United States Department of Agriculture
Natural Resources Conservation Service

CEAP Conservation Insight
Conservation Effects Assessment Project
April 2011

Conservation Practices Benefit Western Native Trout

Summary Findings

Over the past century, stream habitat degradation has resulted in salmonid declines across the American West.

The response of wild trout to stream improvement efforts from 1989 to 2009 was examined primarily on private ranchlands in the Blackfoot River Basin, Montana. Population densities were estimated to examine the response of native and non-native trout to conservation practices on 17 streams.

Three years after restoration treatment, total trout density increased 59 percent from pre-treatment conditions and approached that of relatively undisturbed reference streams. Improvements in most streams were followed by increasing and sustained trends in total trout density, although individual stream population responses varied between native and non-native species and among treatment sites based on environmental and human use factors.

Stream restoration efforts have resulted in the expansion of native fish populations across several tributaries and within the main stem of the lower Blackfoot River.

Management Insights

Effective stream restoration can be achieved through a landscape approach to river conservation and scientific evaluation to determine the sources of and solutions to population declines.

Community-based collaborative stream restoration efforts can lead to sustained project success.

Ecologically-based grazing systems based on native trout habitat requirements are important.

Long-term monitoring of the condition of stream systems and aquatic biota can support ongoing project evaluation and adaptive management of conservation strategies.

Background

Coldwater streams across the American West once supported a diversity of native salmonids. Landscape degradation caused by mining, timber extraction, stream channelization, dams, intensive riparian grazing and surface water diversions, overfishing, and introduction of exotic species, however, has reduced native stocks to imperiled status. In response, various public (State, tribal and Federal) agencies and private (conservation and industry) organizations have developed strategies to help recover, better manage, and protect native salmonid populations across western landscapes.

While stream restoration work has expanded in recent years, efforts to monitor and evaluate biological response to restoration have been limited, resulting in lack of data to inform new restoration work or effective adaptive management of restored systems (Roni et al. 2008). Of stream improvement projects that have been evaluated, many report successful population increases in stream-dwelling salmonids. Yet most of these projects focus on artificial habitat enhancement measures installed in isolation of landscape-scale processes and ecological conditions. Few studies describe the influence of small-scale projects across larger watersheds, identify community-level shifts in species composition, or test the effectiveness of stream improvements on private ranchlands (Reeve et al. 2006, Roni et al. 2008).

In the Blackfoot River Basin of western Montana, a collaborative effort of river restoration has been underway for the past 20 years, based on a strategy of scientific assessment coupled with voluntary community involvement (Blackfoot Challenge 2009, Pierce et al. 2005). Fisheries biologists and other natural resource specialists, conservation organizations, and private landowners are working collaboratively to improve coldwater environments and recover depleted populations of two native inland salmonids (westslope cutthroat trout [fig. 1] and bull trout, a federally listed threatened species). These native species occur in a river environment dominated by non-native salmonids and a watershed degraded by historic land use practices.

Montana Fish, Wildlife and Parks (MFWP) biologists and others conducted extensive biological monitoring of restored and reference stream reaches between 1989 and 2009. To help assess the overall effectiveness of reach-scale stream restoration practices this study

Figure 1. Westslope cutthroat trout

Ron Pierce

examines the response of wild trout, with emphasis on native trout, to stream improvements conducted on small tributaries in the Blackfoot Basin between 1989 and 2009. Through a contribution agreement between NRCS and the Blackfoot Challenge, the Conservation Effects Assessment Project (CEAP) supported a comprehensive analysis of 20 years of biological monitoring data, led by MFWP. This CEAP conservation insight summarizes findings from this analysis.

