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Blackfoot River Restoration: A Thirty-Year Review of a Wild Trout Conservation Endeavor

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Abstract.—The Blackfoot River restoration endeavor is an ongoing collaborative, comprehensive, and successful river conservation story in western North America. This chapter describes the restoration framework and process that shaped the first 30 years of this wild trout conservation story. The program began in the late 1980s when fish population surveys identified widespread habitat degradation and depleted numbers of wild trout throughout lower elevations of the Blackfoot River basin and the precarious status of migratory native trout. These initial findings triggered basinwide protective angling regulations for native trout, followed by fish population surveys in all streams. Fisheries data were then combined with basinwide aquatic habitat assessments to facilitate a collaborative multiscale restoration methodology to improve the ecological integrity of the river and its tributaries. Elements of the restoration framework included (1) basin-scale fish and habitat data collections that helped to identify human-induced limiting factors and promote landowner education/cooperation, (2) pilot restoration projects and prioritizations of tributary restoration work, (3) the site-specific integration of passive restoration (e.g. grazing and revegetation) and active restoration (e.g. fish screens, channel reconstruction) techniques, (4) the application of the reference reach concept within the restoration framework, and (5) the essential role of watershed groups in fundraising, implementation planning, and watershed-scale conservation easement protection, especially on private ranchlands. Finally, this chapter summarizes programmatic elements, specific case studies, and restoration techniques that preceded wild trout population expansion in the tributaries and main-stem Blackfoot River. The purpose of this chapter is to help others understand how we approached and implemented a major watershed restoration program.

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Introduction

After more than 60 years of stocking hatchery trout in the rivers and streams of western Montana, a 1974 decision by the Montana Fish and Game Commission facilitated an end to stocking practices and ushered in the era of wild trout management (Zackheim 2006). This management philosophy relied on the concept of self-propagating fisheries rather than hatchery supplementation. Decades of stocking also masked a long legacy of mining, dewatering, overgrazing, and other forms of stream degradation throughout western Montana. Once stocking ended, it became increasingly evident that managing for wild trout would not only require reductions in angler harvest, but also restoration of spawning and rearing habitat to recover the natural productivity of damaged trout streams.

Given this context, the Blackfoot River restoration endeavor can be traced to the mid-1980s when public perception of declining wild trout populations in the Blackfoot River prompted Montana Fish, Wildlife and Parks (MFWP) to assess fish populations in the main-stem river and its primary tributaries (Peters and Spoon 1989; Peters 1990). Early investigations confirmed depleted trout populations, overharvest of spawners, precariously low numbers of migratory native trout, and widespread degradation of the tributaries, especially at lower elevations of the watershed (Peters and Spoon 1989; Moore et al. 1991; Pierce et al. 2001, 1997). These initial findings led to basin-scale catch-and release regulations for native trout in 1990, greatly expanded fish population and habitat assessments in tributaries, as well as small-scale, pilot-level restoration projects on private ranchlands (Aitken 1997; Pierce et al. 1997). Increased data collection and early successes on pilot projects led to the incremental development of a stream restoration methodology for the Blackfoot River basin and the expansion of stream restoration from 1990 to the present.

As restoration practices gained social acceptance, the restoration program evolved into an iterative, multiscale native-trout recovery process (Pierce et al. 1997, 2013). Basin-scale fish population information, life-history studies (e.g., movement and habitat use using radiotelemetry), and comprehensive habitat assessments identified anthropogenic limiting factors while directing restoration activities to individual tributary populations. Restoration methods included enhancing instream flows in trout-rearing areas, preventing fish loss in irrigation canals, reconstructing altered streams to naturalize channel form and function, and fencing livestock from riparian areas. The scope and scale of projects gradually expanded outward from the central Blackfoot River valley as human-induced limiting factors were identified and opportunities allowed. Within this framework, monitoring and project evaluation were essential in measuring ecological effectiveness, promoting landowner education, and facilitating adaptive management (Pierce et al. 2013; Penaluna et al. 2016).

This chapter emphasizes the basic restoration framework and phased restoration approaches in the Blackfoot River watershed while providing examples of wild trout responses to the restoration program over a 30-year period. The framework includes (1) watershed-scale fish and habitat data-collection techniques that led to stream prioritizations; (2) strengthened stakeholder relationships through public outreach and fisheries information sharing; (3) how pilot projects, natural channel design methods, and concepts of the reference reach were applied (Harrelson et al. 1994; Rosgen 1996; Pierce et al. 2013); and (4) the essential role of watershed groups. Finally, this chapter summarizes major program elements (landscape connectivity and conservation easement protection, basin-scale and spring creek restoration) using various case studies to help clarify multiscale trends in wild trout response using long-term (>5 years) monitoring data.

Study Area: The Blackfoot River Basin and Its Wild and Native Trout

The Blackfoot River is one of the most scenic, physically diverse, and biologically complex rivers in western Montana. As a headwater basin (6,008 km^2) in the upper Columbia River watershed, it drains the western edge of the Continental Divide via 3,060 km of perennial streams and joins the Clark Fork River near Missoula (Figure 1). Milltown Dam, a run-of-the-river hydroelectric facility, was located at the junction of the Blackfoot and Clark Fork rivers until it was removed in 2008. The Blackfoot River main stem is now free-flowing, 212 km in length, and 1 of 12 renowned blue-ribbon trout rivers in Montana with a publicly (MFWP) held appropriated Murphy instream flow summer water right of 19.8 m^3/s. In 2015, the 1971 priority date of the Murphy water right gained more senior status (i.e., 1904) when the Montana Legislature ratified the Confederated Salish Kootenai Water Compact with Senate Bill 262.

The hydrology of the basin is a snowmelt-dominated regime. As measured at the Bonner gauging station (U.S. Geological

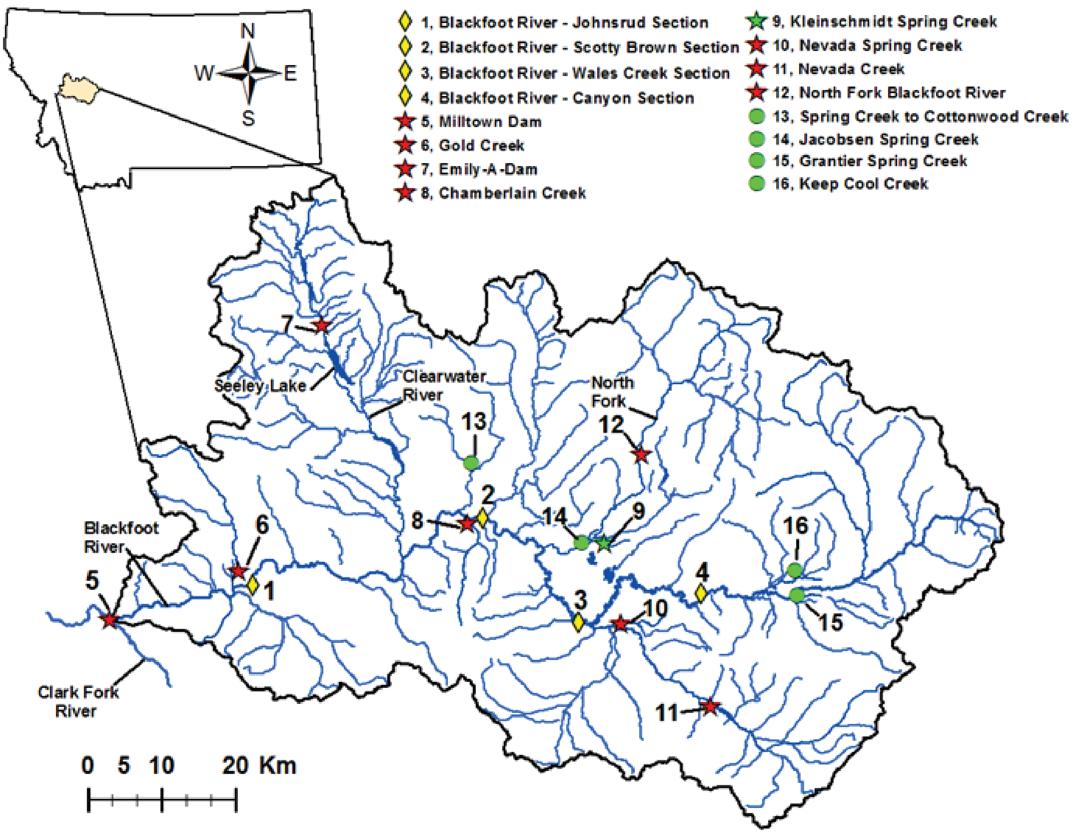

Figure 1. Blackfoot River location map in western Montana including major streams within the basin. Map numbers (1–16) relate to stream names/locations in the legend. The diamonds (1–4) show long-term fish population monitoring sites on the mainstem Blackfoot River. Stars (5–12) refer to tributary restoration case studies described in this report. Green circles (13–16) and the green star (9) show spring creek study sites.

Survey Bonner gauge #12340000), river discharge ranges from a high of >140 m^3/s during spring runoff to base flows of 14–20 m^3/s, with a mean annual discharge of about 45 m^3/s. The physical geography of the watershed ranges from high-elevation, glaciated mountains with alpine meadows to timbered forests at the mid-elevations and prairie pothole topography on the valley floor. Glacial landforms, moraine and outwash deposits, and erratic boulders variably cover the floor of the entire Blackfoot and Clearwater River valleys. These features exert a controlling influence on the physical attributes of the Blackfoot River and the lower reaches of most tributaries.

Land ownership in the basin is comprised of public and private holdings: 46% U.S. Forest Service (federal), 36% private, 11% state of Montana, and 7% Bureau of Land Management (federal). In general, public lands and private conservation properties (e.g., The Nature Conservancy holdings) consist of large, forested tracts in mountainous areas, whereas private timber, residential, and agricultural lands are found in the foothills and valley bottoms.

The Blackfoot River watershed supports various cold-, cool- and warmwater fishes. Species richness generally increases with distance downstream. Within this setting, migratory native trout (i.e., Bull Trout *Salvelinus confluentus* and Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi*) have a basinwide distribution and spawn and rear within small- to medium-sized tributaries. As these fish mature, they emigrate to larger, more-productive streams, rivers, and lakes where they grow to maturity before returning to natal tributaries to spawn. Resident trout of these species complete all stages of growth and maturity in small- to medium-sized tributaries and do not migrate to main-stem river or lakes. Predominant introduced wild trout in the main stem and larger tributaries include Rainbow Trout *O. mykiss* and Brown Trout *Salmo trutta*, while Brook Trout *Salvelinus fontinalis* are common in headwater streams.

