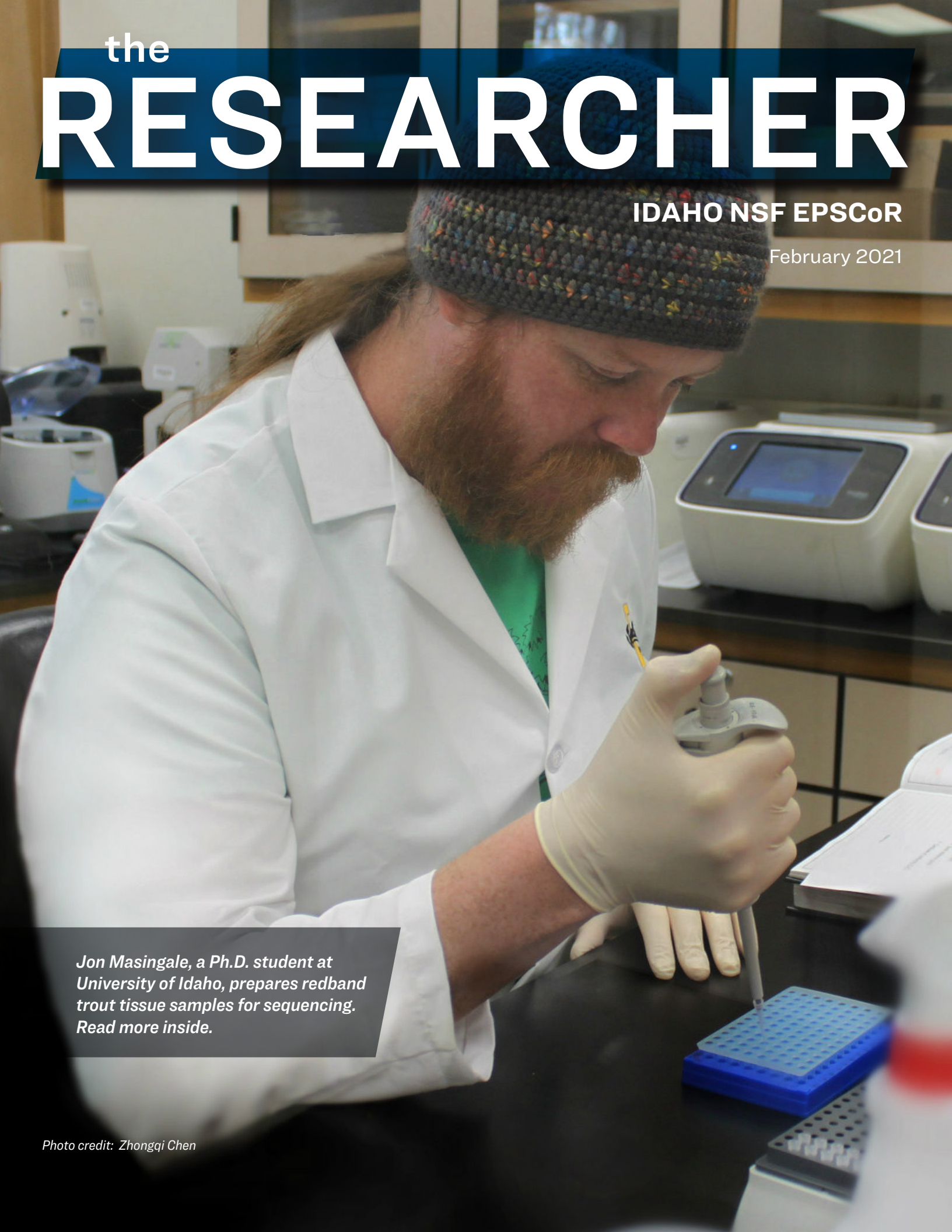
the RESEARCHER

IDAHO NSF EPSCoR

February 2021



Jon Masingale, a Ph.D. student at University of Idaho, prepares redband trout tissue samples for sequencing. Read more inside.

