

# the RESEARCHER

IDAHO NSF EPSCoR

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A new NSF project, Broadening Research Capacity in Biology (BRC-BIO), led by Boise State's Allison Simler-Williamson, will involve a series of common garden experiments that manipulate sagebrush populations and their soil microbial communities, like the one shown here, initially funded by a GEM3 SEED grant. Read more on page 11.



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### Andy Kliskey

The five-year mark of GEM3 came up on Sep 30, 2023, and the project entered a no-cost extension period that has enabled us to support key personnel and projects through the end of 2023. A dynamic group of GEM3 graduate students, led by Haley Netherton-Morrison, Molly Garrett, Meg Dolman, Carlos Dave Dumaguit, and Jacob Heil, organized an extremely successful session at the Ecological Society of America's Annual Meeting in August highlighting the critical role our graduate and undergraduate students have in contributing to the next revolution in biological sciences. Meanwhile a group of GEM3 graduate students and faculty participated in the Smithsonian Conservation Genomics Bioinformatic Workshop as reported by Morgan Calahan and Mosope Abanikannda – providing an opportunity to extend the workforce development and training outcomes for GEM3. The successes of GEM3 undergraduate student engagement is highlighted by College of Idaho's Professor, Jeff Cooper, who expounds on the benefits of the GEM3 Summer Authentic Research Experiences (SARE) program for 2- and 4-year college students. Readers are treated to what sustainability in Track-1 projects should look like – GEM3 seed grant awardee, Assistant Professor Alison Simler-Williamson, turning the modest seed award investment from GEM3 into a nationally competitive Building Research Capacity in Biology grant from the National Science Foundation (NSF).

With the announcement of I-CREWS, EPSCoR in Idaho breaks new ground by pursuing Idaho's first Track-1 project to formally partner with Coeur d'Alene Tribe and Shoshone-Bannock Tribes alongside BSU, ISU, and UI. I-CREWS also represents the first Track-1 project in recent years to include engineering and engineers, and to partner with the Idaho National Laboratory. The new project team is diligently working through the mandatory strategic planning process and kickstarting a compelling new Track-1 endeavor.

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

## LETTER FROM THE DIRECTOR

Idaho EPSCoR is on the cusp of transition as the GEM3 Track-1 project wraps and we ramp up Idaho's new NSF Track-1 award, Idaho Community-engaged Resilience for Energy-Water Systems (I-CREWS). In this issue of the Researcher we focus on a range of efforts to sustain Idaho's research capacity building through the concluding activities of GEM3 and the new directions being taken in I-CREWS.



# I-CREWS Research

## Idaho Awarded \$20 Million to Study Future Energy and Water Use in State

*University of Idaho press release, May 2023*

**MOSCOW, Idaho** — Idaho researchers will receive \$24 million for a new research project on the impact of changes in climate, population and technology on energy and water use in Idaho.

The funding comes through a \$20 million five-year award from the National Science Foundation (NSF) Established Program to Stimulate Competitive Research (EPSCoR), with the state contributing an additional \$4 million.

Researchers from University of Idaho, Boise State University, Idaho State University, the Coeur d'Alene Tribe and the Shoshone Bannock Tribes are leading the award in collaboration with utility companies, state and federal government agencies, and Idaho cities and counties. Researchers will work to identify energy and water use strategies that will be resilient to Idaho's changing needs, based on ongoing feedback from communities.

"This project is necessary right now because the intersection of water and energy issues is critical to Idaho's people, industries and livelihoods," said Idaho EPSCoR Director Andrew Kliskey, who is the research

project principal investigator and a U of I professor. "It demonstrates big picture, use-inspired, science-informed approaches."

The project is titled Idaho Community-Engaged Resilience for Energy-Water Systems (I-CREWS).

"NSF EPSCoR in Idaho plays an instrumental role in strengthening education, collaborations, research excellence and competitiveness in support of Idaho's Higher Education Research Strategic Plan, which recognizes research as a key to student success and Idaho's future economic vitality. The research dollars from NSF will help Idaho identify solutions to some of the most pressing questions our state faces — water and energy resiliency," Gov. Brad Little said.

