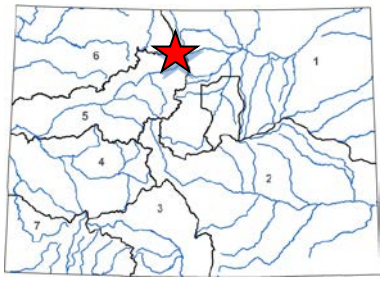
COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Ecosystem Restoration of Select Sites in the Kawuneeche Valley
Northern Colorado Water Conservancy District
January 2021 Board Meeting

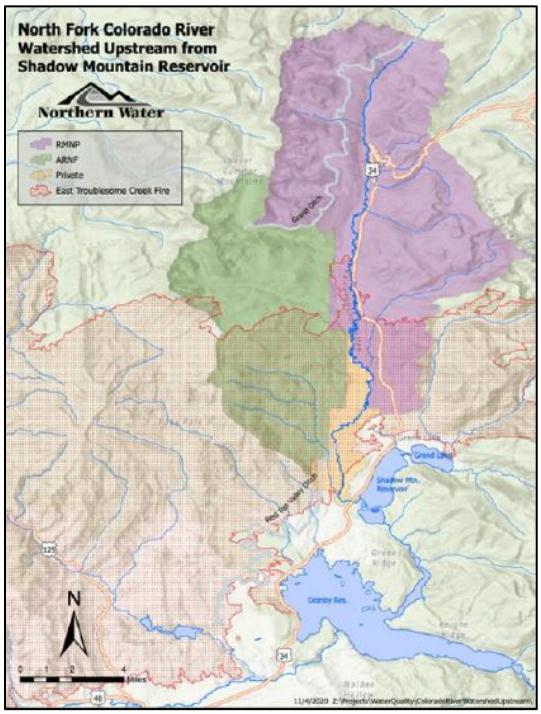
Colorado Watershed Restoration Program Application



LOCATION	
County/Counties:	Grand
Drainage Basin:	Colorado

DETAILS	
Total Project Cost:	$211,595
Colorado Watershed Restoration Program Request:	$105,444
Recommended amount:	$73,550
Other CWCB Funding:	$0
Other Funding Amount:	$61,151 secured
Applicant Match:	$45,000 secured
Project Type(s): Watershed Restoration	
Project Category(Categories): Watershed/Stream Restoration	
Measurable Result: Changes in surface and groundwater levels, sediment accumulation and transport, channel dimensions, and riparian plant communities	

This watershed health restoration project develops a long-term collaborative effort by the Kawuneeche Valley Ecosystem Restoration Collaborative to work cooperatively with other stakeholders to functionally restore riverine ecosystems of the Kawuneeche Valley. Watershed-scale restoration of the stream network will reduce erosion and stabilize eroding channels, improve channel and floodplain connectivity, re-establish riparian and wetland vegetation, and enhance riparian and terrestrial habitats. Members of the Collaborative and local residents recognize excessive sediment and nutrient inputs to Shadow Mountain Reservoir (SMR) from the North Fork of the Colorado River, which, if left unaddressed, could impair the functioning of critical water supply infrastructure. Sediment and nutrient inputs to SMR will likely increase in the future due to the East Troublesome Fire.



While certain problem areas within Rocky Mountain National Park (RMNP) have been documented, conditions elsewhere in the watershed are largely unknown, particularly within the burned area. There is broad agreement on the need for watershed-scale channel and riparian restoration, but the specific locations for interventions and the most appropriate restoration approaches have not been identified. Furthermore, stakeholder and community perspectives on current conditions, desired future conditions, and acceptability of various interventions are not yet known.

This proposed project involves (1) science-based assessments of environmental conditions and stakeholder/community perspectives, (2) analysis of post-wildfire risks in the burned, (3) data-driven feasibility analyses to evaluate the suitability of restoration approaches, and (4) a process to objectively identify and prioritize restoration sites. This restoration planning and feasibility project will provide the required information for watershed-scale channel and riparian restoration that meets stakeholder goals. Subsequent phases of this long-term collaborative effort will include implementation of restoration measures, monitoring and evaluation, and adaptive planning and management.

The budget identifies a 52% overhead charge from Colorado State University (CSU). The CWCB has negotiated an overhead charge with CSU of 15%, and they do honor this for the CWCB grantees. This amounts to a cost savings of $21,894.

The budget also identifies $10,000 for short-term fire recovery needs related to the East Troublesome fire. CWCB staff anticipates a dedicated funding source for 2020 fire recovery projects. The anticipated timeline for this funding source is March-April 2021, however it is pending approval from the General Assembly.

The recommended funding amount reflects deductions for the cost savings from CSU overhead and the removal of the $10,000 fire recovery request.

CWCB COLORADO WATERSHED RESTORATION PROGRAM
GRANT APPLICATION

Ecosystem Restoration of Select Sites in the Kawuneeche Valley

Submitted by:
Northern Colorado Water Conservancy District

On behalf of The Kawuneeche Valley Ecosystem Restoration Collaborative:
National Park Service (RMNP), US Forest Service (USFS), Grand County, Town of Grand Lake, Bureau of Reclamation (Reclamation), Northern Colorado Water Conservancy District (Northern Water), Colorado River Water Conservancy District (CRWCD), The Nature Conservancy (TNC)

NOVEMBER 5, 2020

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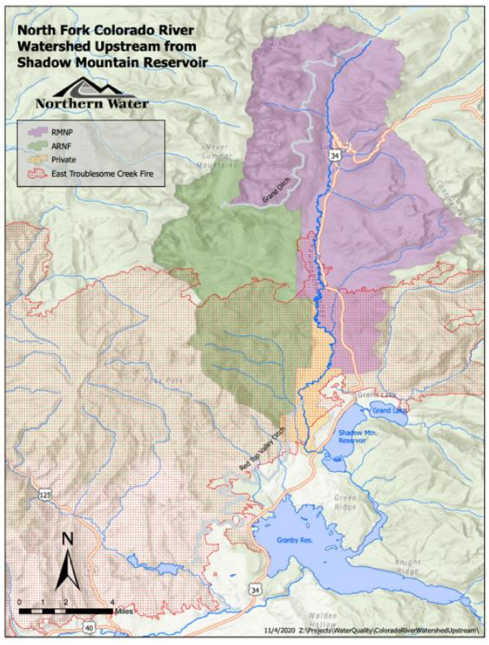
PROJECT PROPOSAL SUMMARY

Project Title:	Ecosystem Restoration of Select Sites in the Kawuneeche Valley
Project Location:	North Fork Colorado River watershed (see map below & attached)
Grant Type:	Watershed/Stream Restoration Grant
Grant Request/Amount:	$105,444.00
Cash Match Funding:	$106,151.00
Project Sponsor:	Northern Colorado Water Conservancy District (Northern Water)
Contact Information:	Kimberly Mihelich, Source Water Protection Specialist kmihelich@northerwater.org 303-827-4692

Project Description: This watershed health restoration project develops a long-term collaborative effort by the Kawuneeche Valley Ecosystem Restoration Collaborative (Collaborative) to work cooperatively with other stakeholders to functionally restore riverine ecosystems of the Kawuneeche Valley. (see map). Watershed-scale restoration of the stream network will reduce erosion and stabilize eroding channels, improve channel and floodplain connectivity, re-establish riparian and wetland vegetation, and enhance riparian and terrestrial habitats. Members of the Collaborative and local residents recognize excessive sediment and nutrient inputs to Shadow Mountain Reservoir (SMR) from the North Fork of the Colorado River, which, if left unaddressed, could impair the functioning of critical water supply infrastructure. Sediment and nutrient inputs to SMR will likely increase in the future due to the East Troublesome Fire, which has to date burned 19,017 acres within the southern half of the Project area.

While certain problem areas within Rocky Mountain National Park (RMNP) have been documented, conditions elsewhere in the watershed are largely unknown, particularly within the burned area. There is broad agreement on the need for watershed-scale channel and riparian restoration, but the specific locations for interventions and the most appropriate restoration approaches have not been identified. Furthermore, stakeholder and community perspectives on current conditions, desired future conditions, and acceptability of various interventions are not yet known.



Our proposed project involves (1) science-based assessments of environmental conditions and stakeholder/community perspectives, (2) analysis of post-wildfire risks in the burned area of the watershed, (3) data-driven feasibility analyses to evaluate the suitability of restoration approaches throughout the watershed, and (4) a process to objectively identify and prioritize restoration sites. This restoration planning and feasibility project will provide the required information for watershed-scale channel and riparian restoration that meets stakeholder goals. Subsequent phases of this long-term collaborative effort will include implementation of restoration measures, monitoring and evaluation, and adaptive planning and management.

PROJECT PROPOSAL & APPLICATION EVALUATION CRITERIA

BACKGROUND & INTRODUCTION

The watershed of the North Fork of the Colorado River has a complex environmental and social history, and the current hydrologic, geomorphic, and ecological functioning of the river is to some extent constrained by past land uses (Andrews 2015). One of the more ubiquitous and impactful changes to riverine function has been the loss of historic beaver (Castor canadensis) populations. While most of the watershed has been protected as part of Rocky Mountain National Park (RMNP) since 1915, extensive beaver trapping beginning in the 1820s (DeVoto 1947) have effectively extirpated these ecosystem engineers. The last beaver dam in the Kawuneeche Valley was built in 2004 just upstream from the Timber Creek campground, but it breached during spring runoff in 2005. Landforms created by beavers contain extensive fine-grained alluvial deposits that can be eroded when beavers are no longer present. Channel incision in these former wetland areas can significantly lower water tables, causing willows to die back and inhibiting their recovery (Bilyeu et al. 2008, Johnston et al. 2011, Marshall et al. 2013). The loss of tall willow communities has limited the opportunity for beaver to reestablish within the watershed, and has likely exacerbated ongoing channel and floodplain erosion, reduced storage of sediment and nutrients on floodplains surfaces, and increased sediment delivery to Shadow Mountain Reservoir.

The North Fork watershed experienced several other significant anthropogenic and natural disturbances since the 1880s. Construction of Grand River Ditch (Woods and Cooper 2005, Andrews 2015) and Specimen Mountain Ditch reduced total annual runoff. Periodic debris flows from Grand Ditch breaches and waste ways introduced large sediment pulses into the channel network (Rubin et al. 2012; Rathburn et al. 2013, 2019; Grimsley et al., 2016). Ranching operations cleared willows from extensive portions of the Kawuneeche Valley, including areas that are now part of RMNP. Abandoned ditches and drainage structures on former ranch lands changed the patterns of water availability in the valley by draining some wetlands and irrigating others. Development of the mining town of Lulu City, forest cutting associated with settlement, extensive tree mortality from bark beetle infestations, and heavy ungulate browsing have also altered watershed processes. Moose were not present in the region prior to their introduction to Colorado in the 1970s, but their reliance on willow for summer browsing has substantially altered woody riparian plant communities. These land use and ecological stressors resulted in changes to vegetation and wildlife of the Kawuneeche Valley, profoundly altering ecological and hydrological function of the watershed, driven by an almost complete transformation of the tall willow-beaver ecosystem to a short willow ecosystem (Fig. 1).

In October 2020, approximately 19,017 acres (42%) of the North Fork Watershed was burned by the East Troublesome Fire. While patterns of burn severity and future erosion potential have not yet been determined, enhanced runoff and sediment fluxes from burned areas will likely exacerbate ongoing sediment and nutrient impairment of the North Fork and SMR. Assessments of the impacts of the fire as related to erosion risks in the lower portion of the valley are expected to be completed during the next year.

The cumulative impacts of these stressors within the watershed highlight the need to restore the physical and biological processes to recreate the beaver-willow ecosystems that formed the Kawuneeche Valley (Schweiger et al. 2016). Suitable restoration treatments could alter the geomorphic and ecological trajectory of the channel network to promote a heathy, resilient, and functioning watershed, thereby reducing sediment and nutrient loads to downstream waters.

Kawuneeche Valley Ecosystem Restoration Collaborative

In 2020, the Kawuneeche Valley Ecosystem Restoration Collaborative (Collaborative) formed to explore opportunities for ecosystem restoration in the Kawuneeche Valley and to develop a phased implementation plan. The Collaborative is comprised of entities with jurisdiction over portions of the project area, including: National Park Service (RMNP), US Forest Service (USFS), Grand County, Town of Grand Lake, Bureau of Reclamation (Reclamation), Northern Water, Colorado River Water Conservancy District (CRWCD), and The Nature Conservancy (TNC).

APPLICANT QUALIFICATIONS

Project Team - Project Sponsor & Stakeholder Level of Participation

Northern Water is the lead project sponsor and fiscal agent. Other members of the Collaborative are equal participants and decisions regarding projects and outreach activities will be made with support from the whole the Collaborative. Individuals who will be active in administration and management of this project include: Koren Nydick and Scott Esser (RMNP), Kimberly Mihelich and Mark Coleman (Northern Water), and Jennifer Wellman (TNC) (resumes attached).

The Project Team also includes a group of interdisciplinary faculty and scientists from CSU, working in a technical advisory and consulting capacity, and the project will be one of applied ecosystem restoration rather than academic research. The collective knowledge and experience of the CSU team, and access to existing unpublished data sets from the project area, uniquely position the Collaborative to develop and implement data-driven restoration treatments.

Cash Match Commitments and Funding Sources

The Collaborative secured $106,151 of cash contributions to initiate this first phase of our efforts. RMNP, TNC and Northern Water each contributed $30,000 to the project which will support the CSU team's work on the initial project planning tasks, such as assessing current conditions and identification of restoration opportunities. TNC and Northern Water developed a contract to consolidate funds and expedite project tasks. In consideration of post fire implications, Northern Water is contributing an additional $15,000 to assist the CSU team with post-wildfire recovery opportunities in the project area and lab analyses that will be conducted during this project. A detailed budget is attached.

ORGANIZATIONAL CAPABILITY

History of Accomplishments in the Watershed: Projects & Planning Examples

Northern Water has a long history of collaborating with other entities and stakeholders to meet the needs of water users while protecting the environment. Northern Water and other Collaborative members have been actively involved with a range of other entities in adaptive

management and other collaborative efforts to restore aquatic environments in the Upper Colorado River Basin. Several examples follow.

Grand Lake Adaptive Management (GLAM)
A cooperative effort by Northern Water, Reclamation, Grand County, the Northwest Colorado Council of Governments and the Colorado River District to implement the Water Quality Control Commission's narrative clarity standard for Grand Lake.

Colorado-Big Thompson Headwaters Partnership (CBTHP)
A partnership comprised of Northern Water, Reclamation, USFS, RMNP, Colorado State Forest Service, and Western Area Power Administration to proactively restore forest and watershed health and preplan post-wildfire responses to protect watersheds that influence Colorado-Big Thompson Project infrastructure and water supplies.

Upper Colorado Wild & Scenic (UCW&S)
A collaborative effort of a diverse group including East and West Slope water interests, Federal Agencies, CPW, CWCB, local government, conservation and recreation groups and others, to develop a plan to preserve high quality natural and recreational values in the Upper Colorado River Basin.

Colorado River Headwaters Project (CRHP)
A cooperative effort to implement improvements to offset some effects transmountain diversions have had in the headwater streams in the Upper Colorado River basin. The CRHP is a collaborative effort of the Irrigators of the Lands in the Vicinity of Kremmling (ILVK), Grand County, Northern Water, Denver Water, Colorado River District, Colorado Parks and Wildlife, and Conservation groups.

Grand County Learning By Doing (LBD)
A partnership between Colorado Parks and Wildlife, Colorado River District, Denver Water, Grand County, Middle Park Water Conservancy District, Northern Water, Trout Unlimited and others. LBD is guided by and charged with updating the Grand County Stream Management Plan. It moves beyond previous conflicts to foster a shared vision of river health and implement projects to improve in Grand County's aquatic environments.

Project Staffing Levels

The Collaborative and the team of experts it has assembled has the organizational capacity and expertise to successfully complete the project as described in this proposal. Personnel from each member of the Collaborative and CSU team along with their time dedicated for this project are described below.

Entity	Staff Members	Time
Northern Water	• Esther Vincent, *Environmental Services Director* • Curtis Hartenstine, *Water Quality Dept. Manager* • Mark Coleman, *Aquatic Ecologist* • Kimberly Mihelich, *Source Water Protection Specialist*	5% 5% 10% 15%
TNC	• Jennifer Wellman, *Freshwater Technical Project Manager*	10%
RMNP	• Koren Nydick, *Chief of Resource Stewardship*	5%

	• Scott Esser, *Continental Divide Research Learning Center Director*	5%
River District	• Mike Eytel, *Senior Water Resources Specialist*	<5%
USFS	• Thomas Matthews, *Hydrologist*	<5%
USBOR	• Jeff Rieker, *Eastern Colorado Area Office Manager*	<5%
Grand County	• Katherine Morris, *Water Quality Specialist*	<5%
Town of Grand Lake	• Steve Kudron, *Mayor*	<5%
CSU Team	• David Cooper, Senior Research Scientist • Bruce Baker, *USGS Research Scientist, retired* • Brett Bruyere, Associate Professor • Sara Rathburn, *Professor* • John Sanderson, *Director, CCC* • Jeremy Shaw, *Research Scientist* • Jeremy Sueltenfuss, Assistant Professor • Cherie Westbrook, *Professor* • Ellen Wohl, *Professor*	10% <5% 10% <10% <5% 30% 10% <5% <5%

Project Budget & Timeline

Our estimated project total is $211,595. We are requesting $105,444 of CWCB Watershed Restoration grant funds and have secured $106,151 of cash contributions for the match requirements. We expect project tasks that are not funded by this grant to begin as early as December 2020. CWCB grant-funded tasks will begin as soon as the grant is awarded and contracted. All tasks are expected to be complete by December 2021. Please see the attached Scope of Work and Project Budget Spreadsheet (Attachments 1 & 2) for complete descriptions of tasks and a detailed budget breakdown.