Photo credit: Zhongqi Chen

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of the Idaho EPSCoR Office

the
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IDAHO EPSCoR

University of Idaho

BOISE STATE UNIVERSITY

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LETTER FROM THE DIRECTOR

Dr. Andy Kliskey

We start into 2021 having had a very productive and collaborative 2020 Idaho EPSCoR Annual Meeting in December. I was impressed with how our GEM3 program, from students through faculty and staff, pivoted to the online format we adopted. I was also excited by the opportunities that this online approach provided in the form of working group sessions with multiple breakout discussions. In particular, I want to highlight and offer kudos to each of our graduate students and postdocs who delivered online posters on the progress of their research and to those who gave lightning talk presentations. And additional kudos to Denise Pfeifer and the team who pulled the poster program together, ensuring a very constructive set of sessions. To everyone on the GEM3 leadership team who organized, presented, and facilitated sessions – thank you!

There were numerous action items that we can take from the plenary and working group sessions, and I have encouraged all participants to think about how they might take lessons learned or information gained from the annual meeting into their education, research, and outreach efforts this year. We now have a documented set of integration frameworks and diagrams that working groups are using and developing to both guide the convergence of our science and foster additional crosstalk among teams. These frameworks will continue to be refined throughout the coming year.

I especially want to thank those who shared ideas and experiences about broadening participation of all people in Science, Technology, Engineering, and Mathematics (STEM). This meeting highlighted some important aspects of our working environments that are essential for success. I echo the sentiment of the NSF Director, Dr. Panchanathan, who reminds us that, "The need for a robust and diverse STEM workforce has been reiterated for decades, and it is one of the current administration's top priorities in order to maintain America's historical preeminence in the STEM fields." I look forward to developing constructive ways to address this need and to create a positive and productive science arena for everyone.

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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.

GEM3 Research

ON THE COVER

Jon Masingale is a Ph.D. student working with the GEM3 trout mechanisms team at the University of Idaho on a common garden experiment to discover genotype x environment interactions that contribute to thermal adaptation in redband trout.

To study these differences, the mechanisms team collected newly hatched redband trout from three distinct ecotypes (desert, cool montane forest, and cold montane forest). Individual fish from all ecotypes were reared in a common garden experiment using three temperature regimes that ranged from optimum to stressful (15, 18, and 21°C). The team then conducted a series of behavioral and physiological experiments to determine interpopulation differences in thermal tolerance and habitat selection cues.

To understand genetic mechanisms behind these traits, they are performing high-throughput whole-genome sequencing to generate high-density single nucleotide polymorphism (SNP) markers using DNA extracted from fin tissue samples. Population genomics and quantitative genetics approaches are being used to identify adaptive loci. In addition, RNA sequencing methods will be used to identify the influence of environment on gene expression in various organ tissues.

Working with the GEM3 modeling team, phenotypes and their associated adaptive loci will be integrated into agent-based models that simulate and predict the adaptive capacity of natural populations in response to climate change scenarios spanning the next century.

Idaho Hosts First All-Online EPSCoR Annual Meeting

Idaho NSF EPSCoR recently held the program's annual meeting entirely online December 8-10, 2020 to discuss progress on the current Idaho EPSCoR RII Track-1 project, Linking Genome to Phenome to Predict Adaptive Responses of Organisms to Changing Landscapes (GEM3). The meeting theme, "Collaboration, Integration, and Convergence," highlighted progress of GEM3 objectives and provided opportunities to share research highlights and integrate across disciplines to understand the impacts of environmental and social change on Idaho's landscapes, wildlife, and people.

Dr. Mark C. Urban delivers keynote address during Idaho EPSCoR Annual Meeting.

The event keynote, "Forecasting a Better Future for Earth" was provided by Dr. Mark C. Urban, a biologist and associate professor in Ecology and Evolutionary Biology at the University of Connecticut. Dr. Urban's work focuses on the ecological and evolutionary mechanisms that shape natural communities across multiple spatial scales. The keynote address explored factors affecting biodiversity, the interaction of those factors with a changing climate, and the need for improved predictors to forecast a better future for biodiversity. Learn more about Dr. Urban's research here: **http://hydrodictyon.eeb.uconn.edu/people/urban/**

The GEM3 project, which is currently in the third year of a five-year award, brought together over 130 participants via Zoom, including stakeholders and researchers from the University of Idaho, Boise State University, Idaho State University, and other institutions to highlight GEM3 research accomplishments and priorities. GEM3 Project Advisory Board members, consisting of experts from key research areas from around the nation, were also in attendance to review progress and offer observations and suggestions.

