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Collaboration, Commitment, and Adaptive Learning Enable Eradication of Nonnative Trout and Establishment of Native Westslope Cutthroat Trout into One-Hundred Kilometers of Cherry Creek, a Tributary to the Madison River, Montana

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Abstract.—A collaborative group of fisheries managers and researchers (Cherry Creek Working Group) took advantage of an 8-m waterfall, 100 km of upstream habitat, and a 3 ha-lake to eradicate nonnative trout and introduce native Westslope Cutthroat Trout (WCT) *Oncorhynchus clarkii lewisi* in Cherry Creek, a tributary to the Madison River. This project was part of a larger, broad-scale effort to restore WCT within the Madison River basin. The project was logistically and politically complex and required long-term commitments by

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state and federal agencies, a private landowner, nongovernmental partners and university researchers. We describe and discuss the social, legal, and logistical challenges that arose during this project and provide our perspective on why this project succeeded in spite of these challenges. Administrative and legal challenges delayed implementation of the project for several years, but all challenges were resolved in favor of the project's collaborators. Over a 12-year period, nonnative trout occupying the area were eradicated using piscicides, and more than 39,000 WCT eyed eggs and fry were introduced into four geographic areas (phases) that were separated by natural or temporary fish barriers. Population recovery, measured by comparing pre- and post-treatment trout densities and mean sizes, appeared to occur in 3–4 years. We summarize research that documents the effects of piscicides on nontarget species and the expansion of introduced WCT and their progeny to fill all available habitats, along with lessons learned that are helpful to others designing species conservation efforts of similar scale and complexity.

Introduction

At the time of initial European exploration into western North America, Westslope Cutthroat Trout (WCT) *Oncorhynchus clarkii lewisi* were distributed across most accessible waters draining the northern portion of the Rocky Mountains in Idaho, Montana, and Wyoming, USA (Figure 1), and southern Alberta and British Columbia, Canada, including a few disjunct areas to the west (Behnke 1992). Subsequently, humans have affected the quality, availability, and connectivity of their habitat; introduced numerous nonnative species into waters they historically occupied; and occasionally overharvested them. By the early 1990s, WCT had been lost from an estimated 40% of their historical habitats, and populations with little to no evidence or suspicion of hybridization occupied less than 25% of their historical habitats in the United States (Shepard et al. 2005). The decline in WCT throughout their native range led to several petitions for listing them in the United States under the Endangered Species Act (ESA; e.g., USFWS 2003), being listed as threatened in Canada (COSEWIC 2006) and designated as a species of special conservation concern by many fish and habitat management agencies. The Montana Natural Heritage Program lists WCT as "apparently secure and/or suspected to be declining" globally (G4) but a "species of concern" (S2) within the state.

In Montana, WCT are native in most waters west of the Continental Divide, and east of the Divide they are native in the Missouri River drainage upstream of the Marias River and in some disjunct island mountain ranges in central Montana (Figure 1). They historically occupied about 28,000 km of habitat within the Missouri River basin, but by the 1990s, they occupied only about 1,700 km (6% of historical stream kilometers) and were primarily restricted to relatively small headwater tributaries (Shepard et al. 1997, 2003). In the Madison River drainage, WCT historically occupied slightly less than 2,000 km, but by the 1990s they only occupied about 80 km (4% of historical stream kilometers; Shepard et al. 2003). The level of introgression of many of these populations was unknown. We know with near certainty that by 2003, genetically pure aboriginal Madison WCT occupied only about 4 km of stream in two locations, each with base flows of less than 0.03 m^3/s. Habitat alteration and competition and introgression with nonnative species were primary agents of these declines.

Montana Fish, Wildlife & Parks (MFWP) is the agency responsible for conservation, stewardship, and management of all fish species within Montana. To address the

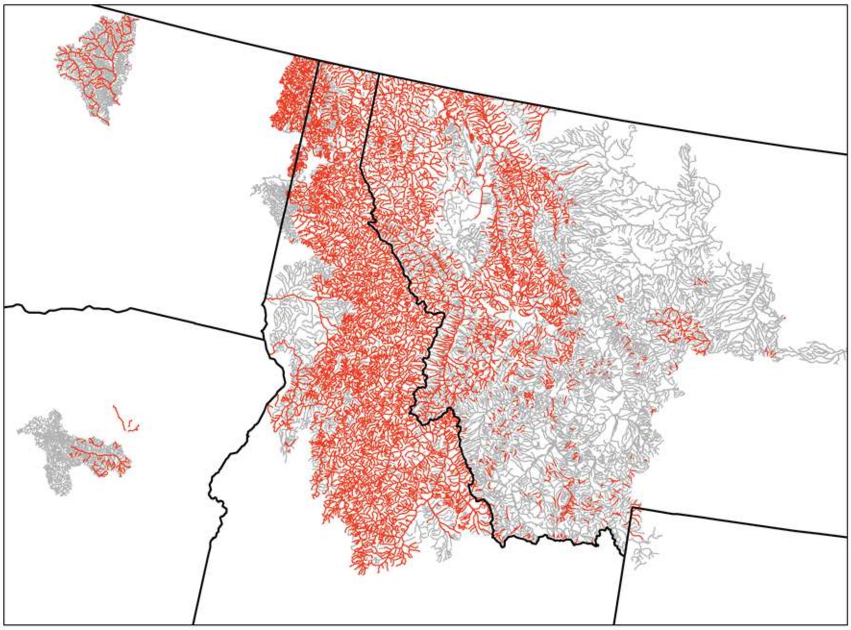

Figure 1. Westslope Cutthroat Trout historical (gray) and current (2005) distribution, from Shepard et al. 2005.

declining status of WCT, MFWP held a series of open forum meetings beginning in 1996 when the state's governor convened a conservation summit and invited representatives from state and federal agencies, Indian tribes, agricultural producers, resource extraction industries, conservation organizations, and private landowners to attend and become involved in WCT conservation. These meetings led to the formation of a Westslope Cutthroat Trout Steering Committee, composed of representatives of many of these varied interests, and a Technical Committee, composed of fisheries professionals who served as technical advisors to the Steering Committee. The Steering Committee used scientific information provided by the Technical Committee and considered social and economic issues to make policy recommendations to MFWP.

One such policy was a formal *Memorandum of Understanding and Conservation Agreement for Westslope Cutthroat Trout in Montana* (WCTMOU; MFWP 1999). The WCTMOU identifies conservation and restoration goals and objectives for WCT in Montana, and states,

> The management goal for Westslope Cutthroat Trout in Montana is to ensure the long-term, self-sustaining persistence of the subspecies within each of the five major river drainages they historically inhabited in Montana (Clark Fork, Kootenai, Flathead, upper Missouri, and Saskatchewan), and to maintain the genetic diversity and life history strategies represented by the remaining populations.

Specific objectives detailed in the WCTMOU are

1. To protect all genetically pure WCT populations,
2. To protect introgressed (<10% introgressed) populations,
3. To ensure the long-term persistence of WCT within their native range,
4. To provide technical information, administrative assistance, and financial

resources to assure compliance with listed objectives and encourage conservation of WCT, and

5. To design and implement an effective monitoring program by the year 2002 to document persistence and demonstrate progress towards goal.

Objective 3 further states,

> The long-term persistence of Westslope Cutthroat Trout within their native range will be ensured by maintaining at least ten population aggregates throughout the five major river drainages in which they occur, each occupying at least 50 mi of connected habitat.

The Cherry Creek project offered an opportunity to restore WCT to nearly 100 km (60 mi) of connected habitats and help meet this WCTMOU objective for long-term persistence of the subspecies.

The WCTMOU was updated in 2007 and coupled with a similar document for Yellowstone Cutthroat Trout (YCT) *Oncorhynchus clarkii bouvieri* called the Memorandum of Understanding and Conservation Agreement for Cutthroat Trout in Montana (CTMOU; MFWP 2007). Additional conservation, tribal, agency and resource extraction interest groups joined with the original signatories to support the updated conservation agreement.

In this chapter we describe and summarize the genesis of the Cherry Creek project, the challenges faced and how they were resolved, the methodology of our piscicide treatments and fish and embryo translocations, why we believe the project was successful, how we incorporated research and monitoring efforts into the project, and the monitoring and research results to date. Because the Cherry Creek project is one of the largest native trout conservation projects successfully completed to date, it was instrumental in paving the way for additional large-scale native trout restoration projects in Montana and across the range of interior Cutthroat Trout. One important goal of the project's collaborators (Cherry Creek Working Group [CCWG]) is sharing our experiences and lessons we learned while implementing this project. We summarize these lessons in each section of the project for ease of reference.

Project Area

The Cherry Creek drainage is a fifth-level hydrologic unit code (HUC) waterway (HUC number 1002000714; USGS 2018) and is the largest tributary volumetrically in the lower 65 km of the Madison River. The project area ranges in elevation from approximately 2,652 m mean sea level (msl) at the headwaters of Cherry Lake to 1,539 m msl at the barrier waterfall, and approximately 1,350 m msl at its confluence with the Madison River. There are an estimated 145 km of stream above an 8-m barrier waterfall (Cherry Creek Falls; Figure 2), mostly in first- and second-order drainages (National Hydrography Dataset; USGS 2013). The waterfall is approximately 13 km upstream of the Cherry Creek confluence with the Madison River.

Historically fishless above the barrier waterfall, the only known fish introduction in the project area occurred in 1924, when fry of an unknown species were planted in Cherry Lake by a forest ranger along with the Flying D Ranch manager and his 10-year-old son (as related to MFWP personnel by the son when he was 90 years old). The following year, the boy caught YCT in Cherry Lake. We suspect that Rainbow Trout *Oncorhynchus mykiss* and Brook Trout *Salvelinus fontinalis* were introduced into the drainage by ranch hands or sportsmen over time. Based on pretreatment distributions determined by electrofishing, we estimate that about 100 of the 145 km of streams in the project area were occupied by nonnative Rainbow Trout, YCT, and/or Brook Trout prior to eradication (Figure 3). No other fish species occupied the project area.

Land ownership within the project area is both public and private. Phase 1 (Figure

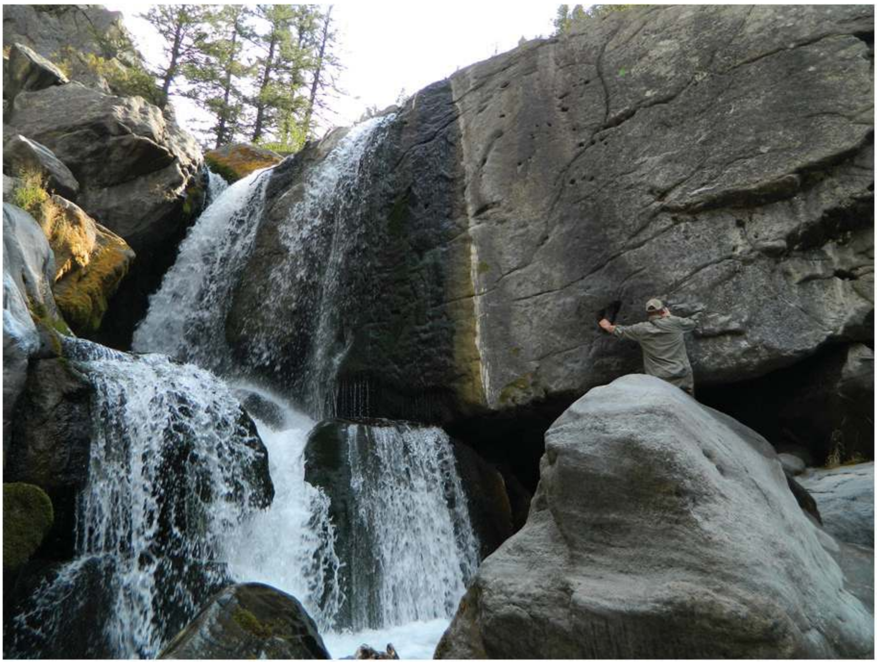

Figure 2. Cherry Creek waterfall at stream kilometer 13. This waterfall is the downstream extent of the project area.

3) of the project area is primarily managed by the Gallatin National Forest (GNF), while Turner Enterprises, Inc.'s (TEI) Flying D Ranch encompasses most of Phases 2–4. State of Montana lands are also present. Turner Enterprises, Inc. manages the Flying D Ranch for bison production, timber extraction, and commercial hunting while promoting conservation and restoration of native species and their habtats. Conservation work has included riparian and range restoration, forest management, wolf and native fish restoration, and other similar activities. About 44,500 of the 47,400 ha of the ranch are under conservation easement with The Nature Conservancy. The GNF lands are managed primarily for recreation and livestock grazing. A small portion of the project area (Cherry Lake, its inlet streams, and a short section of its outlet stream) lies within the Lee Metcalf Wilderness Area.

Due to the large size of the project area, we broke the area into smaller sections, or phases, for treatment. Natural or manmade barriers were used to separate the phases and prevent fish in untreated downstream phases from migrating upstream into treated phases between years (Figure 3). Phase 1 was isolated from the remainder of the watershed by two natural waterfalls. We converted two irrigation weir sites into barriers between Phases 2 and 3 (hereafter, the Phase-2 barrier) and Phases 3 and 4 (hereafter, the Phase-3 barrier).

The Phase-2 barrier site was a removable pin-and-plank irrigation diversion structure with concrete sidewalls and apron. With planks removed, this weir did not impede upstream movement of aquatic organisms prior to modification in November 2004 for this project. To make this site a fish passage barrier, six 20 cm × 20 cm × 6 m treated beams were bolted together, placed with a backhoe against the upstream side of the concrete sidewalls, and covered with fine-mesh coconut fiber mat to capture

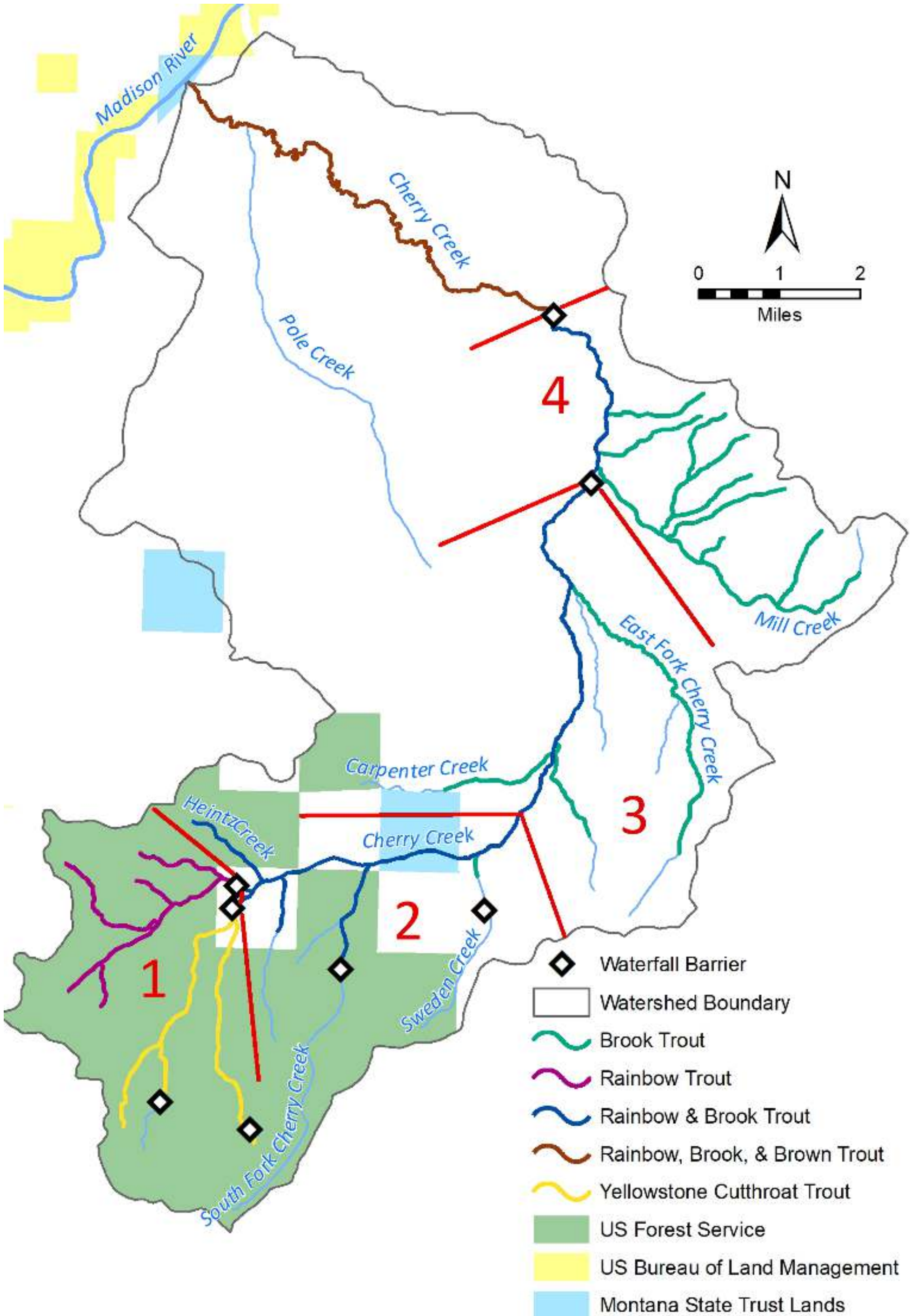

Figure 3. Map of the Cherry Creek drainage showing 2002 pretreatment fish distributions and phases. The downstream extent of the project area is a waterfall 13 stream kilometers upstream of the Cherry Creek mouth. The only fish species in the project area were Brook Trout, Rainbow Trout, and Yellowstone Cutthroat Trout.

and hold fine sediment to prevent seepage between and around the beams. Height of the constructed barrier was ~1.2 m, the maximum site topography would allow but not sufficient to prevent fish passage. Thus, a screen constructed of angle iron and aluminum electrical conduit was bolted at an angle to the downstream face of the barrier in July 2005 to block fish attempting to leap over the barrier. The angled screen allowed most debris to wash off. Although of modest height, we never saw or documented a fish passing over this temporary barrier with the screen attached during the project. Just upstream from this barrier site, a small side channel that flowed around the barrier site was disconnected from the main stem by placing concrete highway jersey barriers at the upstream end of the side channel and covering with fine-mesh coconut fiber mat secured along their base with stream gravel. This effectively dewatered the side channel.

The Phase-3 barrier site included a permanent 1.2-m concrete irrigation weir spanning the entire Cherry Creek stream channel with a 5-m-long downstream concrete apron, as well as a large off-channel spring that created a side channel of about 0.14 m^3/s adjacent to Cherry Creek starting above the concrete weir site and entering Cherry Creek immediately below the weir. Although the spring channel is isolated from the main stream channel above the weir during low flow periods, we were concerned that overbank flows could connect the spring channel to Cherry Creek and fish passage around the weir barrier; thus, a small, wooden temporary barrier was constructed near the mouth of the spring channel in summer 2006, about 1 year prior to the initial chemical treatment of Phase 3. This irrigation diversion site is a partial impediment to upstream aquatic organism passage, and the structure has caused streambed deposition that, over time, resulted in significant aggradation of the stream channel bed upstream of the weir. In September 2008, a 30-cm beam was attached to the top of this weir, raising its height to 1.5 m. Modeling based on water depth on the apron and fish jumping ability indicated that the barrier height alone was adequate to prevent upstream fish passage; thus, a screen was not attached to the downstream face of the Phase-3 barrier at that time.