Wild trout (native and nonnative species) in the watershed depend on tributary habitat during some portion of their life cycle. Therefore, trout species composition and abundance in the Blackfoot River closely reflects the number and quality of nearby tributaries. Biotic relationships among the Blackfoot River and tributary systems vary among river reaches. Some reaches include environments that are naturally (and seasonally) harsh (i.e., intermittent reaches, excessively warm reaches or those prone to winter anchor ice), and/or lack functional tributaries. Within this natural setting, native trout have adapted to a complex, glacially formed riverscape and have developed diverse life-history tactics that include landscape-scale migratory behavior. However, complex life histories and large-scale migrations make native trout especially vulnerable to adverse changes to the aquatic ecosystem. This is particularly true for Bull Trout, a migratory, obligate coldwater char that spawns in discrete upwelling areas and rears in the larger, colder tributaries before moving down stream to larger, more productive rivers and lakes in the Blackfoot River basin (Swanberg 1997; Benson 2009).

Traditional land use in the basin (e.g., mining, timber harvest, and agriculture) have all contributed to habitat degradation and fish-population declines, most of which occurs on the valley floor and foothills of the watershed on agricultural ranch lands. However, a legacy of riparian/aquatic degradation also extends upstream to commercial timber holdings and mining districts, as well as state and federally managed lands. Anthropogenic fisheries impairments were identified on most tributaries (163 of 180) that were surveyed outside of designated wilderness area (Pierce et al. 1997, 2008, 2016). Perturbations varied widely and included culvert crossings and runoff from forest roads, stream dewatering and fish entrainment in irrigation canals, riparian overgrazing and streamside feedlots, channelization of streams, mining disturbance, and streamside residential development (Figure 2).

Restoration Concepts

High-quality stream environments for wild trout include sufficient water quantity and quality, as well as diverse physical channel features that provide food, cover (security) and adequate living space (Orth and White 1999). Stream connectivity provides the mechanism for migratory fish to move among streams or stream reaches and to complete their life cycles. Identification of human-induced limiting factors is essential when attempting to correct impairments and improve wild trout populations. Limiting factors include environmental factors that hold a population below its full potential or natural carrying capacity (Meehan 1991). The concepts of managing for wild trout, focusing on native fish, restoring and connecting habitats, and correcting human-induced limiting factors form the general foundation of the Blackfoot River wild trout restoration program.

Basic restoration planning involves the biogeography of fishes, understanding impacts of habitat impairment, and the role that stakeholders (e.g., private landowners and the angling public) play in restoration outcomes. At a secondary level, restoration methods also consider (1) stream potential (i.e., reference conditions), (2) the relationships of project scale (i.e., stream reach, stream and watershed) to the problem, (3) indirect and/or downstream benefits of restoration actions (e.g., increased flow or improved water quality), and (4) the uncertainty associated with restoration outcomes.

Reducing outcome uncertainty, above all, requires that cooperating parties commit to long-term success and sufficient information on which to base restoration decisions. Project information involves recognizing not only the sources of impairment, but also reasonable assessments of biological poten-

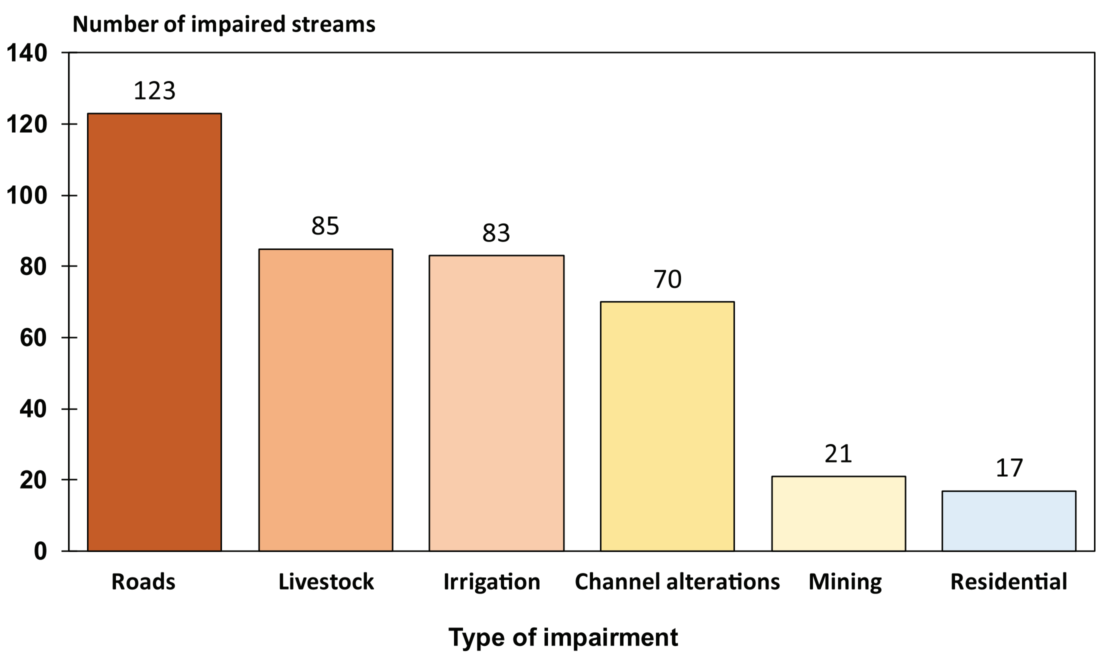

Figure 2. Number of fisheries impaired streams by major land use category.

tial. As described below, obtaining this information usually involves (1) establishing a thorough preproject (fish population and habitat) baseline, incorporating the concept of the reference reach; (2) understanding life history, habitat requirements, anthropogenic impacts, and limiting factors related to target and, in some cases, nontarget species; (3) identifying clear and attainable restoration goals with measurable objectives; (4) developing realistic time frames necessary for project and population recovery; (5) assessing the ability to correct limiting factors; and (6) developing postproject monitoring protocols to ensure projects meet their intended objectives. A willingness to modify subsequent restoration methods based on monitoring results is also important for landowner education, adaptive management, and long-term program success.

Restoration Framework

With these general concepts in mind, the Blackfoot restoration framework included several phased and interrelated elements that began and ended with fish-population data collection (Figure 3). Within this framework, collection of basin-scale fisheries information led to prioritization of tributary projects, which facilitated implementation planning, and ultimately ended with evaluation of restoration outcomes and fish-population response. From the onset, this process engaged stakeholders (e.g., landowners, conservation groups, agencies, and anglers) and informed them with fisheries data. This facilitated a strong educational component that included active and full-time participation of local watershed/conservation groups, including those directly involved with restoration (i.e., the Big Blackfoot Chapter of Trout Unlimited [BBCTU]) and landscape protection (e.g., Blackfoot Challenge and The Nature Conservancy). Within the basic framework, more detailed descriptions of fish population and habitat survey techniques, restoration methodologies, restoration prioritization processes, natural channel design, and reference reach concepts are described below.

Data Collection: Fish Populations, Trout Life Histories, and Stream Habitat Surveys

Fish populations surveys

Longitudinal fish population inventories were completed on all accessible tributaries (1,663 surveys at 772 survey sites on 223 streams) and along the main-stem Blackfoot River from the headwaters to the mouth (Figure 4). Blackfoot River survey sites, established in the late 1980s (prior to restoration work), identified precariously low numbers of native trout and significant recruitment limitations. Tributary fish population sampling began in 1989 with opportunistic surveys that employed consistent, intensive, single-pass electrofishing methods for each survey. When applied consistently, these surveys allowed simple and direct comparisons of fish population metrics over time (i.e., species composition, distribution, relative abundance, and size structure) and within and among small stream sampling locations (Kruse et al. 1998; Pierce et al. 2013). These initial (phase 1) surveys typically began in headwater reference reaches and proceeded downstream in reaches representing the diversity in stream type, land ownership, and land use. Subsequent (phase 2) surveys were more intensive and focused at restoration sites, as outlined in the next paragraph. With an emphasis on potential restoration measures, these initial fish population surveys also noted individual land-use problems (e.g., streamside feedlots, overgrazing, unscreened irrigation ditches, channelization, dewatering, fish passage obstructions, and excessive riparian timber harvest) that potentially impacted fisheries.

