

**Colorado Water Center
Colorado State University**

**Annual Technical Report
2019**

Participatory Mapping of Colorado Watershed Ecosystem Services

Project Type: Annual Base Grant

Project ID: 2019CO031B

Products

No products were published during the reporting period. However, a thesis chapter was created, and it will be published in November to CSU's database. Subsequently, it will be submitted as a journal article by the end of the year.

Information Transfer Program

Some of the results and analysis advice were shared with the Big Thompson Watershed Coalition to help them with a similar project located in a smaller study area just around the Big Thompson River in Loveland. A portion of the project findings were presented in Dr. Jone's graduate course focused on ecosystem services and the 2019 CSU Geographic Information System (GIS) Day (see attached and link to story map).

Student Support

Number of Students directly or indirectly supported:
1 Graduate

Notable Achievements and Awards

No notable achievements or awards at this time.

Quantifying Groundwater Recharge Below a Losing Stream Reach in the Denver Basin

Project Type: Annual Base Grant

Project ID: 2019CO032B

Products

Conference Presentation: AGU poster presentation: “Effects of diurnal, large-amplitude stream temperature patterns on streambed hydraulic gradients and fluxes along a mountain-front channel,” December 2019.

In-progress Peer-Reviewed Journal Article: Data and results from this project will be included in an upcoming paper titled “Stage and temperature controls on streambed flux variations in small, mountain-front channels”.

One of the undergraduate students is conducting an honors undergraduate research project in support of this project.

Information Transfer Program

Groundwater pressure and temperature data from this project has been organized and stored on a Warner College of Natural Resources network drive and is ready to be transferred on demand. Data has already been shared with our Denver Basin municipal partners (Castle Rock Water), who supported a related study focused on groundwater recharge sources.

Student Support

Number of Students directly or indirectly supported:

2 Undergraduate

1 Graduate

Notable Achievements and Awards

Over the course of the reporting period, 4 piezometer nests, 1 deep piezometer, and 2 stream gages were added to the Douglas County Streambed Monitoring Network. This provided essential data for subsequent numerical heat and flow modeling and expanded the spatial coverage of the analysis.

Floodplain Forest Establishment and Legacy Sediment Within the Yampa River Basin, Northern Colorado

Project Type: Annual Base Grant

Project ID: 2019CO033B

Products

Conference Presentations:

Kemper, J.T., Thaxton, R.D. Rathburn, S.L., Friedman, J.M., Mueller, E.R., Scott, M.L. Connecting the dots: building a sediment-ecological connectivity framework to link tributary erosion to downstream floodplain forest establishment in a large river network. American Geophysical Union Fall Meeting, (online) December 1-17, 2020.

Kemper, J.T., Thaxton, R.D. Rathburn, S.L., Friedman, J.M., Mueller, E.R., Scott, M.L. Sediment-ecological connectivity: exploring the links between tributary erosion and floodplain forest establishment in a large river basin. Geological Society of America (GSA) Annual Meeting (online), October 26-30, 2020. (Poster)

Kemper, J.T., Rathburn, S.L., Friedman, J.M. Examining the links between upstream erosion and downstream floodplain forest establishment in the Yampa River Basin. Binghamton Geomorphology Symposium (Denver, CO) October 11-13, 2019. (Poster)

Kemper, J.T., Rathburn, S.L., Friedman, J.M. Floodplain forest establishment and legacy sediment in the Yampa River Basin, Colorado. Geological Society of America (GSA) Annual Meeting (Phoenix, AZ), September 22-25, 2019.

Information Transfer Program

Not applicable since this was a research project, not an information transfer project.

Student Support

Number of Students directly or indirectly supported:

1 Undergraduate

1 Graduate

Notable Achievements and Awards

Work supported by the project was awarded the Geological Society of America Quaternary Geology & Geomorphology Stanley A. Schumm Award (2019) and the Geological Society of America Robert K. Fahnestock Award (2020).