The geology around this Phase-3 barrier site creates a unique localized flow and temperature dynamic in Phase 4 of Cherry Creek. During July and August, much of the flow in Cherry Creek above the concrete weir goes subsurface and the channel can be completely dry in August during normal or below average flow years. Subsurface water loss begins several km above the barrier site but increases substantially as it approaches the barrier. When present, the dewatered reach is typically 1–1.5 km in length just above the barrier site. Much of the water returns to the surface in a number of in- and off-channel springs within the immediate vicinity of the weir, including the spring we constructed the barrier on in 2006, contributing approximately 0.45 m^3/s to stream discharge within a 180-m reach upstream of and adjacent to the weir. These springs moderate water temperature, maintaining the stream temperature downstream of this site at about 10–13°C during the summer months.

Once we felt sure that we had achieved nonnative trout eradication, these two temporary barrier sites were restored to their original pretreatment condition in 2011. The Phase-2 main- and side-channel barriers were removed, the 30-cm beam was removed from the top of the Phase-3 barrier, and the wooden barrier on the adjacent spring channel was removed and all disturbed areas reclaimed. Consideration was given to completely removing the concrete weir at the Phase-3 barrier, but the 1.2-m differential in streambed elevation would have led to significant sediment transport, turbidity, and channel change, even if weir removal was done incrementally. Removal of the weir could also have affected the springs that maintain streamflow and cooler water temperatures year-round through much of Phase 4. Alternatively, in 2016, two large rock step pools were constructed downstream of the concrete weir (Figure 4). These pools improved aquatic organism passage by reducing the jump height over the weir from about 1.2 m to about 46 cm.

Mistakes, learning experiences, and innovations

We initially thought the existing 1.2-m irrigation weir between Phases 3 and 4 would serve as a fish movement barrier, but we discovered adult fish, primarily Rainbow Trout, in the lower portion of Phase 3 in spring 2008 and 2009 after Phase-3 chemical treatments in 2007 and 2008. The 30-cm beam was secured to the top of the concrete weir in September 2008. Nevertheless, during spring runoff in 2009, fish were observed jumping from the standing wave at the toe of the barrier and swimming up the laminar water flow and over the Phase-3 barrier, necessitating a third piscicide treatment of a portion of Phase 3 in 2009. An inclined screen was subsequently added to the barrier in July 2009, and after this screen was added, no additional fish were documented passing the barrier. We discovered that even though modeling may conclude that a barrier will effectively prevent fish passage, it does not guarantee that fish will not be able to pass the structure. Monitoring and direct observation were critical to identifying the ability of fish to pass this partial barrier and for modifying it into a complete barrier. Having the resources in place to be able to quickly address the problem was also critical.

With the experience gained on the Cherry Creek project, we feel that we can now chemically treat larger areas more expeditiously than we did during this project, potentially reducing or eliminating the need for barriers while reclaiming large subdrainages, drainages, or watersheds for native fish conservation.

Project Genesis and Environmental Analyses

An important catalyst for the Cherry Creek project occurred about 10 years before the project was conceived. In the late 1980s, whirling disease *Myxobolus cerebralis* was introduced into the Madison River, likely through an illegal Rainbow Trout introduction. Routine monitoring of trout populations in the Madison River detected a widespread and significant decline of the

Figure 4. Pre (left) and post (right) photos of Phase-3 barrier showing the results of step pool construction.

Rainbow Trout population upstream of Ennis, Montana by 1991, and by 1996, the number of Rainbow Trout larger than 300 mm decreased from a long-term average of 620/km to 125/km (Clancey 1997). Angler success, commercial outfitting, and other businesses in Ennis and surrounding communities suffered significantly due to the diminished Rainbow Trout population in the Madison River. While MFWP and others were making substantial efforts to address the effects of whirling disease, MFWP considered native trout conservation as part of the solution to restore the trout population and, subsequently, angling in the Madison River. After careful consideration, MFWP decided to restore native WCT in selected tributaries to the Madison River. This effort was designed to accomplish two objectives: (1) to initiate a long-term WCT conservation and restoration program that contributed toward meeting the goals outlined in the developing WCTMOU, and (2) to provide source populations of trout potentially less affected by whirling disease that could provide fish to the Madison River via downstream fish movement to diversify and improve recreational angling opportunities. Montana Fish, Wildlife & Parks expected that chemical removal of nonnative fish would be necessary in some locations to achieve the probable goals of the developing WCTMOU and the WCT conservation and restoration program.

In 1997, MFWP began a widespread investigation of Madison River tributaries upstream of Ennis Reservoir to assess their fish populations, species compositions, and habitat suitability and identify streams that could be included in WCT restoration efforts (Clancey 1998a; Sloat et al. 2000). After learning of MFWP's conservation effort through a local newspaper article, Ted Turner, founder and chairman of TEI, directed his staff to contact MFWP through Dr. Calvin Kaya at Montana State University to inquire about the feasibility of including the Cherry Creek drainage in the program. Dr. Kaya had worked with TEI's Flying D Ranch and MFWP in 1994 to conduct an experimental Arctic Grayling *Thymallus arcticus* introduction into a section of Cherry Creek to assess how they would interact with the existing sympatric nonnative Rainbow Trout and Brook Trout populations. Monitoring the following year showed that there were no Arctic Grayling remaining in Cherry Creek. On June 25, 1997, representatives of MFWP and TEI, along with Dr. Kaya, met in Ennis to discuss the possibility of exploring the Cherry Creek drainage to determine its feasibility for supporting populations of WCT, and possibly Arctic Grayling and other native nongame fish species. These discussions led to an agreement between MFWP and TEI that allowed MFWP to lead a short-term, intensive effort to survey the upper Cherry Creek basin to assess its suitability for WCT.

Cherry Creek is one of only five tributaries to the lower 65 km of the Madison River (below Ennis Reservoir) and is one of the largest tributaries in the Madison drainage in terms of drainage area, stream discharge, and stream miles. Cherry Creek Falls (Figure 2) is a critical feature that made Cherry Creek particularly attractive for a large-scale WCT restoration effort. Above the waterfall are approximately 145 km of stream (National Hydrography Dataset; USGS 2013) and a 3-ha headwater lake (average depth 4.5 m; maximum depth 12 m). Brook Trout, Rainbow Trout, and YCT were the only fish species found above the waterfall—none of which are native to the Madison River drainage.

Nine people surveyed a significant portion of the upper Cherry Creek drainage (Figure 3) from August 25 to 29, 1997. During this time, fish species composition and distribution surveys were conducted, stream discharges were measured, habitat characteristics were observed and noted as to whether they were suitable for WCT, and initial consideration was given to the logistical effort necessary to manage a crew conducting a large-scale fish eradication project in this remote area.

Upon completion of the initial surveys, two fisheries professionals who had experience conducting chemical eradication projects visited the site to offer their assessments. Dr. Bruce Rosenlund of the U.S. Fish and Wildlife Service (USFWS) in Colorado had conducted many similar, but smaller, projects in Colorado, including in Rocky Mountain National Park. Dr. Rosenlund spent three days with members of the CCWG assessing the drainage. Dr. Robert Gresswell of the USFWS, who had conducted a similar project in Arnica Creek in Yellowstone National Park (Gresswell 1991), spent one day in the area with project leaders. They both concluded that a physical effort (using netting and electrofishing) to eradicate nonnative fish would fail due to the size and complexity of the watershed, but that a chemical eradication effort could be successful if a dedicated effort could be sustained. Among the difficulties they cited were the ability to sustain a large-scale, multiyear effort and how to manage water and North American beavers *Castor canadensis* in several large beaver pond complexes. Based upon the feasibility work, the assessments of these experienced biologists, and additional discussion between MFWP and TEI about expanding the effort to potentially include other native aquatic species such as Arctic Grayling, Rocky Mountain Sculpin *Cottus bondi* (formerly Mottled Sculpin *C. bairdii*) and western pearlshell *Margaritifera falcata*, a decision was made to move forward with an environmental assessment (EA) analyzing the Cherry Creek project.

The state of Montana requires an EA be done for all state actions that can potentially impact public health and welfare or the environment (Montana Environmental Policy Act). For the Cherry Creek project, this process began in December 1997 when public scoping meetings were held in Bozeman, Ennis, and Three Forks. A draft EA was developed and released in April 1998 (Bramblett 1998), with a 32-d public review and comment period. The state's EA was developed and written to also meet National Environmental Policy Act (NEPA) standards, allowing the GNF to use the same analysis as the basis for its decision making regarding application of piscicides and related use of mechanized equipment within the Lee Metcalf Wilderness portion of the project area. The EA considered several alternatives for restoration of native fish in Cherry Creek, ranging from physical removal of nonnative fish to the introduction of WCT and Arctic Grayling without the removal of nonnative fish, but ultimately concluded that chemical eradication (i.e., application of piscicides) of nonnative fish had the highest likelihood of success. The public was notified through press releases and legal notices in several southwestern Montana newspapers, through live and recorded radio programs, and by mailing or delivering 120 copies of the EA to sporting and conservation organizations, government agencies, and interested parties. During this comment period, public meetings were held in Bozeman, Three Forks, and Butte to take comment on the EA. Copies of the EA were available at several MFWP offices in southwest Montana and at the public meetings. After considering public comments, a final EA and formal decision notice were finalized in July 1998 (Clancey 1998b; USFS 1998).

The U.S. Environmental Protection Agency (EPA) authorizes two compounds to be used as piscicides—Antimycin A and rotenone. Both occur naturally in the environment but must be combined with other carrier agents that enhance mixing and dispersal in water in order to effectively function as a piscicide. Both piscicides were analyzed in the EA and authorized for use on the project. The product names used during the Cherry Creek project are Fintrol (Antimycin A) and CFT Legumine (rotenone). Rotenone powder was also used in some locations such as springs and seeps and was administered following the procedures described by Finlayson et al. (2000).

As required by state statute, MFWP applied for and received a permit from the Montana Department of Environmental Quality (DEQ) that allowed a short-term exemption to state water-quality standards for application of piscicides for the removal of "undesirable and nuisance aquatic species" in the project area. Additionally, MFWP applied for and received a short-term exemption from the DEQ for turbidity exceedance that might occur during installation of temporary fish movement barriers used to divide the project area into phases to facilitate piscicide application across years. Finally, MFWP received two authorizations from the GNF for use of mechanized equipment and application of piscicides in the Lee Metcalf Wilderness. All these permits were procured by August of 1998.

During the planning and development for this project, we recognized a unique opportunity to incorporate research within the project. Too often practitioners of conservation projects fail to collect information that allows objective evaluation of success or failure (Pullin and Knight 2001; Sheller et al. 2006; Anderson et al. 2014). We agreed to conduct project activities in a way that maintained enough scientific rigor and allowed collection of data to compare fish population characteristics (e.g., density and size structure) before and after restoration; to assess project impacts on nontarget organisms; to evaluate how WCT donor source (e.g., nearest neighbor single population versus genetically variable broodstock) influenced population recovery and project success, and to measure survival, condition, and movement of translocated individuals. This information was intended to inform future restoration and translocation efforts and provide information on donor-source selection criteria.

Parallel to the beginning of the Cherry Creek project, the Sun Ranch, a privately owned property in the upper Madison Valley, entered into a formal agreement in 1999 to assist MFWP with WCT conservation and recovery by building and operating a small conservation hatchery, dubbed the Sun Ranch Hatchery (SRH). This facility incubates eggs taken from wild donor populations and has the capacity to rear a limited number of the fry during their first summer to provide both eyed eggs and young-of-the-year WCT for introduction into restoration sites. The Sun Ranch also constructed a brood rearing pond to develop a Madison River/upper Missouri River WCT broodstock. Some of the fry reared in the facility's fry-rearing troughs are released into the Sun Ranch Pond (SRP) each year to maintain the brood and incorporate as much genetic diversity into the brood pond as feasible. The Sun Ranch facility was an important component of the Cherry Creek project because its isolation allowed for wild donors to be used with a minimal risk of transferring disease into state-owned hatchery facilities, and its operators could focus solely on meeting conservation needs in Cherry Creek. This facility is also playing an important role in WCT restoration in Yellowstone National Park, Wyoming.

Mistakes, learning experiences, and innovations

Project opportunities such as Cherry Creek are rare at this scope and scale. Private entities can be creative and instrumental in helping public resource agencies be more nimble or flexible in finding solutions (e.g., TEI and the SRH). Common ground and mutually desired outcomes arising from different places (e.g., ethical beliefs, legal obligations, and recreational opportunities) can create collaborators from diverse interests such as state, federal, and private entities.

Interestingly, delays in implementation of the project (next section) provided opportunities for us to become more educated and gain experience with piscicide application. During the several years the project was delayed, we were able to participate in similar but much smaller piscicide projects in Idaho and Crater Lake National Park. The field experience gained while assisting with these projects removed some of the mystique of handling, applying, and detoxifying piscicides and managing large field crews.

Issues, Concerns, and Legal Challenges

During the public scoping process in 1997, many conservation-minded individuals and groups supported the project, but it was not without controversy. There were several reasons for opposition, but the primary issues raised included a general disdain for Ted Turner and the perceived cozy collaboration between the state of Montana and TEI, concerns regarding the effects of piscicides on the environment and human health and livelihoods, opposition to the removal of an existing wild trout population, and perceived impacts to the designated wilderness area that encompassed a small portion of the Cherry Creek headwaters. Although piscicide use for restoration work was not new to fisheries management in the late 1990s, piscicides had not been commonly used for native trout conservation in many Rocky Mountain states at that time (with a few notable exceptions such as Stuber et al. 1988 and Gresswell 1991). Montana was no exception, and in large part due to an unfamiliarity with piscicides in general, some members of the public were skeptical of their proposed use in Cherry Creek.

As the environmental review process proceeded and the EA was released for public comment, a small number of vocal individuals began insistently objecting to the project, often arguing unrelated issues involving Mr. Turner's environmental and personal beliefs, lack of public access to the privately held TEI properties, and a 1996 land trade between TEI and the state of Montana that consolidated blocks of public and private lands. As project opponents threatened administrative and legal challenges via letters to local newspapers and by word of mouth, some regional MFWP administrators became uneasy with the project. Consideration was given to abandoning the proposal, but key MFWP administrators at the state level, including the agency director, supported the project and were committed to seeing the public environmental review process run its course.

Project opponents petitioned the USFWS to list the "Cherry Creek cutthroat" as a distinct population segment of YCT, stating that it had evolved in a harsh headwater environment, was resistant to whirling disease, successfully competed with nonnative species; and was genetically pure. However, the petition did not provide any scientific data to substantiate these claims and the USFWS could find no evidence to support the petition. The USFWS did not consider this population of YCT unique because fish stocked from this same strain are found in numerous other mountain lakes with similar conditions. They stated that the source of the YCT initially stocked in Cherry Lake and its outflow originated from MFWP's Yellowstone River Trout Hatchery in Big Timber. Fish from this hatchery were released in mountain lakes in the Missouri River drainage and for many years were routinely stocked in fishless mountain lakes throughout Montana. The individual who stocked these YCT in Cherry Lake in 1924, on his 10th birthday, stated that he did not know the source of the fish. Yellowstone Cutthroat Trout are not considered native to Cherry Creek and Cherry Lake since the area is well outside the fish's historical range of the Yellowstone and Snake River drainages. Additionally, the Cherry Creek basin is within the known historical habitat (i.e., the Madison River) of the Westslope subspecies of Cutthroat Trout.

Written response to the EA included 21 individuals or groups supporting the proposal, 40 opposed, and 222 individuals that signed an opposing form letter. One state agency submitted a letter of comment without taking a stance on the proposal. Comments and questions were wide-ranging and often not pertinent to the proposed project. Some comments were legitimately concerned with issues such as the effect of piscicides on nontarget organisms, the use of a gas-powered outboard motor on Cherry Lake within the Lee Metcalf Wilderness, or concern over the loss of public access and angling opportunity on the national forest. On the other hand, similar to the public scoping process, many comments were tangential extensions of ongoing land management and wildlife-related issues with MFWP, TEI's Flying D Ranch, or Mr. Turner himself. Others questioned the environmental review process and the responsibility of federal agencies in that process while a few tried to connect the project with their belief that the United Nations was creating a one-world government and Mr. Turner was complicit because he had pledged to make a large donation to the United Nations.

In the July 6, 1998 decision notice approving the proposed project, the CCWG provided a response to the comments submitted by the public regarding the EA (Clancey 1998b). Comments were sorted into 17 separate categories, including concerns about the effects of the piscicide on water quality and nontarget organisms, project impacts on federally designated wilderness, genetic integrity of the donor fish and disease concerns, privatization of water and wildlife, public awareness of the project, impacts of introduced WCT on land management activities and recreational opportunities, and impacts on hunting and fishing, including to an existing hunting outfitter business. Some commenters felt it was a conflict for MFWP to enter into a formal agreement with TEI for project funding or questioned the authority of the regional forester to direct GNF involvement in the project. Other issues raised were not pertinent to the project, such as questioning how a fish named the Westslope Cutthroat Trout could be native east of the Continental Divide.

Chemical treatment was scheduled to begin in August 1998 but was halted the morning of the first day due to last minute logistical and scheduling concerns raised by TEI. These concerns were resolved relatively quickly but not in time to salvage fieldwork in 1998, so the project was rescheduled for August 1999. This delay led to a cascade of legal filings and decisions that prevented fieldwork until 2003. It also provided our first lesson on the importance of clear and consistent communication among CCWG members.

Prior to the 1999 start date, a few of the most vehement project opponents contacted both of Montana's U.S. senators and Montana's lone U.S. representative, asking them to intervene and stop the project by requiring the GNF to rescind or not authorize necessary permits or decisions for project related actions on forest lands, and to intervene with Montana state agencies that had permitting authority over various aspects of the project. These requests were not simultaneous but were made in a serial manner, apparently to maximize the time necessary for the CCWG to address them and was planned by opponents to delay project implementation for as long as possible. All three Congressional offices contacted MFWP and the GNF to gather information about the project, and one U.S. senator sent a staff member from Washington D.C. for a 2-d field visit. That senator sent a letter to project leaders acknowledging their openness about the project and thanking them. Ultimately, all three offices responded that the project was legal, that proper federal procedures had been followed, and that the project was within the state's authority. Simultaneous with the congressional inquiries, project opponents teamed with an attorney who represented cyanide heap leach gold mines in Montana to legally challenge the Cherry Creek project. Their premise was that if mining companies cannot release pollutants into a Montana stream without a Montana Pollution Discharge Elimination System (MPDES) permit, then MFWP should not be allowed to either. They threatened a lawsuit against the DEQ that triggered the DEQ to conduct a separate EA assessing the legality and public safety of using piscicides. During this EA process, the DEQ suspended their previously issued permits to apply the chemicals in the project area. Montana Fish, Wildlife & Parks did not object to the permit suspension while the DEQ conducted its analysis.

The DEQ EA was released on July 29, 1999. Public comment was accepted through September 14, 1999. On October 14, 1999, the DEQ issued a decision authorizing and reissuing the permits to conduct the chemical treatments with no modifications. In their decision document, the DEQ identified and responded to 64 comments, many of which were redundant to those addressed in MFWP's 1998 EA. Montana Fish, Wildlife & Parks had stated that if the DEQ's EA resulted in reissuance of the permits, chemical treatment of Cherry Lake may be conducted as late as October or November 1999; however, the opponent's attorney appealed the DEQ decision within minutes of it being issued. He challenged the DEQ EA on five points: (1) the DEQ erred in not requiring MFWP to apply for and receive an MPDES permit, as is required for industrial effluent; (2) the DEQ erred by failing to apply the state's nondegradation statute, a violation of the state's constitution, which guarantees its citizens the right to a "clean and healthful environment"; (3) the DEQ erred in granting a series of short-term exemptions to certain state statues for a multiyear project; (4) the DEQ failed to determine if the project was necessary; (5) and the DEQ failed to determine if the nonnative trout to be eradicated were "undesirable and nonnative species."

