in three streams: Birch Creek, Castle Creek, and Mammoth Creek. Sterile, hybrid tiger trout – stocked to satisfy sport fishing interest during BCT

restoration – were also collected in Castle Creek. Distribution sampling in the uppermost reach of Castle Creek in Sidney Valley also found a small number of Brook Trout. The only fish observed in Lowder Creek were one BCT and two tiger trout found just downstream of Lowder Pond during distributional sampling. No fish were observed in Threemile Creek, Delong Creek, or Indian Hollow.

Stream length occupied by BCT, as well as observed BCT biomass, decreased in 2021 in all streams of the upper Sevier River drainage where BCT had been previously documented (Table 3). Decreases resulted from habitat restriction and marginal environmental conditions incident to severe drought (Birch Creek: -1.7 km), extirpation following the Brian Head Fire (Threemile Creek and tributaries: -15.1 km), and temporary population reduction during removal of nonnative trout (Mammoth Creek: -3.7 km). A single increase of 10.6 km in occupied habitat was observed in Castle Creek, where BCT were introduced in 2017. Based on the observation of only one individual, BCT apparently did not establish in Lowder Creek after introduction in 2017. The total known stream length occupied by BCT in the upper Sevier River drainage decreased from 26.3 km (16.3 mi) in 2014 to 17.4 km (10.8 mi) in 2021 (Table 1).

DISCUSSION

An updated range-wide Conservation Strategy and Agreement for BCT finalized in 2019 (BCT Conservation Team 2019) will help direct future conservation focus within the Southern Bonneville GMU. The new strategy adopts Trout Unlimited's Conservation Portfolio approach to securing range-wide, long-term persistence by spreading risk of loss from various factors (e.g. invasive species, environmental change, etc.) across a variety of habitats, populations, and management approaches (Haak et al. 2011). Within this approach, range-wide subspecies security is achieved through promotion of genetic integrity, life history diversity, and geographic (or ecological) diversity, backed by large patches of interconnected habitat for resiliency. The Portfolio recommends Shafer and Stein's (2000) "3-R" conservation principles as an adaptable framework to guide development of goals and objectives for BCT conservation within each GMU that help achieve this strength through diversity. These principles include **representation** (preserving existing elements of diversity), **resiliency** (having sufficiently large populations and intact habitats to facilitate recovery from large disturbances), and **redundancy** (preserving enough different populations so that some can be lost without jeopardizing the subspecies). The 3-R

framework will be considered, where applicable, in discussions of current and future BCT conservation actions within the upper Sevier River drainage.

Mammoth Creek Subdrainage

The Mammoth Creek drainage upstream of Mammoth Spring provides up to 42 km (26 mi) of stream habitat for BCT (Fig. 6, Table 4). From the beginning of restoration efforts, project personnel were determined to make every attempt to repatriate the Mammoth Creek drainage with the stream's remnant BCT or their progeny. This goal became much more difficult when it was discovered that the fish were infected by *Myxobolus cerebralis*, the parasite that causes whirling disease, in 2016. State policy prohibits the movement of fish infected by the parasite, even within the same connected drainage or to another waterbody that is already infected. This precluded the most common and effective means of replicating populations through transfer of adult fish. Because whirling disease is not communicated through gametes, collection of fertilized eggs is the only approved way to replicate an infected population. However, previous attempts to collect and fertilize BCT eggs in small southern Utah streams have been unsuccessful due to various factors, including difficulty in collecting fish during high spring flows, low fecundity (i.e. egg quantity per female) due to small body size, and lack of synchronization in maturation among individual fish. Multiple unsuccessful attempts were made to collect and spawn BCT in Mammoth Creek between 2017 and 2021. Most attempts failed due to difficulty in collecting fish during the peak spawning period, when flows were elevated by spring runoff. Even when fish collection was more effective in 2021, adult BCT escaped a temporary instream trap before any were close to full maturation.

The final possibility for preserving the Mammoth Creek BCT remnant was identified in 2020, during preparation for the first piscicide treatment in the main stream. DWR's fish pathologist approved collection of the Mammoth Creek BCT, holding them in a hatchery truck onsite during piscicide application, and returning them to the same stream reach (Wade Cavendar, personal communication). Over 400 BCT were salvaged during the 2020 piscicide treatment, while 171 of those were salvaged again and returned to Mammoth Creek in 2021. While this salvage effort preserved the genetic representation of the remnant Mammoth Creek BCT, it was still not possible to use these fish to populate the rest of the project target area due to transfer restrictions. In addition, numerous natural and constructed barriers will prevent natural upstream migration into unpopulated stream reaches. Following years of frustrating, unsuccessful attempts at gamete propagation, project staff determined that the best course of action for repopulating the Mammoth

Creek drainage was to stock Manning Meadow BCT fingerlings in all tributaries, as well as upper Mammoth Creek upstream of the waterfalls near Castle Creek. In August and September 2021, 31,000 BCT fingerlings were stocked throughout upper Mammoth Creek and several of its tributaries (Fig. A2, A3). The remnant BCT will be allowed to repopulate the reach from the waterfalls, downstream to Mammoth Spring. While some downstream migration of the Manning Meadow BCT will probably happen in the future, the amount of genetic mixture with the Mammoth Creek remnant will have to be accepted, considering the challenges faced by attempts to preserve this genetic stock. The work to hold these remnant BCT and return them to their occupied stream reach at least ensures that some locally adapted genes remain in Mammoth Creek. In addition, preserving these remnant BCT could allow for more future propagation attempts if streamside spawning techniques improve, with the intent of spreading remnant genes further throughout the Mammoth Creek metapopulation.

Manning Meadow BCT were introduced to Castle Creek in 2016-2018. Monitoring in 2021 found that adult BCT were fairly abundant in the Sidney Valley reach of Castle Creek. All fish were similar in size because BCT were stocked only twice in Sidney Valley, in 2016 (triploid BCT to help restore sport fishing) and 2017 (diploid BCT to establish a new population). While female BCT often reach sexual maturation at age 3, no age-1 fish (i.e. spawned in 2020) were observed during the 2021 surveys. Peak spawning activity is typically found in four-year-old fish, so it is possible that BCT spawned in Castle Creek in 2021 went undetected. (This is very common during midsummer surveys as fry have often just hatched and are not very susceptible to electrofishing.) In retrospect, more than one cohort of fertile BCT should have been introduced to Castle Creek to ensure optimal spawning potential. Informal sampling should be repeated in the coming years to monitor establishment of the population and determine if additional stocking will be needed.

BCT fingerlings were stocked in the Castle Valley reach of Castle Creek in 2018, at the road crossing upstream of Station 1 and downstream of the extensive beaver pond complex where the Deer Creek ditch originates (Fig. A4). Only a limited number of tiger trout were observed at Station 1 and lower Castle Valley in 2021. In contrast, distribution sampling observed that BCT were moderately abundant in the higher gradient reach upstream of Castle Valley. The beaver pond complex in upper Castle Valley was not sampled due to the difficulty in sampling such habitat with electrofishing gear, but likely provided some suitable habitat for BCT. Stream flow was observed to decrease with decreasing elevation in lower Castle Creek during 2021, even becoming

intermittent just upstream of the confluence with Mammoth Creek. These observations indicated that, as a losing reach, lower Castle Creek may provide only a seasonal refuge for BCT during years of extreme drought, like 2020 and 2021. A stocking of more BCT fingerlings was scheduled for Castle Valley in mid-October 2021, but was cancelled after early snowstorms caused snow bridging and surface ice on the stream. Stocking will likely be conducted in Castle Valley in 2022, and will include introducing BCT to favorable habitat in the upper reach of the Deer Creek ditch.

While surveying for the upper extent of BCT occupation in the Castle Creek headwaters in July 2021, DNF crews discovered a single, small (~150 mm, 6 in) Brook Trout in a spring tributary just upstream of Sidney Valley. While the presence of a Brook Trout in the stream five years after nonnative removal was enough cause for concern, the fish's small size was additionally alarming as it could signify the potential for previously undocumented spawning. DNF brought the Brook Trout to DWR personnel and the fish was carefully examined. Despite its small size, the fish had the overall appearance of an older fish, which was certainly plausible given its residence in a very small, cold spring tributary. DNF and DWR crews conducted additional electrofishing passes through the entire length of Castle Creek and its spring tributaries upstream of Station 3 in the following weeks to determine the extent of Brook Trout occupation. An additional three Brook Trout were found in and removed from Castle Creek, while another six were caught and removed from the spring tributary in the northwest corner of Sidney Valley (Fig. A5). The fish were of varying sizes, from 75 mm (3 in) to 250 mm (10 in) in length. Based on the observed spatial distribution, the spring tributary was the likely refuge for Brook Trout during the 2015 and 2016 piscicide applications. The discovery of just 10 individuals (most in a small, marginal tributary) provides hope that additional electrofishing in 2022 can remove all Brook Trout from the system and preclude the need for more rotenone treatments.

Lowder Creek supported a high density of Brook Trout prior to BCT restoration, despite being a small, often marginal tributary. Similar to lower Castle Creek, BCT stocked in Lowder Creek in 2017 failed to successfully establish, likely due to drought in the subsequent years. Drought conditions can significantly impact BCT populations by reducing stream flow and, therefore, available habitat, as well as by elevating stream temperature (Hadley et al. 2015). Even though the number of BCT originally stocked in these streams was relatively high (several thousand), survey results demonstrated the need for attempting to establish multiple cohorts when founding a population with fingerling fish.

Threemile Creek Subdrainage

Experience gained following the Twitchell Canyon fire in the middle Sevier and Beaver River drainages demonstrated that active habitat improvement and sufficient resting from livestock grazing can yield positive effects on stream channel stabilization and recovery, as well as survival potential of stream fish populations (Hadley et al. 2017, 2018). Some of these lessons can help inform planning for work to restore BCT and their habitat in the Threemile Creek drainage. High-intensity flooding was common in the first five years following the large, high-severity Twitchell Canyon fire, and limited the potential for large woody debris placed during that time period to remain in the stream channel. These observations demonstrated the need to wait for sufficient time for significant upland recovery before attempting to place large woody debris in the channel. Even after flood events strong enough to displace debris out of the active channel subsided, monsoon storms still produced flows that moved woody debris downstream within the channel. This wood still provided benefits, creating large debris jams that trapped transported sediment and began to restore lost stream grade. Woody debris placement was observed to be most effective in narrow, confined canyons. In broad, open valleys, even the less intense flood events that followed upland recovery were likely to displace woody debris out of the stream channel, or move the channel away from the debris. All of these factors must be considered when planning stream habitat improvement following a fire.

Evidence of recent flooding was observed in upper Delong Creek during BCT monitoring efforts in July 2021, four years after the 2017 Brian Head fire (Fig. 7). While it is unknown if this flood event would have been severe enough to impact habitat stability and fish survival, it did confirm that significant flows continue for years after a fire and must be considered in any decision regarding land or fish population management. Additionally, the cumulative effects of all post-fire flooding events impacted bank stability and fish habitat in Delong Creek. Grade control structures installed above and below culverts at road crossings were destroyed. Fish habitat was degraded as channel incision combined with subsequent sediment deposition within the incision to produce a wider, shallower channel with fewer pools than the pre-fire channel. Delong Creek is a relatively steep and confined channel where bank stability is controlled by rocks and other large structures, making it conducive to large woody debris placement, or the placement of other hardened structures. However, the presence of valuable infrastructure (forest roads and bridges; developed springs feeding the Panguitch City culinary water system) will need to be considered prior to

implementing such work. An evaluation should be completed in 2022 or 2023 to determine what work is feasible and warranted, and what funding may be available for implementation. Environmental compliance for stream restoration work was already completed for Delong Creek under the Brian Head Fire Rehabilitation project, so any implementation can occur immediately after planning and design.

DWR conducted monitoring surveys in Threemile Creek in July 2021 and found the stream channel to be lacking in pool structure and dominated by riffles. During a complete walk-through of the stream from the Delong Creek confluence downstream to the DNF-BLM boundary in August 2021, DNF staff observed evidence of recent flooding, as well as the cumulative effects of flooding since the Brian Head Fire, including head cutting, channel incision, loss of bank stability, loss of riparian hydric species, and channel widening (Fig. 8). Channel erosion impacts were more prevalent in the upper reach, with the lower reach receiving sediment deposition from that erosion. Despite these impacts, woody riparian vegetation had maintained or was recovering in many areas, providing stream shading and cover.

In Threemile Creek's somewhat open valley, fine-grained soils dominate the bank substrate and bank stability is primarily controlled by strongly rooted riparian vegetation (e.g. sedge, willow, river birch). The case of Fish Creek (Middle Sevier River drainage), which was burned by the Twitchell Canyon Fire in 2010, can help illuminate the best approach to stream recovery after a fire in this stream type. Large woody debris was placed in Fish Creek four to five years after the fire as a temporary means of providing channel and bank stability, in addition to fish habitat, while riparian vegetation was reestablishing. Much of the debris was subsequently displaced out of the active stream channel by a long-duration high spring runoff event in 2019, four to five years after placement and nine years after the fire. Woody riparian plant species (primarily cottonwoods, but also including some willows and river birch) initially experienced favorable regeneration during a four-season period of reduced grazing after the fire. Following this incomplete resting period, livestock use in the riparian area resumed and eventually increased. Livestock began spending an inordinate amount of time in the riparian zone, despite abundant feed growth on adjacent upland benches and slopes. Since Fish Creek acts as the water source for several pastures, the riparian area experienced a constant, near season-long livestock presence, even when most livestock were grazing elsewhere on the allotment. Even though the number of livestock grazing the area at any time was relatively modest, continuous grazing pressure on the riparian habitat still resulted in a

net loss to the riparian vegetation that had begun to recolonize and limited the establishment of that vegetation during the subsequent years. The native fish species that were introduced after habitat work was completed successfully established populations in Fish Creek. However, those fish still found only limited stream habitat and shading due to the scarcity of riparian vegetation. More than ten years after the fire, efforts to finally recover the riparian plant community will likely rely on costly riparian planting and active herding by the grazing permittee.