PROPOSAL EFFECTIVENESS

Information Used to Develop Proposed Project

Our assessment of existing conditions within the Kawuneeche Valley will draw upon our team's extensive experience developed from nearly 80 combined years of applied research and restoration along the upper Colorado River, its tributaries, meadows, riparian areas and former beaver sites. Our knowledge of the physical and ecological conditions of the project area enable us to effectively assess flow regimes, sediment transport, riverine and riparian conditions, modifications from historic and current uses, and hydrologic effects on wetland functioning. We will leverage our existing long-term knowledge and data on channel and riparian vegetation conditions, fluxes of sediment and water, and land use and ecological stressors within the project area to efficiently fill information gaps and provide a science-based phased restoration plan that meets the objectives of the stakeholder community.

Project Objectives and Relationships

The long-term goal of the Collaborative is to functionally restore riverine ecosystems of the North Fork of the Colorado River, from its headwaters in RMNP downstream to Shadow Mountain Reservoir. Watershed-scale restoration of the stream network will reduce erosion and stabilize eroding channels, improve channel and floodplain connectivity, re-establish riparian and wetland vegetation, and enhance riparian and terrestrial habitats. The restored river, floodplain, and valley bottom will support critical ecosystem functions by shifting some reaches

from erosional or incising states to depositional states, as well as enabling the re-establishment of sustainable riparian vegetation and beaver populations. Depositional reaches will serve as sinks for sediment and nutrients, thereby improving downstream water quality and protecting water supply infrastructure. Increased subsurface water storage in these reaches will help to augment base flows and increase aquatic habitat area during low-flow periods in the late summer through winter. Restored channel segments will also activate the floodplain with over-bank flows more frequently, thereby raising the water table to support a more robust riparian plant community, which can increase nutrient retention and removal within the watershed. The enhancement of woody riparian vegetation, as well as the addition of sediment retention structures such as simulated beaver structures (SBS) and managed log jams will increase aquatic habitat complexity. These actions to restore ecological and fluvial processes will also support improved recreational opportunities.

The Collaborative seeks CWCB funding to support the initial phase of this long-term endeavor, consisting of a planning and feasibility analysis to assess current conditions and identify sites where restoration efforts should be focused. We will use detailed technical assessments of existing and historic conditions throughout the watershed to identify and prioritize restoration sites within the project area and determine the appropriate restoration approaches. These are the first steps toward implementing watershed-scale riparian ecosystem and habitat restoration projects to promote sediment retention, improve water quality, re-establish channel and floodplain connectivity, enhance native riparian and wetland vegetation establishment and improve recreational opportunities within the project area.

Monitoring/Implementation Plan and Measuring Success

We propose a pre- and post-treatment monitoring program similar to one being used in the RMNP-sponsored SBS project on the east side of the park. The assessment of existing geomorphic, ecological, and water quality conditions will provide pre-treatment baseline data for the entire channel network, with continued monitoring at all sites prioritized for restoration in subsequent phases. Post-treatment monitoring (expected to begin in 2022) will assess changes in surface water and ground water levels, sediment accumulation and transport, channel dimensions, and riparian plant communities within each treated area. Criteria for measuring success may vary among sites and restoration treatments, according to the particular characteristics, needs, and goals for each site. The duration and specific criteria for monitoring success at each site will be identified prior to any treatment implementation, based on what is learned during the current phase of investigation. Where possible, all studies, data collection, and data archiving will follow the methods and protocol of the NPS RMNP Inventory and Monitoring Program (Schweiger et al. 2015), allowing these study sites and data to be incorporated into the larger monitoring program.

ATTACHMENT 1: SCOPE OF WORK

Grantee and Fiscal Agent: Northern Colorado Water Conservancy District, on behalf of the Kawuneeche Valley Ecosystem Restoration Collaborative
Primary Contact: Kimberly Mihelich, Source Water Protection Specialist
Address: 220 Water Avenue, Berthoud, CO 80213
Phone: 303-827-4692
Project Name: Ecosystem Restoration of Select Sites in the Kawuneeche Valley
Grant Amount: $105,444.00

INTRODUCTION AND BACKGROUND

The project is focused on geomorphological and ecological restoration of the riverine environment of the North Fork Colorado River (North Fork) watershed. Excessive sediment and nutrients enter Shadow Mountain Reservoir from the North Fork, and this will likely increase due to the recent East Troublesome Fire. While certain problem areas within Rocky Mountain National Park have been documented, conditions in much of the North Fork watershed are largely unknown, particularly within the burned area. There is broad agreement on the need for watershed-scale channel and riparian restoration, but the specific approaches and locations for interventions have not been identified. Furthermore, stakeholder and community perspectives on desired future conditions and acceptability of various interventions are unknown. This project addresses an urgent need for community resilience and strategic intervention to address the devastating effects of the fire.

OBJECTIVES

The objectives of this project are to:

1. Assess existing geomorphic, ecological, water quality conditions, and human dimensions relating to ecological restoration in the project area, including parts of the watershed affected by the East Troublesome fire
2. Complete feasibility analyses of the suitability of available restoration approaches throughout the watershed, and
3. Identify and prioritize sites where restoration should be pursued.

TASKS

TASK 1 – Geomorphic Assessment

Description of Task

Excessive sediment and nutrient inputs to SMR from the North Fork watershed are likely driven by a range of land use and ecological stressors. Debris flows from periodic breaches in the Grand Ditch are well known and dramatic sources of fine sediment inputs to the stream network, and natural debris flows also occur (Rubin et al. 2012; Rathburn et al. 2013, 2019; Grimsley et al., 2016). Recent declines in willow abundance (Fig 1) and vigor may also reduce bank and floodplain sediment stability. While grazing pressure on willows by large herbivores received considerable attention within RMNP and other regions, historic willow clearing on formerly

private parcels now within the park also had lasting impacts on riverine function and sediment fluxes within the Kawuneeche Valley. Localized hydraulic alterations at road crossings, irrigation infrastructure, and other developed areas could also induce bank and bed erosion that contributes excess sediment. In addition to these localized sediment sources, the hydraulic conditions, channel dimensions, and riparian vegetation throughout the Kawuneeche Valley appear to be in the process of long-term adjustment to the 19th and 20th century loss of beaver populations (Westbrook et al. 2006) and debris jams (Van et al., 2016, unpublished report). The Collaborative's interdisciplinary team will conduct a hierarchical geomorphic assessment of the North Fork watershed to characterize channel condition, delineate sources of excessive sediment, identify potential stressors, and outline opportunities to restore riverine function. This information will be used to help determine the suitability of available restoration approaches and provide baseline pre-treatment data sets to evaluate project effectiveness in the future.

While this task is funded by external matching funds from the Collaborative, it is described in detail because it forms a basis for subsequent tasks and analyses.

Method/Procedure

1. Classification of Channel Condition:

We will classify the erosional status of the channel network within the North Fork Colorado River watershed using existing data sets and recent high-resolution aerial and satellite imagery. The classification will encompass approximately 85 mi of channels including Onahu Creek, Bowen Gulch, and Baker Gulch, in addition to known sediment sources such as Lulu Creek and Lady Creek. All channel segments within the stream network will be classified as (a) eroding, (b) aggrading, or (c) stable based on recent changes in channel and bank morphology, vegetation type and extent, and sediment characteristics. Potentially eroding segments will be delineated based on the presence of retreating or collapsing cut banks, incised channels, and sediment plumes from eroding upland surfaces, ditches, and roads. Potentially aggrading segments may be identified from relatively wide and shallow channels, and the presence of log jams, beaver dams, or other obstructions that reduce flow velocity and sediment transport. Potentially stable segments would lack the previously mentioned characteristics and show relatively little change in channel dimensions and vegetation cover over the past decades. This channel classification and mapping will be used to identify eroding channel segments and sediment sources for more detailed site assessments.

2. Analysis of Sediment Sources and Potential Stressors:

Site visits and field data collection will be performed at all accessible channel segments that were classified as potentially eroding in our channel classification (Task 1.1). In addition, a subset of segments classified as potentially aggrading and stable will be visited, to validate and ensure the accuracy of our classification. During site visits, our team will document channel geometry and sediment characteristics, locations and extents of active erosion, the type and status of riparian vegetation, evidence of recent changes, and potential land use stressors. Channel segments that are sources of excessive sediment and nutrient inputs are expected to exhibit the following: exposed fine sediment on banks and lower floodplain surfaces; reduced ground cover, and exposed roots and pedestaled stems of woody plants; and/or topographical evidence of

sediment loss such as rills, gullies, soil piping, collapsing or retreating banks, and channel incision. Land use or ecological stressors associated with each eroding channel segment will be identified using evidence from site visits, aerial imagery, historical documentation, and interviews with members of the Collaborative. Potential stressors will likely include: sediment plumes from breaches in the Grand Ditch that flowed down Lulu Creek and Lady Creek; loss of beaver dams; historic land clearing and willow removal; hydraulic alterations associated with past and current road crossings, irrigation infrastructure, and urban development; localized channel realignment or straightening; and overgrazing by large herbivores.

3. Prioritization of Sediment Sources and Associated Stressors:

The site assessments (Task 1.2) will be used to rank the eroding channel segments in terms of severity and location, in order to prioritize restoration planning. Severity of erosion will be assessed using existing data sets from the study area, and information gathered during site visits. Metrics for evaluating erosion severity could include measurements of bed load and suspended load, area of active erosion, and rate of channel incision or widening derived from aerial imagery.

Eroding channel segments will also be categorized by associated land use or ecological stressors, to help guide the selection of potential restoration approaches. Since sediment inputs and channel erosion could be driven by a number of stressors that vary by location and geomorphic setting, a suite of restoration strategies will likely be needed. Localized erosion from hydraulic alterations associated with relict and active infrastructure may be fairly obvious to diagnose and have straightforward remedies. Similarly, sediment plumes in the upper Kawuneeche Valley from past breaches in the Grand Ditch represent discrete and known problem areas that could be potentially stabilized by vegetation treatments or structural means. More ubiquitous stressors such as reduced riparian vegetation cover, and loss of beaver dams and log jams provide opportunities to test low-cost and simple restoration techniques such as SBS's and managed log jams.

Deliverables

- GIS Map Layer showing the locations of channel segments in the watershed, classified by erosional status and associated stressors
- A matrix of channel segments ranked by erosion severity and grouped by associated stressors
- Included in Assessment Report

TASK 2 – Ecological Assessment

Description of Task

This task is only briefly described here, since it is funded by external matching funds from RMNP.

An ecological assessment funded by RMNP will characterize the current status of riparian vegetation throughout the Kawuneeche Valley, identify areas where woody vegetation

abundance and vigor has declined in recent decades, and identify abandoned ditches and drains on formerly private parcels that could be restored. Since beaver are strongly dependent on tall (>2 m) willows and aspen for building dams and winter food, beaver occupancy is highly correlated to the presence and height of tall willows in RMNP (Sherer et al. 2010). Restoration of tall willow stands can improve habitat suitability for beaver who build and maintain dams that trap and stabilize sediment. Current and historic aerial imagery will be used to delineate (a) tall willow stands, (b) short willow stands, (c) areas where willows are nearly absent, and (d) other relevant woody vegetation types. Comparison of changes in willow conditions will provide important baseline information on where tall willow stands have been in the past, current condition of willows in the study area, and help identify opportunities for restoration at sites where willows were removed by past disturbance, or sites with persistent willows but heavy browsing pressure. We will also identify locations with relict ditches and drains within the study area, which can contribute to altered riparian vegetation by locally lowering the water table. Removal of abandoned drainage infrastructure could be a simple approach to help restore riparian water table regimes, promote willow growth and beaver occupancy, and reduce erosion potential.

TASK 3 – Water and Sediment Chemistry Assessment

Description of Task

CWCB funds are not requested for this task. Longitudinal analysis of total nitrogen and phosphorus in water and sediments along the mainstem of the North Fork and principal tributaries will allow us to identify source areas for excessive nutrient inputs to the Colorado River and SMR. Elevated dissolved nitrogen and phosphorus may be generated from areas where vegetation modification has reduced nutrient uptake capacity, or where unsewered urban development has occurred. Elevated total phosphorus inputs are also expected from eroding channels and other sediment source areas, since phosphorus is commonly bound to fine sediment particles. Approximately seven sampling stations will be established within the watershed and will be located to leverage historical water quality data collected by Northern Water and other stakeholders. We will conduct five sampling events during the 2021 growing season, timed to reflect seasonal streamflow variability including spring runoff and late-summer low-flows. Water samples will be analyzed by Northern Water's contract laboratory, High Sierra Water Laboratory, Inc., Oakland, Oregon. Sediment samples will be analyzed by Weld Laboratories, Greeley, Colorado, or another qualified laboratory. All analyses will use industry-standard methods.

The following nutrients will be considered for analysis:

Compound	**Reporting Limit**	**Method**
Ammonia as N (NH3)	1 ppb	EPA 350.1 modified
Nitrate + Nitrite as N (NO3 + NO2)	1 ppb	EPA 353.1 modified
Orthophosphate as P (OrthoP)	1 ppb	SM4500-PE
Total Dissolved Phosphorous (DP)	1 ppb	EPA 365.3
Total Phosphorous (TP)	1 ppb	EPA 365.3

Dissolved Kjeldahl Nitrogen as N (DKN)	35 ppb	EPA 351.2 modified
Total Kjeldahl Nitrogen as N (TKN)	35 ppb	EPA 351.2 modified
Total Suspended Solids (TSS)	0.3 mg/L	EPA 160.2
Total Phosphorous - Sediment	TBD	Standard Method - TBD

TASK 4 – Human Dimensions Assessment

Description of Task

The perceptions, values, interests, and goals of all stakeholders in the North Fork watershed are critical factors in assessing the feasibility and long-term success of restoration. To understand the socio-ecological context of potential restoration projects, we will engage three groups: the Collaborative; the broader group of 16 identified stakeholder groups; and residents of the watershed. Interviews with partners of the Collaborative will identify shared interests and goals, as well as improve communication and decision-making. This engagement within the Collaborative is supported by external matching funds and it is not described in this proposal. Funding from CWCB is requested to support (a) interviews and surveys with identified stakeholder groups to understand their interests, values, and priorities, and (b) online surveys with residents of the watershed to understand their interests, motivations and beliefs as they relate to restoration. These data will be used to help prioritize and evaluate the acceptability of various restoration options during the planning stage.

Method/Procedure

1. Engagement with Identified Stakeholder Groups

Surveys of stakeholder group constituencies will allow us to further understand their specific interests, values, and priorities. The 16 currently identified stakeholder groups represent interests from private, public and non-profit sectors, with foci including environmental quality, recreation, conservation, private lands, and agriculture and water delivery. These include: Trout Unlimited; Upper Colorado River Watershed Group; Three Lakes Watershed Association; Greater Grand Lake Shoreline Association; Rocky Mountain National Park Conservancy; NW Council of Governments; Colorado Parks and Wildlife; Red Top Ditch; Grand Ditch; Middle Park Stock Growers Association; local communities and private landowners. Additional groups may be identified through further discussion and scoping. In addition, 1-2 convening sessions will be used to communicate project status and plans to stakeholder groups.

Surveys: Interviews with stakeholder representatives will result in an initial understanding of the values and interests of importance. These results would be strengthened with additional input and feedback from stakeholders' constituencies, which can also lead to an assessment of where there is high consensus and high divergence among the different stakeholder groups. An on-line survey will ask respondents to rate and/or rank the various values and interests identified in the interviews. We envision a short survey (~ 5 minutes) with an emphasis on survey design that leads to a matrix of priority ratings (high/low) and levels of consensus (high/low), which will further illustrate how stakeholders' collective interests/values align (or not) with Collaborator goals. Our response goal is ~100-125 responses.

Convening Sessions: We anticipate hosting 1-2 live online convening sessions delivered at key junctures during the project, to disseminate information and elicit feedback to ensure that major interests are heard. Oftentimes the specific goals or needs for such sessions can be difficult to anticipate in the early planning stages, but we know there will likely be a need to communicate important and/or complex information, solicit feedback to influence a forthcoming decision, or a similar goal that is best accomplished in real-time. Working in partnership with the Collaborative, the technical team will determine when such sessions will occur, and work together to determine the goals and agenda for the sessions. After the interviews and two convenings, the technical team will work with the Collaborative to identify the most salient input, and if and how the project could respond to the input.

