the RESEARCHER

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Carlie Sharpes, Master of Science student at University of Idaho – *read about her research on page 7*

Photo Credit: UI Photographic Services

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the RESEARCHER

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LETTER FROM THE DIRECTOR

Andy Kliskey

Entering Year 4 of the GEM3 project represents an opportunity for bringing together the strengths of Idaho's research, education, and outreach efforts. In September 2021 we highlighted our NSF EPSCoR Track-1 project successes and outcomes before a national panel of experts at our virtual Site Visit. The overall response from the panel was exceedingly positive, with notable praise to our graduate students, postdoctoral scientists, and early-career faculty hires.

The panel noted that each of the research areas, Modeling, Mechanisms, and Mapping of GEM3 (the 3Ms) stand alone as examples of amazing science. However, what really pushes the boundaries of science is the highly integrative nature of and connections between individuals, disciplines, and institutions contributing to the 3Ms. Without doubt this integration is the most noteworthy contribution of the project.

So, it is our ability to think laterally and to creatively connect separate elements of the project that our research and education teams must continue to steadily build toward. In this newsletter we emphasize some excellent examples of research that connects across these different Ms for redband trout. It is no surprise that our graduate students and postdoctoral scientists are at the forefront of this convergent research!

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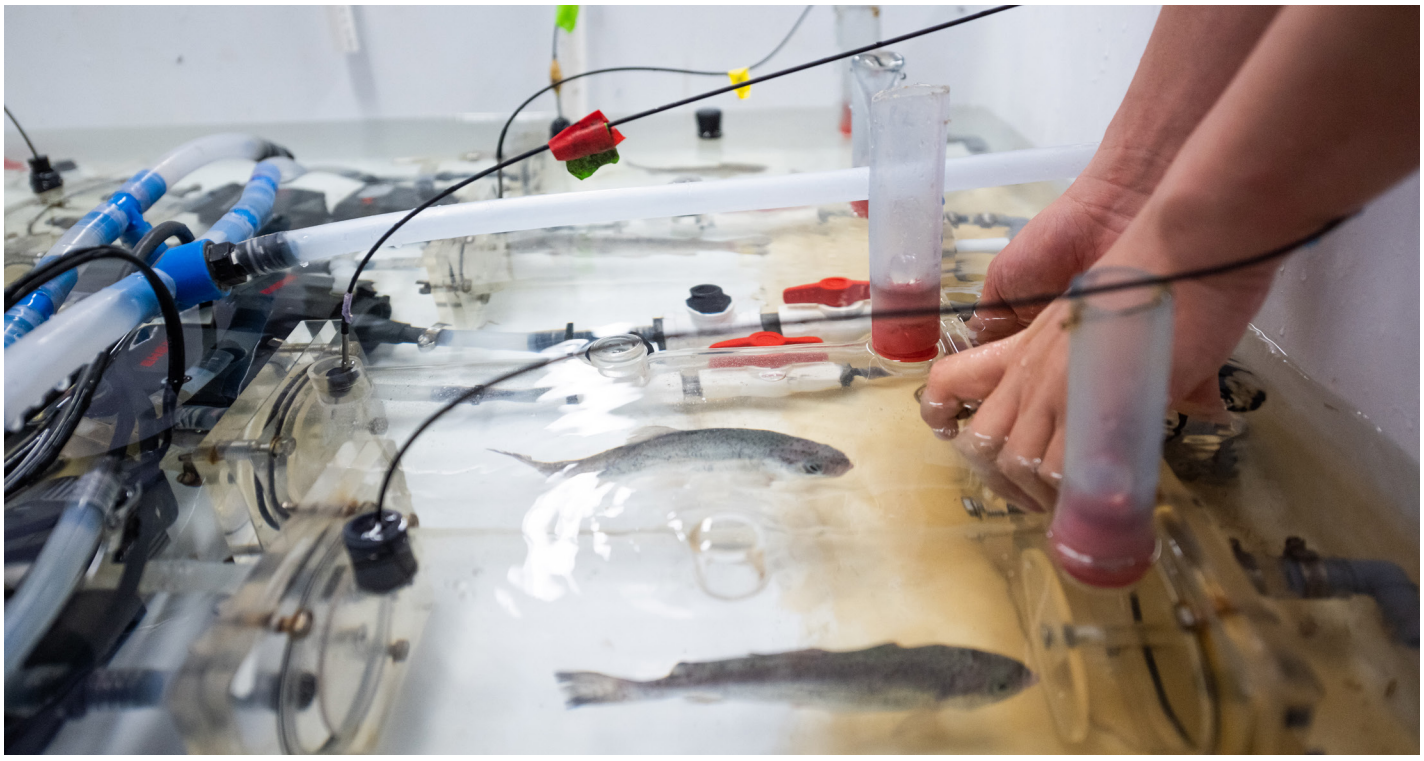
Unless otherwise noted in feature byline, articles and features in this publication are written by Sarah Penney with editing and content contributions by EPSCoR administrative team.

