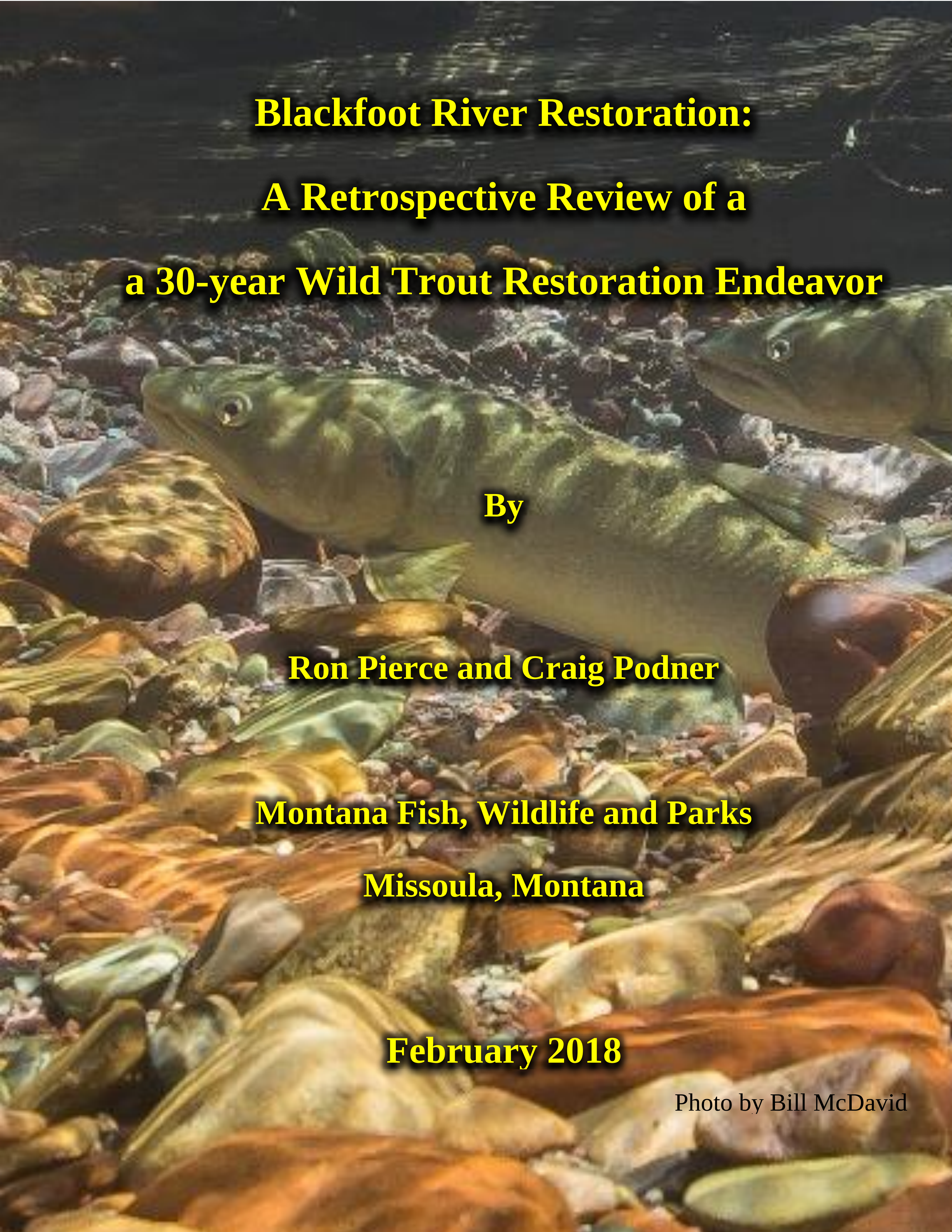

Blackfoot River Restoration:

A Retrospective Review of a

a 30-year Wild Trout Restoration Endeavor

By

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February 2018

Photo by Bill McDavid

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***Abstract* -** The Blackfoot River restoration endeavor is one the most collaborative, comprehensive and successful river conservation stories in western North America. This summary report describes the biological (fisheries) framework (elements and phased approach) that helped to shape the first 30 years of this wild trout conservation story. The program began in the late 1980s when fish population surveys identified depleted numbers of wild trout throughout the lower elevations of the basin, which included the precarious status of migratory native trout in the Blackfoot River. These findings triggered basin-wide protective trout angling regulations, followed by fish populations surveys in all streams, aquatic habitat assessments and the incremental development of a collaborative restoration methodology (1990 - present) to improve spawning and rearing tributaries. The framework specifically describes: 1) how basin-scale fish and habitat data collections helped to identify human-induced limiting factors, promote landowner education and pilot projects, and prioritize tributary work; 2) the essential role of watershed groups in fund-raising and implementation planning; and 3) how passive restoration (grazing strategies and fish screens) and active restoration (natural channel design) techniques and the concept of the reference reach were integrated into the restoration framework. This review ends with a series of 10 long-term case studies that describe the wild trout response to restoration, including those influencing migratory native trout of the Blackfoot River. Finally, this entire report was written as a case study to help guide future restoration ventures in other western watersheds.

Acknowledgments

This report was the product of a long-term collaboration among agencies, conservation groups and private landowners. Don Peters, retired FWP fisheries biologist, was an early leader in the development of the Blackfoot River restoration endeavor. In addition, over 20 FWP fisheries field worker have helped with data collection and stakeholder coordination over the years. A myriad of local, state, and federal agencies and conservation organizations have all helped implement this fisheries program. Above all, special thanks to the Big Blackfoot Chapter of Trout Unlimited for their 30 years of dedicated effort. Federal collaborators include the U.S. Fish and Wildlife Service Partners for Fish and Wildlife, Bureau of Land Management, Forest Service and USDA Natural Resources Conservation Service. State agencies include the Department of Natural Resources and Conservation, Department of Environmental Quality all contributed. Country Conservation Districts assisted on many fronts. Utilities that helped fund mitigation included Montana Power Company and Northwestern Energy. The Blackfoot Challenge, The Nature Conservancy, Five Valleys Land Trust and Montana Land Reliance also played important roles. Untold numbers of private landowners, university professors, students, volunteers, consultants, contractors and kids all helped. Special thanks to Ryen and Greg Neudecker, Stan Bradshaw and Dave Rosgen for their long-term contributions to the fisheries field work. Ryan Kovach and Ladd Knotek provided review of the report.

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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 so ushered in the era of *wild trout* management. This philosophy of wild trout management relied on the concept of self-sustaining trout populations through natural reproduction. Because decades of stocking also masked a long legacy of stream degradation in the river valleys of western Montana, once stocking ended, it became increasingly evident that managing for wild trout not only required reductions in angler harvest, but also a need to restore spawning and rearing streams to help recover the natural productivity of damaged trout streams.

With this background in mind, the Blackfoot River restoration endeavor can be traced to the mid-1980s when public perceptions of declining trout population in the Blackfoot River prompted Montana Fish, Wildlife and Parks (FWP) to assess fish populations in the mainstem river and its primary tributaries. With initial funding support from the Big Blackfoot Chapter of Trout Unlimited, these early investigations confirmed depleted trout populations, the over-harvest of spawners, along with low-elevation degradation of the tributary system, including toxic mine waste draining in the headwaters of the Blackfoot River. These initial findings led to basin-scale protective angling regulations for native trout in 1990, greatly expanded fish population and habitat assessments in tributaries, as well as small scale pilot-level restoration project on private lands. Increased data collections and early project successes on pilot projects led to the incremental development of a stream restoration methodology for the Blackfoot Basin and the expansion of tributary restoration from 1990 to the present.

Over time, the restoration of aquatic habitat evolved into an iterative, multi-scale native trout recovery process, whereby the scope and scale of restoration expanded as information and stakeholder cooperation were generated. Basin-scale fish population information, life history studies (e.g., movement and habitat use using radio telemetry) and comprehensive habitat assessments helped to identify human-induced limiting factors while directing restoration activities to individual tributary stocks. As an iterative process, restoration expanded on a landowner-by-landowner and tributary-by-tributary basis. Methods included enhancing flows in rearing areas, preventing juvenile fish loss to irrigation diversions, reconstructing altered streams and fencing livestock from riparian areas. These types of actions were expanded to adjacent tributaries as human-induced limiting factors were identified and opportunities allowed. Within this framework, monitoring and project evaluation provided the mechanisms to identify measures of ecological effectiveness, while also identifying where addition work was required (i.e., adaptive management).

This purpose of this 30-year report is to capture the biological framework (i.e., elements and the phased approach) and various examples of wild trout responses to the Blackfoot River restoration program. Major elements include: 1) fish and habitat data collection techniques that led to prioritization processes, 2) strengthening stakeholder relationships through fisheries information sharing, and 3) applying methods of natural channel design and the concept of the reference reach (i.e., comparing geomorphically and vegetatively stable stream with populations unaffected by direct human impacts to impaired conditions) to restoration/conservation techniques. Finally, this report briefly summarizes 10 case studies streams with long-term (>5-year post restoration) monitoring data that describe restoration field techniques. These examples describe habitat change and the multi-scale response of wild trout to program activities.

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) to the upper Columbian River, the Blackfoot River drains the western edge of the Continental Divide through 3,060 km of perennial streams and joins the Clark Fork River near Missoula (Figure 1). The Blackfoot River is free-flowing, 212 km in length and one of twelve renowned *blue-ribbon* trout rivers in Montana with a 1972 appropriated *Murphy* in-stream flow summer water right of 19.8 m^3s as measured at the USGS Bonner (#12340000) gauging station. In 2015, this 19.8 m^3s water right gained more senior (1904) status 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 in the lower river near Bonner, river discharge ranges from a high of >140 m^3s during spring runoff to baseflows of 14-20 m^3s and a mean annual discharge of about 45 m^3s. The physical geography of the watershed ranges from high-elevation glaciated mountains with alpine meadows, to timbered forests at the mid-elevations and to prairie pothole topography on the valley floor. Glacial landforms, moraine and outwash deposits, glacial lake sediments and erratic boulders variably cover the floor of the entire Blackfoot River valley and exert a controlling influence on the physical features of the Blackfoot River and the lower reaches of most tributaries.

Land ownership in the Blackfoot River Basin is a mix of public and private: 36% private land owners; 46% USFS land, 11% by the state of Montana, and 7% by the BLM. In general, public lands and large tracts of private conservation (i.e., The Nature Conservancy) properties comprise large forested tracts in mountainous areas of the watershed, whereas private timber and agricultural lands are found in the foothills and lower valley areas.