Most of the restoration work (75%) occurred on private ranch land. To facilitate

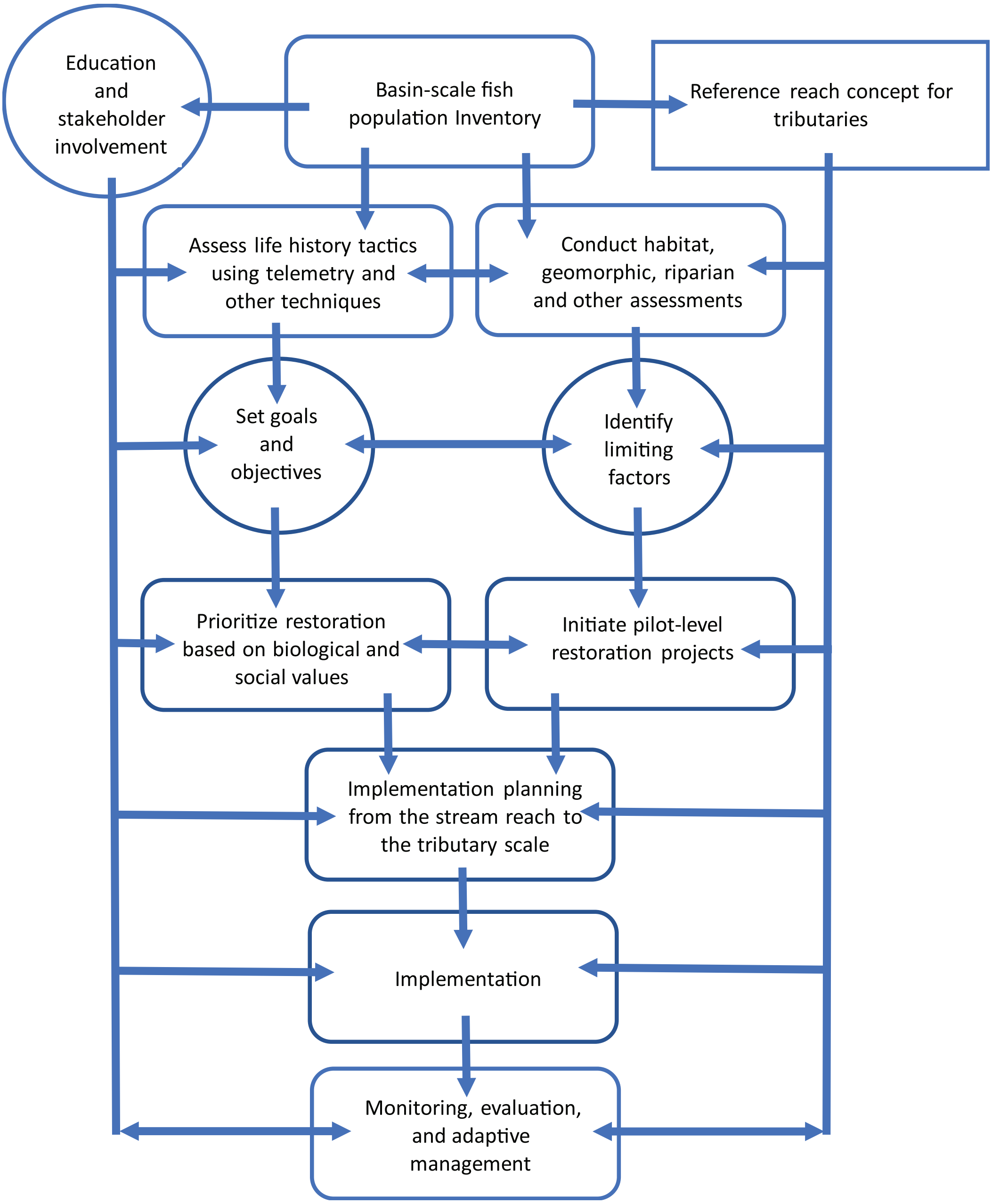

Figure 3. Flow chart summarizing basic framework of the Blackfoot River tributary restoration process. The process engages stakeholders and relies on the reference reach concept throughout all phases of the restoration process.

access to private lands and begin the process of landowner education, field biologists invited private landowners (and their families) to participate in fish sampling (electrofishing) surveys. This fostered initial landowner–agency relationships and basic awareness of stream health issues through private consultation. Other electrofishing surveys were

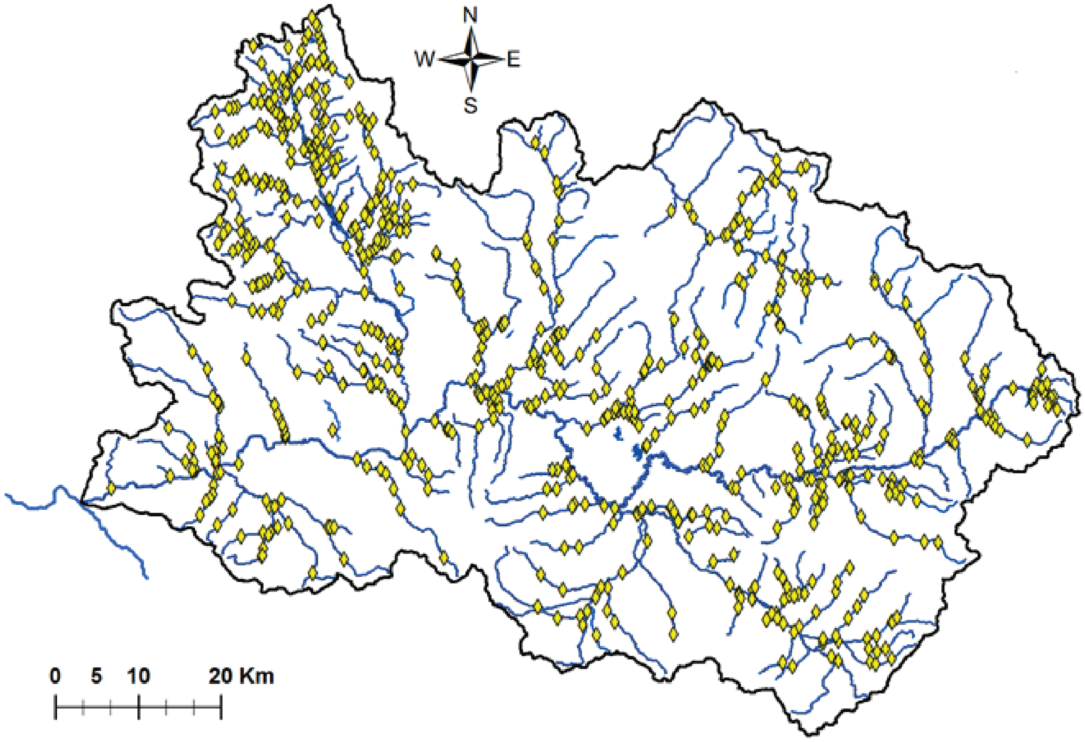

Figure 4. Longitudinal fish populations survey sites (n = 772, yellow diamonds) established on 223 streams between 1988 and 2016 in the Blackfoot River watershed.

used to sample irrigation canals and ditches to assess fish loss, collect genetic samples, and provide fisheries data for research needs. Once streams entered the restoration phase, more quantitative (phase 2) fish-population surveys (e.g., mark-and-recapture or depletion estimates) were established to monitor specific projects (e.g., Pierce et al. 2013).

Fish life-history investigations

In addition to electrofishing surveys, nine radiotelemetry studies were completed between 1996 and 2014 to identify the spawning behavior of adult migratory salmonids (Bull Trout, Westslope Cutthroat Trout, Rainbow Trout, and Mountain Whitefish, *Prosopium williamsoni*) in the Blackfoot River watershed and Clearwater subwatershed (Swanberg 1997; Swanberg and Burns 1997; Schmetterling 2001, 2003; Pierce et al. 2007, 2009, 2012, 2014b; Knotek 2017). Each study investigated the timing of migrations, seasonal habitat use, and spawning locations while also identifying sources of mortality between capture sites and natal tributaries. As with electrofishing surveys, private landowners and local school classes often participated, which included an MFWP Adopt-A-Trout program (Schmetterling and Bernd-Cohen 2002). As technology advanced, genetic techniques allowed identification of nonhybridized, native trout populations and assignment of individual river fish to tributaries of origin using new genetic assignment methods. Using the latter technique, Bull Trout captured in the Blackfoot River or Clearwater chain of lakes were assigned to their natal tributaries with high accuracy (>95%; Pierce and Podner 2016; Knotek 2017). In addition, recent advances in environmental DNA analyses provided reach-specific information on species presence–absence and incidental presence, which can be difficult to reliably detect using standard electrofishing techniques. New techniques and additional life-history information, when merged with standard tributary electrofishing investigations, helped to clarify the status of migratory and stream resident trout populations, as well as identify key factors affecting and limiting them.

Habitat surveys

Physical habitat surveys typically followed fish population surveys. Habitat survey techniques identified habitat features, stream condition (impairments), and restoration opportunities on individual streams, on stream reaches, and across individual land ownerships (Pierce and Peters 1990; Pierce et al. 1990, 1997, 2001, 2002, 2004; Pierce 1991; Koopal 1998). Like electrofishing surveys, habitat surveys typically began at an upstream reference reach and proceeded downstream. These surveys often crossed many land ownerships and covered several kilometers. Depending on expected sample size, every 10th, 4th, or 2nd habitat unit (pool/riffle sequence) was measured for length, wetted width, maximum depth, and bank-full width at riffles; residual pool depth; and pool frequency. Assessment of functional instream wood within the low-flow and bank-full channels along the longitudinal profile was also completed. In addition, riparian vegetation, potential vegetation, and recruitment of instream wood were cataloged. Anthropogenic perturbations in riparian areas (grazing, land clearing, or timber harvest) were noted and/or mapped on 7.5-min quadrangle maps and aerial photographs. Later, high-resolution geographic information system-based aerial photos and multispectral imagery helped evaluate degraded reaches (Fitzgerald 1997; Marler 1998). To characterize survey reaches in greater detail and better identify limiting factors, habitat survey methods adopted more detailed geomorphic survey methods (Rosgen 1994, 1996). These surveys, performed within representative reaches of the habitat surveys, identified reference reach conditions, as well as human-related channel/riparian alterations (e.g., Pierce et al. 2013). Pebble counts (Wolman 1954) and streambed core samples (McNeil and Ahnell 1964) described substrate and spawning area conditions, including anthropogenic sediment (Pierce et al. 2006, 2017; Neudecker et al. 2012; Eby et al. 2015). In addition, stream discharge and continuous water temperature data collection were standard in tributary assessments (Pierce et al. 2009, 2012, 2014a, 2014b). Benthic invertebrate sampling helped clarify certain land use and physical stream habitat relationships (Pierce et al. 2008, 2017). Minimum instream flow assessments, based on the concept of the wetted riffle (Leathe and Nelson 1989), were also completed where water leasing or other conversions to instream flow were pursued.

Pilot Projects and Tributary Prioritization

Pilot projects

With basin-scale data collection fully underway in the early 1990s (Figure 4), reach-scale pilot restoration projects were initiated with landowners willing to demonstrate stream improvement techniques to help educate surrounding landowners. These projects began in the central Blackfoot valley and expanded outward (Figure 5).