The Montana Board of Environmental Review (BER) considered the appeal. The BER appointed a hearings examiner who gathered information about the project and reviewed pertinent state statutes and administrative rules. The hearings examiner issued his opinion on July 11, 2000, recommending summary judgment to the DEQ, essentially dismissing all five points of contention. On September 28, 2000, the BER issued summary judgment to the DEQ but stipulated a 33-d stay of execution to allow the appellant the opportunity to file a petition for judicial review in the Montana District Court. On October 31, 2000, the appellant filed the petition against the BER, DEQ, and MFWP. The elements of the lawsuit were that (1) since the permit from the DEQ to apply piscicide was not subject to nondegradation statue, it is a violation of the (Montana) constitutional clean and healthy environment provision; (2) application of the piscicide to outstanding resource waters (within wilderness area) violates statutory and constitutional provisions (federal regulations); (3) since the project was to be completed over a period of up to 10 years, it violated the short-term nature of the permit that allows short-term exceedance of certain water-quality parameters; and (4) the DEQ did not independently determine the necessity of the project.

Montana Fish, Wildlife & Parks submitted a response to the petition on November 29, 2000. After a series of fact finding, the FWP filed its argument for summary judgment on August 6, 2001, arguing, among other things, that the project supports both the Clean Water Act and Montana citizens' right to a clean and healthful environment by restoring a native fish to state waters. On March 28, 2002, the Montana District Court ruled for the agencies (Montana District Court 2002), finding (on the four elements listed above) (1) that the existing and beneficial uses of the water in question would be preserved upon completion of the activity, which included application of EPA-registered pesticides in accordance with the labels; (2) the same determination as item 1; (3) that though the project is anticipated to be underway for up to 10 years, the actual application of the piscicides would occur for no more than a few hours each day for 3 weeks or less in any year. (The permits are valid for only 1 year and MFWP must apply for a new permit each year, which provides the DEQ the opportunity to review and approve, modify, or deny the permit on an annual basis.); and (4) that it is not the DEQ's responsibility to determine whether the proposed activity itself is necessary, but instead to determine if an exemption from water-quality standards is necessary to conduct the proposed activity.

With the favorable ruling from the Montana District Court, MFWP planned to implement the project in August 2002. In early June, project opponents filed a 60-d notice of intent to sue MFWP in the Federal District Court of Montana. On July 3, in face of the threatened lawsuit, MFWP made the decision to again postpone the project to avoid the cost of preparing for and initiating the project only to have it suspended by court order, should a court decide that was appropriate. Project opponents were notified of MFWP's decision to postpone but then subsequently did not file the threatened lawsuit.

During Montana's 2001 legislative session, a state senator from the Bozeman area publicized his intent to introduce a bill into the legislature that would specifically prohibit expenditure of state money for piscicide applications on the Cherry Creek project. Montana Fish, Wildlife & Parks administrators feared the bill could be expanded by other legislators to prohibit other native fish conservation or restoration actions. The newly appointed MFWP director proposed to the senator that MFWP would not spend any state money on piscicide application for the project if he would not introduce his bill, and the legislator agreed. Consequently, TEI committed additional funding to the project to support MFWP's field staff time and expenses for piscicide applications. Other MFWP expenditures related to the project, such as planning, administrative and monitoring costs, were not affected by this agreement.

In 2003, MFWP notified project opponents that the project was scheduled to begin August 1, and opponents filed a 60-d notice of intent to sue on June 1. However, this time, MFWP initiated the project as scheduled on August 1 and the lawsuit was filed. The federal district court judge dismissed the suit due to a technical error by the litigants and their bad-faith tactics. Montana Fish, Wildlife & Parks negotiated with the litigants to allow completion of first-year treatments by August 20, 2003, and the litigants agreed not to seek an injunction against the project in 2003. Litigants re-filed the federal lawsuit on October 31, 2003. Elements of the lawsuit were (1) as used during the project, piscicides meet the federal Clean Water Act (CWA) definition of "pollutant" and are being applied from a "point source," therefore subject to an NPDES/MPDES review. (Parties agreed on the point-source issue, so the remaining issue was whether the piscicide or its residue were pollutants); and (2) the CWA and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) are in conflict over exemption of FIFRA-approved pesticides from certain provisions of the CWA because discharge of pesticides, even for their intended purpose, constitutes a waste because not all the pesticide applied is absorbed by the target organisms, but also by nontarget organisms.

The Federal District Court of Montana ruled in March 2004 (U.S. District Court for the District of Montana 2004) that (1) the piscicide was applied in full accordance with its label in a manner that does not constitute pollution, it performed as intended and dissipated rapidly, leaving no trace of residue. Because the piscicide functioned as intended, it is not a pollutant or a chemical waste, therefore not subject to NPDES/MPDES review; (2) there is no conflict between the CWA and FIFRA based on the EPA's valid reasoning to coordinate the CWA and FIFRA, and on the EPAs long-standing administration of the CWA and FIFRA (EPA 2003).

The judge's ruling went on to state that one of the provisions of the CWA is to restore biological integrity to the nations waters and that the Cherry Creek Project

> comports four-square with the stated objective of the CWA to restore biological integrity of the drainage by removal of invasive pest species of trout and reintroduction of native species of trout.

On June 14, 2004, project opponents appealed the federal district court's ruling to the Ninth Circuit Court of Appeals. A three-judge panel of the Ninth Circuit considered the appeal and on September 8, 2005 ruled (1) since the piscicide (Antimycin A) was applied to the waters of Cherry Creek in accordance with its FIFRA label, with no residual or unintended effect, it is not a waste and therefore not a pollutant for CWA purposes; and (2) therefore, an NPDES permit was not necessary (U.S. Court of Appeals for the Ninth Circuit 2005).

After initial chemical treatments in 2003, the project was conducted as scheduled through the remaining years of the legal challenges.

It should be noted that a case in the U.S Sixth Circuit Court of Appeals in 2009 tested a similar situation (National Cotton Council et al. v. EPA) in which that appellate court vacated the EPA's 2006 Final Rule on Aquatic Pesticides and found that point-source discharges of biological pesticides and chemical pesticides that leave a residue into waters of the United States were pollutants under the CWA. As a result of that decision, NPDES permits are now generally required for these types of discharges as of October 31, 2011. Montana developed an NPDES permit system that has been used since 2012 to permit and conduct piscicide projects and is compliant with the EPA's requirements.

Mistakes, learning experiences, and innovations

Throughout the years of administrative and legal challenges, strong leadership among all the partners was critical to maintain focus, continuity, and commitment to completing project goals. This required consistent communication between members of the CCWG and within each agency. Montana Fish, Wildlife & Park's legal staff coordinated closely with project leaders to ensure the technical accuracy of the legal filings, which allowed the courts to clearly see the legitimacy of the project. Project leaders and the collaborating parties did not try to gloss over or hide any potential drawbacks or uncertainties related to the project or to chemical treatments. Doing so would have been damaging to the credibility of the CCWG and possibly led to termination of the project.

Collaboration and Delegation

An important element of the success of the Cherry Creek project was the collaboration between the three primary partners of the CCWG. The success of this collaboration over the duration of the project can be attributed in large part to consistent staff (e.g., little turnover in permanent staff over the course of the project); a shared vision important to all partners; clearly defined fiscal, logistical, and operational roles and responsibilities for each partner; and a common work ethic. Perhaps most importantly, the process of defining roles and the tools used to do that resulted in clear communication and trust among the partners and individual biologists.

The partners used a variety of tools to coordinate their roles at different management levels. These tools were essential to translating both broad formal agreements (e.g., both MFWP and the U.S. Forest Service (USFS) were signatories to the WCTMOU) and mutual interests in native fish conservation (declared as part of the missions of TEI, the GNF, and MFWP) to actual activities on the ground. Both the tools and the relationships that were formed in using them served to maintain partner engagement and coordination throughout the course of the project, including project challenges and setbacks, and postproject monitoring.

The first tool used by the partners was a formal memorandum of understanding (MOU) laying out the framework for the Cherry Creek project. Specifically, the MOU described project objectives; responsibilities of each entity, including planning, permitting, and respective authorities; and established an Incident Command System (ICS) structure to manage project implementation. Although not legally required, this MOU was requested by leadership of all partners, in no small part because this was the first restoration project in Montana using piscicides for fish removal on such a large scale that involved multiple partners across a mixed ownership landscape. The USFS suggested use of the ICS, given the agency's experience using this structure to safely manage logistically challenging and interjurisdictional work, and other partners concurred.

In general, the MOU defined the partners' roles by statutory responsibility. For example, by State of Montana statutes, MFWP holds authority for fish and wildlife management within Montana on lands of most ownerships. Federal lands can be an exception, but the USFS defers fish and wildlife management to states in cases where those actions are consistent with federal law, where those actions are not specifically delegated by federal law to the USFS, or by agreement with the states. Thus, MFWP took the lead in authorizing the overall Cherry Creek project as a fisheries management action. However, because of multijurisdictional boundaries (private, state, federal, and wilderness) within the project area, all three parties had the discretionary authority to approve separate aspects of the overall project.

Montana Fish, Wildlife & Parks was responsible for approving and overseeing the removal of nonnative trout, stocking genetically pure WCT, and applying piscicides and associated detoxifying agent outside the wilderness boundary. Under the direction of MFWP, TEI hired a consultant to write the 1998 draft EA analyzing and disclosing the effects of the overall project as required by the Montana Environmental Policy Act and NEPA, along with compiling a literature review on the effectiveness and potential effects of rotenone and Antimycin A.

The USFS retained decision authority for pesticide application and mechanized equipment use within the Lee Metcalf Wilderness, as delegated to the USFS by the Wilderness Act of 1964 (U.S. Code, volume 16, sections 1131–1136). The Association of Fish and Wildlife Agencies agreement (USFS et al. 2006) provides guidance to state fish and wildlife management agencies, the USFS, and Bureau of Land Management personnel for the management of fish and wildlife populations in wilderness areas in accordance with the Wilderness Act. Under the Wilderness Act, designated land-management officials can approve the use of otherwise prohibited tools or activities (such as pesticides or mechanized equipment) if traditional wilderness management tools or activities cannot achieve the desired objectives or if otherwise prohibited tools could be used with less impact to wilderness character than traditional tools. To approve prohibited tool use, the GNF was required to analyze the effects of the use of those tools on wilderness character against more traditional tools and activities through the Minimum Requirements Decision Guide, separately from NEPA. For this project, application of pesticides, nonlanding helicopter flights for restocking, outboard boat motors, electrical pumps, and scuba diving equipment were analyzed and approved. A

NEPA analysis, decision notice, and finding of no significant impact were required for the USFS to authorize a pesticide use permit for the application of piscicides within wilderness.

Turner Enterprises, Inc. owners and managers of the Flying D Ranch retained authority for those activities that occurred within the boundaries of the ranch beyond fisheries management actions. Turner Enterprises, Inc. handled logistical concerns such as authorizing access for project activities; permitting, constructing, and maintaining temporary fish movement barriers; implementing beaver and beaver dam management; coordinating food, transportation, and lodging; purchasing and maintaining project equipment; and hiring temporary field staff to assist with the project. Turner Enterprises, Inc. has also conducted much of the pre- and posttreatment population monitoring under permit from MFWP.

The MOU provided the framework within which a second set of tools nested: partnership agreements (PA) and interagency agreements allowing the partners to transmit funds from one entity to the next and to further define responsibilities beyond statutory roles. One such PA was between MFWP and TEI, allowing the transfer of funds to cover many MFWP expenses for the project. The GNF entered into a second PA with MFWP and TEI, defining the roles of the partners on all lands within the project area, including financial allocations. This PA used the relatively newly enacted Wyden Amendment authority (Public Law 109-54, Section 434, passed in 1998), which authorized the USFS to use USFS resources on private lands when there is a partnership action with a clear benefit to public resources, such as fish and wildlife and their habitats managed by the USFS. This was the first time that the GNF used Wyden authority, and it allowed the GNF to maintain the same roles in support of the project throughout project implementation regardless of landownership where activities were occurring. Turner Enterprises, Inc. and GNF also consummated an access PA that allowed GNF biologists access, for purposes related to project activity, across private land to the forest via previously closed routes. Finally, the GNF entered into an interagency agreement with the Bureau of Land Management so that boxes of hand-held radios could be ordered from the National Interagency Fire Center. This allowed all project personnel to carry a radio, greatly facilitating field operations, including piscicide application and detoxification.

Project partners held annual coordination meetings to review roles and responsibilities as spelled out by the MOU and agreements, as well as to plan operations for the upcoming field season. At these meetings, adjustments were made as needed, including identifying whether formal adjustments needed to be captured in the MOU or agreements.

Finally, the ICS was a tool also defined under the MOU, but its use was tailored to project implementation by a written set of ICS documents covering all aspects of project roles and responsibilities. The ICS is commonly used by state, federal, and local agencies to manage natural disaster and other complex incident responses (Figure 5), as the ICS structure can be molded to achieve very specific project needs. As such, some of these roles and responsibilities aligned directly with the formal authorities of different partner representatives, but others corresponded with skill sets of project staff or were eliminated for this project because they were unnecessary.

The ICS is a standardized approach to the command, control, and coordination of incident response, providing a common hierarchy within which personnel from multiple agencies can be effective. The ICS was initially developed to address problems of interagency responses to wildfires but slowly evolved as the preferred coordination model to address similar issues related

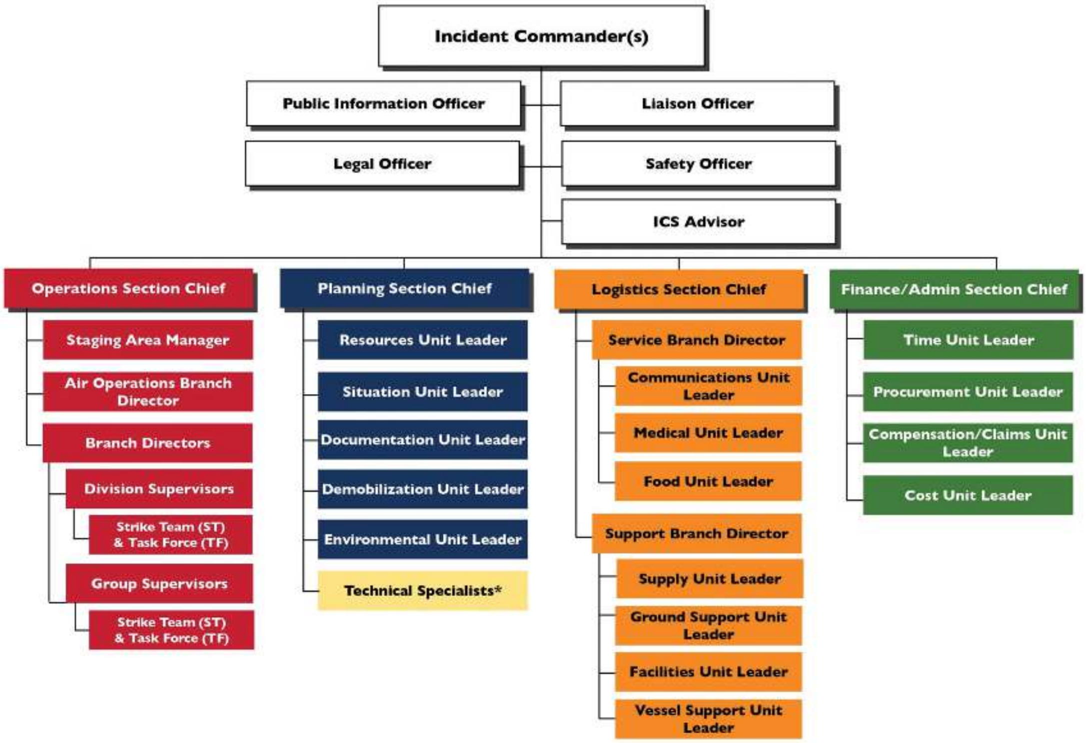

Figure 5. Structure of the Incident Command System and command, command staff, general staff, and substaff positions.

to the responses of other disasters ranging from active shootings to hazardous materials scenes throughout the United States. During a large-scale and rapid response to a natural disaster, an individual (or a unified group) typically occupies one of the command, general, and substaff positions without collateral duties to minimize distractions. Because this project was planned and coordinated over a relatively long period of time, lead partners from MFWP, TEI, and the GNF could be involved in multiple collateral duties without compromising the safety of crew members or the effectiveness of the treatment.

For the most part, finance, procurement, and administration section duties were shared among all partner leads prior to implementation, as previously spelled out in the project-specific MOU and PAs. Several units or substaff positions, such as air operations, were not required to implement this project. Table 1 describes the assigned duties for the Cherry Creek project organized using the ICS organizational structure.

In addition to ICS roles, standard ICS procedures were adapted for this project, some of which are discussed here. First, the equivalent of preseason incident management team meetings were held to reaffirm and review roles, discuss lessons learned, and incorporate any changes in ICS structure or operations. Second, during the actual project, daily briefings for project personnel, with reports and input from various ICS leads, were critical for detailing a day's treatment objectives, communication procedures, personnel assignments, and safety concerns. Third, project leads from each agency held evening planning meetings to review daily operations, adjust tactics, address personnel or safety issues, and prepare

Table 1. Various partnership responsibilities as related to the levels of the Incident Command System. MFWP = Montana Fish, Wildlife & Parks; GNF = Gallatin National Forest; TEI = Turner Enterprises, Inc.

Command and general staff	Substaff positions	Lead	Responsibilities
Incident Commander		MFWP	Management oversight of the implementation of the overall project.
Public Affairs Officer		MFWP	Public information releases were handled by MFWP Region 3 staff.
Safety Officers		Shared	All partner leads acted as safety officers regardless of affiliation. Maintained a daily check in/check out list accounting for crew members during and end of shift.
		MFWP	Provided licensed pesticide coordinator
			Provided all implementation and safety training as related to the various chemicals and associated personal protective equipment (PPE).
		GNF	Established an emergency communication and evacuation plan.
			Provided all other safety training using the agencies job hazard analysis protocol, including "Bear Aware" and bear spray training.
Operations Section	Divisions/ Strike Teams	Shared	All partnership entities provided personnel and volunteers to implement treatment operations. Personnel were assigned to individual drip stations or backpack spraying teams.
		MFWP	Provided oversight and operation of the detoxification station.
Planning Section	Resources	TEI/GNF	Assigned personnel to daily tasks. Provided morning safety and operation briefings. Maintained daily inventories of personnel and equipment.
	Situation	MFWP	Monitored stream flows and calculated pesticide application rates.
Logistics Section	Communications	GNF	Provided radios for all personnel, radio use training, and a general communication plan.

Table 1. Continued.

Command and general staff	Substaff positions	Lead	Responsibilities
	Medical	GNF	Provided medical supplies.
	Food	TEI	Provided meals for crew members.
	Supply	TEI	Provided and maintained supplies such as drip stations, hip boots, bear spray, PPE, and backpack sprayers.
	Facilities	TEI	Provided lodging facilities.
	Ground Support	Shared	Each partner provided transportation for their own employees.

the next day's plan. Fourth, when personnel were divided into separate groups to treat different portions of stream during a day, leaders were assigned to each group; these leaders checked in with the incident commander during the day. The incident commander delegated this role to another project lead in his absence so that operations could be maintained. Fifth, radio communication was critical to effective choreography of operations, from logistically coordinating crews of up to 35 people hiking to setting up along various stream reaches during a day, choreography of chemical application (coordination of drip station timing, notifying backpack sprayers of sites that needed sprayed, etc.), resolving safety issues (e.g., lightning storms, bear sightings, and accidental pepper spray discharges), and managing crew egress from the field. Sixth, project leaders ensured that at least one first aid kit and qualified first aid person was with each group of chemical applicators. Finally, project leads conducted a review of a year's operations so that lessons learned could be incorporated to adjust the next year's operations.