Specific assessment objectives were to—

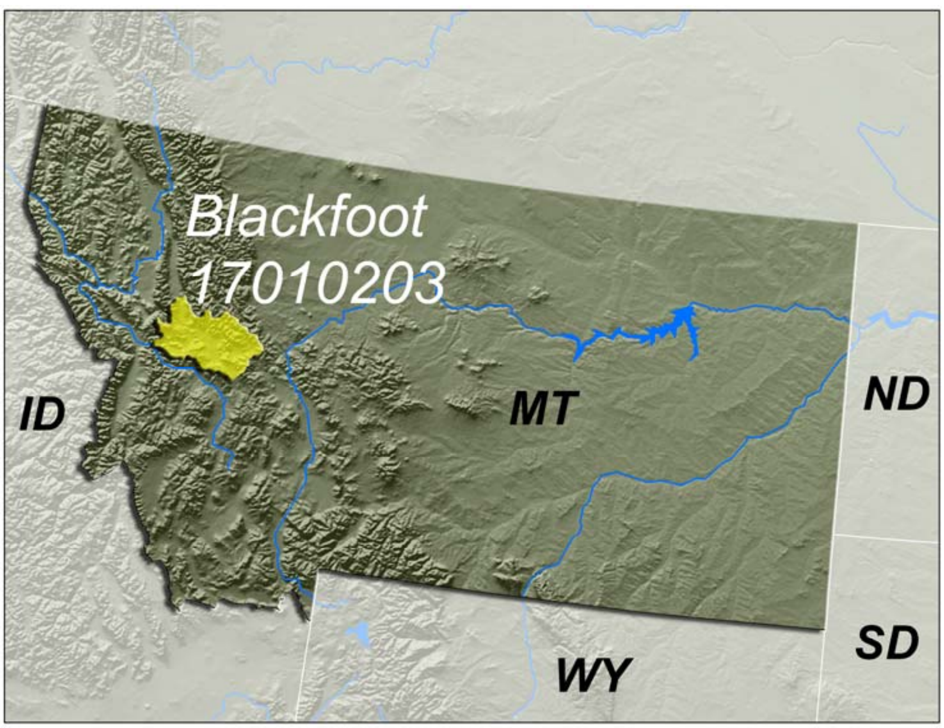
- identify reach-scale changes in total trout abundance on 17 restoration treatment streams,
- assess trends in native and non-native trout abundance in restored stream reaches,
- review the efficacy of reach-scale strategies and the influence of such projects on the recovery of fluvial native trout in the Blackfoot River Basin, and
- provide future management direction to improve restoration strategies as well as broad guidance for stakeholders working in similar community-based river conservation projects.

Assessment Area

The Blackfoot River is a free-flowing, fifth-order tributary of the upper Columbia River in west-central Montana (fig. 2). The watershed contains high-elevation glaciated peaks and alpine meadows, mid-elevation boreal and montane forests, and semi-arid prairie-pothole and glacio-alluvial plains. Streams range from steep, small and heavily rock-armored headwater areas to low-gradient alluvial channels on the valley floor. Landownership is primarily public and industrial forestlands at higher and mid-elevations; the foothills and valley floor are dominated by private ranchlands. Traditional land uses in the basin include mining, timber production, cattle ranching, irrigated hay production, and recreation.

Species composition, distribution, and life histories of trout vary greatly within the Blackfoot Basin. Two native salmonids and three naturalized non-native species occupy various stream environments within the basin (table 1). As in other watersheds across the Intermountain West, naturalized non-native rainbow trout and brown trout occupy the lower elevations of the basin where they dominate the main stem of the Blackfoot River and lower reaches of most tributaries. Non-native brook trout typically occupy the lower reaches of small tributary streams but are rarely found within the lower river or steeper headwater areas. Conversely, native salmonids are present basin-wide and tend to dominate mid-to-upper stream reaches, but occupy the mainstem Blackfoot River in relatively low abundance. Life histories of native westslope cutthroat trout and bull trout include both stream-resident and migratory (fluvial) traits. Stream-resident westslope cutthroat trout are generally small, locally abundant, and widespread within smaller tributaries where they spend their entire lives. Fluvial westslope cutthroat trout are less common, wide-ranging, and capable of reaching much larger adult sizes. They occupy the entire Blackfoot River but rely on interconnected tributaries for spawning, rearing, and migration. Similarly, fluvial bull trout are wide-ranging across the larger, colder streams. Bull trout spawn in discrete upwelling areas, rear and seek refuge in cold tributaries during the heat of summer, and occupy the larger, more productive river environments for wintering, foraging, and migration.

