the RESEARCHER

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Carolyn Dadabay (far right), College of Idaho chemistry professor, along with GEM3 SARE students (L-R), Drew Wyman, Brayden Christensen, and Doris Bechet, during a site-visit in Summer of 2022 to the Soda Fire site to meet with other GEM3 collaborators and collect sagebrush as part of their SARE project, "The Chemical Environment of the Sagebrush Microbiome."

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the RESEARCHER

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LETTER FROM THE DIRECTOR

Andy Kliskey

GEM3 outcomes and impacts are emerging rapidly and span numerous facets of the project – research, education, workforce development (WFD), professional development, and partnerships. This newsletter issue highlights a broad range of these outcomes and impacts.

The work on mapping sagebrush recovery after wildfire by Trevor Caughlin and team, has led to an NSF EAGER award. Their GEM3 Vertically Integrated Project (VIP) is providing important training and WFD impact, while the research outcomes are supporting actionable science to inform ecosystem restoration. The groundbreaking work of Sven Buerki and team to sequence the big sagebrush genome has major implications for the conservation and restoration of sagebrush steppe. GEM3 team members Chris Caudill, Kitty Griswold and Shawn Narum organized the annual American Fisheries Symposium in Spokane recently, where they highlighted innovative science approaches and the role of integrative understanding for forecasting the effects of warming on fish populations. Congratulations to GEM3-trained postdoc Travis Seaborn, now an Assistant Professor, who is an example of the training, career, and professional development strengths of EPSCoR. The myriad outcomes emerging from early-career faculty Kathryn Turner's plant ecological genomics research lab and program range from a VIP to valuable collaborations with other EPSCoR researchers in the state – all contributing to a larger understanding of adaptation to rapidly changing environments around the world. New ISU Indigenous STEM Scholar, Laticia Herkshan, is helping to meet critical needs by bridging across Shoshone-Bannock Tribes, ISU, and GEM3 on research and STEM initiatives. Finally, the GEM3 graduate students organized a hugely successful retreat at the McCall Outdoor Science School (MOSS) for community building, professional development, and integration, as an opportunity recommended by both the National Science Foundation virtual Site Visit panel and the GEM3 Project Advisory Board.

Many more details are provided for each of these stories in this newsletter. In addition, more than 100 GEM3 participants are hearing and sharing details and examples of these and other outcomes and their impacts at the first in-person Idaho EPSCoR Annual Meeting since 2019 in Boise, Idaho, this October 25-27.

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GEM3 Research

Caughlin Lab Applies Drone Technology to Map Sagebrush Recovery After Wildfire

By Trevor Caughlin

In Idaho and across the Western U.S., human activity has increased the occurrence of wildfires in the region, posing a severe threat to sagebrush, which cannot resprout after fire. Declining sagebrush cover has prompted large-scale restoration efforts by the Bureau of Land Management and other agencies. Despite these efforts, sagebrush restoration outcomes are often uncertain. Supported by the GEM3 EPSCoR award, Trevor Caughlin and his lab are using drone technology to map and model sagebrush demography in post-fire landscapes.

The Caughlin lab's most recent efforts to understand sagebrush restoration involve developing new remote sensing technologies to map and model individual plants over large spatial extents. Field plots are often limited to small spatial extents, typically <1 m2, challenging our ability to quantify continuous spatial variation in plant demography over larger areas. To address this limitation, we are using drones to quantify the spatial distribution and demographic rates of sagebrush plants. We have established a workflow to quantify individual size and four demographic rates from Unmanned Aerial System (UAS) imagery: recruitment, growth, survival, and flower stalk production. Applying our methods across four landscapes undergoing post-disturbance recovery, we are able to correctly detect 89% of sagebrush plants >10 cm in height. For detected plants, there is agreement between field-measured height and UAS-derived height (R2 = 0.69). Building off these results, we are able to measure survival of detected plants with 85% accuracy, height growth with 0.1 m error, and predict flower stalk production (R2=0.64). These preliminary results have led to successful funding from a National Science Foundation EAGER grant, which the lab has used to conduct flights over twelve post-fire landscapes in Southwestern Idaho. These data will be used to develop new maps and models to quantify how individual plant demography changes spatial patterns as landscapes recover from wildfire.