The example of Fish Creek demonstrated that active habitat restoration through placement of large woody debris and/or other hardened structures may not be effective for post-fire recovery in a low-gradient, open-valley channel type. In these channel types, maintaining existing riparian hydric species, or recovering them, may be the best strategy for preventing channel degradation and fish habitat loss. Limiting grazing pressure on riparian vegetation – both prior to disturbance and long enough after disturbance that the strongly-rooted species become fully established and resilient to livestock use – holds a greater potential for both short-term recovery and long-term stability.

Only the upper reaches of Threemile Creek were burned over by the Brian Head fire, leaving a large portion of the riparian area unburned. Previous overuse of this pasture had already prompted implementation of a rest period in 2012, five years before the fire. This period of rest continued through 2018 and was followed by limited use by livestock moving on and off the Forest. Despite unauthorized, continued overuse of the pasture during the rest period (similar season-long grazing by a limited number of livestock as discussed in the Fish Creek example), the mature woody riparian species were maintained throughout much of the Threemile Creek drainage below the Delong Creek confluence. This vegetation, coupled with the wide valley bottom, helped to defray some of the erosive energy of post-fire stream flows. Uplands surrounding the burned-over Threemile-Delong confluence experienced considerable aspen regeneration following the fire, which may have helped defray use by livestock and other wild ungulates; although much of this regeneration is still not past the point of being impacted by browse pressure. As discussed previously, while initial impacts to channel stability were not as great in Threemile Creek, the long-term runoff changes following the fire do appear to be degrading at least the upper portions of the channel below the Delong confluence. The existing riparian woody vegetation in Threemile Creek has facilitated the use of beavers as a cost-effective tool to maintain and improve channel form and function. In 2021, DWR and DNF partnered to introduce fourteen beavers to Threemile

Creek, with the intent of improving stream habitat. Despite evidence of recent, relatively large flood events in late August 2021, four active beaver dams were identified by DNF along Threemile Creek, indicating that at least some of these reintroductions were initially successful. While beaver dams work to improve stream channel stability, create and diversify fish habitat, and increase substrate and water available for riparian vegetation, proper grazing management will be instrumental to allow beaver-clipped vegetation to resprout, maintain, and spread. DWR and DNF will continue to coordinate with livestock permittees, Garfield County officials, and BLM to facilitate future reintroductions of beavers, as necessary.

A number of triploid BCT were stocked in Threemile Creek in fall 2021 (Fig. A8) to monitor survival potential in current conditions. If these fish survive, diploid BCT will be introduced in that stream in the coming years. Indian Hollow experienced less effects of post-fire flooding and may currently provide some of the most stable habitat for reintroduction of BCT in the Threemile Creek drainage, though it is small and historically supported only small numbers of fish in limited habitat. While it was originally hoped that progeny from the Mammoth Creek remnant could be used to refound the Threemile population, the failures in propagation will result in the stocking of Manning Meadow BCT throughout this drainage, unless replication of some other nearby remnant (East Fork Sevier, Middle Sevier) is desired. Habitat recovery in lower Threemile Creek will also help facilitate reestablishment of other native fish species (Southern Leatherside, Mountain Sucker, Speckled Dace) that were also extirpated after the Brian Head fire.

Birch Creek

Birch Creek exhibited decreases in both occupied habitat and BCT biomass due to extreme drought conditions in 2020 and 2021. The lower reach of Birch Creek is a marginal stream for BCT and the lower extent of BCT occupation will always be dictated by stream flow and temperature (i.e. it will fluctuate according to annual weather variation). Accordingly, BCT occupied 0.7 km (0.4 mi) less habitat in lower Birch Creek during 2021 than in 2014. Lower stream flow (i.e. reduced water volume) has a lower thermal mass, so the higher air temperatures associated with severe drought often yield higher daily peak water temperatures in the reduced flow. Riparian vegetation like willows can mitigate some of this warming through stream shading. On small narrow streams like Birch Creek, even tall herbaceous grasses, sedges, and forbs can provide significant stream channel shading. Heavy grazing activity on stream banks and in riparian areas over the last 25 years, since the 1996 Pole Creek fire, has impacted the establishment of

willows and continues to limit later seral riparian grasses and forbs. Due to these concerns, water temperature data loggers were deployed by FNF in 2021 at two sites: Station 1 (low elevation) where flow was reduced by drought, but shading was abundant due to the river birch canopy; and Station 3 (high elevation) where flow was higher, but a long, open reach just upstream was more heavily grazed and lacking in shading. Unfortunately, both data loggers went missing and could not be retrieved in fall 2021. Additional attempts to obtain water temperature data in Birch Creek will be made before the next BCT monitoring is conducted in 2028.

Due to workload, Birch Creek was sampled in late September 2021, one to two months later than historic surveys. Small fish measuring 50 to 70 mm (2-3 in) were found to be abundant at the highest sampling station, Station 4. All fish seen during sampling are typically netted and recorded. After review of water temperatures measured at Station 4 in previous years, as well as Manning Meadow brood stock growth rates, it was determined these were likely age-0 fish and they were excluded from analysis. The large number of age-0 fish at Station 4, even in a drought year, is somewhat encouraging but also indicates that – in small, marginal streams – successful reproduction may be episodic or spatially localized across the years. (Age-0 fish are consistently removed from statistical analysis of the BCT population for two primary reasons: First, their catchability with electrofishing equipment is low and highly variable, and is significantly affected by the seasonal timing of the survey and second, their abundance is highly variable across years.)

While statistical analysis of age-0 BCT is not warranted for the reasons noted, the presence of age-0 BCT, especially in high numbers, can help identify factors that affect spawning and recruitment in the short term, and have ramifications for long-term population dynamics. An abundance of age-0 BCT found at the highest sampling station in Birch Creek in 2021 indicated that, despite drought conditions, BCT experienced favorable spawning in spring, followed by successful hatching and rearing for the next several months. Survival through the summer may have been supported by a strong monsoon season in 2021. BCT measuring 80 to 100 mm (expected age-1 size) were mostly absent in all stations, however. This absence may indicate that BCT spawned in 2020 experienced lower survival during the two drought-impacted growing seasons since they were spawned. It is also possible that some of the fish measuring 60 to 70 mm were yearling fish that experienced slower growth due to drought conditions. (The length distribution of fish between 50 and 70 mm in length was unimodal, providing no discrete distinction between potential cohorts.) The observation of the age-0 fish in 2021 at Station 4 suggested that the highest

reach of Birch Creek likely provides valuable habitat for BCT spawning and rearing. However, the lack of age-1 fish across all stations or age-0 fish at other stations shows recruitment of young fish to the population can be significantly impacted by annual precipitation patterns.

Natural fluctuation in occupied habitat, BCT biomass, spawning success, and recruitment potential are expected to follow annual changes in flow, temperature, and habitat quality in small streams. Habitat conditions can exacerbate or mitigate the effects of variation in precipitation. BCT biomass experienced reductions at all Birch Creek stations in 2021, as would be expected during a severe drought. Station 1 sits in the lower reach of Birch Creek, where the riparian zone was outside the 1996 fire and is currently less impacted by grazing due to dense river birch, but fluctuations in stream flow volume and water temperature are more prevalent. BCT biomass at this station was near the typical for Birch Creek in 2009 and 2014 (27-34 kg/ha), but decreased to 13 kg/ha in 2021 (Table 5). Based on the habitat and land uses at this station, this decline was most likely driven by drought, although sediment from the adjacent road may have also contributed.

Birch Creek Station 2 sits within the 1996 fire perimeter and is grazed heavily. This station, as well as other stations in Birch Creek, has historically exhibited BCT biomass measures below average for southern Utah trout streams (Platts and McHenry 1988, Hepworth and Beckstrom 2004). Station 3 is also located within the fire perimeter but is mostly shaded and protected from grazing by an island of woody shrub vegetation. BCT biomass here has remained fairly constant across the years, likely because of more consistent flow in this middle stream reach, better habitat conditions, and less grazing impacts. Station 4 is located within the fire perimeter but was in an island of burned and unburned conifer. BCT biomass was high at this station in 2008, perhaps due to fish being reintroduced into this area in preceding years, with the standing and down timber providing protection from grazing. Biomass had declined by 2021, which may be attributed to a combination of increasing livestock access to the reach, decreased flow, and drought-related habitat impacts.

Given how extreme the recent drought has been, it was heartening to see that BCT still occupied Birch Creek to the extent and abundance observed in 2021. Across the years, however, livestock use of the open areas within the 1996 fire perimeter has remained high, with riparian herbaceous stubble heights observed to be shorter than the four-inch minimum standard for hydric species that applies to all riparian areas on the FNF (USDA Forest Service 2001) (Fig. 9). Birch Creek was initially rested from livestock for four years after the 1996 fire to help aspen recover

and grow tall enough to escape grazing, which did occur in many areas. Riparian woody shrub species have not recovered so well, however, and the heavier grazing use in open stream reaches continues to limit their recruitment. Increasing willows and having taller and more vigorous late seral herbaceous riparian plants would increase stream shading, improve habitat complexity, and help protect streambanks. The decrease in BCT biomass and occupied stream length observed in Birch Creek in 2021 demonstrates that properly administering land uses to ensure Forest Plan standards are being met is essential for securing the long-term viability of this BCT population.

CONCLUSION

The latest BCT Conservation Strategy (BCT Conservation Team 2019) designated the Mammoth Creek restoration project as a key effort to securing population resiliency in the Southern Bonneville GMU. Although the drainage provides up to 42 km (26 mi) of habitat for BCT colonization, natural barriers prevent full connectivity of the entire system. Barriers constructed to facilitate nonnative trout removal will be removed as appropriate during population establishment. As has been the case in many of the fractured stream systems in southern Utah, large, partially connected drainages like Mammoth Creek provide a type of functional resiliency that allow for assisted recovery of Cutthroat Trout populations after stochastic events. Continued periodic monitoring can direct needed fishery management actions and help offset the lack of full connectivity. In addition to increasing resiliency, the Mammoth Creek project will maintain representation of the upper Sevier River drainage's only BCT remnant, though at a smaller scale than was originally intended. Preserving this remnant also maintains the potential opportunity for future replication if onsite propagation techniques can be improved. The Brook Trout discovered in the headwaters of Castle Creek in July 2021, while low in density, could jeopardize a substantial portion of this restoration project. Mechanical Brook Trout removal efforts in Castle Creek should be a high priority for BCT conservation in 2022 and 2023 to eliminate this threat.

Maintaining redundancy of BCT populations in the upper Sevier River drainage will also be achieved in the future by restoring populations lost to wildfire in Threemile Creek and its tributaries, as well as Left Fork Sanford Creek. Reestablishment in the Threemile Creek drainage will require additional efforts to help stabilize and recover stream channel stability, fish habitat, and riparian vegetation. Reintroduction of BCT to Left Fork Sanford Creek was delayed for several years as attempts at streamside egg propagation were made in Mammoth Creek. Since these attempts failed, BCT from the Manning Meadow brood were scheduled to be stocked in Left Fork

Sanford Creek in fall 2021. Extremely low flow in the bottom reach of the stream prompted postponement of the stocking until DNF and DWR personnel can more fully evaluate the stream's suitability, which should occur in 2022. Collaborative efforts to mitigate impacts of land management actions – grazing, fire, roads, etc. – will help maintain redundancy in Birch Creek, as well as all other populations once they are established. A previously planned project to replicate BCT in Bear Creek was intended to also help relieve competition and predation stress from Brown Trout on native Southern Leathersides (Hadley et al. 2015). DNF, BLM, and DWR personnel abandoned this project after further evaluation determined that Bear Creek supports limited year-round trout habitat. This means that (1) Brown Trout are found in very low densities and do not currently pose a significant threat to Leathersides, and (2) BCT would experience a low likelihood of establishment if introduced.

Up to 67.5 km (41.9 mi) of total stream habitat are available to BCT in the upper Sevier River drainage within the streams where restoration has been conducted in the past (Birch Creek, Threemile Creek drainage, Left Fork Sanford Creek) or is currently in progress (Mammoth Creek drainage). In 2021, BCT occupied just 26% of this available habitat, leaving 50 km (31 mi) of stream for future expansion or reestablishment. No other restoration efforts are recommended outside of these streams at this time, instead conservation focus will be shifted to maintaining and improving these previously restored populations and their habitat. Though future restorations will not be actively pursued in the short-term, opportunities for replicating BCT in other streams in the upper Sevier River drainage will be considered on a case-by-case basis.