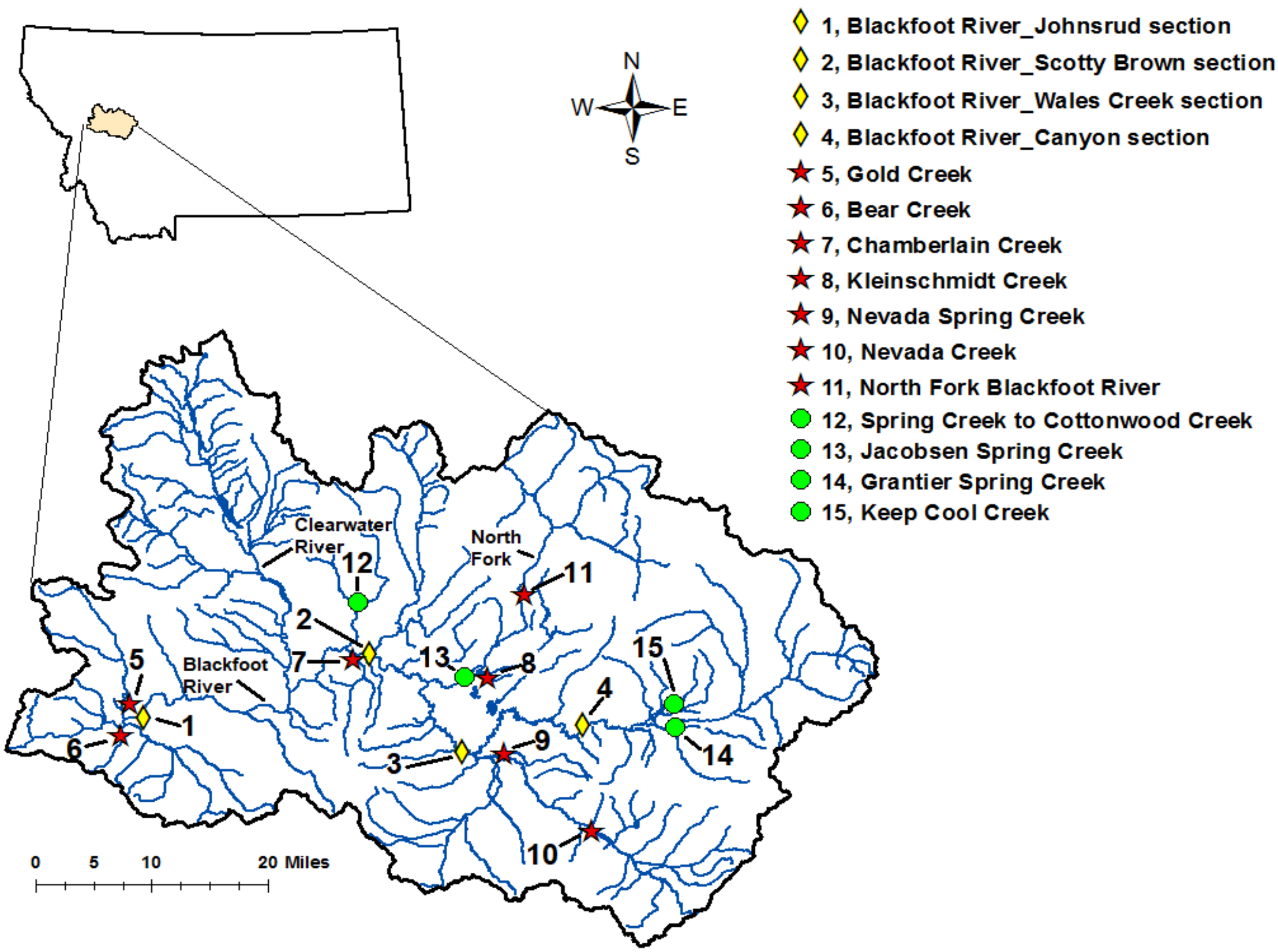
The Blackfoot River watershed supports a variety of cold-, cool- and warm-water fishes. Within the watershed, the distribution of fish species changes longitudinally - a pattern in which species richness increases in the downstream direction and with increasing stream size. In contrast to this general distribution, imperiled native fish of the Blackfoot River (i.e., migratory bull trout *Salvelinus confluentus* and westslope cutthroat trout *Oncorhynchus clarkii lewisi*) tend to spawn in discrete areas and rear in small- to medium-sized streams before out migrating to the larger, more productive streams, rivers and lakes where they grow to maturity. These broad areas of native fish use overlap at the low elevations with over 20 other species, including non-native sport fish such as rainbow trout (*O. mykiss*) and brown trout (*Salmo trutta*).

With few exceptions, wild trout of the Blackfoot River depend on tributary habitat during some portion of their life history. As such, community richness and population abundance of fishes in the mainstem Blackfoot River closely reflect the number and quality of nearby tributaries.

Biotic relationships between the Blackfoot River and tributary systems also vary by river reach. Some reaches of the Blackfoot River support naturally (and seasonally) harsh environments, while others support few, if any, functional tributaries. The subtle, but often complex, adaptations of native trout engender long-term evolutionary pressures of glacially-formed riverscape. However, the extensive use of the watershed also makes imperiled native fish of the Blackfoot River highly vulnerable to adverse (human-related) alterations to the aquatic (e.g., tributary) ecosystem. This holds especially true for bull trout, a highly migratory, obligate cold-water char that spawns in upwelling areas and rears in the larger colder, tributaries before moving down valley in the larger, more productive rivers and lakes.

Some segments of the river system support low abundance of wild trout, including imperiled native trout. Trout distribution and abundance vary spatially due to an array of natural

Figure 1. Blackfoot River location map in western Montana including major streams within the basin. Map numbers (1-15) relate to stream names/locations in the legend. The diamonds (1-4) show long-term fish population monitoring sites on the mainstem Blackfoot River. The stars (5-10) refer to tributary case studies involving for restoration. The green circles (12-15) show spring creek study sites involving the riffle/spawning site study.



conditions and human impairments. Natural conditions limiting trout fisheries involve drought stressors, areas of high instream sediment loads, low instream productivity, naturally intermittent tributaries, extreme cold- and warm summer temperatures and severe winter icing of the lower mainstem river. Traditional land-use in the basin (e. g., mining, timber harvest and agriculture) have all contributed to habitat degradation and fish population declines, especially in the low reaches of the tributary system. Currently, the majority of habitat degradation occurs on the valley floor and foothills of the watershed and largely on private agricultural ranchlands. However, a legacy of riparian/aquatic degradation also extends up-valley to commercial timber lands and mining districts, as well as state and federally managed lands. Human-induced fisheries impairments have been identified on most (80%) tributaries, which include a wide array of perturbations that include mining contamination, dewatering and entrainment of fish to irrigation ditches, excessive riparian grazing and riparian timber harvest, excessive nutrients, road encroachment and fish passage barriers at culverts. The matrix of natural conditions and human impairments produces an array of trout assemblages that vary regionally within the watershed and longitudinally across river and tributary reaches.

Restoration Concepts

High quality wild trout habitat is defined as a stream possessing water of sufficient quantity and quality where an arrangement of physical channel features provides food, cover (security) and space in an environment that allows a population to thrive. Stream connectivity provides the mechanism for migratory fish to move among streams or stream reaches and to complete their life cycle, which rely on a variety of stream conditions. When attempting to correct fisheries-impairments (e.g. degraded habitat) on streams, identifying human-induced limiting factors is essential to successfully reestablish stream-dwelling wild trout. Limiting factors are defined as any factor that inhibits or limits the population below its full potential. This concept of managing for wild trout, focusing on native fish, restoring and connecting habitats, and correcting other human-induced limiting factors forms the general foundation of the Blackfoot River wild trout restoration initiative.

Restoration planning, at a basic level, involves the biogeography of fishes, understanding the fisheries effects of habitat impairment, and the role that stakeholders (e.g. private landowners and the angling public) play in restoration outcomes. At a secondary level, the methods and outcomes of restoration must further consider 1) stream potential, 2) the relationships of project scale (i.e. stream-reach, stream and watershed) to the problem, 3) a recognition of tradeoffs, 4) indirect and/or downstream benefits of restoration actions, and 5) uncertainty (i.e., risk) of restoration outcomes.

Reducing uncertainty of outcomes, above all, requires that cooperating parties commit to success and have sufficient information from which to base restoration decisions. Project information involves recognizing not only the sources of impairment, but also reasonable assessments of biological (i.e., fisheries) potential. As described below, obtaining this information usually involves: 1) establishing a thorough pre-project (fish population and habitat) baseline; 2) understanding life-history, habitat associations, human impairments and limiting factors related to target and, in some cases, non-target species; 3) identifying clear and attainable restoration goals and measurable objectives; 4) developing realistic time-frames necessary for project and species recovery; 5) recognizing an ability to correct up-and downstream limiting factors; and 6) developing post-project monitoring protocols through recovery phases to ensure the projects meet their intended objectives. A willingness to modify restoration methods based on monitoring results is also important in adaptive management. Restoration practices further conform to the public trust responsibilities of several local, state, and federal natural resource and permitting agencies, which includes ESA designated 'critical habitat' for certain species. Consideration of off-site concerns may be applicable to restoration outcomes and may involve downstream beneficial uses including improved water quality and quantity, and/or recruitment of recreational species to the Blackfoot River. Less predictable outcomes may result from the influences of exotic fishes, diseases and climate change.

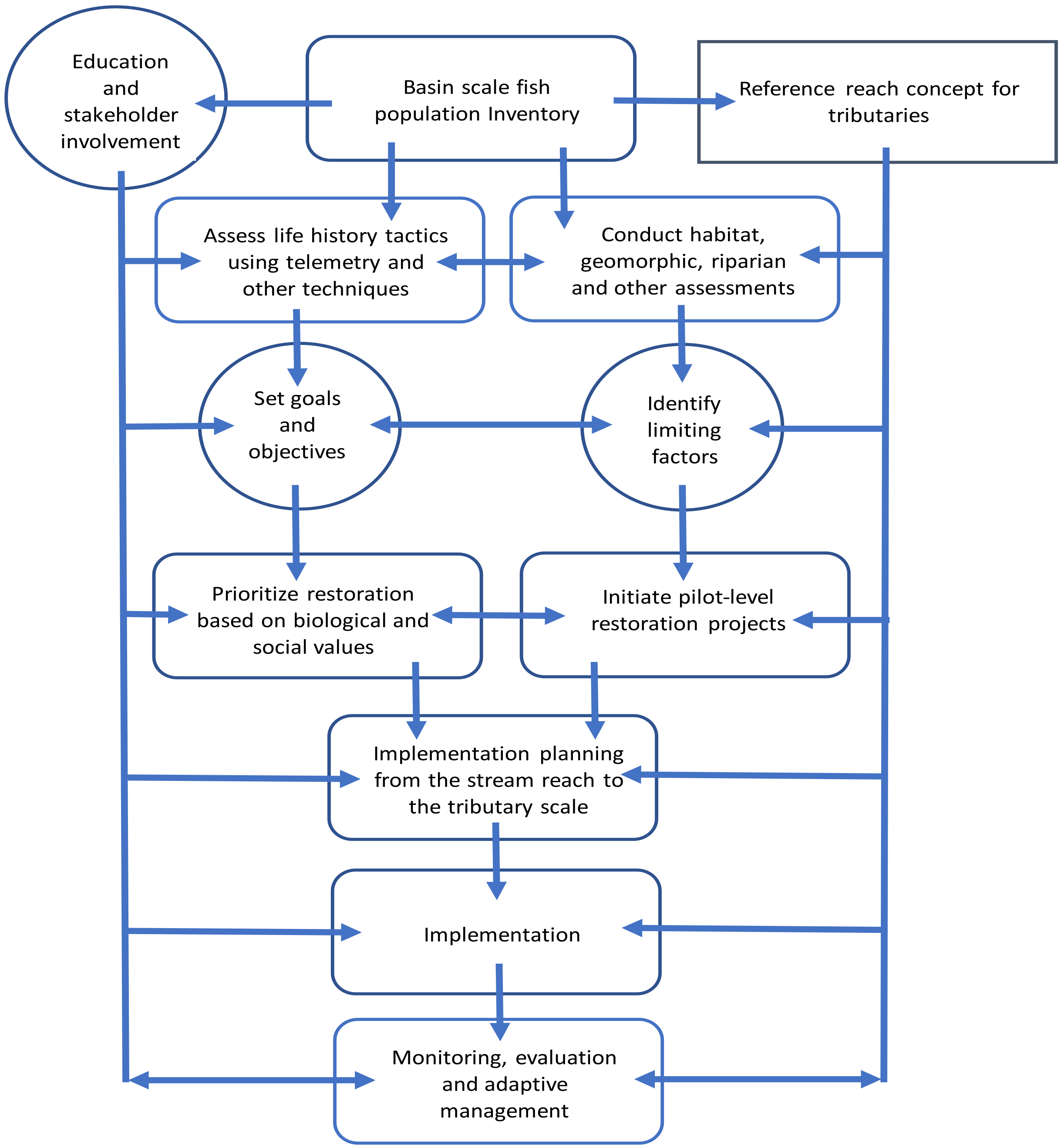
Restoration Framework

With these restoration concepts in mind, the basic Blackfoot restoration framework includes several essential phased and interrelated elements that begin and end with fish population data collection (Figure 2). Within the basic framework, basin-scale fisheries information leads to prioritization of tributary work, which facilitates implementation planning, and ultimately ends with evaluation of restoration outcomes with emphasis on fish population response. This process engages stakeholders (e.g., landowners, conservation groups, agencies and anglers) from the onset, includes a strong landowner educational component, and relies on the active and full-time participation of local watershed/conservation groups (e.g., Trout Unlimited, Blackfoot Challenge and The Nature Conservancy). In addition to this basic framework, more detailed descriptions of restoration methodologies, restoration prioritization process, habitat surveys and natural channel design techniques, and scientific literature (peer-reviewed and agency reports) that emphasizes fish and habitat relationships are described below.