Along with technical results, the project has also built capacity for research and collaboration in Idaho. At Boise State University, twenty undergraduates have received independent research experience in the Caughlin lab via the Mapping Sagebrush Vertically Integrated Project (VIP). The project has also supported collaboration with professor Donna Delparte at Idaho State University, who is a technical genius when it comes to drones and has generously lent her expertise to map sagebrush after wildfire. Finally, the project has also led to collaborations and ongoing discussions with state and federal agencies who are interested in applying high-resolution maps to natural resource management.

Altogether, this research will address the critical need for actionable science that can inform ecosystem restoration after climate-induced megafires in the Western U.S. Across this region, land managers spend hundreds of millions of dollars annually to stabilize or restore sagebrush landscapes after wildfires. Post-fire monitoring data is crucial for effective decision-making on land management, prompting increased acquisition of aerial imagery. Our research is enabling new ways to acquire ecological information from remotely sensed data, including growth and survival rates of establishing plants.

Students pictured from left to right: Andrii Zaiats (Boise State PhD Candidate), Cana Foncannon, and Amy Johnson (undergraduates in the mapping sagebrush VIP). Students are collecting ground data for drone mapping at Castle Rocks State Park. Photo credit: Trevor Caughlin

Genomic Resources Can Help Determine the Impact of Climate Change on Sagebrush Populations

By Sven Buerki, Peggy Martinez, and Anthony E. Melton

A recent report led by the USGS demonstrated that the ecologically and economically important sagebrush steppe of western North America is among the most imperiled habitats worldwide with more than 350 threatened species. This habitat used to cover more than 1 million km2, but only half of its distribution remains mainly due to drought, fire and invasive species (Fig. 1). Big sagebrush (*Artemisia tridentata* Nutt.; sunflower family) is a keystone species of the sagebrush steppe and the focus of large-scale restoration efforts (Fig. 1). GEM3 researchers are currently contributing to determining the genetic underpinning of plant drought tolerance by conducting literature review and designing controlled experiments. Ultimately, our goals are to develop tools and resources, such as the sagebrush genome and lines of genetically identical sagebrush plants, to facilitate the study of how sagebrush responds to drought (incl. heat) and better predict how the species will respond to climate change.

A review published in the International Journal of Molecular Sciences (https://doi.org/10.3390/ijms232012297) analyzed scientific abstracts of nearly 8,000 publications from the past 40 years to better understand patterns of research conducted on drought adaptation in plants. Climate change is threatening native plant communities and ecosystems worldwide as extreme weather events increase in frequency. There are many studies that have investigated the genomic basis of plant responses to drought. However, the extent of this research throughout the plant kingdom is unclear, particularly among species critical for the sustainability of natural ecosystems. We aimed to better our understanding of genome-to-phenome (G2P) connections (to unravel the rules of life) in drought-stressed plants and identify focal species for future research. Bioinformatic tools were developed (and published in Genes: https://doi.org/10.3390/genes12020293) to mine and link information from databases and abstracts from 7,730 publications. We identified 1,634 drought-response genes among 497 plant species. Most (83.30%) of these species are plants that are used in agriculture or are model organisms, leaving a large gap of ecologically important or drought-adapted species such as the big sagebrush. There