STATEMENT OF EQUAL OPPORTUNITY

Native Cutthroat Trout conservation is supported by funds from the US Government through the Federal Aid in Sport Fish Restoration Act (Dingell-Johnson Act) of 1950. DWR has agreed to include the following statement in any material or media developed for public distribution with federal funding:

In accordance with Federal law and U.S. Department of Agriculture policy, this institution is prohibited from discriminating on the basis of race, color, national origin, sex, age, or disability. (Not all prohibited bases apply to all programs.)

To file a complaint of discrimination, write USDA, Director, Office of Civil Rights, Room 326-W, Whitten Building, 1400 Independence Avenue, SW, Washington, DC 20250-9410 or call (202) 720-5964 (voice and TDD). USDA is an equal opportunity provider and employer.

LITERATURE CITED

Behnke, R. J. 1976. Summary of information on the status of the Utah or Bonneville Cutthroat Trout, Salmo clarki utah. Prepared for Wasatch National Forest, Salt Lake City, UT. 14 pp.

Behnke, R. J. 1992. Native trout of western North America. American Fisheries Society Monograph 6, Bethesda, MD. 275 pp.

Bonneville Cutthroat Trout Conservation Team. 2019. Bonneville Cutthroat Trout range-wide conservation agreement and strategy. Publication number 18-11. Utah Department of Natural Resources, Division of Wildlife Resources, Salt Lake City. 82 pp.

Duff, D. A. 1988. Bonneville Cutthroat Trout: current status and management. American Fisheries Society Symposium 4: 121-127.

Evans, R. P. and D. K. Shiozawa. 2004. Genetic status of Utah Cutthroat Trout populations I: White River, Right Fork: Tributary; White River, Right Fork; Timber Canyon; Birch Creek; Henry's Fork Trailhead; Halls Fork; and Beaver Creek, UT. Final report to Utah Division of Wildlife Resources. Brigham Young University, Provo.

Evans, R. P. and D. K. Shiozawa. 2005. Genetic status of Utah Cutthroat Trout populations II: Toms Creek, Alf, 03070208S, 04090222B, 04070224L, 04090109P. Final report to Utah Department of Natural Resources, Division of Wildlife Resources. Brigham Young University, Provo.

Evans, R. P., D. Houston, S. Oh, and D. K. Shiozawa. 2013. Genetic status of Utah Cutthroat Trout populations – January 2013 samples. Final report to Department of Natural Resources Division of Wildlife Resources. Brigham Young University, Provo.

Evans, R. P., and D. K. Shiozawa. 2014a. Genetic status of Utah Cutthroat Trout populations November 2013 samples. Final report to Department of Natural Resources Division of Wildlife Resources. Brigham Young University, Provo.

Evans, R. P., and D. K. Shiozawa. 2014b. Genetic status of Utah Cutthroat Trout populations July 2014 samples. Final report to Department of Natural Resources Division of Wildlife Resources. Brigham Young University, Provo.

Golden, M. 2012. Dixie National Forest Fish Surveys FY2011. Cedar City, UT: Dixie National Forest, Supervisor's Office.

Haak, A., J. Williams, and W. Colyer. 2011. Developing a diverse conservation portfolio for Bonneville Cutthroat Trout. Available: http://tucsi.tu.org/Documents/Portfolios/bct-conservation-portfolio-july14-2011-final.pdf. Accessed January 31, 2018.

Hadley, M. J., M. E. Golden, and J. E. Whelan. 2015. 2014 survey of Bonneville Cutthroat Trout in the upper Sevier River drainage, Utah. Publication number 15-04. Utah Department of Natural Resources, Division of Wildlife Resources, Salt Lake City. 29 pp.

Hadley, M. J., M. J. Ottenbacher, M. E. Golden, and J. E. Whelan. 2010. Survey of Bonneville Cutthroat Trout in the upper Sevier River and East Fork Sever River drainages, 2008-2009. Publication number 10-20. Utah Department of Natural Resources, Division of Wildlife Resources, Salt Lake City. 32 pp.

Hadley, M. J., J. W. Whelan, J. H. Swensen, and N. R. Braithwaite. 2018. 2017 survey of Bonneville Cutthroat Trout in the middle Sevier River drainage, Utah. Publication number 18-10. Utah Department of Natural Resources, Division of Wildlife Resources, Salt Lake City. 87 pp.

Hadley, M. J., J. W. Whelan, J. H. Swensen, and J. Jimenez. 2017. 2016 survey of Bonneville Cutthroat Trout in the upper Beaver River drainage, Utah. Publication number 17-01. Utah Department of Natural Resources, Division of Wildlife Resources, Salt Lake City. 36 pp.

Hepworth, D. K., M. J. Ottenbacher, and C. B. Chamberlain. 2002. A review of a quarter century of native Cutthroat Trout conservation in southern Utah. Intermountain Journal of Sciences 8: 125-142.

Hepworth, D. K., M. J. Ottenbacher, C. B. Chamberlain, and J. E. Whelan. 2003. Abundance of Bonneville Cutthroat Trout in southern Utah, 2001-2002, compared to previous surveys. Publication number 03-18. Utah Department of Natural Resources, Division of Wildlife Resources, Salt Lake City. 66 pp.

Hepworth, D. K., and S. Beckstrom. 2004. A simple 4-step method to manage for quality fishing: implementing Utah's Blue Ribbon Fishery Program. Publication number 04-24. Utah Department of Natural Resources, Division of Wildlife Resources, Salt Lake City. 15 pp.

Hickman, T. J. 1978. Systematic study of the native trout of the Bonneville Basin. M.S. Thesis, Colorado State University, Fort Collins.

Kershner, J. 1995. Bonneville Cutthroat Trout. *In* M. K. Young, editor. Conservation assessment for inland Cutthroat Trout. General Technical Report RM-256. Fort Collins, CO: U.S.

Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 pp.

Klar, G. T. 1978. Adaptive significance of lactate dehydrogenase B^3 isozymes in Rainbow Trout, Salmo gairdneri, and a biochemical comparison of Cutthroat Trout (Salmo clarki) populations. Ph.D. dissertation, Utah State University, Logan.

Lentsch, L., Y. Converse, and J. Perkins. 1997. Conservation agreement and strategy for Bonneville Cutthroat Trout (*Oncorhynchus clarki utah*) in the state of Utah. Publication number 97-19. Utah Department of Natural Resources, Division of Wildlife Resources, Salt Lake City. 73 pp.

Lentsch, L. D., C. A. Toline, J. Kershner, J. M. Hudson, J. Mizzi. 2000. Range-wide conservation agreement and strategy for Bonneville Cutthroat Trout (*Oncorhynchus clarki utah*). Publication number 00-19. Utah Department of Natural Resources, Division of Wildlife Resources, Salt Lake City. 90 pp.

May, B. E., and S. E. Albeke. 2005. Range-wide status of Bonneville Cutthroat Trout: 2005. Utah Division of Wildlife Resources, Salt Lake City.

Ohlhorst, S. 1991. Electrophoretic analysis of native Cutthroat Trout populations. Final report to the Utah Division of Wildlife Resources.

Ottenbacher, M. J., and D. K. Hepworth. 2003. Upper Sevier River drainage management plan, Hydrologic Unit Code 16030001. Publication number 03-38. Utah Department of Natural Resources, Division of Wildlife Resources, Salt Lake City. 38pp.

Platts, W. S., and M. L. McHenry. 1988. Density and biomass of trout and char in western streams. Gen. Tech. Rep. INT-241. U.S. Forest Service, Intermountain Research Station, Ogden, UT. 17pp.

Shafer, M. L., and B. A. Stein. 2000. Safeguarding our precious heritage. Pages 301-321 in, B. A. Stein et al., editors. Precious heritage: the status of biodiversity in the United States. Oxford University Press.

Shiozawa, D. K., R. P. Evans, and R. N. Williams. 1993. Relationships between Cutthroat Trout populations from ten Utah streams in the Colorado River and Bonneville drainages. Interim report to Utah Division of Wildlife Resources. Brigham Young University, Provo.

Shiozawa, D. K., and R. P. Evans. 1994. Relationships between Cutthroat Trout populations from thirteen Utah streams in the Colorado River and Bonneville drainages. Final report to Utah Division of Wildlife Resources, Contract No. 93-2377. Brigham Young University, Provo.

Thompson, C. K. 1987. Report on meristic and electrophoresis of selected Utah Cutthroat Trout populations. Utah Division of Wildlife Resources. Fisheries Experiment Station, Logan.

Thron, J. E. and P. A. Miller. 2002. Meristic analysis for Bonneville and Colorado River Cutthroat Trout in the State of Utah, Annual Report 2001. Utah Division of Wildlife Resources Publication Number 02-15.

USDA Forest Service. 2001. Forest Plan Amendment of Forage Utilization Standards & Guidelines. Richfield, Utah: U.S. Department of Agriculture, Forest Service, Intermountain Region, Fishlake National Forest.

U.S. Fish and Wildlife Service. 2001. Status review for Bonneville Cutthroat Trout (*Oncorhynchus clarki utah*). United States Department of the Interior, U.S. Fish and Wildlife Service, Regions 1 and 6. Portland and Denver. 153 pp.

Van Deventer, J.S. 1989. Microcomputer software system for generating population statistics from electrofishing data—user's guide for MicroFish 3.0. USDA Forest Service, General Technical Report INT-254. 29 p.

Zippin, C. 1958. The removal method of population estimation. Journal of Wildlife Management 22: 82-90.

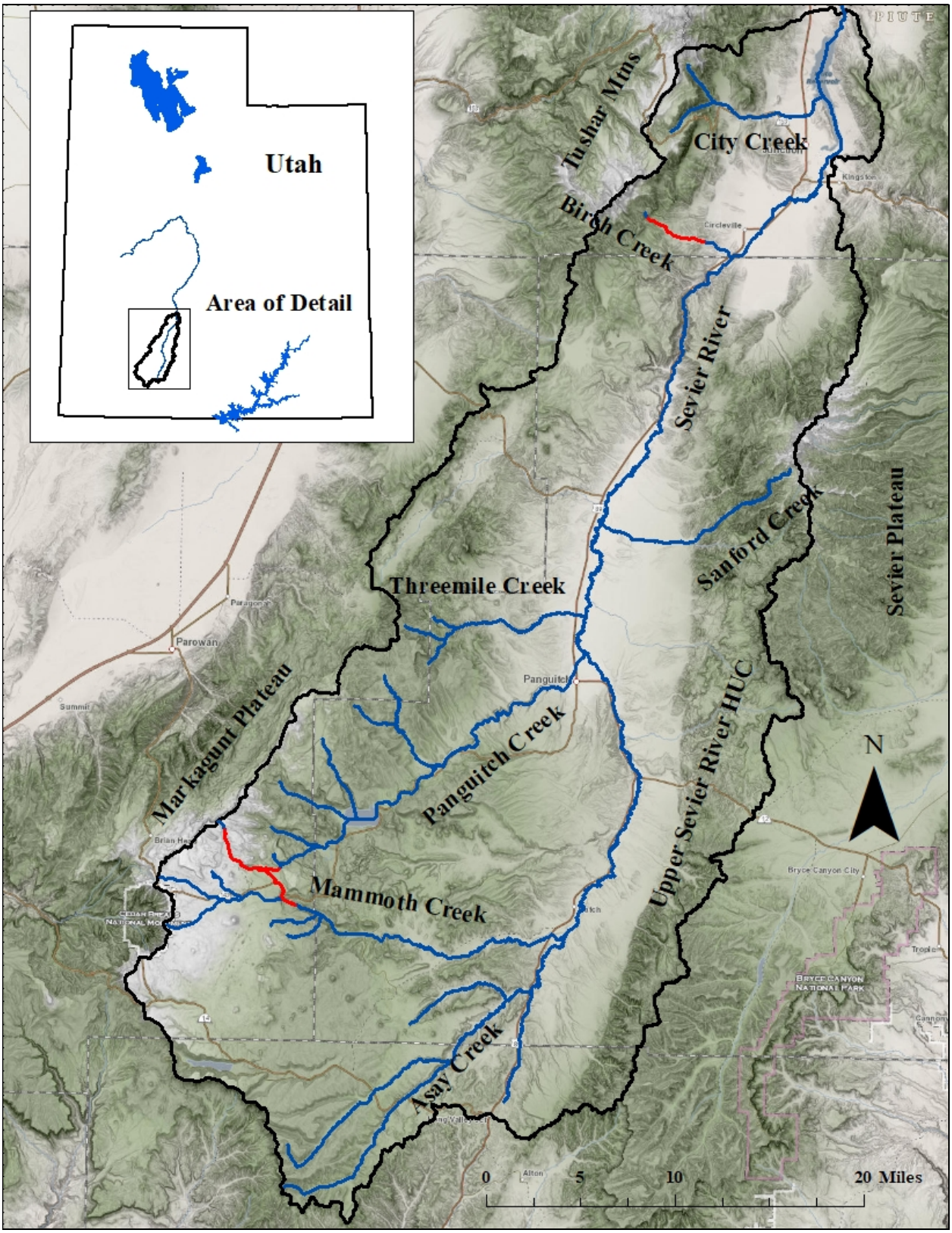

Figure 1. The upper Sevier River drainage (HUC 16030001) of southwestern Utah. Current (2021) Bonneville Cutthroat Trout distribution highlighted in red.