Breakout sessions for working groups allowed for a convergence of ideas on topics such as modeling, trout and sagebrush integration, social ecological systems, scenarios and forecasting, collaborative proposals for future funding, broadening participation, and workforce development training. Key highlights of the meeting were the virtual GEM3 poster presentations and the live lightening talks that included over 40 students and postdoctoral fellows sharing research on a broad range of topics aligned with the GEM3 research focus.

Towards Producing a Reference Genome for Sagebrush: A Tool to Foster Genome to Phenome Research

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

Big sagebrush (*Artemisia tridentata*; hereafter referred to as sagebrush) is a keystone species of the sagebrush steppe in the western United States. As part of the GEM3 multi-disciplinary project, we seek to understand how genetic diversity and phenotypic plasticity affect sagebrush's response to environmental change, specifically drought, shaping both population response and adaptive capacity.

Growth chamber for propagating and maintaining the clonal lines of sagebrush for genomic and G×E research. The top inset shows how small cuttings of the clones are placed onto culture plates to allow for initial growth; the second and third insets show the clonal plantlets in boxes. These plantlets have grown roots and are developing biomass, which will be essential for getting enough leaf tissue for genome assembly. Photo credit: Peggy Martinez.

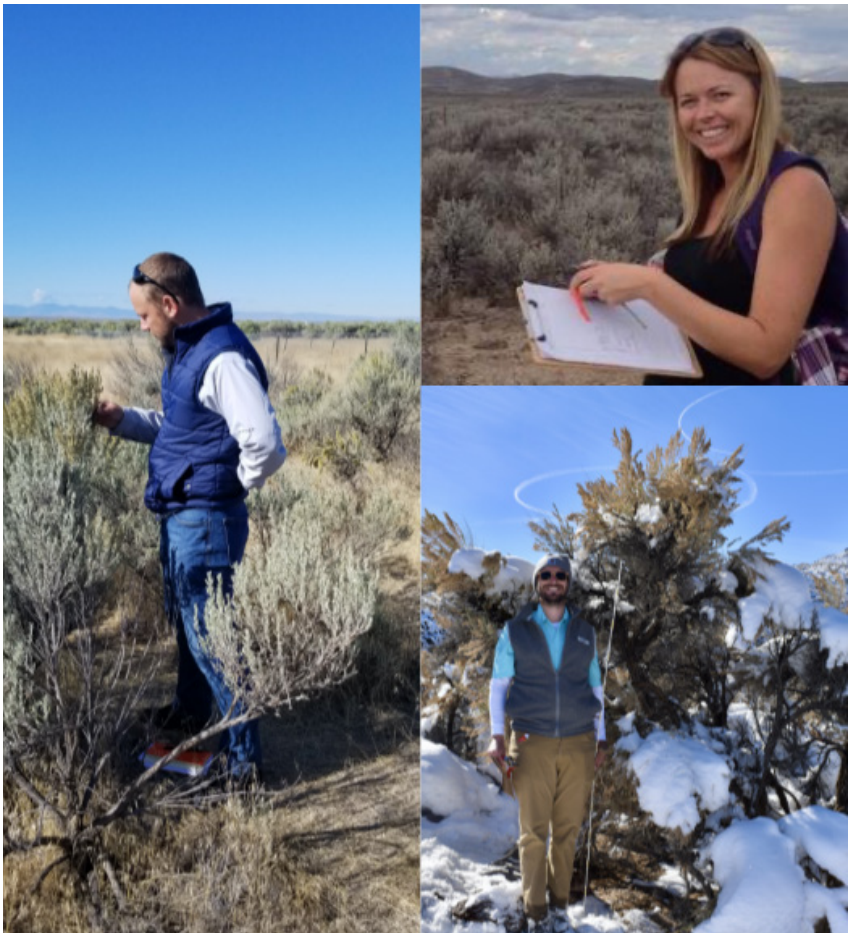
Understanding mechanisms underpinning drought adaptation require a genome to phenome approach. This approach requires a reference genome representing genotypes adapted to particular environmental conditions. Sequencing and assembling a genome can be a difficult task, especially for relatively large genomes, like that of sagebrush (~9.5 giga-bases), which is three times larger than the human genome. If the sagebrush genome was stretched out, it would measure 10.5 feet in length. To get enough plant material to extract sufficient amounts of DNA for sequencing, we collaborated with Marcelo Serpe (BSU) and Rachel Barron (Simplot) to develop methods allowing propagating an individual plant many times, making hundreds of genetically identical plantlets. This method will be an invaluable resource, not only to produce the biomass for genome sequencing, but also to conduct genotype-by-environment (G×E) experiments. Having the ability to include plants of known genomes in our experiments will allow inferring the genetic contribution in responding to climate change across the sagebrush steppes. Such data can then be provided to the GEM3 Modeling team to best incorporate genetics into their models. Such research may ultimately facilitate the reintroduction of sagebrush in degraded habitats. Such work will be conducted in synergy with stakeholder, especially the U.S. Forest Service, represented by Bryce Richardson.