Another type of agreement that can be useful when management agencies and private landowners consider collaborative conservation of species under ESA consideration, such as WCT was at the time of this project, is a Candidate Conservation Agreement with Assurances (CCAA). It was clear at the beginning of the Cherry Creek project that regardless of the outcome, WCT could potentially be listed under the ESA. Endangered Species Act listing can bring federal oversight to activities on private land that would not otherwise be considered if the species had not been restored on that property prior to its listing. While the "cloud" of federal oversight does not concern TEI, it can and does intimidate many private landowners. The CCAA is designed to address conservation needs of a species that potentially may become listed by asking landowners to voluntarily conduct conservation actions that will protect the population of that species on their private lands and could ultimately preclude the need for listing. In return, the landowner is provided assurances that they will not be subject to future regulatory obligations beyond what was agreed to at the time they entered into the CCAA, even if the species is listed. In an effort to expand WCT restoration on private lands in Montana, MFWP developed and formally entered into a WCT CCAA with the USFWS in 2007. Turner Enterprises, Inc. signed onto MFWP WCT CCAA through a certificate of inclusion (COI) in June 2009. Although the Cherry Creek project was already well underway, the COI affirmed that if TEI allowed MFWP to establish WCT in the Cherry Creek project area, TEI would not be held to additional regulatory obligations if WCT were listed under the ESA in the future. Further, the COI preemptively permitted any incidental take of WCT that might occur during regular ranching or recreational activities if the species was listed. While a CCAA is for species that have not yet been listed, the Safe Harbor Agreement process can provide similar assurances to private landowners working with already listed species.

Mistakes, learning experiences, and innovations

A well-thought-out MOU, PA, and ICS structure led to the continuity between partners and years and was the basis for clear communication. The need for lengthy planning and coordination became less necessary as the project progressed. With adequate time, training, and oversight, a planned proactive project such as the Cherry Creek project can be successfully completed and accomplished with no major injuries to personnel or property. Individuals can be assigned collateral duties within the ICS structure, not compromising the safety of crew members and effectiveness of the treatment. It is imperative that the treatment personnel have direct communication with each other and with those attending the detoxification facilities. Therefore, it is recommended that temporary radio repeaters be placed, instead of using the person-to-person relay system to communicate up and down the project area. Though we did not have the need for them during the Cherry Creek project, we recommend that trained backcountry emergency management technicians be within communication and able to be responsive to incidents in a timely manner.

Piscicide Treatments

Each year's preparation for conducting chemical treatments included using backpack electrofishers to confirm the upstream distribution of nonnative trout in the phase to be treated, measuring stream discharges to estimate the quantity of piscicide necessary for treatment, installing staff gauges to monitor changes in stream discharge, using EPA-compliant tracer dyes to determine mixing and travel time of stream flow, and capturing and posting sentinel fish at specific points based on bioassay results. Some activities could be conducted weeks before chemical application (e.g., fish distributions), others no more than 24 h prior to treatment (e.g., measuring or monitoring stream discharge). Additionally, training on command structure, logistics, equipment, communications, backcountry safety, food and waste management, and piscicide use and safety was provided to crews each year prior to the initial treatment and as new crew members arrived on the project site.

The volume of Cherry Lake was estimated from a hand-drawn map made by GNF personnel a decade or more prior to the project. We used a hand-held depth finder transported by a raft prior to treatment of the lake to re-estimate the volume of the lake, which confirmed the earlier GNF measurements.

Prior to application of piscicides, streamflow travel time was measured by applying enough tracer dye to create a visible plume at the most upstream point chemical would be applied. The leading edge of the dye plume was tracked and renewed when necessary to maintain an easily visible plume. Sequentially numbered, orange-painted wooden stakes and flagging were used to mark each 15-min interval for Fintrol and 30-min interval for CFT Legumine along the stream. The upstream starting point was labeled as station 0; then, subsequent stations were sequentially numbered as 1, 2, 3, and so forth. Thus, if stations were marked every 30 min of stream travel, station 1 would be 0.5 h downstream of the starting point, station 2 would be 1 h downstream, and so on. Determining travel time and marking the stations was important to plan drip station spacing but also allowed pretreatment detection of side-channel water, springs, and small tributaries that needed to be sprayed, as personnel conducting the dye tests necessarily had to walk each stream section that was to be treated.

Stream discharge measurements were conducted prior to applying the tracer dye. A graduated 30- or 60-cm metal staff gauge was installed at each measuring site. If the gauge reading changed significantly between dye testing and piscicide application, a new stream discharge measurement was taken and used to recalculate the piscicide quantity necessary for treating that section. Stream discharge was measured using either a USGS model 622 type AA current meter or a USGS model 625 pygmy current meter, since renamed model 6200 and 6205, respectively. Stream discharges measured throughout the project area ranged from less than 0.001 m^3/s to more than 0.85 m^3/s.

Pretreatment bioassays were conducted in a representative section of stream to determine the persistence of the piscicides, minimum lethal concentrations, and our ability to detoxify them with potassium permanganate. Bioassays were conducted for EPA-registered piscicides Fintrol (active ingredient [a.i.] Antimycin A, 10%) and CFT Legumine (a.i. rotenone, 5%). The Antimycin A bioassay was conducted August 1, 2003; the rotenone bioassay was conducted on July 29, 2007. We did not feel it was necessary to conduct bioassays every year or in every phase as preliminary water chemistry analysis suggested that pertinent parameters (temperature, alkalinity, and pH) were relatively consistent throughout most of the project area. We stated in the EA that in areas where we suspected antimycin may have reduced effectiveness, we may need to use rotenone to achieve an effective treatment. In our discussions of piscicide concentration throughout this chapter, we will be describing the concentration of Antimycin A or rotenone a.i., not the quantity of the Fintrol or CFT Legumine formula. When discussing the product in more general terms, we will refer to them by their product names of Fintrol and CFT Legumine.

To determine the persistence of Antimycin A in a stream, four sentinel fish were placed in net holding bags or plastic buckets with holes drilled in them (i.e., flow-through buckets) at 15-min streamflow travel time intervals downstream for a total distance of 4 h below a single piscicide application point. Antimycin A was applied at a test concentration of 12 parts per billion (ppb) for 6 h 40 min, and the sentinel fish were monitored for up to 48 h to determine the exposure time necessary to achieve 100% mortality.

An Antimycin A serial dilution bioassay was conducted simultaneously with the travel time bioassay. Six plastic buckets with sentinel fish were placed 10-min streamflow travel time downstream of the piscicide application point. All six buckets were placed in the stream so the stream water would regulate the water temperature in the buckets, but stream water did not mix with water in the buckets (nonflow through buckets). About an hour after initiation of the persistence bioassay, untreated water in each bucket was replaced with the appropriate amount of treated stream water to achieve a range of Antimycin A concentrations in the buckets (12, 10, 8, 4, 2, and 0 ppb). Sentinel fish in each bucket were monitored, and their condition was noted hourly. Water in the buckets was aerated with portable aquarium pumps, and 3 gal of water in each bucket was replaced every hour with the appropriate ratio of treated and untreated stream water to maintain the test concentration.

In the Antimycin A persistence bioassay, 100% mortality was achieved as far as 90 min downstream but required almost 45 h to occur at that station (Table 2). Sentinel fish in the serial dilution bioassay showed complete mortality of all fish at all test concentrations except the control (i.e., 0 ppb; Table 3). In general, the lower the test concentration, the more time required to achieve complete

Table 2. Rainbow Trout mortality downstream from a station applying 12 ppb Antimycin A (4.18 ml Fintrol) to a 0.0014 m^3/s stream during bioassays. The station operated on August 1, 2003, from 1250 to 1930 hours (6 h 40 min).

Travel time (minutes below station)	Time post initial exposure (h : min)	Fish condition (dead/unstable/upright)	Percent mortality
15	6:25	2/1/1	50
	21:00	4/0/0	100
30	6:14	0/1/3	0
	20:44	4/0/0	100
60	5:48	0/0/4	0
	20:12	0/1/3	0
	24:06	0/3/1	0
	30:19	1/2/1	25
	46:04	4/0/0	100
90	5:31	0/0/4	0
	19:59	0/0/4	0
	25:36	0/0/4	0
	29:51	0/0/4	0
	45:52	4/0/0	100
120	4:52	0/0/4	0
	19:07	0/0/4	0
	23:36	0/0/4	0
	29:30	0/0/4	0
	45:29	0/0/4	0
180	4:08	0/0/4	0
	18:00	0/0/4	0
	22:06	0/0/4	0
	28:25	0/0/4	0
	43:53	0/0/4	0
240	3:11	0/0/4	0
	5:30	0/0/4	0
	21:06	0/0/4	0
	27:25	0/0/4	0
	42:54	0/0/4	0

mortality. After consideration of the bioassay results, we decided to apply 10 ppb Antimycin A every 30 min of streamflow time for an 8-h duration. Bioassays indicated that this would result in complete mortality of fish within an acceptable time and reduced the risk of fish surviving a lower Antimycin A concentration or a less-frequent application interval. When determining treatment dosages and intervals based on bioassay results, it is important to consider the additional stress the sentinel fish may be under from capture and holding activities and the potential impact on bioassay results. One might expect the sentinel fish to be more susceptible to the effects of a piscicide than free-swimming fish, thus being reasonable but conservative in selection of treatment

Table 3. Fish condition (dead/unstable/upright) of sentinel Rainbow Trout exposed to various bioassay concentrations of Antimycin A for 6 h 40 min.

Antimycin A concentration (ppb)	Time post initial exposure (h : min)										
	1:00	2:00	3:00	4:00	5:00	6:00	6:40	21:18	25:20	29:23	47:52
0	0/0/4	0/0/4	0/0/4	0/0/4	0/0/4	0/0/4	0/0/4	0/0/4	0/0/4	0/0/4	0/0/4
2	0/0/4	0/0/4	0/0/4	0/0/4	0/0/4	0/0/4	0/0/4	2/1/1	3/0/1	3/0/1	4/0/0
4	0/0/4	0/0/4	0/0/4	0/0/4	0/0/4	0/0/4	0/0/4	4/0/0			
8	0/0/3	0/0/3	0/0/3	0/1/2	1/0/2	3/0/0					
10	0/0/4	0/0/4	0/0/4	1/3/0	2/2/0	4/0/0					
12	0/0/4	0/0/4	0/0/4	1/3/0	4/0/0						

dosage and interval based on bioassay results is warranted.

A detoxification bioassay was conducted by applying Antimycin A to the stream at 12 ppb while simultaneously running a detoxification (hereafter, "detox") station at 15 min streamflow travel time downstream (Table 4). Potassium permanganate ($KMnO_4$) was applied at 5 parts per million (ppm). Sentinel fish were held in net bags 15, 30, and 60 min downstream of the detox station. A chlorine meter was used to measure $KMnO_4$ reduction at points 15 and 30 min downstream of the detox station. Reduction occurs as $KMnO_4$ is consumed by instream biological demand and by interaction with Antimycin A. The interaction between the strong oxidizer $KMnO_4$ and Antimycin A effectively stops its effect on aquatic organisms (e.g., detoxifies the piscicide). This detoxification bioassay showed that we could fully neutralize Antimycin A within 30 min of contact with $KMnO_4$.

Five years after the Cherry Creek bioassays were completed, Moore et al. (2008) developed standard procedures for National

Table 4. Remaining $KMnO_4$ (expressed as a percentage of total $KMnO_4$), and fish condition (dead/unstable/upright) of sentinel Rainbow Trout at points downstream of bioassay detoxification station.

Travel time (minutes below $KMnO_4$ station)	Time post $KMnO_4$: Fintrol mixing (h : min)	Percent $KMnO_4$ remaining	Time post initial exposure (h : min)	Fish condition (dead/unstable/upright)
15	2:45	14.6		
	3:45	21.9		
	4:05	25.7		
			5:41	1/0/4
			21:15	3/0/2
30	2:45	8.1		
	3:45	12.4		
	4:05	10.8		
			5:26	0/0/5
			21:00	0/0/5
60			4:56	0/0/5
			20:30	0/0/5

Park Service projects using Antimycin A. They recommend that Antimycin A be applied at concentrations of 5–25 ppb for 7–8 h to conduct an effective treatment. Our bioassay results and treatment dosages comported with these recommendations.

Only a persistence test of rotenone was conducted. Sentinel fish were placed every 30 min out to 4 h of streamflow time, and 50 ppb (0.050 ppm) rotenone was applied to the stream for nearly 8 h. This resulted in complete mortality of fish in less than 4 h at all but the lowest sentinel station (Table 5). The CFT Legumine label allows application up to 4 ppm formula (200 ppb rotenone). In developing standard procedures for rotenone projects, Finlayson et al. (2000) recommended that flowing water bioassays be designed using the expected treatment duration. In the case of Cherry Creek, the results of the persistence bioassay allowed us to reduce the expected treatment time. During treatments, we applied 50 ppb rotenone to the streams at 3-h intervals for a 4 h duration. This conservative spacing and treatment time insured overlap between adjacent stations and prevented areas of potential sublethal concentrations while providing adequate exposure time for complete mortality.

We initially planned to use Fintrol throughout the entire project area, but production issues in 2007 resulted in a lack of availability of reliable Fintrol, so we switched to CFT Legumine. We completed Phases 1 and 2 with Fintrol and used CFT Legumine throughout Phases 3 and 4. In some instances throughout all phases, concentrations of piscicide were reduced in the downstream drip stations to reduce the potential for piscicide concentrations to accumulate or "snowball." We employed this tactic when approaching the downstream end of a phase or on occasions when the piscicide seemed to be carrying farther than bioassays indicated. Generally, daily applications of Fintrol lasted between 6.5 and 7 h (targeted at 8 h) while CFT Legumine applications lasted between 3.5 and 4 h (targeted at 4 h).

We attempted to have sentinel fish deployed throughout a treatment area at least 2 d prior to initiating any piscicide applications. This was precautionary to ensure that sentinel fish mortality was not caused by electrofishing or handling stress. Sentinel fish are useful to determine how far the pi-

Table 5. Results of a 50-ppb rotenone (1 ppm CFT Legumine) bioassay in the East Fork Cherry Creek to determine effective exposure time. Run time of the application station was 7 h 22 min, stream discharge was 0.013 m^3/s. CFT Legumine application was initiated at 0933 hours on July 29, 2007. NA = not applicable.

Sentinel fish station[a]	Time of initial exposure	Time of 100% mortality	Hours of exposure until 100% mortality
30	1003	1050	0:47
60	1033	1255	2:22
90	1103	1255	1:52
120	1133	1400	2:27
150	1203	1455	2:52
180	1233	1615	3:42[b]
210	1303	1615	2:48
240	1333	NA[c]	

[a] Minutes of stream flow time downstream of application station.
[b] Two fish dead, one gravely ill at 1455 hours (2:22 h of exposure).
[c] 100% mortality of sentinel fish was confirmed the following morning at 1145 hours.

scicide traveled each day and how effective each day's treatment was. This daily feedback provided information for us to determine if we should adjust piscicide concentrations higher or lower, or if drip station spacing was appropriate. Over the course of the project we came to prefer flow-through buckets over net bags for holding sentinel fish, as mink, raccoons, and other predators were more likely to tear open the net bags and eat the fish or allow them to escape.

Chemical treatments were conducted annually from 2003 through 2010. Our design called for treating each phase for two consecutive years. We felt that this approach would be more likely to achieve complete eradication of nonnative trout by overcoming errors and issues such as overlooking small streams, springs, and off-channel waters that held fish; localized water chemistry parameters that rendered the piscicide less effective over short reaches; incomplete treatment of interstitial, under bank, and beaver dam habitats; incomplete kill on developing eggs in the gravels; and crew error and inattention caused by fatigue after consecutive long work days over a large area. In hindsight, we believe that at least 2 years of treatment on every reach of stream was absolutely critical to project success, as several of these factors did occur and are discussed later.

Annual treatments were generally confined to a 2–3-week period in August, but circumstances did require us to conduct some treatments at other times. For example, in 2010, two full treatments of Phase 4 were conducted in August and September in an effort to accelerate completion of the project. Also, single-day treatments of certain areas were conducted in September 2007 and 2009, and in October 2008 and 2010 if we either suspected or were certain that unwanted fish remained. Table 6 provides greater detail on annual treatments.

Typically, one phase of the project area was treated each year. Each phase was broken into daily work units that varied in size (e.g., stream length treated) based on remoteness, volume of water, number of drip stations required, number of backpack sprayers needed, and size of field crew. Chemical treatment of a work unit was initiated only after existing fish distributions were confirmed, dye testing was completed, and sentinel fish were deployed. Typically, in headwater streams and tributaries, treatment started at the stream source or several hundred meters above any natural drop structure that, based on appearance and fish distribution surveys, prevented further upstream movement of fish. Treatments were primarily designed to treat a section of the main stem each day, including the tributaries that flowed into that main-stem section. On some occasions, all personnel and equipment were necessary to treat a larger tributary for multiple days. As sections of the main stem or larger tributaries were completed, we used mesh block nets to temporarily prevent upstream movement of fish back into already completed portions. Each treatment day, we ran drip stations about 150 m upstream of all block nets installed the previous day, so we had some overlap between days and did not have untreated water entering the treatment area for the day. We followed this protocol until we had treated the phase downstream to the barrier each year.

Cherry Lake was at the headwaters of Phase 1. It was treated by applying piscicide from a two-person raft and a 53-L plastic tank outfitted with a battery powered electric diastolic pump (Figure 6). The quantity of Fintrol necessary to treat the lake volume was applied to the lake by mixing small quantities of Fintrol with lake water in the 53-L tank and pumping the mixture to various depths throughout the lake through a weighted nozzle manifold.

We applied piscicide to all streams with a steady flow drip station or bucket system dubbed the "Montana Bucket" (Figure 7), by backpack sprayers, and occasionally using a

Table 6. Summary of Cherry Creek piscicide treatments by year, 2003–2010.

Year	Phase[a]	Number of stream kilometers treated[b]	Number of treatment days	Number of worker days[c]	Piscicide quantity used
2003	1[d]	20.3	13	284	18.5 L Fintrol
2004	1	20.3	12	240	24.2 L Fintrol
					3.8 L CFT Legumine
2005	2	15.3	8	220	26.5 L Fintrol
					3.8 L CFT Legumine
					454 g rotenone powder
2006	2	15.3	10	256	22.3 L Fintrol
2007	2	7.2	12	264	34.0 L CFT Legumine
	3	42.4			
2008	3	42.4	8	158	55.3 L CFT Legumine
					908 g rotenone powder
2009	3	9.1	2	16	21.6 L CFT Legumine
					227 g rotenone powder
2010	3	9.1	10	200	84.8 L CFT Legumine
	4	49.8			

[a] Phase 1 = 20.3 stream kilometers; Phase 2 = 15.3 stream kilometers; Phase 3 = 42.4 stream kilometers; Phase 4 = 22.0 stream kilometers.
[b] Stream length treated includes multiple treatments of a phase or section of a phase within a given year.
[c] Number of worker days includes all preparatory and support activities and treatments.
[d] Phase 1 also includes the 0.3 ha (130,000 m^3) Cherry Lake.

rotenone sand gel mix (rotenone powder label; Finlayson et al. 2010) to create a dough ball that dissolved over time in the water. The Montana Bucket was actually a design used by B. Rosenlund in his Colorado treatments. The system consists of a 13-L plastic bucket, a lid with a polyvinyl chloride screw-cap fitting, an automatically filling pet watering bowl (Figure 8) with a size 53 twist bit hole drilled in the bowl, a 1.2-m section of garden hose, and a common garden hose gate valve. Once at the assigned site on the stream, personnel assembled the bucket, gate valve, hose, and dog bowl. Ideally, the bucket, with lid on, would be firmly leveled (with leveling blocks or on-site materials) on the streambank several centimeters above the stream. The dog bowl was stabilized closely above the stream surface on a stick or rock platform constructed of on-site materials, insuring that the chemical stream from the dog bowl would drain directly into flowing water, not into an eddy or still water area. Once the bucket and dog bowl assembly were well located and stable, the bucket was filled approximately halfway with clean stream water, checked for leaks, dosed with chemical through the fitting in the lid, and completely filled with water. The station attendant then waited until a prescribed time to open the gate valve between the bucket and garden hose to start applying the piscicide to the stream. Drip stations were started each day in an upstream to downstream sequence that coordinated start times to ensure a steady coverage of piscicide at a fish-killing concentration through each day's treatment area.