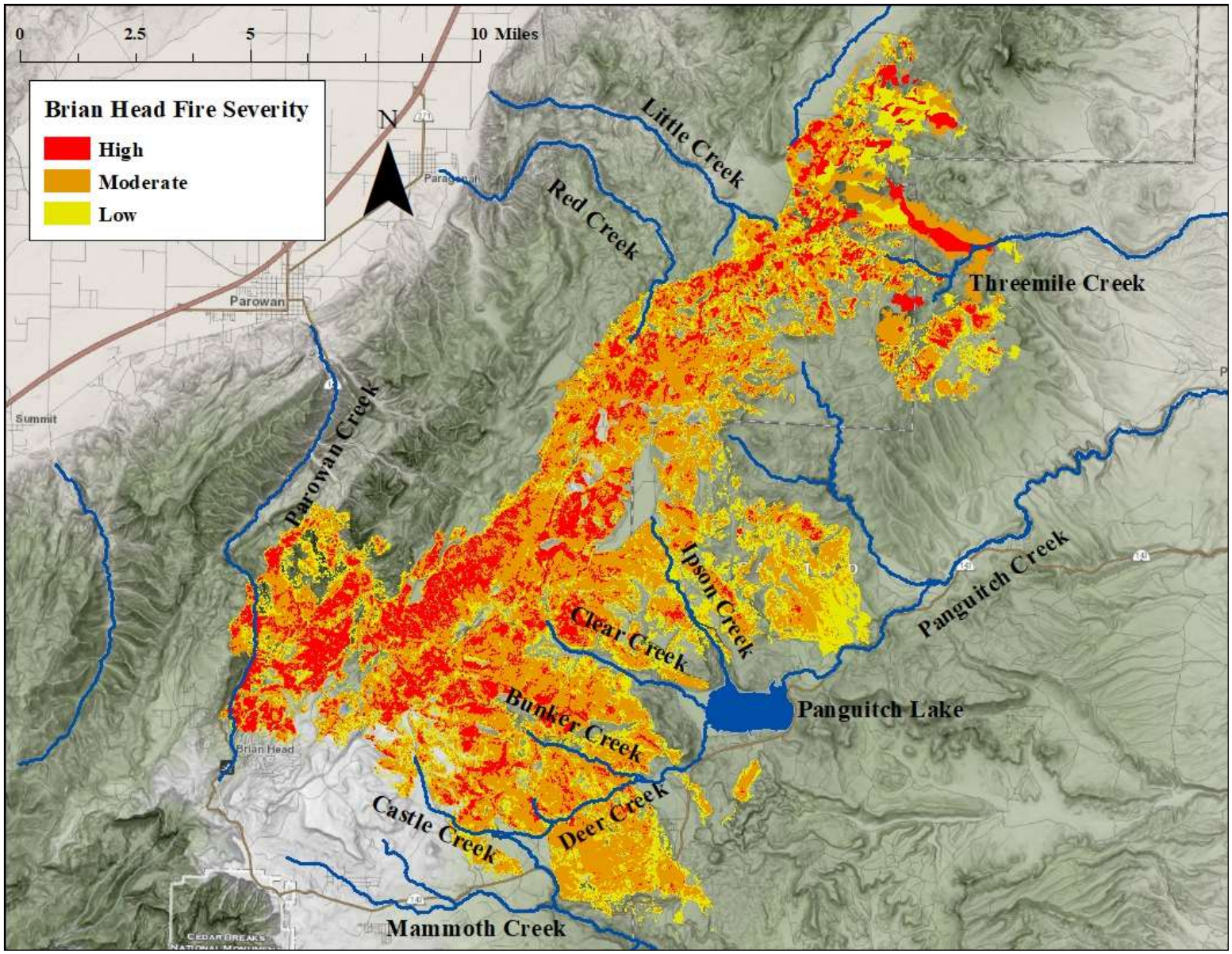

Figure 2. Area burned by the Brian Head fire in 2017.

Figure 3. Delong Creek, Station 1, before the Brian Head fire in 2014 (top) and after the fire in 2017 (bottom).

Figure 4. Threemile Creek, Station 1, before the Brian Head fire in 2014 (top) and after the fire in 2017 (bottom).

Figure 5. Personnel conduct an electrofishing survey in Castle Creek.

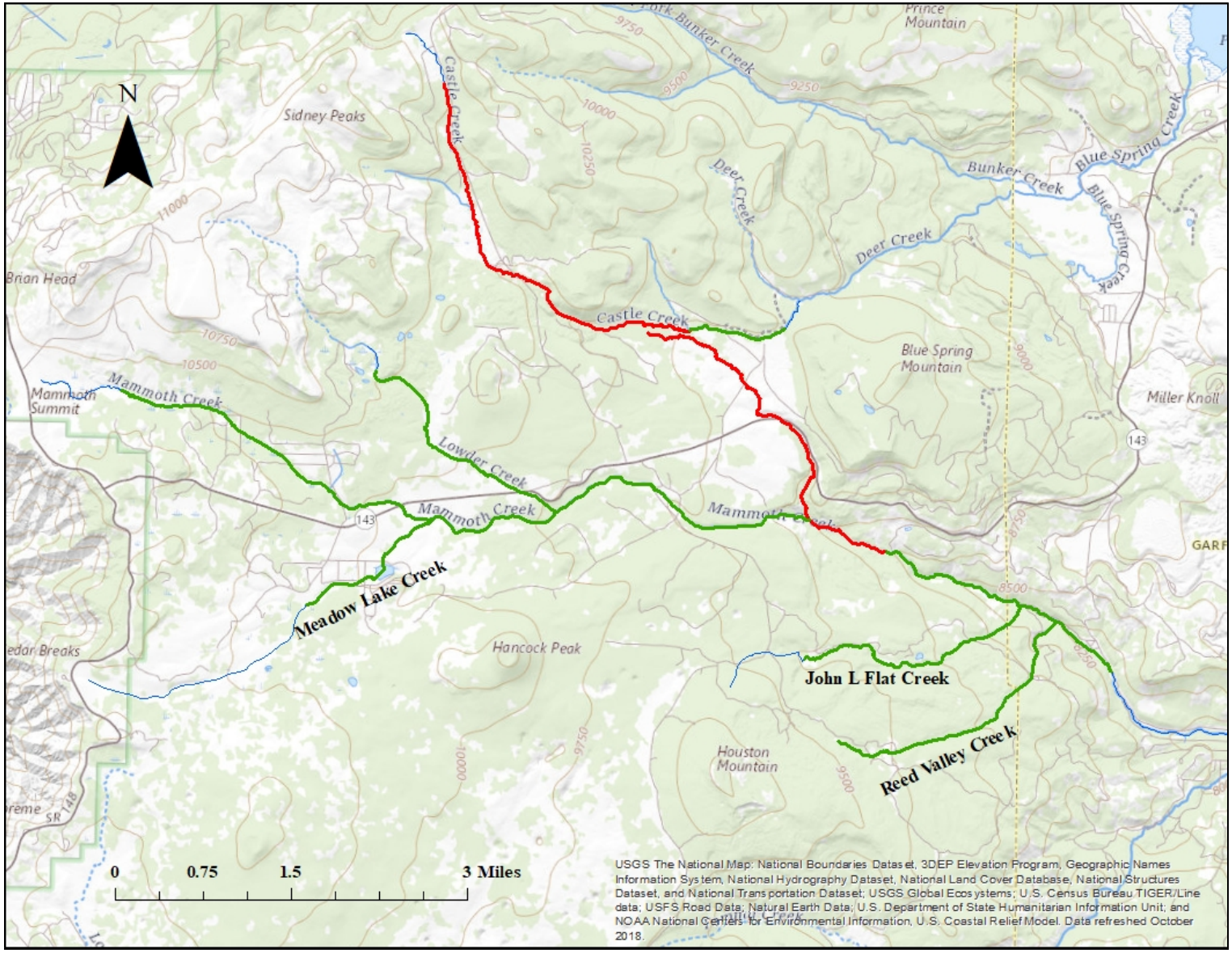

Figure 6. Upper Mammoth Creek and its tributaries. Habitat currently occupied by Bonneville Cutthroat Trout is highlighted in red, potential habitat is highlighted in green.

Figure 7. Evidence of flooding in upper Delong Creek in July 2021.

Figure 8. Head cutting, channel incision, and channel widening observed in Threemile Creek in August 2021.

Figure 9. Birch Creek Station 2, showing short riparian herbaceous stubble height and sparse riparian woody shrub vegetation.

Table 1. Comparison of stream length (km) occupied by Bonneville Cutthroat Trout in the Upper Sevier River drainage, 2001 to 2021. *Italics* denote stream length occupied by remnant populations, normal text denotes stream length occupied by restored and/or expanded populations, and **bold** text denotes totals for the year (remnant plus restored).

Survey Years	Known Occupied Stream Length	Change From Previous Survey
2001-2002	*0 km* 18.0 km **18.0 km**	+15.1 km (Threemile Cr & tribs) +2.9 km (LF Sanford Cr) **Total: +18.0 km**
2008	*0 km* 21.4 km **21.4 km**	+6.3 km (Birch Cr) -2.9 km (LF Sanford Cr) **Total: +3.4 km**
2014	*4.9 km* 21.4 km **26.3 km**	*+4.9 km (Mammoth Cr)* **Total: +4.9 km**
2021	*1.2 km* 16.2 km **17.4 km**	*-3.7 km (Mammoth Cr)* -15.1 km (Threemile Cr & tribs) -0.7 km (Birch Cr) +10.6 km (Castle Cr) **Total: -8.9 km**

Table 2. Total acres in each 6th field Hydrologic Unit Code (HUC) watershed affected by the Brian Head fire; percent of those acres burned at high, moderate and low severity; and the percent that was unburned and outside of the fire perimeter.

Watershed	Total acres	High	Moderate	Low	Unburned	Outside perimeter
Bear Creek	33,684	1%	2%	1%	0%	96%
Blue Spring Creek	12,729	8%	36%	15%	9%	32%
Butler Creek	13,826	3%	15%	9%	10%	63%
Center Creek-Parowan Creek	16,572	20%	25%	9%	8%	38%
Dry Lakes Creek	14,208	8%	11%	5%	5%	71%
Fivemile Hollow-Panguitch Creek	16,088	0%	1%	3%	3%	92%
Haycock Creek	12,900	1%	19%	19%	16%	46%
Ipson Creek	16,261	14%	41%	15%	12%	18%
Little Creek	14,546	6%	12%	5%	1%	76%
Middle Mammoth Creek	16,102	0%	4%	2%	3%	90%
Red Creek	31,803	3%	8%	2%	1%	86%
Sandy Creek	15,262	2%	3%	5%	0%	90%
Threemile Creek	13,208	8%	18%	9%	6%	59%
Upper Mammoth Creek	25,906	1%	6%	4%	4%	85%

Table 3. Comparison of Bonneville Cutthroat Trout population status in the Upper Sevier River drainage by individual stream, 2001 to 2021. Trends noted as an increase (↑) or decrease (↓) if values changed by more than 10%; >0 indicates that trout were present but biomass or range was not measured. Biomass presented is a mean of all sampling stations where BCT were detected.

State water identification number	Stream/tributary (indentation denotes tributaries)		Occupied Habitat		Biomass		
		Year	km	Trend	kg/ha	Trend	Comments
VI AA 550	Birch Creek	2002	>0	--	>0	--	Restoration in progress
		2008	6.3	↑	30	↑	Population expansion
		2014	6.3	↔	30	↔	Population stable but marginal
		2021	5.6	↓	20	↓	Impacted by drought
VI AA 780	Mammoth Creek	2008	>0	--	>0	--	Unknown remnant
		2014	4.9	↑	41	↑	Remnant verified 2012
		2021	>1.2[1]	↓	>0[1,2]	↓	Restoration in progress
VI AA 780D	Castle Creek	2014	--	--	--	--	Nonnative trout
		2021	10.6	↑	191	↑	BCT restored 2015-2018
VI AA 780G	John L Flat Creek	2014	--	--	--	--	Nonnative trout
		2021	>0[2]	↑	>0[2]	↑	Restoration in progress
VI AA 780E	Lowder Creek	2014	--	--	--	--	Nonnative trout
		2021	>0[2]	↑	>0[2]	↑	Restoration in progress
VI AA 780H	Meadow Lake Creek	2014	--	--	--	--	Nonnative trout
		2021	>0[2]	↑	>0[2]	↑	Restoration in progress
VI AA 780F	Reed Valley Creek	2014	--	--	--	--	Nonnative trout
		2021	>0[2]	↑	>0[2]	↑	Restoration in progress
VI AA 650A	Sanford Creek, Left Fork	2002	2.9	--	35	--	BCT introduced 1999
		2008	0	↓	0	↓	Lost to 2002 Sanford Fire
		2014	0	--	0	--	Reintroduction postponed
		2021	0	--	0	--	Reintroduction planned for 2022
VI AA 680	Threemile Creek	2001	11.3	--	45	--	Restored in 1994
		2008	11.1	↔	37	↓	Population stable but variable
		2014	10.6	↔	46	↑	Population stable but variable
		2001	0[3]	↓	0[3]	↓	Lost to 2017 Brian Head fire
VI AA 680A	Delong Creek	2001	3.4	--	143[4]	--	Restored in 1994
		2008	3.4	↔	50	↓[4]	Population stable
		2014	3.2	↔	142	↑	Population stable
		2001	0	↓	0	↓	Lost to 2017 Brian Head fire
VI AA 680A 01	Indian Hollow	2001	1.4	--	66	--	Restored in 1994
		2008	1.4	↔	19	↓	Marginal habitat
		2014	1.3	↔	105	↑	Habitat improved
		2001	0	↓	0	↓	Lost to 2017 Brian Head fire

[1] – Salvaged remnant BCT returned to portion of remnant reach.
[2] – Fingerling BCT stocked in fall 2021.
[3] – Triploid BCT stocked in 2021 to gauge survival potential.
[4] – The 2001 survey included only one station in the lower stream. A second station was added in 2008 in the upper drainage, which contained lower BCT density at that time.

