



Department of Watershed Sciences

Spring 2019

Graduate Student

Research Symposium



Friday, April 12, 2019

Huntsman Hall 320

8:30 am – 2:15 pm

Utah State University
Quinney College of Natural Resources
Department of Watershed Sciences
Graduate Student
Research Symposium

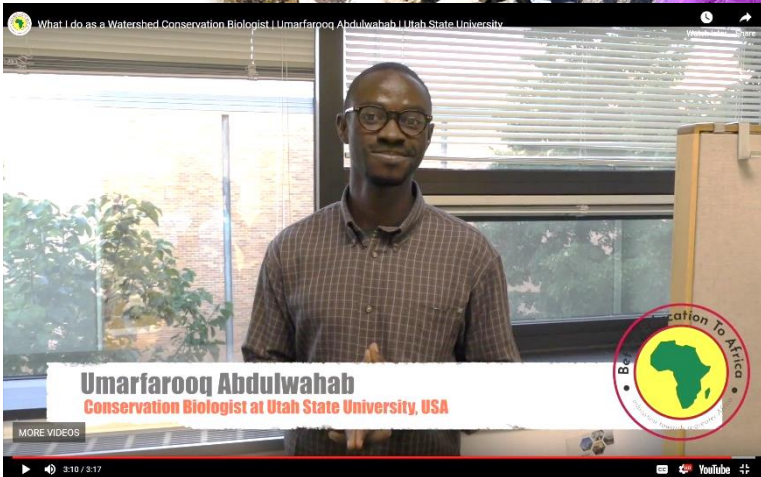
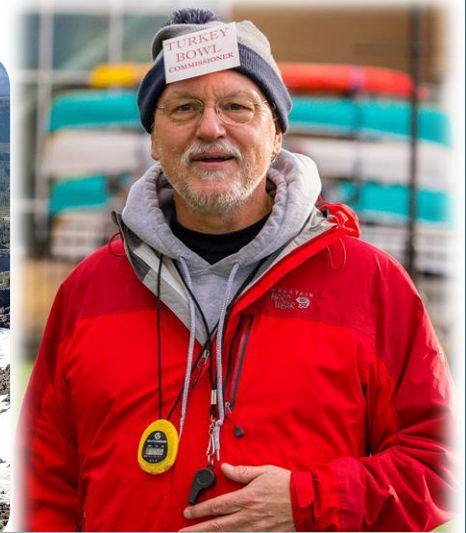
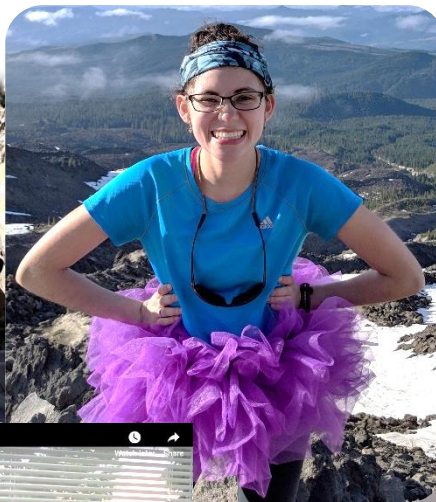
April 12, 2019

Welcome to the Department of Watershed Sciences Graduate Research Symposium. This symposium provides an opportunity for our graduate students to present ideas about their thesis/dissertation research and to receive feedback regarding their plans. Your comments and insights are welcome and expected.

Today, we will hear from eight M.S. and nine Ph.D. students. Their presentations are a sample of the diversity of water resource, conservation, and ecosystem science issues that faculty, students, and research associates in the Department of Watershed Sciences explore.

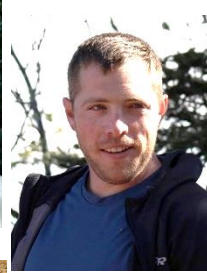
3:00pm: Spring Softball Game (Graduate Students vs. Faculty/Staff)
on the Aggie Legacy West & Center Fields.