Snowmelt Modeling at Fine Scale for Mine Infiltration Estimation at Summitville

Project Type: Annual Base Grant

Project ID: 2019CO034B

Products

In-Progress Peer Reviewed Article:

Kingston, A.P., S.R. Fassnacht, and J.E. Derry, in review. Fine Scale Data Collection for Future Snowmelt Modeling near Silverton, Colorado. Colorado Water (submitted September 2020).

Information Transfer Program

None yet. We expect to work with the Center for Snow and Avalanche Studies (CSAS) (snowstudies.org) on this in the future.

Student Support

Number of Students directly or indirectly supported:

1 Graduate

Notable Achievements and Awards

No notable achievements or awards at this time

Diel Signals in Hydrologic and Chemical Signals Along the North Saint Vrain

Project Type: Annual Base Grant

Project ID: 2019CO035B

Products

Undergraduate Research Report: Temporal trends and spatial patterns in nitrogen concentration and flux across Colorado

Author: Spencer Rhea

Conference Presentations:

Palm, D. Diel Patterns in Physical and Chemical Properties of a Montane River-Floodplain, AGU Hydrology Days, (poster)

Palm, D. Analysis of diel variations in hydrologic and chemical signals along the North Saint Vrain, National Conference on Undergraduate Research (Presentation)

Information Transfer Program

Training for undergraduates in field and data analysis research techniques

Student Support

Number of Students directly or indirectly supported:

2 Undergraduate

1 Graduate

Notable Achievements and Awards

Undergraduate Research Report:

Rhea, S. Temporal trends and spatial patterns in nitrogen concentration and flux across Colorado

Conference Poster Presentation:

Palm, D. Diel Patterns in Physical and Chemical Properties of a Montane River-Floodplain, AGU Hydrology Days (Poster)

Conference Presentation:

Palm, D. Analysis of diel variations in hydrologic and chemical signals along the North Saint Vrain, National Conference on Undergraduate Research, (Presentation)

Student Training and Subsequent Career Development:

Danielle Palm is a Hydrologic Technician with the California Water Science Center:

<https://www.usgs.gov/staff-profiles/danielle-palm>

Spencer Rhea is a data scientist in the Bernhardt Lab at Duke University:

<https://bernhardtlab.weebly.com/people.html>

The Dynamic Nature of Snow Surface Roughness

Project Type: Annual Base Grant

Project ID: 2019CO036B

Products

The attached paper was published prior to the reporting period but was supported by previous NIWR funds.

Sanow, J.E., S.R. Fassnacht, D.J. Kamin, G.A. Sexstone, W.L. Bauerle, and I. Oprea, 2018. Geometric versus anemometric surface roughness for a shallow accumulating snowpack. *Geosciences*, 8(12), 463. <https://doi.org/10.3390/geosciences8120463>

Sanow, J.E., and S.R. Fassnacht, in review. Temporal and spatial effects of snow depth on snow surface roughness throughout the White River watershed. *Colorado Water* (submitted September 2020).

Information Transfer Program

None at this time.

Student Support

Number of Students directly or indirectly supported:

1 Undergraduate (not funded, but for research mentorship from the Graduate Student)

1 Graduate

Notable Achievements and Awards

No notable achievements or awards at this time.

Selecting Cost-effective Water Quality Management Practices Under Climate Change

Project Type: Annual Base Grant

Project ID: 2019CO037B

Products

Wei, Xiaolu, and Ryan T. Bailey. 2019. Assessment of system responses in intensively irrigated stream-aquifer systems using SWAT-MODFLOW. *Water* 11, no. 8: 1576.

Wei, Xiaolu. 2019. Improved assessment of nitrogen and phosphorus fate and transport for intensively managed irrigated stream-aquifer systems. Ph.D. dissertation, Colorado State University.

Sheng, Di. In progress. Differentiated payment for provision of ecosystem services. Ph.D. dissertation, Colorado State University.