Table 4. Length of stream habitat (km and miles) available to Bonneville Cutthroat Trout colonization in the Mammoth Creek drainage.

Stream Name	Habitat (km)	Habitat (miles)
Mammoth Creek	16.21	10.07
Castle Creek	12.01	7.46
John L Flat Creek	3.68	2.29
Lowder Creek	3.57	2.22
Meadow Lake Creek	2.35	1.46
Reed Valley Creek	4.11	2.55
Total	**41.93**	**26.05**

Table 5. Bonneville Cutthroat Trout biomass (kg/ha) observed in Birch Creek, by station, during regular monitoring surveys, 2008-2021.

Station	BCT Biomass		
	2008-09	2014	2021
1	27	34	13
2	10	31	24
3	28	29	27
4	56	24	14
Mean	30	30	20

APPENDIX

Survey results and maps for individual streams (coordinates are presented in NAD83 datum)—contained in the following pages as outlined below by drainage, stream, and tributary:

Birch Creek—NATIVE TROUT POPULATION SURVEY

1. General Information— Date: **Sep 27 and 28, 2021** Biologist: **J. Whelan**
2. Stream Information—
   Name, catalog #, section, county: **Birch Creek, VI AA 550, 01, Piute**
3. Survey Site Information (see attached map)—
   Upstream range of native trout (general description and UTM): **Steep gradient in headwater canyon—120379688E 4226597N**
   Downstream range of native trout (general description and UTM): **0.6 km below Station 1—120384479E 4224601N**
   Location (UTM) and description of barriers: **Diverted and seasonally ephemeral prior to reaching Sevier R.**
   Stream Length—Occupied habitat: **5.58 km (3.47 mi)** Available habitat: **6.26 km (3.89 mi)**[1]
   Survey method & equipment: **backpack battery electrofisher; multiple-pass deletion**
   Survey sites (general description and UTM)—
      Station 1: **Just above 3rd road crossing; 120383912E 4224782N**
      Station 2: **Just below picnic area; 120381178E 4225829N**
      Station 3: **Just above picnic area; 120380513E 4226178N**
      Station 4: **Upper end of valley below headwater canyon; 120380014E 4226418N**

Parameter	**Station 1**	**Station 2**	**Station 3**	**Station 4**
Station length (m)	100 m	100 m	100 m	100 m
Mean stream width (m) (n)	0.81 m (10)	1.27 m (10)	1.18 m (10)	1.18 m (10)
Station area (hectares)	0.0081 ha	0.0127 ha	0.0118 ha	0.0118 ha
BCT				
Removal Pattern	3 0	7 2	7 3	6 1
Population estimate (95 % CI)	3 (NA)	9 (±2)	10 (±3)	7 (±1)
Capture probability	1.000	0.818	0.769	0.875
Mean length (mm) (n)	154 (3)	145 (9)	144 (10)	236 (30)
Mean weight (g) (n)	35 (3)	37 (9)	31 (10)	155 (30)
Mean KTL (n)	0.74 (3)	1.04 (9)	0.92 (10)	1.13 (30)
Number fish per km (95 % CI)	30 (NA)	90 (±20)	100 (±30)	70 (±10)
Number fish per ha (95 % CI)	373 (NA)	711 (±159)	848 (±254)	593 (±85)
Biomass (kg per ha) (95 % CI)	13 (NA)	24 (±5)	27 (±8)	14 (±2)

4. Comments: Young-of-the-year abundant at Station 4, but also observed at stations 2 and 3.

[1] – Observed in 2014.

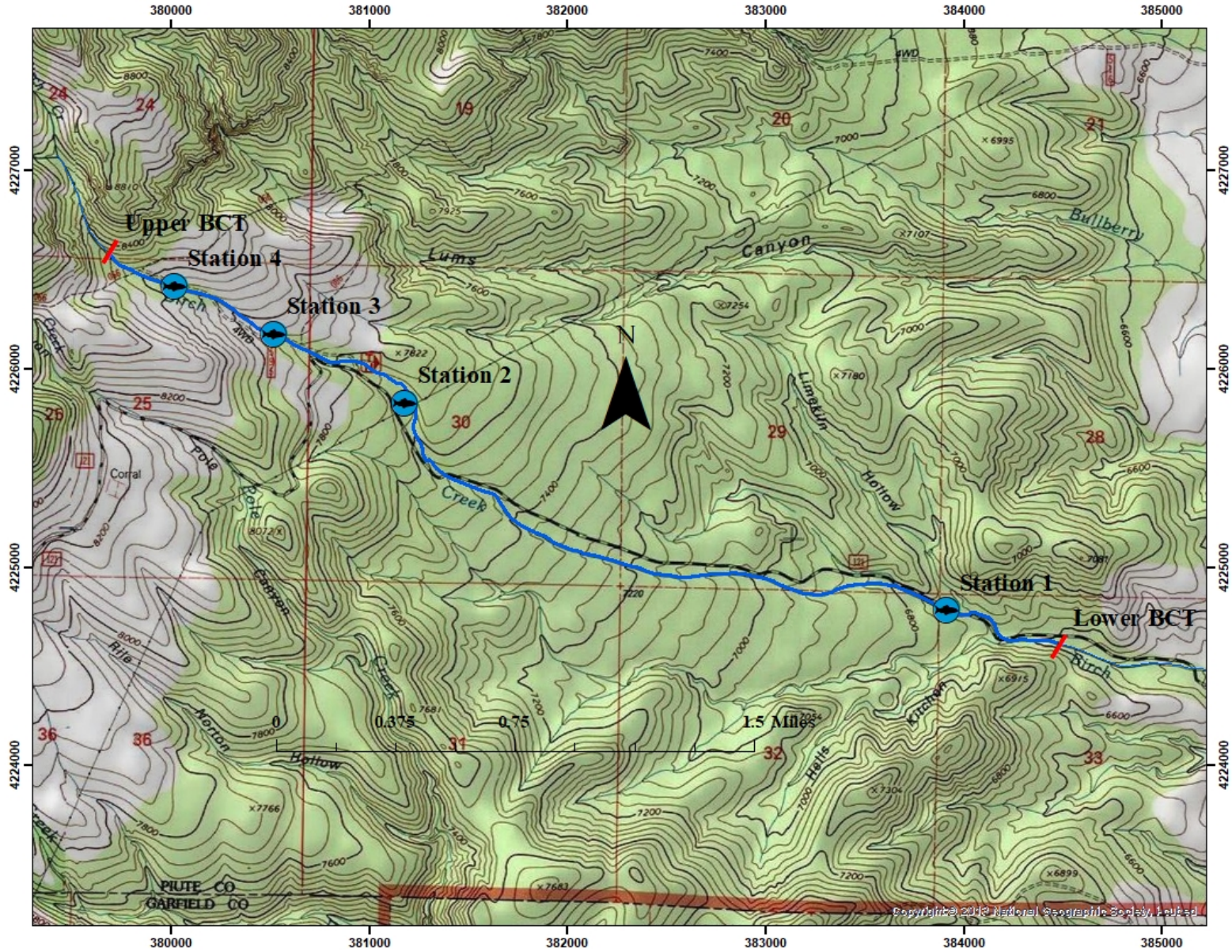

Figure A1. Locations of survey stations and BCT distribution in Birch Creek.

Mammoth Creek—NATIVE TROUT POPULATION SURVEY

1. General Information— Date: **July 16, 2021** Biologist: **M. Hadley**
2. Stream Information—
   Name, catalog #, section, county: **Mammoth Creek, VI AA 780, 01, Iron & Garfield**
3. Survey Site Information (see attached map)—
   Upstream range of native trout (general description and UTM): **Castle Creek confluence—120343565E 4174587N**
   Downstream range of native trout (general description and UTM): **Upper constructed fish passage barrier**
   Location (UTM) and description of barriers: **Constructed barriers—120352084E 4167104N (lower), 120349596E 4168200N (upper); waterfalls upstream of Castle Creek confluence—120347929E 4168547N**
   Stream Length—Occupied habitat: **1.17 km (0.73 mi)[1]** Available habitat: **16.21 km (10.07 mi)[2]**
   Survey method & equipment: **Rotenone treatments and recon; BCT salvage and stocking.**
   Survey sites (general description and UTM)—**Surveys not repeated in 2021 due to ongoing removal of nonnative trout and restoration of BCT.**
4. Comments:

[1] – 171 remnant BCT salvaged during 2021 rotenone treatment returned to reach between upper fish passage barrier and Castle Creek confluence. (Approximately 146 fish per km.)

[2] – From Mammoth Spring upstream to headwaters at base of Brian Head Peak. BCT fingerlings stocked throughout Mammoth Creek upstream of waterfalls in fall 2021.

John L Flat Creek—NATIVE TROUT POPULATION SURVEY

1. General Information— Date: **Fall 2021** Biologist: **M. Hadley**
2. Stream Information—
   Name, catalog #, section, county: **John L Flat Creek, VI AA 780G, 01, Iron & Garfield**
3. Survey Site Information (see attached map)—
   Upstream range of native trout (general description and UTM): **NA**
   Downstream range of native trout (general description and UTM): **NA**
   Location (UTM) and description of barriers: **Porcupine Lake dam—120349903E 4166672N**
   Stream Length—Occupied habitat: **>0 km (>0 mi)[1]** Available habitat: **3.68 km (2.29 mi)[2]**
   Survey method & equipment: **Rotenone treatments and recon; BCT stocking.**
   Survey sites (general description and UTM)—**Surveys not conducted in 2021 due to ongoing removal of nonnative trout and restoration of BCT.**
4. Comments:

[1] – Fingerling BCT stocked in stream just below John L Flat in fall 2021.
[2] – From Mammoth Creek confluence upstream to springs in John L Flat.

Reed Valley Creek—NATIVE TROUT POPULATION SURVEY

1. General Information— Date: **Fall 2021** Biologist: **M. Hadley**
2. Stream Information—
   Name, catalog #, section, county: **Reed Valley Creek, VI AA 780F, 01, Iron & Garfield**
3. Survey Site Information (see attached map)—
   Upstream range of native trout (general description and UTM): **NA**
   Downstream range of native trout (general description and UTM): **NA**
   Location (UTM) and description of barriers: **Steep grade/cascade at rim of Mammoth Creek canyon—120351605E 4166574N**
   Stream Length—Occupied habitat: **>0 km (>0 mi)[1]** Available habitat: **4.11 km (2.55 mi)[2]**
   Survey method & equipment: **Rotenone treatments and recon; BCT stocking.**
   Survey sites (general description and UTM)—**Surveys not repeated in 2021 due to ongoing removal of nonnative trout and restoration of BCT.**
4. Comments:

[1] – Fingerling BCT stocked in stream in Reed Valley in fall 2021.
[2] – From Mammoth Creek confluence upstream to springs in Reed Valley.