Water and energy systems rely on each other. In Idaho, water generates more energy than other sources — such as natural gas, coal power plants and solar power — through both hydropower and other power generation processes. Energy is needed for many uses, including irrigating crops and delivering water to humans. But drought and climate change limit water availability. Idaho will need to balance its demands on these two interdependent resources as the state's population increases, technology advances and community priorities evolve, say the researchers.



*Aerial view of the Snake River in Idaho.*

## Water Use cont.

Through the EPSCoR award, the researchers will identify strategies for energy and water use that will be resilient to future changes across a range of Idaho's communities, landscapes and watersheds.

"Idaho is the perfect place for this study, because we have a variety of ecosystems, community types and management practices," Kliskey said. "We have everything from the semi-arid south to northern temperate forests and a cross section of rural towns, Native American communities and urban centers. By having such a variety of case studies, we hope our findings will be helpful for many communities across the West as they plan."

The research project will probe how social systems, such as government decision-making and local knowledge, inform how urban, rural and tribal communities handle future energy and water use challenges. Idaho communities will have direct access to findings as they emerge throughout the project.

"By working with communities, we think the resulting energy and water use strategies will be more effective and equitable," Kliskey said. "There is a much better chance the community will support and implement sustainable strategies if there is community engagement during the planning stage."

EPSCoR awards are designed to enhance research competitiveness across the country. The project will advance research and education across multiple disciplines, computer modeling capacity, workforce development initiatives and research partnerships in Idaho.

I-CREWS will involve more than 35 university and college faculty, plus eight new early-career hires, 10 postdoctoral researchers, 20 graduate students and more than 120 undergraduate researchers, with supporting projects reaching more than 500 students and community members. Students will hone the technical skills necessary to fill energy and water systems workforce needs.

Partnerships are also planned with state and federal agencies, the Center for Advanced Energy Studies, public and private utilities, Idaho National Laboratory and tribal nations. A Tribal Nation Research Network will be created to support the development of tribally originated research.

"The collaborative effort that this award represents is phenomenal, with the partnership among all levels of our higher education institutions, the Tribal Nation Research Network and other agencies and utilities," said Doyle Jacklin, Chair of the Idaho EPSCoR Committee. "This level of cooperation will be integral to creating more resilience to the vast changes Idaho is experiencing in our communities."

The co-principal investigators are U of I Professor Karla Eitel, U of I Professor Alistair Smith, BSU Associate Professor Kathleen Araújo and ISU Graduate Faculty & Research Administrator Kitty Griswold.

For a complete list of partners and more information, view the NSF EPSCoR news release and Idaho EPSCoR I-CREWS page (<http://www.idahoepscor.org/i-crews>).

This project is anticipated funding to the Regents of the University of Idaho by the National Science Foundation. The anticipated FY23 funding released is \$2,099,031, of which 100% is the federal share and the anticipated total funding authorization is \$20,000,000.

## I-CREWS Research

### I-CREWS Strategic Planning Underway

Members of Idaho's new statewide National Science Foundation (NSF) EPSCoR Track-1 Research Infrastructure Improvement (RII) project gathered in Moscow, Idaho on October 11-13th, 2023, for a Strategic Planning Workshop for the Idaho

Community-engaged Resilience for Energy-Water Systems (I-CREWS) project.

The meeting provided an opportunity for leadership in Idaho's NSF EPSCoR award to connect, communicate, and coordinate planned research and education activities related to the I-CREWS project.

Participants included over 30 I-CREWS leads from around the State including Idaho research institutions, 2-year and 4-year colleges, Tribal partners, and national laboratory collaborators.