Information Transfer Program

Di Sheng presented the preliminary results of this project at the 2019 AAEA Annual Meeting.

Student Support

Number of Students directly or indirectly supported

2 Graduate

Notable Achievements and Awards

No notable achievements or awards at this time

Assessing Status of Water Quality and Environmental Health of Our Nation's Rivers

Project Type: Coordination Grant

Project ID: 2019CO002S

Products

Miller, J.L., Schmidt, T.S., Sandstrom, M.W., Van Metre, P.C., Mahler, B.J., Nowell, L.H., Carlisle, D.M., and Moran, P.W. 2020. Common insecticide disrupts aquatic communities: A mesocosm to field ecological risk assessment of fipronil and its degradates in U.S. streams. Science Advances.

Information Transfer Program

Results from this project were featured in the online news release website "EurekaAlert!". The article can be found here: "Fipronil, a common insecticide, disrupts aquatic communities in the U.S." October 23, 2020. (by Mary Guiden). https://www.eurekaalert.org/pub_releases/2020-10/csu-fac102320.php

Student Support

Number of Students directly or indirectly supported:

No students were supported by this project.

Notable Achievements and Awards

No notable achievements or awards at this time

Measuring Hydraulic and Thermal Conditions of High Elevation Headwater Streams in Regions of North-Central Colorado

Project Type: Coordination Grant

Project ID: 2019CO003S

Products

White, D., Morrison, R., and Roberts, J. 2020. Range-wide habitat assessment of Greenback Cutthroat Trout under altered flow regimes. American Geophysical Union Hydrology Days. Fort Collins, CO. April 13–14.

Information Transfer Program

No information transfer program activities occurred during this reporting period.

Student Support

Number of Students directly or indirectly supported:

2 Graduate

Notable Achievements and Awards

No notable achievements or awards at this time

Validating Modeled Streamflow Transport Dynamics and Floodplain Habitat Connectivity for Larval Endangered Fish of the Middle Green River, Utah

Project Type: Coordination Grant

Project ID: 2019CO004S

Products

None, yet.

Information Transfer Program

None, yet.

Student Support

Number of Students directly or indirectly supported:

None, yet.

Notable Achievements and Awards

No notable achievements or awards at this time

Floodplain Forest Establishment Dnd Legacy Sediment Within Whe Yampa River Basin, Northern Colorado

Project Type: Annual Base Grant

Project ID: 2019CO033B

Project Impact:

Sediment loads are declining across the Colorado River Basin due to both dams and land management in the headwaters designed to mitigate erosion. Cottonwood floodplain forests, ubiquitous but declining basin-wide, are disturbance-driven ecosystems dependent on sediment-laden floods for establishment. Here we investigate the linkages between tributary erosion and downstream cottonwood floodplain forest establishment in the Little Snake/Yampa River Basin.

Inspection of historical documents and aerial photographs suggests that three key tributaries of the Yampa underwent significant historical erosion via arroyo incision in the late 19th to early 20th century. Dendrochronology results indicate establishment dates of cottonwood forests in downstream locations along the mainstem Yampa River lag this period of arroyo incision by several decades. Taken together, findings suggest that sediment wave(s) initiated by historical headwater erosion were transported >100 km downstream over multiple decades and resulted in the construction of geomorphic surfaces necessary for forest replenishment. We propose that the demonstrable link between headwater erosion and distal downstream forest establishment shown here validates the idea that upstream watershed dynamics play a key role in governing downstream ecological processes. From these results, two important management implications arise: 1) cottonwood forests along the Yampa River will likely decline regardless of the maintenance of the current flows, and 2) management of upstream sediment loads and flows are fundamental to the long-term health of Yampa River forests. Overall, the results of this study suggest that holistic, basin-scale management of watershed resources – land, sediment, and water – is essential for floodplain forest and ecosystem health.