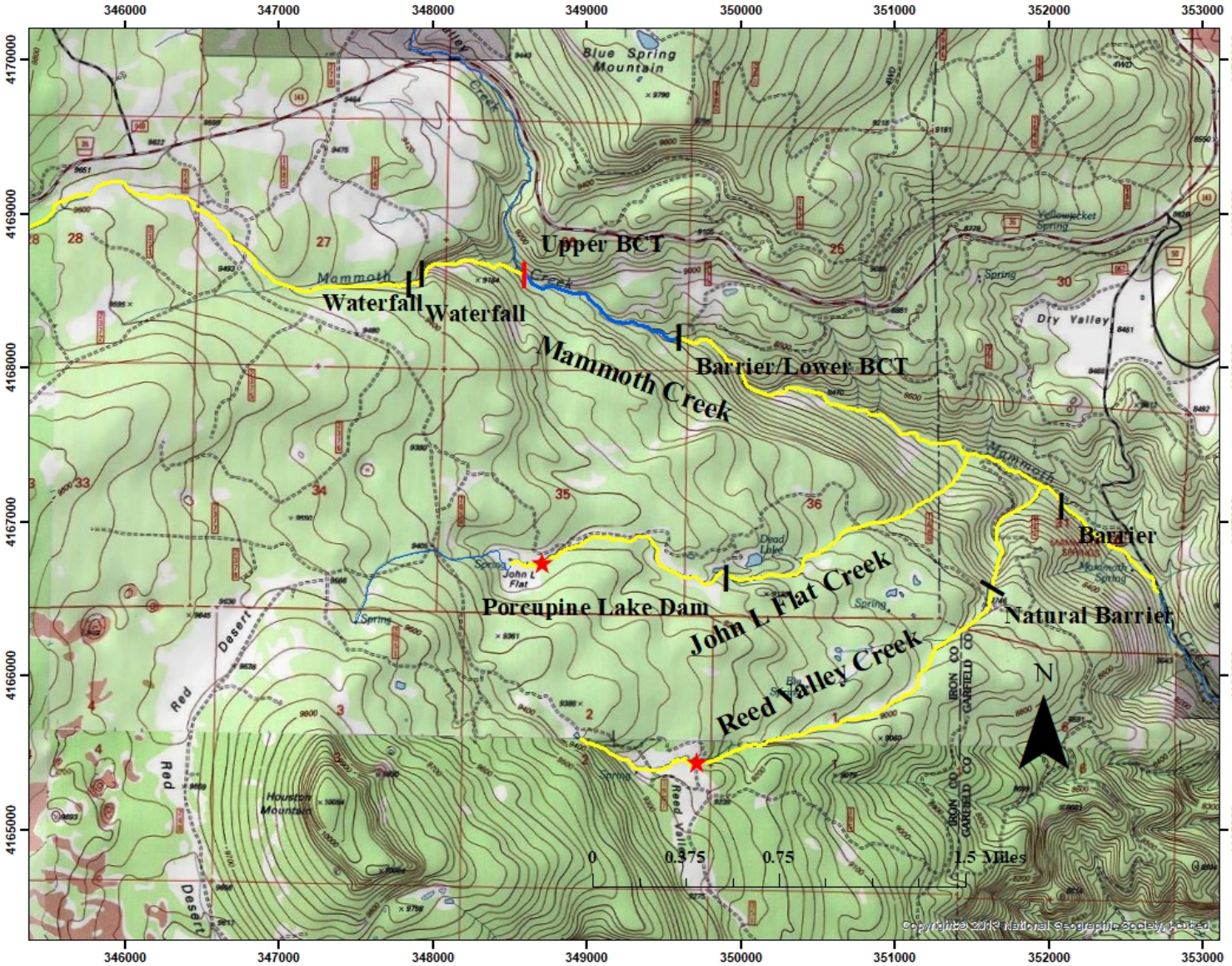

Figure A2. Locations of barriers, current BCT distribution, potential BCT distribution (yellow highlight), and 2021 fingerling BCT stocking sites (red stars) in the Mammoth Creek middle reach, John L Flat Creek, and Reed Valley Creek.

Meadow Lake Creek—NATIVE TROUT POPULATION SURVEY

1. General Information— Date: **Fall 2021** Biologist: **M. Hadley**
2. Stream Information—
   Name, catalog #, section, county: **Meadow Lake Creek, VI AA 780H, 01, Iron**
3. Survey Site Information (see attached map)—
   Upstream range of native trout (general description and UTM): **NA**
   Downstream range of native trout (general description and UTM): **NA**
   Location (UTM) and description of barriers: **None**
   Stream Length—Occupied habitat: **>0 km (>0 mi)[1]** Available habitat: **2.35 km (1.46 mi)[2]**
   Survey method & equipment: **Rotenone treatments and recon; BCT stocking.**
   Survey sites (general description and UTM)—**Surveys not conducted in 2021 due to ongoing removal of nonnative trout and restoration of BCT.**
4. Comments:

[1] – Fingerling BCT stocked in Meadow Lake and in stream above lake in fall 2021.
[2] – From Mammoth Creek confluence upstream to springs above Meadow Lake.

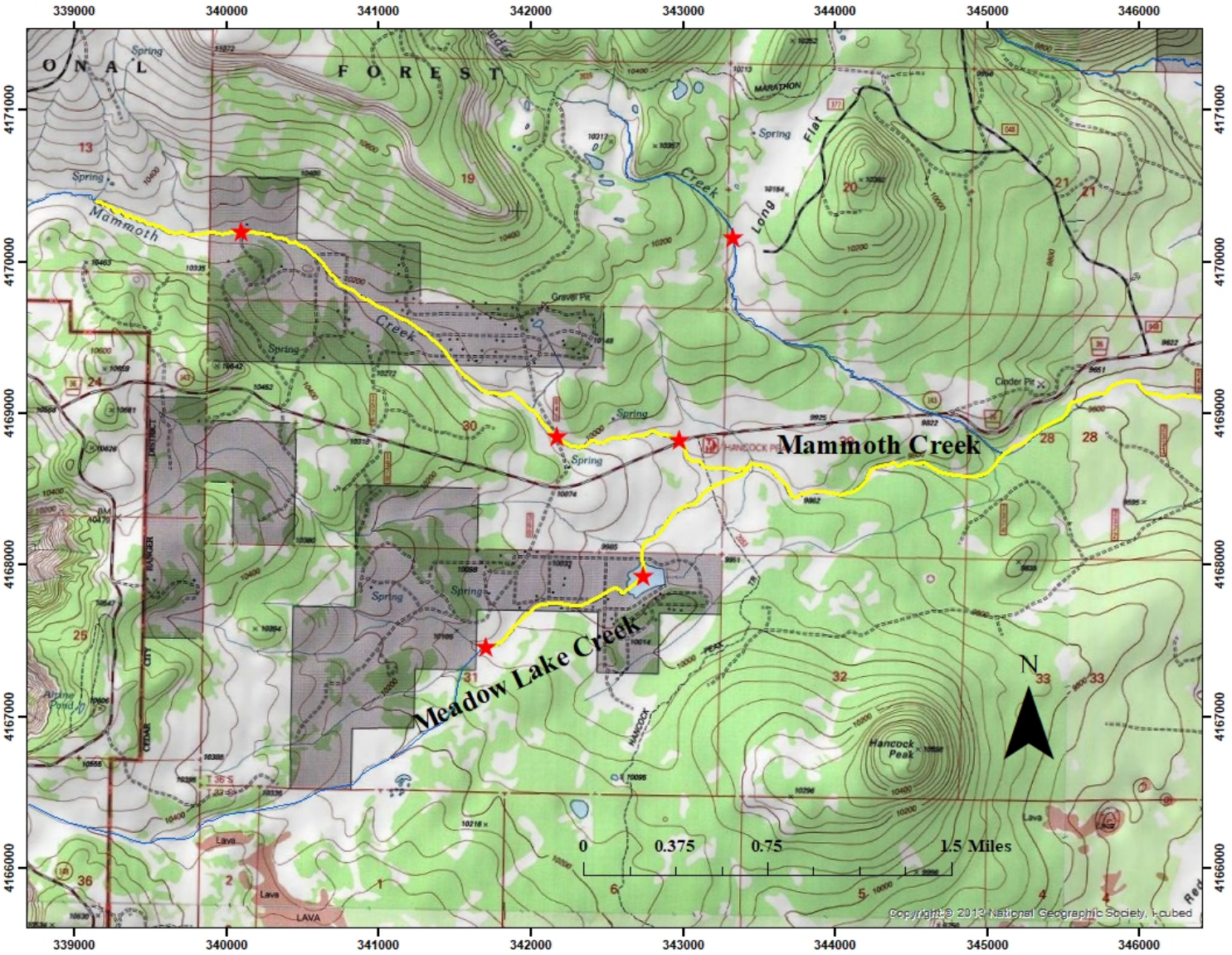

Figure A3. Locations of potential BCT distribution (yellow highlight) and 2021 fingerling BCT stocking sites (red stars) in the Mammoth Creek headwater reach and Meadow Lake Creek.

Castle Creek—NATIVE TROUT POPULATION SURVEY

1. General Information— Date: **July 15 and 19, 2021** Biologist: **M. Hadley, M. Golden**
2. Stream Information—
   Name, catalog #, section, county: **Castle Creek, VI AA 780D, 01, Iron**
3. Survey Site Information (see attached map)—
   Upstream range of native trout (general description and UTM): **Confluence of headwater springs—120343565E 4174587N**
   Downstream range of native trout (general description and UTM): **Mammoth Creek confluence**
   Location (UTM) and description of barriers: **Constructed barrier near UT143—120348418E 4169807N; constructed barrier in Deer Creek ditch—120348233E 4171243N**
   Stream Length—Occupied habitat: **10.62 km (6.60 mi)** Available habitat: **12.01 km (7.46 mi)[1]**
   Survey method & equipment: **backpack battery electrofisher; multiple-pass deletion**
   Survey sites (general description and UTM)—
      Station 1: **Lower Castle Valley; 120347896E 4170230N**
      Station 2: **Lower Sidney Valley; 120344131E 4172148N**
      Station 3: **Upper Sidney Valley, in grazing exclosure; 120343967E 4172729N**

Parameter	**Station 1**	**Station 2**	**Station 3**
Station length (m)	100 m	100 m	100 m
Mean stream width (m) (n)	1.08 m (10)	2.48 m (10)	1.68 m (10)
Station area (hectares)	0.0108 ha	0.0180 ha	0.0168 ha
BCT			
Removal Pattern	0	20 0	25 5
Population estimate (95 % CI)	0 (NA)	20 (NA)	30 (±2)
Capture probability	NA	1.000	0.857
Mean length (mm) (n)	NA	226 (20)	236 (30)
Mean weight (g) (n)	NA	130 (20)	155 (30)
Mean KTL (n)	NA	1.10 (20)	1.13 (30)
Number fish per km (95 % CI)	0 (NA)	200 (NA)	300 (±20)
Number fish per ha (95 % CI)	0 (NA)	808 (NA)	1,789 (±119)
Biomass (kg per ha) (95 % CI)	0 (NA)	105 (NA)	277 (±18)

4. Comments: [1] – Includes 1.38 km (0.86 mi) in the Deer Creek ditch where BCT have not yet been introduced.

Other species sampled:

Station 1 tiger trout –
Fish per km – 30 (±10)
Fish per ha – 277 (±92)
Biomass – 124 (±41)

Station 3 tiger trout –
Fish per km – 50 (NA)
Fish per ha – 298 (NA)
Biomass – 74 (NA)

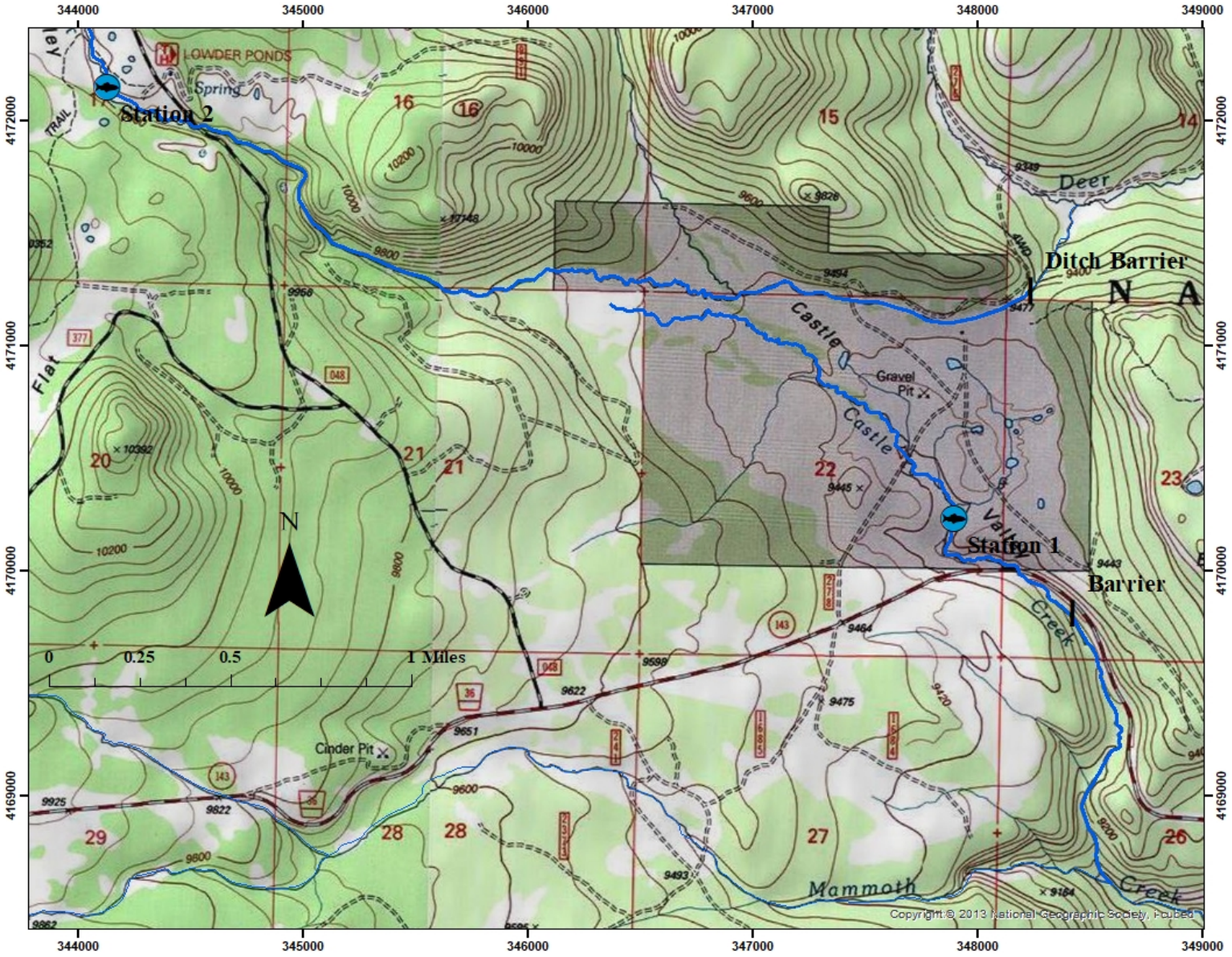

Figure A4. Locations of barriers, survey stations, and BCT distribution in lower Castle Creek.