## I-CREWS Research cont.

The purpose of the meeting was to create the I-CREWS strategic plan, mapping out and guiding the project's path for the next 5 years. To achieve this, members of the I-CREWS team met to start converting the successful proposal's content into the structure for a Strategic Plan—a format that allows the team to align efforts and implement the project's activities and objectives. The Plan also describes how the RII Track-1 project aligns with the science, technology, engineering, and mathematics (STEM) research and other project element priorities defined in Idaho's Higher Education Research Strategic Plan.

Andy Kliskey, Idaho EPSCoR Project Director, provided welcome and opening remarks and gave an overview of the I-CREWS mission, goals, and framework. NSF Program Director, JD Swanson, was also in attendance and explained NSF's expectations for the strategic planning process in the context of NSF EPSCoR's programmatic goal to strengthen STEM capacity and capability nationwide. The meeting was facilitated by John Riordan, Leadership Development Consultant, who provided a review of the strategic planning framework and set of ground rules to guide the workshop.

Participants reviewed the overarching cross-project research strategy for the project to determine timelines and best approaches for working with/in I-CREWS testbed sites, discussed the community and Tribal engagement strategy, and identified gaps and barriers across the next 5 years that need to be addressed.

Project Area leads also provided an overview of the content highlights for their respective areas, including how the proposed work will advance the state of knowledge in the relevant research area or contribute to broader societal impacts.

Next steps include engaging the other I-CREWS partners and collaborators to help complete the plan and implement activities to meet first-year goals and objectives. Component working groups have been established and community-engagement strategies are being developed by the team.

Through efforts such as strategic planning, NSF EPSCoR in Idaho is fostering collaborations across Idaho, catalyzing new research and education, and helping our state to compete in national and global contexts.



Members of Idaho's new statewide National Science Foundation (NSF) EPSCoR Track-1 Research Infrastructure Improvement (RII) project during a strategic planning meeting held in Moscow, Idaho on October 11-13th, 2023.

## Data Management

### Breaking the Open Data Ceiling

by Andrew Child

The White House announced 2023 as the Year of Open Science. Federal agencies have been working in overtime to launch and adapt national initiatives and policy changes to embrace open science initiatives more fully. Open Science is the movement to make scientific research, data and their dissemination available to any member of an inquiring society, from professionals to citizens.

The US National Aeronautics and Space Administration (NASA) recently launched its TOPS initiative (Transform to Open Science) and the US National Institute of Health (NIH) introduced its updated Data Management and Sharing Policy. As open science continues to be adopted across funding agencies and research institutions, we can expect to witness the transition from guarding research data within private research silos to openly sharing research products within public facing repositories, and Idaho will not be left in the dark!

Idaho EPSCoR made remarkable strides in open data practices over the last few years. Here are a few open data highlights from the Year of Open Science:

### 100+ Data Products

In the final year of funding, the GEM3 project (Current RII Track-1 Award; OIA-1757324) surpassed 100 publicly available data products, with 101 products currently available within the GEM3 metadata catalog and 13 additional products currently in

## Data Management cont.

review for release over the coming year. Data products are currently shared within seven private, government and institutional repositories, and include raw and derived research data, reproducible workflows, software, webpages, code, scripts and more. Responsibly sharing data within public repositories provides complete transparency by researchers regarding the reproducibility and replicability of their work. Additionally, open data access provides raw and derived data products that can be used as the foundation of future research and collaborations.

### **Schema.org: the Future of Data Search**

We all know the first place you are going to search if you need to find a piece of information on the internet... Just Google it! Finding open data isn't always as easy as finding lodging for five in Oahu, but can it be?!? Idaho EPSCoR data products cataloged within the University of Idaho Research Computing and Data Services (RCDS) repository are now documented with Schema.org metadata descriptors which greatly improves data discovery through search engines and AI technology. This specialized descriptive language allows datasets to be cataloged by automated bots and subsequently increase data findability using search engine optimization within tools like Google's Dataset Search and general search engines.

### **Reproducible Workflows Lead to Reproducible Science**

In addition to releasing over 1,000 gigabytes (Equivalent to 250,000 12MP photos) of raw data over the last year, both unoccupied aerial systems (UAS) and genomics researchers within the GEM3 project publicly released reproducible workflows and code to increase transparency and reproducibility within the open science initiative. Open access to scientific workflows and protocols allows researchers to advance science at a much faster pace and has been shown to reduce research costs within future studies.