2. Engagement with the Broader Community

The broader community of stakeholders includes the ~15,000 permanent and seasonal residents, local business, and groups associated with Rocky Mountain National Park. This constituency will likely have broad diversity in overall interest, motivations and beliefs as they relate to restoration. We propose an online survey to understand constructs such as: public attitudes, beliefs and values related to restoration; desired future conditions; trust with project partners, and acceptance of various restoration strategies outlined in this proposal. This will provide an important baseline for subsequent public outreach and communication efforts. In addition, we can determine potential differences among subgroups (e.g., permanent vs seasonal residents), and target outreach and messaging accordingly. The survey, adapted from the stakeholder survey described above, will be distributed via list-servs, local media, social media, property records and other sources. Normally we would expect a low response rate from audiences with passive engagement with a survey topic. However, with the recent and extreme East Troublesome Fire, we expect to see a higher than normal level of engagement and would set a goal of ~200 responses.

Deliverables

- A written summary of interview and survey results relating to Stakeholder Groups and the Broader Community
- A story map with ~8-10 points that illustrates key findings
- 1-2 convening sessions for Stakeholder Groups
- Results and recommendations summarized in a technical report

TASK 5 - Restoration Feasibility Analyses

Description of Task

Using information gathered during our geomorphic and ecological assessments, coupled with existing field and remotely sensed data, we will analyze the feasibility of a portfolio of restoration approaches for each eroding channel segment or sediment source area identified in Task 1, as well as areas of excessive nutrient inputs identified in Task 3. Available restoration approaches currently consist of simple and minimally invasive interventions that do not require engineering studies and can be readily implemented. These include simulated beaver structures (SBS), woody riparian vegetation planting, ungulate exclosures, removal of relict ditches/drains,

and managed logjams. Our team's extensive experience within the project area and well-established connections with RMNP and other members of the Collaborative uniquely positions us to leverage the wealth of existing knowledge and data sets from within the watershed. Maps showing the relative feasibility of each restoration approach will be developed for the entire channel network of the North Fork Watershed.

Method/Procedure

1. Simulated Beaver Structures

Methods such as the Beaver Restoration Assessment Tool (BRAT) (MacFarlane et al. 2017) and other beaver habitat suitability models (Dittbrenner et al. 2018; Scherer et al. 2009) will be used to determine where physically suitable beaver habitat occurs and where SBS may be appropriate. These model results will be supplemented with maps of historic beaver dam locations derived from aerial photographs, field observations during the geomorphic and ecological assessments (Tasks 1 and 2), and existing data sets that cover parts of the project area (Cooper unpublished) to provide a robust perspective on potential locations for SBS. RMNP implemented three SBS on the east side of the park to gain experience with their construction, hydrologic and sediment retention benefits, and enhancement of willow growth.

2. Riparian Vegetation Planting

Data from the Ecological Assessment (Task 2) will be used to map areas where planting riparian vegetation can reestablish or enhance tall willow communities. Potential planting areas will be identified by comparing extant riparian vegetation to nearby reference areas and existing ungulate exclosures within the Kawuneeche Valley, as well as analysis of changes to willow communities within the study area over the last 20 years. Relicts of the late 20th century beaver-willow ecosystem exist in three small exclosures erected for a moose herbivory study in the late 1990s, which can be used reference sites and to evaluate the growth and success of any plantings.

3. Ungulate Exclosures

Information gathered during the Ecological Assessment (Task 2) will be integrated with existing reports (Cooper 2008) to determine potential locations for new ungulate exclosures. Feasible areas will include those where tall willow communities persist but are subjected to heavy browsing pressure. We will also consider five key locations that have been identified for potential ungulate exclusion fencing within portions of the Kawuneeche Valley (Cooper 2008), based on more than 10 years of collaboration between key members of our team and RMNP staff.

4. Relict Ditch/Drain Removal

Relict or abandoned drainage structures that alter channel hydraulics and wetland hydrology will be identified and mapped during the Ecological Assessment (Task 2). These will be considered candidates for removal wherever they exist and conflict with restoration goals.

5. Managed Logjams

Log jam spacing along channels throughout the watershed will be compared to documented log jam spacing on nearby reference streams (Van et al., 2016). Channel segments with log jam spacing below reference levels will be considered potential locations for wood additions.

Deliverables:

All data, maps, and presentations will be maintained in an online platform for data sharing in collaboration with Northern Water on a publicly accessible web site.

- Map of potential SBS locations, design options and feasibility
- Map of vegetation planting locations and feasibility
- Map of ungulate exclosure locations and feasibility
- Map of relict ditch/drain removal locations, types and feasibility
- Map of managed log jam locations and feasibility
- Results and recommendations summarized in Feasibility Report

TASK 6 - Pilot Sites Assessment

Description of Task

To identify and prioritize potential restoration sites, we have expanded upon an existing evaluation framework developed by RMNP staff working with CSU experts on streams, riparian vegetation and beavers, who comprise the core of our project team. This framework can be applied to any restoration technique and uses a matrix of criteria to identify locations that are prime candidates for successful treatments. The original criteria were developed for projects on NPS land, and we have added criteria that reflect the needs and concerns for portions of the watershed outside of RMNP.

Method/Procedure

For each eroding channel segment identified in Task 1, all restoration treatments considered in Task 5 will be evaluated against the following criteria:

1. Relative Feasibility Score: Rated High, Moderate, or Low. The relative feasibility for each restoration technique established through the Feasibility Analysis (Task 5).
2. Professional Judgement: Rated High, Moderate, or Low. High indicates the collective group considered the location to have high potential for restoration.
3. Ability of Restoration to Increase Sediment Retention: Rated High, Moderate, or Low. High indicates the location to have high potential to retain sediment.
4. Ability of Restoration to Increase Nutrient Retention: Rate High, Moderate, or Low. High indicates that the treatment/location will have high potential to retain or sequester nitrogen or phosphorus.
5. Degree of Restoration Required: Rated High, Moderate, or Low. High indicates a smaller amount of restoration is required to put the location on a successful trajectory. Low indicated a larger amount of restoration is required.
6. Benefit Multiplier: Rated High, Moderate, or Low. High indicates that the location, if restored, would have major beneficial impacts downstream or to adjacent areas.

7. Existence of Baseline and Monitoring Data: Rated High, Moderate, or Low. High indicates there is a large amount of baseline or monitoring data available to assess changes and success.
8. Logistical Feasibility of Restoration: Rated High, Moderate, or Low. High indicates that the project location has minimal logistical concerns for implementation or subsequent treatments.
9. Covered by Existing Management Plan: Rated High or Low. High indicates the location is covered by an existing management plan.
10. Level of Compliance Effort: Rated High, Moderate, or Low. High indicates that the compliance needs of the location are minimal or impacts to other resources are small.
11. Compatible with Public/Stakeholder Values and Acceptance: Rated High, Moderate, or Low. High indicates strong compatibility with values and acceptance as determined through Task 4.
12. Compatibility with Existing Land Uses: Rated High, Moderate, or Low. High indicates strong compatibility with existing and foreseeable land uses.
13. Urban/Wildland Interface and Infrastructure: Rated High, Moderate, or Low. High indicates compatibility with existing and foreseeable WUI and infrastructure.
14. Impacts to Water Management: Rated High, Moderate or Low. High indicates minimal conflict with water rights and water management infrastructure.

Deliverable:

- Matrix of evaluation criteria scores for each restoration approach within every eroding channel segment or sediment source area
- Recommendations provided in Final Report

TASK 7 – Post-Wildfire Assessment

Description of Task

Approximately 42% of the project area of the lower Kawuneeche Valley is within the current East Troublesome Fire burn area. Post-fire assessments are forthcoming, so the effects of the fire on the North Fork watershed have yet to be described in detail; however, it is assumed that fire will dramatically contribute to erosional hazards in the valley and its hillslopes. As post-fire assessments provide a clearer picture of the types and extent of fire impacts, we will pursue opportunities to incorporate post-fire rehabilitation into our broader and integrative restoration actions. The project team will require assistance from a specialist, yet to be selected, in post-fire recovery and hillslope processes. We anticipate the specialist will support the CSU team in scoping projects and restoration areas affected by fire. The funding for this task is intended to help cope with fire-related impacts and support the other tasks scoped here, but we are committed to coordinating with broader response efforts by RMNP, USDA Forest Service, and other agencies, local communities and landowners throughout the project.

Method/Procedure

It is anticipated that site visits and field assessments in accessible burned portions of the project area will be conducted along with analyses of available post-fire assessments (e.g. BAER

assessment and soil burn severity maps, USGS post-fire debris flow hazards mapping CFRI post-fire erosion prediction model, etc).

Deliverables

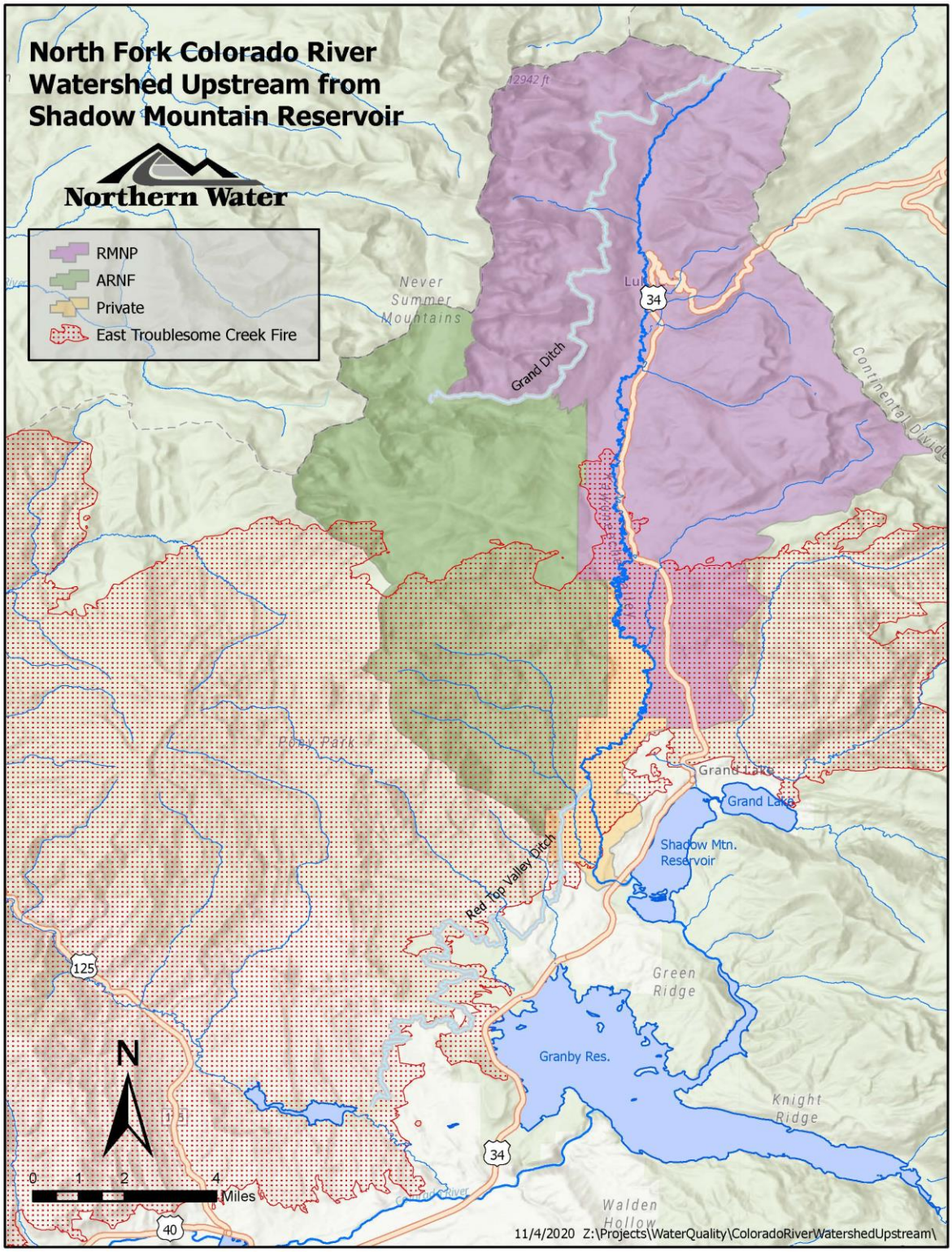
- Maps of burn severity in Project Area
- Flooding, debris flow, and sediment transport analysis
- Prioritization of areas in critical need of post-fire treatment
- Recommendations for post-fire restoration activities and priority treatments (schematic designs, construction drawings)

ATTACHMENT 2: PROJECT BUDGET SPREADSHEET

TASK	DESCRIPTION	TIMELINE		EXTERNAL FUNDING	CASH CONTRIBUTIONS			TOTAL PROJECT COSTS
		Target Start Date	Target End Date	CWCB Grant	Match Total	Northern Water / TNC	RMNP	CWCB Grant + Cash Matches
	CSU Project Management			**$1,284**	**$2,567**	**$1,284**	**$1,284**	**$6,418**
	CSU Travel: 200 miles RT Ft. Collins to Gr. Lake @$0.55/mile * 16 total trips			**$880**	**$880**	**$880**	**$0**	**$2,640**
1	**Geomorphic Assessment**	**1-Dec-2020**	**30-Sep-2021**	**$0**	**$24,940**	**$24,940**	**$0**	**$49,880**
	Channel classification					*$9,029*		
	Analyze sediment sources (largely field)					*$8,088*		
	Prioritize sediment sources					*$7,823*		
2	**Ecological Assessment**	**1-Dec-2020**	**30-Sep-2021**	**$0**	**$23,350**	**$0**	**$23,350**	**$46,701**
	Vegetation mapping						*$16,002*	
	Relict Ditch Mapping						*$7,348*	
3	**Water & Sediment Chemistry Assessment (CSU Field Work)**	**1-May-2021**	**31-Oct-2021**	**$0**	**$6,664**	**$5,553**	**$1,111**	**$13,327**
4	**Human Dimensions Assessment**	**1-Feb-2021**	**31-Dec-2021**	**$22,543**	**$7,073**	**$7,073**	**$0**	**$36,689**
	Communication & roles within Collaborative					***$7,073***		
	Interests & goals of 16 stakeholders			*$9,711*				
	Attitudes of broader community			*$12,832*				
5	**Restoration Feasibility Analysis**	**1-Mar-2021**	**31-Dec-2021**	**$25,339**	**$0**	**$0**	**$0**	**$25,339**
	Simulated Beaver Structures			*$7,404*				
	Riparian Vegetation Planting			*$9,901*				
	Ungulate Exclosures			*$4,348*				
	Relict Ditch/Drain Removal			*$1,511*				
	Managed Logjams			*$2,176*				
6	**Pilot Sites Assessment**	**1-Mar-2021**	**31-Dec-2021**	**$9,128**	**$0**	**$0**	**$0**	**$9,128**
	CSU SUBTOTAL (DIRECT COSTS)			$59,174	**$65,474**	$39,729	$25,745	**$190,121**
	CSU INDIRECT COSTS (17.55%) *						$4,518	
	CSU INDIRECT COSTS (52%) **			$30,770	**$25,177**	$20,659		**$76,607**
	CSU TOTAL (DIRECT + INDIRECT)			$89,944	**$90,651**	$60,389	$30,263	**$180,595**
7	**Post-Wildfire Response/Early Implementation**	**1-Dec-2020**	**30-Sep-2021**	**$10,000**	**$10,000**	**$10,000**	**$0**	**$20,000**
	Laboratory Analysis of Nutrient Concentrations			**$5,500**	**$5,500**	**$5,500**	**$0**	**$11,000**
	WILDFIRE & LAB TOTALS			**$15,500**	**$15,500**	**$15,500**	**$0**	**$31,000**
			GRAND TOTAL	**$105,444**	**$106,151**	**$75,889**	**$30,263**	**$211,595**

* CSU indirect cost, by agreement, for RMNP funds
** CSU standard indirect cost

ATTACHMENT 3: PROJECT AREA MAP



ATTACHMENT 4: PHOTOGRAPHS OF PROJECT AREA

Figure 1. Kawuneeche valley in 1995 (top) and the identical location in 2018 showing the loss of tall willows from the valley. This scale of willow loss has occurred throughout the study area.

Figure 2. East Troublesome burn area extends into the Kawuneeche Valley near Coyote Valley trailhead. (Photo obtained via RMNP Twitter on Oct. 23, 2020)

ATTACHMENT 5: LITERATURE CITED

Andrews, T. G. 2015. Coyote Valley: Deep History in the High Rockies. Harvard University Press. 352 pages.

Bilyeu, D., D. J. Cooper, N. T. Hobbs. 2008. Water tables constrain height recovery of willow on Yellowstone's Northern Range. *Ecological Applications* 18:80-92.

Cooper, David. 2008. Ungulate fence locations in the Kawuneeche Valley, Rocky Mt. National Park. Unpublished report to RMNP.