Integrating Geospatial Technique with Stream Temperature Modeling to Understand Redband Trout

Redband trout, one of the two focal taxa studied in GEM3 and a subspecies of rainbow trout, have a preference for cool streams with temperature less than 70 F and can survive daily cyclic temperatures of up to 81 F for a short period of time. A recent concern is that the redband population is facing a high risk of reduction. One possible explanation for this is ongoing habitat loss caused by warming temperatures. Previous studies have found that increases in stream temperature in the Pacific Northwest were due to climate change and a loss of riparian buffers. Therefore, modeling stream temperatures, especially under future scenarios, can help us better understand what we should do for redband trout habitat conservation.

William Wang, a postdoctoral researcher with the Institute for Modeling Collaboration and Innovation (IMCI) at the University of Idaho, is improving the predictive ability of a stream temperature model from the angle of riparian canopy height estimation. Wang has been trained as a geospatial modeler with expertise in geographic information systems and machine learning for the past ten years. Before joining the Idaho EPSCoR project, Wang received his Ph.D. in geography from the University of Connecticut. To link geospatial analysis to hydrological modeling, Wang is closely collaborating with Chris Caudill (associate professor of fisheries at the University of Idaho), Tim Link (professor of hydrology at the University of Idaho),



Respirometers at the Hagerman Fish Culture Experiment Station designed to study oxygen consumption by redband trout.

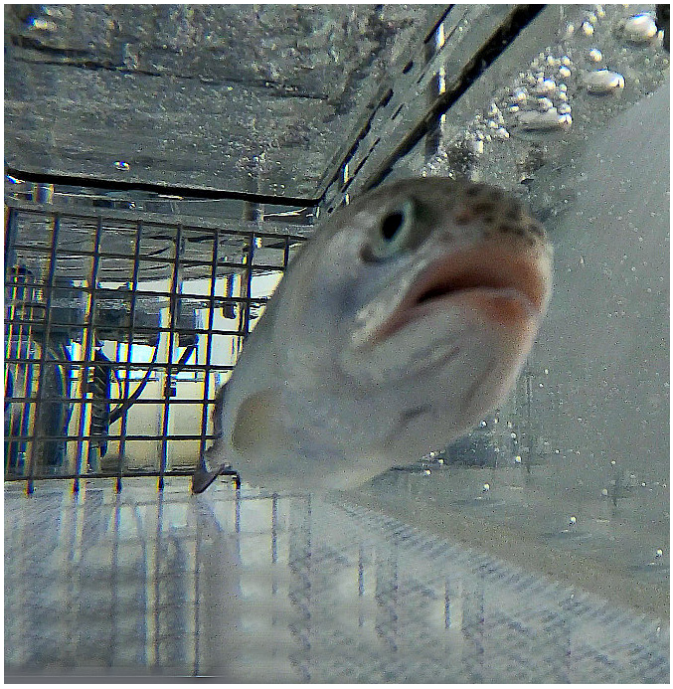
Photo Credit: UI Photographic Services

Research cont.

and many other specialists across the program. The three primary research challenges they are trying to answer are: 1) how to obtain a more accurate estimation of riparian canopy height by using machine learning techniques, 2) how to quantify the impact of tree canopy height on stream temperature over various time scales, and 3) how stream temperatures change under future climate and landscape scenarios?