6:30pm: Social at Peter Wilcock's house (1624 Sunset Dr., Logan)



WATS Graduate Student Research Symposium Schedule

8:30 **Welcome: Dr. Peter Wilcock**



8:45 **John Draper, Ph.D. in Ecology**
Major Advisor: Dr. Trisha Atwood

9:00 **Leighton King, MS in Ecology**
Major Advisor: Drs. Janice Brahney & Soren Brothers

9:15 **Gregory Goodrum, MS in Watershed Science**
Major Advisor: Dr. Sarah Null



9:30 **Angela Merritt, Ph.D. in Watershed Science**
Major Advisor: Dr. Charles Hawkins

9:45 **Zachary Ahrens, MS in Watershed Science**
Major Advisor: Dr. Phaedra Budy

10:00 **Brian Healy, Ph.D. in Ecology**
Major Advisor: Dr. Phaedra Budy



10:15 **Break**

10:30 **Donald Benkendorf, Ph.D. in Ecology**
Major Advisor: Dr. Charles Hawkins

10:45 **Umarfarooq Abdulwahab, Ph.D. in Ecology**
Major Advisor: Drs. Charles Hawkins & Edward Hammill

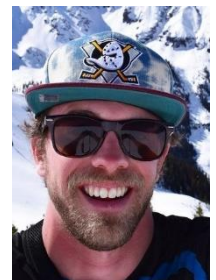
11:00 **Austin Bartos, MS in Ecology**
Major Advisor: Dr. Janice Brahney



11:15 **Jack McLaren, Ph.D. in Ecology**
Major Advisor: Drs. Soren Brothers & Phaedra Budy

11:30 **Ali Farshid, Ph.D. in Watershed Science**
Major Advisor: Dr. Sarah Null

11:45 **Xueyan Zhang, MS in Watershed Science**
Major Advisor: Dr. Jiming Jin



12:00 **Lunch**

1:00 **Rae Robinson, MS in Ecology**
Major Advisor: Dr. Karin Kettenring

1:15 **Marshall Wolf, Ph.D. in Ecology**
Major Advisor: Dr. Edward Hammill

1:30 **Lindsay Capito, MS in Watershed Science**
Major Advisor: Dr. Janice Brahney



1:45 **Christina Morrisett, Ph.D. in Watershed Science**
Major Advisor: Dr. Sarah Null

2:00 **Karen Bartelt, MS in Watershed Science**
Major Advisor: Dr. Joseph Wheaton

Abstracts

John Draper, Ph.D. in Ecology

Major Advisor: Dr. Trisha Atwood

Carnivores Become Frugivores and Alter Landscape Carbon Storage

Seed dispersal is a crucial life stage for plants that has landscape level consequences. How plants are dispersed across a landscape influences plant survival, plant community composition, and ecosystem functioning, including carbon storage. Many plant species have evolved to utilize animals as vectors of dispersal. For animal-dispersed plants, the physiology and movement ecology of the animal determines the pattern of dispersal across a landscape. Members of the order *Carnivora* are important seed dispersers in North America; they can disperse seeds further from the parent and in more open landscapes than other taxa. Worldwide grasslands are naturally being converted to shrublands and woodlands, which increases the carbon storage capacity of the landscape. These changes in plant communities and their ecosystem functions in North America are potentially due to the expansion of a seed-dispersing carnivore, the coyote (*Canis latrans*), and how they deposit seeds differently from other dispersers. My study will evaluate the effect of coyote consumption of fruits on seed viability and germination rates, model landscape-level seed dispersal by coyotes, and determine the maximum potential dispersal to model potential plant community changes and how these changes affect landscape carbon storage capacity. All models will be formulated using both current climatic conditions and those predicted by climate change models. Results of this study will illuminate how carnivores affect seed viability and dispersal of the fruits they consume and how these effects alter plant communities and landscape carbon storage.

Leighton King, MS in Ecology

Major Advisor: Drs. Janice Brahney & Soren Brothers

The response of Utah Lake's plant community structure to cultural eutrophication

Shallow lakes often do not respond gradually to increasing nutrient concentrations, but rather exhibit self-stabilizing regimes: a clear water, macrophyte dominated regime or a turbid, phytoplankton dominated regime. Utah Lake is a large, shallow lake located in north-central Utah and features the hallmark indicators of a turbid eutrophic lake, including recurrent harmful algal blooms. Despite local debate regarding the cause of eutrophication, there is no empirical record as to whether this lake's waters were historically clearer and if so, when the transition occurred. Here, I use paleolimnological analyses to identify and reconstruct shifts in macrophyte production and community composition. Preliminary data from sediment cores indicate a transition in the lake's recent history marking a shift from macrophyte to phytoplankton dominance. Additionally, I examine the role that the loss of benthic primary production plays in maintaining the eutrophic state by pairing present day water quality measurements with primary production modeling and laboratory experiments. This question is significant, as the impact that regime shifts have had on the primary production of Utah Lake are not fully understood. Due to the lake's high turbidity, contemporary benthic production rates are not substantial, but may have been important during historical periods featuring abundant macrophytes. This study will provide a clear historical framework for the timing of environmental shifts as they may relate to natural variability or anthropogenic forcing in the catchment and lake, as well as an examination of the role that shifts in plant community structure may have played in establishing and perpetuating eutrophic conditions in shallow lakes.