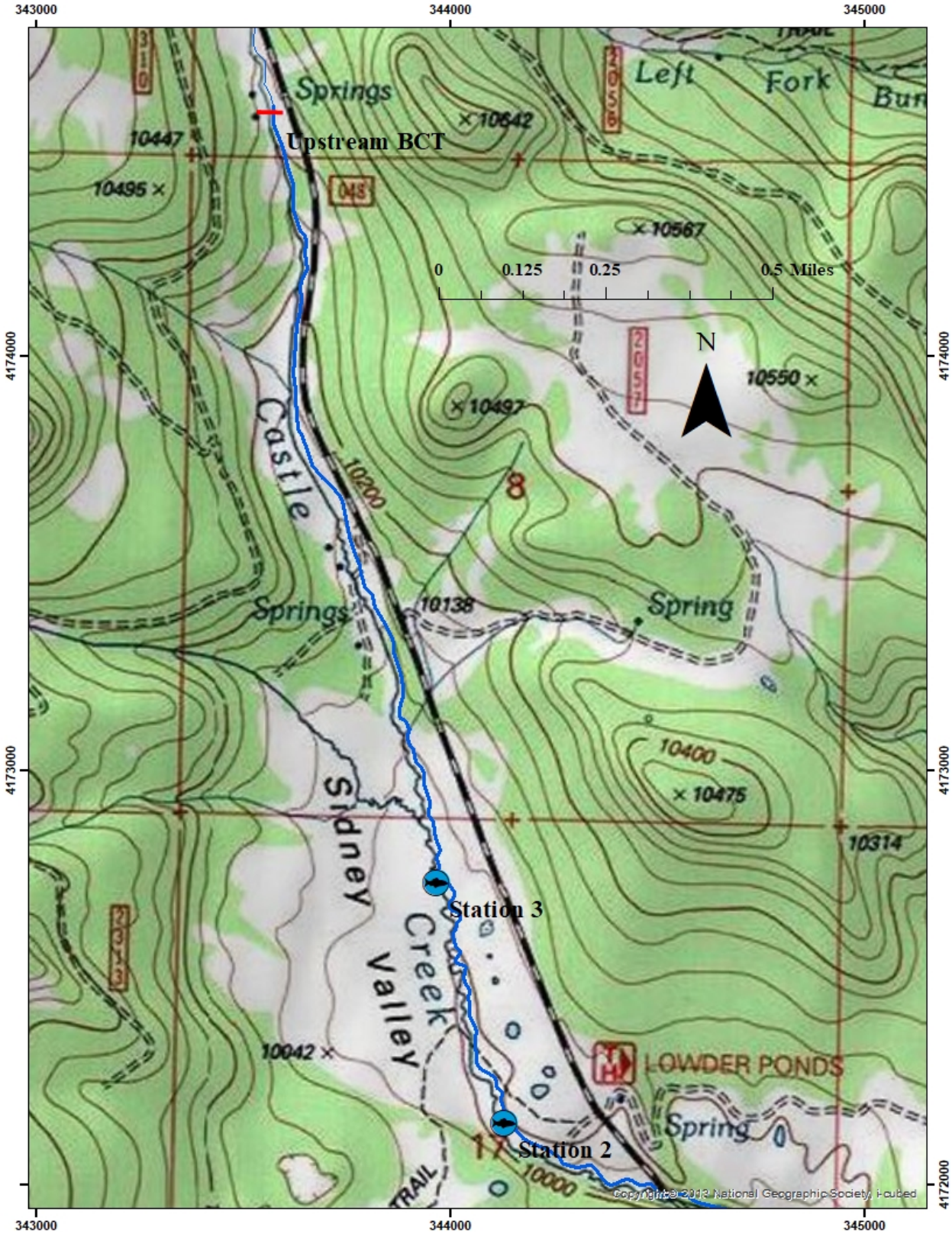

Figure A5. Locations of survey stations and BCT distribution in upper Castle Creek.

Lowder Creek—NATIVE TROUT POPULATION SURVEY

1. General Information— Date: **July 19, 2021** Biologist: **M. Hadley**
2. Stream Information—
   Name, catalog #, section, county: **Lowder Creek, VI AA 780E, 01, Iron**
3. Survey Site Information (see attached map)—
   Upstream range of native trout (general description and UTM): **NA**
   Downstream range of native trout (general description and UTM): **NA**
   Location (UTM) and description of barriers: **Constructed barrier near UT143—120344853E 4168921N**
   Stream Length—Occupied habitat: **>0 km (>0 mi)[1]** Available habitat: **up to 3.57 km (2.22 mi)[2]**
   Survey method & equipment: **backpack battery electrofisher; single-pass census**
   Survey sites (general description and UTM)—
      Station 1: **Long Flat; 120343329E 4169832N**

Parameter	**Station 1**
Station length (m)	100 m
Mean stream width (m) (n)	0.83 m (10)
Station area (hectares)	0.0083 ha
BCT	
Removal Pattern	0
Population estimate (95 % CI)	0 (NA)
Capture probability	NA
Mean length (mm) (n)	NA
Mean weight (g) (n)	NA
Mean KTL (n)	NA
Number fish per km (95 % CI)	0 (NA)
Number fish per ha (95 % CI)	0 (NA)
Biomass (kg per ha) (95 % CI)	0 (NA)

4. Comments: One BCT and two tiger trout observed in Lowder Creek just downstream of Lowder Pond on July 20, 2021.

[1] – Fingerling BCT stocked in Long Flat in fall 2021.

[2] – From Mammoth Creek confluence upstream to Lowder Pond.

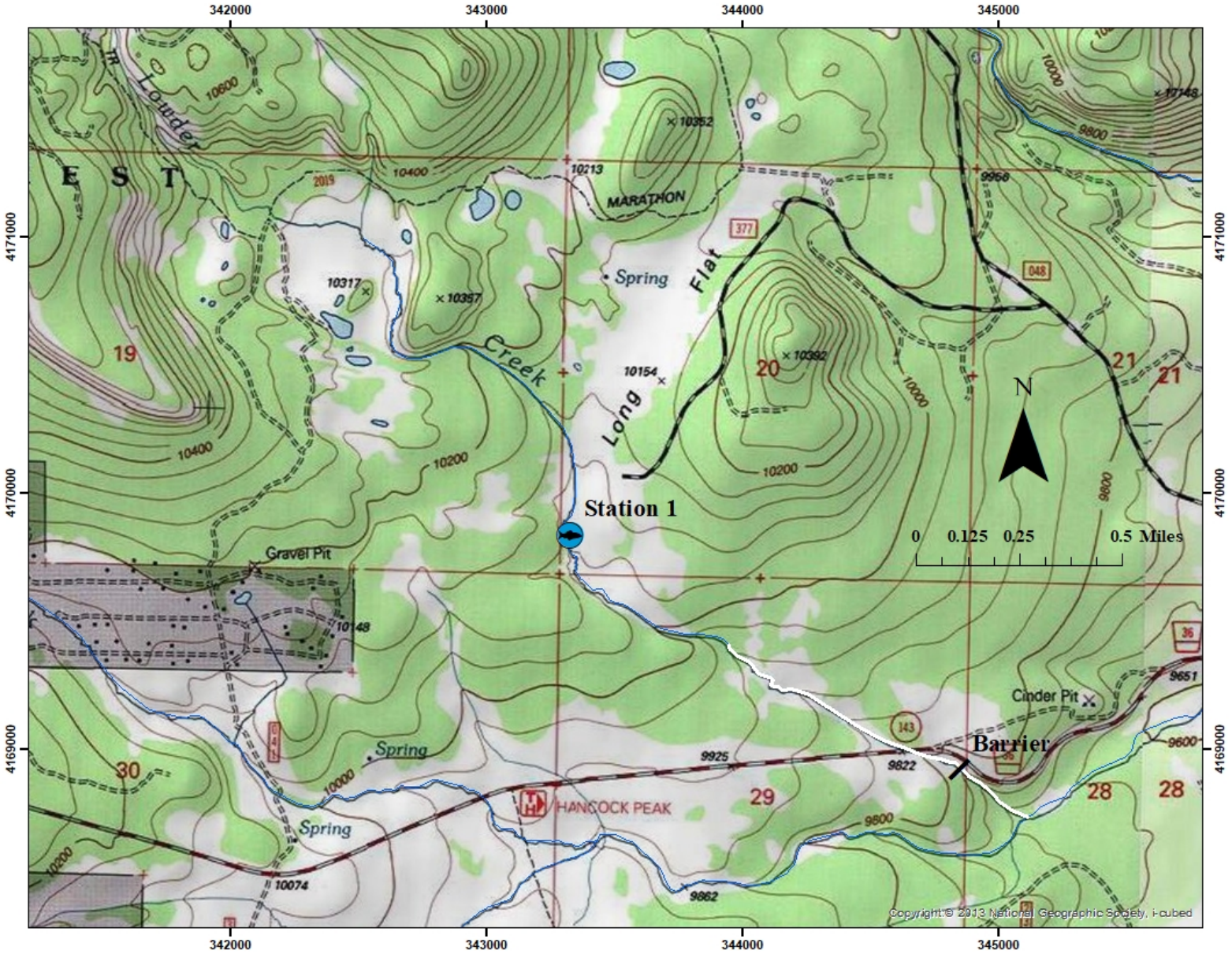

Figure A6. Locations of survey stations, barriers, and 2021 dry reach (white highlight) in Lowder Creek.

Threemile Creek—NATIVE TROUT POPULATION SURVEY

1. General Information— Date: **July 8, 2021** Biologist: **M. Roundy**
2. Stream Information—
   Name, catalog #, section, county: **Threemile Creek, VI AA 680, 01, Garfield**
3. Survey Site Information (see attached map)—
   Upstream range of native trout (general description and UTM): **NA**
   Downstream range of native trout (general description and UTM): **NA**
   Location (UTM) and description of barriers: **Constructed barrier at BLM road crossing— 120369113E 4191419N**
   Stream Length—Occupied habitat: **0 km (0 mi)** Available habitat: **up to 10.58 km (6.57 mi)**
   Survey method & equipment: **backpack battery electrofisher; single-pass census**
   Survey sites (general description and UTM)—
      Station 1: **Just upstream of Forest boundary; 120367571E 4192155N**
      Station 2: **~2.6 km (1.6 mi) upstream of Station 1; 120364618E 4192126N**
      Station 3: **Just upstream of confluence w/ Delong Creek; 120363337E 4191759N**

Parameter	**Station 1**	**Station 2**	**Station 3**
Station length (m)	100 m	100 m	100 m
Mean stream width (m) (n)	1.14 m (10)	1.57 m (10)	1.23 m (10)
Station area (hectares)	0.0114 ha	0.0157 ha	0.0123 ha
BCT			
Removal Pattern	0	0	0
Population estimate (95 % CI)	0 (NA)	0 (NA)	0 (NA)
Capture probability	NA	NA	NA
Mean length (mm) (n)	NA	NA	NA
Mean weight (g) (n)	NA	NA	NA
Mean KTL (n)	NA	NA	NA
Number fish per km (95 % CI)	0 (NA)	0 (NA)	0 (NA)
Number fish per ha (95 % CI)	0 (NA)	0 (NA)	0 (NA)
Biomass (kg per ha) (95 % CI)	0 (NA)	0 (NA)	0 (NA)