Cooper D.J., J. Dickens, N. T. Hobbs, L. Christensen, L. A. Landrum. 2006. Hydrologic, geomorphic and climate controls on willow establishment in a montane ecosystem. *Hydrological Processes* 20: 1845-1864.

Cooper, D. J., K. Kaczynski, J. Sueltenfuss, S. Gaucherand, C. Hazen. 2017. Mountain Wetland Restoration: The Role of Hydrologic Regime and Plant Introductions After 15 Years in the Colorado Rocky Mountains, U.S.A. *Ecological Engineering* 101: 46-59.

DeVoto, B. 1947. Across the Wide Missouri. Houghton Mifflin Company, NY.

Dittbrenner, B.J., M.M. Pollock, J.W. Schilling, J.D. Olden, J.J. Lawler, and C.E. Torgersen. 2018. Modeling intrinsic potential for beaver (Castor Canadensis) habitat to inform restoration and climate change adaptation. PloS ONE 13(2): e0192538.

Gage, E.A. & Cooper, D.J. 2004. Controls on willow cutting survival in a montane riparian area. *Journal of Range Management*. 54: 597-600.

Gage, E. A. & Cooper, D. J. 2004. Constraints on willow seedling establishment in a Rocky Mountain montane riparian floodplain. *Wetlands* 24:908-911.

Grimsley, K., Rathburn, S., Friedman, J., and Mangano, J., 2016, Debris flow occurrence and sediment persistence, Upper Colorado River Valley, Rocky Mountain National Park, *Environmental Management:* 58(1):76-92, doi:10.1007/s00267-016-0695-1.

Johnston, D., D.J. Cooper, N. T. Hobbs. 2011. Relationships between groundwater use, water table, and recovery of willow on Yellowstone's northern range. *Ecosphere 2*: article 20.

Lautz, L., C. Kelleher, P. Vidon, J. Coffman, C. Riginos, H. Copeland. 2019. Restoring stream ecosystem function with beaver dam analogues: Let's not make the same mistake twice. Hydrological Processes 33: 174-177.

Marshall, K., NT Hobbs, D.J. Cooper. 2013. Stream hydrology limits recovery of riparian ecosystems after wolf reintroduction. *Proceedings of the Royal Society*, B.280 20122977; doi:10.1098/rspb.2012.2977

MacFarlane, W., J. Wheaton, M. Jensen. 2014. The Utah beaver restoration assessment tool: A decision support and planning tool. Final report to Utah Division of Wildlife Resources.

MacFarlane, W., J. Wheaton, N. Bouwes, M. Jensen, J.T. Gilbert, N. Hough-Snee, J.A. Shivik. 2018. Modeling the capacity of riverscapes to support beaver dams. Geomorphology 277:72-99.

Rathburn, S.L., Rubin, Z.K., and Wohl, E.E. 2013. Evaluating channel response to an extreme sedimentation event in the context of historical range of variability: Upper Colorado River, Rocky Mountain National Park, Colorado. Earth Surface Processes and Landforms 38: 391- 406

Rubin, Z.K., Rathburn, S.L., Wohl, E.E., and Harry, D.H. 2012. Historic range of variability in geomorphic processes as a context for restoration: Rocky Mountain National Park, Colorado. Earth Surface Processes and Landforms 37:209-222

Schweiger, E. W., E. Gage, K. Driver, D. Cooper, L. O'Gan, and M. Britten. 2015. Rocky Mountain Network wetland ecological integrity monitoring protocol: Narrative, version 1.0. 13 Natural Resource Report NPS/ROMN/NRR—2015/991. National Park Service, Fort Collins, Colorado.

Schweiger, E.W., J. B. Grace, D. J. Cooper, M. Britten, B. Bobowski. 2016.Beyond bioassessment: How does human disturbance influence wetland ecological integrity in Rocky Mountain National Park? *Ecosphere* 7: e01548. 10.1002/ecs2.1548.

Sherer, R. D., J. Shepherd, R. Ditgen, B. Noon, I Leinwand. 2010. Occupancy of beaver (Castor canadensis) in Rocky Mt. National Park. Researchgate.net/publication/266880361.

Van, B., Merrill, J., and Rathburn, S. 2016. Wood loads and jam spacing on the Upper Colorado River, Rocky Mountain National Park. Unpublished Report.

Westbrook, C., D. J. Cooper, B. Baker. 2006. Beaver dams and floods in controlling hydrologic processes of a mountain valley. Water Resources Research 42: W06404,doi:10.1029/2005WR004560

Westbrook, C., D. J. Cooper, B. Baker. 2011. Beaver Assisted River Valley Formation. River Research and Applications 27: 247-256.

Woods, S. W. and D. J. Cooper. 2005. Hydrologic Factors Affecting Willow Seedling Establishment along a Subalpine Stream, Colorado, USA. Arctic, Antarctic and Alpine Research 37: 636-643.

ATTACHMENT 6: LETTERS OF SUPPORT

- Grand County
- RMNP
- TNC

BOARD OF COMMISSIONERS

RICHARD D. CIMINO
District I, Fraser 80442
MERRIT S. LINKE
District II, Granby 80446
KRISTEN MANGUSO
District III, Kremmling 80459

E-Mail: grndcty1@co.grand.co.us
PHONE: 970/725-3100
Fax: 970/725-0565
KATHERINE MCINTIRE
County Manager
CHRISTOPHER LEAHY
County Attorney

Mr. Chris Sturm
Colorado Water Conservation Board
1313 Sherman Street, Room 721
Denver, CO 80203

November 4, 2020

Dear Watershed Restoration Program Grant Reviewers,

I am writing to express Grand County's support for the Kawuneeche Valley Ecosystem Restoration Collaborative's (the Collaborative) proposal "Ecosystem Restoration of Select Sites in the Kawuneeche Valley". From the 2003 CDPHE *Shadow Mountain Lake Restoration Project* report by HDR Engineering, to our cooperating agency status on the Grand Ditch Breach Restoration Project; from our annual participation for over a decade in the Three Lakes Technical Committee to the development and execution of the Grand Lake Clarity MOU, Grand County has been advocating for ecosystem restoration in the Colorado River upstream of Shadow Mountain Reservoir for nearly two decades now. We were pleased to join the Collaborative last year and we are proud to partner with Northern Water, Rocky Mountain National Park, Colorado State University, The Nature Conservancy, the Town of Grand Lake, the U.S. Forest Service, the Colorado River District and others on this unique project. We are pleased that the political will and resources have come together at this critical time to support restoration in the Kawuneeche Valley, and appreciative that Northern Water is willing and able to offer its expertise and capacity to coordinate this restoration effort.

The need for ecosystem restoration work in the Kawuneeche Valley has suddenly become dire now that the East Troublesome Fire, just last week, blazed through the region and destroyed valuable habitat and property. At this time, nearly 194,000 acres have burned, around 300 homes, and countless natural treasures were lost. The impact to wetlands, rivers, and the uplands is extraordinary, and remedial efforts to protect against additional loss from debris flows and impacts to water supplies is imperative.

P.O. BOX 264 HOT SULPHUR SPRINGS CO 80451

Grand County is committed to assisting the Collaborative with restoration efforts through our participation whenever possible, help with coordination, access to maps and imagery, property ownership, local communication and outreach, access within easements, and other means, as appropriate.

Over the past year, the Collaborative hired a local expert team to assess existing geomorphic and ecological conditions, identify potential restoration areas, and seek alignment between federal, state, and private lands. The Collaborative is additionally committed to responding to the immediate need for post-fire restoration in critical areas of the watershed. This project will fund the technical evaluation and selection of sites that, when restored, will reduce sediment and nutrient inputs to Shadow Mountain Reservoir and other headwaters of the Colorado River.

The Collaborative has a monumental task of working with local communities in the aftermath of wildfire to better understand their needs and respond to extensive natural resource damage. The fire's destruction will set the stage for long-term restoration potential, and it is critical to begin that process now. As Burned Area Emergency Response (BAER) processes are currently evaluating the extent of loss to the entire watershed, participation of team members from the U.S. Forest Service and Rocky Mountain National Park will be crucial to the Collaborative in relaying technical information about new priority restoration areas.

By submitting this proposal, we support Northern Water's role as the Collaborative's fiscal agent to maintain a centralized system of project management and continuity in our restoration work. We believe this project aligns with the CWCB's Watershed Restoration Program goals as well as the wishes of the local community to protect aquatic habitat, mitigate the aftermath of fire, including efforts to prevent debris flows and potential floods, and to restore vital areas of the Kawuneeche Valley floodplain. This project has strong potential to rehabilitate parts of the landscape for long-term resilience and increased water security for local communities – both of which are goals of the Colorado Water Plan. Thank you for your consideration of our proposal.

Sincerely,

Katherine McIntire
Grand County Manager

United States Department of the Interior

NATIONAL PARK SERVICE
Rocky Mountain National Park
Estes Park, Colorado 80517

IN REPLY REFER TO:

Mr. Chris Sturm
Colorado Water Conservation Board
1313 Sherman Street, Room 721
Denver, CO 80203

November 2, 2020

Dear Watershed Restoration Program grant reviewers,

I am writing on behalf of Rocky Mountain National Park in support of the Kawuneeche Valley Ecosystem Restoration Collaborative's (the Collaborative) proposal "Ecosystem Restoration of Select Sites in the Kawuneeche Valley". Our organization joined the Collaborative last year and we are proud to partner with Northern Water, Colorado State University, The Nature Conservancy, Grand County, the Town of Grand Lake, the US Forest Service, the Colorado River District and others on this unique project. The Collaborative is a locally-driven group of organizations seeking solutions to water supply and water quality challenges in the Upper Colorado River watershed.

The Collaborative's ecosystem restoration work in the Kawuneeche Valley is imperative now that the East Troublesome Fire, just last week, blazed through the region and destroyed valuable habitat and property. At this time, nearly 194,000 acres burned, and many homes and natural treasures were lost. The impact to wetlands, the rivers, and the uplands is extraordinary.

Rocky Mountain National Park interest in this collaboration is rooted in the desire to restore wildlife habitat, improve water quality of the Upper Colorado watershed, and preserve these resources for future generations. These objectives are in alignment with several of the Park's restoration objectives outlines in the Elk and Vegetation Management Plan and the Fire Management Plan.

The Collaborative has hired a local expert team to assess existing geomorphic and ecological conditions, identify potential restoration areas, and seek alignment between federal, state, and private lands. We are additionally committed to responding to the immediate need for post-fire restoration in critical areas of the watershed. This project will fund the technical evaluation and selection of sites that, when restored, will reduce sediment and nutrient inputs to Shadow Mountain Reservoir and other headwaters of the Colorado River.

The Collaborative has a monumental task of working with local communities in the aftermath of wildfire to better understand their needs and respond to extensive natural resource damage. The fire's destruction will set the stage for long-term restoration potential and it is critical to begin that process now. Burned Area Emergency Response (BAER) processes are currently evaluating the extent of loss to the entire watershed; team members from the US Forest Service and Rocky Mountain National Park play a crucial role in the Collaborative in relaying technical information about new priority restoration areas. By

submitting this proposal, we support Northern Water's role as the Collaborative's fiscal agent to maintain a centralized system of project management and continuity in our restoration work. We believe this project aligns with the CWCB's Watershed Restoration Program goals as well as the wishes of the local community: to protect aquatic habitat; mitigate the aftermath of fire, debris flows, and potential floods; and restore vital areas of the Kawuneeche Valley floodplain. This project has strong potential to rehabilitate parts of the landscape for long-term resilience and increased water security for local communities – both of which are goals of the Colorado Water Plan. Thank you for your consideration of our proposal.

Koren Nydick
Chief of Resource Stewardship
Rocky Mountain National Park

The Nature Conservancy
2424 Spruce Street
Boulder, CO 80302
nature.org/coriver

Mr. Chris Sturm
Colorado Water Conservation Board
1313 Sherman Street, Room 721
Denver, CO 80203

November 3, 2020

Dear Watershed Restoration Program grant reviewers,

I am writing on behalf of The Nature Conservancy's Colorado River Program in support of the Kawuneeche Valley Ecosystem Restoration Collaborative's (the Collaborative) proposal for Watershed Restoration Grant funding. In 2019, The Nature Conservancy joined the Collaborative and we are proud to partner with Northern Water, Rocky Mountain National Park, Colorado State University, Grand County, the Town of Grand Lake, the US Forest Service, the Colorado River District and others on this unique project.

The Collaborative's ecosystem restoration work in the Kawuneeche Valley is imperative since the East Troublesome Fire blazed through the region and destroyed valuable habitat and property. At this time, nearly 194,000 acres have burned and many homes and natural treasures were lost. The impact to wetlands, the rivers, and the uplands is extraordinary.

Over the past year, the Collaborative built momentum and pooled resources to hire a local expert team to assess existing geomorphic and ecological conditions, identify potential restoration areas, and seek alignment between federal, state, and private landowner needs. TNC committed $30,000 toward the initial technical project which is being re-aligned to respond to the immediate need for post-fire restoration in critical areas of the watershed. This project will fund the technical evaluation and selection of sites that, when restored, will reduce sediment and nutrient inputs to Shadow Mountain Reservoir and other headwaters of the Colorado River.

By submitting this proposal, TNC supports Northern Water as the Collaborative's fiscal agent who maintains centralized project management and continuity in our restoration work. We believe this project aligns with the CWCB's Watershed Restoration Program goals as well as the wishes of the local community: to protect aquatic habitat; mitigate the aftermath of fire, debris flows, and potential floods; and restore vital areas of the Kawuneeche Valley floodplain. This project has strong potential to address and rehabilitate parts of the landscape for long-term resilience and increased water security for local communities.

Thank you for your consideration of the Collaborative's proposal.

Taylor Hawes, Director
Colorado River Program

ATTACHMENT 7: RESUMES OF ACTIVE TEAM MEMBERS

Collaborative:

- Scott Esser, RMNP
- Mark Coleman, Northern Water
- Kimberly Mihelich, Northern Water
- Jennifer Wellman, TNC

CSU Team:

- David Cooper, Senior Research Scientist
- Bruce Baker, USGS Research Scientist, retired
- Brett Bruyere, Associate Professor
- Sara Rathburn, Professor
- John Sanderson, Director, CCC
- Jeremy Shaw, Research Scientist
- Jeremy Sueltenfuss, Assistant Professor
- Cherie Westbrook, Professor
- Ellen Wohl, Professor

Scott M. Esser
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1000 US HWY 36
Estes Park, CO 80517
Email: Scott_Esser@nps.gov

WORK EXPERIENCE:

National Park Service
Rocky Mountain National Park
1000 Hwy 36
Estes Park, CO 80517

Dates Employed: 2002-Present
Grade Level: GS-0408-12 Step 1

Current Title: Director - Continental Divide Research Learning Center (CDRLC)

Throughout my career at Rocky Mountain National Park I have held several positions and served many roles within the Resource Stewardship division. Currently, I am the Director of the Research Learning Center which has the goal of collecting research data and information so it can be used in management decisions. Prior to my role as Director, I was the parks research coordinator, botanist, and wetland restoration specialist. During this time I conducted several wetland/riparian restoration projects including the Grand Ditch Breach Restoration, Hidden Valley wetland restoration, Glacier Creek Livery wetland restoration, Fan Lake/Roaring River wetland restoration, and Moraine Park golf course restoration to name a few. Each of these projects involved preliminary data collection to support the design and planning of each restoration through the implementation of a variety of wetland restoration techniques to restore ecological processes. These projects include extensive partnerships and project management skills to ensure success and project objectives to be met.

EDUCATION:

Colorado State University
Graduate Degree Program in Ecology
Fort Collins, CO 80523 U.S.A.
M.S. Ecology 2015
Thesis: Topography, Disturbance and Climate: Subalpine Forest Change 1972-2013, Rocky Mountain National Park, USA.