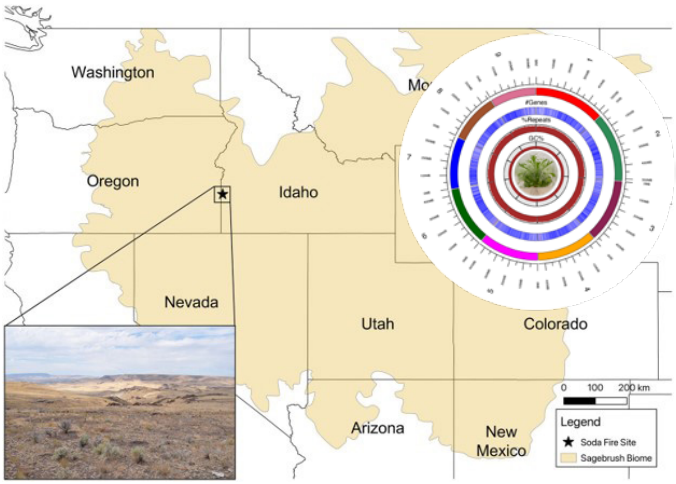

Figure 1. Map highlighting the sagebrush steppe (also known as Sagebrush biome) and the Soda Fire site (burned in 2015) in Idaho, USA, where the individual used to assemble the big sagebrush reference genome originated. The sagebrush steppe currently covers an estimated range of 653,316 km2. The map of the big sagebrush genome showing the nine pseudo-chromosomes, gene density, percentage of repeats and GC content is displayed in the top right corner. A photo of a sagebrush plant maintained in vitro at Boise State University originating from the Soda Fire region is displayed at the center of the map of the genome. Adapted from Melton et al. (2022; https://doi.org/10.1093/g3journal/jkac122).

are large gaps in G2P research literature and database connectivity, with only 21% of abstracts being linked to gene and taxonomy (the science naming organisms) data in the National Center for Biotechnology Information database (NCBI). Abstract text mining was more successful at identifying potential G2P pathways, with 34% of abstracts containing gene, taxa, and phenotype information. This research has shown a clear path forward for G2P research - expanding G2P studies to include non-model plants, particularly those adapted to drought stress, will help advance our understanding of drought responsive G2P pathways.

In parallel of this previous study, we have focused our efforts in sequencing, assembling and annotating a reference genome for big sagebrush serving as basis to study adaptations to drought and other climatic stress. This research was recently published in G3 Genes|Genomes|Genetics (https://doi.org/10.1093/

g3journal/jkac122) as part of an international collaboration led by researchers based at Boise State University (BSU) (Fig. 1). This article presents a first chromosome level genome sequence established from an individual from the Soda Fire region (Owyhee County, ID, USA) currently maintained in culture at BSU (Fig. 1). This 4.2 giga (10e9) base pair genome is composed of nine chromosomes (each composed of ca. 500 million base pairs), more than 43,000 genes and 78% repeats (patterns of DNA occurring in multiple copies throughout the genome) making this genome among the most available repetitive plant genomes (Fig. 1). Our analyses also revealed that the genome is highly complex showing signatures of past hybridization, polyploidization-to-diploidization events (a process involving whole genome duplication followed by chromosomal structural rearrangements leading to reducing the genome to its original chromosome numbers, while keeping genes providing adaptation to climatic conditions), and high levels of out-crossing.

Now that we are equipped with the reference genome and lists of drought-responsive genes, we can delve deeper into the genetic mechanisms of drought response in big sagebrush. We will also be able to use this genome to identify genes and their associated metabolic pathways that are expressed under imposed drought by conducting gene-by-environment experiments. This resource will also facilitate re-sequencing of whole genomes from different populations to compare their architectures, gene content and overall population genetics and evolutionary histories. Integrating these studies will allow determining mechanisms of local adaptation in big sagebrush populations and identify those that will likely respond better to a changing climate. Such data can then be provided to the GEM3 Modeling team to best incorporate genetics into their models and ultimately facilitate the conservation and restoration of the ecologically and economically important sagebrush steppe.

Former EPSCoR Student is New Indigenous STEM Scholar

Laticia Herkshan, a member of the Shoshone-Bannock Tribe and participant in both the Idaho EPSCoR MILES and GEM3 Research Infrastructure Improvement (RII) Track-1 projects, recently graduated with her Doctorate in Political Science from Idaho State University (ISU) in May 2022 and will be serving as ISU's new Indigenous STEM Scholar.