Wang leads the GEM3 stream temperature modeling group and has proposed that "random forest," a decision-tree-based ensemble learning method, is capable of strengthening the model performance for estimating tree canopy height. Unlike most previous studies only focusing on one criterion for evaluation, this study used two, namely prediction accuracy and spatial predictive ability, to select the optimal hybrid model for estimating canopy height. Results show that the model tends to produce underestimates and overestimates when the corresponding true tree canopy heights are very high or low, respectively. Thus the modeling can be relatively weakened at the most extreme ends of the tree canopy heights. This research made a significant step towards stream temperature modeling over mixed vegetation landscapes, providing a deeper understanding of approaches to model riparian canopy heights at local and global scales. Further analysis will keep focusing on stream temperature modeling that integrates geospatial techniques with hydrological modeling. A distinct workflow has been articulated, and it covers a combined method based on the Distributed Hydrology Soils Vegetation Model (DHSVM) and River Basin Model (RBM).

Currently, redband trout only occupy 42% of their historical stream habitat range, indicating a primary threat of habitat degradation and fragmentation. When climates are more unstable and human interventions are unexpected, a realistic scenario-based model can be of immediate significance and more desirable for decision-makers. The outcomes of this project make better conservation and protection of habitat for sensitive cold-water species, particularly redband trout, possible through visualizing the spatial transformation of their thermal refuges in the state of Idaho.



Underwater footage of redband trout in temperature controlled rearing tanks and swim tunnel experiments.

Photo Credit: UI Photographic Services

Content provided by Hui (William) Wang, postdoctoral researcher from the Institute for Modeling Collaboration and Innovation (IMCI) at the University of Idaho.

Modeling of Landscape Change in Owyhee County

The population in the Treasure Valley grew by 25% from 2010 to 2020, as indicated by the 2020 census. Meanwhile, the rural and open space adjacent to these urban areas continues to see increased pressure on the outdoor recreation facilities and resources, as pointed out by the Idaho Statewide Comprehensive Outdoor Recreation Plan in 2018. Understanding how rapid growth in the Treasure Valley will affect recreational activities and land use in nearby Owyhee County in the southwestern corner of Idaho is important to recreationists, local community members, and land managers.

Li Huang, a postdoctoral fellow at the University of Idaho, is helping to lead research to explore this issue. Huang, who works closely with Dan Cronan (an assistant professor in landscape architecture, as well as the Center for Resilient Communities, at University of Idaho) and Andy Kliskey (a President's Professor and the co-director of the Center for Resilient Communities at University of Idaho) on modeling future scenarios, is investigating the interactions of population growth, recreational visitations, and land use change across the Treasure Valley and Owyhee County, and how the urbanization in Boise and Nampa is playing a role. For example, the increasing demand for outdoor activities will spread across a large area and utilize the resources outside of the urbanizing valley, leading to more visitations and altering the rural landscape in Owyhee County. The research is based on a framework that extends coupled human and natural systems into a "tele-coupling" framework, where "tele-" means the coupled interactions occurring over distances.

Li Huang has a Ph.D. in geography from University of Idaho and a M.S. in urban and regional planning from Peking University. His research interests include ecosystem services and human-environmental interactions. Specifically, his research focuses on scenario modeling of landscape change by stakeholder involvement and geospatial modeling and visualization tools.

Research cont.

This study aims to model the tele-coupling effects at the local scale and provides suggestions for landscape management. The group recently presented their research during the Annual Modeling and Simulation (ANNSIM) Conference in July 2021. Their presentation, *Modeling of Landscape Change and Tele-coupling in Local Socio-ecological Systems: A Simulation of Land Use Change and Recreational Activities in Southern Idaho, United States,* explored the historical trend and spatial distribution of the recreation visitations in Owyhee County.

Based on meetings with a local stakeholder advisory group in Owyhee County, the increased recreation of people living in the Treasure Valley is one of the biggest concerns for the community.

Initial results show that the trend in increasing visitations in Owyhee County is indeed driven by visitors from nearby Treasure Valley rather than from local population change. The spatial distribution of recreational visits is related to proximity to Boise and Canyon County, as well as the location of infrastructure and attractions like roads, trails, and parks.