Gregory Goodrum, MS in Watershed Science

Major Advisor: Dr. Sarah Null

Improving Aquatic Habitat Representation in Utah Using Large Spatial Scale Environmental Datasets

Water resources systems models are widely used to examine tradeoffs among human water uses. However, aquatic habitats are difficult to represent in ways that are ecologically meaningful, yet sufficiently generalizable for different species, systems, and spatial scales. Past approaches have relied on simplified habitat-streamflow assumptions, or used species-specific habitat suitability models that are data intensive. The increasing abundance of large spatial scale environmental datasets present the opportunity to improve aquatic habitat representations by intersecting multiple habitat variables and validating habitat suitability using organism presence

data. I will develop a geospatial habitat suitability model using publically-available large spatial scale environmental datasets to better understand tradeoffs between habitat representation accuracy and simplicity. This approach is novel because it uses publically-available large spatial scale input data and organism presence data to validate tradeoffs between the number and combination of habitat variables and ecological relevance of habitat suitability classifications. This model will be applied as a case study estimating habitat suitability for Bonneville cutthroat trout (*Oncorhynchus clarki utah*) and bluehead sucker (*Catostomus discobolus*) throughout Utah. Bonneville cutthroat trout have well-described habitat and life-history requisites, while bluehead sucker habitat is not well described. Both species are actively managed in Utah. I will develop a geodatabase of monthly habitat variables for stream reaches, classify habitat suitability using literature-based thresholds, and use species presence data to quantify tradeoffs between habitat representation simplicity and accuracy. The generalized model developed for Utah will improve instream habitat representations for water resource systems modeling and species conservation management.

Angela Merritt, Ph.D. in Watershed Science

Major Advisor: Dr. Charles Hawkins

Non-Perennial stream bioassessment: the development of a biological condition index specific to streams with days of zero flow

There is a need to develop reliable methods and standards of bioassessment for streams with periods of zero-flow, known as non-perennial (NP) streams. Researchers use a group of tools, biological condition indices (BCI), for the bioassessment of freshwater bodies, but BCIs have not been developed for NP streams, even though NP streams make up at least 50% of most freshwater stream networks. The existing BCIs were developed for perennial streams and likely will not work on NP streams because the natural conditions of NP streams are thought to differ from those measured in perennial streams. In particular, arid NP hydrologic regimes have lengthy, irregular, or both lengthy and irregular periods of zero flow that can strongly influence the specific species that can inhabit these NP streams. Furthermore, the physical characteristics of arid and semi-arid streams create variable degrees of connectivity between NP wet refugia that can extirpate or promote less tolerant or tolerant species. In contrast to perennial streams, little is known about what flow attributes most strongly influence natural differences in freshwater assemblages across NP streams. A better understanding of the full variation in NP hydrologic regimes and how biological assemblages differ among them is needed to develop a BCI appropriate for NP streams. My research objectives are to:

- a. Classify NP streamflow regimes focusing on the arid southwest US.
 - b. Test for differences in assemblage composition between different NP and P streamflow regimes.
 - c. Use the knowledge gained in (b) to develop a biological condition index specific to NP streams.
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Zachary Ahrens, MS in Watershed Science

Major Advisor: Dr. Phaedra Budy

Unintended fragmentation: fish community impacts and conservation implications of the Piute Farms Waterfall, San Juan River, UT