Tributary prioritization

To better focus on biological priorities, multicriteria decision trees were periodically developed to prioritize tributaries and guide proposed restoration actions. Matrices integrated fish-population and life-history information for migratory native trout and sport fisheries on the Blackfoot River, stream-health information, and social/financial elements

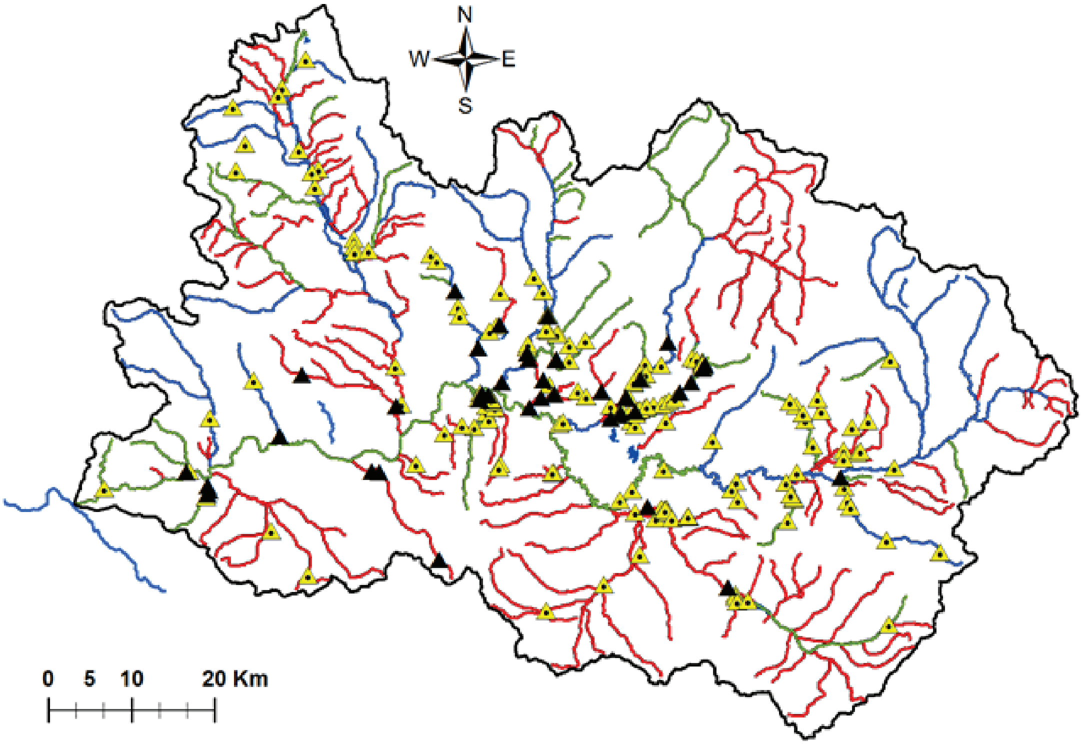

Figure 5. The 2008 Blackfoot River restoration prioritization template for native trout (blue streams = high priority, green streams = moderate priority, red streams = low priority) along with the location of 199 completed restoration projects (yellow and black triangles) on 75 tributaries. Black triangles represent 42 restoration sites completed between 1990 and 1997; yellow triangles represent 157 projects completed between 1997 and 2017, showing the spatial expansion of the restoration program.

(Table 1). The most recent strategy (Pierce et al. 2007) was developed for 180 tributaries in response to (1) an increasing number of watershed interest groups; (2) state, regional, and federal fisheries management directives; (3) the development of drought, subbasin, and U.S. Environmental Protection Agency water quality improvement plans; (4) Endangered Species Act-designated critical habitat for the recovery of Bull Trout; and (5) recently completed fish population inventories in the Clearwater River subwatershed (Pierce et al. 2008; Knotek 2017). This prioritization provided a native trout-based template for restoration projects, which integrated all fisheries-related improvement programs into a single guiding strategy.

Implementation Planning and the Importance of Watershed Groups

Implementation planning

Stream restoration typically focused on correcting obvious human impacts to fish populations and natural stream function. Within a context of stream priorities, implementation planning typically occurred from the stream reach to the tributary scale. Planning often involved an interdisciplinary team of agency specialists (e.g., biologist, hydrologist, grazing and water rights specialists), nonprofit conservation groups (i.e., 501(c)3: BBCTU and Blackfoot Challenge) and cooperating landowners/managers. Once major projects were selected, fisheries biologists surveyed

Table 1. Restoration prioritization scoring criteria for streams in the Blackfoot River basin. Point values were applied to 182 streams, with scoring weighted toward native trout and biological benefits in identifying the highest priority streams.

	Biological benefits – 150 possible points	Points
1	Bull Trout spawning (yes/no)	20/0
2	Bull Trout rearing (yes/no)	10/0
3	Bull Trout core area (yes/no)	10/0
4	Westslope Cutthroat Trout presence (fluvial/resident/none)	20/10/0
5	Sport fisheries value to the Blackfoot River (multiple species/single species/ none	20/10/0
6	Technically able to address entire stream system (yes/no)	20/0
7	Provides increased stream flow to the Blackfoot River (yes/no)	20/0
8	Improves downstream water quality by reducing sediment (yes/no)	10/0
9	Improves downstream water quality by reducing temperature (yes/no)	10/0
10	Improves downstream water quality by reducing nutrients (yes/no)	10/0
	Social and financial consideration – 50 possible points	
11	Landowner/manager cooperation in the watershed (high/moderate/low)	20/15/10
12	Cost-effectiveness cost/mile (low moderate/high)	20/10/5
13	Demonstration/education value (high/low)	10/5
	Total possible points	200

or updated information on fish populations and habitat conditions to quantify response variables, which usually involved the use of reference (control) reaches. This information supported project design, fundraising, contracting, permitting, landowner agreements, and monitoring. Ultimately, all projects on high-priority streams with this level of planning were funded with the support of regulatory agencies.

The importance of watershed groups

Most of the project administration and fundraising (private donations, foundations, and state and federal grants) were coordinated through BBCTU and agency partners. The nonprofit status of BBCTU and other conservation groups provided a mechanism for generating tax-deductible private funds and cost-effective implementation. In addition to fundraising, BBCTU often obtained local, state, and federal stream permits for private land projects in coordination with agency partners. Project bids (consulting and construction) conformed to state and federal procurement policies that included the development of qualified vendors lists derived through a competitive process. A minimum project cost triggered the qualified vendor list, from which BBCTU solicited bids for consulting and contractor services. Bid contracts were signed between BBCTU and vendors upon bid acceptance. Depending on the specific project, landowners were responsible for certain costs and project maintenance once construction was completed. Written 20-year agreements for project maintenance were signed by landowners and BBCTU on each project. Last, BBCTU supervised contractors during project construction in consultation with agency specialists. This coordinated work often entailed several overlapping techniques that were specifically tailored to the individual problems. These included riparian grazing (36 streams), fish passage improvements (32 streams), channel reconstruction (27 streams), fish screens (18 streams), and instream flow enhancement projects (17 streams). All private land projects sought collective benefits for landowners and aquatic resources and were completed voluntarily. To date, projects have been completed at 199 locations on 75 streams (Figure 5).

Unlike BBCTU, the Blackfoot Challenge focused on broadscale watershed conservation that included organizing educational tours, drought planning, and forest restoration and helped to coordinated conservation easement strategies among cooperating agencies, land trust organizations, and private landowners. The Blackfoot Challenge ultimately helped to increase large-scale land protection (conservation easement and land purchases) in the watershed from 6.5 km^2 in 1975 to 1,623 km^2 in 2016, which included 1,628 km of riparian corridor (Figure 6).

Stream Restoration Techniques

Instream habitat improvement using natural channel design

Restoration techniques were tailored to site-specific problems that required both passive and active methods. Passive methods (e.g., improving riparian grazing and revegetation) relied on natural recovery to address the cause of degradation. Active restoration included new diversions, fish screens, or channel and riparian area modifications with machinery to directly restore habitat features (e.g., natural channel morphology and instream wood) on altered streams that could not otherwise be restored using passive methods alone. Almost all active channel reconstruction projects required pas-

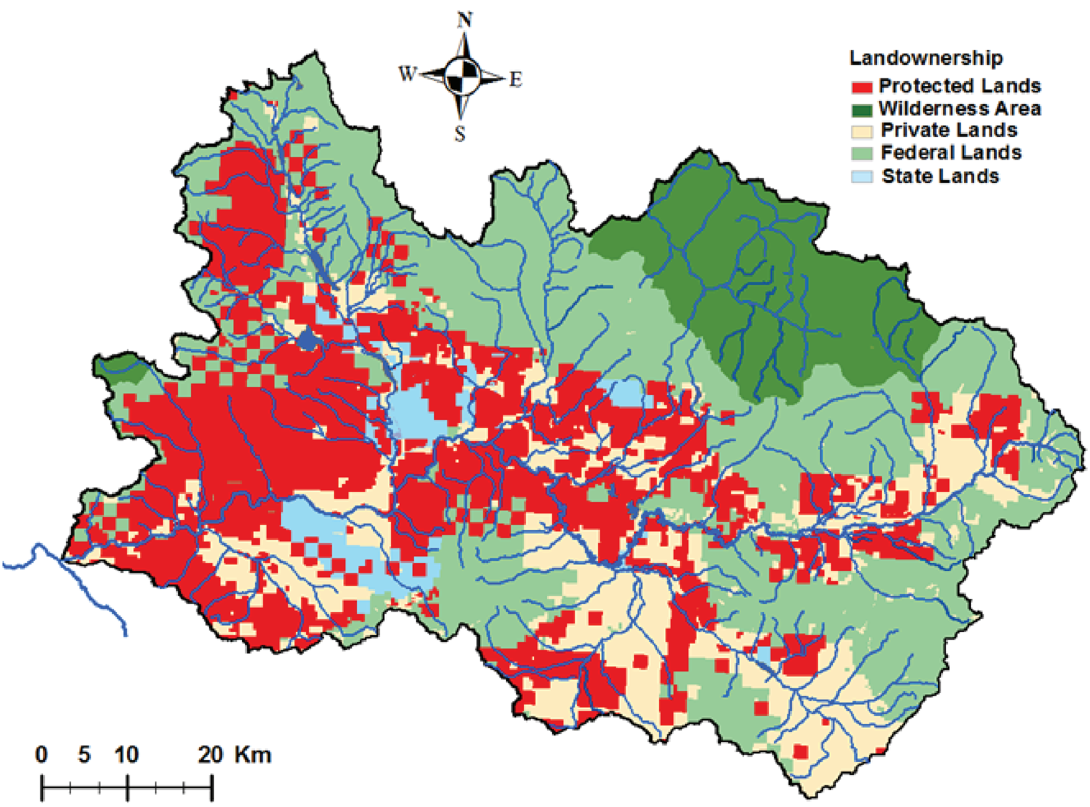

Figure 6. Current land ownership status in the Blackfoot River Watershed. Red areas show either private lands converted to public ownership or private lands with conservation easement protection.

sive methods to ensure vegetative recovery through compatible land use (e.g., managed riparian grazing) once the stream was restored to a more natural condition.