Figure 2. Location of the Blackfoot River Basin in Montana



Stream Restoration Efforts

Stream restoration projects were identified through thorough assessment of tributary fish populations, habitat conditions, and related detrimental land uses (e.g., overgrazing, unscreened irrigation diversions, and dewatering) that relate to treatable human-induced limiting factors (Pierce et al. 1997, 2005). Project feasibility was then determined based on native fisheries values, importance of the fish population to the Blackfoot River, and assessments of landowner interest in stream improvements.

Stream restoration efforts were intended to return degraded streams to a geomorphically stable and natural state capable of maintaining habitat-forming processes (fig. 3). This typically involved renaturalizing severely damaged channels; instream placement of habitat structures (wood and rock); planting native vegetation to provide filtration, shade, and channel stability (Hansen et al. 1995); enhancing instream flows through formal water leases or voluntary measures; and modifying irrigation diversions with fish ladders in movement corridors and/or screening irrigation ditches to prevent losses of migratory native fish (Pierce et al. 1997, 2008). While not all stream restoration projects included USDA cost-share or technical assistance, all involved actions equivalent to use of one or more NRCS conservation practices (e.g., Fish Passage [Practice Code 396], Prescribed Grazing [528], Riparian Herbaceous Cover [390], and Stream Habitat Improvement and Management [395]). Multiple restoration actions were taken to correct the limiting factors (table 2). Adapting management in the study area proved necessary in many streams, including correcting design or maintenance deficiencies with fish ladders or fish screens on six streams, correcting grazing deficiencies on seven streams, and reconstructing segments of two streams.

Due to the complexity of stream restoration solutions, numerous partners were involved in delivery of restoration work. In addition to private landowners, primary cooperators were conservation groups (Big Blackfoot Chapter of Trout Unlimited, Blackfoot Challenge, The Nature Conservancy), State and Federal agencies (MFWP, U.S. Fish and Wildlife Service, NRCS, U.S. Forest Service), and others (Pierce et al. 2008).

Assessment Approach

To determine the influence of small stream (reach-scale) improvement efforts, investigators compiled fish population monitoring data on 17 treatment (restored) and 18 reference sites periodically surveyed between 1989 and 2009 (fig. 4). Standard backpack electrofishing surveys were conducted directly within stream improvement project areas. Reference reaches of unaltered low-elevation streams where fish populations were relatively unaffected by human activities were also surveyed. All treatment sites used in this analysis had at least one year of pre-project fish population data immediately preceding treatment work and a minimum of five and up to 20 years of post-treatment population monitoring data.

Table 1. Blackfoot River Basin salmonids

	Life history traits		General basin distribution			
Species	Stream resident	Migratory (fluvial)	Mainstem Blackfoot River	Lower tributary reaches	Middle tributary reaches	Upper tributary reaches
Native						
West slope cutthroat trout (*Oncorhynchus clarki lewisi*)	X	X	X	X	X	X
Bull trout* (*Salvelinus confluentus*)	X	X	X	X	X	x
Non-native						
Rainbow trout (*Oncorhynchus mykiss*)	X	X	X	X		
Brown trout (*Salmo trutta*)	X	X	X	X		
Brook trout (*Salvelinus fontinalis*)	X			x	X	x