Stream fragmentation and non-native species introductions are among a suite of anthropogenic disturbances shaping the structure and function of freshwater ecosystems. The impacts of such alterations contribute to the global decline of stream fish biodiversity and may be synergistic in their effects. For example, the Colorado River basin's endemic native fish assemblage is imperiled not only by decreased stream system connectivity and physical habitat loss (attributable to numerous dams and diversions), but also by predatory and competitive pressure from non-native fish, which thrive in and proliferate from those altered habitats. On the San Juan River, Utah, an anomalous anthropogenic waterfall poses a likely barrier to upstream movement both for ESA-listed migratory fish Colorado Pikeminnow *Ptychocheilus lucius* and Razorback Sucker *Xyrauchen texanus* and potentially invasive predatory sportfish from a downstream impoundment (Lake Powell). Reservoir storage projections show decreasing likelihood of waterfall inundation by Lake Powell. Given the likely permanence of this novel feature and its potential to influence imperiled species, I propose to weigh its relative costs (impeding native fish migration) versus benefits (spatially limiting detrimental species interactions) to native fish conservation. I will collect fish, their diets and stable isotope samples along a river continuum spanning the waterfall and test whether metrics of fish community composition, structure and species interactions differ between reaches above and below the feature. Additionally, I will develop a population viability model for San Juan River Razorback Sucker which integrates the afore-

mentioned empirical data with simulated barrier management scenarios (e.g., full or selective fish passage). Elucidating the likely positive or negative effects of this barrier on native fish populations and potential species interactions will inform management decisions regarding the waterfall (i.e., should fish passage be considered, and if so, what type?) as well as other future endangered fish recovery efforts.

Brian Healy, Ph.D. in Ecology

Major Advisor: Dr. Phaedra Budy

Efficacy of conservation strategies for imperiled desert fishes of the Colorado River basin across multiple scales

Worldwide, arid-land aquatic ecosystems are imperiled due to combined pressures of anthropogenic water use, damming of rivers, and the negative effects of invasive species introductions. Desert fishes evolved in an environment characterized by seasonally-variable temperatures and frequent flooding and drought. Stabilized flow and thermal regimes in the post-dam era favor invasive fishes whose life history strategies evolved in stable and predictable environments, leading, in part, to imperilment of many unique fauna. Across the Colorado River basin, conservation actions including invasive fish suppression, stocking, translocations, and flow experiments designed to encourage juvenile fish recruitment, or augment or establish new populations, are underway to recover endangered fishes. Yet the responses in population dynamics of both native and invasive fishes have been equivocal; environmental variability and ecosystem complexity have sometimes confounded the interpretation of results. Nevertheless, assessments of responses in demographic rates, while accounting for the effects of environmental variation, can improve understanding of the ecology of native fishes, while informing managers of the efficacy of conservation actions. Thus, the objectives of my dissertation research are to: 1) quantify the effects of invasive fish suppression and environmental variability on demographic vital rates (i.e., survival, recruitment, mortality) of native fishes and invasive salmonids, and 2) assess factors contributing to the likelihood of establishing self-sustaining humpback chub (*Gila cypha*) populations in small Colorado River tributaries; 3) the development of a population viability model for invasive brown trout (*Salmo trutta*) to evaluate management scenarios meant to minimize effects of predation and competition to native fish populations; and 4) conduct a range-wide survival analysis for razorback sucker (*Xyrauchen texanus*). Through detailed evaluations of drivers of vital rates of imperiled native fishes from individual tributary to basin-wide scales, my research will provide valuable insights into their population ecology, and assist fisheries managers in designing effective conservation strategies.

Donald Benkendorf, Ph.D. in Ecology

Major Advisor: Dr. Charles Hawkins

Validating the interpretation of thermal species distribution models to test macroecological hypotheses and enhance ecological assessments

A major impetus for modeling species distributions is to identify the most important environmental factors that influence distributions. Yet, to confidently interpret species distribution models (SDMs), we must understand the causal mechanisms that underlie model predictors. For example, SDMs imply that temperature is often a dominant factor influencing the distribution of freshwater macroinvertebrates. However, a strong SDM-derived relationship between temperature and probability of occurrence does not guarantee a causal association, which could instead be caused by a variable correlated with temperature. This ambiguity as to which factors are actually causing variation in probability of occurrence hinders our confidence in model interpretation. Developing a better understanding of how temperature affects species fitness and distribution is especially timely given the rapid changes in temperature that are occurring globally as a result of climate change. Additionally, a mechanistic interpretation of the predictors used in species distribution models is needed to develop and properly interpret biotic indices designed to diagnose the causes of observed alteration in biological communities. Such stressor-specific indices can be used by natural resource managers to identify the specific stressors (e.g. temperature, sediment, salinity) responsible for biological impairment by sampling and analyzing the biotic assemblage. The three objectives of my research will each comprise a single chapter of my dissertation. These specific objectives are to: 1) determine the potential importance of temperature in controlling macroinvertebrate distributions by constructing species distribution models from field data and estimating species upper thermal limits, 2) experimentally determine upper thermal limits to growth and survival of various macroinvertebrate taxa to assess if field-derived temperature-distribution relationships are consistent with experimentally-derived effects of temperature on fitness, and 3) develop a temperature-specific biotic index that can diagnose if thermal modification has altered stream invertebrate assemblages from their natural condition.