Laticia Herkshan, new ISU Indigenous STEM Scholar

Herkshan was first introduced to Idaho EPSCoR as an undergraduate student through her participation in the MILES Undergraduate Research and Internships (MURI) Program. In the current GEM3 project, Herkshan has been working on exploring the research relationship between the Shoshone-Bannock Tribes and Idaho State University.

Her work includes collaboration with the ISU Department of Sociology with GEM3 mentors, Morey Burnham, assistant professor, and Georgia Hart-Fredeluces, post-doctoral fellow. Herkshan also works closely with Liz Redd-Kickham from the Department of Anthropology. The team, currently in the data analysis phase, reports that most view significant room for improvement in mutual understanding and collaborative efforts between the Tribes and Idaho State University. Through their efforts, preliminary findings helped inform the recent ISU workshop series, '(Re)Cultivating & (Re)Newing Reciprocal Research' held virtually earlier this year.

Herkshan's research provides a strong foundation for her new role at ISU. In July, 2022, Herkshan was selected to serve as an "Indigenous STEM Education and Research Scholar." Her role consists of cataloging and organizing past and current STEM education initiatives within the Tribal community that will provide a clearer big picture view of which programs students are exposed to, and what their goals are. Herkshan hopes to use that to inform future STEM education initiatives.

Scholar cont.

Secondly, Herkshan will get the opportunity to work within the Shoshone-Bannock community to find out what the STEM education needs and priorities are by talking with elders, youth, educators, STEM professionals, and others. According to Herkshan, "I am really excited to be able to collaborate and advocate with community members to work toward identifying and creating STEM curricula that are inclusive of our culture, traditions, values, and needs."

Also, as a part of Herkshan's position, she will also continue to work with ongoing and new projects that examine and aim to improve the research relationship between the Tribes and ISU. Herkshan states, "This position is really unique in that I get to work in sort of a liaison role with both GEM3 mentors and Shoshone-Bannock affiliated mentors. I will also be collaborating with Shoshone-Bannock community members from various departments and backgrounds. I am thankful that this position was created and is being carried out in a truly collaborative nature, with support from both the Tribes and ISU."

Other collaborators include working closely with Colden Baxter (Idaho State University, Biology professor), Sammy Matsaw (Shoshone-Bannock Tribes, Fish & Wildlife Department Researcher) and Jessica James (Shoshone-Bannock Tribes, Education Program Manager).

While this project has just begun, the first significant outcome, as noted by Herkshan, is that the 'Indigenous STEM education and research scholar' position was collaboratively created. "I don't know of any other positions like this that have been created between the Shoshone-Bannock and Idaho State," states Herkshan. "By serving Indigenous and Tribal youth through STEM programming that is respondent to their community's needs, values, and culture," states Herkshan, "we can, increase Indigenous and Tribal interest and representation in STEM education, degrees, and careers."

Herkshan's new position is the second Tribal Scholar position supported through Idaho EPSCoR; the first position began at University of Idaho in 2021 and was filled by Shanny Spang Gion.

Both positions aim to increase representation from Native American students in STEM fields and recognize that including a diversity of experiences and knowledge systems can lead to greater innovation and creativity in problem solving and achieving goals related to science, technology, engineering, and mathematics.

> *"I would like to thank Idaho EPSCoR for the opportunities that I've been afforded since I was an undergraduate, through my doctoral degree, and now as a professional. I've gained so much knowledge, skill, and confidence through the research and work I've done with EPSCoR and I am sincerely grateful. Tsaan' Aishe (thank you)!"*
>
> *—Laticia Herkshan*

GEM3 Research

Understanding the Ecological and Evolutionary Impacts of Human Disturbance on Plant Systems

Big sagebrush (*Artemisia tridentata*) is a foundational species of the North American West. Threatened and endangered species rely on it. And yet the range of this iconic species is shrinking due to pressure on several fronts, including invasive species, encroaching native species, altered fire regimen, and changing environments.

The Turner Lab is working to understand the evolutionary impact that invasive species and land use change has had on big sagebrush, and how big sagebrush may be able to adapt to, and succeed, in the face of these pressures.