For this research, the widely available Multi-Layer Perceptron Neural Network (MLPNN) model is incorporated with the tele-coupling effects to provide high accuracy in simulating land use change. The MLPNN, an artificial neural network model with multiple layers and large numbers of tele-connections to represent across the landscape, can learn and simulate complex non-linear patterns such as land use change. It also suggests that management of local landscapes might need coordination across political boundaries and to be adjusted according to scale as demographics change and human activities spread over a wide area and impact neighboring and even distant places.

As one stakeholder has pointed out, "working across jurisdictional boundaries in the Owyhee region would allow people in different states to learn from each other." The Treasure Valley is expected to continue growing, so collaborative efforts are needed to accommodate the impacts of the most populated area in Idaho on rural landscapes and local environments.

Content provided by Li Huang, a postdoctoral fellow at the University of Idaho.

Dry Creek Boise foothills located in the Treasure Valley. *Photo Credit: Boise State University*

Preserving Local Ecology Through Redband Trout Research

Growing up in Boise, Idaho, Carlie Sharpes spent a considerable amount of time exploring Idaho's landscapes and their natural beauty. "Like a lot of Idaho youth," Sharpes notes, "I enjoyed climbing trees, floating rivers, hiking, and sitting around campfires. I think my surroundings and experiences certainly influenced what I became interested in, and what I deemed as important at an early age."

Her interest in local ecology grew and helped influence her decision to pursue a graduate degree doing what she loves. Sharpes, who is currently a graduate student in the Master of Science (M.S.) program at University of Idaho (UI), is majoring in Environmental Science. Through her studies, many things came to light early on. "Once you begin to learn about ecology," states Sharpes, "it isn't long before you realize that an overwhelming amount of ecosystems are imperiled due to climate change and habitat degradation or fragmentation. It was clear that many of our ecosystems need significant conservation efforts so they can be enjoyed by generations to come."

Through her graduate studies and interest in conservation, Sharpes became involved in research with the Idaho EPSCoR GEM3 project where she works closely with a research team at the Hagerman Fish Culture Experiment Station in Hagerman, ID.

Carlie Sharpes, Master of Science student at University of Idaho

Photo Credit: UI Photographic Services

Research cont.

Sharpes' research project, titled *'Swimming in thin air': Evaluating the combination of hypoxic and thermal stress as an additive or synergistic effect,* aims to understand the combined effects of thermal and hypoxic stress as an additive or synergistic effect on redband trout native to distinct desert, cool montane, and cold montane habitats in Idaho. The cardiac function of these trout when under thermal and low oxygen (hypoxic) stress may be influenced by genetic composition and/or their ability to acclimate to warmer water.

Her collaborative efforts include working with her thesis major professor, Brian Small (UI professor of fish physiology and director of the Hagerman Fish Culture Experiment Station) and Chris Caudill (UI associate professor of fisheries), and Shawn Narum (senior scientist/lead geneticist with Columbia River Inter-Tribal Fish Commission) on her overall experimental design. She also works closely with fellow UI graduate student, Jonathan Masingale, on coding and fish sampling, as well as UI post-doc, Zhongqi Chen, who serves as her mentor in experimental protocol and statistical analyses for the maximum cardiac function under acute warming and low oxygen tolerance.

Outcomes from the research will show the ability of redband trout to cope with thermal and hypoxic stress (response to temperature and oxygen levels in water) depending on where they are from (desert, cool montane, or cold montane habitat), and how long redband trout can persist during thermal and hypoxic stress depending on their acclimation temperature. It will also show effects of acute thermal stress on redband trout both with and without aquatic hypoxia.

This research may give vital information about the future of redband trout populations. Redband trout are listed as a sensitive species and have been petitioned to be on the endangered species list multiple times because several populations have gone extinct. This research can show the effects of hypoxia, or dissolved oxygen deficiency, in addition to shifting thermal regimes in native redband rivers and streams as well as show how redband can cope with these stressors. These results can aid in modeling future population dynamics of redband as their habitat quality shifts in the face of climate change. These models can provide useful information for fisheries management and conservation of redband trout in their native range.

With Sharpes nearing her graduation date, she is hoping to become a conservation biologist to help aid in preserving the local ecosystem, stating, "I just hope that my work can aid in the ongoing conservation research on Idaho's native redband trout, a crucial piece of our local ecology."