Umarfarooq Abdulwahab, Ph.D. in Ecology

Major Advisor: Drs. Charles Hawkins & Edward Hammill

Developing a data-driven decision support system to improve conservation planning for species of concern on Department of Defense and surrounding lands in coastal California

Effective conservation of endangered species requires 4 components: high resolution data on the location of species of interest, understanding of their habitat requirements, understanding the threats posed to the species, and an effective plan for their management. Of all vertebrate taxa, amphibians represent the class with the highest proportion of threatened and endangered species. In the USA, California boasts one of the most biologically diverse and threatened biota, but conservation can be hindered by human development, climate change, novel pathogens, and fire risk. Areas with little to no human disturbance, including military installations, serve as refuges for rare, threatened, endangered or otherwise sensitive species. This study will develop a data-driven decision support system to identify the optimal mix of land uses to best protect species of concern on three military installations and surrounding lands in south-coastal California. My approach incorporates three novel techniques to develop a decision support tool for four sensitive amphibians and a turtle in California: (1) high-quality species occurrence data obtained from eDNA surveys, (2) models that can predict the habitat suitability of different locations within a landscape, and (3) powerful software that can objectively identify optimal conservation solutions. 200 sites occurring on water bodies (lakes, streams, ponds, and wetlands) within the study areas have been systematically selected. Triplicate environmental DNA (DNA that is released into the environment by an organism) samples will be collected at each site and used to document the presence/absence of the target species as well as the occurrence and pathogen load of chytrid fungus (*Batrachochytrium dendrobatidis*). I will develop species distribution models, occupancy models, and decision support systems for each target species. This study will test whether the use of eDNA data improves the performance of species distribution and occupancy models, identify methods that can best predict species distribution and occupancy, and provide a common tool that can be used by natural resource managers and other stakeholders to guide decisions on conservation planning and management.

Austin Bartos, MS in Ecology

Major Advisor: Dr. Janice Brahney

Quantifying novel pathways of cyanotoxin exposure to humans

The prevalence of cyanobacteria (blue-green algae) blooms and their associated cyanotoxins in lakes near urban centers is an increasing global issue that poses an environmental and human health hazard. Climate and anthropogenic changes to lake systems, such as increased water temperatures and eutrophication, can exacerbate harmful algae blooms and promote cyanotoxin production. Exposure to cyanotoxins can result in acute and chronic health effects such as liver disease and an increased risk for neurological disease. Drinking water and recreation as pathways for cyanotoxin exposure are well documented. However, experimental data is lacking on the fate of these toxins in the terrestrial environment. Standard methods for cyanotoxin extraction from soil and plants do not exist, and the capacity for bioaccumulation in food crops is not well documented. To fill these knowledge gaps, I will 1) create a cyanotoxin extraction procedure and quantify uptake of three cyanotoxins, Microcystin-LR, Nodularin, and beta-Methylamino-L-alanine, in lettuce from drip-irrigation water using three environmentally relevant concentrations. 2) Quantify atmospheric transport of cyanotoxin-laden sediment from the Great Salt Lake by capturing dust and measuring cyanotoxin presence. 3) Define relationships between environmental variables and cyanobacteria presence in U.S. lakes using the EPA National Lakes Assessments and statistical models. The results of my research will provide data to develop guidelines regarding the use of cyanotoxin contaminated soil and irrigation water and on the consumption of affected crops.