For active channel reconstruction and instream habitat restoration, methods evolved from the use of reference reaches alone to incorporating natural channel design concepts (Rosgen 1994, 1996). Over time, stream classification and related survey techniques became standard in stream assessments, restoration designs, and monitoring programs (Rosgen 1996, 2007, 2011; Pierce et al. 2013). Unlike enhancement techniques, natural channel design involved a geomorphic approach that fits naturally stable streams within the proper valley type. The Rosgen (1994) stream classification system provided the basis of this approach by quantifying channel dimension, pattern, and profile. In addition, riparian health, instream habitat, and fish population surveys, along with measurements of discharge, sediment, and bed and bank stability, permitted the assessment of existing and potential channel (i.e., references) conditions. Geomorphic indicators of the bank-full channel, prediction analyses (reference reaches and dimensionless ratios), and validation (regional curves for western Montana; Lawlor 2002) defined naturally functioning channels and provided the basis for natural channel design.

Final restoration designs sought to emulate naturally complex stream channels capable of conveying flows, transporting sediment, and supporting essential habitat features. Vegetation colonization through intensive seeding, mature shrub, and sod mat transplants, and other bioengineering methods provided immediate fish habitat as well as long-term bank stability. Strategically placed streambank and habitat structures allowed for shrub colonization and further provided long-term channel stability and habitat complexity once vegetation was reestablished. Compatible livestock grazing systems were also an essential component for success (Pierce et al. 2013). Ultimately, restoration projects attempted compatibility with ecologically sound and sustainable land-use practices, conservation of high-quality aquatic habitat, and improvement of native aquatic species.

Programmatic Elements: Landscape Connectivity, Restoration Techniques and Multiscale Trout Response

Four major restoration program elements were selected to illustrate implementation concepts and add relevant long-term case studies to the body of restoration literature: (1) landscape connectivity and Bull Trout recovery, (2) evolution of restoration methods on basin-fed streams that drain from the surrounding mountains, (3) spring creek restoration on the valley floor, and (4) multiscale fisheries response, including trout community response and population trends in the Blackfoot River. Each specific case study included at least 5 years of postrestoration monitoring. All tributary electrofishing metrics were standardized to age-1 and older trout per 30 m, unless otherwise noted. All population estimates of abundance were calculated at the 95% level of confidence (i.e., point estimate ±95% CI). Other analyses of statistical significance varied by project as described (and cited) in the specific case study.

Landscape connectivity and Bull Trout recovery

Functional and resilient Bull Trout populations require habitat that is cold (<13°C), clean (low sediment), complex (with deep pools, overhanging banks, and downed trees), and connected (lacking migration barriers) (USFWS 2010, 2015). Given these species-specific habitat requirements, along with wide-ranging and complex life histories, Bull Trout recovery in the Blackfoot River watershed required a landscape perspective.

In the greater Blackfoot River watershed, major improvements in habitat connectivity included the removal of Milltown Dam at the mouth the Blackfoot River (Figure 7), removal of Emily-A Dam (Figure 8) on the Clearwater River, and fish-friendly improvements at irrigation canals on the north fork of the Blackfoot River (hereafter, North Fork). These measures targeted various native trout life stages (juvenile, subadult, adult) and migratory life histories, including adfluvial (lake dwelling) fish in the

Figure 7. The top photo shows Milltown dam prior to its removal in 2008. The bottom photo was taken at the same site in 2014.

Figure 8. Before (top) and after (bottom) photos show Emily-A Dam before and after removal, which now allows uninhibited upstream fish passage.

Clearwater subwatershed and fluvial (river dwelling) fish that inhabit stream networks associated with the Blackfoot, Clark Fork, and lower Clearwater rivers.

Like adfluvial populations, fluvial Bull Trout originating in the North Fork are migratory, obligate coldwater char that spawn in discrete groundwater upwelling areas in the larger headwater streams (Swanberg 1997; Pierce et al. 2006). The North Fork system supports the largest population of migratory Bull Trout in the Blackfoot and upper Clark Fork watersheds of western Montana. Adults spawn primarily in undeveloped (e.g., designated wilderness) watersheds and juveniles disperse downstream throughout the river system. Once mature (age 5–7), adult Bull Trout return to spawn in their natal spawning areas.

Beginning in the 1990s, electrofishing, trapping, and telemetry studies identified Bull Trout spawning and rearing areas, spawning behavior, and movements patterns of adult fish (Swanberg 1997; Schmetterling 2003; Benson 2009; Pierce and Podner 2016). In addition, redd counts helped to track population size and trends. Trapping and radiotelemetry identified Milltown Dam as a complete barrier to upstream movement for all fish (including Bull Trout) attempting to ascend the upper Clark Fork and Blackfoot rivers (Schmetterling 2003). In addition, electrofishing identified losses of out-migrant juvenile Bull Trout to five irrigation canals on the main-stem North Fork as a major limiting factor (Pierce et al. 1997). In the Clearwater River system, a large (3 m high), low head dam (Emily-A Dam) constructed in the 1960s completely blocked upstream fish movement upstream of Seeley Lake in the river main stem (Benson 2009). Once identified, habitat connectivity projects were initiated at each site. Fish screens were first placed in all five canals on the North Fork (1990s), Milltown Dam was later removed (2008), and, finally, the Emily-A Dam was removed (2010) and replaced with a step-pool channel that maintained the same crest elevation (Figure 6).

Comprehensive project monitoring confirmed fisheries impacts related to the dams and the importance of restoring connectivity in these main-stem systems. For instance, Bull Trout redd counts increased in the North Fork following protective angling regulation and fish screening in the 1990s. Subsequent removal of Milltown Dam likely also contributed to increasing redd counts after 2008 (Figure 9). Similarly, Bull Trout redds upstream of Emily-A Dam increased from about 19 to 20 redds pre-project to an average of 50 redds after interim (manual capture and release) and permanent fish passage were re-established (Figure 9). Despite positive trends in the strongest remaining migratory populations, small populations of Bull Trout in the lower Blackfoot River watershed have undergone dramatic population declines over the past 30 years (Pierce and Podner 2016). These declines spatially overlap with intensive land use and where warmer stream temperature regimes favor expansion of nonnative competitors (e.g., Brook Trout and Brown Trout; Al-Chokhachy et al. 2016; Pierce al. 2016). According to recent projections (Isaak et al. 2015), regional warming will continue to reduce thermally suitable Bull Trout habitat significantly by 2040, highlighting the importance of high-elevation refugia (e.g., headwater areas of the North Fork; Pierce et al. 2018).

Restoration Methods in Basin-Fed Streams

Unlike broadscale habitat connectivity, small-scale stream restoration projects emphasized natural channel design and reference reach concepts. Within this context, the case studies below highlight fish population response to habitat improvements on basin-fed streams and discuss the evolution of restoration methods to a range of anthropogenic perturbations.

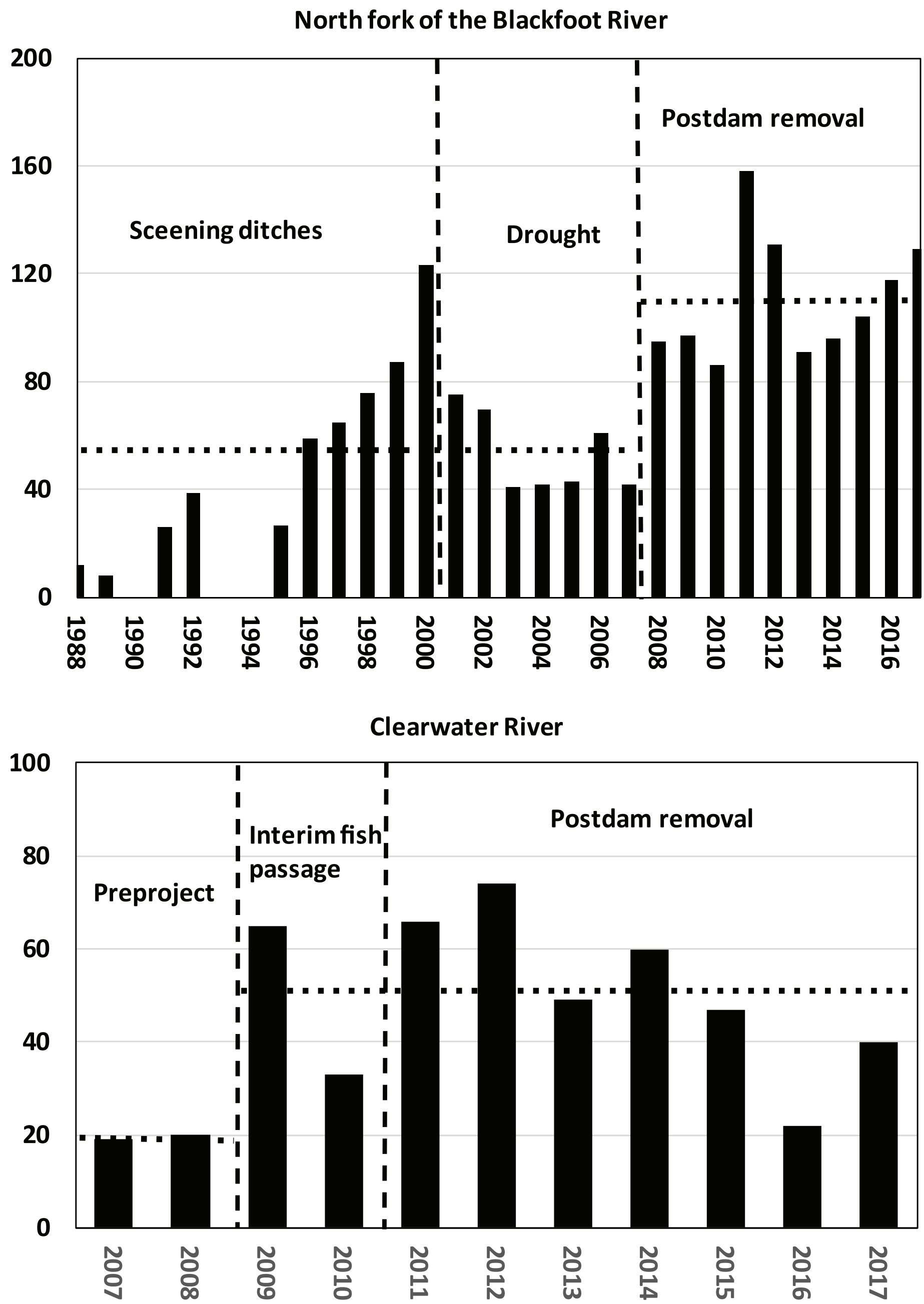

Figure 9. Bull Trout redd counts in the north fork of the Blackfoot River, 1988–2017 (top) and in the Clearwater River upstream of Emily-A Dam, 2007–2017 (bottom). For the north fork, catch-and-release regulations were enacted in 1990, followed by (1) ditch screening installation in the 1990s, (2) 7 years of protracted drought (2001–2007), and (3) the removal of Milltown Dam in 2008. Redd counts upstream of the Emily-A Dam show 2 years of preproject baseline, 2 years of manual interim fish passage, followed by 7 years of full fish passage. The horizontal dotted lines show the yearly mean for redd counts before and after fish passage.