Kathryn Turner, head of the Turner Lab and assistant professor in the Biological Sciences

Kathryn Turner, assistant professor in the Biological Sciences Department at ISU

Department at ISU, started her position as a new Track-1 hire at the start of the Idaho EPSCoR GEM3 project in Fall 2019.

Turner's lab focuses on plant ecological genomics and invasion biology. The team is investigating how genetic diversity in populations of big sagebrush has been affected by fragmentation, range contraction, invasive species, and restoration efforts. They also investigate evolution in invasive plant species such as diffuse knapweed and blue mustard. By using common garden experiments in the greenhouse and field, the team looks for evidence of phenotypic evolution, and genomic analyses to identify underlying genetic variation.

The team's most recent work includes taking advantage of genomic data that they pull from natural history collections such as herbaria (also known as legacy data) to investigate how genetic variation has changed in big sagebrush and invasive plants over the past ~150 years.

In addition to Turner's research, she leads a Vertically Integrated Project (VIP) course which is part of the educational component of the GEM3 program. Within this VIP, undergraduates, graduates, and postdocs work together as a research team to investigate variation in the early life history traits of big sagebrush. The VIP team is working on a literature review of germination requirements and seedling growth rates, using growth chambers to perform their own germination experiments, and maintaining and collecting data from a common garden field experiment established at Sterling Wildlife Management Area in 2020.

Turner's work is highly collaborative. The team works with researchers at Idaho State University (ISU), Boise State University (BSU), and College of Idaho (CoI) to investigate phenotypic and genetic variation in big sagebrush in multiple projects. For example, the team has been working with Leonora Bittleston (BSU) and Carolyn Dadabay (CoI) to investigate changes in big sagebrush microbiomes over different timescales and are using herbarium specimens to identify sagebrush leaf microbial communities from up to 100 years ago. They also have very helpful ongoing collaborations with agency and non-profit partners, including Idaho Fish and Game, the USGS, and the Sagebrush Steppe Landtrust.

Some significant outcomes include producing data that will help us better understand genetic diversity within big sagebrush. The team is also working to identify sagebrush traits (and populations) that may be better at competing with invasive cheatgrass as seedlings, an important life history stage for healthy populations and restoration efforts. They are also working to understand the relationship between genome size and nutrient requirements, helping us to better understand the distribution of sagebrush on the landscape and improve restoration success.

In understanding these processes in sagebrush, the team is contributing to our larger understanding of adaptation to rapidly changing environments around the world, in many species.

To learn more about Kathryn Turner's lab and research visit www.Kathryngturner.com.

GEM3 Education

Reflections on the GEM3 Graduate Student Retreat

By Haley Netherton-Morrison and Molly Garrett

In an ongoing effort to build a stronger graduate student community within GEM3, fourteen students from Boise State University, Idaho State University, and University of Idaho gathered at the McCall Outdoor Science School (MOSS) in McCall, Idaho for a weekend of community building, professional development, and integration across the GEM3 teams.

We kicked off the weekend with each student presenting a lightning talk to get everyone introduced to each other and their research. We carried this community building theme into the next morning with an abstract ice-breaker, where each of us had to match details from students' talks the day before to published literature. We had fun matching abstracts to graduate research, and it had the added bonus of identifying common themes between us. This activity was followed by CV and website feedback breakout groups, where newer graduate students could ask questions and

Retreat cont.

everyone received comments on their materials. The attendees ranged from first semester Master's students to fourth year PhD students, which led to some great discussions around tips and tricks for CVs, graduate school, and developing a research project (and the twists and turns that entails).

We spent the remainder of the second day focused on defining where each of us fits within the GEM3 project and finding commonalities throughout our projects that could be used as springboards for integration. After reviewing the project overview materials from previous site visits, we were joined via Zoom by Kitty Griswold (Idaho State University) and Sanford Eigenbrode (University of Idaho) to further discuss integration – what does it mean to integrate, and how can we move integration efforts forward as graduate students? Following the panel, we broke into groups to diagram how we might fit our projects together, before working out a very preliminary diagram across the GEM3 teams. We hope to build on this diagram during the student session at the upcoming Idaho EPSCoR Annual Meeting, so that students who were unable to make it can add their projects and linkages.