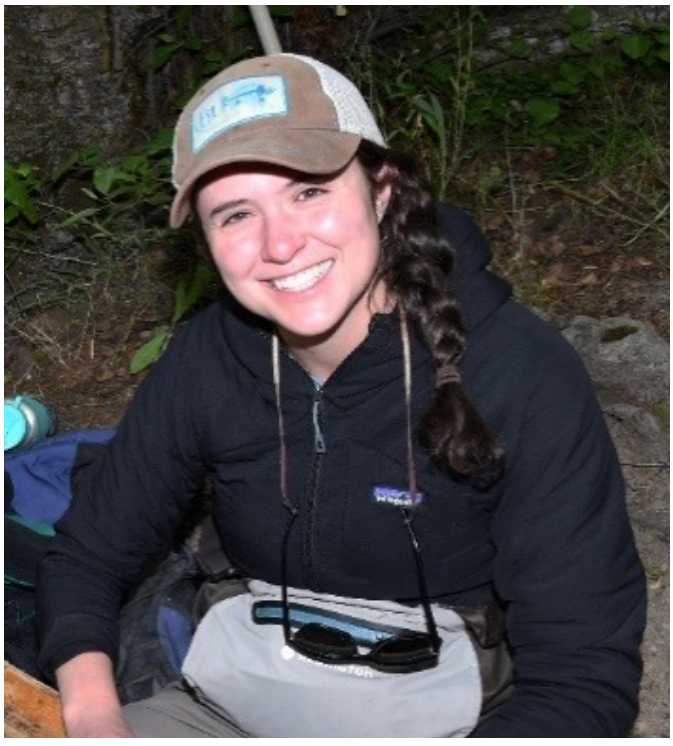
"It was clear that many of our ecosystems need significant conservation efforts so they can be enjoyed by generations to come."

Carlie Sharpes

ISU Graduate Students Team Up on Research of Redband Trout

Anna Ringelman recently completed her M.S. degree at Idaho State University (ISU) as part of the GEM3 trout mechanisms team. Over the past two years, Ringelman measured habitat quality for redband trout in desert and montane streams to determine how seasonal changes in streamflow, temperature, and food availability limit the abundance of suitable habitat. Using a bioenergetic foraging model, Ringelman estimated how the energetic quality of trout habitat changes over a summer-fall growing season and how the pattern differs between desert and montane ecosystems. Her modeling approach also allowed her to estimate how predicted changes in temperature may affect future conditions for trout under different climate change scenarios. She is currently putting her experience to work as a new regional fisheries biologist for the Arizona Game and Fish Department in Tucson, Arizona.

Ben Kline is a current M.S. student at Idaho State University examining genetic variation of redband trout in Idaho. Kline's research has focused on examining epigenetic variation of redband trout by comparing DNA methylation patterns of heat-shock protein genes that have been associated with thermal stress responses in fishes. Kline's approach to the topic is based on comparing wild trout populations from different areas of Idaho with contrasting thermal regimes from desert and montane ecosystems. As part of the trout mechanisms team at ISU, Kline sampled wild trout populations to capture how DNA methylation



Anna Ringelman, Master of Science student at Idaho State University

Ben Kline, Master of Science student at Idaho State University

Spotlight cont.

patterns may change before, during, and after peak summer temperatures and determine whether those patterns differ in direction and magnitude between desert and montane streams. Following completion of his degree this fall, he plans to begin a Ph.D. program at Michigan State University in East Lansing, Michigan.

Tyler Breech is a current Ph.D. student at Idaho State University and part of the GEM3 trout team. Breech's project is focused on describing the major axes of phenotypic and genetic diversity in *Oncorhynchus mykiss*, including many of the native trout species from western North America.

He has been compiling DNA and tissue samples of native trout populations collected from throughout the West to estimate genetic distance among trout species and determine if current measures of species diversity are captured in estimates of genetic diversity. Breech has also been collecting phenotypic samples (of observable characteristics of individual fish), paired with genetic samples, by building an archive of digital photographs from trout sampling locations. In doing so, he plans to examine the degree of agreement between external observable diversity and genetic diversity among native trout species.