*Listed as Threatened under the Federal Endangered Species Act

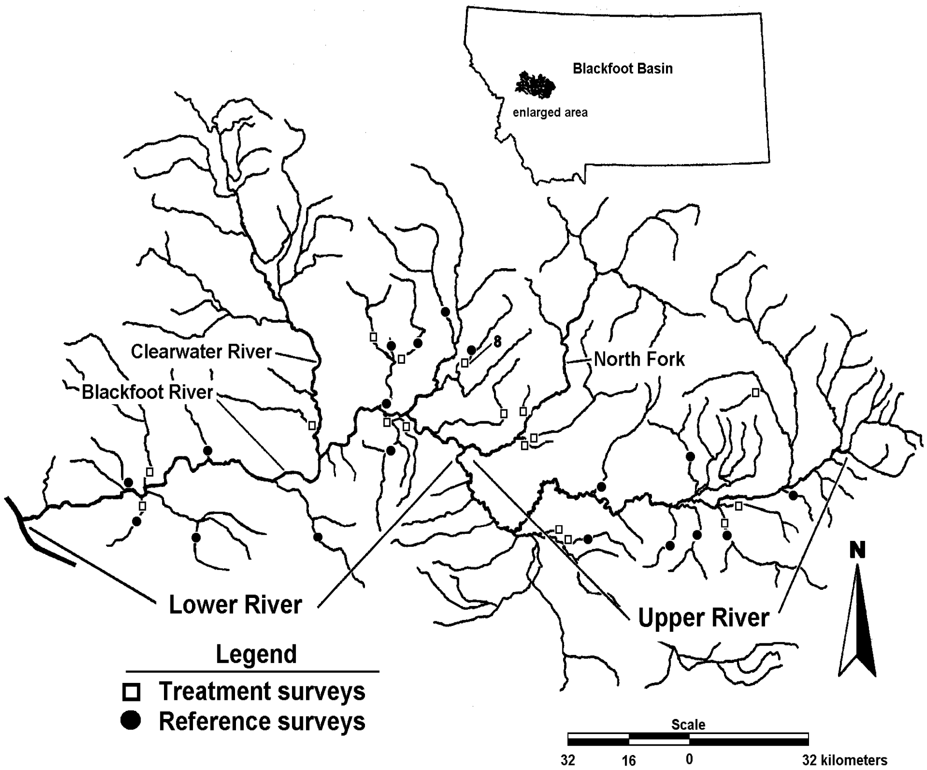
Figure 3. Nevada Spring Creek before (left) and after (right) restoration

Ron Pierce (both)

Table 2. Restoration treatments applied in 17 stream reaches in the Blackfoot River Basin, Montana. Most streams received more than one type of restoration treatment.

Restoration treatment	Number of streams
Riparian grazing changes	14
In-stream flow enhancement	12
In-stream habitat structures	9
Channel reconstruction	7
Fish ladders or screens in irrigation diversions	6

Figure 4. Locations of fish population monitoring surveys on restored (Treatment) and Reference stream reaches in the Blackfoot River Basin, Montana.



To identify temporal response of wild trout populations for individual streams, density estimates were log-transformed using the natural log function, and linear and nonlinear regression analyses were performed for native, non-native, and total trout density estimates on individual streams from pre-treatment through post-treatment monitoring periods. Akaike Information Criteria (AIC) model selection was used to correct for small sample sizes and to determine which model best explained changes in trout abundance post-treatment in each stream (Akaike 1974).

To analyze overall trends, individual stream population density estimates were combined into a hierarchical matrix that averaged native, non-native, and total trout densities across all streams at three-year intervals. To identify the response of native and non-native trout groups across all streams, linear and nonlinear regressions were performed with AIC model selection to determine the best-fit model for each group.

Basin-wide Restoration Response

One-year-old and older salmonids increased in all categories (native, non-native, and total trout) following restoration treatment. As a group, total trout densities increased an average of 59 percent above pre-treatment conditions 3 years after restoration, at which point total densities were not statistically different from reference streams. Total trout densities continued to increase for up to 6 years post-treatment before stabi-

Figure 5. Mean total trout abundance in restored (black dots) and reference sites (red line), +/- 1.96 standard error