We closed the retreat with discussions about next steps and a Zoom career panel featuring Kim Andrews (University of Idaho), Brooke McWherter (Dalhousie University), and Amanda Stahlke (USDA-ARS and RiversEdge West). The retreat not only provided a fantastic opportunity to connect with other students, but it also led to a number of exciting ideas for next steps at both the Annual Meeting and beyond. Some of these ideas include building our integration and collaboration skills through a Toolbox Dialogue Initiative workshop, setting up a monthly reading group and seminar series, and continuing to work toward some larger products.

Retreat participants on the McCall Outdoor Science School campus, situated on Payette Lake in McCall. (Photo Credit: Molly Garrett)

Haley Netherton-Morrison and Allegra Sundstrom present the SES sketch. BSU master's students Adedotun Arogundade and Carlos Dumaguit present the sagebrush team's sketch. ISU master's students Adam Zambie and Kyle Rufo present the trout team's sketch. (Photo Credits: Molly Garrett)

We'd like to thank all of the people who helped make this retreat possible as well as our attendees for a productive and fun-filled three days!

"Having an opportunity to make social and professional connections after COVID was fantastic. It is very much rewarding to discuss my own research with other interested researchers as opposed to my friends outside of my field and my dogs." *—Carlos Dumaguit*

"Spending the weekend at MOSS for the GEM3 Graduate Student Retreat was fantastic! For most of us, it was the first time that we had come together in person. It was wonderful to connect, learn about each other's research, discuss opportunities for collaboration, and explore our broader role within GEM3."

—Meg Dolman

"The GEM3 grad retreat was an awesome and valuable experience. We were able to build community with our peers across the state, discuss the intersection of our projects, and develop professional skills. I am glad I got to go and look forward to the collaborations that will come from it."

—Jacob Heil

GEM3 Education

Meet Undergraduate ISU Researcher, Aaliyah Tovar

Aaliyah Tovar, an undergraduate student majoring in biology (biomedical sciences) at Idaho State University (ISU), wasn't interested in research early on in her academic career. According to Tovar, a college education was only for people who wanted to become a doctor, lawyer, or teacher. She notes that within her community of Rupert, Idaho, no career avenues, other than agricultural or automotive, were really discussed within her family.

"My parents never really got too much of a say in their futures," states Tovar, "Both my parents went right to work after high school to support themselves and a baby. From then on, their aspirations for me were to graduate high school, attend college, and to find a stable job."

As a high school student, Tovar found that she enjoyed biology classes and eventually decided to go to ISU as a pre-med student majoring in biology.

Tovar states that she had never really given much thought about the concept of research; however, as she began to take more classes, the topic of research came up various times and the idea of becoming engaged with a research project began to take hold. According to Tovar, "STEM outreach was particularly weak at my high school, and the concept of academia and research seemed surreal. Research was mysterious and the concepts involved seemed abstract, which only furthered my curiosity."

Tovar began looking at various research opportunities at ISU and was introduced to the world of research by her major advisor, Heather Ray, ISU associate professor in developmental biology. Tovar was offered an opportunity to work in Ray's lab which focused on developmental biology and the impact gene mutations have on early development.

Having some knowledge of development through her high school healthcare courses, the opportunity spurred Tovar's interest, not only in Ray's lab but in the world of research. Tovar states, "While I had a weak understanding of the different concepts involved, I became encouraged to broaden my knowledge."

A semester later, Tovar was offered a GEM3 Summer Authentic Research Experience (SARE) position in Ray's lab and jumped at the chance to connect with other researchers and delve deeper into research throughout the summer. The focus of the SARE project was to examine how the loss of function in Masp 1, a protein coding gene, impacts gene expression and how these changes are involved in craniofacial defects and developmental disorders.