Each drip station had its own attendant, unless two drip stations were within

Figure 6. Inflatable raft set-up used to apply Fintrol to Cherry Lake.

line of site from each other, where one attendant could observe and tend to both. As required, all attendants used appropriate personal protective equipment when setting up, charging, and tending a drip station. The quantity of chemical (i.e., dose or charge) was specific for each station each day, depending on the stream discharge and the intended application concentration at that site.

Backpack sprayers were used to apply piscicide to off-channel waters, such as disconnected side channels, springs and seeps, or small tributaries that did not have drip buckets, as well as stagnant stream margins that water did not readily mix into. The objective of backpack piscicide application was to treat any water not treated by drip stations and eliminate any peripheral freshwater sources for fish that may reduce or eliminate their exposure to the piscicide. The backpack sprayers were filled in a process similar to the drip buckets. The sprayer was filled half full with a bail bucket, generally 5–10 mL of Fintrol or 10–15 mL of CFT Legumine were used to charge the sprayer, two green dye tablets were placed in the tank, and the tank was filled with water. Care was taken to avoid

Figure 7. The Montana Bucket trickle system and sentinel fish bag on Cherry Lake Creek. The sentinel fish bag is upstream of the piscicide application point to monitor the effectiveness of the station above the one shown here.

Figure 8. Close-up view of the dog waterer trickling piscicide/stream water mixture into the stream during the Cherry Creek project.

incorporating debris in the backpack tank that could plug the spray hose or nozzle. The dye tablets were used to brightly color the solution in the spray tank so that multiple sprayers working an area could identify water that had already been sprayed and gauge how quickly their spray solution was flushed from areas such as stream margins or backwaters. Workers using the backpack sprayers worked in a downstream direction and were generally assigned to cover an area between a specific set of stations along the stream. They did not initiate spraying until at least an hour after the stream treatment with the buckets started. This was to ensure that the piscicide was far enough downstream so that if fish were flushed out of areas sprayed, they would be entering treated water in the stream. Workers were provided with enough piscicide to refill their sprayer several times over the course of the day, if necessary, and to allow them to apply an adequate volume of piscicide to large off-channel pools when encountered.

An extremely critical element of the project was adequate and reliable field communications. The GNF was responsible for providing hand-held radios and training personnel in their use and in proper radio etiquette. Effectively conducting the field operations would have been impossible without adequate field communications. Crew members were frequently spread over several miles of the drainage any given day, and radio communication allowed project leaders to be informed of issues or problems that arose, make informed decisions, alter treatment plans as conditions changed, redirect backpack sprayers, or address any number of situations. Importantly, the radios were critical for crew communications in the potential event of an emergency, such as severe weather, wildfire, bear encounters, or serious injury to a crew member, some of which occurred during the project.

The removal of nonnative fish was assessed with multiple methods, which provided assurance that treatment had been successful. A work unit or phase was typically not considered clean (all fish eradicated) unless no additional fish mortalities were observed during the second or subsequent treatments. In some cases, additional treatments were required (Table 6). After a clean treatment, substantial electrofishing was conducted throughout a phase to further confirm that no fish remained. Finally, environmental DNA (eDNA) samples were collected in 2015 according to methods of Carim et al. (2016) to assess whether nonnative salmonids could be detected. All eDNA samples were negative (Carim et al. 2015), indicating successful eradication of the targeted nonnative salmonids.

Mistakes, learning experiences, and innovations

Relatively few problems arose over 8 years of piscicide treatments with field crews of 16–24 people in the field for 10–14 d annually in a remote field setting. We attribute this to the command structure that was in place, training provided, consistent personnel in supervisory and lead roles for each partner over the course of the project, dedicated field staff, and a little bit of luck. Expected minor problems encountered included improper radio etiquette, disrespectful behavior in camp or towards fellow crew members, and failure to take care of equipment. Occasionally, a crew member failed to complete their assigned duties, failed to follow treatment schedule or procedure, or became distracted in the field. These errors had the potential to be costly in time, materials, and treatment effectiveness but were minimized by the command structure, rotating daily responsibilities (drip station, spraying, sentinel fish, dye testing, etc.), and, when possible, providing days off when individuals or the entire crew requested.

We were not able to achieve complete kill of the YCT in Cherry Lake using Fintrol. Antimycin A was initially applied at 4 ppb throughout the lake on August 4, 2003, and significant fish mortality was observed. Upon completion of the first treatment, we set gill nets to assess the thoroughness of the treatment. Three YCT were captured by gill net 2 d after the initial treatment, so another 4 ppb of Antimycin A was applied. No fish activity was observed, and nothing was captured in gill nets for two more days; however, fish were then observed rising to feed on surface insects. Two additional YCT were captured in gill nets on the morning of August 20, 2003, so the lake was treated for a third time to 4 ppb that day. Rising fish were again observed that evening.

In 2004, we applied 12 ppb of Antimycin A to Cherry Lake on the first day of treatments. Gill nets were again set in the lake, and 16 d later, 16 YCT were found in the gill nets. The gill nets were left in the lake and checked periodically through the fall of 2004. The nets were left in the lake overwinter. On the initial check of the gill nets in July 2005, the decayed carcasses of six fish were found in the nets, but no additional fish were caught the remainder of 2005. Nevertheless, the lake was treated again in August 2005 at a concentration of 8 ppb Antimycin A. No dead fish were observed. Follow-up genetic testing of the restored Cherry Lake population has confirmed that only WCT occupy the lake, indicating that original YCT population was completely eradicated by our multiple treatment and gill netting effort.

We do not definitively know the reason for the failure of the Fintrol to eradicate fish in Cherry Lake, but we surmise that it was due to inadequate mixing of chemical throughout the lake. Accelerated photodegradation of the Antimycin A at the high elevation of this lake is also a possibility; however, it did not appear to be a degradation or water chemistry issue as fish in the inlets and outlet of the lake succumbed to the piscicide as expected. There did not appear to be any significant spring upwellings in the lake basin where fish could access untreated water, as inflow to and outflow from the lake was similar. A scuba inspection of the lake bottom on July 27, 2005 found only one small spring upwelling of relatively insignificant volume.

During the EA process, several members of the public stated that they fished in Cherry Lake every year. To reduce the impact of the treatment on recreational angling in the lake, we agreed to stock the lake with catchable WCT as soon as feasible after removal of the nonnative YCT. Our intent was to initially stock the lake with age-3 and age-4 WCT males retired from MFWP's WCT conservation brood at Washoe Park Hatchery (WPH) so they would be large enough for angling but would not reproduce. We hoped that they would die out as WCT we intended to establish from a wild donor source through fry stocking reached maturity. However, the only WPH WCT available in 2006 were age-2 females, so we stocked 165 of them into Cherry Lake. At that age, visual sex determination is difficult. In July 2009, several size-classes of WCT were observed in Cherry Lake, indicating that reproduction had occurred since 2006. Because we wanted to establish a wild-sourced WCT population in Cherry Lake rather than having the WPH genetics descending from the lake into Phase-1 streams, gill nets were deployed in the lake and a rotenone treatment was conducted in August 2009 in the primary inlet spawning stream. While we do not believe that we completely removed all the WPH WCT from the lake, we did significantly reduce their numbers and removed most, if not all, spawning-sized fish from the lake. After this netting effort, we stocked the first year-class of age-0 wild-sourced WCT into Cherry Lake. The remaining WPH WCT descendants in Cherry Lake would have continued to mature but would have had only one or two spawning seasons prior to the 2009 wild-source male age-0 introductions reaching sexual maturity and beginning to spawn with the remaining WPH WCT.

We failed to locate and treat two tributaries in Phase 1 in 2003. These tributaries were located after treatments were completed in 2003. One of these streams was overlooked because it flowed through tall grass and had a discharge of slightly less than 0.001 m^3/s. It was identified when surrounding vegetation began to dry out and we noticed a narrow strip of green grass on the hillside. The other was a stream of 0.014 m^3/s that simply was not seen in dense forest underbrush during preproject surveys. Nonnative trout occupied both streams, and both were treated with piscicides in 2004. Similarly, in Phase 2, an off-channel spring pool was completely missed by backpack sprayers in 2005 but was found and treated with piscicides in 2006. It was occupied by about 30 Brook Trout. An ephemeral connection between the pool and Cherry Creek provided the Brook Trout access to Cherry Creek. The Brook Trout in the off-channel spring spawned in fall 2005, resulting in dozens of age-0 Brook Trout in the main stem of Cherry Creek that were killed in the 2006 treatment. We retreated the Phase-2 main-stem reach and the lower ends of all tributaries for a third time in 2007, just in case any other fish had survived.

On rare occasions, a drip station tipped over before it was empty, spilling the remaining chemical solution onto the ground or into the stream. In the four times this happened over 8 years of treatments, it was due either to inattentiveness or because of difficult site conditions at the treatment station (e.g., sloping or uneven streambanks) or both. Commonly, as the fluid level in the bucket dropped, the bucket became more unstable and susceptible to tipping, despite being weighted with rocks on the lid. If the bucket tipped into the stream, we refilled it to the level it was when it spilled and charged it with piscicide to achieve one-quarter of the designed treatment concentration. We did this because we wanted to maintain a piscicide concentration that would continue treating that reach of stream but minimize the impact of the spill on nontarget organisms. If piscicide detoxification was occurring downstream, the operators of the detoxification station were notified of the spill and reminded to monitor sentinel fish carefully and be ready to adjust the concentration of potassium permanganate applied, if necessary. Because there were only a few instances of buckets tipping and they generally occurred well upstream of the detoxification site, there was never a need to adjust the level of potassium permanganate in response to a chemical spill. If the bucket tipped onto the ground rather than into the stream, we refilled it to the level it was when it spilled and charged it with piscicide to continue treating the stream at the designed treatment concentration.

In 2003, the first year of eradication efforts, we started treatments by establishing the uppermost drip station approximately 200 m above the end of fish in a given tributary, as defined by electrofishing surveys. Sometimes this was well below the stream source. On two occasions, fish were observed above the uppermost drip station during treatment. In those events, we either instructed backpack sprayers to make sure the area above the drip station was treated or, if streamflow warranted, additional drip stations were deployed upstream. After this happened the second time, we adapted our strategy and made it a rule to start drip station treatment at the stream source, unless there was a clear barrier to fish movement (e.g., waterfall) at a point lower down the drainage and no fish had been found upstream of that barrier during electrofishing surveys.

An unexpected problem occurred in 2008 and 2009 when some adult fish in Phase 4 ascended past the Phase-3 barrier into the previously treated Phase 3, despite modeling showing that the barrier should have been impassable. The fish jump model was based on known swimming speeds for Rainbow Trout, water velocity, depth of water on the apron or splashpad below the barrier, and a range of leaping angles. Phase 3 was treated in its entirety in 2007 and 2008. Again in 2009 several adult fish were discovered above the barrier in the lower part of Phase 3. In early July 2009 fish were observed passing over the Phase-3 barrier. We determined that fish were not leaping over the barrier from the splash pad, but rather jumping from the 25-cm standing wave between the toe of the barrier and the overflowing water, something the modeling effort had not anticipated. An angled screen was constructed and attached to the downstream face of the barrier, and no additional fish made it over the barrier. A third piscicide treatment of the Phase-3 main stem and lower ends of tributaries was conducted in 2009 to remove the fish that had ascended the barrier.

The most significant and disappointing problem occurred in 2010, the highest water year during the project. As previously described, in an average water year, approximately 1 km of main-stem Cherry Creek dewaters upstream of the Phase-3 barrier. Then, starting about 180 m above the barrier, springs begin to recharge streamflow to about 0.45 m^3/s at the barrier. However, during spring runoff in 2010, the Phase-3 barrier area was inundated with flood water, creating overland surface flow between Cherry Creek and the adjacent spring channel. After the initial flood event receded, we sandbagged the margins of Cherry Creek and the spring channel in case water level increased again (Figure 9). Fearing that fish may have been able to swim around the main stem and spring barriers during the flood event, we decided to treat the Phase-3 main stem a fourth time. Additionally, the higher-than-normal late-summer surface flows maintained a weak surface water connection through this typically dewatered reach. Treatment of the main stem of Cherry Creek in 2010 was initiated in early August, with a single drip station applying 50 ppb rotenone at the Phase-2 barrier and another at the lower end of Carpenter Creek, a tributary to Cherry Creek downstream of the Phase-2 barrier. Throughout the day, sentinel fish in main-stem Cherry Creek were observed to determine the effective travel distance of the rotenone. In previous treatments of Phase 3, rotenone applied at the Phase-2 barrier was

Figure 9. Phase-3 barrier after peak discharge receded and sandbagging was completed to prevent further flooding that potentially could allow fish to pass the barrier.

lethal to sentinel fish for no more than about 6.4 km downstream and degraded below a lethal concentration about 1.2–1.6 km above the Phase-3 barrier. The dewatered reach above the Phase-3 barrier also typically prevented rotenone from carrying further, if it even persisted that far. In 2010, sentinel fish several kilometers above and at the Phase-3 barrier showed no signs of rotenone toxicity by late evening, several hours after rotenone should have arrived at those locations. Although a detox station had already been set up and was potentially operable at the mouth of Cherry Creek Canyon (about 1 km below the end of Phase 4 at Cherry Falls or a point that is about 6 km below the Phase-3 barrier and 14.3 km below the rotenone application point at the Phase-2 barrier), it was not activated that evening based on the condition of the sentinel fish located at and above the Phase-3 barrier, and we did not want to release potassium permanganate unnecessarily. The following morning, numerous dead fish were observed several kilometers downstream of the detox station. We determined that most of these fish had not drifted down from Phase 3 or 4 because there were Brown Trout *Salmo trutta* and Mountain Whitefish *Prosopium williamsoni* among the dead fish, species that were not present in the project area.

The decision was made to continue with the treatment that day as scheduled, activate the detoxification station as previously planned, and investigate the extent that rotenone had carried the previous day. All sentinel fish through Phase 4 were already dead, indicating that an unplanned but thorough treatment of Phase 4 had occurred during the night. Additionally, 33 of 37 surplus sentinel fish being held at the detox station were dead, as well as most sentinel fish already deployed at points downstream of the detox site. Through electrofishing, we determined that the rotenone from the previous days treatment (one drip bucket at the Phase-2 barrier, one on Carpenter Creek, and backpack sprayers cumulatively applying 50 ppb rotenone) had remained lethal for approximately 20.9 km downstream to a point 4.8 km upstream of Cherry Creek's confluence with the Madison River and 6.6 km below the site of the detoxification station.

Treatments were completed as scheduled in August 2010, despite the bad publicity generated by the overkill incident. During an investigation to determine why the incident occurred, all calculations and streamflow measurements were double-checked and found to be correct. The rotenone potency was tested by an analytical laboratory and found to be within label specifications. No other obvious application errors, such as an inadvertent spill of rotenone, occurred. Phase 3 does include a large beaver dam complex. The dams had been broken and drained to the extent possible, but several still had modest pools of slow-moving water in them. These pools were also sprayed by backpack sprayers. We can only surmise that a significant amount of rotenone was slowed down in the beaver dam complex and degraded more slowly than anticipated due to reduced agitation in the pools, slightly cooler water temperatures from the higher streamflow, and increasing afternoon cloud cover. Darkness and cooling evening water temperatures would have further slowed rotenone degradation, possibly allowing low dosages of rotenone to flow out of Phase 3 during the night. This same scenario may have occurred in previous years, but the dewatered reach prevented outflow from Phase 3. If the surmised scenario is plausible, it is likely that an extremely low rotenone concentration with up to 12 h of exposure was adequate to cause fish mortality during the night. This incident caused MFWP to develop a formal piscicide policy, including strict detoxification guidelines.

Although projects using rotenone and, in at least one case, toxaphene were conducted in Montana from the 1950s through the 1970s to control nongame or nonnative fish species, these projects were all one-time efforts to reduce the abundance of a target species in a single water body or portion of a drainage. The Cherry Creek project launched a programmatic effort by MFWP and other resource agencies to conserve and restore native Cutthroat Trout throughout their historical range in Montana by eradicating competing or hybridizing species across entire watersheds. The controversy encountered during the planning and initiation of the Cherry Creek Project, as well as the overkill event during the last year of treatment, resulted in the development of a programmatic approach to use of piscicides for native trout conservation and restoration in Montana, as well as a formalized MFWP piscicide use policy developed by members of the Piscicide Technical Committee. Proposed projects are critically assessed to determine feasibility, cost-effectiveness, and biological significance (e.g., hybrids in lakes influencing genetic purity of fish downstream, lack of aboriginal WCT within a larger geographic area, and need to expand small WCT populations). A committee of MFWP fisheries biologists, technicians, and administrators was convened to establish standards for development and certification of personnel to conduct piscicide projects and to ensure compliance with state and federal regulations governing use of piscicides. Using the Cherry Creek EA as a template, this committee developed a boilerplate EA so all projects would use the same format and provide consistent, relevant, and accurate information to the public. The boilerplate EA is updated as new information or issues arise. Information specific to each piscicide project is incorporated into the EA for that project.

Montana law requires that individuals applying restricted use pesticides in Montana be licensed by the Montana Department of Agriculture (DOA). However, due to the relatively few individuals in the state that occasionally used piscicides, training and licensing specific to piscicides was not available. Over the course of the Cherry Creek project, as MFWP's broader piscicide program developed, MFWP worked with the DOA to develop training and certification specific to piscicide use that includes initial certification and then continuing education credits to maintain certification. Other agencies and organizations also use this training process. For example, some Yellowstone National Park biologists and technicians are certified by the DOA and maintain their piscicide applicator certifications through MFWP Piscicide Committee training and adhere to Montana's Piscicide Policy when planning and conducting projects in Yellowstone National Park.

Montana Fish, Wildlife & Park's formal Piscicide Policy directs procedures in six areas: (1) Piscicide Committee membership, (2) applicator responsibilities and training requirements, (3) assistance to projects, (4) treatment procedures and checklist, (5) species of concern and benthic macroinvertebrate sampling protocol, and (6) rotenone detoxification procedures.

Significant elements of the Piscicide Policy include internal review of EA's prior to public release, pre- and posttreatment monitoring of nontarget organisms, piscicide detoxification guidelines, development of various levels of applicators based on experience and frequency of conducting piscicide projects, and assignment of specific duties based on an applicators level of experience. For instance, only the top two levels of applicators are allowed to conduct or supervise detoxification. Additionally, the policy requires appointment of an "independent applicator." This individual is a certified piscicide applicator who is not otherwise involved with the proposed project. This individual is responsible to critically review the EA prior to public release, serve as an on-the-ground observer and devil's advocate for the first day or two of a project, and ensure compliance with established standards for personnel safety and treatment procedures.