Jack McLaren, Ph.D. in Ecology

Major Advisor: Drs. Soren Brothers & Phaedra Budy

Assessing the impact of anthropogenic nutrient enrichment in the Henry's Fork Headwaters

Western U.S. rivers are experiencing changes in nutrient flux from urban development and changes to migratory fish populations, which could influence productivity of ecologically, economically, and culturally important trout populations. The Henry's Fork of the Snake River in east Idaho is experiencing rapid development due to excellent recreational opportunities, including fly-fishing,

nonmotorized boating, and proximity to Yellowstone National Park. An increase in development will require new avenues of wastewater disposal and changes in the management of stocked migratory salmon, resulting in nutrient flux changes in the river. We seek to understand how the ecology of the Henry's Fork will respond to anthropogenically-driven nutrient flux change, including 1) understanding the effect of nutrients on primary productivity and whole-stream metabolism 2) linking changes in primary productivity to changes in stream ecosystem structure and food webs, focusing on trout growth and habitat, and 3) developing a nutrient budget for the Henry's Fork under various climate and development scenarios. Methods will include observational comparative studies among different reaches of the Henry's Fork a nutrient addition experiment, and statistical and systems modeling. Our results will assist local resource managers in mitigating human development for the benefit of the Henry's Fork ecosystem and the trout that call it home. We aim to advance the field of stream and fish ecology by more closely examining how nutrients can affect stream ecosystems, including concepts such as the paradox of enrichment, the river continuum concept, and the management usefulness of ecosystem metabolism.

Ali Farshid, Ph.D. in Watershed Science

Major Advisor: Dr. Sarah Null

Robust aquatic habitat representation to improve water resources decision-making

My research explores trade-offs between human water demands and aquatic habitat water requirements through systems analysis modeling. While quantifying human water demands is routine in systems models, aquatic habitats are typically represented simplistically, mainly because of the complexities in aquatic habitat quantification. These complexities have caused environmental objectives to be represented as constraints in models, which removes environmental objectives from the water resources decision making process. My research objectives are to: 1) evaluate tradeoffs between human water uses and aquatic habitat water requirements, 2) quantify the robustness of aquatic habitat representation sets to incompletely-understood habitat representation using: Robust Decision-Making (RDM) framework, and 3) assess the concessions between accuracy and generality in water resources systems modeling. I will use the RDM framework to understand uncertainties of aquatic habitat representation and to analyze trade-offs. I will formulate water resources systems models that include aquatic habitat and human water use objective functions. Results will be a set of compromises or trade-offs. In addition, with the aim of RDM framework, I will provide and analyze the Pareto frontier and the Pareto approximate frontier to show the trade-offs between gains and losses for human and the species in the study region. I will focus on Utah's Bear and Weber watersheds. In the Bear watershed, water managers have proposed new dams which will likely disconnect aquatic habitats. In contrast, in the Weber watershed, water managers are planning to remove some barriers to restore rivers. In both cases, ecologically-meaningful aquatic habitat representation will maximize aquatic habitat benefits while human water needs are present. I will focus on aquatic habitats for Bonneville cutthroat trout and bluehead suckers in these two watersheds because these species have habitat needs that are relatively well-understood and they are species that the state wishes to protect.

Xueyan Zhang, MS in Watershed Science

Major Advisor: Dr. Jiming Jin

Responses of snowpack and runoff to climate change over the Western United States

The goal of this study is to simulate and project how snowpack responds to a warming climate and quantify its contribution to the runoff over the western United States (U.S.). Snowpack, as a natural reservoir in the western U.S., is significantly declining due much to climate change. Meanwhile, the timing and amount of runoff affected by those of the snowmelt water also have obvious changes such as decreases in its total amount and occurrences of earlier peak. For this project, we will use the community Noah land surface model with multiparameterization options (Noah-MP) to simulate snow water equivalent (SWE) and runoff. Noah-MP will be driven by the reanalysis data produced with the Phase 2 of the North American Land Data Assimilation System for the western U.S. over the historical period (1980-2005). The simulations will help us understand SWE and runoff changes over this region. Noah-MP will then be used to project the SWE and runoff for the future (2006-2100). It will be driven by the outputs of three global climate models under four representative concentration pathways from the fifth phase of the Coupled Model Intercomparison Project. The results from this project will provide strong insights into water resource managements for the western U.S.

Rae Robinson, MS in Ecology

Major Advisor: Dr. Karin Kettenring

Investigation of seed-based restoration techniques in Great Salt Lake wetlands following *Phragmites australis* invasion and control

Great Salt Lake wetlands are of great ecological, economic, and cultural importance. One of the greatest threats to Great Salt Lake wetlands is the invasive, non-native grass *Phragmites australis*. *Phragmites australis* invades wetlands and replaces native plant communities making wetlands inhabitable for many wildlife species. Restoring a mosaic of native wetland plant communities following *P. australis* control is crucial to maintaining quality habitat and other regionally significant ecosystem services Great Salt Lake wetlands provide. Though active restoration of native plants is an effective technique in preventing the recolonization of invasive species, on Great Salt Lake well-tested seeding practices are lacking. My proposed research will address this knowledge gap by identifying the environmental conditions most likely to foster high germination and seedling survival, thereby informing strategic site selection of future restoration efforts. I will also identify best practices for the selection of species and seeding densities for revegetation.