Gold Creek

Lower Gold Creek, encompassed by industrial timberland in the lower Blackfoot River watershed (Figure 1), was the first restoration action to evaluate the performance of habitat structures in a stream with variable channel morphology (Schmetterling and Pierce 1999). Physical habitat structures were placed in two stream types prior to a major flood event: (1) a confined (>2% gradient) channel (i.e., Rosgen B stream type), and (2) an unconfined lower gradient (<2%) channel (i.e., Rosgen C stream type). The project was initiated in 1996 after decades of riparian timber harvest and intentional removal of large wood from the channel led to the dramatic loss of pool habitat and complexity (Pierce 1991; Figure 10). Based on an

Figure 10. Gold Creek: 1996 prerestoration (top) photo shows a B stream type (Rosgen 1994) lacking instream complexity and pools. The postrestoration (bottom) photo shows a wood-and-boulder-formed plunge pool at the same site immediately following installation.

upstream reference reach and a formula for natural pool spacing (Rosgen 1996), a total of 66 pools were created within a 4.8-km section of stream. The project used onsite native material (i.e., large wood and glacial erratic boulders) to construct four types of pool-forming habitat structures (debris collectors, log-formed plunge pools, lateral scour pools, and rock-formed pools; Schmetterling and Pierce 1999).

Once completed, average wetted pool area of the channel increased from 1% (prerestoration) to 14% (postrestoration), which was similar to the reference reach (Schmetterling and Pierce 1999). The project then withstood a ~50-year frequency flood event the following spring. Of the original 66 structures, 85% remained intact and stable. However, structure retention was significantly higher in the B stream type than in the C stream type (94% versus 58%, $P < 0.001$). For the unconfined stream reach, structures emphasizing lateral scour pools had the highest retention rate (75%), whereas rock-formed pools had the lowest retention rates (40%). From these findings, MFWP concluded that improving pool habitat and the ability to withstand major floods was a function of stream type and the type of structure employed. These results changed the way habitat structures were installed in unconfined stream types to those better suited to meandering channels. In the confined reach, long-term (18-years) trout-population monitoring suggested an increase in total trout abundance for age-1 and older trout with a catch per unit effort of 5.6 trout/30 m prerestoration (1996), compared to an average of 12.9 fish/30 m from 1997 to 2015 (MTFWP, unpublished data).

Nevada Creek

Located immediately downstream of a large irrigation storage reservoir, the Nevada Creek demonstration project involved reconstruction of 1.34 km of channel to restore natural channel features to a heavily degraded and unstable section of a laterally extended, meandering (C4) stream type (Rosgen 1994; Figure 11). Prior to restoration, Nevada Creek was relatively incised and overwidened, with eroding banks that contributed an estimated 191 kg/m/year of fine sediment to the channel (Dave Rosgen, Wildland Hydrology, unpublished data). The steam also lacked woody riparian vegetation due to decades of intensive riparian grazing. Channel reconstruction reduced the width-to-depth ratio from 56 to 24, elevated the incised channel, added lateral scour pool habitat structures (instream wood) on the outer stream bends, and placed layered willow cutting to reestablish riparian shrubs along the new floodplain and streambank margins (Figure 11).

The Nevada Creek project also included a three-stage, inner berm channel designed to maintain a low width-to-depth ratio and thereby help mitigate irrigation-related low-flow conditions. In addition to active channel restoration, livestock were fenced from the immediate stream corridor. Like Gold Creek, the Nevada Creek project underwent a significant flood in the spring following project construction with a peak daily flow of 21.6 m^3/s versus the average peak daily flow of 4.02 m^3/s for the 1939–2017 period of record (U.S. Geological Survey provisional data station #12335500). Though the channel adjusted, there was little change in pattern, dimension, or profile, and no lateral pool habitat features failed. Prerestoration (2010) and postrestoration (2016) trout population monitoring indicated a significant increase in abundance (4.6 ± 1.6 to 13.6 ± 2.5 for age-1 and older trout per 30 m) and a more than 200% increase in biomass (1.7 km to 3.6 kg/30 m) (MTFWP, unpublished data).

Chamberlain Creek

Chamberlain Creek was selected for a series of initial, comprehensive restoration projects after fish-population surveys indicated

Figure 11. Nevada Creek restoration photo point showing a lateral scour pool with habitat structures (instream wood) on the outer stream bends that incorporated layered willow cutting to re-establish riparian shrubs along the new floodplain (top photo taken in 2010) and the same streambank after 6 years (2016, bottom photo) of recovery.

that Westslope Cutthroat Trout abundance was 94% lower in downstream disturbed areas relative to an upstream reference reach. Irrigation diversions and dewatering also blocked migratory corridors between Chamberlain Creek and the Blackfoot River (Peters 1990; Pierce 1991; Pierce et al. 1997). Restoration methods included spatially overlapping techniques involving reconstructing a scarified channel (Figure 12) and adding large in-

Figure 12. Chamberlain Creek in 1989 just after it was bulldozed to construct an instream pond (top photo) and in 2008 after stream restoration (bottom photo).

stream wood to a 2-km reach where the loss of riparian conifers from streamside roads reduced wood recruitment. In addition, riparian grazing and irrigation systems were upgraded (consolidation of ditches and installation of a fish ladder) and instream flows were enhanced through water leasing during the low-flow summer irrigation season. Riparian roads were obliterated and culverts were replaced to meet fish standards and natural stream function. All ranch lands in the lower watershed were also enrolled in conservation easement programs that protect open space, ranchlands, and wildlife habitat from residential development (e.g., subdivisions). Last, all private industrial forest land in the middle and upper Chamberlain Creek watershed (77.2 km^2) was transferred to public ownership in 2010 with provisions to remove 8.9 km of riparian roads.

Age-1 and older Westslope Cutthroat Trout increased from a prerestoration of 2.5 trout/30 m to a long-term average of 19.2 trout/30 m after project completion (Pierce et al. 2013). Seven years postrestoration, radiotelemetry research confirmed reconnection for migratory trout when most (7 of 11) Westslope Cutthroat Trout radio-tagged in the Blackfoot River between Gold Creek and the North Fork (65 km) ascended Chamberlain Creek to access spawning areas within and upstream of the restoration reach (Schmetterling 2000, 2001). With the completion of stream restoration, conservation easements, and land exchanges, the Chamberlain Creek project addresses all known major impairments to fisheries and riparian corridors at a scale that encompassed the entire watershed.

Spring Creek Restoration

Spring creeks drain aquifers on the valley floor in areas that spatially overlap with intensive agricultural land use. Because of wet streambanks and low hydraulic energy, spring creeks are prone to disturbance (e.g., intensive grazing) and often require extended recovery periods once disturbed (Pierce et al. 2017). The spring creeks described below were fully reconstructed, managed for full vegetative recovery, and intensively monitored for habitat changes and biotic response.

Kleinschmidt Creek and neighboring spring creeks

Kleinschmidt Creek, a small, alluvial, spring-fed tributary of the North Fork Blackfoot River, was fully reconstructed using natural channel design principles, then closely monitored over a 10-year period (Pierce et al. 2014a, 2015). The project converted a straightened, overwidened stream with a degraded riparian zone (i.e., Rosgen C5 stream type) to a deep, narrow, meandering meadow stream (i.e., Rosgen E4 stream type; Figure 13). This conversion specifically reduced channel wetted surface area by 69%, reduced width-to-depth ratio (150–8.8), increased bank-full mean velocity (0.27–0.67 m/s), increased hydraulic shear stress (7.4–13.7 N/m^2), and increased particle entrainment size (11–21 mm) in riffles. This case study also documented positive trout response trends (increased abundance and higher biomass) associated with placement of instream habitat structure (wood) and riparian recovery (Figure 14). However, the most significant change was water temperature reduction. Summer temperatures in Kleinschmidt Creek declined an average of 3.5°C, with average daily maximum temperatures about 1.5°C colder than those in receiving waters (Figure 15).