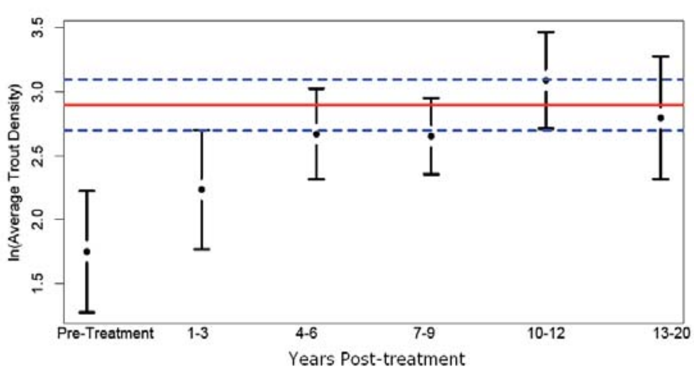


Figure 6. Mean native and non-native trout densities before and at 3-year intervals after restoration. Both groups were best-fit by non-linear asymptotic regression models explaining over 90 percent of the observed variation. Error bars represent +/- 1.96 standard error, indicating that native and non-native trout abundances are not significantly different from one another when measured across all restored streams.

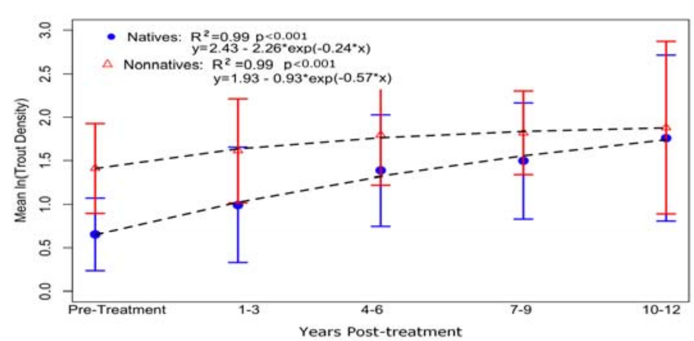


Figure 7. Examples of statistically significant increases in total trout density post restoration. Fish densities in Cottonwood Creek (left) were best-fit by a non-linear asymptotic regression model where fish densities substantially increased and then stabilized about 5 years post-treatment. Trout densities in Nevada Spring Creek (right) are best-fit by a linear regression model where trout densities continue to increase 8 years post-treatment

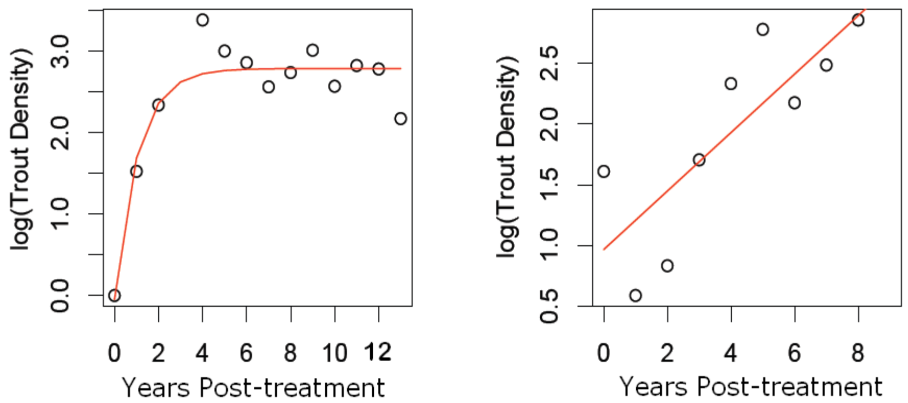
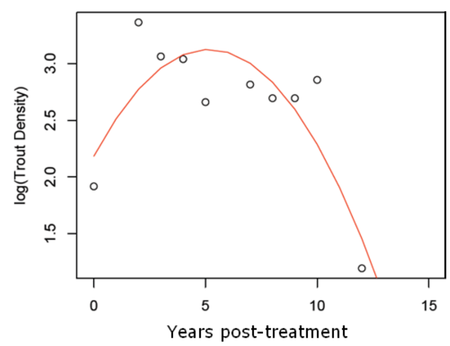


Figure 8. Blanchard Creek was best-fit by a nonlinear quadratic regression model. Here, trout densities substantially increased following stream improvements and then decreased below pre-treatment conditions following reintroduction of stream degrading land management practices.



lizing near reference stream densities (fig. 5). Likewise, native and non-native trout showed significant increasing trends in population density. Similar to total trout densities, native and non-native trout densities increased substantially the first 6 years post-treatment and remained stable-to-increasing at 12 years post-treatment (fig. 6).