Aaliyah Tovar, ISU GEM3 SARE student

"Research has allowed me to build up confidence in myself and my capabilities," notes Tovar. Working under the guidance of her faculty mentor, Tovar was eventually named the lead of the research team on the Masp 1 research project and is now serving in a mentor position as well. "As a mentor," explains Tovar, "my role is to help explain to mentees the background of the project, how to conduct the experiments, and to explain the purpose of the different processes involved."

Through SARE, Tovar was able to meet and work with students from various colleges. Tovar was also able to participate in the Idaho Conference for Undergraduate Research (ICUR) in Boise, ID over the summer to present her research. She was also invited to present her research at the Society for Advancement of Chicanos and Native Americans in Science (SACNAS) conference in October, with ICUR providing travel support.

Currently, Tovar is still participating in research and hopes to continue doing research in the future as a way of preparing for her future career. "Through research I have been able to find mentors amongst professors and peers who help me better myself academically and as a person," notes Tovar.

Tovar is set to graduate in Spring 2024, and plans to continue on her path of becoming a doctor in a Hispanic community.

GEM3 Dissemination

Adaptation and Plasticity in Fishes in a Warming Environment

By Chris Caudill

Idaho EPSCoR GEM3 faculty, including Chris Caudill, Shawn Narum, and Kitty Griswold, helped organize the 152nd Annual American Fisheries Symposium that took place in August 2022 in Spokane, WA. The event included 19 talks over two days including speakers from U.S. and Canada.

Temperature is a key driver controlling the physiology, behavior, ecology and distribution of fishes. Fishes display genetic adaptations and phenotypically plastic responses such as acclimation, developmental plasticity, and movement to changes in temperatures. As many habitats warm up, an increased understanding of adaptive and plastic mechanisms is needed to predict fitness, population, and species distribution responses.

The symposium addressed recent advances in our understanding of: 1) the responses of fish to thermal stress and underlying genetic, physiological, and behavioral mechanisms; 2) how these mechanisms interact with each other and environmental diversity to affect demographics in natural populations; and 3) the relative magnitude and scope for genetic and plastic mechanisms to allow persistence of populations as thermal exposure increases under climate warming.

Symposium participants contributed work from a wide range of taxa to examine how genetic traits, acclimation and plasticity may buffer fishes from climate warming. Genomic studies revealed adaptive thermal signature across (or within populations and trans-generational epigenetic response to thermal stress).

Several studies found acclimation conditions affect tolerance, sometimes in complex ways among genetic populations. Notably, thermal and oxygen stress frequently co-occur, with interacting effects on behavior or performance.

Other innovative approaches included genetic tagging to monitor cold water refuge, monitoring stress hormones across thermal regimes, and use of otolith chemistry to monitor movement across a fire landscape.

New modeling approaches included use of occupancy models to partition thermal effects from other factors on fish distribution, while agent-based models simulated effects of warming and bioactive estrogen or role of thermal genetic adaptation and phenotypic plasticity.

Collectively, the studies demonstrate both adaptation and acclimation acting at a range of scales and highlight the opportunity to elucidate the relative importance and interactions among genomic traits, plasticity and environmental conditions. Such integrative understanding will be critical to predicting effects of warming on fish populations.

A description of the symposium and a 200-word summary will appear in Fisheries in the next couple of months. Visit https://afsannualmeeting2022.fisheries.org/ for additional details about the scientists who presented their work and their findings.

GEM3 Workforce Development

Travis Seaborn Transitions to Early-Career Faculty Position

Travis Seaborn, former University of Idaho post-doc and member of the GEM3 team, has transitioned into a new role at North Dakota State University (NDSU). Seaborn is now an assistant professor of applied ecology at NDSU and was part of a climate change hiring initiative which also included a hire focused on agriculture. His new role is a natural extension of his efforts while in the GEM3 project, which was focused on understanding the adaptive capacity of redband trout.

Seaborn will continue to work on questions of adaptive capacity, and he looks to understand how movement, genetic variation, and environmentally-induced changes in traits of individuals influence the ability for a species to persist when facing a changing environment.