The objectives of this research are to: 1) Determine how environmental conditions (salinity, temperature, water potential, light) affect survival across life stages (germination, emergence, establishment, survival) of five native species used in revegetation (*Schoenoplectus americanus*, *Bolboschoenus maritimus*, *Schoenoplectus acutus*, *Juncus balticus*, *Distichlis spicata*). 2) Determine the most effective seed mix compositions to establish a diverse assemblage of native species. 3) Determine the most effective seeding densities to establish a diverse assemblage of native species. To accomplish these objectives, I will examine the outcomes of large and small-scale revegetation seedings across a range of environmental conditions on Great Salt Lake. In single species field plots (96 0.25 m² plots across 2 sites), I will track individual native plant seedlings across life stages to calculate life stage transition probabilities over a range of environmental conditions that will be monitored in the field (Obj 1). To investigate seed mix compositions, I will apply a high-diversity seed mix, low-diversity seed mix, and passive-revegetation control and monitor native plant and *P. australis* emergence and establishment during the growing season (90 1m² plots across 2 sites) (Obj 2). To investigate seeding densities, I will monitor revegetation outcomes of a large-scale seeding effort of two seeding densities in the early and late-growing season in Great Salt Lake wetlands (90 1m² plots, across 3 sites) (Obj. 3). This research will expand the current knowledge of wetland restoration techniques for establishing a mosaic of native plant communities. With the increasing landscape-level threat of *P. australis* and the urgent need to maintain habitat and wildlife biodiversity on Great Salt Lake, this proposed research is timely and imperative to informing management decisions and improving revegetation outcomes.

Marshall Wolf, Ph.D. in Ecology

Major Advisor: Dr. Edward Hammill

Understanding beaver mediated changes to stream habitat and ecosystem services across spatial scales

Within the Intermountain West, beaver (*Castor canadensis*) represent a keystone species that was ubiquitous across the landscape prior to Indo-European settlement. However, beavers were extirpated from many stream systems by fur trapping, agriculture and human settlement. This loss of beaver has altered the structure of functioning of stream ecosystems, and the extent of these changes remains a central question for stream ecologists. As we have learned more about the importance of beavers in stream ecosystems, they have been increasingly used as tools for stream restoration through translocations and mimicry of their hydro-engineering. However, little is known about how these beaver mimicking restoration projects influence riparian habitat and ecosystem services (ES) over the course of their life cycle. Further, few studies have attempted to quantify changes to habitat and ES over a natural beaver dam's life cycle. The broad objective of my dissertation is to understand how the age of beaver complexes impact the structure of habitat and delivery of ES across a variety of stream order scales. I will accomplish this objective by answering several research questions: (1) How does the provisioning of ES and multi-taxa habitat quality vary within the life cycle of a beaver complex? (2) Does beaver complex age influence species diversity and occupancy of amphibians or aquatic macroinvertebrates? (3) Can beaver dam analogs be used to improve water quality, hydroperiod and habitat within an EPA-listed impaired watershed? In order to answer these research questions, I will use a multi-faceted approach incorporating space-for-time substitutions and before-after-control-impact study designs across a variety of spatial scales. Study sites will include natural beaver complexes and restoration projects across the Intermountain West at the landscape, watershed, and reach scales. Age-explicit predictive models of habitat for multiple taxa and ecosystem function will be created from this data set. This research will test ecological theories in the landscape, community, and meta-community ecology fields. Further this work will produce a decision

support tool to better inform managers, landowners, and restoration practitioners within the Intermountain West of where they should place projects to achieve their long-term stream restoration goals.