Stream-scale Restoration Response

Individually, restored stream reaches varied in trout population response. Of the 17 treatment streams, 10 showed statistically significant increases in total trout densities. Of these, densities in four streams stabilized 5 to 10 years post-treatment, represented by significant nonlinear asymptotic regression models (fig. 7). In three streams, densities continued to increase 5 to 13 years post-treatment, represented by linear regression models. Three of the 10 streams initially displayed significant increases in trout densities that then declined 5 to 10 years post-treatment, largely in response to whirling disease escalation and prolonged drought (Pierce et al. 2008, 2009). Of these, only one (Blanchard Creek) fell below pre-treatment densities, after reintroduction of overgrazing practices (fig. 8). While not statistically significant, an additional six streams showed substantial increases in post-treatment total trout densities. Typically, restoration projects supported increases in the trout species that were dominant prior to treatment.

Within the Rocky Mountain region of the American West, non-native trout species are often limited to the lower elevations (Paul and Post 2001). This pattern was seen in the Blackfoot Basin where stream improvement projects in the low elevations and bottomlands generally favored predominantly non-native species (i.e., rainbow and brown trout), and projects in the foothills and mountains of the mid-to-upper basin generally favored native westslope cutthroat trout.

Of those streams with significant increases in total trout densities, three streams displayed significant increases in non-native trout densities, whereas five streams had significant increases in native trout densities. Of the 17 streams, only two displayed substantial increases in both native and non-native trout densities, although this trend was not significant for non-native trout in one of these streams.

Water Temperature Response

A critical component to bull trout persistence is its reliance on cold thermal habitats (USFWS 2002, Rieman et al. 2007). Although several stream improvement projects resulted in bull trout expansion, restoration work on Kleinschmidt Creek significantly reduced water temperature entering the North Fork Blackfoot River—a stream designated as critical bull trout habitat (USFWS 2010). Following complete reconstruction, the wetted surface area of Kleinschmidt Creek declined 56 percent and maximum water temperatures declined from 21°C to 14°C (Pierce et al. 2002, 2006) to the optimal range for both westslope cutthroat trout and bull trout. Thus, cold water from Kleinschmidt Creek has the potential to exert a substantial cooling effect on receiving waters of the Blackfoot River. This form of restoration-induced cooling of spring creeks on the floor of the Blackfoot Valley may ultimately prove necessary to buffer low-elevation bull trout streams from projected loss of thermal habitat driven by climate warming (Rieman et al. 2007).

Native Fluvial Trout

Radio telemetry studies on bull trout and westslope cutthroat trout indicate that fluvial fish spawn and rear in tributary streams but spend much of their adult lives in the main stem of the Blackfoot River. Migrations of over 60 miles from the Blackfoot River to headwater tributaries during high flows for spawning are common. In addition to good aquatic habitat quality, open migration corridors are critical to the recovery and persistence of these migratory native trout. Therefore, re-establishing native trout migration corridors was targeted on eight streams.

Whereas most projects targeted small segments of streams, restoration work on Chamberlain Creek directly influenced migratory westslope cutthroat trout by targeting multiple limiting factors, including those affecting fish movement. Before treatment, Chamberlain Creek had been identified as potential spawning habitat for fluvial westslope cutthroat trout, but channel degradation in the lower reaches made habitat unsuitable and precluded the migratory connection between upstream high-quality habitats and the Blackfoot River (Peters 1990). Screening irrigation ditches (fig. 9), installing a fish ladder, enhancing flows, reconstructing altered channels, and removing livestock from the riparian area increased densities of westslope cutthroat trout above pre-treatment levels throughout the project reach and re-established full migratory connectivity with the Blackfoot River (Pierce et al. 1997). Following stream improvements, a majority of fluvial westslope cutthroat trout spawners radio-tagged in the middle Blackfoot River ascended the treatment reach of Chamberlain Creek to access upstream spawning areas (Schmetterling 2001), thereby restoring Chamberlain Creek as a primary spawning tributary for migratory westslope cutthroat trout in the basin.