Similar to Kleinschmidt Creek, two other nearby spring creeks were fully reconstructed to restore the natural pattern, dimension, and profile of a stream within its valley. Like Kleinschmidt Creek, both spring creeks exhibited similar (3–4°C) reductions in water temperatures following channel renaturalization (Pierce and Podner 2016), which further corroborated the cooling potential of groundwater-dominated streams. In these three examples, water cooling is biologically relevant because these streams enter Endangered Species Act-designated Bull Trout critical habitat in a reach used as thermal (summer) refugia (Swanberg 1997; USFWS 2010). Because these streams are now colder than the receiving waters, they

Figure 13. Kleinschmidt Creek prerestoration (top, 2001) and postrestoration (bottom, 2014) photos. The top photo shows a straightened and overwidened section of channel with a channel-altering rock dam that induced upstream deposition of fine sediment. The bottom depicts the restored E stream type (Rosgen 1994) 13 years after channel reconstruction.

not only enhance habitat quality for Bull Trout, but also add capacity to buffer projected warming trends in the main-stem North Fork (Isaak et al. 2015). Last, the three spring creeks are now protected by conservation easements that prevent future

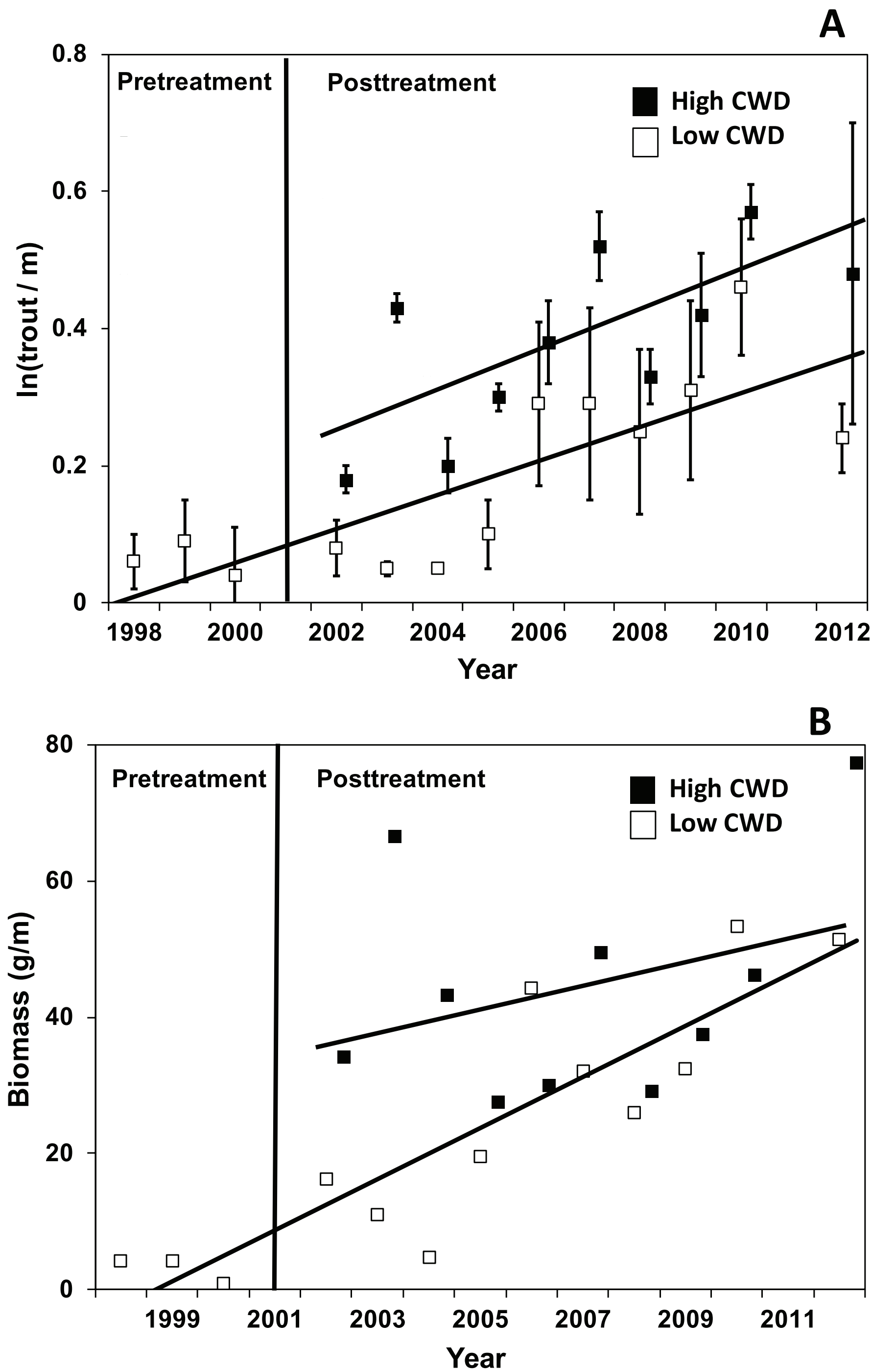

Figure 14. Trout response per linear meter of stream to high and low coarse woody debris (CWD) in Kleinschmidt Creek. From depletion surveys, graph **(A)** estimates age-1+ abundance (±95% confidence interval) and graph **(B)** age 1+ biomass. High and low CWD refers to the amount of coarse woody debris within the channel. The linear lines are best-fit to estimates of abundance and biomass for the two CWD treatment groups (from Pierce et al. 2015).

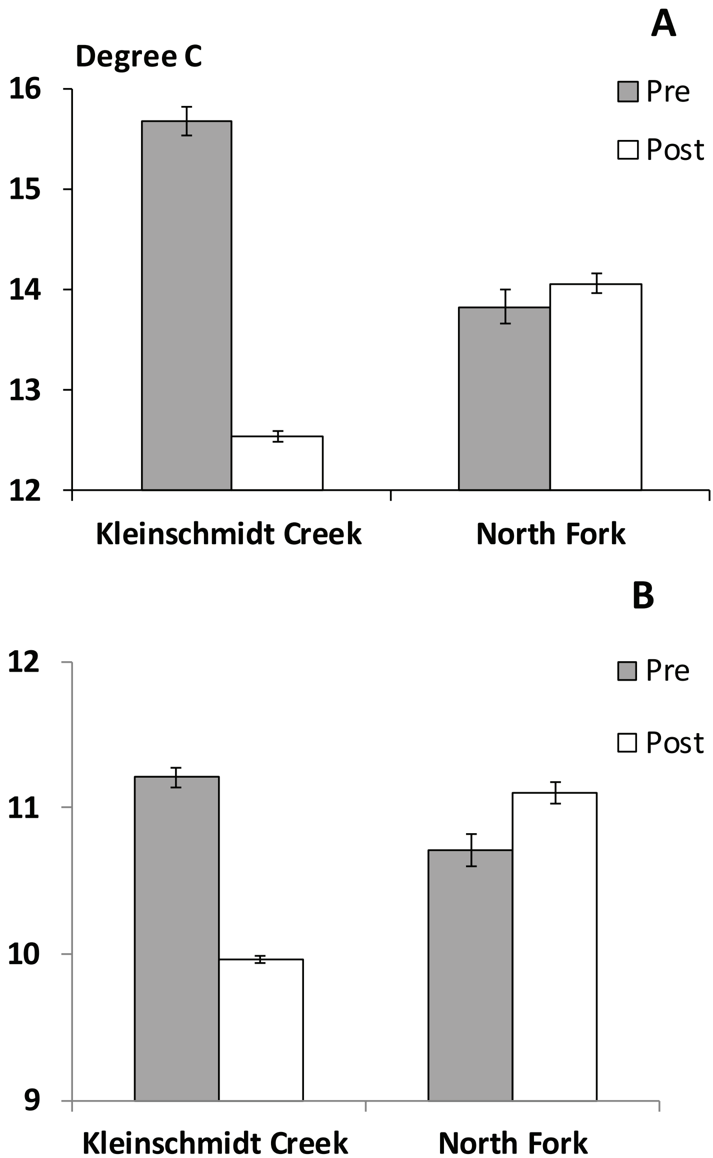

Figure 15. Prerestoration (1998, 1999, and 2001) and postrestoration (2002, 2004, 2010, 2012, and 2013) water temperatures (June through September) for Kleinschmidt Creek (restoration site) and the North Fork Blackfoot River (control site): **(A)** average maximum daily temperatures, **(B)** mean daily temperatures, and **(C)** average daily range of temperatures (from Pierce et al. 2014a).

channel and riparian degradation along Kleinschmidt Creek.

Nevada Spring Creek complex

Nevada Spring Creek flows from an artesian spring, whereas previously discussed spring creeks drain alluvial aquifers. Restoration of the Nevada Spring Creek included complete reconstruction of 7.1 km of stream channel (Pierce et al. 2014b). Like Kleinschmidt Creek, this work converted an incised, overwidened, and overgrazed stream (i.e., a Rosgen C5 stream type) to a deep, narrow, more meandering channel type (i.e., Rosgen E5 stream type; Figure 16). This project reduced average width-to-depth ratio from 22 to 3.2, enhanced instream flows, and reconnected a small, restored Westslope Cutthroat Trout spawning tributary located upstream of the project (Pierce et al. 2013, 2014b). Following restoration of both streams, stream-resident Westslope Cutthroat Trout dispersed downstream into the newly restored habitat (Pierce et al. 2013), re-establishing a migratory Westslope Cutthroat Trout population. Westslope Cutthroat Trout then increased in abundance downstream of the restoration project from zero fish in 2005 to 11.0 ± 2.1fish/300 m in 2016 (Pierce and

Figure 16. Photos of the Nevada Spring Creek project before (1994, top) and after (2012, bottom) reconstruction. Note channel incision, erosion of streambanks, and high channel width prior to restoration.

Podner 2016). Adult spawners from this migratory population are now returning to their spawning areas (Pierce et al. 2014b). The Nevada Spring Creek property is also protected by conservation easements, with special stipulations that prevent disturbance in the riparian corridor. Last, water from the artesian spring source (up to 0.28 m^3/s) was permanently dedicated to instream flows through a conversion of private water rights to public (MFWP) ownership. Though the project appears promising, recent monitoring indicates that elevated nutrient and sediment issues still need to be addressed (Pierce et al. 2016).

Sediment assessments on spawning riffles in restored spring creeks

Riffle morphology of four degraded spring creeks (Rosgen C4–C5 stream types) was compared to four fully restored and functioning streams with deeper and narrower channel forms (Rosgen E4 stream types) by Pierce et al. (2017) (Figure 17). Specifically, this study examined the correlation of (1) natural channel form with riffle substrates and trout spawning site quality, and (2) riffle/sediment relationships with macroinvertebrate taxa and two biotic indices. Despite no change in channel slope, riffles in restored streams had lower median width-to-depth ratios (11.7 versus 17.4; $P = 0.028$), higher velocities (0.61 versus 0.42 m/s; $P = 0.029$), and a lower-percentage fine sediment <6.3 mm (24% versus 40%; $P = 0.057$). These conditions all indicate higher-quality spawning sites than the degraded (unrestored) group of streams. The study concluded that stream restoration can improve trout spawning substrate by facilitating sediment transport via reduced channel width-to-depth ratios and improved riparian and land management. When all streams were considered, a strong positive correlation between the number of sediment tolerant taxa and the percent fine sediment less than 0.85 mm was identified (rho = 0.901; $P = 0.002$), along with a negative correlation between the percent of sediment less than 6.3 mm and the number of clinger taxa (rho = −0.650; $P = 0.080$). Of the two biotic indices, a negative correlation of the fine sediment biotic index (Relyea et al. 2012) with sediment less than 6.3 mm (rho = −0.622; $P = 0.097$) suggests that it may be a better indicator of spring creek habitat integrity and restoration effectiveness than other fine sediment metrics.