Research summaries provided by Ernest Keeley, Idaho State University professor of fish ecology.

Tyler Breech, doctoral student at Idaho State University

Visiting Tribal Scholar Energizes Indigenous STEM Efforts

Shanny Spang Gion, University of Idaho Visiting Tribal Scholar

Photo Credit: UI Photographic Services

In fall of 2020, a new Visiting Tribal Scholar position was created at the University of Idaho (UI) to identify ways in which institutions of higher education could facilitate Indigenous student education, increase enrollment, and increase success rates of existing students.

The two-year position, which receives financial support from the College of Natural Resources and Idaho NSF EPSCoR GEM3 project, aims to increase completion rates for Native American students by providing culturally responsive support in the form of mentoring to Indigenous students, Indigenizing curricula in the affiliated programs, and direct linkages to regional tribes to engage in research or projects of mutual interest to the scholar and college.

Shanny Spang Gion, who has a B.S. in environmental science from Montana State and an M.S. in interdisciplinary studies with a focus in hydrogeology and technical communication from Montana Tech, was selected as the first new Visiting Tribal Scholar.

In a recent interview, she provided some additional details about herself and her new role at UI:

Spotlight cont.

Tell us about yourself.

My name is Shanny Spang Gion. I am a mother, wife, auntie, sister, daughter and granddaughter. I am Northern Cheyenne and Crow and an enrolled citizen of Northern Cheyenne.

How did you become involved in EPSCoR?

The Idaho EPSCoR network does some phenomenal research and work. I first became aware of and involved with EPSCoR through the direct support EPSCoR provides in funding my position. In the broader context of research, it is central to my position's intention to support engagement with academic research in ways that uphold and center tribal values, knowledge, paradigms, and sovereignty so that we can build better relationships with tribal nations. EPSCoR has allowed me the space and provided support to explore and enact changemaking in higher education in service to and with Indigenous communities.

How did you become interested in your current research field?

While I maintain an interest in all things water, my own graduate research journey greatly informed my current and evolving interest in applying Indigenous Research Methods and Methodologies and bringing forward Indigenous knowledge systems in ways that center tribal sovereignty. I'm very interested in the processes in which Indigenous knowledges, worldviews and paradigms are upheld, applied and brought into relationship with other knowledge systems (e.g., in university academia), which requires doing deep and necessary work in constantly questioning and understanding ethics, values, and relevancy of academic work to tribal nations.

What is your current research/project?

There are several aspects of this work that I'm excited to share. Currently, I am working in the University of Idaho's College of Natural Resources (CNR) along with other UI faculty to envision, plan and establish truly mutually beneficial, culturally inclusive and consensual collaborations with tribal nations and communities and our college, specifically. In particular, we are working toward establishing and sustaining good relationship with local tribal nations that is centered in listening to and truly understanding tribal interests, and whether those interests/priorities involve or don't involve, our college. In essence, we are taking the lead from tribal nations in if/how we work to support their priorities. Additionally, we are working to make truly inclusive and appropriately informed intellectual space for Indigenous ways of knowing in our college by taking a critical lens to course development and existing curriculum. I am excited to share that we are currently planning for an Indigenous Science course.

"EPSCoR has allowed me the space and provided support to explore and enact changemaking in higher education in service to and with Indigenous communities."

Shanny Spang Gion

Describe your collaboration efforts with other faculty, researchers, and other departments.

The work being done would not be possible without the support and direct collaboration efforts of College of Natural Resources leadership, including Dennis Becker (dean) and Steven Shook (associate dean). I have also been very fortunate to work with and have support from Vanessa Anthony-Stevens (associate professor of social and cultural studies in the College of Education, Health & Human Sciences), Philip Stevens (associate professor of anthropology, director of American Indian Studies in the College of Letters, Arts and Social Sciences) and Dylan Hedden-Nicely (J.D., associate professor of law and director of the Native American Law Program in the College of Law) who are all co-PIs on a research project titled "Higher Education and Tribal Nation Building," which is greatly informing the approach we take in the College of Natural Resources.