Snowmelt Modeling at Fine Scale for Mine Infiltration Estimation at Summitville

Project Type: Annual Base Grant

Project ID: 2019CO034B

Project Impact:

The purpose of this study was to acquire and understand the impact of fine resolution inputs on snowmelt in Southern Colorado, specifically Senator Beck Basin. Modeling of snowmelt is key to providing useful new information for water resources management, especially in southern Colorado and basins with similar topographic variability and climate conditions. This study demonstrated that the variation in temperature and relative humidity as we move up in elevation along a transect could be significant, even in a study area of Senator Beck Basin's size. Additionally, there are interesting patterns over the day and during the melt period in the data highlighting the importance of fine-scale variability in meteorological driving data for snowmelt modeling. This variability can change our understanding of melt processes and snowmelt rates, providing crucial information to water managers about snowmelt input into headwater river systems. Given the utility of the sensor data from this study, data collection will continue in Senator Beck Basin along the transect. Future research will use these results to downscale meteorological data from the Weather Research and Forecast (WRF) model to input the data into SnowModel to better inform melt characteristics and runoff patterns.

Diel Signals in Hydrologic and Chemical Signals Along the North Saint Vrain

Project Type: Annual Base Grant

Project ID: 2019CO035B

Project Impact:

To increase understanding of river-floodplain function, this study will investigate physical and chemical changes occurring at diel timescales within a river-floodplain along the North Saint Vrain River in Colorado. River-floodplain systems provide ecosystem services that increase river network resiliency to human disturbances; however, a deeper understanding of river functioning is necessary for management and restoration projects that support rivers' natural processes. For example, while research on water quality often involves sampling at weekly or monthly intervals, physiochemical changes occur in shorter time intervals and require different sampling approaches to evaluate their impact on river system functions. This research uses both real-time sensor data and bi-hourly grab samples collected from different floodplain habitats within the North Saint Vrain watershed over a one-day period. Current data is from in Fall 2018 and is part of a longer-term data set still underway. Water samples were analyzed for dissolved oxygen, dissolved organic carbon, and trace mineral, nutrient, and gas concentrations. For each water quality constituent, the daily data was analyzed for cyclic diel patterns using sinusoidal curve fitting, and when cyclic patterns were present, the amplitude was calculated. The presence and amplitudes of cyclic behavior were then compared for each constituent across all floodplain sites. Findings from this study suggest that in the floodplain, cyclic physiochemical behavior is controlled by the degree of connectivity with the main channel. These efforts aim to expand and complement concurrent work findings investigating weekly and seasonal patterns in the role of mountain river-floodplains on network-scale water quality. Through these different time scales, we expect to see comparative evidence of changes in physical and chemical concentrations. The fine temporal scale approach is also anticipated to prove a valuable assessment tool for future stream-based scientific research and resource management for river-floodplain ecosystem services.

The Dynamic Nature of Snow Surface Roughness

Project Type: Annual Base Grant

Project ID: 2019CO036B

Project Impact:

This project enabled the student PI to collect a vast array of data, specifically meteorological data focusing on wind speeds at various heights above the ground and snow surface datasets from terrestrial lidar scans. These datasets are being used to compare wind (anemometric) and surface (geometric) based roughness estimates. These data are used in climate, meteorological, land surface, snowpack, and hydrological modeling. In all existing models, these surface characteristics are considered static and constant for any snowpack. However, the data collected in this project illustrate the dynamic nature of the snowpack surface, and this can have a strong impact on the sensible and latent heat fluxes. For water resources, this influences the amount of water stored in the snowpack, in particular, how much is lost to sublimation. For climate modeling, this influences the energy balance. The datasets collected from this project are being used to develop a new dynamic snow surface roughness formulation that will enable more accurate modeling of snow-covered areas.