Multiscale Trout Response Trends in Tributaries and the Blackfoot River

Tributary to watershed-scale restoration

In addition to the individual stream case studies, Pierce et al. (2013) compared total trout abundance for a group of 18 stream restoration projects against a group of 23 reference streams to evaluate broad watershed-scale response trends. Most of the streams (11) were actively restored using principles of natural channel design. Compared with prerestoration conditions, actively restored streams revealed common pattern of deeper and narrower channels (width-to-depth ratio reduction of 20.0 verses 9.2), increased sinuosity (1.2 versus 1.5), more pool habitat (21.9% versus 46% pool area) and lower maximum summer water temperatures (20°C versus 16°C) following restoration. In addition, 11 projects that underwent flow enhancement increased minimum summer flows from an average of 0.052 m^3/s prerestoration to an average of 0.144 m^3/s postrestoration.

Prior to these changes, total trout abundance across all 18 sites was significantly lower than 23 reference sites, with an average of 5.7 trout/30 m for restoration sites compared with 18.6 trout/30 m for reference sites ($P = 0.0001$). By 3 years postrestoration, average abundance for age-1 and older trout in treatment sites had reached 14.1 trout/30 m and were no longer statistically different from reference sites (i.e., 19.5 trout/30 m; $P = 0.012$). Following this initial increase, total

Figure 17. Example photos for two of eight spring creek study reaches. The top photo displays a wide, shallow degraded (unrestored) stream, whereas the bottom photo shows a deeper, narrow (restored) stream.

trout abundance for all treatment sites remained elevated near the average reference between 4 and 12 years posttreatment.

This rapid initial response was driven mostly by irrigation-based projects (fish screens, fish ladders, and instream flow), whereas streams that were fully reconstructed (e.g., Kleinschmidt Creek) often required extended (>10 year) recovery periods. This study also concluded that consistent monitoring was essential for landowner education and adaptive management necessary to sustain restoration benefits. Most active restoration projects (7 of 13) that included a riparian grazing component required adjustments in riparian grazing practices to protect projects from continued livestock impacts.

Blackfoot River

To evaluate long-term (28 year) trends in trout community composition and abundance in the main-stem Blackfoot River, trout species composition (fish >152 mm) was compared in four river reaches (Figure 1) where population monitoring data predate changes to fishing regulations (1990) and implementation of restoration projects. These data show consistent, long-term, community-level changes that include significant increases in migratory Westslope Cutthroat Trout abundance (Figure 18; Pierce and Podner 2016). These results reflect improved metapopulation function and multiple management strategies (watershed-scale protective regulations, targeted restoration, and habitat connectivity) that collectively improved the Blackfoot River Westslope Cutthroat Trout fishery. These results provide further evidence that significant ecological perturbations can be corrected at multiple spatial scales.

Summary

The Blackfoot River watershed wild trout program represents a comprehensive 30-year case study of progressive river restoration, fisheries management, and landscape protection on both public and private lands. The restoration program began when fisheries data revealed that angling regulations alone could not fully restore wild trout populations and that riparian and aquatic habitat restoration were necessary to restore naturally functioning and biologically productive trout streams. With goals of improving trout recruitment to the Blackfoot River and the status of migratory native trout, restoration practices gained momentum during the 1990s, then expanded outward from the central Blackfoot River valley as updated fisheries, habitat, and water-quality information identified human-induced limiting factors. With an emphasis on key spawning and rearing tributaries and movement corridors, stream prioritization guided allocations of funding and consolidated field work to important habitats used by migratory native trout. Once sites were selected for restoration, reference reach information helped to quantify effects of human impairments relative to functional natural stream conditions. Reference conditions also provided templates for natural channel design, as well as a basis for fundraising, permitting, and postrestoration monitoring and evaluation. Long-term monitoring of habitat changes revealed deeper, narrower, colder stream segments with lower instream sediment levels and improved habitat connectivity. Improved conditions preceded notable examples of fish population recovery, including trout recolonization, re-establishment of migratory life history expression, increases in fish abundance and biomass, and community-level shifts towards Westslope Cutthroat Trout in the Blackfoot River. The benefits of riparian restoration and conservation easement protection also extend to a myriad of riparian-dependent wildlife species.

Montana Fish, Wildlife and Parks originally estimated that a 50-year restoration process would be required to substantially reverse a century of human damage to the river ecosystem. After 30 years, this chapter

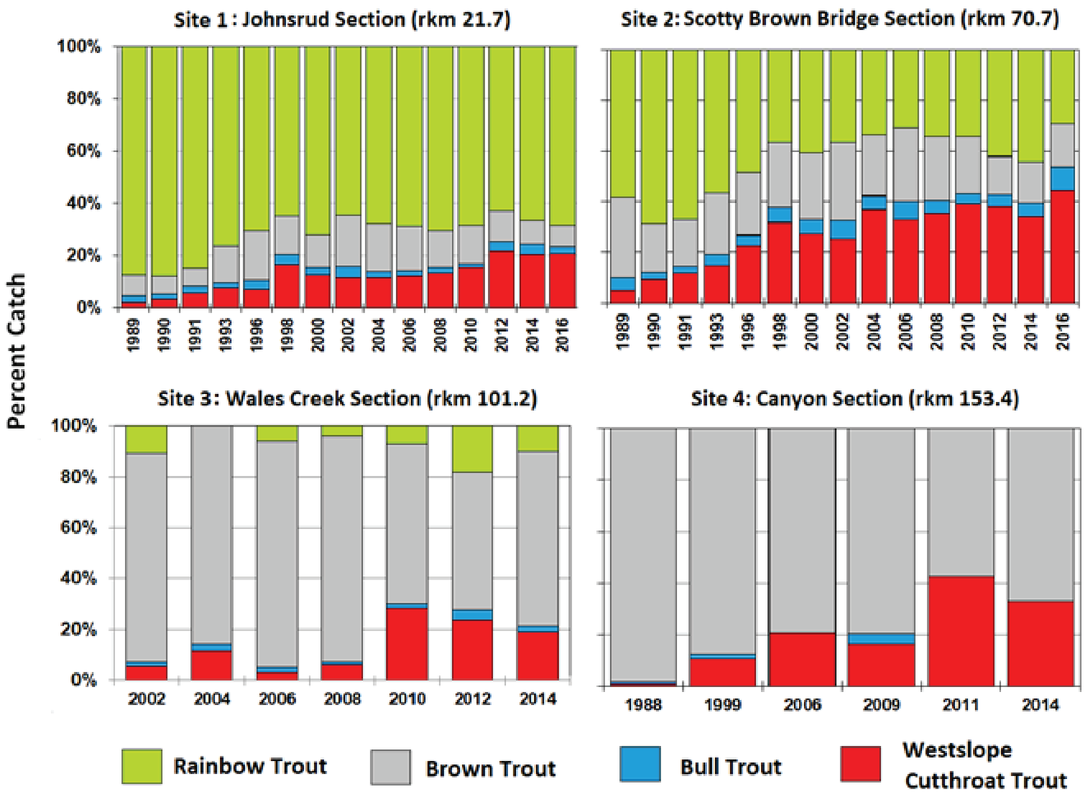

Figure 18. Percent trout species composition (fish >150 mm in total length) for four electrofishing monitoring reaches of Blackfoot River (1988–2016). The graphs show the changing composition of the trout community longitudinally and over time. Mark-and-recapture estimates in the Johnsrud and Scotty Brown Bridge sections show statistically significant increases for Westslope Cutthroat Trout. The acronym “rkm” (river kilometer midpoint) refers to the midpoint of the population survey reach. Monitoring site locations are shown on Figure 1.

was written, in part to promote the continuity of the restoration program. However, restoration alone will not solve many contemporary problems afflicting wild trout. In addition to habitat and fish passage problems described in this chapter, exotic diseases, invasive species, and climate change are now emerging threats to wild trout in the Blackfoot River watershed (e.g., Pierce et al. 2009, 2018; Isaak et al. 2015; Al-Chokhachy et al. 2016). Though targeted restoration can mediate some of these conditions (e.g., whirling disease and anthropogenic warming from land use; Pierce et al. 2009, 2014a; Eby et al. 2015), future wild trout conservation measures will need to consider additional restoration strategies. One strategy, new to the Blackfoot River watershed and specific to native trout, is a developing large-scale (137 km of perennial streams) rotenone project in designated wilderness area upstream of a large waterfall barrier in the headwaters of the North Fork (Pierce et al. 2018). If completed, this project will replace hybrid *Oncorhynchus* (predominantly Rainbow Trout) with genetically pure Westslope Cutthroat Trout and possibly Bull Trout in a large, protected, and pristine conservation area. As the Blackfoot River restoration program transitions from low-elevation habitat restoration projects to this high-elevation replacement project, similar replacement projects should be considered in the high country where historic stocking of nonnative hatchery trout into high elevation lakes has created headwater sources of hybridization.

In closing, it was the early engagement of stakeholders, individually tailored one-on-one solutions to tributary impairments, comprehensive data collections, and a programmatic emphasis on migratory native trout recovery that advanced the scope and scale of restoration program. As the MFWP restoration program matured, both BBCTU and the Blackfoot Challenge have also become more established, effective, and inclusive. Both groups, led by shopkeepers, outfitters, ranchers, and their cooperating agencies facilitated communication, education, and conflict resolution that would not otherwise exist from agency programs alone. This involvement not only helped foster restoration, but also helped secure funds for monitoring while helping to overcome the practice of small-scale projects common to most restoration programs (Bernhardt et al. 2005; Roni 2005; Reeve et al. 2006). After 30 years, this collaboration revealed that river restoration and watershed-scale conservation can both be achieved with long-term vision, dedication, and cooperation.

Acknowledgments

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