University of Wisconsin-Madison
Madison, WI 53706 U.S.A.
B.S. 2001
Major: Biological Aspects of Conservation (Botany)

PUBLICATIONS and ABSTRACTS:

- Schwartz, F., B.D. Taff, B. Lawhon, D. Pettebone, **S.M. Esser**, A. D'Antonio. 2019. Leave No Trace bouldering ethics: Transitioning from the gym to the crag. Journal of Outdoor Recreation and Tourism, 25, 16-23. (Article)
- Butera, B. and **S.M. Esser**. 2019. A Forest in Motion: Student Citizen Scientists Investigate How Trees Respond to Changing Mountain Climate. The Science Teacher, 22-33. (Article)
- Ashton, I.A., B. Baldwin, B. Bobowski, **S.M. Esser**, P. McLaughlin. 2016. 100 Years of Research in Rocky Mountain National Park. Park Science. 32. 68-69. (Article)
- Svajda, J, S. Korony, I. Brighton, **S.M. Esser**, and S. Ciapala. 2016. Trail Impact Monitoring in Rocky Mountain National Park, USA. Solid Earth, 7, 3117-3149. (Article)
- Watry, M. K. and **S.M. Esser.** 2015. Improving Visitor Experience by Reducing Bear Confrontations and Property Damage in Rocky Mountain National Park. Proceedings of the 2015 CDRLC Biennial Research Conference. Estes Park, CO.
- Davis, C, C.S. Brown, **S.M. Esser.** 2015. Managing Cheatgrass with Imazapic in Rocky Mountain National Park: Lessons learned from a six year study. Proceedings of the 2015 CDRLC Biennial Research Conference. Estes Park, CO.
- **Esser, S.M.,** J.S. Sibold, B.R. Bobowski. 2014. Subalpine Forest Change 1972-2013, Rocky Mountain National Park, USA. Proceedings of the 2014 Biennial Science Conference on the Greater Yellowstone Ecosystem. October 6-8.
- **Esser, S.M.** and B.R. Bobowski. 2012. Restoration of the Grand Ditch Breach in the Upper Kawuneeche Valley of Rocky Mountain National Park. Proceedings of the 2012 Rocky Mountain National Park Research Conference, March 26. Estes Park, CO.
- **Esser, S.M.** and B.R. Bobowski. 2012. Restoration of the Grand Ditch Breach in the Upper Kawuneeche Valley of Rocky Mountain National Park. Proceedings of the 2012 High Altitude Revegetation Conference, March 6-8. Fort Collins, CO.
- Davis, C., C.S. Brown, **S.M. Esser**. 2012. Effects of selective imazapic application on *Bromus tectorum* and non-target species in Rocky Mountain National Park. Proceeding of the 2012 High Altitude Revegetation Workshop, March 6-8, 2012, Fort Collins, CO.
- Claassen, V. J. Cheatham, **S.M. Esser**, and S. Wynn. 2012. Bear Lake Road Improvement Project: Soil Harvesting and Reapplication. Proceeding of the 2012 High Altitude Revegetation Workshop, March 6-8, 2012, Fort Collins, CO.
- **Esser, S. M.,** J. R. Maugans, L. H. Pilkington, L. R. Springer, L. Wheatley, and B. R. Bobowski. 2010. Glacier Creek Wetland Restoration in Rocky Mountain National Park (Updated). Proceedings of the 2010 High Altitude Revegetation Conference, March 2-4, 2010. Fort Collins, CO.

- Stevens, M. and **S. M. Esser**. 2009. Growth-defense tradeoffs differ by gender in dioecious trembling aspen (*Populus tremuloides*). Biochemical Systematics and Ecology. 37, 567-573. (Article)
- Pilkington, L. H., J. R. Maugans, **S. M. Esser**, L. R. Springer, and B. R. Bobowski. 2009. Development of Site-Specific Treatment and Restoration Strategies for High Elevation Cheatgrass (*Bromus tectorum*) Infestations in Rocky Mountain National Park, Colorado. Proceedings of the Ecological Society of America Annual Meeting, August 2-7, 2009. Albuquerque, NM.
- **Esser, S. M.**, J. R. Maugans, L. H. Pilkington, L. R. Springer, L. Wheatley, and B. R. Bobowski. 2009. Glacier Creek Wetland Restoration in Rocky Mountain National Park. Proceedings of the 62nd Annual Society for Range Management Conference. February 8-12, 2009. Albuquerque, NM.
- Springer, L. R., J. R. Maugans, L. H. Pilkington, L. Wheatley, **S. M. Esser**, and B. R. Bobowski. 2008. Native Forest Restoration of Timber Creek Campground in Rocky Mountain National Park. Proceedings of the Society of American Foresters National Convention, November 5-9. 2008. Reno-Tahoe, NV.

Mark Coleman
Northern Water
220 Water Avenue
Berthoud, CO 80513
Email: mcoleman@northernwater.org

SUMMARY

I'm an environmental professional with a diverse history, having worked laboratory biology, field ecology research, and R&D for a small mammal research habitat for the International Space Station, and software development. This brief resume describes work most relevant to the Kawuneeche Valley restoration initiatives.

RELEVANT EXPERIENCE

Northern Water **Dates Employed: 2018-Present**
Berthoud, Colorado

Title: Aquatic Ecologist
As Aquatic Ecologist, I have assisted in development and implementation of fish tissue Mercury monitoring programs for environmental permit compliance for the Windy Gap Firming Project, and I assisted with preparation of the application for 401 Certification of the Northern Integrated Supply Project. More generally, I provide technical support as a fish and aquatic habitat specialist on project teams for stream/river restoration projects, including the Colorado River Connectivity Channel and I assist the Water Quality team with temperature monitoring program planning and aquatic life issues. I provide technical support to collaborative stakeholder groups in the Upper Colorado River Basin (Learning By Doing, Upper Colorado Wild & Scenic), advising on monitoring and assisting with evaluation of restoration priorities. I am also a member of the regulatory affairs group at Northern Water and the Water Quality Control Division's Temperature Technical Advisory Committee.

Coleman Ecological **Dates Employed: 2007-2011**
Fort Collins, Colorado

Title: Owner
As an ecological consultant, I completed first major review of the thermal tolerances of Colorado fishes and built the database of qualified data used by the CDPHE to calculate water temperature standard thresholds. For Northern Water, I completed a statistical analysis to understand factors driving water clarity in Grand Lake and presented this analysis on behalf of Northern Water to the Colorado Water Quality Control Commission during regulatory hearings for a proposed clarity standard in the lake. For the US Fish and Wildlife Service, I completed a report reviewing published and unpublished data to construct an account of the life-history and ecology of the greenback cutthroat trout. I also conducted a range of desktop and field assessments of fish and fish habitat related to proposed restoration projects.

EDUCATION

Colorado State University, Fort Collins, Colorado
Ph.D. Fishery & Wildlife Biology 2007
Dissertation: Cold summer stream temperatures reduce recruitment of native cutthroat trout populations

University of Wisconsin-Madison, Madison, Wisconsin
M.S. Zoology 1997
Major: Zoology – specializing in ecophysiology/environmental endocrinology

University of Washington, Seattle, Washington.
B.S. Zoology 1995
Major: Zoology

SELECTED PUBLICATIONS AND ABSTRACTS

Todd, A. S., **Coleman, M. A.**, Konowal, A. M., May, M. K., Johnson, S., Vieira, N. K. M., & Saunders, J. F. 2008. Development of New Water Temperature Criteria to Protect Colorado's Fisheries. *Fisheries*, *33*(9), 433–443.

Coleman, M.A. 2008. (Presentation) Assessing thermal suitability of streams for establishment of native trout conservation populations in high-elevation streams. Annual Meeting of the American Fisheries Society Western Division, Portland, Oregon.

Coleman, M.A. 2008. (Presentation) New temperature standards to protect aquatic life in Colorado. Annual Meeting of the American Fisheries Society Colorado-Wyoming Chapter, Cheyenne, Wyoming.

Coleman, M.A., Fausch, K. D. 2007. Cold summer temperature limits recruitment of age-0 Colorado River cutthroat trout. *Transactions of the American Fisheries Society* 136:1231–1244.

Coleman, M. A., & Fausch, K. D. (2007). Cold Summer Temperature Regimes Cause a Recruitment Bottleneck in Age-0 Colorado River Cutthroat Trout Reared in Laboratory Streams. *Transactions of the American Fisheries Society*, 136, 639–654.

Coleman, M.A. 2007. Cold summer stream temperatures reduce recruitment of native cutthroat trout populations. Ph.D. Dissertation. Department of Fish, Wildlife, and Conservation Biology, Colorado State University.

Coleman, M.A. 2007. Life-history and ecology of the greenback cutthroat trout. Report to the U.S. Fish and Wildlife Service, The Greenback Cutthroat Trout Recovery Team, the Colorado Natural Heritage Program, and Colorado State University.

Coleman, M.A. 2007. (Presentation) Climate change & native trout. What does the future hold for native cutthroat trout in Rocky Mountain National Park. Rocky Mountain National Park Climate Change Adaptations Workshop, Estes Park, Colorado.

Coleman, M.A., Fausch, K.D. 2006. The role of cold summer temperatures in translocation success in native cutthroat trout in high elevation Colorado streams. Final Report to the Central Utah Completion Act, Colorado Division of Wildlife, and USDA Forest Service.

Coleman, M.A., Fausch, K.D. 2005. (Presentation) Can cold summer temperatures reduce recruitment of cutthroat trout and explain differences in translocation success? National Meeting of the American Fisheries Society, Anchorage, Alaska.

Coleman, M.A., Fausch, K.D. 2004. (Presentation) Can low summer water temperature cause recruitment bottlenecks in translocated cutthroat trout populations? Meeting of The Colorado-Wyoming Chapter of the American Fisheries Society, Fort Collins, Colorado (Mar. 7 – 10, 2005).

Millspaugh J.J., **Coleman M.A.**, Bauman P.J. et al. 2000. Serum profiles of American Elk, *Cervus elaphus*, at the time of handling for three capture methods, *Canadian Field Naturalist* 114: (2) 196-200.

Coleman, M.A., Garland, T., Jr., Marler, C.A. et al. 1998. Glucocorticoid Response to forced exercise in laboratory house mice (Mus domesticus), *Physiology & Behavior* 63(2):279-285.

Kimberly Mihelich

Source Water Protection Specialist • Northern Colorado Water Conservancy District
220 Water Avenue, Berthoud, CO 80513 • kmihelich@northernwater.org • 303-827-4692

Professional Experience

Northern Colorado Water Conservancy District, Berthoud, CO **December 2019 – Present**
Source Water Protection Specialist

I am responsible for coordinating source water protection and forest health projects for Northern Water. I collaborate with internal and outside agencies and groups to enhance Northern Water's efforts in source water protection and forest health and support the Water Quality Department's effort to prepare for emergencies that could affect its source water supply.

General Duties and Responsibilities

- Serves as the Northern Water Representative on various coalitions, committees, partnerships, and working groups related to source water protection and forest health.
- Develops cooperative relationships with various stakeholders interested in source water protection and forest health.
- Supports other departments with project management activities related to the management of natural resources such as NEPA processes, wetlands mitigation and other project mitigation activities.
- Communicates effectively with federal, state, county, and local agencies, and non- governmental organizations
- Organizes and facilitates meetings; prepares documents and presentations to communicate about source water protection and forest health with Northern Water constituents (such as web material and public education presentations).
- Writes, applies for, and administers various grant programs benefiting source water protection and forest health and participates on state grant review committees.
- Develops and manages source water protection and forest health projects, including selection of contractors, contract negotiations; administers contracts according to Northern Water's process, implementation, schedule, budget, etc.
- Provides natural resources expertise on a variety of subjects including source water protection, forestry and wildfire, stream and watershed restoration, and ANS issues.
- Conduct, or supervise consultants for data collection, project implementation, and monitoring as it relates to the source water protection and forest health program.
- Develop source water quality protection response, protocols, and mitigation plans for emergency situations (such as a wildfire in the watershed or an oil leak in a reservoir).
- Research and prepare written technical reports and make presentations on recommendations pertaining to source water emergency response planning issues, partnerships, and projects.
- Develop cooperative relationships with various stakeholders interested in source-water emergency response planning.
- Manage source water emergency response planning projects, including stakeholders' coordination, implementation, schedule, budget, etc.

Colorado Rural Water Association, Pueblo West, CO **March 2009 – December 2019**
Source Water Protection Specialist

Spearheaded development and implementation of source water protection plans for community water systems throughout Colorado to address specific needs as outlined in the EPA 1996 Safe Drinking Water Act Amendments.

Key Projects

- Pueblo Board of Water Works & Pueblo West MD Source Water Protection Plans, 2019
    - Water sources: Surface water intakes on Pueblo Reservoir and Arkansas River
    - Priority issues: HAZMAT spills, wildfire, aquatic nuisance species
    - BMP implemented: Development of an emergency notification call-down list in conjunction with Pueblo County Office of Emergency Management
- City of Fort Collins Source Water Protection Plan, 2016
    - Water sources: Surface water intakes on Horsetooth Reservoir and Cache la Poudre River
    - Priority issues: Forest health, wildfire, historical and active mines, spills on roadways
    - BMP implemented: Development of a mine inventory and action plan and spill response plan

- Greenhorn Valley Source Water Protection Plan, 2014
    - Water sources: Surface water intakes on Greenhorn Creek
    - Priority issues: Wildfire, flooding
    - BMP implemented: Construction of new headgate and settling pond for flood mitigation and sediment control
- Sedgwick County Children's Water Festival, 2018, 2019
    - Lead organizer of event held for elementary-aged children from grades 3-6
    - 305 students from five schools and 15 presenters participated in event

Education

Colorado State University (CSU), Fort Collins, CO, B.S., Microbiology **Aug. 2003 – May 2006**

Jennifer L. Wellman
The Nature Conservancy
PO Box 955
Hayden, CO 81639

cell: (505) 235-6280
email: jennifer.wellman@tnc.org

Ms. Wellman is the Freshwater Technical Project Manager for The Nature Conservancy in Colorado. She oversees projects in river and ecosystem restoration, diversion and irrigation rehabilitation, integrated water management planning, and watershed protection throughout the Upper Colorado River Basin. She develops and implements projects with agricultural partners, federal, state and local governments, and local conservation organizations to optimize water management and drought-climate resilience. Prior to joining The Nature Conservancy, she was a science program coordinator for the University of Wyoming, an environmental consultant to private landowners and federal agencies, and hydrologist for the Pueblo of Santa Ana in New Mexico. She has broad technical expertise in community outreach, socio-hydrologic monitoring, watershed science, and riparian restoration using holistic, systems solutions to locally-driven water projects.

EDUCATION

University of Wyoming - Instructional Technology (MS)
Wyoming Center for Environmental Hydrology and Geophysics

USACE Wetland Delineation Certification – Albuquerque, NM

Colorado State University - Fort Collins, CO – Watershed Science (MS Program)

University of Arizona - Tucson, AZ – Geography & Women's Studies (BA)

School for International Training – Nepal Program

EXPERIENCE

Current	Freshwater Technical Project Manager, The Nature Conservancy, Colorado
2014 – 2019	Senior Program Coordinator, Wyoming EPSCoR, Fort Washakie, WY
2012 – 2014	Extension Educator, University of Wyoming, Wind River Reservation
2012 – 2014	Owner, Wellman Water Consulting, Lander, WY
2001 – 2012	Water Resources Division Manager, Pueblo of Santa Ana, NM
1999 – 2001	Hydrologist, New Mexico Environment Department, Santa Fe, NM

SELECT PROFESSIONAL SERVICE

Current	Yampa River Fund, Advisory Technical Committee Member
Current	Ditch and Reservoir Company Alliance, Board Member
2016-2019	Wind River Native Advocacy Center, Board Member
2017-2019	MakerSpace 307, Board Member

Bios and CVs of Team Members

DAVID JONATHAN COOPER

I am a broadly trained ecologist specializing in interdisciplinary research to inform resources management and restoration. I work on studies of vegetation, ecophysiology, hydrology, soils, carbon dynamics, wildlife-vegetation interactions and restoration needs and solutions. I have worked in RMNP for 34 years, and have focused much of my work in the Colorado River watershed. I and many graduate students have collaborated with RMNP on many dozens of projects over the years and I serve as an expert for the park on riparian ecology and restoration topics. I have worked in more than 30 national park units across the US and with every federal agency that manages land and water. I also work for state and local governments, private organizations including water management districts, ski areas, homeowners associations, environmental organizations and many non-profits. I have a global research program in mountain wetlands, specializing in the Andes, Carpathians, Tibet and Alaska. I am on national panels with Federal agencies addressing wetland delineation.

EDUCATION

Ph.D. University of Colorado, May 1983. Biology
B.A. University of Colorado, May 1975. Environmental Biology

EXPERTISE

Wetland and riparian ecosystems studies, wetland and riparian restoration, wetland flora and vegetation analysis, wetland hydrology-vegetation interactions

CURRENT POSITIONS

Senior Research Scientist/Professor, Department of Forest and Rangeland Stewardship, Colorado State University, Fort Collins, Colorado USA 80523 Phone: 970-491-5430 *David.Cooper@colostate.edu*
Faculty, Graduate Degree Program in Ecology, Colorado State University, Fort Collins, Colorado USA 80523.
Adjunct Professor, Department of Geography and Environmental Management, University of Waterloo, Waterloo, Ontario, CANADA
Visiting Professor, Departmento de Recursos Hidricos, Facultad de Ingenieria Agricola, Universidad Nacional Agraria la Molina, Lima, PERU
Professorship under the Chinese Academy of Sciences President's International Fellowship Initiative, Chengdu, CHINA

National Park Service Awards

2014 - Stewardship Award, Rocky Mountain National Park, US National Park Service.
2013 - Project Team Award, Rocky Mountains Cooperative Ecosystems Studies Unit (RM-CESU), US National Park Service
2007 - Intermountain Region's 2007 Natural Resources Research Award, National Park Service.
2004 - Special Achievement Award, Great Sand Dunes National Monument, National Park Service
2004 - Certification of Appreciation, National Park Service, Water Resources Division
2004 - Abandoned Mine Reclamation award for restoration of the Snake River Gravel Pit Office of Surface Mining, Grand Teton National Park, Wyoming
2003 - Intermountain Regional Director's Award 2003 for research to support natural resource management, National Park Service

I have been principal or co-principal investigator on over 270 sponsored research grants/contracts at CSU totaling more than $15 million - a few current/recent projects are listed below.