Seaborn, who considers himself an interdisciplinary conservation biologist, uses an array of computational tools in conjunction with

field work. Within GEM3, many tools were used to understand how redband trout may respond to climate change, including use of genetics, distribution modeling, individual-based simulations, and other methods. In addition, Seaborn has been involved in modeling and genetics work on Yellowstone cutthroat trout.

Travis Seaborn, former U of I post-doc, holding a westslope cutthroat trout

Seaborn's work within GEM3 has allowed him to collaborate with many entities. According to Seaborn, "I've been lucky to publish with folks from all Idaho Universities, the Columbia River Inter-Tribal Fish Commission, and the U.S. Forest Service. I'm very thankful for the connections I've made, which have allowed me to do things like mentor and teach students from across the state."

Outcomes from Seaborn's work while in the GEM3 project include development of new software to simulate questions about climate change and genetics, a better understanding of the process to integrate genomics into modeling (specifically regarding translocations), and a greater understanding of the connection between genetics and the environment for redband trout. These pieces will help improve our understanding of fish evolution and ecology as populations face changing environments, which will in turn, help to inform management.

"I couldn't say enough about how great being a part of an EPSCoR project was with regards to building my professional network and being a part of a big team science project," states Seaborn, "I feel like the big team aspect allowed me to investigate research questions I couldn't begin to try to answer on my own."

To learn more about Travis Seaborn's research visit: www.travisseaborn.com

University of Idaho 3-D Printing Technology Team is Developing a Future Workforce

Michael Maughan with high school students performing tensile test experiments

In the fall of 2021, the University of Idaho was awarded nearly $4 million from the National Science Foundation's (NSF) EPSCoR Research Infrastructure Improvement (RII) Track-2 Program to support developing 3-D printing technology to turn Idaho wood waste into sustainable building construction materials.

This RII Track-2 Focused EPSCoR Collaboration award will allow University of Idaho and Auburn University research teams to create a foundational framework to utilize renewable and waste feedstocks to make and utilize 100% bio-based materials for the Advanced Housing Manufacturing Industry of the Future.

The project is led by College of Engineering assistant professor Michael Maughan and involves an interdisciplinary research team from both collaborating institutions.

In Spring of 2022, the members of the project team visited Pullman High School's AP Chemistry class in Pullman, Washington, as part of their workforce development initiative, giving a hands-on lesson on the molecular deformation of polymers. A "polymer" is a chemical compound with molecules bonded together

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3-D Printing cont.

in long, repeating chains. Because of their structure, polymers have unique properties that can be tailored for different uses. The term "deformation" refers to modifications of the shape or size of an object due to applied forces or a change in temperature.

Approximately 38 students participated in inquiry-learning based activities focused on polymer molecule deformation and also conducted tensile testing (a test that measures the force required to break a sample specimen). An informational presentation on state-of-the-art activities at the University of Idaho was also given in addition to a more thorough discussion about polymer microstructure.

The scientific knowledge gained from this project will allow for better use of timber waste materials in Idaho, thereby increasing housing affordability and sustainability, ultimately contributing to the mitigation of climate change.

To learn more about this project visit the Printimber website: http://www.printimber.org.

More about SARE *(on the cover)*

The Summer Authentic Research Experiences (SARE) is designed to engage Idaho undergraduates in the science, technology, engineering, and mathematics (STEM) fields related to GEM3 research and increase the number, diversity and preparation of skilled scientists and engineers in GEM3 fields.

This summer there were approximately 31 students placed in research experiences across Idaho including at least 10 inter-institutional locations where students were able to work away from their home institution with faculty from one of Idaho's partnering institutions. There were also 17 students placed from Idaho's primarily undergraduate institutions. All students also took part in the Idaho Conference for Undergraduate Research poster session showcasing their SARE research.

SARE student profiles will soon be added to the Idaho EPSCoR website's Student Regional Map (located under "Research") where you can learn more about undergraduate research taking place in Idaho!