Data Collections: Fish population, Life History and Habitat Surveys

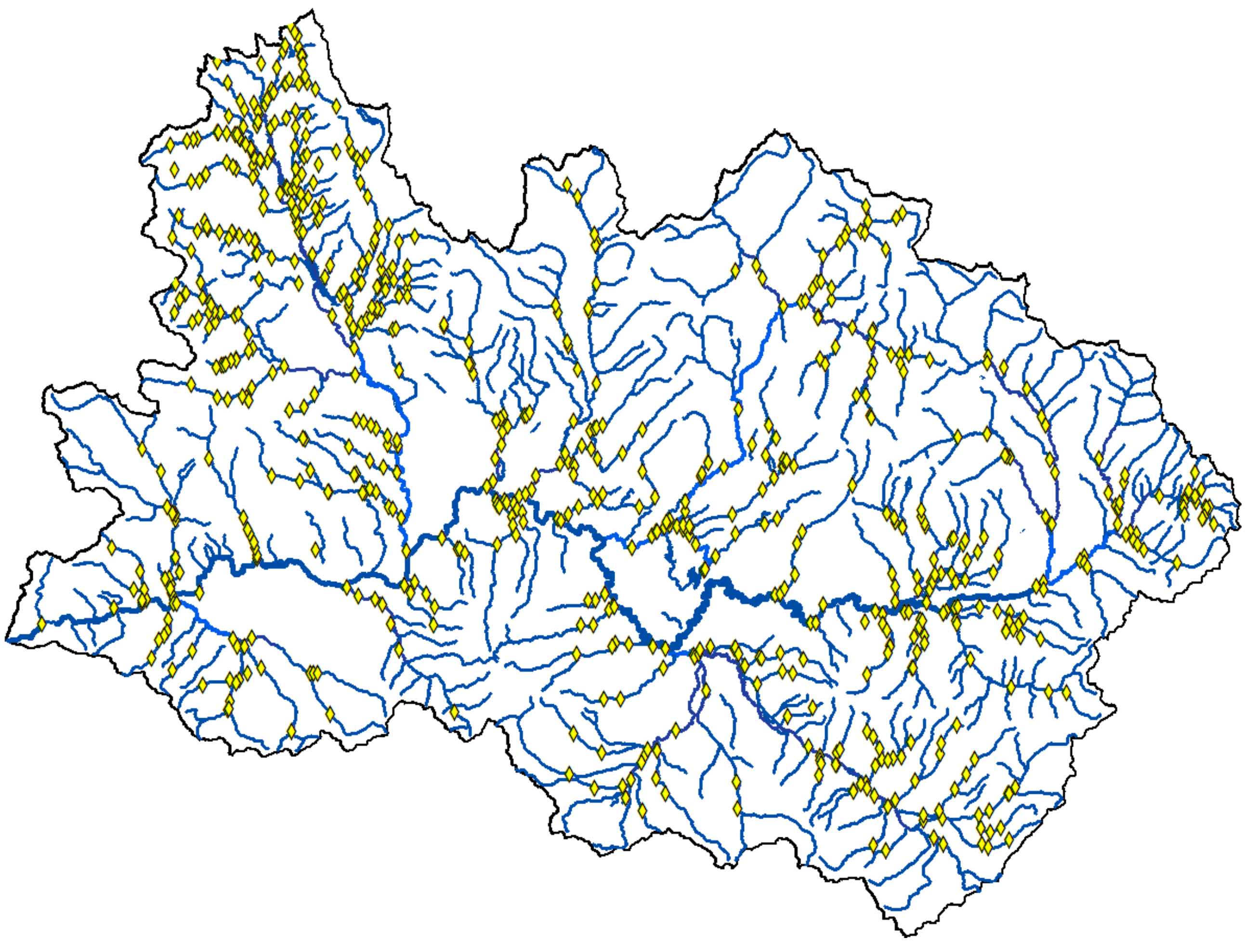
Fish populations surveys - Fish population inventories were completed on all accessible primary tributaries to the Blackfoot River (1,663 surveys at 772 survey sites on 223 streams) along with longitudinal sampling sites (n=10) from the headwaters to the lower reaches of Blackfoot River (Figure 3). Original Blackfoot River survey sites, sampled prior to restoration work, identified very low numbers of native trout and recruitment limitations brought on by various natural and human condtions. Tributary fish population sampling began in 1989 with opportunistic, logitudinal surveys that employed standard intensive single-pass electrofishing methods. These allowed direct comparision of several fish population metrics (species composition, distribution, abundance and size structure) across sampling sites and among species. Surveys typically began at headwater reference reaches and proceeded downstream. Sampling sites were established in reaches defined by changes in stream type, land ownership and land use. With an eye on potential restoration actions, these surveys identified hundreds of individual land use issues (e.g., streamside feedlots, over grazing, nutrient runoff, unscreened irrigition ditches, dewatering, culvert barriers and excessive timber harvest) that potentially impacted fisheries.

Figure 2. Flow chart showing basic elements of the Blackfoot River tributary restoration process. The process engages stakeholders at all phases and relies on the reference reach concept through most aspects of the restoration process.



To facilitate access to private land and begin the process of landowner education, field biologists invited private landowners and their families to participate in electrofishing surveys. Once completed, survey results were shared with landowers. At this stage, initial landowner/agency relationships were established along with a basic awareness of stream issues. Other electrofishing surveys were used to sample irrigiation ditches, collect genetic samples and provide fisheries data for special research studies. Once streams entered a restoration phase, more quantitative fish populations surveys (e.g., mark and recapure or depletion estimates) were established within treatment sites to monitor restoration projects.

Figure 3. Blackfoot River basin showing fish populations survey sites (yellow diamonds) established between 1988 and 2016.



Life-history investigations – In addition to electrofishing surveys, nine special radio telemetry studies were completed between 1996 and 2014 to identify the spawning behavior of adult migratory native salmonids (bull trout, westslope cutthroat trout and mountain whitefish

(*Prosopium williamsoni*) from the Blackfoot River and Clearwater chain of lakes. Each of these studies identified the timing of migrations, seasonal habitats (summering and wintering areas) and spawning locations, while also identifying limiting factors (e.g., fish passage barriers, losses to irrigation ditches) between capture sites and natal tributaries. As technology advanced, genetic tests using individual fish's DNA allowed genetic assignment work, whereby a tissue sample (fin clip) collected from a bull trout captured in the Blackfoot River or Clearwater lakes could be used to assign that fish to its natal stream of origin. In addition, recent advances in environmental DNA (eDNA) allowed for detailed investigations involving presence/absence or incidental use of streams, which was often difficult to detect using standard electrofishing techniques. This type of life history information, when merged with tributary electrofishing investigations, helped to identify the status of trout metapopulations including migratory stocks and stream resident populations.

Habitat surveys – Fish population surveys typically preceded physical habitat surveys. Habitat surveys in the Blackfoot Basin typically relied on continuous surveys that focused on identified stream condition (impairments) and restoration opportunities specific to individual streams and individual land ownerships. Like electrofishing surveys, habitat surveys typically began at a randomly selected habitat unit within an upstream reference reach and proceeded downstream. In some cases, these surveys crossed across many land ownerships and covered several kilometers. Depending on expected sample size, habitat features were sampled at the 10%, 25% or 50% intensity, which included habitat unit (pool/riffle) measurements (e. g., length, wetted width, max depth, and bankfull width at riffles, residual pool depth and pool frequency) and assessments of functional wood within the active and bankfull channels and along the longitudinal profile. In addition, riparian vegetation, potential vegetation and recruitment of instream wood, as well as human-altered riparian areas (grazing, land clearing or timber harvest) were identified with both field data and quad maps and aerial photographs, which later included high resolution GIS-based aerial photos (e.g., NAIP) and advanced imagery (e.g., LIDAR).

To characterize survey reaches in greater detail and to help identify limiting factors, more detailed Rosgen geomorphic surveys were performed within representative reaches of the habitat survey to identify reference reach conditions and to identify the degree of human-related channel/riparian alterations for departure analysis. Wolman pebble counts and McNeil core samples described substrate and spawning area conditions including anthropogenic sediment. Other data collections variously included measurements of water chemistry (TDS, pH, Conductivity) and nutrients (N, P) depending on water quality questions. In addition, stream discharge, continuous water temperature data collections were standard, and macroinvertebrate sampling variously identified land use/habitat relationships. Minimum instream flow assessments, based on the concept of the wetted riffle, were completed on certain streams where water leasing or other conversions to instream flow were pursued.

Restoration Prioritization

Restoration prioritization – With basin-scale data collections and an active restoration initiative underway, multi-criteria decision trees were periodically developed to prioritize and guide restoration actions. These matrices focused on tributary-based restoration relationships with the Blackfoot River, and so included tributary fish populations and life history information for migratory native trout and sport fisheries, as well as other stream health information (Table 1). The most recent strategy, completed in 2007, was developed for 182 streams in response to 1) an increasing number of watershed interest groups, 2) a cadre of federal, state and regional fisheries management directives, 3) the recent development of drought, sub-basin and TMDL plans, and 4) ESA designated critical habitat for the recovery of bull trout, and 5) recently completed fish

Table 1. Restoration prioritization scoring criteria for streams within the Blackfoot Basin. The point values were applied to 182 streams. Scoring was weighted towards native trout and biological benefits to identify the highest priority streams.

Prioritization scoring criteria

	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 adddress entire stream system (yes/no)	20/0
7	Provides increased stream flow 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
	Possible points	**200**

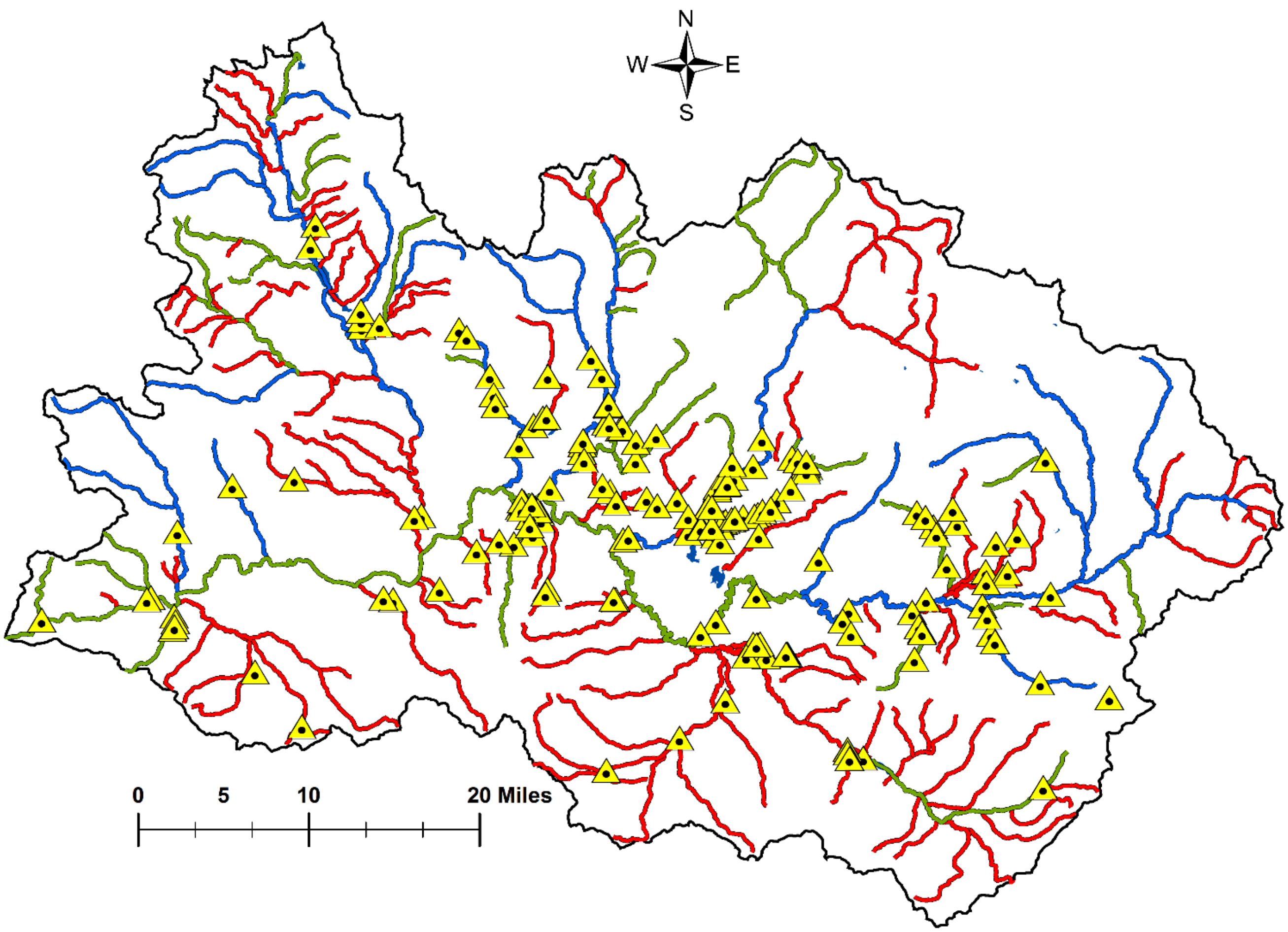
population inventories in the Clearwater River drainage. The purpose of this planning document was to guide stakeholder involvement (effort and funding) to common priorities involving the needs of native fish because these fish are indicators of ecosystem heath. To this end, this plan provides a basin-wide, native fisheries-based, priority-driven template for restoration projects. The rationale for generating this prioritization was that by integrating all fisheries-related restoration programs into a single guiding strategy, the Blackfoot stakeholders could better meet a common suite of conservation goals.