While some reach-scale projects have clearly improved environmental conditions for migratory trout, others express limited spatial influence beyond the footprint of the project due to nearby human actions that continue to degrade aquatic environments. Furthermore, some projects that registered gains in trout abundance after restoration subsequently experienced declines due to unsuccessful implementation of land management plans. These factors illustrate the need to consider offsite influences and long-term management of restoration projects to ensure success.

Community-level Shifts

Several streams showed recolonization or community-level shifts from non-native to native trout species. Bull trout, for example, recolonized segments of four small tributaries from adjacent spawning areas once fish passage and instream flows were re-established (Pierce et al. 2008). While this recolonization was gradual in three of these streams, recolonization of upstream segments in one (Snowbank Creek) was rapid and included multiple-year classes, resulting in bull trout reproduction within 4 years.

Westslope cutthroat trout expansion was seen in two spring creeks (Grantier Spring Creek and Nevada Spring Creek) where they were largely absent before treatment. In pre-treatment Nevada Spring Creek, westslope cutthroat trout were incidental and brown trout were dominant; however, after improving stream conditions in the lower 4.2 km of Wasson Creek, westslope cutthroat trout expanded downstream into Nevada Spring Creek where they became dominant (Pierce et al. 2008). In the case of Grantier Spring Creek, early surveys in 1990 and 1994 identified brook trout and brown trout as the only salmonids present; conversely, both non-native species were scarce 15 years after channel reconstruction and westslope cutthroat trout were predominant. Despite a significant decline in total trout density, the recolonization of westslope cutthroat trout, including large adults, elevated total trout biomass above pre-treatment levels. Spawning surveys completed in Grantier Spring Creek identified westslope cutthroat trout redds in 2009, and subsequent surveys found fry throughout Spring Creek, indicative of successful reproduction. These finding suggest that restoration can clearly improve native fish populations without removing non-native species.

At a broader spatial scale, a 20-year upward trend in native trout densities has developed in the lower Blackfoot River, which includes a modest community-level shift from about 5 percent native fish in 1989 to about 30 percent native fish in 2008 (Peters 1990, Pierce et al. 2008). This contrasts with the greater non-native trout response seen in some low-elevation tributary streams. Native trout appear to be increasing in the lower Blackfoot River due to (1) the wider distribution of native fish and migratory life history tactics of the many interconnected stocks using the larger river system; (2) no-harvest angling regulations for native fish versus allowable harvest of non-native trout; (3) other fisheries improvements such as screening native fish from irrigation ditches in critical migration corridors in larger tributaries such as the North Fork (Pierce et al. 1997, 2008); and (4) life history strategies (i.e., spawning and rearing in headwaters) that tend to buffer both bull trout and westslope cutthroat trout from the low-elevation presence of whirling disease (Pierce et al. 2009).

Conversely, wild trout in the upper Blackfoot River have yet to respond to limited stream improvements, and in some cases main stem river populations (e.g., westslope cutthroat trout) continue to decline (Pierce et al. 2008). This lack

Figure 9. Fish screen installed to keep fish out of irrigation ditches

Ron Pierce

of response relates to environmental challenges beyond physical habitat problems, including the influence of heavy metal contamination from past mining activity. Broad land-use impacts occur across most tributaries in the upper Blackfoot Basin, and recent small-scale stream improvements, although successful, have yet to influence population trends in the upper Blackfoot River (Pierce et al. 2007, 2008).