### **Move to the Future of Open Science**

We've all witnessed global scientific open science collaboration, as scientists throughout the world have shared data to combat the COVID-19 pandemic. Open science is the way of the future. As initiatives continue to increase across the research landscape, join Idaho EPSCoR in responsibly advancing open science and open data practices throughout statewide research programs and perhaps, the world.

## GEM3 Research

### **Student Perspectives on Collaboration and Integration at the 2023 Ecological Society of America Conference (ESA)**

By Haley Netherton-Morrison

With the goal of speaking to our personal experiences of navigating research integration across scales, species, disciplines, and career stages, nine GEM3 graduate and undergraduate students presented in an organized Inspire Session at the 2023 Ecological Society of America Conference (ESA) in Portland, Oregon in August 2023. The idea for the session first emerged during the 2022 GEM3 Graduate Student Retreat, where 14 GEM3 graduate students gathered

for a weekend of community-building, professional development, and integration across research projects. Several retreat participants expressed an interest in working toward a larger product to showcase student efforts within the GEM3 project. With this goal in mind, I (Haley Netherton-Morrison) and the rest of the organizing team (Molly Garrett, Meg Dolman, Carlos Dave Dumaguit, and Jacob Heil) began working to outline the session theme and identify a conference and session format.

We decided that ESA's Inspire Session format would be a great fit because of its emphasis on lightning talks aimed at stimulating conversation, and we began recruiting speakers to share their perspectives and takeaways on navigating integration and collaboration on such a large, interdisciplinary project. In October 2022, we submitted a session proposal titled "Collaboration and Integration Across Scales, Species, and Studies: Graduate Student Perspectives".

However, as our session continued to develop, we realized we want to broaden the student perspectives to include undergraduate perspectives, made possible by the addition of Harrah Friedlander and Kaitlyn Opland to our speaker line-up. Altogether, our session touched on projects related to sagebrush, trout, and associated biota and also emphasized workforce development, engagement and partnerships, and collaboration across these taxa, with highlights from each talk listed below.

**Meg Dolman**, a PhD Candidate at Boise State University, was the first speaker and kicked off the session by providing context for the GEM3 project, including the three M's (mechanisms, modeling, and mapping), the Vertically Integrated Projects (VIP) and Summer Authentic Research Experiences (SARE) programs, the evolution of the GEM3 community, and the simplified session figure.

**Carlos Dave Dumaguit**, former Boise State University student on GEM3 team and now a PhD student



Idaho session speakers at the 2023 ESA Conference in Portland, Oregon. (Photo Credit: Leonora Bittleston)

at University of Utah, emphasized the role of collaboration in the sagebrush genomic work and his MS research through a collaboration counter, and also shared how his experiences with VIP, SARE, and his MS have made him a more confident and established researcher.

**Jacob Heil**, a PhD Candidate at Boise State University, used his PhD work on characterizing the sagebrush leaf microbiome to highlight the broader impacts of the sagebrush microbiome work, particularly through research and education opportunities for undergraduate students in SARE, VIP, and microbial physiology labs.

**Jessica Bernardin**, a PhD Candidate at Boise State University, not only shared her own experiences as a mentor to undergraduate students, but also highlighted SARE and VIP experiences at multiple career stages. In doing so, she shared the skills that were gained through the pitcher plant metadata VIP, the sagebrush phyllosphere microbial interactions VIP, and the microbial ecology SARE and VIP programs.

**Kaitlyn Opland**, a BS student at Boise State University, shared her experiences with SARE and VIP research as well as the challenges and opportunities that emerged during the research process, including rediscovering her love for research and finding community within her research team and the courses associated with VIP.

**Harrah Friedlander**, former University of Idaho student and now a PhD Student at The University of Queensland, told the story of how SARE led her to pursue not only a senior thesis on the impacts of sagebrush genetic and environmental factors on arthropods, but also ignited a passion for working as part of a collaborative team that she plans to pursue in her PhD program.