Implementation Planning and the Importance of Watershed Groups

Implementation Planning - Restoration typically focused on correcting obvious human impacts to fish populations and natural stream function, including migration barriers, stream de-watering, fish losses to irrigation canals, degraded (overgrazed) riparian areas and stream channelization. Within a context of restoration priorities, implementation planning typically occurred from the stream-reach to the tributary scale, which often involved an interdisciplinary team of agency specialists (biologist, hydrologist, project manager, grazing specialists, water rights specialists), conservation groups (BBCTU and Blackfoot Challenge) and cooperating landowners/managers. Once major projects are selected for restoration, fisheries biologists (re)surveyed fish populations and habitat conditions to quantify response variables, which usually involved the use of reference (control) reaches. Depending on limiting factors and habitat objectives, habitat data included geomorphic surveys, minimum instream flows, fish passage, water quality, riparian vegetation and spawning area assessments. At this stage, lead planners were charged with ensuring that the “source” of degradation was addressed versus the “symptoms” of degradation. The sum of this information supported and led into project design, fund-raising, contracting. permitting and landowner agreement phases.

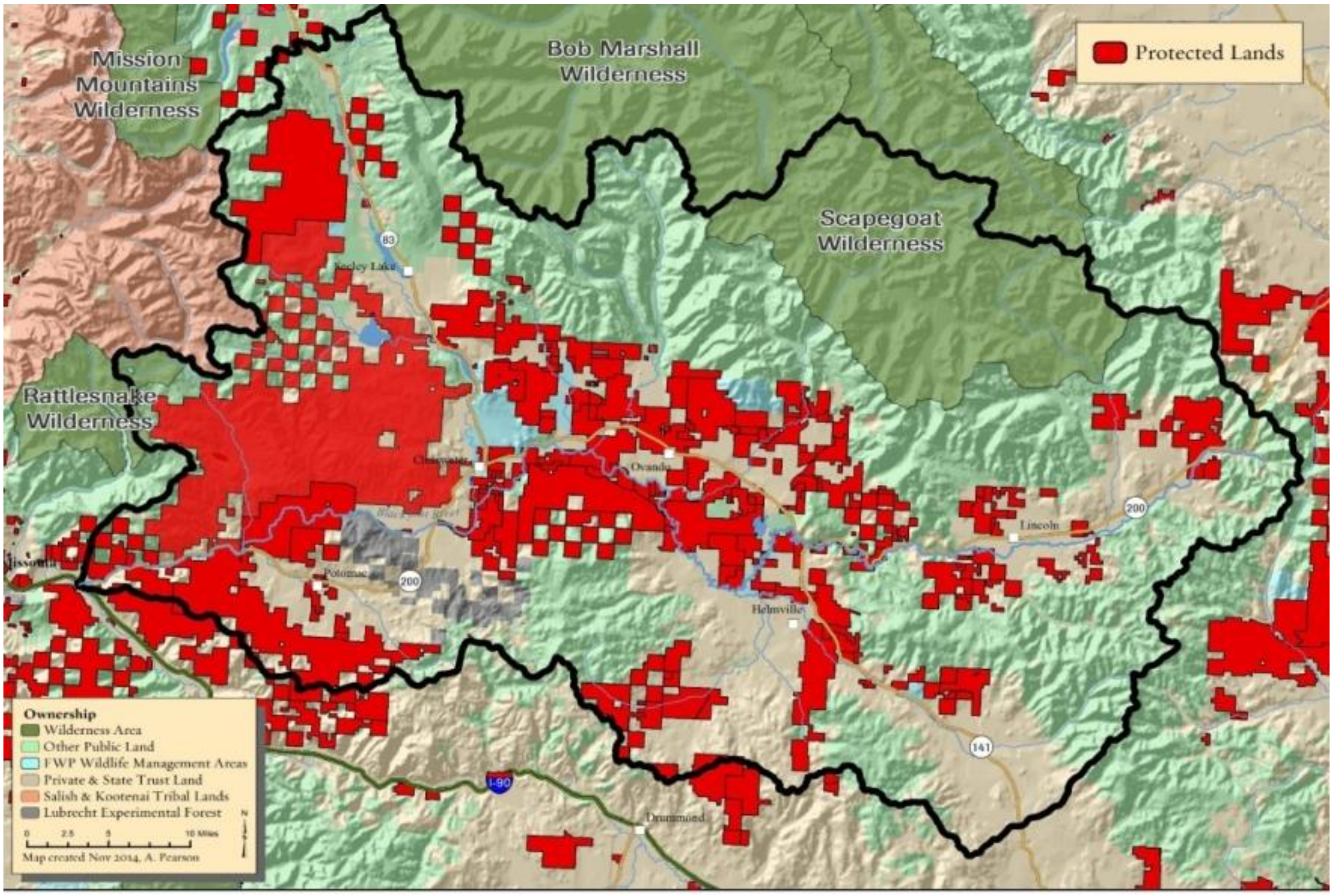
Watershed Groups **–** Most of the project administration and fund-raising (landowner contributions, private donations, foundations and state and federal grants) was coordinated through BBCTU and agency partners. The non-profit status (i.e., 501(c)3) of BBCTU and other conservation groups provides a mechanism for generating tax-deductible private funds. In additions to fund-raising, BBCTU generally obtained local, state and federal stream permits on behalf of cooperating landowners. Project bids (consulting and construction) conformed to State and Federal procurement policies. These policies included the development of a Blackfoot watershed *qualified vendors lists* (QVL) derived through a competitive process. A minimal project cost triggered the use of the QVL. BBCTU solicited bids from the QVL for both consulting and contractor services. Bid contracts were signed between BBCTU and selected vendors upon bid acceptance. Depending on the specific project, landowners are responsible for certain costs, construction and project maintenance once projects are completed. Written (20 year) agreements with landowners to maintain projects are arranged with cooperators on each project. Lastly, BBCTU oversees and directs contractors during construction. The most recent distribution map of completed projects at 178 locations on 64 streams is shown in Figure 4. Depending on the specific project, this work often entailed several concurrent objectives, such as fish passage improvements (32 streams), fish screens (18 streams), riparian grazing (36 streams), instream flows (17 streams) and active channel restoration (27 streams). Each project sought benefits for landowners and aquatic resources and were completed voluntarily.

Figure 4. Blackfoot River restoration prioritization for native trout (blue = high priority, green = moderate priority, red = low priority) along with 178 sites (yellow triangles) where restoration projects were completed on 64 tributaries (GIS file provided by BBCTU).



In addition to the vital role of BBCTU, the Blackfoot Challenge (a 501(c)3 nonprofit organization) more broadly assists with watershed conservation by organizing landowner education tours, drought planning, forest restoration and assists with conservation easement strategies with cooperating agencies (e.g., FWP, U.S. Fish and Wildlife Service, Department of Natural Resources and Conservations), land trust organizations (Montana Land Reliance, Five Valleys Land Trust, The Nature Conservancy) and private landowners. This specific collaboration ultimately helped to increase land protections (conservation easement and land purchases) in the Blackfoot Valley from about 6.5km^2 in 1975 to 1,623 km^2 in 2016 (Figure 5), which included 1,628 km of easement protection on riparian corridors.

Figure 5. Blackfoot River Basin with landownership patterns. The red areas show conservation lands converted to either public ownership or private land with easement protection (File provided by TNC).



Stream Restoration Techniques

Instream Habitat Restoration using Natural Channel Design – Restoration project employed both *passive* and *active* methods. Passive methods, (e.g., improved riparian grazing, enhancing instream flows, screening irrigation ditches and revegetation) are most essential because passive methods rely on natural recovery and so address the cause of riparian/aquatic degradation, versus the symptoms of degradation. Unlike passive restoration, active restoration methods involve entering the channel with heavy machinery and reconstructing severely damaged streams, or directly restoring habitat conditions (e.g., natural channel morphology, instream wood) where high degraded or otherwise highly altered. Almost all active channel project undertaken in the Blackfoot also require passive methods to ensure compatible land use (e.g., sensitive riparian grazing) once active channel work has been restored the stream to more natural form and function.

For active habitat restoration, our methods evolved from the use of references reaches to natural channel design (NCD) techniques as first described by Rosgen stream types in the 1980s. Over time, the Rosgen stream classification and related survey techniques became standard in stream surveys, assessments of stream condition, restoration design and monitoring. Unlike enhancement techniques, NCD involve a geomorphic approach that fits the geomorphically stable stream to the proper stream valley. The Rosgen stream classification provides the basis of this approach by quantifying channel dimension, pattern, and profile. Riparian health, instream habitat, and fish population surveys, along with measurements of discharge, sediment, and bed and bank stability, permit the assessment and evaluation of existing and potential channel conditions as well as biological attributes of the project. NCD aims to restore natural channel stability, or dynamic equilibrium, and habitat to impaired streams. Streams in dynamic equilibrium are generally more biologically productive and provide higher quality and more complex habitat than altered or unstable streams. Geomorphic indicators (bankfull channel), prediction analysis (reference reaches and dimensionless ratios), and method validation (regional curves) define naturally functioning channels and provide the basis for natural channel design.

The final restoration design seeks to mimic a stream in dynamic equilibrium with its watershed, and to provide a diverse and complex channel capable of conveying flows, transporting sediment, and integrating essential habitat features. Vegetation colonization through mature shrub and sod mat transplanting, as well as other revegetation efforts, along with woody materials and rock provide immediate fish habitat and temporary bank stability. These structures allow for shrub colonization which, when established, provide long-term channel stability and habitat complexity. Proper land management is essential to the success of these methodologies. Most restoration projects necessarily incorporate compatible grazing strategies and other land management changes. As final outcomes, restoration projects must be consistent with ecologically sound and sustainable practices, contribute to conservation of high quality aquatic habitat, and protect native aquatic species.

Restoration Case Studies: Long-term Monitoring and Evaluations

The case studies described below are currently among the most comprehensive in the published restoration literature. Unlike the essay on the restoration framework, the case studies are cited and emphasize long-term (>5 years post restoration) published field studies. In addition to those citations, a list of restoration-related studies from the Blackfoot Basin are also referenced at the end of this report. Most of the case studies employed natural channel design methods and the concept of the reference reach. In addition, the case studies emphasize a range of human impacts involving habitat simplification, channel degradation, dewatering, over-grazing, ditch entrainment, elevated water temperature and anthropogenic sediment. The case studies are organized chronologically and hierarchically (stream reach to basin scale), followed by a brief summary of community response trends in the Blackfoot River.