4. Comments: Impacted by 2017 Brian Head Fire.

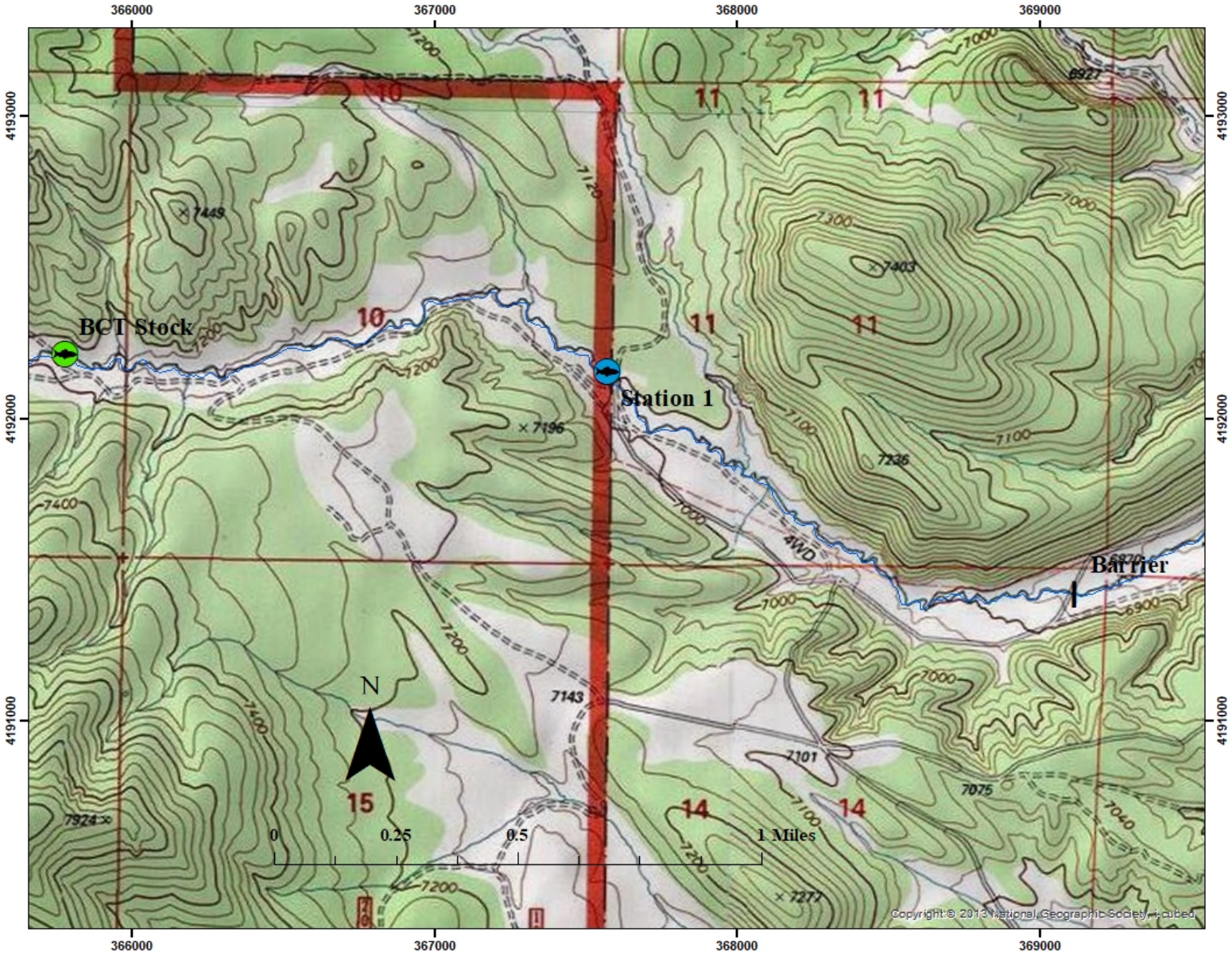

Figure A7. Locations of survey stations, barriers, and BCT stocking site in lower Threemile Creek.

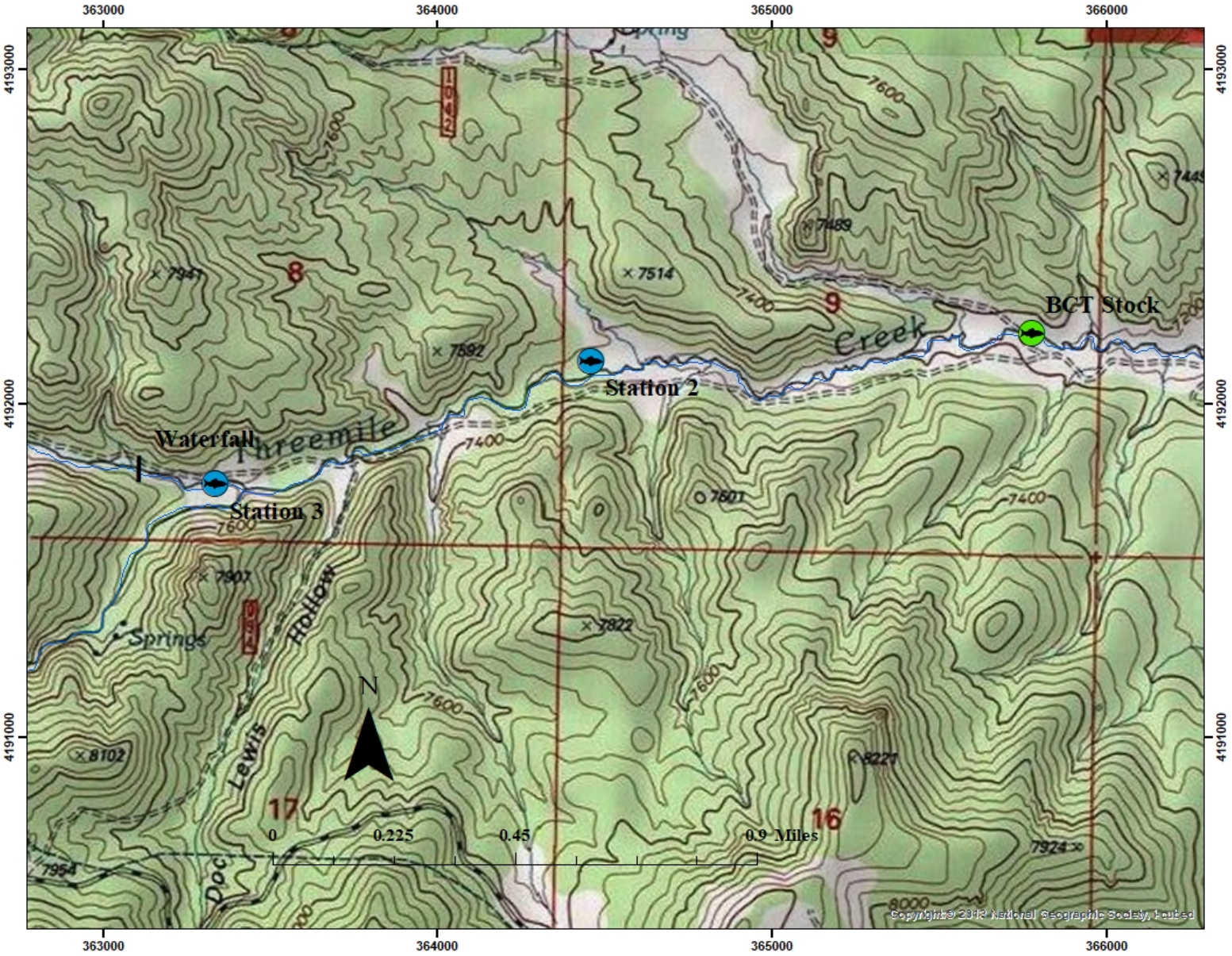

Figure A8. Locations of survey stations and barriers in upper Threemile Creek.

Delong Creek—NATIVE TROUT POPULATION SURVEY

1. General Information— Date: **July 8 and 20, 2021** Biologist: **M. Golden, M. Roundy**
2. Stream Information—
   Name, catalog #, section, county: **Delong Creek, VI AA 680A, 01, Garfield**
3. Survey Site Information (see attached map)—
   Upstream range of native trout (general description and UTM): **NA**
   Downstream range of native trout (general description and UTM): **NA**
   Location (UTM) and description of barriers: **Waterfall 1.2 km upstream of Threemile confluence--120362594E 4191206N; waterfall just west of Iron-Garfield county line--120360712E 4191188N**
   Stream Length—Occupied habitat: **0 km (0 mi)** Available habitat: **up to 4.51 km (2.80 mi)**
   Survey method & equipment: **backpack battery electrofisher; single-pass census**
   Survey sites (general description and UTM)—
      Station 1: **Just upstream of Threemile confluence; 120363321E 4191704N**
      Station 2: **Just upstream of Indian Hollow confluence; 120362348E 4190712N**

Parameter	**Station 1**	**Station 2**
Station length (m)	100 m	100 m
Mean stream width (m) (n)	1.41 m (10)	1.09 m (10)
Station area (hectares)	0.0141 ha	0.0109 ha
BCT		
Removal Pattern	0	0
Population estimate (95 % CI)	0 (NA)	0 (NA)
Capture probability	NA	NA
Mean length (mm) (n)	NA	NA
Mean weight (g) (n)	NA	NA
Mean KTL (n)	NA	NA
Number fish per km (95 % CI)	0 (NA)	0 (NA)
Number fish per ha (95 % CI)	0 (NA)	0 (NA)
Biomass (kg per ha) (95 % CI)	0 (NA)	0 (NA)

4. Comments: Impacted by 2017 Brian Head Fire.

Indian Hollow—NATIVE TROUT POPULATION SURVEY

1. General Information— Date: **July 20, 2021** Biologist: **M. Golden**
2. Stream Information—
   Name, catalog #, section, county: **Indian Hollow, VI AA 680A 01, 01, Garfield**
3. Survey Site Information (see attached map)—
   Upstream range of native trout (general description and UTM): **NA**
   Downstream range of native trout (general description and UTM): **NA**
   Location (UTM) and description of barriers: **None**
   Stream Length—Occupied habitat: **0 km (0 mi)** Available habitat: **up to 1.30 km (0.81 mi)**
   Survey method & equipment: **backpack battery electrofisher; single-pass census**
   Survey sites (general description and UTM)—
      Station 1: **Just upstream of Delong Creek confluence; 120362381E 4190538N**

Parameter	**Station 1**
Station length (m)	100 m
Mean stream width (m) (n)	1.07 m (10)
Station area (hectares)	0.0107 ha
BCT	
Removal Pattern	0
Population estimate (95 % CI)	0 (NA)
Capture probability	NA
Mean length (mm) (n)	NA
Mean weight (g) (n)	NA
Mean KTL (n)	NA
Number fish per km (95 % CI)	0 (NA)
Number fish per ha (95 % CI)	0 (NA)
Biomass (kg per ha) (95 % CI)	0 (NA)

4. Comments: Impacted by 2017 Brian Head Fire.

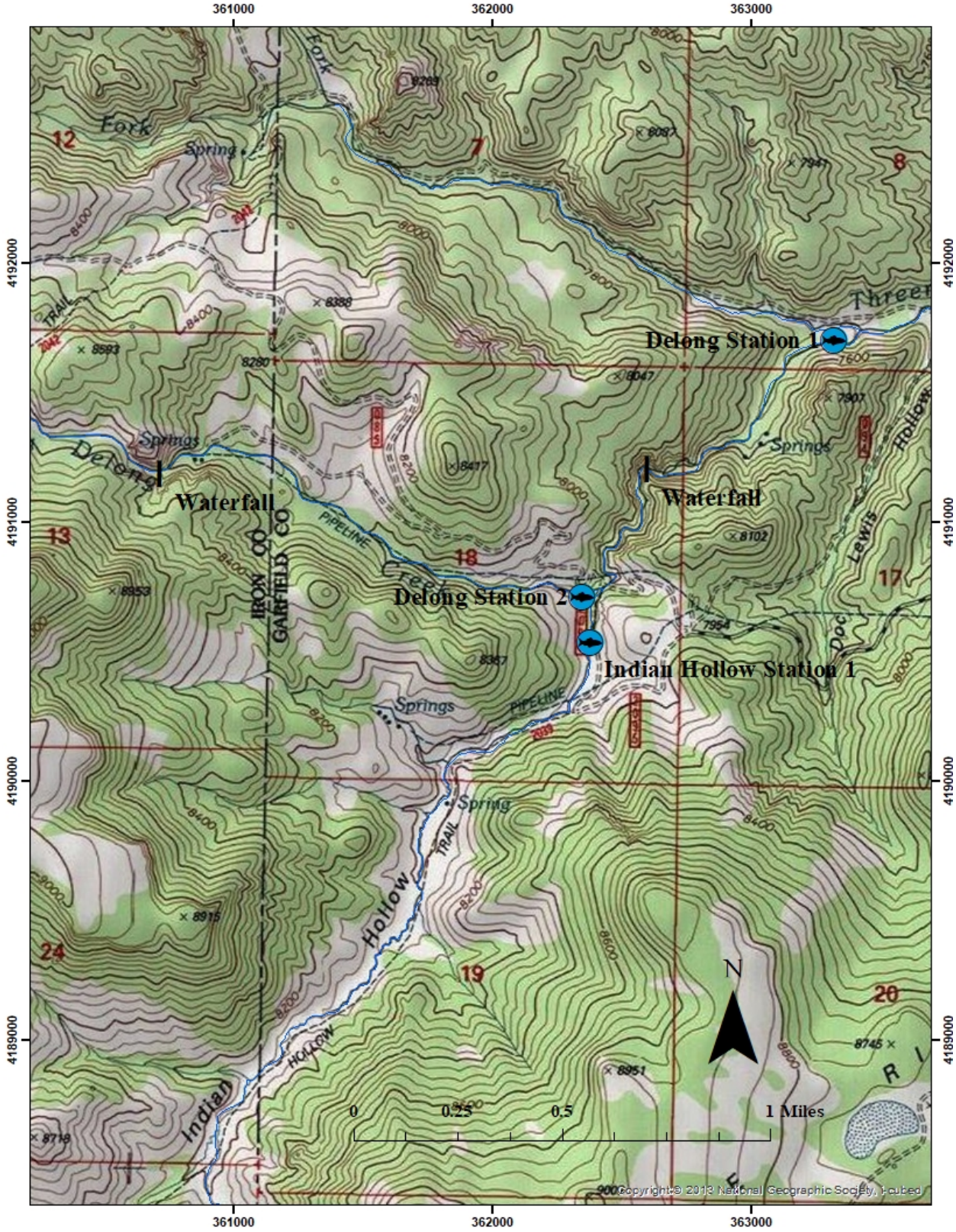

Figure A9. Locations of survey stations and barriers in Delong Creek and Indian Hollow.