Montana's permitting system for piscicide applications also evolved as a result of the Cherry Creek project. Prior to this project, the DEQ did not have an application form for piscicide activities. Their standard process was to have MFWP biologists complete the DEQ application for turbidity exceedance, but to write in information describing the piscicide activity rather than turbidity generating activities. Nevertheless, at one point in 1999, as threats of lawsuits over the Cherry Creek project were made by opponents, a DEQ staff attorney criticized MFWP's lead Cherry Creek biologist for using the DEQ's turbidity exceedance application form to apply for a piscicide permit. Eventually, the DEQ and MFWP worked together to develop an appropriate application form for piscicide applications.

Westslope Cutthroat Trout Translocations

The primary goal of the Cherry Creek project was to establish a large, self-sustaining population of genetically pure WCT by translocating embryos obtained from existing upper Missouri Drainage WCT populations. However, given the scale of the project area, the limited number of wild donor sources in the entire upper Missouri, and research goals, we ultimately decided to use both wild and hatchery sources of WCT, some from outside the upper Missouri, to start the new WCT population in Cherry Creek.

Wild donor populations were selected based on their proximity to Cherry Creek, genetic purity, population abundance, disease-free status, and assumption that they were aboriginal WCT. Potential Cherry Creek donor WCT populations were screened based on their genetic purity (Shepard et al. 2003,

2005) and spatial structuring (Drinan et al. 2011). Pathogen screening was done for all potential donor populations. The standard MFWP disease panel for testing translocation eligibility includes (1) *Aeromonas salmonicida*, which is the bacteria that causes furunculosis; (2) infectious hematopoietic necrosis virus; (3) infectious pancreatic necrosis virus; (4) viral hemorrhagic septicemia virus; (5) *Renicterium salmoninarum*, the bacterium that causes bacterial kidney disease; and (6) *Myxobolus cerebralis*, which is the parasite that causes salmonid whirling disease. Testing fish for pathogens requires sacrificing fish and surrogate trout species were often used, when available. A sample size of 60 fish provides 95% confidence in identifying the presence of pathogens in the population, assuming a 5% infection rate (AFS-FHS 2014), and this level of testing is consistent with MFWP fish health policy. Ultimately, four wild donor streams were selected, none from the Madison River drainage but all from the upper Missouri drainage (Muskrat, Ray, White's, and Bray's Canyon creeks).

Donor streams were electrofished in June, prior to and during spawning, to capture mature, adult WCT, which were held in live cars near their site of capture until they became sexually ripe. Typically, the largest wild WCT in donor streams were 250 mm in length, but average sizes of mature adults were typically 130–150 mm, with some mature males as small as 100 mm. After capture, fish were monitored at least twice weekly, and when ripe, they were spawned on site (Figure 10; Table 7). A nonlethal fin clip was taken from each fish that donated eggs or sperm. Fin clips from each donor adult were sent to the Conservation Genetics Laboratory at the University of Montana and analyzed for genetic purity. This complimented the population level genetic assessment done to identify potential donor streams and insured that all donors were genetically pure. These fin clips were also archived in order to genetically back-assign progeny to parents and donor stock.

Two captive composite populations (broodstocks) were also used to provide eggs or fry for restocking Cherry Creek (Table 7). A small portion of eggs from each individual wild donor stream were kept at the SRH until they hatched. These fry were reared in troughs until approximately mid-September, when they were transferred to the brood pond prior to freeze up. Once the fish in the pond attained sexual maturity, typically 2 years for males and 3 years for females, they were captured by angling or netting and spawned into egg lots, as described above. Lengths of the mature Sun Ranch Pond (SRP) fish were generally 300–400 mm, despite being first-generation descendants from 150 to 250 mm wild parents. No effort was made to determine the natal stream for each adult fish from SRP prior to spawning them because we wished to randomly mix genetics among the different donor stocks held in the SRH. However, genetic samples were taken from individual fish spawned at SRP so the stream of origin from each parent could be back-assigned and progeny from these pairs could be back-assigned to their parents and streams of origin. Fish in the pond became sexually mature in May, about 2 months earlier than adults in the wild donor streams. Because of earlier maturity, SRP embryos were incubated in colder water to slow incubation and better match timing of egg development from wild donor streams that did not arrive at the hatchery until late June or July.

The second composite population that was used for introductions was MFWP WCT conservation broodstock housed at the WPH in Anaconda (Table 7). This broodstock was founded in 1983 and 1984, with wild fish collected from 12 donor streams in the South Fork Flathead River drainage and 2 donor streams in the Montana reach of the Clark Fork River drainage and has periodically been infused with gametes from

Figure 10. Spawning donor Westslope Cutthroat Trout on site at the stream of capture.

the wild founding populations to maintain genetic viability. The WPH WCT were the most genetically diverse source introduced into Cherry Creek. Fish were spawned and incubated on site at the WPH. Similar to SRP eggs, WPH eggs had to be incubated at colder temperatures so eyed eggs would be ready about the same time as wild-sourced eggs. Fin clips were taken from the WPH adults that contributed egg lots to the project.

We followed the same spawning protocol for all fish contributing gametes to Cherry Creek. We stripped each female of eggs and split the eggs between two 1-L insulated bottles. The green eggs in each bot-

Table 7. Number of donor stream crosses and the number of males and females used from each stream.

Donor source	Crosses	Males	Females	Adults
Brays Canyon	7	7	7	14
Muskrat Creek	73	73	37	110
Ray Creek	68	68	35	103
Sun Ranch Pond	29	29	15	44
Washoe Hatchery	60[a]	60	60	120
Whites Creek[b]	28	28	18	46
Total	265	265	172	437

[a] Data sheets indicate 21 parental crosses were combined into three egg lots.
[b] Does not include egg lots used to provide age-0 fry for Cherry Lake introductions in 2009, 2011, and 2014.

tle were fertilized with milt from different males to produce a unique male × female cross, called an "egg lot" (Table 8). Next, we rinsed away remaining milt with freshwater and allowed the fertilized eggs to water-harden in a water-iodophor solution for 30 min. After water hardening was complete, the water-iodophor solution was drained and the eggs were rinsed with freshwater. Wild eggs were packed in coolers for transport to the incubation facility at the SRH, which is located more than 160 km from some of the donor streams.

We held all eggs in vertical tray incubators until the eyed-stage. Eggs from the WPH population were incubated in vertical incubation trays at that hatchery. Incubating eggs were treated with formalin every 3 to 7 d to reduce fungal outbreaks. We controlled water temperatures during early incubation to slow incubation of gametes collected in May and accelerate incubation of gametes collected in late June and early July so that all eyed eggs were released into remote site incubators (RSIs) from July 4 to August 4, except in 2007 when releases occurred from June 19 to July 24. After the eggs had reached the eyed stage, we removed dead eggs, counted the number of survivors, and transported the surviving eggs to the study site in 1-L insulated bottles.

Introduction of genetically pure WCT from selected wild donor populations and brood sources was primarily accomplished by placing eyed eggs in RSIs (Figure 11; B. Shepard, B. B. Shepard and Associates, and colleagues, unpublished manuscript). Tables 9 and 10 detail the number of donor-source eyed eggs and estimated number of donor-source WCT fry released by year, respectively. Tables 11 and 12 show the number of eyed eggs placed in RSIs and the number of fry released, respectively, by phase and year. With the exception of Cherry Lake, Phases 1 and 2 received only eyed eggs (Table 13). For stocking Cherry Lake, we used same-sex WPH broodfish (see discussion above in the Mistakes, Learning Experiences, and Innovations subsection of the Piscicide Treatments section) to jump-start this population for public angling (including by outfitters) and then introduced cohorts of 630, 1,000, and 2,200 age-0 WCT (fry) in 2009, 2011, and 2014, respectively, from one of the four wild-donor streams (i.e., Whites Creek). Because of inlet and outlet stream spawning, trout populations in Cherry Lake are self-sustaining. Phase 3 was restocked with mostly eyed eggs, but 4,000 age-0 SRP fish (fry) were stocked near the bottom of Phase 3 in 2010. Phase 4 was stocked with 4,850 age-0 SRP fry, as well as triploid (ster-

Table 8. Number of egg lots introduced into Cherry Creek by donor stream and year.

Donor source	2006	2007	2008	2009	2010	Total
Brays Canyon					7	7
Muskrat Creek		22	27	24		73
Ray Creek		25	23	20		68
Sun Ranch		13	13		3	29
Washoe Hatchery	4	21[a]	21	12	2	60
White's Creek[b]	3	8	9	8		28
Total	7	89	93	64	12	265

[a] These 21 parental crosses were combined into 3 egg lots for transfer into remote streamside incubators but here are counted as 21 egg lots.
[b] Does not include egg lots used to provide age-0 fry for Cherry Lake introductions in 2009, 2011, and 2014.

Figure 11. Typical remote streamside incubator (RSI) setup. Water enters via pipe from left, upwells through "gravel" (artificial substrate), and then flows out the top of the RSI. In this setup, the fry exited the RSI voluntarily and were captured in the second bucket to the right so we could calculate the timing of departure and numbers of surviving fry. Without the trap, the fry would drop directly into the stream.

Table 9. Number of donor source eyed-eggs placed in Cherry Creek remote streamside incubators (RSIs), by year.

Donor source	2006	2007	2008	2009	2010	Total
Brays Canyon					1,066	1,066
Muskrat Creek		5,445	3,204	4,004		12,653
Ray Creek		3,467	1,700	1,911		7,078
Sun Ranch		3,075	3,277		398	6,750
Washoe Hatchery	720	1,015[a]	2,645	1,714	154	6,248
White's Creek	725[b]	1,015	974	636		3,350
Total	1,445	14,017	11,800	8,265	1,618	37,145

[a] Confusing data sheets indicate that an additional 108 eggs more than shown here may have been placed in RSIs.
[b] This is the count of eggs made at the Sun Ranch Hatchery prior to transport to the RSIs. Many died during transport so the actual number of eggs placed in the RSIs was significantly less than this number.

Table 10. Estimated[a] number of donor source fry released from Cherry Creek remote streamside incubators (RSIs), by year.

Donor source	2006	2007	2008	2009	2010	Total
Brays Canyon					665	665
Muskrat Creek		4,414	2,354	2,620		9,388
Ray Creek		2,871	1,256	1,336		5,463
Sun Ranch		1,985	2,634		302	4,921
Washoe Hatchery	138	715	2,044	1,296	116	4,309
White's Creek	139	722	781	392		2,034
Total	277	10,707	9,069	5,644	1,083	26,780

[a] Assumes that the survival rate of each donor stock within each RSI was equal, so we applied the overall RSI fry survival rate to the number of eyed eggs from each donor that were placed into each RSI.

Table 11. Number of eyed eggs placed at remote streamside incubator sites, by phase and year. RSI = remote streamside incubator.

Phase	RSI site	2006	2007	2008	2009	2010	Total
1	Cherry Creek	723	7,112				7,835
	Cherry Lake Creek	722	6,905			7,627	
	Pika Creek[a]			5,845			5,845
2	Tributary 1			5,955			5,955
	South Fork Cherry Creek			4,024		4,024	
	Tributary 2					819	819
3	Carpenter Creek 1			4,241	4,241		
	Carpenter Creek 2				799	799	
Total		1,445	14,017	11,800	8,265	1,618	37,145

[a] Informal name given for project purposes to primary Cherry Lake Creek Phase-1 tributary.

ile) WPH WCT and same sex (male) age-3 WPH WCT. The larger triploid and same-sex fish used in Phase 4 were intended to jump-start a recreational fishery on the Flying D Ranch while limiting natural reproduction of these hatchery-origin fish in the system until the eyed eggs and fry released in the upper phases had time to mature and migrate downstream into Phase 4. This project was the first time triploid WCT had been developed and used in Montana. Although the potential supply of eggs from WPH was essentially unlimited, we made a concerted effort not to overwhelm the other sources by stocking WPH eggs in ratios similar to, or less than, the other, more limited wild sources. Hence, when larger fish needed to be stocked for various reasons (e.g., in Cherry Lake and Phase 4), we used same-sex or triploid individuals to prevent reproduction by these WPH-sourced fish as much as practical until wild-source fish were sexually mature.

Sources contributing to the Cherry Creek restocking were (1) four individual wild, aboriginal WCT populations; (2) a mixture of the four wild populations from the WCT broodstock developed at the SRH; and (3) the WCT statewide conservation broodstock from the WPH.

Table 12. Estimated[a] number of fry released from remote streamside incubator (RSI) sites, by phase and year.

Phase	RSI site	2006	2007	2008	2009	2010	Total
1	Cherry Creek	182	5,476				5,658
	Cherry Lake Creek	95	5,231				5,326
	Pika Creek[b]			4,356			4,356
2	Tributary 1			4,713			4,713
	South Fork Cherry Creek				2,811		2,811
	Tributary 2					583	583
3	Carpenter Creek 1				2,833		2,833
	Carpenter Creek 2					500	500
Total		277	10,707	9,069	5,644	1,083	26,780

[a] Assumes that the survival rate of each donor stock within each RSI was equal, so we applied the overall RSI fry survival rate to the number of eyed eggs from each donor that were placed into each RSI.
[b] Informal name given for project purposes to primary Cherry Lake Creek tributary.

Table 13. Summary of phase treatments and Westslope Cutthroat Trout (WCT) introductions. RSI = remote streamside incubator.

Phase	Treatment years	Years of introductions	Number of WCT introduced	Introduction method
1	2003, 2004	2006–2008	15,275	RSI
		2009, 2011, 2014	3,830	Age-0 fry[a]
2	2005, 2006, 2007[b]	2008–2010	8,107	RSI
3	2007, 2008	2009, 2010	3,333	RSI
	2009[b], 2010[b]	2010	4,000	Age-0 fry
4	2010	2011, 2012	4,850	Age-0 fry
		2010, 2012	6,420	Age-1 triploid[c]
		2011	2,000	Age-3 males[c]

[a] Introduced into Cherry Lake.
[b] Mainstem treatment only.
[c] Age-3 Washoe Park Hatchery males and age 1 triploid (sterile) fry were stocked to jump-start a recreational fishery. These fish were isolated from upstream phases by the Phase-3 barrier.

In summary, stocking of the Cherry Creek Project area was as follows:

- 26,780 newly hatched fry into streams in Phases 1–3 via eyed eggs in RSIs from 2006 to 2010.
- 165 age-2 WPH WCT into Cherry Lake in 2006 (most of these were removed by gill netting in 2009).
- 3,830 age-0 Whites Creek fry stocked into Cherry Lake in 2009, 2011, and 2014.
- 8,850 age-0 SRP fry stocked into Phases 3 and 4 in 2010–2012.

- 6,420 age-1 WPH triploids into Phase 4 in 2010 and 2012.
- 2,000 age-3 WPH males into Phase 4 in 2011.

Stocking densities of wild fry were low:

- 0.69 fry/m of stream length via RSI in Phases 1–3 (26,780 age-0 fry; range of 0.5–1.1 fry/m at various monitoring sites).
- 0.14 fry/m in Phases 3 and 4 (8,850 age-0 SRP fry).
- 0.36 fry/m throughout the entire project area (a total of 35,630 age-0 fry was stocked into the 100 stream kilometers where nonnative trout had been eradicated).

Mistakes, learning experiences, and innovations

Locating and confirming WCT populations that met our requirements for introduction to Cherry Creek required significant effort. Genetically pure WCT populations had been previously identified through efforts unrelated to the Cherry Creek project (Shepard et al. 2003). Even so, careful screening and rescreening of potential donor populations was done to confirm their genetic status (no evidence of hybridization, level of genetic diversity, spatial genetic structure relative to the restoration site; Drinan et al. 2011), population abundance, disease status, and timing and locations of spawning. Developing the methods to capture, hold, and spawn WCT from the selected donor populations required forethought, trial and error, and dedicated staff to sustain that effort for a period of several weeks each year. We demonstrated that prespawn, mature, wild-adult WCT could be captured by electrofishing, separated by sex, and held in perforated plastic storage containers in their streams of origin for up to several weeks prior to successfully spawning them. Green-egg to eyed-egg survivals from these spawning pairs was relatively high (average of 79%). Incubating fertilized eggs to the early eyed stage prior to moving them to RSIs resulted in eyed-egg to emergent-fry survivals of greater than 70% (Table 14; Shepard and colleagues, unpublished manuscript). In other words, despite the spawning stress, remoteness of both the source and recipient sites, multiple times they were transported over relatively long distances, and relatively little care given to

Table 14. Donor source contributions of Westslope Cutthroat Trout eggs and age-0 fry introduced into Cherry Creek.

Donor source	Number of contributing adults	Number of viable eggs produced	Estimated[a] number of fry released
Bray's Canyon Creek	14	1,066	665
Muskrat Creek	110	12,653	9,388
Ray Creek	103	7,078	5,463
Sun Ranch brood pond	44	6,750	4,921
Washoe Park Hatchery	120	6,248	4,309
Whites' Creek[b]	46	3,350	2,034
Total	437	37,145	26,780

[a] Assumes that the survival rate of each donor stock within each remote streamside incubator (RSI) was equal, so we applied the overall RSI fry survival rate to the number of eyed eggs from each donor that were placed into each RSI.

[b] Does not include adults used or eggs taken for Cherry Lake stocking.

the RSIs, more than half of the green eggs collected for this project resulted in fry stocked into Cherry Creek. Although not an absolute prescription, we found that locating a few RSIs near the uppermost boundary of potential trout distributions, spacing RSIs about 5–10 km apart, and annually translocating about 5,000–7,000 eyed eggs into RSIs at each site in a downstream progression over 3 to 5 years can adequately seed a vacant habitat the size of Cherry Creek. Translocating embryos or fish from multiple donor sources and high genetic heterozygosity of donor populations likely improves translocation success due to increased genetic diversity (Andrews et al. 2016).

In 2006, the pilot year of translocations, RSIs were located near the headwaters of Cherry Lake Creek and upper Cherry Creek, so as was typical for all back-country RSI sites, the eggs had to be carried to the RSI sites in coolers on pack frames. Pickup of the eyed eggs incubating at SRH was delayed by the Fourth of July holiday weekend; thus, the eggs were too advanced and started hatching during transport to RSIs. The newly hatched sac fry were very fragile, and most died during transport. Consequently, only 95 fry were released from RSIs in Cherry Lake Creek (13% egg-to-fry survival) and 182 fry from RSIs in upper Cherry Creek (25% survival) in 2006. Transport of eyed eggs to RSI sites was not delayed by holidays or weekends in later years.

Monitoring and Research

Monitoring

Complete eradication of nonnative trout was achieved in 100 km of stream and Cherry Lake from 2003 through 2010, followed by successful translocation of native WCT eyed eggs and fry (Figure 11; Table 13). From 2006 through 2010, 37,145 eyed eggs were placed in RSIs in Phases 1, 2, and 3, resulting in 26,780 age-0 fry released into project waters, a 72% egg-to-fry survival rate (Table 14). Remote site incubator stocking density for Phases 1–3, which contain 74 stream km, was 0.36/m; however, as all RSIs were stationed in the approximately 39 km of stream habitat upstream of and in Carpenter Creek, the stocking rate for that area was 0.69/m (Figure 12). Eradication of nonnative trout was confirmed by repeated piscicide treatments that killed no or few fish during the final treatment effort in each phase and by fish monitoring efforts following piscicide treatments. Extensive annual electrofishing sampling throughout the stream network from 2007 to 2016 captured one 200-mm Brook Trout at the foot of the waterfall barrier between Phases 1 and 2 in Cherry Lake Creek during 2009. This Brook Trout was immediately killed. It was the only nonnative fish we found during extensive annual fish sampling after we had completed treatments in any phase. Cherry Lake posttreatment monitoring was accomplished using gill nets and angling, and the inlet and outlet streams to the lake were monitored using electrofishing and direct observations by personnel walking along these streams. After the last piscicide treatment of Cherry Lake in August 2005 killed no fish, we never found nor had reports by anglers of any nonnative trout in Cherry Lake through 2018.