**Molly Garrett**, a PhD Candidate at the University of Idaho, shared the parallels between community genetic interactions/processes and the interdisciplinary synergism required to study them that emerged through the course of her PhD work with GEM3. Molly also emphasized the benefits and need for team science to tackle complex challenges, such as improving restoration practices in the sagebrush steppe ecosystem.

**Carlie Sharpes**, former University of Idaho student and now an Aquaculturist with the Klamath Tribes, discussed the synergism that was required by collaborators to unravel whether hypoxic and thermal stress have an additive or synergistic effect on redband trout, the focus of her MS research at the University of Idaho.

**Haley Netherton-Morrison**, a PhD Candidate at Boise State University, was the final speaker of the session. My talk focused on opportunities and challenges that emerged while working with stakeholder and community partners on my PhD research, with an emphasis on how to better support student researchers in doing research that is designed to meet both stakeholder and researcher needs and objectives.

In addition to our student session, there were many additional GEM3 student projects presented at the ESA conference. Molly, Jessica, and I (Haley) presented our work in oral sessions throughout the week and Meg, Adetotun Arogundade (BSU), Arden Engel (BSU), Treyton Harris (ISU), and Ryan Wickersham (BSU), presented their research during the poster sessions.

Thank you to GEM3 leadership, Idaho EPSCoR, and everyone who helped make this organized session possible as well as the session co-organizers and speakers for making this such a fantastic end for many of our GEM3 experiences, including my own!

## Reflections from GEM3 students:

“I am beyond grateful for GEM3 and this opportunity to share my experiences at such a large conference. In a way, this was similar to a culminating project or capstone, embodying my journey: how from my undergraduate research career all the way through a successful graduate thesis and defense, the GEM3 community has scaffolded me with mentors, resources, finances, and experiences that continue to shape how I carry myself as a learner and researcher.”

— **Carlos Dave Dumaguit, Co-Organizer**

“This was my first time being a part of a bigger research team. Even though we all did not work together in the lab setting, we worked together to connect our results with each other and it really painted the bigger picture of our interconnected research. I loved getting to be a part of this team!”

— **Kaitlyn Opland**

## Workforce Development

### Insights from the Smithsonian Conservation Genomics Bioinformatics Workshop

By **Morgan Calahan & Mosope Abanikannda**

Graduate students from Idaho’s research institutions included Morgan Calahan (BSU), Mosope Abanikannda (UI), and Jon Masingale (UI). Faculty members Ernest Keeley (ISU) and Miranda Striluk (CWI) also attended. Held at the Smithsonian Conservation Biology Institute’s facility, the workshop equipped participants with the knowledge and tools to conduct their own conservation genomics projects.

Attendees worked with clouded leopard genomic data to learn the process of genome annotation, including, but not limited to: processing raw data, cleaning,

calling variants across the genome, gene prediction and annotation, as well as further downstream analyses. Attendees continue to collaborate with course graduates in this research. A significant portion of the skills acquired will be directed towards research occurring at the universities represented by the attendees, including the analysis of genomic data from redband trout, sagebrush and Columbian Sharp-tailed Grouse in Idaho.

Notably, GEM3 attendees documented these workflows through an open-access GitHub page



and repository, sharing this process of genomic data analysis. This initiative showcases GEM3-sponsored participants' commitment to advancing not only their research but also empowering fellow researchers in conservation genomics through reproducible science.

Participants gain hands-on experience in designing and executing conservation genomics projects, development of critical skills in handling genomic data and utilizing population genomics software, and collaboration on a real-world project, resulting in a manuscript submission to a peer-reviewed journal.



*Participants from the Smithsonian Conservation Genomics Bioinformatics Workshop.*

## Workforce cont.

The outcomes contribute to the advancement of conservation genomics research globally, fostering a community of researchers proficient in sophisticated genomic analyses. By engaging participants, including those sponsored by EPSCoR, in collaborative, real-world projects, the workshop not only enhanced individual capabilities but also promoted best practices for teamwork in genomics research.