Additional faculty that were part of this project were Karla Eitel (associate research professor of natural resource conservation and director of education, McCall Outdoor Science School in the CNR), Dianne Baumann (assistant professor of American Indian Studies, in the College of Letters, Arts, and Social Sciences), and Chris Hamilton (assistant professor, Department of Entomology, Plant Pathology and Nematology in the College of Agricultural and Life Sciences).

Since then, in CNR we have established an ad hoc committee with support of the CNR leadership that includes Karla Eitel, Lisette Waits (Department of Fish and Wildlife), and Alistair Smith (Department of Fire, Rangeland and Fire Sciences) who are critical to developing the vision, process, and practices that our college can enact toward true nation building.

What are some outcomes that are a result of your work?

The relationship building that happens with tribal nations is core to the work we are doing. With good and mutually beneficial relationships in place, an anticipated outcome is that we establish and sustain critical space for Indigenous research, methods, and methodologies. Additionally, I am very excited that, internal to our college, we are actively engaging in heart work, which has to happen to understand and make space for other ways of knowing.

What are the broader societal impacts of your work?

The work we are doing in the College of Natural Resources is a long and continually engaged process. A broader societal impact I envision is the expansion of defining knowledge, science and ways of knowing that not only makes space for applying Indigenous knowledges, but also can assist students in their understandings of tribal nations, toward building more meaningful relationships with tribal nations in their respective future professional work.

What are your future goals?

A personal goal of mine is to complete a doctoral degree at University of Idaho with a research focus in serving tribal communities. In the broader context of research, it is central to my position's intention to support engagement with academic research in ways that uphold and center tribal values, knowledge, paradigms, and sovereignty so that we can build better relationships with tribal nations.

Exploring the Sagebrush Microbiome

Engaging Idaho 2-year and 4-year colleges, also known as primary undergraduate institutions (or PUIs), is an objective of the GEM3 project and the Summer Authentic Research Experience (SARE) program is a unique way to create avenues for PUI students and faculty to get involved in GEM3 research.

Miranda Striluk, College of Western Idaho (CWI) faculty with a background in microbial ecology, became familiar with EPSCoR through her involvement in the collaborative EPSCoR RII Track-2 award, Genomes Underlying Toxin Tolerance Community (GUTT-C). She was able to work closely with many GEM3 faculty and following the GUTT-C project, applied to serve as a co-mentor for GEM3's SARE program. She then began working on "Exploring the Sagebrush Microbiome," a research project led by Leonora Bittleston, faculty in the Department of Biological Sciences at Boise State University (BSU) and recent hire supported by the GEM3 project.

Sagebrush form is the foundation of the many species in the sagebrush steppe, which covers a vast portion of Idaho. With recent increases in the frequency and intensity of fires and droughts, sagebrush is becoming more and more threatened, and restoration is often unsuccessful. A better understanding of the sagebrush microbiome is needed to improve restoration and replanting efforts.

The team's research focus, "Exploring the Sagebrush Microbiome" characterizes the leaf-associated microbiome of big sagebrush, since it is currently unknown. Microbes, despite their small sizes, can have large impacts on plants and animals.

Hiking into the Dry Creek Boise Foothills field site. Pictured L-R: Aubrey Osorio (SARE undergraduate, BSU), Rachel Capezza (undergraduate, BSU), Miranda Striluk (faculty, CWI), Leonora Bittleston (faculty, BSU), and Jacob Heil (Ph.D. student and SARE mentor, BSU)

Photo Credit: Boise State University

Sagebrush *(Artemisia tridentata)* is an important plant species in our local environment that supports wildlife and a healthy ecosystem, but little is known about the bacteria and fungi that live in sagebrush leaves.