Monitoring the recovery of the new WCT population in Cherry Creek was an important part of assessing the success of the project. Several monitoring sections of varying length (depending on objective) have been established throughout the project area. Three 100-m monitoring sections, one each in Phases 2–4, were first sampled prior to treatment with piscicides in 2001 to provide comparison of pre- and posttreatment population abundance and fish size. These sites have been subsequently sampled every year, unless fish were not present due to treatment. Additional 100-m posttreatment monitoring sites were established in Phases 1 and 2, in part to assess fry survival from RSIs, and several have been sampled regu-

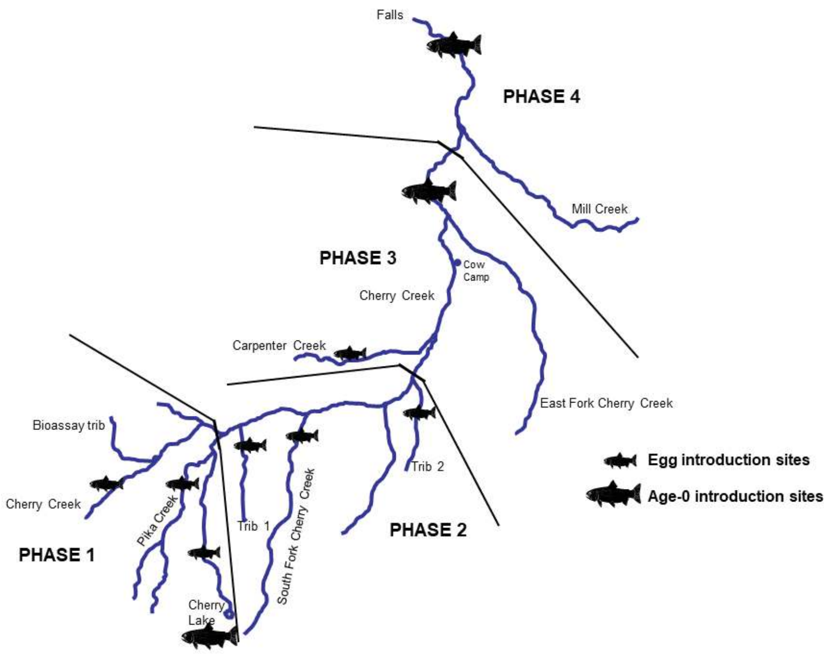

Figure 12. Cherry Creek restoration area showing treatment phases and Westslope Cutthroat Trout introduction sites.

larly since WCT have been introduced. Other preproject fish population estimates were made by Moran (2001) in several sections of Phases 3 and 4 as part of an assessment of the 1994 Arctic Grayling introduction and by the USFS Rocky Mountain Research Station personnel, who took advantage of the piscicide treatments to compare population estimates derived from various sampling methods (e.g., snorkeling and electrofishing) to the actual population of dead fish following treatment in Phases 2 and 3 (R. Thurow, U.S. Forest Service, personal communication). Several of these sites have been resampled.

Pre- and posttreatment fish abundances in monitoring sections indicated that WCT abundance increased rapidly and surpassed nonnative trout abundances 3 to 5 years after they were first translocated as fry (Figure 13). Our data indicates that once the translocated fry matured and successfully spawned, their progeny rapidly filled available habitats. Cherry Creek's base flow wetted width is approximately 5–6 m wide where these monitoring sections are located. Phase 4 was mostly populated by downstream drift of wild and naturally produced WCT originating in the upper three phases. Mean lengths of trout captured in these monitoring sections indicated that when trout abundances were low, the average lengths were highest, but that average lengths of WCT remained higher than average lengths of nonnative trout, even when abundances of WCT were higher than abundances of nonnative trout (Figure 13).

Based on postproject monitoring that expanded population abundances in sample sections to the streams that supported WCT, we estimate that 28,000 WCT occupied the 39 km of stream from Carpenter Creek upstream by 2016 (Figure 14). Expanding these estimates for the upper basin throughout the project area, we estimate that between 50,000 and 100,000 WCT occupied the project area in 2017, almost all of which are descendants of the original fish introduced as eyed eggs or fry. While no gill-net sampling

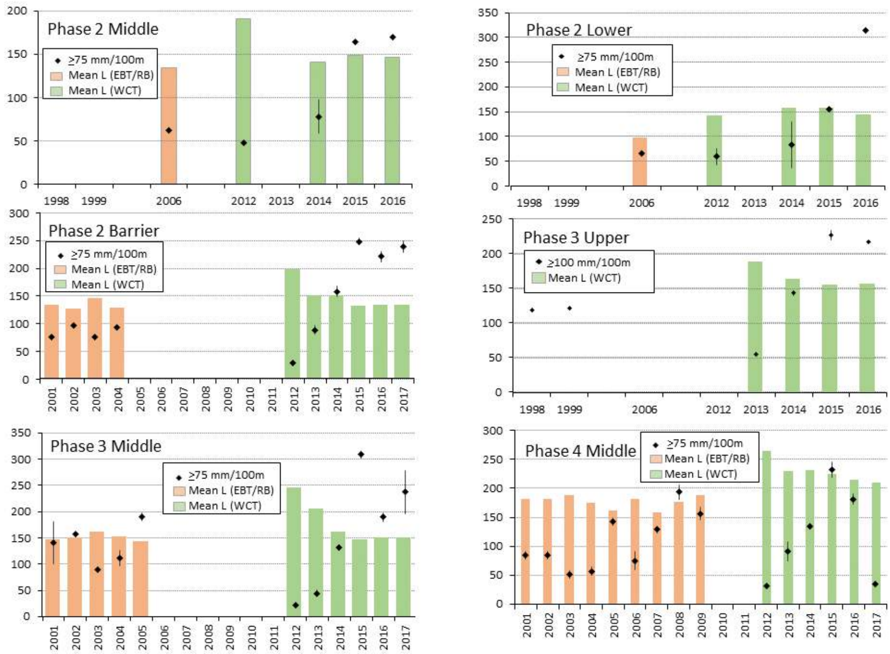

Figure 13. Densities (#/100 m) and mean length of pretreatment nonnative trout (Brook and Rainbow trouts) and posttreatment native trout (Westslope Cutthroat Trout) in six monitoring sections of Cherry Creek.

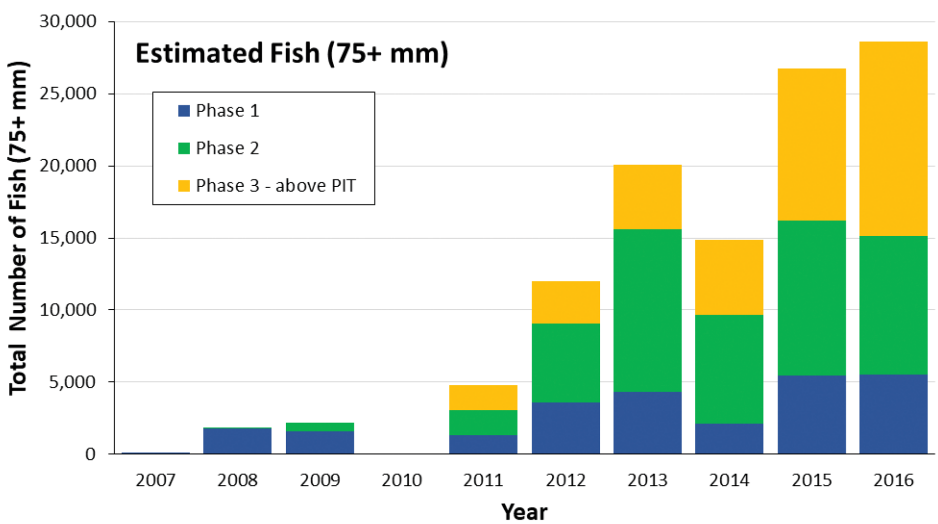

Figure 14. Estimated number of Westslope Cutthroat Trout 75 mm and longer in Cherry Creek basin from 2007 to 2016 by year and location in Phases 1 through 3.

has occurred at Cherry Lake since 2009, angler reports suggest that the lake is currently occupied by a robust population of genetically pure WCT.

Although we expected the new WCT population would thrive, it was unknown how well the stocked fry would survive and how soon they would fill the vacant habitat. We were astonished by how quickly the population expanded. Initially, about 91% of age-1 and 58% of age-2 WCT had moved less than 1,000 m from their RSI release site, mostly in a downstream direction (Andrews et al. 2013), but as habitats near release sites filled and as fish aged, more WCT moved downstream. Throughout the watershed, estimated fish densities increased dramatically about 3 to 5 years following WCT translocations, indicating that natural reproduction was occurring, and survival was high (Figure 14). We expect both numbers and size of WCT to moderate as the population fills the available habitat, and perhaps exceed carrying capacity for a year or two. We are beginning to see WCT in poorer condition, an indication of resource limitation. Based on the data in hand, it appears that pre- and posttreatment fish abundances and average sizes will be similar or that posttreatment populations and sizes will be slightly higher once the initial recovery wave attenuates. This is an important outcome as a common question related to native fish restoration work is how the restored population will compare with the pretreatment, nonnative population.

Apart from Cherry Lake, all live-fish stocking occurred in Phase 4, except the 4,000 age-0 SRP brood progeny stocked into the lower portion of Phase 3 in 2010. Upstream movement of the larger fish stocked into Phase 4 was blocked by the Phase-3 barrier until fall 2011. Even with the mixed-class stocking in Phase 4, it took about 4 years posttreatment for the population density to recover. However, that is not surprising since all the larger fish (same sex and triploids) stocked were not meant to reproduce, but rather to support recreational angling. However, that larger-size component of released WCT is evident in the initial posttreatment monitoring data (Phase 4 Middle; Figure 13). Population recovery in Phase 4 was dependent on the 4,850 age-0 wild sourced Cutthroat Trout stocked in 2011–2012 and downstream movement of wild source fish and their progeny from the upper phases. The 4,850 age-0 fish represent slightly more than one fish per 5 m of stream (0.22 fish/m) in Phase 4. The estimated number of WCT in Phase 4 in 2017 decreased significantly from previous years (Figure 13); however, this estimate was conducted 1 month later in the fall than previous years, so fish had likely already moved out of the sample section seeking pools for overwintering and were unavailable for capture in the monitoring section.

Electrofishing in monitoring sections in Cherry Creek downstream of Cherry Falls and in the Madison River has documented WCT dispersing and establishing downstream of the project area. Montan Fish, Wildlife & Parks has conducted annual mark–recapture electrofishing population estimates in a 6.4-km section of the Madison River immediately adjacent to the Cherry Creek confluence since 1967 to monitor naturalized populations of Rainbow Trout and Brown Trout in the river. Few, if any, Cutthroat Trout were historically captured in that section. An MFWP electrofishing crew began capturing WCT in this river section in 2012 and in March 2016 captured 130 WCT between 180 and 360 mm. Anglers are now pursuing WCT in the river, and many anglers have reported catching WCT, with some proudly sending photos of captured WCT to MFWP. In 2016, anglers reported catching WCT in the river as far as 37 km downstream of Cherry Creek. Although the most severe impacts of whirling disease seen in the Madison River in the early 2000s have abated to some degree (Clancey and Lohrenz 2015), the outcome of the Cherry Creek project is evidence that the strategy implemented by MFWP in the late 1990s to both restore native Cutthroat Trout in tributaries to the Madison River and diversify the fishery in the river was well considered.

Research overview

The Cherry Creek project was first and foremost a conservation effort to expand distribution of wild WCT in the Madison drainage and improve their conservation status, but secondarily, this project provided a unique opportunity to research a variety of restoration-related topics. Combining research efforts with conservation efforts presented some logistical challenges but in some cases also increased efficiencies that improved the project. For instance, RSIs had to be set up, operated, and maintained to translocate the eyed eggs from the selected donor sources to meet the main project objective of establishing a genetically pure WCT population. Simultaneously, to conduct their research on donor fitness, graduate students and their crews needed to operate and monitor RSIs, so they were tasked with conducting this element of the introductions rather than agency employees. We implemented adaptive management by making some changes to WCT translocations during the project based on preliminary research results. Research conducted as part of this restoration project evaluated the translocation, establishment, and expansion of WCT (Shepard and colleagues, unpublished manuscript); the relative fitness, behavior, and plasticity of WCT from different donor stocks (Andrews 2012); and the effects of water temperature on embryo survival and early growth of WCT originating from different stocks that evolved under different thermal regimes (Drinan 2010). We are continuing to collect data to compare the population structure of the pretreatment nonnative salmonid population and the posttreatment native WCT population to inform questions regarding ecological equivalence and recreational opportunity (e.g., size and number of fish; Figure 13). Research was also conducted to assess the effects of piscicide treatments on nontarget organisms such as aquatic invertebrates (Skorupski 2011; C. Kruse, Turner Enterprise, Inc., and D. L. McGuire, McGuire Consulting, unpublished data), amphibians (Billman 2010), and American dippers (also known as water ouzels) *Cinclus mexicanus*, which are a stream-obligate passerine bird (Donnelly 2018). Additionally, research evaluated the effects of environmental variables on piscicide efficacy and persistence (Brown 2010). We encouraged all researchers to publish their results in peer-reviewed journals.

Efficacy of piscicides.—Brown's (2010) doctoral dissertation is entitled "Environmental Conditions Affecting the Efficiency and Efficacy of Piscicides for Use in Nonnative Fish Eradication." He examined the efficacy of piscicides related to fish species and fish size and assessed how sunlight, organic matter, and turbulence influences piscicide effectiveness. He also evaluated the rate of piscicide mixing in a stream related to where it is applied (center of channel or along the edge). He developed models to predict rotenone persistence in various stream channel types. He concluded that increases in sunlight, organic matter, and turbulence all reduced the efficiency of both rotenone and Antimycin A, and his models can be used to better design piscicide treatments (Brown et al. 2011).

Piscicide effects on nontarget organisms.—Skorupski (2011) completed a master's thesis entitled "Effects of CFT Legumine Rotenone on Macroinvertebrates in Four Drainages of Montana and New Mexico." His thesis had two general objectives: (1) to demonstrate the influence CFT Legumine rotenone has on benthic macroinvertebrates for restoration projects in Montana and New Mexico, and (2) to evaluate the immediate response by means of invertebrate drift. His results indicated that effects of piscicide treatments on macroinvertebrates were small and relatively short-term (1 year) for Specimen and Cherry Creek projects in Montana. For the Comanche and Costilla Creek projects in New Mexico, there were more measurable impacts on the aquatic community. He suggested that impacts he observed in three of the four projects may have been related more to potassium permanganate treatments that were used to detoxify rotenone than from the rotenone itself. Nonetheless, aquatic macroinvertebrates in all four projects recovered 1 year after treatment. His study of macroinvertebrate drift found significant increases in macroinvertebrate drift during rotenone application but a delayed drift response compared to previous studies reported in the literature. Rotenone appeared to have the greatest immediate influence on the early life stages of Ephemeroptera and Plecoptera orders. Skorupski (2011) concluded that rotenone impacts on macroinvertebrate communities could be reduced if managers apply the minimal dosages and durations that are needed to eradicate nonindigenous fish species.

Kruse and McGuire (unpublished data) sampled macroinvertebrate communities at several locations in Cherry Creek about 6 years prior to piscicide treatments, the year prior to treatments, immediately before and after treatments in the same year, 2 to 3 years following the final treatment, and most recently in 2017 or 7 years after the last chemical treatment and 20 years after the initial sample. Data are still being analyzed, but as is common with macroinvertebrate data, the results are variable. In general, he found that the number of individuals declined immediately following a treatment and were further suppressed by consecutive years of treatment (average decline was around 40%), but numbers recovered and on average surpassed pretreatment levels within 2 to 3 years after the last treatment. The higher numbers of macroinvertebrates posttreatment were likely due to the lower number of fish in the stream at the time of sampling. Macroinvertebrate recovery may have occurred sooner, but samples were not collected more frequently. Number of taxa also declined, but these results were harder to interpret due to sampling inconsistencies. The number of taxa usually rebounded after the final piscicide treatment but remained lower than pretreatment numbers by about 10% 3 years later.

Billman's (2010) master's thesis is entitled "Investigating Effects of the Piscicide Rotenone on Amphibians in Southwestern Montana through Laboratory Experiments and Field Trials." She tested the effects of up to 2 ppm CFT Legumine rotenone formula (100 ppb rotenone) on various larval and mature stages of native Columbia spotted frogs *Rana luteiventris* and boreal toads *Anaxyrus boreas* in the laboratory (Billman et al. 2011) and in wetlands near Cherry Creek and at High Lake, Yellowstone National Park (Billman et al. 2012). In the laboratory study, she found that tadpole mortality increased with CFT Legumine concentration and exposure period, but effects decreased with age. In the field studies, she found that within 24 h following application of ~50 ppb rotenone at both locations, there was 100% mortality in gill-breathing tadpoles, but non-gill-breathing metamorphs, juveniles, and adults were apparently unaffected. One year following rotenone treatments, tadpoles were found in both sites. Where fish were removed, tadpole abundance was higher than pretreatment abundance after 2 years, which she attributed to reduced predation by fish on macroinvertebrates and tadpoles.

Donnelly (2018) examined the impacts of piscicide treatments on American dippers nesting along Cherry Creek. Dippers feed on a narrow range of aquatic insects (primarily individuals within the orders Ephemeroptera, Plecoptera, and Trichoptera) and small fish. They nest on mid- and near-stream features such as boulders, large woody debris, sheer banks, and bridges. Donnelly examined adult body condition in relation to timing of piscicide application. Body condition of adult dippers was significantly lower the spring immediately following a summer piscicide treatment (i.e., "during treatment") when compared to before and after treatment. This significant effect was attributed to declines in larval aquatic insects in the months following piscicide application. There was no significant difference between pre- and posttreatment body condition after one full year, but the latter was somewhat higher.

A common theme among all the studies that evaluated the effects of piscicide treatments on nontarget organisms was an obvious short-term impact on these nontarget organisms the year or years of the piscicide treatments, followed by a relatively quick recovery in 1 to 2 years. In some cases, it appears the lack of larger fish in the newly establishing translocated WCT population may have allowed amphibians and dippers to rebound relatively quickly and perhaps be in better condition or reach higher abundances due to less fish predation on macroinvertebrates and/or smaller fish providing prey.

Westslope Cutthroat Trout research.—Drinan's (2010) master's thesis was entitled "Thermal Adaptation of Westslope Cutthroat Trout *Oncorhynchus clarki lewisi*," in which he studied thermal adaptation in four wild populations and one hatchery stock of WCT. Mean summer water temperatures in the streams where he collected wild gametes ranged from 6.7°C to 11.2°C. After spawning fish in the wild, embryos were brought into a captive facility and incubated and reared their first summer under three different thermal regimes. Differences in embryonic development, embryonic survival, and juvenile growth were measured. He found that the colder the native stream, the greater the mortality at warm temperatures, but not the converse (Drinan et al. 2012). His findings suggest that in the short term, fisheries managers should consider local adaptations prior to translocating fish between streams (i.e., fish from cold native streams may perform better when moved to cold recipient streams). These results also suggested that because many Montana WCT populations are isolated in cold headwater streams, a fairly rapid increase in water temperature caused by global warming might be detrimental to their long-term persistence. One of the wild populations and the hatchery stock he evaluated were translocated into the Cherry Creek project area.

We integrated Drinans' (2010) findings into our study design for evaluating WCT translocations into RSIs in Cherry Creek. Our research to test the effects of water temperature on fitness of donor stocks from different streams called for splitting the eggs from each donor female used during 2006 and 2007 and placing half of these eggs in Cherry Lake Creek (a cold tributary; Figure 15) and half in upper Cherry Creek (a warm tributary; Figure 15). We spawned each half of these eggs with different males, so we could genetically back-assign progeny. We followed this egg introduction protocol from 2006 to 2010. Tissue samples were taken from each mature adult when we collected gametes. Genetic analyses were used to identify the genetic signature of each donor adult, so when their progeny were captured in the stream they could be back-assigned to each pair using microsatellite genetic analyses.