Lindsay Capito, MS in Watershed Science

Major Advisor: Dr. Janice Brahney

The role of receding glaciers in Didymo bloom formation

Overgrowth or “blooms” of *Didymosphenia geminata* (Didymo) have increased across North America in recent decades and the cause is still unknown. Didymo is a lotic diatom capable of producing large overgrowths of carbohydrate stalk. Overgrowths can range from mild to stream-covering events and can wreak havoc on water infrastructure and have consequences to stream ecosystems, the latter through the alteration of habitat as well as periphyton and macroinvertebrate community composition. Though the environmental trigger is unknown, didymo overgrowth has been statistically linked to conditions of high light, low inorganic phosphorus, and low streamflow. Because glacial meltwaters are richer in particulates and inorganic phosphorus than are unglaciated streams, the loss of glaciers in the mountain west could be a driving factor in the increase in Didymo blooms. My proposed research will examine the relationship between declining glacial cover and Didymo blooms in the Intermountain West. We will evaluate the relationship between glaciated streams and the presence of Didymo to assess if declining glacial cover is leading to increased Didymo presence. We will accomplish this by pairing field observations with a controlled experiment wherein we will manipulate physical conditions to simulate degrees of deglaciation. The experiment will test the effect of varying degrees of turbidity, nitrogen to phosphorous ratios, and the ratio of organic to inorganic phosphorous on Didymo stalk formation. By understanding the cause of Didymo overgrowth we are better able to predict the occurrence of mat formation and understand the potential environmental drivers.

Christina Morrisett, Ph.D. in Watershed Science

Major Advisor: Dr. Sarah Null

Linking ecohydrology and social systems to support multi-stakeholder management of the lower Henrys Fork River

Rivers in the arid and semi-arid American West supply water for irrigated agriculture, urban use, hydropower generation, recreational fisheries, and aquatic habitat—a challenging water management landscape. Climate warming exacerbates this challenge. Earlier snowmelt-driven runoff stresses storage infrastructure and shifts agricultural production to earlier in the spring, extending the irrigation-demand season by several weeks. Reduced snowpack decreases late-summer baseflow, warming water and diminishing streamflow available for consumptive withdrawal and storage. Climate models predict greater uncertainty in precipitation and air temperature in the American West—requiring water management strategies that are more resilient to periods of water scarcity. To best adapt water management strategies, we must consider eco-hydrologic relationships as well as the hydro-social system. My doctoral research is conducted in partnership with the Henry’s Fork Foundation and uses an interdisciplinary, place-based approach to identify water management strategies best suited for water supply and ecosystem resiliency in the Henrys Fork watershed. My objectives are to: (1) characterize streamflow-habitat relationships and (2) quantify the effects of groundwater contributions in the lower Henrys Fork to guide a minimum streamflow recommendation, (3) build an optimization model in collaboration with stakeholders to guide reservoir delivery operations that meet multiple downstream objectives, and (4) investigate the adaptive capacity of Teton Valley farmers and ranchers to reduce their irrigation demand. My dissertation uses a watershed-specific example to demonstrate how linking hydrologic, ecological, and social components of water resource management enables multiple stakeholders to adapt to change.

Karen Bartelt, MS in Watershed Science

Major Advisor: Dr. Joseph Wheaton

Evaluating geomorphic responses to beaver dams over time

Beavers (*Castor Canadensis*) are ecosystem engineers that alter stream geomorphology by building dams to impound water. Beaver dams create diverse hydraulics that change channel morphology and increase geomorphic heterogeneity and complexity. Additionally, beaver dams alter valley bottom morphology and increase the lateral extent of riparian habitat by raising the water table, reconnecting or establishing floodplains, and creating multi-threaded channels downstream of the dam.

Beaver dams are dynamic and exist in a variety of physical states throughout their life cycle as they fail and are rebuilt over time. Changes between beaver dam states are common and often inevitable due to a combination of hydrogeomorphic attributes and inactivity or activity by beaver. The different states that beaver dams exhibit over time each uniquely alter channel hydraulics that may result in different valley bottom morphology and associated habitats. Despite the non-permanent nature of beaver dams, it is unclear how geomorphology varies in relation to different beaver dam states. This study will address this knowledge gap by systematically mapping the specific landforms, or geomorphic units, that occur within the channel bed and floodplain of dozens of beaver dam complexes. These data will better quantify and describe the site scale geomorphic complexity associated with beaver dams, and how this complexity shifts over time.

The use of beavers for stream restoration is gaining in popularity. Geomorphic complexity is a frequent target of stream restoration due to links between geomorphic complexity and habitat diversity. A clearer understanding of the geomorphic complexity that results from beaver dams and how this differs over time is an essential component of long term expectation management for restoration practitioners.