2018-2022 – Fen reclamation in the Alberta Oil Sands. Suncor Energy, Alberta, Canada. $675,000.
2018-2020 – Measuring land use impact to peatland hydrology, water chemistry, and vegetation.

Implications for peatland management, restoration and conservation. State of Washington Natural Heritage Program and EPA Region VIII. $66,000.
2018-2020 – Assessing the effects of the Mount Evans highway on wetlands. Colorado Department of Transportation. $135,000.
2017-2021 - LTREB Renewal: Understanding controls and state-transition on Yellowstone's northern range. N.T. Hobbs, D.J. Cooper, D. Smith, G. Sprong. National Science Foundation of the U.S. $475,000.
2016-2017 – Developing a database and concepts for wetland restoration in national park units in the NPS intermountain region. US National Park Service. $200,000.
2016-2017. Analysis of stream diversion effects on riparian vegetation. Great Basin National Park, Nevada. US. National Park Service. $73,000
2015-2020 – Restoring the carbon accumulation function of Tuolumne Meadows, Yosemite National Park, California. State of California and Yosemite National Park. $527,000
2015-2018 – Resource assessment, restoration and erosion control at Navajo National Monument, Arizona. US National Park Service. $98,000.
2015-2016. Assessment of stream crossing impacts to ephemeral streams on military lands throughout the southwestern U.S. Department of Defense, Legacy Resource Management Program. $129,442. Legacy Project 15-774.

RELEVANT PUBLICATIONS

Rolf O. Peterson, Robert L. Beschta, David J. Cooper, N. Thompson Hobbs, Danielle Bilyeu Johnston, Eric J. Larsen, Daniel R. MacNulty, Kristin N. Marshall, Luke E. Painter, William J. Ripple, Douglas W. Smith and Evan C. Wolf. 2020. Chapter 16. *Indirect effects of carnivore restoration on vegetation*. 25 years of wolves in Yellowstone National Park. IN: Yellowstone Wolves: Reintroduction, Ecology, Behavior, and Conservation. Edited by D. Smith, D. Stahler and D. MacNulty. University of Chicago Press. In Press.

Westbrook, C.J., D.J. Cooper, D. Butler. 2013. Beaver hydrology and geomorphology. In: *Treatise on Geomorphology - Ecogeomorphology* (Butler, D. and Hupp, C., eds.), Elsevier: San Diego.

Hobbs N. T. & Cooper**,** D.J. 2013**.** *Have Wolves Restored Riparian Willows in Northern Yellowstone*? In: "Yellowstone's Wildlife in Transition". Edited by P.J. White, R. Garrott, G. Plumb. Harvard University Press. Pp. 179-194.

Schook, D., A. Borkenhagen, P. McDaniel, J. Wagner, D.J. Cooper. *2019.* Soils and hydrology drive wet meadow formation and approaches to restoration in the western USA. *Wetlands* https://doi.org/10.1007/s13157-019-01200-8

Sueltenfuss, J. & D. J. Cooper. 2019. A new approach for hydrologic performance standards for wetland mitigation. *Journal of Environmental Management.* 231:1154-1163.

Westbrook, C.J., D. J. Cooper, C. Anderson. 2016. Alteration of hydrogeomorphic processes by invasive beavers in southern South America. *Science of the Total Environment* 10.1016/j.scitotenv.2016.09.045

Chimner, R.C, D. J. Cooper, F. Wurster, L. Rochefort. 2016. An overview of peatland restoration in North America, where are we after 25 years. *Restoration Ecology* doi: 10.1111/rec.12434.

E. W. Schweiger, J. B. Grace, D. J. Cooper, M. Britten, B. Bobowski. 2016. Beyond bioassessment: How does human disturbance influence wetland ecological integrity in Rocky Mountain National Park? *Ecosphere* 7: e01548. 10.1002/ecs2.1548.

Kaczynski, K., D. J. Cooper, W. Jacobi. 2014. Interactions of sapsuckers and Cytospora canker can facilitate decline of riparian willows. *Botany* 92: 485-493.

Marshall, K., D. J. Cooper, N. T. Hobbs. 2014. Interactions among herbivory, climate, topography, and plant age shape riparian willow dynamics in northern Yellowstone. *Journal of Ecology* doi: 10.1111/1365-2745.12225

Schimelpfenig, D., D. J. Cooper, R. Chimner. 2014. Effectiveness of ditch blockage for restoring hydrologic and soil processes in mountain peatlands. *Restoration Ecology*. 22, 257-265.

Marshall, K., NT Hobbs, D.J. Cooper. 2013. Stream hydrology limits recovery of riparian ecosystems after wolf reintroduction. *Proceedings of the Royal Society, B.* 280 20122977; doi:10.1098/rspb.2012.2977

Johnston, D., D.J. Cooper, N. T. Hobbs. 2011. Relationships between groundwater use, water table, and recovery of willow on Yellowstone's northern range. *Ecosphere* 2: article 20.

Westbrook, C., D. J. Cooper, B. Baker. 2011. Beaver Assisted River Valley Formation. *River Research and Applications* 27: 247-256.

Bilyeu, D., D. J. Cooper, N. T. Hobbs. 2008**.** Water tables constrain height recovery of willow on Yellowstone's Northern Range. *Ecological Applications* 18:80-92.

Johnston, D.B., D.J. Cooper, N.T. Hobbs. 2007. Elk browsing increases aboveground growth of water stressed willows by modifying plant architecture. *Oecologia* 154:467-478.

Wolf, E. C. D.J. Cooper, N.T. Hobbs. 2007**.** Beaver, streamflow and elk influence willow establishment and floodplain stability on Yellowstone's northern range. *Ecological Applications* 17:1572-1587.

Westbrook, C., D. J. Cooper, B. Baker. 2006**.** Beaver dams and floods in controlling hydrologic processes of a mountain valley. *Water Resources Research* 42: W06404, doi:10.1029/2005WR004560

Cooper D.J., J. Dickens, N. T. Hobbs, L. Christensen, L. A. Landrum. 2006**.** Hydrologic, geomorphic and climate controls on willow establishment in a montane ecosystem. *Hydrological Processes* 20: 1845-1864.

Woods, S. W. and D. J. Cooper. 2005. Hydrologic Factors Affecting Willow Seedling Establishment along a Subalpine Stream, Colorado, USA. *Arctic, Antarctic and Alpine Research* 37: 636-643.

Gage, E.A. & Cooper, D.J. 2004. Controls on willow cutting survival in a montane riparian area. *Journal of Range Management.* 54: 597-600.

Gage, E. A. & Cooper, D. J. 2004**.** Constraints on willow seedling establishment in a Rocky Mountain montane riparian floodplain. *Wetlands* 24**:**908-911.

Chimner, R.A. and, D.J. Cooper. 2003. Carbon balances of pristine and hydrologically modified southern Rocky Mountain fens. *Canadian Journal of Botany* 81:477-491.

Cooper, D.J., L.H. MacDonald, S.K. Wenger, S. Woods. 1998. Hydrologic restoration of a fen in Rocky Mt. National Park, Colorado. *Wetlands* 18: 335-345.

Cooper, D. J. 1990. The ecology of wetlands in Big Meadows, Rocky Mountain National Park, Colorado: the correlation of vegetation, soils and hydrology. *US Department of the Interior, Fish and Wildlife Service*, Biological Report 90(15). October 1990. 45p.

BRUCE W. BAKER
2530 Newport Dr, Fort Collins, CO 80526; bwbaker1967@gmail.com; 970-227-1860 (c); 970-484-6863 (h)

Work Experience

Research Wildlife Biologist (Jan 1990 – Mar 2007) Fort Collins Science Center, US Geological Survey, Fort Collins, Colorado, (formerly US Fish and Wildlife Service, National Biological Service).

Principal Investigator for a series of studies on beaver ecology in RMNP and Douglas Creek in NW Colorado. Training included Rosen's course on Applied Fluvial Geomorphology.

Wildlife Management Biologist (Jul 1979 – Dec 1999) Bureau of Land Management (BLM), Rock Springs and Kemmerer, Wyoming, USA. Work included the restoration of incised streams under intense cattle grazing by using large fenced exclosures, willow plantings, and the reintroduction of beaver at simulated beaver structures (check dams) that were supplemented with aspen for use as beaver food caches and as building material for dams and lodges.

Education

Ph.D. – Wildlife Ecology, Texas A&M University (1979)
M.S. – Wildlife Management, Humboldt State University (1977)
B.A. – Biology, California State University, Northridge (1971)

Publications

Baker BW, HC Ducharme, DCS Mitchell, TRM Stanley, HR Peinetti. 2012. Competition favors elk over beaver in a riparian willow ecosystem. *Ecosphere* 3(11):1-15.

Peinetti HR, BW Baker, MB Coughenour. 2009. Simulation modeling to understand how selective foraging by beaver can drive the structure and function of a willow community. *Ecological Modelling* 20:998-1012.

Westbrook CJ, DJ Cooper, BW Baker. 2006. Beaver dams and overbank floods influence groundwater-surface water interactions of a Rocky Mountain riparian area. *Water Resource Research* 42(6):1-12.

Baker BW, HC Ducharme, DCS Mitchell, TRM Stanley, HR Peinetti. 2005. Interaction of beaver and elk herbivory reduces standing crop of willow. *Ecological Applications* 15:110-118.

Baker BW. 2005. Efficacy of tail-mounted transmitters for beaver. *Wildlife Society Bulletin* 34:218-222.

Baker, BW, HC Ducharme, DCS Mitchell, TRM Stanley, HR Peinetti. **2004.** Why aren't there more beaver in Rocky Mountain National Park? *Proceedings of the Annual Conference of the Colorado Riparian Association* 17:85-90.

Williams CL, SW Breck, BW Baker. 2004. Genetic methods improve accuracy of gender determination in beavers. *Journal of Mammalogy*:1145-1148.

Baker BW. **2003.** Beaver (*Castor canadensis*) in heavily browsed environments. *Lutra* 46:173-181.

Baker BW, E P Hill. **2003.** Beaver (*Castor canadensis*). Pages 288-310 *in* GA Feldhamer, BC Thompson and JA Chapman, eds. *Wild Mammals of North America: biology, management, and conservation.* Second Edition. Johns Hopkins University Press, Baltimore, Maryland.

Baker BW, BS Cade. **1995**. Predicting biomass of beaver food from willow stem diameters. *Journal of Range Management* 48:322-326

Baker BW, DL Hawksworth, JG Graham. **1992**. Wildlife habitat response to riparian restoration on the Douglas Creek watershed. *Proceedings of the Annual Conference of the Colorado Riparian Association* 4:62-80.

Apple LL, BH Smith, JD Dunder, BW Baker. **1985**. The use of beavers for riparian/aquatic habitat restoration of cold desert, gully-cut stream systems in southwestern Wyoming. Pages 123-130 in G. Pilleri (ed.) *Investigations on beavers*, Vol. IV, Brain Anatomy Institute, Berne, Switzerland.

Brett L. Bruyere, PhD

Education

Washington State University	Political Science (BA)	1996
Colorado State University	Natural Resources (MS)	1999
Colorado State University	Human Dimension of Natural Resources (PhD)	2002

Appointments

Instructor, *Colorado State University (CSU) Human Dimension of Natural Resources Dept. 2003-07*
Assistant professor, *CSU Human Dimension of Natural Resources Dept. 2007-11*
Associate Professor, *CSU Human Dimension of Natural Resources Dept.* 2011- current

Selected Publications

Porzecanski, A., Sterling, E., Copsey, J., Appleton, M., Bruyere, B. L., Bynum, N., Farmer, K., Finchum, R., Rakotobe, D., Stanoss, R., Valdés-Velásquez, A. (in press). Systems framework for planning and evaluating capacity development in conservation: Recommendations for practitioners. *Oryx*.

Webb, S.[1], Bruyere, B. L., Halladay, M.[1], & Walker, S.E.[1] (in press). A framework for conceptualizing leadership in conservation. *Oryx*.

Stafford, N. T., Welden[1], R., & Bruyere, B. L. (2018). Media reporting of conflict between wildlife and people spending time in nature. *Wildlife Society Bulletin*, 42(2), 246-253.

Thomas[1], R., Teel, T., & Bruyere, B L. (2018). Metrics and outcomes of conservation education: A quarter century of lessons learned. *Environmental Education Research, 25*(2), 172-192.

McCoy[1], C., Bruyere, B.L., & Teel, T. (2016). Qualitative measures of wildlife value orientations with a diverse population in New York City. *Human Dimensions of Wildlife, 21*(3), 223-239.

Bruyere, B. L. (2015). Giving direction and clarity to "conservation leadership." *Conservation Letters*, *8*(5), 378-382.

Schweizer[1], S., Thompson, J., Teel, T., & Bruyere, B. (2009). Strategies for communicating about climate change impacts on public lands. *Science Communication*, *31*(2), 266-274.

Bruyere, B. L., & Rappe[1], S. (2007). The motivations of outdoor volunteers. *Journal of Environmental Planning and Management, 50*(4), 503-516.

Selected Courses Taught as Primary Instructor

NR 220, Natural Resource Measurements, a four-week summer field course to teach students taxonomy and fundamentals of natural resource sampling methods. Co-taught with four instructors on topics related to geographic positioning systems, orienteering and map reading, human dimensions of wildlife, tree/plant identification, and soil and vegetation impact measurements.

NR 440, Land Use Planning, a course designed to equip students with strategies for planning ecologically and economically viable communities. Course topics include planning processes, natural resource constraints and opportunities, conservation easements and other planning tools, and strategies to balance land use goals related to growth, agriculture, open space, sense of place and environmental services.

NR 549, Conservation Leadership, a graduate course in the Conservation Leadership through Leadership program focused on leadership skills, environmental conflict, communication tools and principles, and strategies for catalyzing change.

NRRT 262, Environmental Communication, an introductory course to basic principles of communication, public involvement, environmental education and social marketing as it relates to natural resources.
NRRT 301, C**onservation Leadership** is a required course of third year students developed in part as a response to an employer survey by our department about desirable skills and knowledge of new employees at the level of a recent college graduate. This pointed to a need for skills around selfawareness, collaborative processes, adaptability and managing uncertainty, all of which are key areas of the course.
NRRT 462, Environmental Communication, a senior level capstone course that addresses how to effectively communicate about complex issues with diverse audiences. Includes communication, education and cognitive processing theory; communication plan development; communication strategies; and media relations.

Synergistic Activities

1. ***Director, Conservation Leadership Masters Graduate program (CSU):*** responsible for curriculum review and revision; strategic planning of co- and extra-curricular activities to complement formal instruction; evaluation with alumni and employers of alumni; supervising coordination of faculty activities to support student learning.
2. ***Member, Warner College of Natural Resources Diversity and Inclusion Committee (CSU)***. Contributing member of advisory committee to the Dean on issues of recruitment, retention and college climate, with an emphasis on defining strategies and responding to relevant events as they occur at national, state, local and university scales that influence student experiences and potential to be fully engaged learners.
3. ***Training Developer, Pathways Human Dimensions of Wildlife Conference (2016; 2020),*** co-coordinate and advise on development, recruitment of participants and delivery of training to 60+ early career conservation professionals from sub-Saharan Africa on topics related to collaborative conservation, leadership, conservation planning and community development.
4. ***Co-Investigator*** for National Geographic Society ***Landscape of Conservation CapacityBuilding*** project (February to November 2019), a collaborative effort with American Museum of Natural History to identify conservation leadership capacity needs in biodiversity hotspots around the world, and develop recommendations for programming.

Sara L. Rathburn, PhD

Professor of Geology

Department of Geosciences, Colorado State University, Ft Collins, CO 80523-1482

Proposed responsibility and function on study team: Lead Geomorphologist

Background and education:
BS, Earth Resources, Colorado State University, 1985
MS, Geosciences, University of Arizona, 1989
PhD, Earth Resources, Colorado State University, 2001
Adjunct Instructor, Miami University, 1993-1995
Assistant Professor, Colorado State University, 2001-2007
Associate Professor, Colorado State University, 2008-2019
Professor, Colorado State University, 2020-present

Relevant experience:
I began research in Rocky Mountain National Park (RMNP) in 2003, and have been actively involved in investigating the hydraulics, sediment transport, channel morphologic change, wood loading and channel restoration on the Upper Colorado River as a result of a debris flow that initiated from Grand Ditch in May 2003. In addition, I research the evolution of glacial valleys and conducted ground penetrating radar surveys in the Lulu City wetland to determine post-glacial alluviation. My other research interests focus on mass movement, channel-vegetation interactions within riparian forests, removal of invasive vegetation, and afforestation efforts to stabilize channel banks. I have advised five graduate students on research projects in RNMP.