Management Challenges

After a century of damaging land-use practices, the Blackfoot River restoration partnership represents a progressive 20-year effort of cooperative stream improvements among diverse stakeholders (Pierce et al. 2008, BBCTU 2010). Funding has expanded to support stream improvements yet remains inadequate to address ongoing instream flow challenges. Long-term fisheries surveys, public outreach and watershed group coordination have helped meet technical and public education needs. Technical advances have improved implementation of practices related to stream renaturalization, fish ladders, and fish screens and irrigation diversions. Finally, the geographic scale of river restoration is now expanding to the upper Blackfoot and Clearwater River subbasins. Yet as the scale and complexity of stream improvements continue to expand, the Blackfoot River restoration endeavor has developed certain growth-related challenges. Like elsewhere across the Pacific Northwest (Roni 2005, Reeve et al. 2006), monitoring and project evaluations are poorly supported and applied piecemeal; consequently, the ability to identify and correct fisheries-related problems through adaptive management has become progressively inconsistent and secondary to project development.

Implementation of riparian grazing practices seems to present exceptional aquatic community restoration challenges. Where successfully applied, ecologically based riparian grazing systems incorporate site potential, streambank conditions, vegetation response, and riparian healing processes as well as the sensitivity of target salmonid species to disturbance. In the Blackfoot Valley, the susceptibility of streambanks to grazing disturbance tends to increase longitudinally (i.e., down-valley) as stream channels transition from rock-armored to more fine-grained alluvial channel types. Similarly, saturated upwelling areas and spring creeks located on the valley floor are highly susceptible to hoof-shear and streambank trampling compared to seasonally dry (or frozen) streambanks.

The sensitivity of salmonids to riparian disturbance varies among species and life stages. Native bull trout are particularly vulnerable to elevated sediment during embryonic and juvenile life-stages and sensitive to elevated water temperatures at all life stages. Successful grazing across environmental gradients therefore depends on the development of site-specific management targets and commitments among cooperators to effectively monitor, identify, and respond to small problems before livestock degradation becomes excessive. Furthermore, the passive recovery of "soft" channel reconstruction projects, as employed in the Blackfoot Basin, often requires years of vegetation regrowth to recover from past land-use practices. With the exception of livestock exclusion however, ecologically-based grazing systems are inherently complex and challenging to apply successfully without intensive monitoring and a willingness to adjust management.

Recommendations

Insights from this study have yielded the following recommendations for maximizing the effectiveness of stream restoration for native salmonids:

- Ensure that stream improvements address the cause of impairment and are compatible with the central tendency of river channels.

- Improve project goal statements and ensure that each project objective is specific, measurable, achievable, and relevant to local fisheries resource conditions to ensure that projects are resource based and that scientifically sound monitoring protocols are possible.

- Develop and adopt ecologically based methodologies for implementing grazing systems based on site-specific conditions. Develop local criteria for streambank damage and riparian health specific to native trout habitat requirements.

- In the absence of suitable performance guidelines, implement grazing management and monitoring plans that allow for corrections and modifications in management using grazing triggers of <10 percent streambank damage for alluvial channels supporting native cutthroat trout and bull trout. Also, specify limits of utilization of woody riparian vegetation that provides for the habitat needs of native fish.

- Continue to monitor fish populations on reach-scale projects and expand monitoring of land management plans.

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The Conservation Effects Assessment Project: Translating Science into Practice

The Conservation Effects Assessment Project (CEAP) is a multi-agency effort to build the science base for conservation. Project findings will help to guide USDA conservation policy and program development and help farmers and ranchers make informed conservation choices.

One of CEAP's objectives is to quantify the environmental benefits of conservation practices for reporting at the national and regional levels. Because fish and wildlife are affected by conservation actions taken on a variety of landscapes, the wildlife national assessment draws on and complements the national assessments for cropland, wetlands, and grazing lands. The wildlife national assessment works through numerous partnerships to support relevant studies and focuses on regional scientific priorities.

This assessment was conducted through a partnership among NRCS, the Blackfoot Challenge, and Montana Fish, Wildlife and Parks (MFWP). Primary investigators on this project were Ron Pierce and Craig Podner (MFWP), with assistance from Kellie Carim (University of Montana).

For more information: www.nrcs.usda.gov/technical/NRI/ceap/