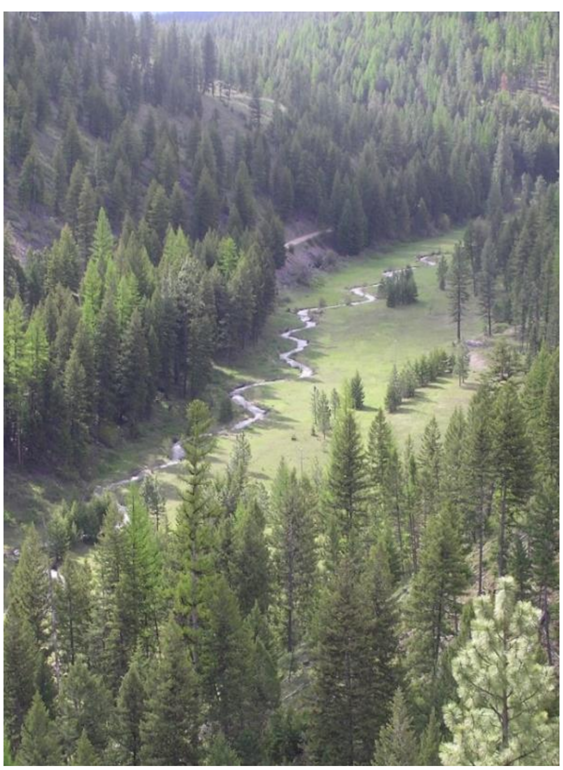
Chamberlain Creek – Chamberlain Creek was selected as one the first comprehensive restoration projects (Figure 1) after severe channel damage was identified in 1989 (Figure 6). Here, channel degradation in the 1980s led to a 94% reduction in Westslope Cutthroat Trout abundance when upstream reference sites were compared to downstream disturbed areas. There was also a loss of migratory connection between Chamberlain Creek and the Blackfoot River by instream dams, diversions, and dewatering (Peters 1990; Pierce 1991, Pierce et al. 1997). Restoration methods included reconstruction to more natural B4-C4 stream types, adding wood to another 2km of stream, removal of livestock from riparian areas, irrigation upgrades (consolidation of two ditches into one and the installation of a fish ladder at the diversion point) and enhanced stream flows through water leasing. In addition, conservation easements were placed on all ranchlands in the lower basin. Following this work, age-1+ Westslope Cutthroat Trout increased from a pretreatment estimate of 2.5 fish/30m to a long-term average of 19.2 fish/30m (Figure 17). Moreover, seven years after treatment, biotelemetry confirmed migratory reconnection, as 73% of fluvial westslope cutthroat trout spawners radio-tagged in the Blackfoot River between Gold Creek and the North Fork (a distance of 65 km) ascended Chamberlain Creek to access spawning areas within and upstream from the treatment

Figure 6. The top photo shows Chamberlain Creek in 1989 just after it was bulldozed to construct an instream pond. The bottom photo at the same site in 2008 shows the restored channel.

reach (Schmetterling 2000, 2001). Lastly, a checkerboard of 77.2km^2 of private industrial forest land in the mid- to upper basin was transferred to public ownership (in 2010) with special easement provisions to remove 8.9km of roads adjacent to streams and to protect riparian areas from intensive land use. Culverts were also removed to meet fish passage and natural stream function. With the completion stream restoration, conservation easements, and land exchanges, the Chamberlain Creek project has now addressed all known primary impairments to fisheries and riparian corridors, while achieving landscape-level conservation for the entire Chamberlain Creek drainage.

Bear Creek – Bear Creek is a small tributary of the lower Blackfoot River with a long history of industrial forestry and intensive grazing. Adverse human impacts included undersized culverts, road drainage and siltation, irrigation dewatering, channelization of the stream, excessive riparian grazing and streamside timber harvest. Many of these impairments were corrected between the 1994 and 2011. Restoration activities included: 1) upgrading or removing culverts and addressing road-drainage problems, 2) improving water control structures at irrigation diversions, 3) reconstruction on 552 m of new B4-C4 channel (Figure 7), 4) enhanced habitat complexity using instream wood on an additional 946m of stream, 4) shrub plantings, and 5) the development of compatible riparian grazing systems for one mile of stream. Fish population response data in the reconstructed reach shown in the reconstructed reach is shown in Figure 19. In 2010, all private

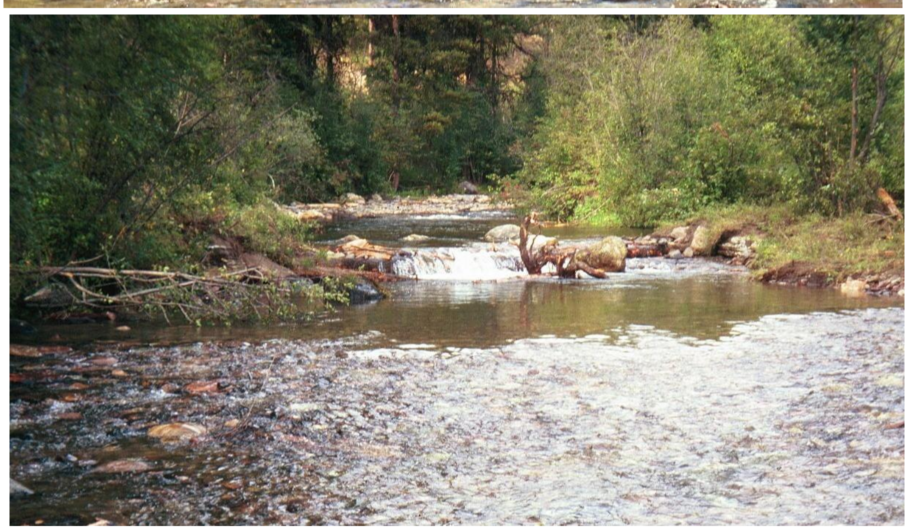
Figure 7. The newly constructed Bear Creek channel on the left and a close-up photo of the stream on the right. Prior to restoration Bear Creek was channelized and relocated on the margin of the valley.



industrial forest land in the Bear Creek drainage was transferred to State of Montana (DNRC) ownership.

*Gold Cree*k – The Gold Creek restoration project, located on industrial timberland in the Blackfoot Basin (Figure 1), was one of the first restoration projects where the performance of habitat structures for two stream types (B and C) were evaluated (Rosgen 1996, Schmetterling and Pierce 1999). This work was later evaluated for trout population response (Pierce et al. 2013). The project was initiated in 1996 after decades of riparian timber harvest and intentional removal of large wood from the channel had occurred, both of which led to the dramatic loss of pool habitat (Figure 8). Based on an upstream reference reach and a channel slope/bankfull width-related formula for natural pool spacing (Rosgen 1996), the Gold Creek project created 66 pools within a 4.8km section of stream with gradients ranging from 2.0-3.4%, which included B3, B4 and C3 stream types. The project used native material (large wood and glacial erratic boulders) from

Figure 8. Photo point from Gold Creek: The pre-restoration (top) photo shows a B stream type lacking instream wood. The post restoration (bottom) photo shows a wood-formed plunge pool at the same site immediately following installation.



onsite sources install four types of pool-forming habitat structures (debris collectors, log-formed plunge pools, lateral scour pools, and rock formed pools).

Once completed, the wetted pool area of the channel increased from 1% pretreatment to 14% post treatment, similar to the reference reach. The project then withstood an estimated 50-year flood event the next spring. Of the original 66 structures, 85% of all structures remained intact and stable with significantly higher retentions rates in the B stream type (94%) verses the C stream type (58%). For the C stream type, lateral scour pools had the highest retention rate (75%); whereas, rock formed pools had the lowest retention rates (40%). The project concluded improving pool habitat and the ability to withstand major floods was a function of stream type and the type of structure employed. These results led to changes in the use of structures for unconfined C stream types to structures more suited to laterally extended channels. Long-term fish population monitoring (pre- and post-restoration) within the B stream type portion of project showed a positive long-term trend in total trout abundance following this work (Figure 19). In 2014, all industrial forest land (41.3 miles, 66% of the drainage) was purchased by The Nature Conservancy as part of a much larger scale conservation project (Figure 5).

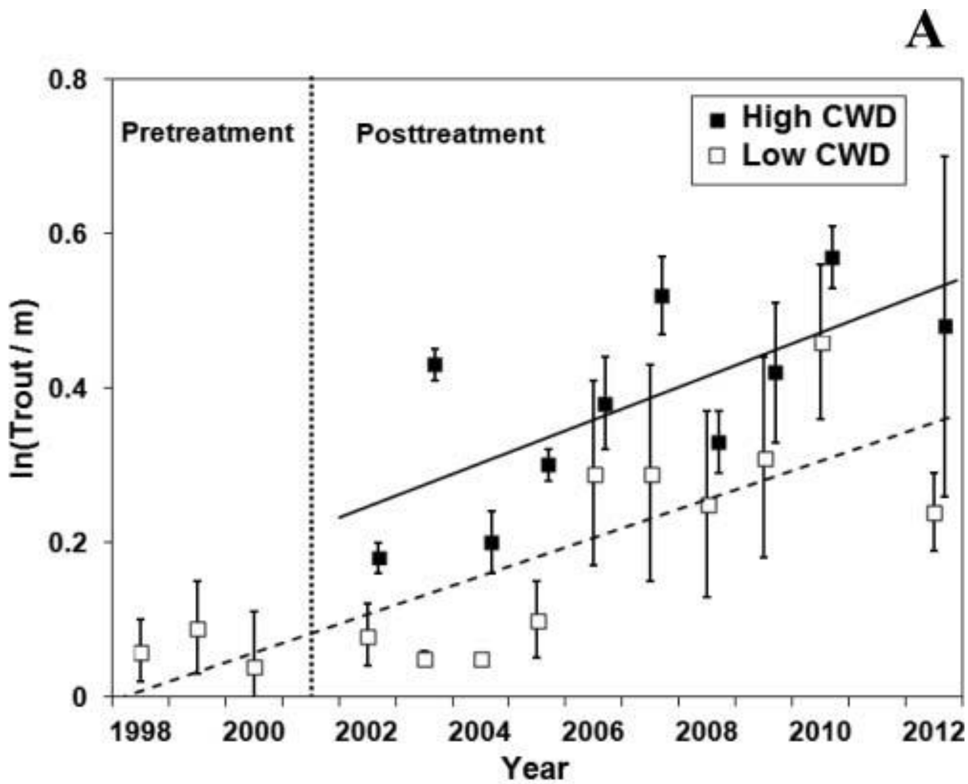
Kleinschmidt Creek – Kleinschmidt Creek, a groundwater-dominated stream, was fully reconstructed using NCD principles, then closely monitored over a 10-year post-restoration period (Pierce et al. 2014a, 2015). The project converted an over-widened and heavily degraded stream (C5) stream to a deep, narrow, more sinuous (E4) stream type (Figure 9). This conversion reduced wetted surface area of the channel by 69%, increased bankfull velocity and hydraulic shear stress, coarsened the substrates in riffle spawning areas and increased pool depth (Table 2). This case study further documented trout response trends (redistribution and population growth, i.e., abundance and biomass) associated with instream habitat structure (wood) and vegetative recovery (Figure 10). Perhaps the most important habitat change that was documented relates to water temperature. Summer temperatures in Kleinschmidt Creek declined 3.5^{o}C into the optimal thermal range of bull trout (i.e., maximum temperatures <13^{o}C) with maximum temperatures about 1.5^{o}C colder than those in the receiving waters (Figure 11). Likewise, two fully reconstructed nearby NCD projects in groundwater-dominated streams have shown similar (3-4^{o}C) reductions in water temperatures following channel renaturalization (Pierce et al. 2016). These temperature reductions are biologically important because these three streams all enter ESA designated critical bull trout in a reach used for thermal refugia (Swanberg 1997). Because these streams now enter the receiving stream at lower temperatures, they provide some buffer against ongoing warming trends (Isaak et al. 2015). Lastly, the three stream projects mentioned here are now under conservation easements, which includes full protection the Kleinschmidt Creek riparian corridor.