We are currently working towards the goal of having several hundred plantlets to be able to sequence the large sagebrush genome, as well as maintain lines of genetically identical plantlets for future research. The sequencing and assembly of the sagebrush genome will be conducted in collaboration with Dovetail Genomics and HudsonAlpha. If all goes as planned, the sagebrush genome will be fully assembled by the end of 2021. This will be a chromosome level assembly that will allow researchers to take a deep dive into the

genomic mechanisms of drought adaptation, and fully characterize genes that give greater drought tolerance.

Sagebrush's large genome is due in part to hybridizing with other species and experiencing whole genome duplication, which lead to the genome having extra copies of all the chromosomes. The team has used a draft assembly of the sagebrush genome to learn how extra copies of genes (resulting from whole genome duplication) could evolve to function in new genetic pathways that can increase drought adaptation. Other genes identified using novel literature mining methods developed by Michael Wojahn (Ph.D. student), Stephanie J. Galla (Postdoctoral Research Associate), and Carlos Dumaguit (Masters Student) that could help sagebrush survive drought will also be studied using the genome and transcriptomes. Over 150 transcriptomes of plants from a G×E experiment conducted by Kara Navock, a previous graduate student supported by GEM3, will be sequenced to reveal genetic mechanisms of drought adaptations. These transcriptomes will give us a snapshot of cellular processes that were ongoing in plants that were in drought conditions and allow us to compare them to transcriptomes of well-watered plants. This research will provide information on how cellular and genetic processes change in plants that are stressed by drought. Transcriptomics will be conducted in collaboration with researchers at HudsonAlpha in Huntsville, AL.

Ultimately, our goals are to develop tools and resources, such as the sagebrush genome and lines of genetically identical plants, to facilitate the study of how sagebrush responds to drought and better predict how the species will respond to climate change.



GEM3 genomics team members Dr. Sven Buerki (left), Dr. Peggy Martinez (top right), and Dr. Anthony E. Melton (bottom right).

GEM3 Key Words:

- **Phenotype:** an observable trait, either directly visible or only measurable
- **Genotype:** the genetic constitution of an individual organism
- **Phenotypic plasticity:** the ability of an organism to change in response to stimuli or inputs from the environment
- **Transcriptomics:** a comprehensive analysis of whole sets of RNA transcripts for a particular cell, tissue, organ, or whole organism
- **Genomics:** the study of genes and their biological function.