The knowledge and skills acquired by participants, with a specific focus on redband trout and sagebrush have the potential to significantly impact conservation efforts in Idaho. As most of the skills developed will be applied to analyze genomic data from these species, the workshop contributed to a deeper understanding of the biodiversity in Idaho, aligning with ongoing GEM3 EPSCoR-funded research initiatives in the region.

## GEM3 Research

### College of Southern Idaho Helps Students Explore the Scientific Method in Meaningful Way

The College of Southern Idaho (CSI) is working to bring research opportunities to undergraduate students through Idaho EPSCoR's undergraduate research program. Jeff Cooper, Professor of Water Resource Management & Agriculture at CSI, originally got involved with EPSCoR shortly after being hired as faculty at CSI in 2015.

Cooper states, "having been involved in a variety of research projects through my academic and professional career, I wanted to open up more similar opportunities for CSI students." He continues, "with a firm belief that going through the research process was not only rewarding, but a vital contribution to the scientific community, I could see utility for both transfer- and technical-minded students." He connected with Idaho EPSCoR and was able to receive funding to support undergraduate research.

At that time, EPSCoR's research experiences were only led by one of Idaho's three research institutions;

however, Cooper was able to secure the first EPSCoR-funded undergraduate research project hosted at CSI and served as a faculty mentor under the MILES Undergraduate Research and Internship (MURI) program funded by Idaho's Track-1 project (NSF award #1301792). The CSI MURI project back in 2015 centered on analyzing the potential of utilizing aerial imagery obtained through small remote sensors to detect soil moisture and texture in untilled and tilled settings to improve water management.

Currently, over 15 CSI students have participated in the EPSCoR-funded research positions stationed at CSI, and it also opened the door for additional 2-4 year colleges to provide research positions to their students as well.

CSI's support of undergraduate research has continued and under the subsequent Idaho EPSCoR project, GEM3, Cooper served as a faculty mentor to

## GEM3 Research cont.

undergraduate students through GEM3's Summer Authentic Research Experiences (SARE) Program.

Although the GEM3 SARE Program had its final round of awards during summer 2023, some selected programs were able to continue research with the help of GEM3 funds. CSI was able to continue efforts into the Fall of 2023. The focus of the current research project is to assess the ability of remote sensing to effectively compare regrowth in burn areas in specific vegetative communities along with exploring the use of open-source geospatial technology to monitor range health.

Abigail Cluff and Kaden Hensley worked on a research project centered on leveraging geospatial assets to investigate riparian vegetation damage and re-establishment in the Badger Fire (2020) area of southern Idaho. Abigail Eidson's project focused on measuring habitat loss of the Cassia Crossbill (*Loxia sinesciuris*) due to the Idaho Badger Creek Fire using remote sensing classification methods. Finally, Shalani Wilcox's research revolved around spatial assessment and documentation of rangeland health on grazing allotments in sensitive areas using low-cost and open-source geospatial technology.

Andrew Cluff, Associate Professor of Engineering at the College of Southern Idaho, assisted with field data collection and processing. Students were involved at every level of the research, from data collection to data analyses. Imagery collection from sUAS, along with RTK GPS control data, played a huge role in the project's progress. None of which could have been accomplished without their support.

Providing students with the tools and research background to address regional issues close to home is something that's not only beneficial to the students, but has both local and societal impacts.

Remote sensing can be effectively used to track regrowth, in riparian areas, with limitations. The use of satellite imagery is often too coarse to effectively classify some vegetative communities.

Imagery collected from small Unmanned Aerial Systems (drones) can provide better resolution for more effective determination of regrowth, however, while the use of drones is more effective, it takes more time to collect and process the data than satellite imagery.

As natural resource managers look for tools to monitor rehabilitation efforts in burned areas, remote sensing can provide qualitative and quantitative solutions. Open-source technology provides useful tools for range health monitoring but will require well-developed training modules to be broadly implemented.