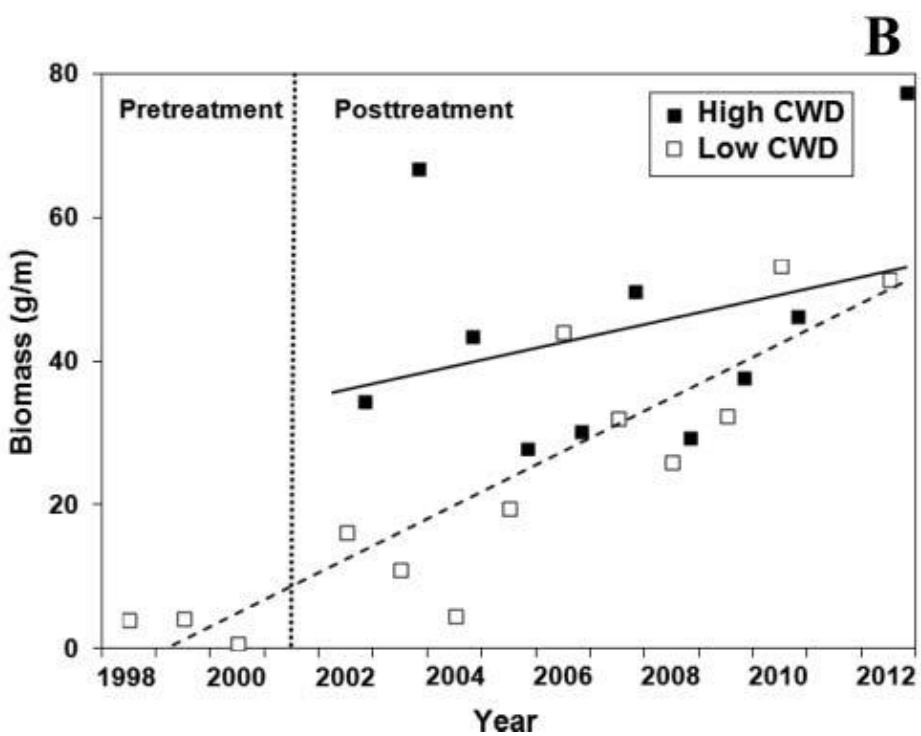
Table 2. Summary of channel morphometrics in Kleinschmidt Creek pre-restoration (1990) and 10 years post-restoration (2011) along with hydraulic relationships of the pre-treatment (C5) and post-treatment (E4) stream types.

Variable	Pretreatment (C5)	Posttreatment (E4)
Channel length (km)	1.97	2.73
Sinuosity	1.1	1.6
Stream slope - S (m/m)	0.0058	0.0040
Valley slope (m/m)	0.0064	0.0064
Bankfull discharge - Q_{bkf} (m^3/s)	0.71	0.71
Mean bankfull width - W_{bkf} (m)	20.1	3.1
Mean bankfull depth - d_{bkf} (m)	0.13	0.35
Bankfull W/D ratio	150	8.8
Mean bankfull cross-sectional area - A_{bkf} (m^2)	2.6	1.1
Mean bankfull mean velocity - $\bar{u}_{bkf}$(m/s)	0.27	0.67
Bankfull shear stress - τ (newtons/m^2)	7.4	13.7
Particle entrainment size (mm)	11	21

Figure 9. Kleinschmidt Creek pre-treatment (left photo, September 2001) and post-treatment photos (right photo, June 2014). The left photo shows a straightened and over-widened section of channel with an example of a channel-altering rock dam that induced upstream deposition of fine sediment within the pre-treatment channel. The right photo shows the restored stream at the same location.

Figure 10. Trout population response trends to channel restoration in Kleinschmidt Creek. The top graph (A) shows estimates of age 1+ abundance and the bottom graph (B) shows age 1+ biomass before and after full channel restoration. 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 wood groups.





Nevada Spring Creek complex - In the case of the Nevada Spring Creek complex, NCD included the complete reconstruction of 7.1 km of stream (Pierce et al. 2014b). This work converted a low-gradient, heavily degraded C5 stream type to a deep/narrow (E5) stream type (Figure 12). This project reduced W/D ratio from 22 to 3.2, enhanced instream flows, then restored and reconnected an upstream native trout spawning tributary (Wasson Creek) to Nevada Spring Creek (Pierce et al. 2013, 2014b). Following NCD work, the resident native cutthroat trout from Wasson Creek dispersed downstream into restored habitat, then reestablished a migratory westslope cutthroat trout population component. Westslope cutthroat trout then increased in abundance downstream of the restoration project from zero fish in 2005 to 11.0±2.1fish/300m in 2016 (Pierce et al. 2016). Adult spawners from this migratory population are now returning to spawn in Wasson Creek (Pierce et al. 2014b). The Nevada Spring Creek property is protected by conservation easements with special protection to prevent disturbance to the riparian corridor. Lastly, instream flows were restored and perpetually protected through a conversion of private water rights to public ownership.

Figure 11. Pre restoration and post restoration water temperatures for Kleinschmidt Creek (treatment site) and the North Fork of the Blackfoot River (control site): (A) average maximum daily temperatures, (B) mean daily temperatures, and (C) average daily range of temperatures.

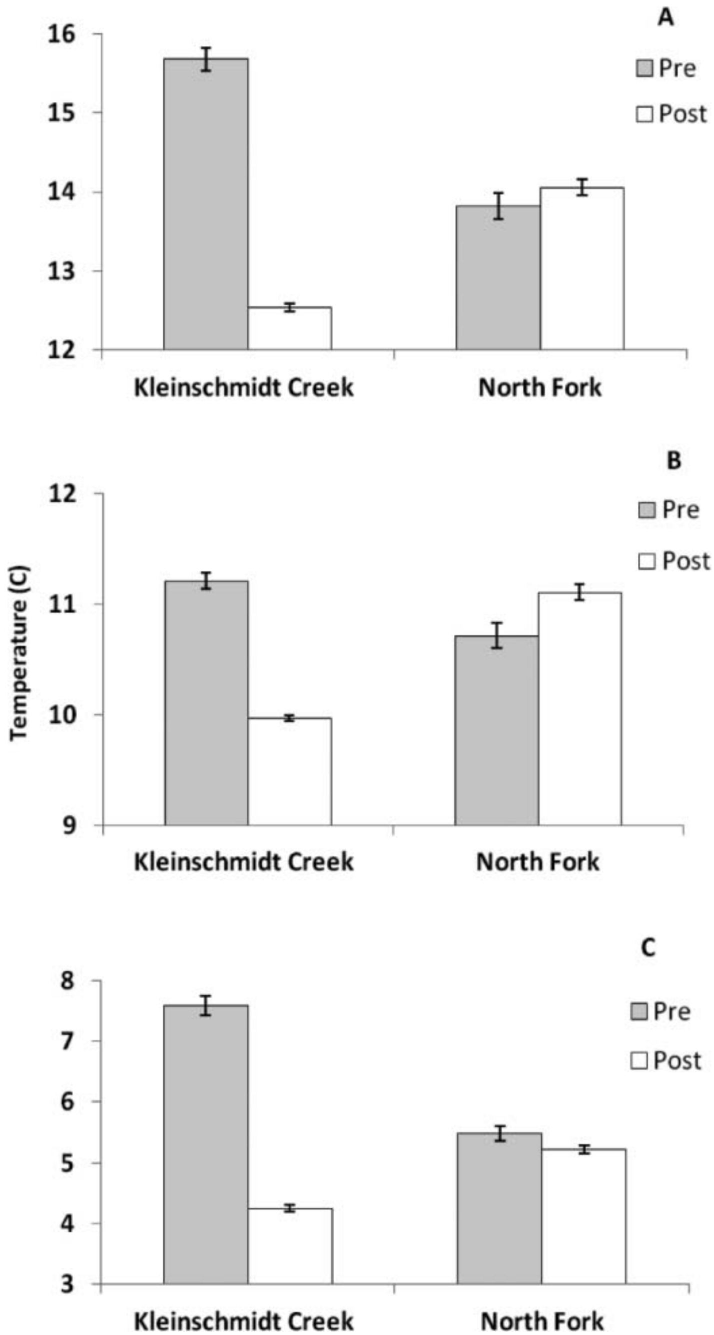


Figure 12. Pre-restoration photo of the Nevada Spring Creek project before (top) and after (bottom) restoration. Note channel incision, erosion of stream banks and high channel width prior to restoration.

Nevada Creek – Located immediately downstream of a large irrigation storage reservoir, this Nevada Creek demonstration project reconstructed 1.34km of channel in 2010 to restore more natural channel features to a degraded (C4) section of Nevada Creek. Prior to restoration, Nevada Creek was incised, over-widened with eroding banks that contributed 0.21 tons of sediment/year to the channel (Dave Rosgen, unpublished data) and lacked woody riparian vegetation due to decades of intensive riparian grazing (Figure 13). Channel reconstruction reduced width/depth ratio from 56 to 24, elevated the channel, added lateral scour pool habitat structure (instream wood) on the outer stream bends and established riparian vegetation along the new floodplain and streambank margins (Figure 14).

Figure 13. This photo shows Nevada Creek prior to restoration with poor habitat quality. Here, the stream had incised and unstable channel and completely lacked woody riparian vegetation.

The Nevada Creek project also included a three-stage inner channel designed to maintain a low width/depth ratio inner channel to help mitigate irrigation-related low flow conditions during low flow periods. In addition to active channel work, livestock were excluded from the immediate stream corridor. Similar to the Gold Creek project, the Nevada Creek project underwent a major flood event the following spring with 5-6 times bankfull flow. Though the channel variously adjusted, the pattern, dimension and profile changed little, and none of the lateral pool habitat features failed due to the change in techniques. Pre-restoration (2010) and post restoration (2016) trout population monitoring showed a 300% increase in the abundance (46±16 to 136±25 age 1 + trout/300m) and a 307% increase in trout biomass (11.7km to 35.9km).

Sediment assessments on spawning riffles in restored spring creeks - This long-term spring creek study explored conversions of several degraded C4-C5 stream types to deeper/narrower E4 stream types (Pierce et al. 2017, Figure 1). Unlike trout response studies, this study emphasized associations of basic channel form with riffle substrates (Figure 15) and trout spawning site quality, along with riffle/sediment relationships with macroinvertebrate taxa groups and two biotic indices. This study included four actively restored (reconstructed E stream types with > 10 years rest from livestock grazing) and four unrestored (C stream types damaged by land use) spring creeks in western Montana with most of the sites (n=5) in the Blackfoot Basin. Despite no change in channel slope, riffles in restored streams had lower width-to-depth ratios (10.2 ± 1.8 versus 19.2 ± 4.6), higher velocities (0.71 ± 0.18 versus 0.39 ± 0.09 m/s), lower percentage of sediment < 6.3 mm (25.9 ± 6.6 versus 41.4 ± 6.2) and higher quality spawning sites than unrestored streams. This study concluded that stream restoration can

Figure. 14. Nevada Creek photo point: The top photo shows restoration of a C4 stream type employing bankfull bench revegetation techniques over toe wood. The bottom photo was taken at the same site 5 years after treatment.

improve spawning substrate by facilitating sediment transport via reduced width-to-depth ratio and improved land management (Figure 16). When all streams were considered, the richness of sediment-tolerant macroinvertebrates were inversely correlated with riffle substrate size; whereas, clinger (sediment-intolerant) richness correlated positively with riffle substrate size. Of the two biotic indices, a significant correlation of the Fine Sediment Biotic Index with sediment < 6.35 mm suggests it may be a better indicator of spring creek habitat integrity and restoration effectiveness.

Figure 15. Cumulative frequency curves for the restored streams and for the unrestored streams. Note the higher levels of fine sediment <6.3mm in the unrestored streams.