Because RSIs were such an important tool in our translocation of embryos but had never been used on the scale of a project like this, Shepard and colleagues (unpublished manuscript) evaluated the use of RSIs for translocating WCT in Cherry Creek to provide perspective for others considering this translocation technique. They found that green-egg to eyed-egg survival averaged more than 79% for most egg lots, but survival for a few lots was extremely low, which they related to poor sperm quality for the single male used because survival of

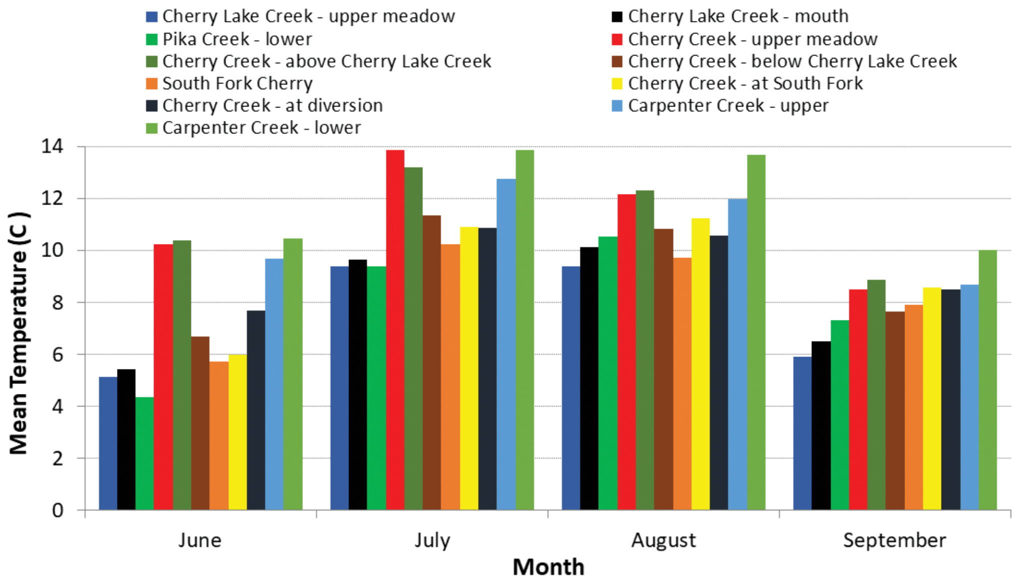

Figure 15. Mean monthly water temperatures at various locations within the Cherry Creek basin from 2008 to 2015. Note the much cooler average water temperatures in the two Cherry Lake Creek sites and in Pika Creek, a tributary to Cherry Lake Creek, and relatively warmer temperatures in upper Cherry Creek above Cherry Lake Creek (upper meadow and above Cherry Lake Creek).

the other half of the same female's eggs was much higher. From 2007 to 2010, eyed-egg to fry survivals averaged greater than 74% and more than 26,000 fry were released from RSIs into Cherry Creek. There were slight but statistically insignificant (Kruskal–Wallis analysis of variance test; $P > 0.10$) differences in eyed-egg to fry survivals among the different donor stocks (average survival ranged from 61% to 73%), but all five donor stocks contributed fry to the new WCT population. We placed RSI sites 5–10 km apart, and the overall fry seeding rates were at least 0.69 fry/m of stream length (range: 0.5–1.1 fry/m). This seeding rate resulted in average densities of about 0.2–1.0 WCT 75 mm and longer per meter of stream length 5 years after eggs were introduced.

Andrews' (2012) doctoral dissertation was entitled "Natural Selection in the Field and the Classroom." In the field portion of her work, she looked for differences in survival, growth, condition, and dispersal following translocation of embryos from five WCT populations to six introduction sites in Cherry Creek. She found that fry emerged from RSIs and dispersed to fill habitat progressively downstream, and to a limited extent upstream, during their first 2 years at large, with wider dispersal occurring the second year (Andrews et al. 2013). Westslope Cutthroat Trout progeny from the captive WPH donors moved shorter distances than progeny originating from wild donor stocks (Andrews et al. 2013). First-generation juveniles that originated from WPH had a higher median survival rate than wild fish. While she found a significant donor source effect for survivals of age-1 and age-2 progeny, she did not find a site effect, indicating that these younger WCT did not perform differently in the warm versus cold stream. However, Drinan's (2010) work suggested that there was an effect of water temperature on incubation success of different stocks, something that was held constant during incubation to the eyed stage for eggs released into Cherry Creek. We may not see an effect of temperature on incubation until we analyze data for the first wild-produced generation of fish that incubate in the cold and warm streams. The higher survivals that Andrews et al. (2016) saw for the captive WPH donor stock may be due to their higher genetic diversity compared to the wild stocks. Nevertheless, Andrews et al. (2016) speculated that that progeny from any of the donor sources used in Cherry Creek would have populated the drainage over time because some progeny from each donor source survived to age 2.

Interestingly, based on the embryo releases during 2007 in the cold tributary that drained Cherry Lake and warmer site in upper Cherry Creek, we found that growth of WCT was much slower, maturity was much later, and longevity was longer for WCT in the colder site than for the other half of the same females' eggs that were released in the warmer water site (Figures 15 and 16). Additionally, successful spawning in this cold tributary was sporadic and only occurred during the warmest years, while in the warmer stream, adult WCT successfully spawned every year (Figure 16). These differences in growth rates, maturation sizes, longevity, and spawning success for the embryos from the same female released into two sites with different thermal regimes illustrates the phenotypic and behavioral plasticity of these fish.

The translocation of WCT into the Cherry Creek basin successfully established a genetically pure metapopulation because (1) nonnative fish were successfully eradicated from 100 stream kilometers and a 130,000-m^3 lake, (2) translocated WCT embryos experienced relatively high survival rates (about 72% survived from eyed egg to fry that dispersed from RSIs) and then successfully reproduced within a few years of their initial release, and (3) all year-classes were represented in WCT populations 5 to 10 years postrelease. Translocations using a mixture of wild sources, which may each individually have relatively low genetic diversity, either together or along with a more genetically diverse captive source, appeared to be a reasonable strategy to conserve overall

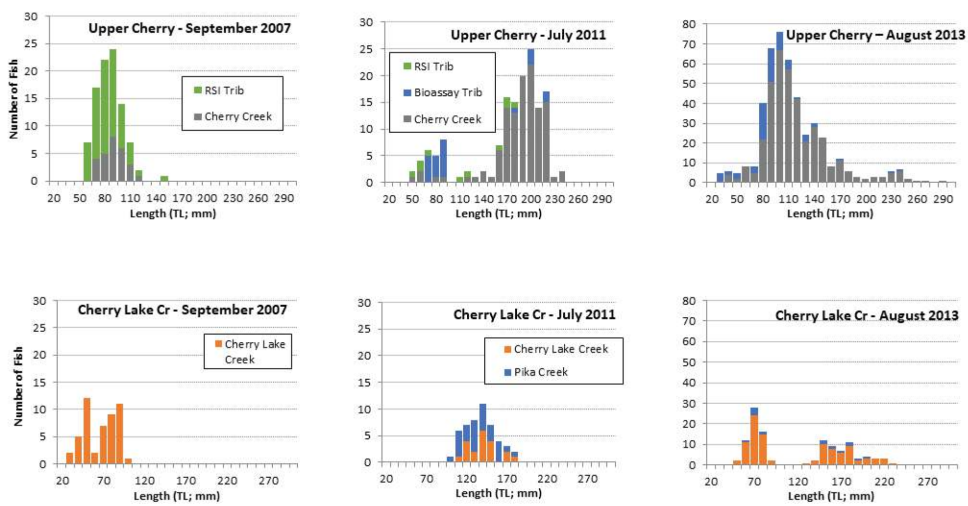

Figure 16. Length–frequency distributions for Westslope Cutthroat Trout captured in upper Cherry Creek (top charts) and Cherry Lake Creek (bottom charts) from 2007 to 2013 showing the growth of the 2007 year-class and evidence of the first successful reproduction in upper Cherry Creek in 2010 and in Cherry Lake Creek in 2013.

genetic diversity of this subspecies in Cherry Creek (Andrews et al. 2016). Using RSIs allowed wild stocks to contribute to translocations but limited the risk of disease and parasites being introduced into the restoration area or brought into captive incubation facilities.

Mistakes, learning experiences, and innovations

Although the scale of the Cherry Creek project was unprecedented and many members of the public and resource agencies were skeptical that it could be done, we demonstrated that removal of a nonnative fish population and reintroduction of native fish can be successful over large spatial scales and complex habitats if implemented methodically across the landscape. The lessons learned and ultimate success of this project led to a more programmatic and mainstream approach to native fish restoration in Montana, as well as across the region, and spawned efforts to attempt additional large, complex restorations.

In reviewing our records of egg transfers to the RSIs, we found some data that are unclear about how many eggs from the WPH were placed in some RSIs, and that some WPH egg lots were combined prior to transfer into RSIs. The number of eggs involved is relatively small and inconsequential to the overall RSI stocking rates and survival of eyed eggs. We have reported the numbers we feel are most reliable and noted them in the pertinent tables. This error is likely due to the fact that several different people were spawning the fish, recording the data, and loading the RSIs over a period of several years, and some may not have clearly understood the detail necessary to fulfil the research objectives. The lesson is that individuals who have accumulated decades of experience and have designed the research need to be ever vigilant that accurate data are being recorded and field operations are properly conducted.

Large-scale native fish restoration efforts provide unique opportunities to conduct research on (1) conservation strategies, such as criteria for selecting donor sources of native species, techniques for eradicating nonnative species and translocating native species, and stocking densities and population recovery expectations; (2) evolutionary ecology, such as local adaptation, inbreeding versus outbreeding depression, and life history plasticity; (3) population demography, such as intrinsic rates of population growth and carrying capacity; and (4) social organization, such as interactions between the public, government agencies and private organizations, management structure to accomplish a large-scale project, and economics of restoration, as a few examples. Involving relevant researchers and statisticians early in the planning stages of native fish restoration efforts ensures that research designs can be incorporated into the project. Integrating research into restoration efforts can provide additional rigor to the planning and implementation of the project and might also provide access to funding sources not otherwise available to complex conservation projects. As described in this and the Research Summary sections, we felt that we were successful at integrating ecological research into the Cherry Creek project. We were less successful in attempting to address some of the social questions related to the project.

Preproject baseline population data, especially abundance, size, and distribution information collected in a statistically rigorous manner, is useful for pre- and post-project comparisons. Surprisingly little information on pre- and postrestoration comparison is available in the literature. Physical habitat, streamflow, and water temperature information are valuable in understanding variations in data over time. We suggest that physical habitat data be collected every 3 to 5 years, but flow and temperature data be collected annually. Fish population data can be collected at whatever frequency is dictated by research or monitoring plans; however, we suggest for trout populations that fish abundance data be collected at least once a generation (every 3 to 5 years) during the first 9 to 15 years after translocations have occurred to document the recovery and expansion of the translocated population.

Collecting and archiving tissue samples from each donor fish used to start a new or supplement an existing native population provides an opportunity to investigate genetic or evolutionary questions in the future. For this project we are using genetic data for back-assignments of progeny to donor pairs or donor populations to assess performance of different donor stocks or pairs (e.g., Andrews et al. 2013, 2016). To successfully assign progeny to parental pairs, a single male's sperm must be used to fertilize each lot of eggs. Depending on research objectives and number of eggs per female, a single females eggs can be divided into multiple lots, each fertilized by a different male. In this "single male" design, there is potential for reduced fertilization rates, embryo survival, or even failure of entire lots of eggs due to poor sperm viability from a single male. However, we believe that this was an acceptable risk given the research objectives on the Cherry Creek Project. Genetic analyses and tagging of individual fish (i.e., using passive integrated transponder tags) can be powerful combination to track the performance of translocated individuals and their progeny. Here, we defined performance as relative survival, growth, and body condition over time among the different donor sources placed in different locations that had different thermal regimes.

Legacy of the Cherry Creek Project

At the implementation of the Cherry Creek project, genetically pure WCT occupied an estimated 836 km (3.0%) of their historical range in the Missouri River drainage in Montana, and nearly all of those populations are in first- or second-order streams, restricted to 8 km or less of habitat, with flows of 0.08 m^3/s or less (Shepard et al. 2003). The Shepard et al. (2003) status review also determined that genetically pure WCT occupied only about 0.7% (13.5 of 1,959.5 km) of their historical range in the Madison River drainage. The Cherry Creek Project increased occupied habitat by 100 km of stream in a fifth-level watershed with as much as 0.57 m^3/s streamflow, thereby increasing occupancy in the Missouri drainage to 3.3% and in the Madison drainage to 5.8% of historic distribution. Successful implementation and completion of the Cherry Creek project launched an ongoing, statewide, programmatic approach to native trout restoration using piscicides in Montana. By 2015, WCT occupied an estimated 5.8% of historical range in Montana's Missouri River drainage, with several populations occupying up to 24 km of habitat with up to 0.34 m^3/s streamflow. The last two known aboriginal Madison drainage WCT populations are being used to establish a new population in Ruby Creek, also in the Madison drainage. Rainbow Trout were chemically eradicated from about 16 km of Ruby Creek from 2012 through 2014, and WCT introductions began in 2015. Ruby Creek has a base flow of 0.28 m^3/s and significant spring influence that maintains favorable water temperatures year-round. Ice rarely forms on Ruby Creek, even in severe winter conditions.

At least partly due to the success of the Cherry Creek project, additional large-scale ambitious piscicide based conservation and restoration projects are now being conducted annually in other regions of Montana where nonnative trout threaten existing WCT populations. Every year, several smaller projects ranging from 2 to 24 km are conducted across western Montana to conserve or restore WCT. In 2017, MFWP completed a 10-year program in the South Fork Flathead River drainage upstream of Hungry Horse Dam to remove hybridized WCT × Rainbow Trout from 21 mountain lakes that were above streams occupied by pure WCT. The smallest of those lakes is 2,960 m^3, the largest is 16 million m^3. Montana Fish, Wildlife & Parks is initiating an effort to remove *Oncorhynchus* hybrid trout with a predominately nonnative Rainbow Trout genetic contribution from the North Fork Blackfoot River above the North Fork Falls to eliminate a source of hybridization to the existing WCT population below the falls and in the main-stem Blackfoot River. It is expected that this project will include treating three mountain lakes and about 73 km of stream flowing up to 1.4 m^3/s.

Yellowstone National Park (YNP) implemented a native trout program in the Madison River drainage within the park in 2013. Yellowstone National Park, with assistance from MFWP, the GNF, TEI, and the USFWS completed a 2-year project to eradicate Rainbow Trout and Brown Trout from approximately 56 km of Grayling Creek, a stream with base discharge at the project barrier of 0.85 m^3/s. They reintroduced native WCT and Arctic Grayling. In 2017, YNP initiated a project to remove nonnative trout from the Gibbon River upstream of Gibbon Falls and introduce WCT and Arctic Grayling. Cherry Creek WCT will be spawned in 2018 to provide eggs for RSI introductions into tributaries of Grebe and Wolf lakes, two of the three lakes in the project area.

Similar to efforts for WCT, MFWP and other partners are conducting piscicide projects to conserve YCT in Montana's Yellowstone River drainage. The largest project completed to date was in Soda Butte Creek, which flows from south-central Montana into the northeastern corner of YNP and is a tributary to the Lamar River where genetically pure YCT reside. A 10-year electrofishing effort to remove nonnative Brook Trout had reduced their numbers in the creek, but their distribution was expanding downstream toward the Lamar River. Montana Fish, Wildlife & Parks, the YNP, the Wyoming Game and Fish Department, the GNF, and the Shoshone National Forest worked together in 2015 and 2016 to salvage YCT from the stream and conduct rotenone treatments in 29 km of stream that successfully eradicated Brook Trout.

Conclusions

The Cherry Creek project is an example of a successful collaboration among state, federal, and private entities to achieve a common goal while allowing each to maintain their legal and statutory authorities, rights, and responsibilities. The success of the project created a pathway for similar efforts to conserve and restore native fish on public and private lands in Montana and elsewhere and emboldened similar efforts in YNP. We believe that the Cherry Creek project was successful for several reasons (see also Kruse et al. 2013):

1. Selection of a restoration site with high-quality and diverse habitat suitable for long-term WCT persistence.
2. Implementation of a systematic approach for nonnative fish eradication over a large scale.
3. An effective collaborative partnership between public resource management agencies and private conservation organizations that created a shared vision and spread financial and logistical obligations.
4. Persistence and mutual support of project partners through social, legal, political, and logistical challenges strengthened the collaborative cohesion and maintained the will to complete the project.
5. Continuity in supervisory personnel for each partner throughout the project, or a transitional period between old and new personnel within an entity, resulted in a smooth, seamless operation.
6. Designation of a point public relations agency and individual that worked cooperatively with the other parties' public relations personnel provided a com-

mon and consistent message to the public and reduced confusion between the cooperating parties.

7. A collaborative process created a trust among the parties and led to open and frank evaluation of issues, problems, and planning.
8. Fair but honest performance reviews winnowed out poorly performing staff, regardless of their affiliation.
9. The communication up the administrative chain in each partner organization carried consistent messaging.
10. The memorandum of understanding and agreements laid the groundwork to build trust among partners and ultimately allowed decisions and actions to be carried out more quickly with less resistance and formality.
11. Use of the best available science and an experimental framework informed project planning, implementation, and monitoring in an adaptive manner that improved the efficiency and outcome.

Beyond serving as a template for successful on-ground efforts to conserve native trout, the Cherry Creek project established procedures and protocols for public involvement, developed and clarified state and federal legal standing to conduct such projects, helped develop public information efforts, and established a model for public/private agency cooperation. In Montana, we are proud of the fact that cooperation between state and federal agencies is the rule rather than the exception, especially when implementing and conducting native fish projects. Private conservation organizations are usually supportive of conservation projects and often comment in favor of projects that are proposed, especially when there is controversy involved. While there may still be public concern and opposition whenever a project is proposed in an area where none have been previously conducted, the public and affected private property owners are becoming more accepting of native fish projects using piscicides as these projects are successfully completed with no negative long-term impacts to nontarget aquatic organisms, wildlife, livestock, water management, public access to waters, and private property issues, and as native fisheries establish and become available for angling.

We estimate the total project cost, including all personnel, planning, implementation, monitoring and research from 1998 to 2018, to be US$2,228,000. We could not document some of the costs between 1998 and 2000, though these costs were minimal due to the relative inactivity of the project, nor could we determine the legal and administrative costs of MFWP and GNF to address the challenges, appeals, and litigation against the project. We estimate project costs as follows:

- TEI
  - o $970,000, which includes
    - § $183,000 to support MFWP during piscicide applications
    - § $90,000 for piscicides and potassium permanganate
    - § $224,000 to support project-related research
    - § $447,000 in general project support, such as proving food, cooks and other support personnel, lodging, equipment purchases, and maintenance.
- National Science Foundation
  - o $800,000, which includes
    - § $100,000 for RSI operation and doctoral candidate support
    - § $700,000 for WCT founder population research, including genetic composition and behavioral research of descendant generations
- The GNF
  - o $165,000
- MFWP
  - o $160,000
- Wildlife Conservation Society
  - o $30,000

- Sun Ranch
  - o $30,000
- Montana State University
  - o $20,000
- Montana Department of Environmental Quality
  - o $15,000
- Various grants
  - o $38,000

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