The following papers and theses are relevant to this project: (* indicates student author)

Rathburn, S., Patton*, A., and Bilderback, E., 2019, Historical debris-flow occurrence in Rocky Mountain National Park, CO, *in* Kean, J., Coe, J., Santi, P., and Guillen, B., eds., Debris-Flow Hazards Mitigation: Mechanics, Monitoring, Modeling, and Assessment, Association of Environmental and Engineering Geologists Special Publication 28:816-823.

Sparacino*, M., Rathburn, S., Singha, K., Covino, T., and Ronayne, M., 2019, Form-based channel restoration decreases hyporheic exchange: Lessons learned from monitoring the Upper Colorado River, *Earth Surface Processes and Landforms* 44(1):191-203, doi:10.1002/esp.4525.

Patton*, A., Rathburn, S., Bilderback, E., and Lukens*, C., 2018, Patterns of debris flow initiation and periglacial sediment sourcing in the Colorado Front Range, *Earth Surface Processes and Landforms* 43:2998-3008, doi:10.1002/esp.4463. (Editor's Choice in 2018).

Rathburn, S.L., and Putman, J.M., 2018, Connecting students and mentors through local research hubs, *Eos* 99:19-23, doi.org/10/1029/2018EO101511.

Rathburn, S., Shahverdian*, S., and Ryan, S., 2018, Post-disturbance sediment recovery: Implications for watershed resilience, *Geomorphology* 305:61-75, doi.org/10.1016/j.geomorph.2017.08.039

Grimsley*, K., Rathburn, S., Friedman, J., and Mangano*, J., 2016, Debris flow occurrence and sediment persistence, Upper Colorado River Valley, Rocky Mountain National Park, *Environmental Management*: 58(1):76-92, doi:10.1007/s00267-016-0695-1.

Rathburn, S.L., Rubin*, Z.K., and Wohl, E.E., 2013, Evaluating channel response to an extreme sedimentation event in the context of historical range of variability: Upper Colorado River, Rocky Mountain National Park, Colorado, *Earth Surface Processes and Landforms* 38:391-406, doi:10.1002/esp.3329.

Rubin*, Z.K., Rathburn, S.L., Wohl, E.E., and Harry, D.H., 2012, Historic range of variability in geomorphic processes as a context for restoration: Rocky Mountain National Park, Colorado, *Earth Surface Processes and Landforms* 37:209-222, DOI:10.1002/esp.2249.

Mangano, J. 2014, Evaluating channel morphologic changes and bed-material transport using airborne LiDAR, Upper Colorado River, Rocky Mountain National Park, CO, MS Thesis, Colorado State University, 91 p.

Van*, B, Merrill*, J., and Rathburn, S., 2016, Instream wood loading and log jam spacing on the Upper Colorado River, Rocky Mountain National Park, unpublished report and poster presented at the Celebrating Undergraduate Research Symposium.

I served as an expert witness and provided technical review of reports in a Natural Resource Damage claim brought by the DOJ. For this work, I developed baseline geomorphic analyses, monitored flow, sediment transport and channel change from 2003-2007 in preparation for restoration, and developed restoration plans for a 2-km reach of the Upper Colorado River impacted by the debris flow and post-event sediment erosion and deposition.

My research in the park was featured in a Rocky Mountain National Park Centennial Celebration Video *Wilderness, Wildlife, Wonder*– by Fall River Productions; in an invited lecture as part of the Centennial Science Behind the Scenery Celebration; and numerous invited seminars at other universities.

Media coverage of my research in RMNP includes:

Rocky Mountain National Park Post-Flood Research video
https://www.nps.gov/rlc/continentaldivide/current-research.htm

Additionally, the site in RMNP served as a research hub for undergraduate research projects and experience (see Rathburn and Putman, 2018 *Eos*).

Other relevant experience includes monitoring fine sediment storage and channel change along two reaches restored by consultants after the 2013 flood on Fish Creek for the Estes Valley Wa

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EXPERIENCE

Center for Collaborative Conservation, Colorado St. Univ., Fort Collins, CO 2019 – Present
I became the Director of the Center for Collaborative Conservation in September 2019. I lead all aspects of the program as we support people and communities to solve conservation challenges through transformative research and education.

The Nature Conservancy of Colorado, Boulder, CO 2005 – 2019
Joined their team in 2005 as a Conservation Ecologist and narrowed my focus to Senior Freshwater Scientist in 2007. In 2009, added the title of Water Program Director. Since 2007, worked with the Colorado Water Conservation Board, Basin Roundtables, US Fish and Wildlife Service, and many other partners to solve environmental and recreation water challenges in wetlands and rivers throughout Colorado and the Colorado River Basin. In 2015, assumed responsibility for TNC's entire science program as Director of Science.

Paluster Environmental Services, Fort Collins, CO 1998 – 2005
As principal and chief scientist, conducted a wide range of studies and projects in botany, plant ecology and hydrology, and managed all aspects of a small business.

Dr. David Cooper, Boulder, Colorado 1999 – 2003
Co-Principal Investigator on a long-term study of evapotranspiration that underpins a major component of the model used to manage groundwater in the San Luis Valley.

Colorado Natural Heritage Program, CSU, Fort Collins, CO 1994 – 1998
Hired to develop a plant community classification for a portion of Colorado's West Slope to characterize and prioritize Colorado's most biologically significant wetlands. In 1997, promoted to lead the community ecology staff of 15 scientists. Represented The Nature Conservancy to define and select projects for the $10.5 million Colorado Wetlands Initiative that protected over 15,000 acres of wetlands.

EDUCATION

Ph.D. in Ecology, 2006
Graduate Degree Program in Ecology, Colorado State University, Fort Collins, CO 80521
Dissertation: Hydrology and conservation of intermountain wetlands

Master of Science in Botany/Field Naturalist Program, 1994
University of Vermont, Burlington, VT

Graduate Study in Environmental Engineering, 22 semester credit hours completed
Purdue University, West Lafayette, IN

Bachelor of Science in Aeronautical and Astronautical Engineering, 1986
Purdue University, West Lafayette, IN

ADDITIONAL RELEVANT TRAININGS

Culture of Philanthropy / Philanthropy by Design, The Nature Conservancy, 2017-2018
Leadership Excellence – Continuing Education, The Nature Conservancy, 2016
Negotiation and Leadership, Program on Negotiation at Harvard Law School, 2015

Leadership Excellence Program, The Nature Conservancy, 2014 - 2015
Emerging Leaders Program, The Nature Conservancy, 2009 - 2010

PUBLICATIONS (Representative only)

Sanderson, J.S., C. Beutler, J.R. Brown, I.C. Burke, T.B. Chapman, R.T. Conant, J.D. Derner, et al. Cattle, conservation and carbon in the Western Great Plains. *In press*. Addington, R.N., B.G. Tavernia, M.D. Caggiano, M.P. Thompson, J.D. Lawhon, and J.S. Sanderson. 2020. Identifying opportunities for the use of broadcast prescribed fire on Colorado's Front Range. Forest Ecology and Management 458 (2020) 117655 https://doi.org/10.1016/j.foreco.2019.117655

Sanderson, J.S., C. Beutler, J.R. Brown, I.C. Burke, T.B. Chapman, R.T. Conant, J.D. Derner, et al. 2020. Cattle, conservation and carbon in the Western Great Plains. Journal of Soil and Water Conservation 75(1):5A-12A. doi:10.2489/jswc.75.1.5A.

Bestgen, K.R., N.L. Poff, D.W. Baker, B.P. Bledsoe, D.M. Merritt, M. Lorie, G.T. Auble, J.S. Sanderson, B.C. Kondratieff. 2019. Designing flows to enhance ecosystem functioning in heavily altered rivers. https://doi.org/10.1002/eap.2005

Perkin, J.S., K.B. Gido, J.A. Falke, K.D. Fausch, H. Crockett, E.R. Johnson, and J. Sanderson. 2017. Groundwater declines are linked to changes in Great Plains stream fish assemblages. PNAS 114(28): 7373-7378. https://doi.org/10.1073/pnas.1618936114

Wilding, T.K., B. Bledsoe, N.L. Poff, and J. Sanderson. 2014. Predicting habitat response to flow using generalized habitat models for trout in Rocky Mountain streams. River Research Applications 30: 805–824. DOI: 10.1002/rra.2678

Sanderson, J.S., N. Rowan, T. Wilding, B.P. Bledsoe, W.J. Miller and N.L. Poff. 2012. Getting to scale with environmental flow assessment: the Watershed Flow Evaluation Tool. River Research and Applications 28:1369–1377.

Rathburn, S.L., D.M. Merritt, E.E. Wohl, J.S. Sanderson, and H.A.L. Knight. 2009. Characterizing environmental flows for maintenance of river ecosystems: North Fork Cache La Poudre River, Colorado, in James, L.A., S.L. Rathburn, and G.R. Whittecar, eds., Management and Restoration of Fluvial Systems with Broad Historical Changes and Human Impacts, Geological Society of America Special Paper 451, p.143-157, DOI:10.1130/2009.2451(10)

Sanderson, J., B. Bledsoe, N.L. Poff, T. Wilding, W. Miller, and N. Fey. 2012. Colorado Basin Roundtable Watershed Flow Evaluation Tool study. Prepared by CDM Smith for the Northwest Colorado Council of Governments.

Sanderson, J., B. Bledsoe, N.L. Poff, T. Wilding, and N. Fey. 2012. Yampa-White Basin Roundtable Watershed Flow Evaluation Tool study. Prepared by CDM Smith for The Nature Conservancy.

Jeremy Robert Shaw

Department of Forest and Rangeland Stewardship, Colorado State University
Campus Delivery 1472, Fort Collins, CO 80523
Cell: (303) 242-7620 | jeremy.shaw@colostate.edu

Education
Ph.D. Ecology, Colorado State University (2015)
M.S. Watershed Science, Colorado State University (2006)
B.S. Forest Environmental Resources, University of Georgia (2000)

Recent Positions
2015-present: Research Scientist I, Colorado State University, Fort Collins CO
2010-2015: Graduate Research Associate, Colorado State University, Fort Collins CO
2007-2010: Water Resources Specialist, Arizona Department of Water Resources, Phoenix AZ
2006: Watershed Coordinator, Division of Environmental Quality, Saipan, CNMI (US)

Recent Grants
2019-2020. Hydrologic drivers of peatland development and carbon accumulation in western Washington. Colorado Water Center. $25,000.
2019-2021. Wetland identification and delineation in Grand Canyon National Park, Arizona. National Park Service. $42,000.
2018-2021. State Highway 5 (Mount Evans Road) Summit Lake Wetland and Hydrology Study. Colorado Department of Transportation. $135,000.
2018-2020. Measuring land use impacts to peatland hydrology, water chemistry, and vegetation: Implications for peatland management, restoration, and conservation. Subcontract from Washington Department of Natural Resources. $67,000.
2018-2021. Ecohydrological impacts of roads in arid environments: Interruption of Sheetflow pathways. National Park Service, Border Resource Protection Program. $47,000.
2016-2018. Development of Science-Based Mitigation Monitoring Plan Guidance, Protocols and Technical Standards - Hydrology Performance Standards. U.S. Army Corps of Engineers. $37,000.
2015-2019. Resource assessment, restoration, and erosion control at Navajo National Monument. National Park Service. $98,000.
2015-2018. Assessment of stream crossing impacts to ephemeral streams on military lands throughout the southwestern United States. U.S. Department of Defense, Legacy Program. $129,000.
2014-2017. Riparian restoration demonstration on the Howard Catonment Area of Yuma Proving Ground. U.S. Army Corps of Engineers. $73,000.

Selected Publications
Shaw, J.R., and J. Sueltenfuss. *In preparation*. Land use impacts to wetlands of the United States. *To be submitted to* Wetlands.
Nichols, M.H., W.K. Brandau, and **J.R. Shaw.** *In revision.* Unintended consequences of rangeland conservation structures. *Submitted to* Journal of Soil and Water Conservation.
Shaw, J.R., and D.J. Cooper. *In revision*. Relative importance of abiotic and biotic limitations to seedling establishment of Sonoran Desert trees. *Submitted to* Journal of Ecology.
Shaw, J.R., D.J. Cooper, and N.A. Sutfin. 2018. Applying a hydrogeomorphic stream channel classification to understand spatial patterns in riparian vegetation. Journal of Vegetation Science 29: 550-559.

Kampf, S.K., J. Faulconer, **J.R. Shaw**, M. Lefsky, J.W. Wagenbrenner, D.J. Cooper. 2018. Rainfall thresholds for streamflow generation in desert ephemeral streams. Water Resources Research 54: 10.1029/2018WR023714.

Nichols, M.H., C. Magirl, N.F. Sayre, and **J.R. Shaw**. 2018. The geomorphic legacy of water and sediment control structures in a semiarid rangeland watershed. Earth Surface Processes and Landforms 43: 909-918.

Kampf, S.K., J. Faulconer, **J.R. Shaw**, D.J. Cooper, and N.A. Sutfin. 2016. Rain and channel flow supplements to subsurface water beneath hyper-arid ephemeral stream channels. Journal of Hydrology 536: 524-533.

Shaw, J.R. 2015. Multi-scale drivers of riparian vegetation form and function in ephemeral stream networks of the Sonoran Desert. PhD dissertation. Colorado State University.

Sutfin, N.A., **J.R. Shaw**, E.E. Wohl, and D.J. Cooper. 2014. A geomorphic classification of ephemeral channels in a mountainous, arid region, southwestern Arizona, USA. Geomorphology 221: 164-175.

Shaw, J.R., and D.J. Cooper. 2008. Linkages among watersheds, stream reaches, and riparian vegetation in dryland ephemeral stream networks. Journal of Hydrology 350: 68-82.

Shaw, J.R. 2006. Watershed and stream reach characteristics controlling riparian vegetation in semiarid ephemeral stream networks. M.S. Thesis. Colorado State University.

Selected Technical Reports

Wolf, E., and **J.R. Shaw.** 2020. Ecological site assessment and wilderness-appropriate restoration design for Log Meadow, Sequoia National Park. Prepared for American Rivers Inc.

Shaw, J.R. 2018. Chapter 4: Land use impacts to hydrology and vegetation. *In* E. Hazelton (Ed.) Manual for Hydrologic Performance Standards in Wetland Compensatory Mitigation. U.S. Army Corps of Engineers. Prepared for the National Technical Committee on Wetland Vegetation.

Shaw, J.R., and D.J. Cooper. 2017. Riparian restoration demonstration on the Howard Cantonment of the U.S. Army Yuma Proving Ground, Arizona. Prepared for U.S. Army Yuma Proving Ground.

Cooper, D.J., E.E. Wohl, S.K. Kampf, D. Harry, **J.R. Shaw**, N.A. Sutfin, and J. Faulconer. 2015. Watershed to local scale characteristics and function of intermittent and ephemeral streams on military lands. Prepared for U.S. Department of Defense, Strategic Environmental Research and Development Program. Contract # RC-1725.

Cooper, D.J., P. Brown, **J.R. Shaw**, and D. Schook. 2010. Timing and causes of cottonwood tree death along Wild Horse Creek, Clabaugh Property, Wyoming. Prepared for Noble Energy and Petro-Canada.

Shaw, J.R., and D.J. Cooper. 2010. Effects of beaver on flow in Bolt's Ditch, Cross Creek, White River National Forest. Prepared for U.S. Forest Service.

Shaw, J.R. 2010. Subflow zones of the San Pedro River watershed. Arizona Department of Water Resources, Adjudications Technical Report.

Cooper, D.J. and **J.R. Shaw**. 2009. Restoration of gravel ponds along Sand Creek. Prepared for Great Sand Dunes National Park.

Shaw, J.R. 2009. Economic geology of the Hopi Indian Reservation. Arizona Department of Water Resources, Adjudications Technical Report.

Shaw, J.R. 2008. Streamflow characteristics of the Hopi Indian Reservation. Arizona Department of Water Resources, Adjudications Technical Report.

Jeremy P. Sueltenfuss, PhD

Biography

I am trained as an ecohydrologist and take a collaborative approach to research and project implementation. My research focuses on wetland ecology and hydrology, and applies ecological science to restore degraded systems. My additional background in wildlife biology and botany provide a strong foundation in most ecological projects. My current research collaborations involve the National Park Service and the US Army Corps of Engineers. My research with the National Park Service is focused on understanding how water moves through and across our landscape, and how plants respond to this movement. I am specifically interested in how water movement has been altered through time, mostly from human modification, and how to restore historic ground and surface water flows. My research evaluates the response of dominant plant species and ecosystem processes to this hydrologic alteration and restoration. In addition to this applied research, I collaborate with the Army Corps of Engineers to provide data-driven policy advice relevant to wetland mitigation. The Army Corps of Engineers has been interested in developing new performance standards for wetland mitigation, although many questions remain as to what it means for an ecological restoration project to be deemed "successful".