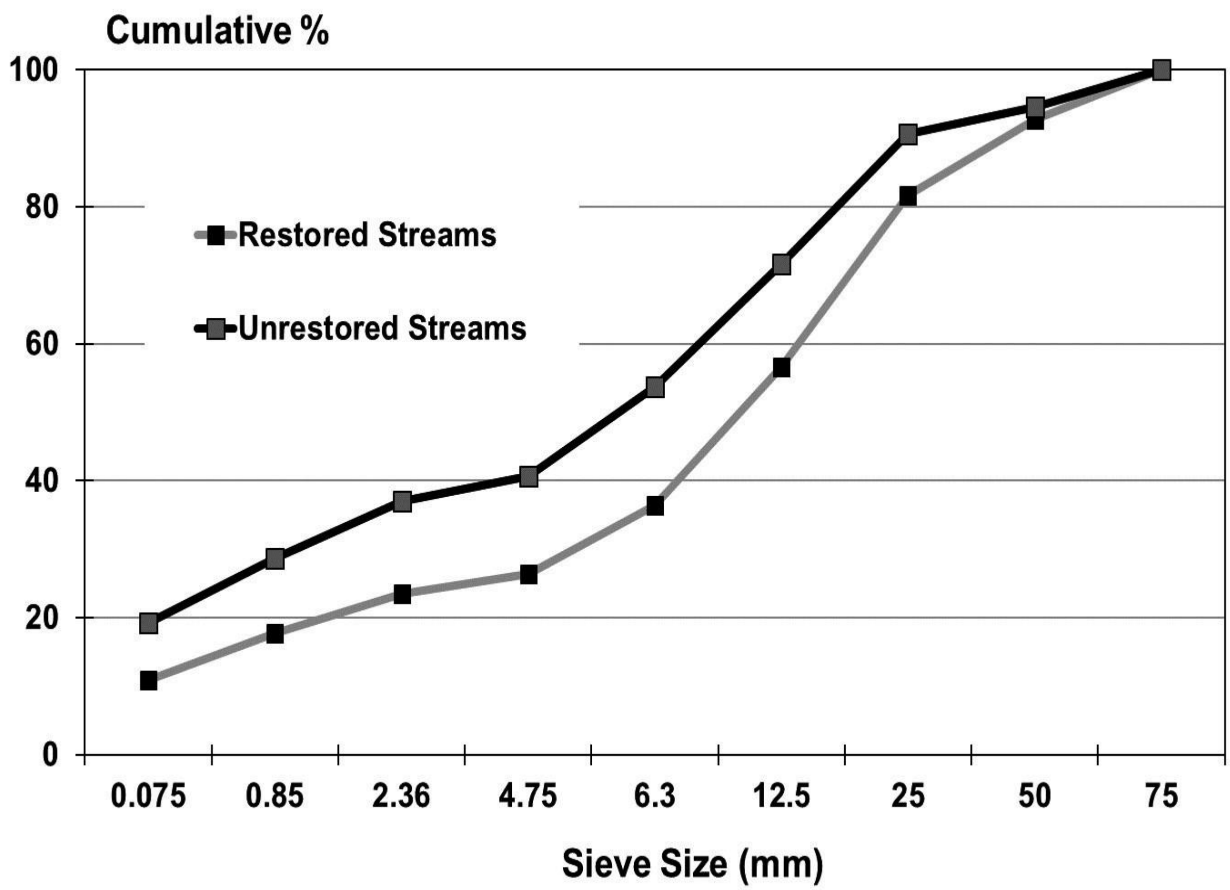
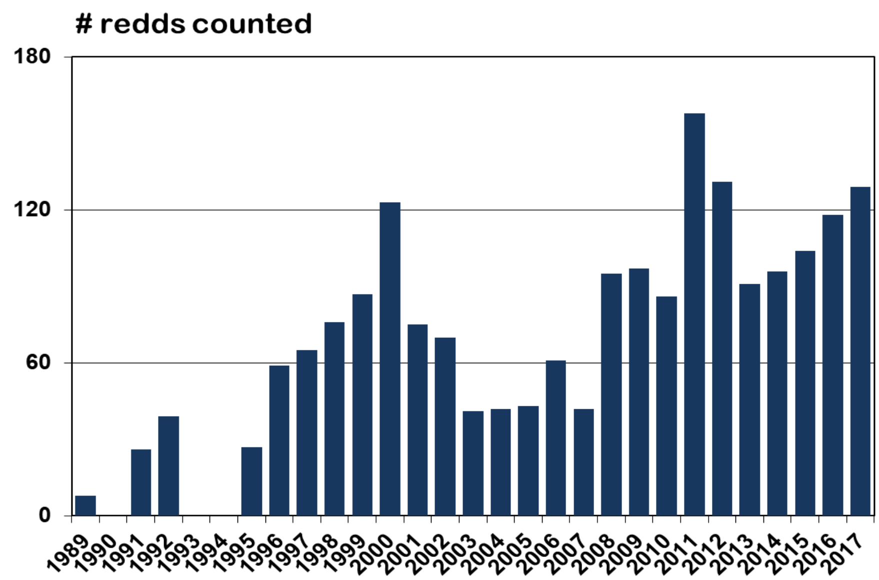


Figure 16. These photos show two of the eight spring creek study reaches, both from the Blackfoot Basin. The top photo shows as wide shallow degraded (unrestored) stream and the bottom shows a deeper, narrow (restored) stream.

North Fork of the Blackfoot River – The North Fork was originally identified as a bull trout stronghold when early settlers named the North Fork the "Salmontrout Fork of the Blackfoot River" in the late 1800s. Like migratory populations elsewhere, the North Fork bull trout is a wide ranging, obligate cold water char that spawns in groundwater upwelling areas in the larger headwater streams (Swanberg 1997, Pierce et al. 2006). The North Fork Blackfoot River supports the largest population of migratory bull trout in the Blackfoot Basin. These bull trout spawn in the Scapegoat Wilderness, and from there juvenile bull trout disperse down valley in some case long distances. As these fish mature, they assume migratory behavior that spans the mainstem Blackfoot and Clark Fork Rivers, as well as the lower Clearwater River as far upstream as Salmon Lake before returning to the natal spawning areas (Swanberg 1997, Schmetterling 2003, Pierce et al. 2016). Because char species rely on cold water, bull trout also require access to the coldest streams (thermal refugia) during the heat of summer. Given their specific spawning habitat needs, wide-ranging and complex behavior and reliance on cold water, bull trout recovery requires a landscape perspective with a strategic emphasis on critical habitats, restoration-induced water temperature reduction and habitat connectivity.

Figure 17. Bull trout redd counts in the North Fork Blackfoot River, 1989-2017. Note the increases following regulations changes in 1990 and in 2008 following the removal of Milltown dam.



During the decade of the 1990s, electrofishing surveys and telemetry studies were used to identify bull trout spawning and rearing areas, spawning behavior and movements patterns of adult fish. In addition, redd counts were used to gauge population size and trends. These investigations identified bull trout losses to five canals on the mainstem North Fork. In addition to screening these canals, the full restoration of four spring creeks to the lower 15km of North Fork watershed was completed where groundwater inflows and spring creek provide cold water refugia (Swanberg 1997, Pierce et al. 2013). Additional work included the removal of Milltown dam (Figure 18), which early telemetry studies documented as a barrier to the upstream migrations of the North Fork bull trout (Schmetterling 2003). Currently, the last major unfinished project within the migration corridors of bull trout is an unscreened irrigation ditch on the lower Clearwater River.

Though redd counts show that adult bull trout numbers continue to increase in the North Fork (Figure 17), bull trout populations in the lower Blackfoot Basin have undergone dramatic population declines in the last 30 years (Pierce et al. 2016). These declines occurred overlap with intensive land use and where warmer streams tend to favor nonnative competitors. In these areas, brown trout are replacing bull trout at the lower elevations of the Blackfoot Basin (Al-Chokhachy et al. 2016, Pierce al. 2016). According to recent projections (Isaak et al. 2015), regional warming will reduce thermally suitable habitat by 2040 with the exception of high elevation refugia (e.g., headwater areas upstream of the North Fork Falls). These projections explain why the upper North Fork is now being considered as a future bull trout translocation/conservation area (Pierce et al. 2018).

Figure 18. The top photo shows Milltown dam prior to its removal 2008. The bottom taken at the same site in 2014.

Multi-scale Evaluation of Tributary Restoration – After two decades of active project implementation, eighteen individual stream restoration projects with long-term (>5 years) post restoration monitoring data (including several described above, Bear Creek, Chamberlain Creek, Kleinschmidt Creek, Nevada Spring Creek and Wasson Creek) were analyzed for fisheries response at a reach, sub-basin scale and basin scales (Pierce et al. 2013). Most of the streams (11) underwent comprehensive active channel restoration using NCD, which included changes to stream types (i.e., G to B, F to E, C to E). These changes led to a common pattern of deeper, narrower channel and more pool habitat, along with corresponding increases in trout abundance (Table 3, Figure 19). Though trout responses (native trout versus nonnative trout) varied by stream, results of these field studies clearly point to a common pattern of increased trout abundance once altered streams are returned to more natural conditions. Community richness also increased in certain streams and native trout responded best in the upper basin. In general, the abundance of age 1+ trout quickly approached reference conditions within 3 years of treatment once the underlying land management practices (dewatering and excessive grazing) were corrected (Figure 20). Compared to irrigation-based restoration techniques, streams that involved full channel reconstruction (e.g., Kleinschmidt Creek below) often required extended (>10 year) recovery periods. The study further concluded that consistent monitoring, landowner education and adaptive management of riparian grazing strategies was all critical for long-term sustainability on projects with active restoration. In fact, most active restoration projects (7 of 13) that included a grazing component required adjustments to riparian grazing to protect new projects from the return

Table 3. Summary of stream pre- and post-treatment habitat conditions associated with trends in trout response. For this table, "nd" refers to no data and "nc" refers to no change resulting from the treatment. Channel-type refers to Rosgen (1994) stream classification. Post-treatment water temperature refers to the maximum summer temperature recorded during the last monitoring year.

Stream name	Channel type		Width/Depth ratio		Sinuosity		% pool area		Max. summer temp (C)		Min. summer flow (m^3/s)	
	before	after	before	after	before	after	before	after	before	after	before	after
Bear Cr.	G	B	< 9	13.3	1.1	1.3	4	66	17	17	0.06	nc
Gold Cr.	B-C	B-C	20.3	nc	1.3	nc	1.5	13	17	nc	0.82	nc
Blanchard Cr.	C	C	nd	nc	nd	1.1	nd	12	nd	25	0	0.09
Cottonwood Cr.	C	C	19.5	nc	nd	nc	nd	nc	nd	20	0	0.22
Shanley Cr.	C	C	nd	nd	nd	nd	nd	nd	nd	16	0.09	nc
Chamberlain Cr.	C	C	nd	19.2	1.1	1.1	9	nd	nd	21	0.01	0.09
Pearson Cr.	B	B-E	variable		1.1	1.3	nd	nd	nd	nd	0	0.03
McCabe Cr.	G	B	3	9	1.2	1.3	nd	31	nd	13	0.11	0.22
Warren Cr.	F	E	>20	13.7	nd	1.3	nd	45	nd	nd	nd	nc
Jacobsen Spring Cr.	C	C	40	11	1.2	1.4	22	32	19	14	0.11	nc
Kleinschmidt Cr.	C	E	10.8	2.8	1.1	1.4	28	53	18	15	0.43	nc
Rock Cr.	C	E	55	6.2	1.1	1.7	3	15	21	15	0.82	nc
Murphy Spring Cr.	B	B	nd	16.7	nd	nc	nd	nc	nd	nd	0.01	0.09
Nevada Spring Cr.	C	E	22	3.2	1.4	1.7	51	71	25	18	0.17	0.28
Wasson Cr.	F	E	3	0.7	1	1.5	nd	nd	22	18	0	0.02
Poorman Cr.	C	C	nd	17.1	nd	nc	nd	nc	16	nc	0	0.09
Grantier Spring Cr.	C	C	19.7	14.6	1.2	2.3	nd	34	nd	13	0.28	0.37
Snowbank Cr.	C-B	C-B	nc	17.8	nc	1.2	nc	44	nd	13	0	0.11

of damaging riparian grazing practices. These adaptive management measures underscore the importance of a consistent long-term monitoring approach to restoration projects.

Figure 19. Before/after population estimates of age 1+ trout abundance (Trout/30m ± 95% CI) for 18 treatment streams surveyed between 1989 and 2010 (untransformed data from Pierce et al. 2013). The dark bars represent native trout and light bars represent nonnative trout. The light vertical arrow point to the pretreatment estimates, and the dark arrows point to the treatment year.