Selecting Cost-Effective Water Quality Management Practices Under Climate Change

Project Type: Annual Base Grant

Project ID: 2019CO037B

Project Impact:

A Soil and Water Assessment Tool (SWAT) Model has been customized for the Colorado Fairmont Drainage District and has been used to suggest best management practices (BMP) for water quality improvement based on tile-drainage system location. The SWAT simulations indicate that tiled-parcels have significantly higher nutrient loading than non-tiled parcels, while the opportunity costs of parcel retirement are not significantly different between tiled and non-tiled parcels. Optimization results show that a cost-effective BMP retires more tiled-parcels with a moderate water quality improvement target. The results further provide policy insights on the payment to ecosystem services design. A higher payment for parcel retirement to tiled-parcels may reduce the social cost of achieving a moderate water quality management target.

Assessing Status of Water Quality and Environmental Health of Our Nation's Rivers

Project Type: Coordination Grant

Project ID: 2019CO002S

Project Impact:

The article, "Common insecticide disrupts aquatic communities: A mesocosm to field ecological risk assessment of fipronil and its degradates in U.S. streams," was published in Science Advances in October 2020 and details the findings of this project. In brief, we measured the toxicity of the insecticide fipronil and associated degradate compounds on stream insect populations and communities and found fipronil compounds to be more toxic to aquatic invertebrate communities than previously known. Notably, the degradate desulfinyl fipronil was 10,000 times more toxic than previously thought based on the best available data resources. Lab experiments demonstrated that fipronil is not only toxic to aquatic invertebrates but disrupts aquatic and aquatic-terrestrially linked food webs by altering insect emergence and causing a trophic cascade that impacted algal growth. Our work highlighted the previous paucity in toxicity data for aquatic insects exposed to these compounds, in particular degradate compounds. Further, this work shows the utility of mesocosm experiments as a tool for understanding toxicity at the community level and generating data for a large number of invertebrate species that can then be applied to field risk assessments. An analysis of field data identified fipronil as the second most frequently detected group of insecticide in U.S. streams. It was frequently detected across all 5 study regions with the highest detection frequency in the Southeast region of the U.S., suggesting contamination of streams by fipronil could be impairing stream health across the U.S.

Measuring Hydraulic and Thermal Conditions of High Elevation Headwater Streams in Regions of North-Central Colorado

Project Type: Coordination Grant

Project ID: 2019CO003S

Project Impact:

This research includes collecting new water temperature, stream discharge, and channel morphometry characteristics to better understand the current hydrothermal (i.e., water temperature and streamflow regime) conditions of headwater streams and lakes in the Southern Rocky Mountains. These systems are remote and, therefore, relatively understudied. This work capitalizes on existing data and collects new data to fill knowledge gaps, particularly related to the reintroduction of threatened Greenback Cutthroat Trout. We also use existing streamflow and water temperature data and these newly collected data to create predictive models. These models are used to predict conditions in unsampled streams and lakes while also being combined with downscaled climate models to evaluate future hydrothermal conditions of these systems. Study streams and lakes are located in headwater regions of the South Platte and Fountain Creek river basins along Colorado's Front Range and also both sides of the continental divide in Rocky Mountain National Park. Initial field measurements indicate a variety of morphological and hydraulic conditions being considered for Greenback Cutthroat Trout reintroduction. In addition, hydraulic modeling results show variable sensitivity in hydraulic habitat suitability for instream ecology. Additional modeling and field data collection are planned for FY20.

Validating Modeled Streamflow Transport Dynamics and Floodplain Habitat Connectivity for Larval Endangered Fish of the Middle Green River, Utah

Project Type: Coordination Grant

Project ID: 2019CO004S

Project Impact:

We seek to validate a stream flow and transport model of an area of the Green River, Utah, that is important for endangered razorback sucker. Using released and recaptured larvae of razorback sucker, sampling will show the extent that modeled streamflows, and streamflow measurements match up with transport patterns of fish. Unfortunately, we have not been able to complete these studies yet, in 2019 due to lack of correctly timed flows and in 2020, due to lack of production of larvae at hatcheries for releases and COVID-19 restrictions on travel and fieldwork. We plan to attempt the work in spring 2021.