Affiliation

Department of Forest and Rangeland Stewardship, Colorado State University
Graduate Degree Program in Ecology, Colorado State University

Current Job Title: Assistant Professor

Education

PhD Graduate Degree Program in Ecology, Colorado State University 2018
MS Graduate Degree Program in Ecology, Colorado State University 2012
BA Biology, Colorado College, honors 2007

Relevant Experience

Assistant Professor - Colorado State University, Dec. 2018-Present
Ecologist– Colorado Natural Heritage Program, Dec. 2012 – Aug. 2015
Graduate Research Assistant – Colorado State University, Aug. 2010 - May 2012
Research Assistant, Colorado College, May2008 – Aug. 2008
Field Ecologist- Catamount Institute for Geography of the Southern Rockies, May 2006 – Aug. 2007

Recent Grants

2019-2021. Grand Ditch Restoration Adaptive Management Monitoring, DOI-NPS-National Park Service, $115,371.00.
2019-2021. Distribution and management testing of Reed Canary Grass, DOI-NPS-National Park Service, $26,934.00.
2018-2019. Assessing baseline riparian conditions prior to any future work aimed at facilitating willow growth and beaver habitat restoration in Rocky Mountain National Park. DOI-NPS-National Park Service, $20,008.00.
2017-2018. Reconstructing historic plant communities using cores from peatlands in the Colorado Rocky Mountains. McIntire-Stennis. $22,382

2017-2018. Testing hydrologic performance standards on various wetland types using existing monitoring data. US Army Corps of Engineers. $62,940
2016-2017. Developing a framework to create hydrologic performance standards for wetland mitigation. US Army Corps of Engineers. $50,000
2016-2018. Sprague Lake Restoration Design and Monitoring in Rocky Mountain National Park. National Park Service. $36,961
2015-2017. Grand Ditch Breach Restoration Design and Monitoring. National Park Service. $20,907 2013-2014. Fort Collins River Restoration Master Planning. Fort Collins Natural Areas. $31,042
2013-2015. Colorado Wetland Tools 4: Watershed Planning Toolbox. Environmental Protection Agency. $214,908 2014. High Park Post-Fire Restoration Monitoring. JW Associates. $32,991
2014. Colorado Department of Transportation Watershed Toolbox Match. $50,000
2013. Restoration Prioritization of the Cache la Poudre Watershed, Trees Water and People. $31,851

SELECTED PUBLICATIONS

Sueltenfuss, J., Cooper, D. J. (2019). A new approach for hydrologic performance standards in wetland mitigation. JOURNAL OF ENVIRONMENTAL MANAGEMENT, 231, 1154-1163.

Cooper, D. J., Sueltenfuss, J., Oyague, E., Yager, K., Slayback, D., Cabero Caballero, E. Marcelo, Argollo, J., Mark, B. G. (2019). Drivers of peatland water table dynamics in the central Andes, Bolivia and Peru. HYDROLOGICAL PROCESSES, 33(13), 1913-1925.

Sueltenfuss, J., Cooper, D. J. (2019). Hydrologic similarity to reference wetlands does not lead to similar plant communities in restored wetlands. Restoration Ecology, 27(5), 1137-1144.

Cooper, DJ., KM Kaczynski, JP Sueltenfuss, S Gaucherand, C Hazen. 2017. Mountain wetland restoration: the role of hydrologic regime and plant introductions after 15 years in the Colorado Rocky Mountains, USA. Ecological Engineering 101: 46-59.

Hribljan, JA, DJ Cooper, JP Sueltenfuss, EC Wolf, KA Heckman, EA Lilleskov, and RA Chimner. 2015. Carbon storage and long-term rate of accumulation in high-altitude Andean peatlands of Bolivia. Mires and Peat 15: Art. 12.

Sueltenfuss, JP, DJ Cooper, RL Knight, RM Waskom. 2013. The creation and maintenance of wetland ecosystems from irrigation canal and reservoir seepage in a semi-arid landscape. WETLANDS 33(5): 799-810

SELECTED TECHNICAL REPORTS

Sueltenfuss, JP, and J Lemly. 2015. Classification for Landscape Level Wetland Functional Assessments in the Rocky Mountains. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado.

Sueltenfuss, JP, K Decker, M Fink, L Granau. 2014. Restoration Prioritization of the Cache la Poudre Watershed. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado

Sueltenfuss JP, G Smith, J Lemly. 2014. National Wetland Inventory Mapping for the Colorado Portion of the Southern Rockies Landscape Conservation Cooperative. Colorado Natural Heritage Program, Colorado State University, Fort Collins, Colorado. 1-66.

Ellen Wohl

Professor of Geology & University Distinguished Professor
Department of Geosciences, Colorado State University, Ft Collins, CO 80523-1482
Proposed responsibility and function on study team: Science advisor

Background and education:
BS, Geosciences, Arizona State University, 1984
PhD, Geosciences, University of Arizona, 1988
Postdoctoral Research Scientist, University of Arizona, 1988-1989
Assistant Professor, Colorado State University, 1989-1995
Associate Professor, Colorado State University, 1995-2000
Professor, Colorado State University, 2000-present
University Distinguished Professor, Colorado State University, 2017-present

Relevant experience:
I have been conducting research in Rocky Mountain National Park and the Colorado Front Range since joining the faculty at Colorado State University in 1989. Much of my research focuses on interactions between river geomorphology and biota, including riparian forests, downed dead wood, and beavers. I have published more than 230 peer-reviewed papers in scientific journals, including the following that are relevant to this project:

Scamardo JE, E Wohl. 2020. Sediment storage and shallow groundwater response to beaver dam analogs in the Colorado Front Range, USA. River Research and Applications 36: 398-409.
Wohl E, E Iskin. 2019. Patterns of floodplain spatial heterogeneity in the Southern Rockies, USA. Geophysical Research Letters 46: 5864-5870.
Laurel D, E Wohl. 2019. The persistence of beaver-induced geomorphic heterogeneity and organic carbon stock in river corridors. Earth Surface Processes and Landforms 44: 342-353. 214.
Wegener P, T Covino and E Wohl. 2017. Beaver-mediated lateral hydrologic connectivity, fluvial carbon and nutrient flux, and aquatic ecosystem metabolism. Water Resources Research 53: 4606-4623.
Livers B and E Wohl. 2015. An evaluation of stream characteristics in glacial versus fluvial process domains in the Colorado Front Range. Geomorphology 231: 72-82.
Polvi LE, E Wohl and DM Merritt. 2014. Modeling the functional influence of vegetation type on streambank cohesion. Earth Surface Processes and Landforms 39, 1245-1258.
Polvi L and E Wohl. 2013. Biotic drivers of stream planform – implications for understanding the past and restoring the future. BioScience 63, 439-452.
Wohl E. 2013. Landscape-scale carbon storage associated with beaver dams. Geophysical Research Letters 40, 1-6.
Polvi LE and E Wohl. 2012. The beaver-meadow complex revisited – the role of beaver in post-glacial floodplain development. Earth Surface Processes and Landforms 37, 332-346.
Kramer NR, E Wohl, and D Harry. 2012. Using ground penetrating radar to 'unearth' buried beaver dams. Geology 40, 43-46.
Polvi LE, EE Wohl, and DM Merritt, 2011. Geomorphic and process domain controls on riparian zones in the Colorado Front Range. Geomorphology 125: 504-516.

I enjoy writing about environmental science for non-specialist audiences and I have written the following books that either focus on Rocky Mountain National Park or include significant sections on the national park:
Wohl E, DN Scott, SE Yochum. 2019. Managing for Large Wood and Beaver Dams in Stream Corridors. USDA Forest Service General Technical Report RMRS-GTR-404, 136 pp.
Wohl E. 2019. Saving the dammed: why we need beaver-modified ecosystems. Oxford University Press.

Wohl E. 2016. Rhythms of change in Rocky Mountain National Park. University Press of Kansas.
Wohl E. 2015. Transient landscapes: insights on a changing planet. University Press of Colorado.
Wohl E. 2013. Wide rivers crossed: the South Platte and the Illinois of the American Prairie. University Press of Colorado.
Wohl E. 2009. Of rock and rivers: seeking a sense of place in the American West. University of California Press.
Wohl EE. 2001. Virtual Rivers: lessons from the mountain rivers of the Colorado Front Range. Yale University Press, New Haven, 210 pp.

I have also worked with the National Park Service on the project that installed beaver dam analogues on the eastern side of Rocky Mountain National Park during summer 2019.

CHERIE WESTBROOK

Biography:
Cherie Westbrook, PhD, is a Professor of Wetland Ecohydrology at the University of Saskatchewan. She is also the Director of the NSERC CREATE for Water Security, which is a value-added program that provides professional and technical skills training to 65 graduate students and postdoctoral fellows at five universities across Canada. Westbrook's research focuses on the ecohydrological processes regulating water and nutrient fluxes, and she works primarily in mountain wetlands. Recently, she has been linking her research to the field of environmental impact assessment through developing science-based tools and conceptual frameworks needed for land use planning. Westbrook has authored over 45 peer-reviewed publications on ecohydrologic topics, and multiple technical reports for government and non-profit agencies. Her research has been highlighted in general public interest periodicals including *Canadian Geographic*, *Nature*, *Smithsonian*, *New Scientist*, and *Atlantic*. Westbrook also serves as an associate editor of the *Annals of the American Association of Geographers*, and as a scientific advisor to Tr'ondëk Hwëch'in First Nation, Saskatchewan Research Council, City of Calgary, Prime Minister Trudeau, Government of Saskatchewan and Banff National Park.

Affiliation:
Department of Geography and Planning & Global Institute for Water Security
University of Saskatchewan, Saskatoon, Saskatchewan, Canada

Current Job Title: Full Professor

Education/Training
Ph.D., Colorado State University, 2005, Ecohydrology
M.Sc., University of Alberta, 2000, Environmental Biology and Ecology
Hon. B.Sc., University of Toronto, 1997, Environmental Science

Key Awards, Distinctions, Editorship
Ecohydrology, Top 10 Most Accessed Paper, 2013-14
Colorado State University, Alumna of the Year, 2011-2012
Associate Editor for Annals of the American Association of Geographers, 2018-present

Track Record of Outreach Success (current commitments)
• Advisor to Government of Yukon on development of a territorial wetlands policy.
• Advisor to Tr'ondëk Hwëch'in First Nation, Yukon on wetlands undergoing placer mining
• Invited speaker at meetings of watershed stewardship groups / NGOs.
• Advisor to City of Calgary on development of a watershed health index.

Research Funding (current only)
Principal Investigator (PI)

Title	Funding Agency (Program)	Years	Total Amount
CREATE for Water Security	NSERC (CREATE)	2016-2021	$1,650,000 CAD
No net loss? Analysis of impact assessment compensation and mitigation plans for wetlands in the BC and Yukon mining resource sector	SSHRC (Explore)	2019-2021	$7,000 CAD

Exploring the effectiveness of using beaver as an aquatic ecosystem restoration tool	NSERC (Discovery)	2017-2022	$160,000 CAD

Co-Investigator (Co-I)

Title	**Funding Agency**	**Years**	**Total Amount**
Mountain Water Futures, phase 2 (PI: S. Carey)	GWF	2020-2024	$1,164,000 CAD
Mountain Water Futures, phase 1 (PI: S. Carey)	GWF	2017-2020	$1,726,083 CAD
Long term changes in wetland and riparian areas in Rocky Mountain National Park, Colorado (PI: D. Cooper)	US National Park Service	2020-2021	$15,000 USD
Ecological controls on the hydrological response to climate change and extreme events in the Canadian Rockies (PI: R. Petrone)	AI-EES*	2020-2023	$500,000 CAD
Wetland ecosystem functions, drivers, evaluation, and management implications (PI: R. Rooney)	AI-EES	2018-2021	$359,111 CAD
Ecosystem services-based regional strategic environmental assessment: Framework development and a model application for Saskatoon's Northeast Swale (PI: Noble)	Environment Canada (Environmental Damages Fund)	2018-2020	$87,000 (100% share between PI and me as Co-PI)

*AI-ESS is Alberta Innovates – Water Innovation Program

Most Significant Recent Contributions

1. Beaver in subantarctic aquatic ecosystems: I spearheaded a project in southern Tierra del Fuego, Argentina where beavers are invasive (Westbrook et al. 2017). The key discovery was that the hydrogeomorphic and ecological processes beaver change can lead to collapse of some habitats and the creation of other, novel ones. The research supported the idea that *Nothofagus* forest regeneration is indeed an important restoration goal but highlighted that restoration of fen (peatland) ecosystems is a previously unrecognized but pressing and challenging restoration need. This and my other research on beaver (see 'key publications') have been featured in many public interest venues, for example, *Science News*, *Canadian Geographic*, the award winning book *Once They Were Hats* by Frances Backhouse, Ducks Unlimited Canada's *BMP Knowledge Exchange webinar* and an upcoming film commissioned by the Livingstone Landowner Group.

2. Biomic River Restoration: The Johnston et al. (2020) collaborative piece of research arose from discussions of an invited group of researchers at a conference. The paper argues that current approaches to river restoration are largely failing and so to reverse long-standing declines in river functions, it is necessary to recognize the influence of biology in addition to physical processes. Required then is a shift in approach that we introduced as 'biomic river restoration'. The work while just published is receiving considerable attention – it's been cited 4 times (Google Scholar) and is in the top 5% of all research outputs scored by Almetric.

3. Peatland Tool Development: My past graduate student and I were the first to figure out how to derive accurate digital elevation models of peatland surfaces from simple photographs taken with hand-held cameras and structure-from-motion technology (Mercer and Westbrook, 2016).

4. Scientific Advisor on Wetland Conservation and Policy: I have been providing scientific advising to the Tr'ondëk Hwëch'in First Nation since 2017 on the loss of wetland function and reclamation strategies in their traditional lands (Indian River Valley) owing to gold placer mining. I have regular contact with the First Nation, and serve as an expert witness at Yukon Water Board hearings on suspending/approving new placer mining licences. I am also part of the scientific advising team working with the Government of Yukon to develop their first wetlands policy.

5. CREATE for Water Security: I spearheaded the development of this cross-university graduate student research and training program, which uses a new training approach, a scholar-practitioner model. The program helps trainees acquire an interdisciplinary understanding of problems, and shows them how they can apply skills acquired academically in a variety of professional settings. So far, 61 graduate students and 4 PDFs have taken part in the program.

Select Recent Publications

Stoll N-L, **Westbrook CJ**. 2020. Beaver dam capacity of Canada's boreal plain in response to environmental change. *Scientific Reports* (accepted pending minor revisions).

Westbrook CJ, Ronnquist A, Bedard-Haughn A. 2020. Hydrological functioning of a beaver dam sequence and regional dam persistence during an extreme rainstorm. *Hydrological Processes* (early view) https://doi.org/10.1002/hyp.13828.

Westbrook CJ. 2020. Beaver as agents of plant disturbance. In: Plant disturbance ecology, second edition, Johnson EA, Miyanishi K (eds.). Academic Press, San Francisco (in press).

England K, **Westbrook CJ.** 2020. Beaver lodge distribution and foraging preferences in urban and protected spaces along the South Saskatchewan River, Canada. *PLoS ONE* (revisions submitted).

Johnson M, Thorne C, Castro J, Kondolf M, Rood S, Mazzacano C, **Westbrook C** (alpha order after first two authors). 2020. Biomic river restoration: a new focus for river management. *River Research and Applications* 36(1): 3-12.

Streich S, **Westbrook CJ**. 2020. Hydrological function of a mountain fen at low elevation under dry conditions. *Hydrological Processes* 34(2): 244-257.

Westbrook CJ. 2019. Beavers as agents of landscape change. *Oxford Bibliographies in Environmental Science*. DOI: 10.1093/obo/9780199363445-0115 (invited)

Goodbrand A, **Westbrook CJ**, van der Kamp G. 2019. Hydrological functions of a peatland in a boreal plains catchment. *Hydrological Processes* 33(4): 562-574.

Morrison A, **Westbrook CJ**, Noble BF. 2018. A review of the flood risk management governance and resilience literature. *Journal of Flood Risk Management* 11(3): 291-304.

Wang X, Shaw E, **Westbrook CJ,** Bedard-Haughn A. 2018. Beaver dams induce hyporheic and biogeochemical changes to riparian areas in a mountain peatland. *Wetlands* 38(5): 1017-1032.

Karran D, **Westbrook CJ**, Bedard-Haughn A. 2018. Beaver-mediated water table dynamics in a Rocky Mountain fen. *Ecohydrology* 11(2): e1923.

Westbrook CJ, Cooper DJ, Anderson CB. 2017. Alteration of hydrogeomorphic processes by invasive beavers in southern South America. *Science of the Total Environment* 574: 183-190.

Painter K, **Westbrook CJ**, Hall BD, O'Driscoll NJ, Jardine TD. 2015. Effects of in-channel beaver impoundments on mercury by bioaccumulation in Rocky Mountain stream food webs. *Ecosphere* 6(10): 1-17.

Morrison A, **Westbrook CJ**, Bedard-Haughn A. 2015. Distribution of Canadian Rocky Mountain wetlands impacted by beaver. *Wetlands* 35: 95-104.

Whitfield CJ, Baulch HM, Chun KP, **Westbrook CJ**. 2015. Beaver-mediated methane emission: The effects of population growth in Eurasia and the Americas. *Ambio* 44: 7-15.