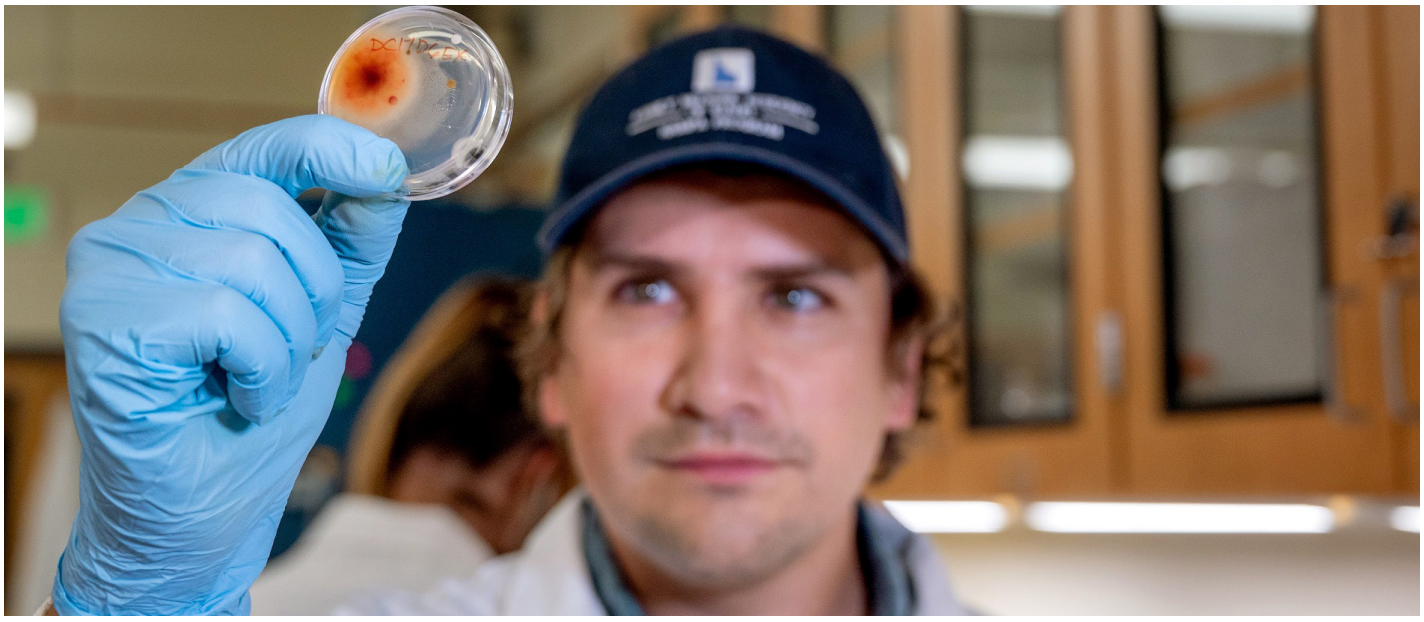
The leaf microbiome might affect leaf chemistry, leaf pathogens, and animals that eat the plant. In this project, the team is characterizing the sagebrush leaf microbiome to understand how it varies from leaf to leaf, how it changes over time, and how it is related to leaf chemistry.

Through collaborative research, the team has developed a better understanding of which microbes are associated with sagebrush, and how they change over time, as well as correlations with plant chemistry and climatic variables. They also have a culture collection of microbes that can be used in future experiments. These efforts will help in future restoration efforts.

In addition to the collaboration between BSU and CWI, the multi-institutional team includes additional faculty and students from Idaho State University and College of Idaho.

As GEM3 approaches the upcoming recruitment period for new SARE research projects for summer 2022, EPSCoR is continuing to explore creative ways to not only encourage multi-institutional collaboration, but to engage PUI faculty in authentic research experiences and connect these experiences back into the classroom. The collaboration between BSU and CWI has already led to new research endeavors. A new BSU-CWI Vertically Integrated Projects (VIP) course will be starting in Spring 2022. Lab modules published on the GEM3 website and additional modules in development are being implemented in multiple laboratory classes at CWI.

According to Striluk, “This project was a great fit for me because I could jump right into the research. Leonora’s lab is full of bright individuals that have created a collaborative environment for all (student, post doc, etc.) to feel comfortable and supported.”



Jacob Heil, Ph.D. student and SARE mentor, working in the Bittleston lab at Boise State University. *Photo Credit: Boise State University*

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Pictured L-R: Jacob Heil (Ph.D. student and SARE mentor, BSU), Rachel Capezza (undergraduate, BSU), Aubrey Osorio (SARE undergraduate, BSU), Leonora Bittleston (faculty, BSU), and Miranda Striluk (faculty, CWI)

Photo Credit: Boise State University