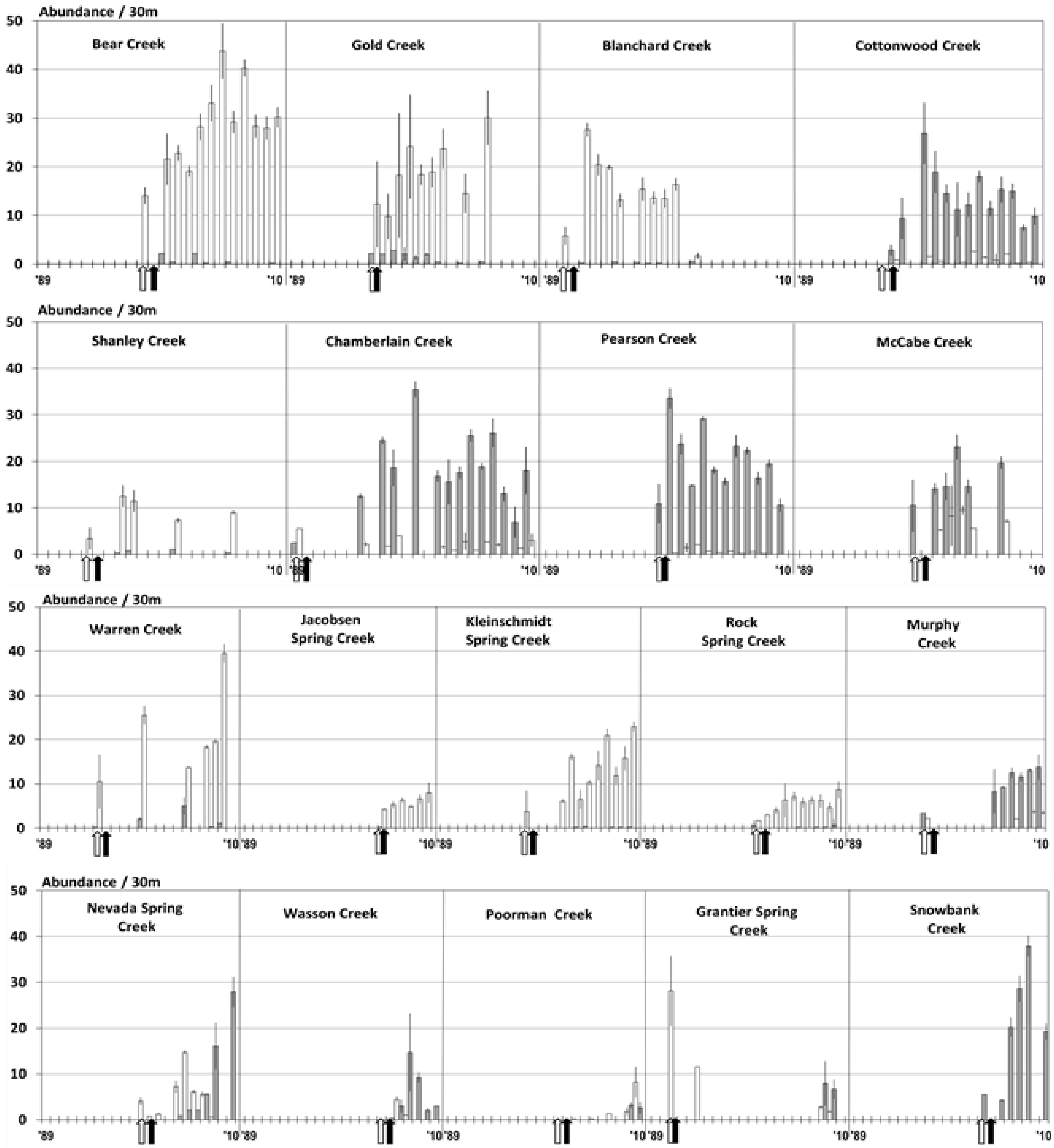
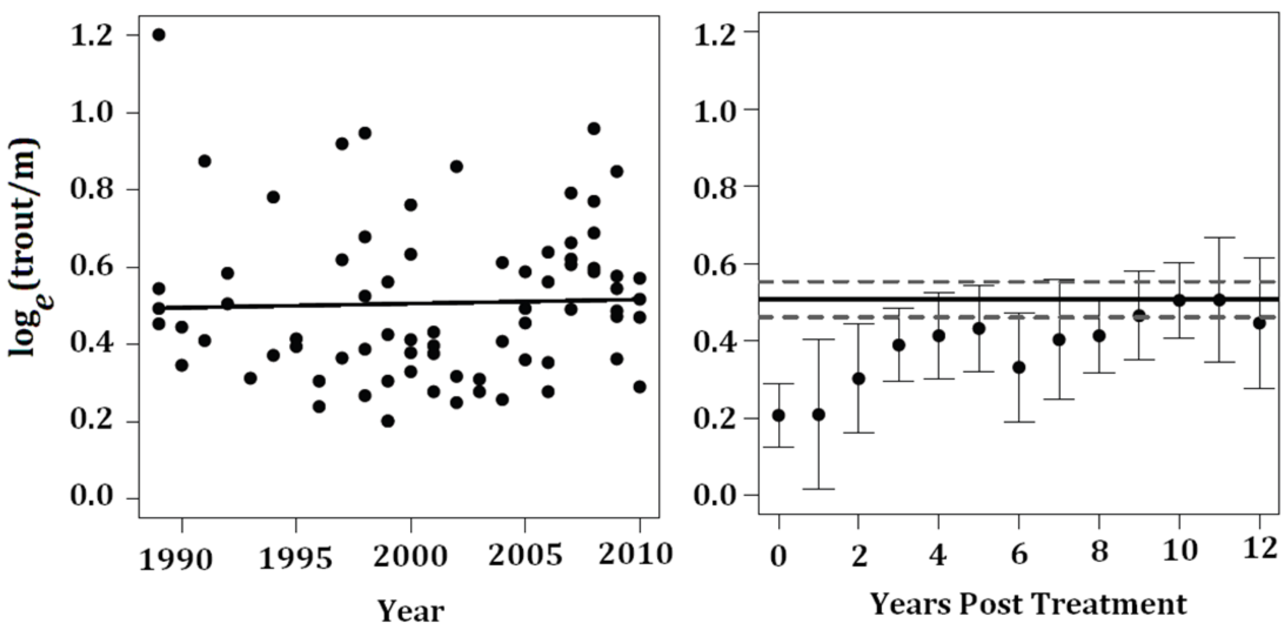
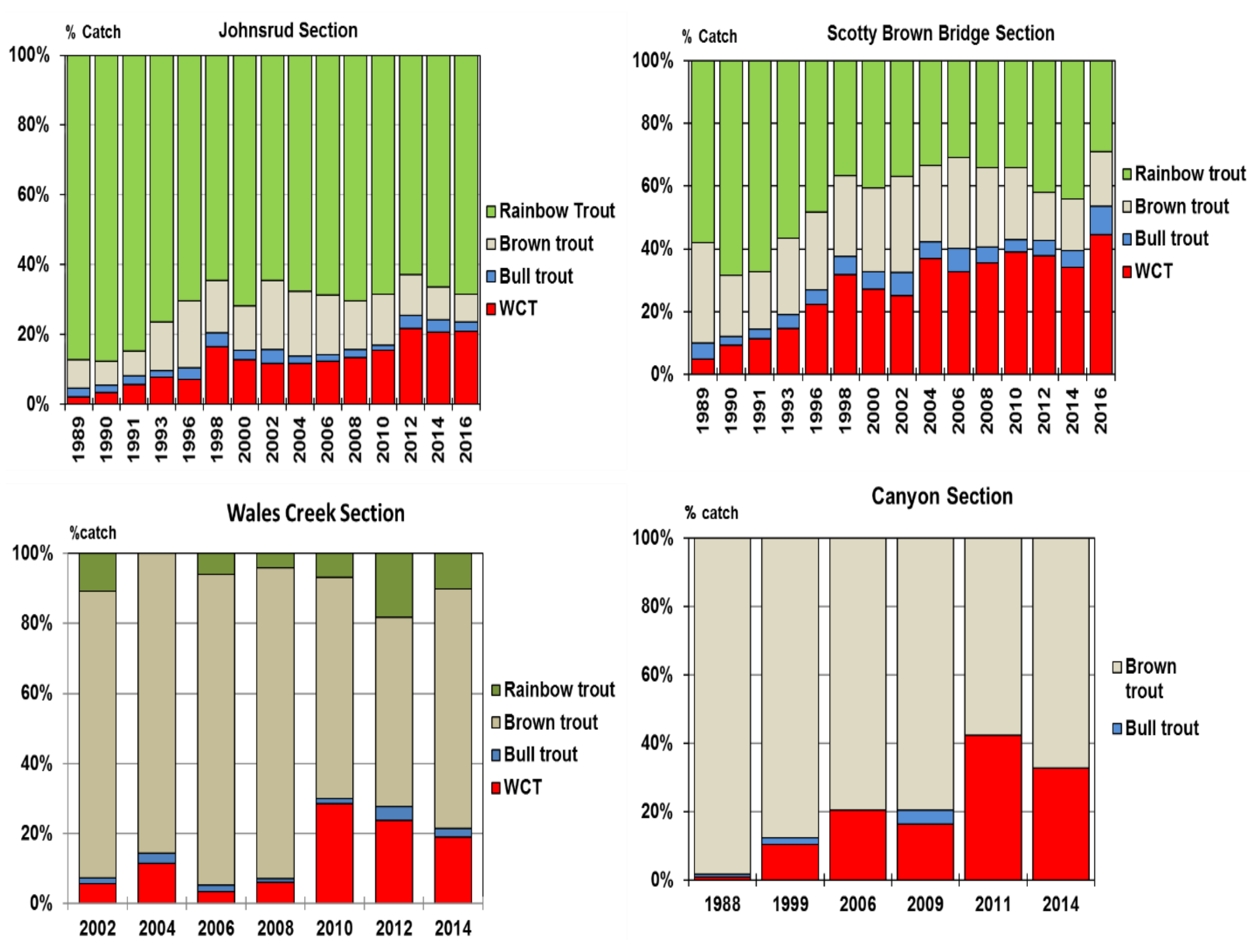


Figure 20**.** The left figure shows estimates of total trout abundance at reference sites by calendar year. Linear regression analysis indicates a long-term stable trend with a slope not significantly different from zero during the study period (slope=0.0001, *P*=0.59). The graphs on the right shows average total trout abundance by years post-treatment. The solid black line represents the grand average of total trout abundance for all monitoring observations in reference sites. Gray dashed lines represent the 95% confidence interval around the reference average. Note: this grand average incorporates both year-to-year and stream-to-stream variation in the reference dataset.



Blackfoot River: Trout Species Composition at Four Long-term Monitoring Sites – Population abundance and the composition of trout communities vary by river reach. In addition, year-to-year variability can be high depending on natural conditions (e.g., drought conditions, temperature extremes) and human effects (e.g., whirling disease, degradation and restoration). To summarize response during the 30-year restoration period, the percent species composition was calculated for four river reaches where population monitoring data predates regulation changes in 1990 and the restoration period (Figure 1). These data show consistent long-term community-level changes that favor westslope cutthroat trout beginning with regulations changes in 1990 (Figure 21). These data along with special research studies (e.g., telemetry) and restoration case studies all reveal that multiple management strategies (basin scale protective regulations and multi-scale restoration) are necessary to improve the status of Blackfoot River native trout.

Figure 21. Percent trout species composition for four reaches of Blackfoot River, 1989-2016. The graphs show the changing composition of the trout community. Long-term monitoring shows a river wide in westslope cutthroat trout metapopulation. Monitoring site locations are shown on Figure 1.



Summary

The Blackfoot restoration methodology represents a compelling 30-year case study of progressive river restoration and landscape conservation. The river project began when fisheries field work revealed that riparian and aquatic habitat restoration were necessary to restore productive trout streams. With goals of improving both tributary recruitment to the Blackfoot River and the status of native trout, restoration gained momentum during the 1990s. Expanded data collections included longitudinal fish population surveys, continuous habitat surveys, assessments of geomorphic stream types, sediment, temperature, water quality and flow data, all of which were used help identify limiting factors. With special attention to spawning and rearing areas and movement corridors, fish and habitat field data helped to prioritize high, moderate and low priorities and so provided strategies to help guide restoration to important habitats used by migratory native trout and other fishes of the Blackfoot River. Once selected for restoration, reference reach data helped to compare (quantify) human impairments against functional natural stream conditions, and so provided templates for natural channel design, as well as a basis for fund-raising, permitting, and post-treatment monitoring and evaluation. Long-term case studies reveal deeper, narrower, colder streams with lower instream sediment levels and improved habitat connectivity. These conditions preceded various forms of population expansion including recolonization, the reestablishment of migratory life history expression, increases in abundance and biomass as well as a community-level shift towards westslope cutthroat trout in the Blackfoot River. Though fish populations have clearly improved, riparian restoration provide essential habitat for a myriad of riparian-dependent wildlife species as well.

Within the biological framework described in this report, engaging stakeholders directly with fisheries field information and coordinating projects with the Big Blackfoot Chapter of Trout Unlimited proved essential to the entire restoration process, especially with respect to private land. From this perspective, Trout Unlimited and other watershed groups have become better established, more effective and more inclusive. In other words, the social framework that helped to enable the first 30 years of the Blackfoot River restoration program has proven very effective as well.

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