Idaho is a state abundant in natural resources. The development of more effective tools to measure and monitor these assets is critical to its long-term stability. The adoption of remote sensing techniques, in conjunction with open-source resources, could provide meaningful instruments to aid in stakeholder decision making. Similar protocols to those studied in this project could be developed and deployed at the statewide level. These protocols could be used as an example for other states, and regions, facing similar challenges.

"The SARE program provided a fantastic experience for students to experience the scientific method in a meaningful way," according to Cooper. "Building such opportunities at this scale, and providing inquiry at this level, is a massive investment, but with incalculable dividends. Observing their growth, and playing a small role in their development, has been one of the highlights of my career."



College of Southern Idaho (CSI) SARE team investigating riparian vegetation damage due to the Idaho Badger Creek Fire using remote sensing classification methods.



## New Award Advances Research Examining Role of Soil Fungi and Bacteria in Big Sagebrush Restoration

By Allison Simler-Williamson

With new funding from the National Science Foundation's Broadening Research Capacity in Biology (BRC-BIO) program, a team of Boise State University researchers will explore where and when we expect populations of big sagebrush (*Artemisia tridentata*) to exhibit a "home field advantage" in relationship to the soil fungi and bacteria they encounter during restoration efforts. Post-fire restoration efforts in sagebrush steppe often involve the movement of sagebrush seeds across geographical areas, but it remains poorly understood whether seedlings' success may be hindered when they encounter 'unfamiliar' soil microbes in sites that are far from seeds' origins.

This new project is led by faculty from Boise State University's Department of Biological Sciences

including Allison Simler-Williamson (PI), and Marie-Anne deGraaff (Co-PI), Trevor Caughlin (Co-PI), and Leonora Bittleston (Co-PI). The Project leverages pilot results collected as part of an NSF EPSCoR-funded seed grant awarded through the GEM3 project in 2020.

Local adaptation occurs when populations evolve to become more successful in their home environments and is foundational to understanding populations' current and future persistence. Harmful and beneficial interactions among species may create "biotic" patterns of local adaptation, in which some organisms have advantages in their "home" communities, compared with populations coming from different or more distant environments. Yet, the strength of this 'home field advantage' varies widely across large landscapes, and the drivers of this variation remain poorly understood.

The proposed work will integrate field- and lab-based 'common garden' experiments, in which sagebrush populations are planted into different combinations of soil fungi and bacteria, identified using DNA sequencing. Results from experiments will be incorporated into models that assess whether populations from contrasting environments differ in their susceptibility to shifting microbial interactions under changing climatic conditions. The project team will collect additional field data to measure how well population models predict sagebrush seedling establishment in ongoing restoration efforts.

This work will generate crucial data about big sagebrush, a declining plant of restoration concern, and how its relationships with soil microbes may shift with climate change and restoration efforts, which move seeds across wide distances. The population models generated by this work are designed to communicate the impacts of microbes on sagebrush in terms of restoration-relevant metrics, as this iconic plant is declining across Idaho and the rest



*GEM3 undergraduate student, Kaitlyn Opland, retrieving sagebrush seeds from a common garden experiment that manipulates sagebrush populations and their soil microbial communities.*

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### Restoration cont.

of the western U.S. The results of this research will be applicable to the selection of suitable seeds for restoration efforts.

This project aims to broaden diverse participation in biological research by undergraduates at Boise State University. This three-year award will support 2 graduate students, 8 undergraduate research positions, and more than 12 course-based undergraduate research experiences through Vertically Integrated Projects at Boise State, including

students mentored through a new Art-Science Integration course, developed by GEM3 collaborators Stephanie Galla, Megan Cattau, and Sarah Dalrymple.

In addition, funding will support PI Simler-Williamson's efforts to improve student community-building and learning outcomes in a large introductory biology course, using active learning materials that incorporate scientific results from this work, focusing on Idaho's changing bacterial, fungal, and plant communities.