GEM3 Research

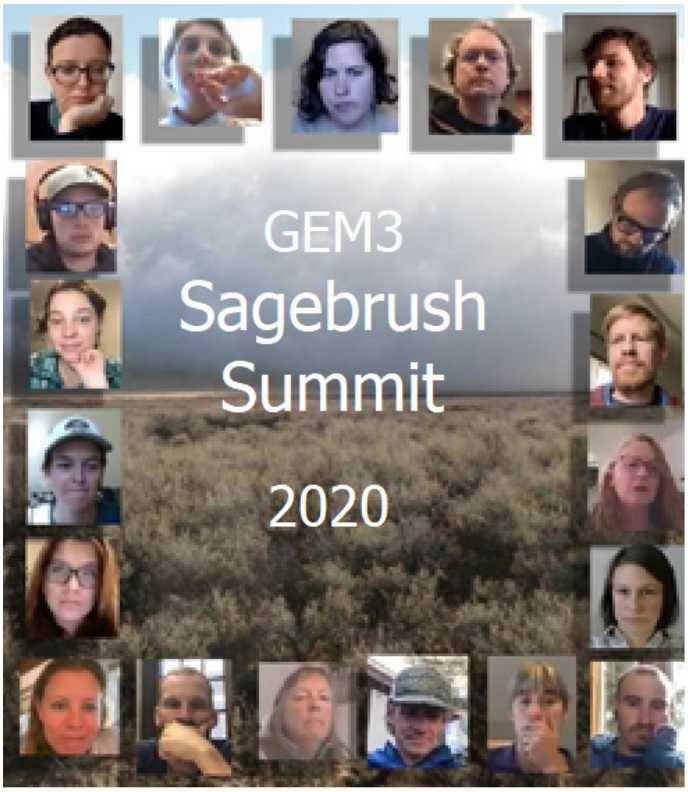
Sagebrush Summit 2020

A statewide GEM3 Sagebrush Summit was held virtually on October 15-16, 2020 to review progress of research in Idaho's NSF EPSCoR Track-1 Research Infrastructure Improvement (RII) award, now in its third year.

As articulated by the EPSCoR program, "RII Track-1 proposals are unique in their jurisdiction-wide scope and complexity; in their integration of individual researchers, institutions, and organizations; and in their role in developing the diverse, well-prepared, STEM-enabled workforce necessary to sustain research competitiveness and catalyze economic development and growth in the jurisdiction" (NSF 20-571). Therefore, regular and coordinated communication to foster team science is essential.

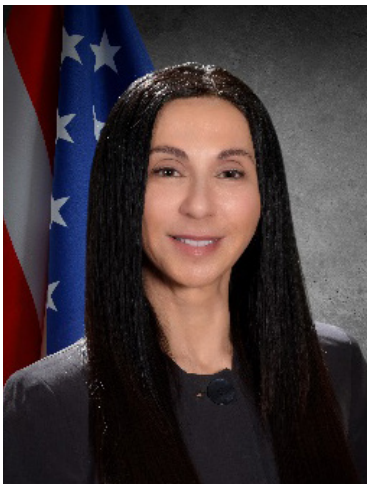
During the Summit, research teams, including the Mechanisms, Mapping, and Modeling teams, presented current efforts addressing the various goals and objectives described in the GEM3 strategic plan. Discussions covered a wide range of topics, from diversity and function in aquaporins, sagebrush hydraulics, sagebrush laboratory studies, Vertically Integrated Projects, and UAS flight updates, to modeling and mapping sagebrush population dynamics, sagebrush hybrid zones, landscape community genetics, and predicting fine-scale forage species distributions.

Over twenty participants engaged in the two-day event, which brought together key GEM3 faculty, postdoctoral fellows, and graduate students involved in GEM3 research from around the state. Participants engaged in small breakout discussions addressing key questions including: 1) What specific changes or mitigation strategies are needed due to unexpected circumstances (like the coronavirus pandemic)?, 2) How can the efforts of Modeling, Mapping, and Mechanisms teams best overlap?, and 3) How do we accomplish additional integration of the sagebrush research and the trout research? Despite the fact that many people miss the opportunity to meet in person, the summit provided an excellent time for participants to share findings, integrate efforts, and plan for next steps in the sagebrush research process.



GEM3 participants connect virtually for 2020 Sagebrush Summit

University of Idaho's Lilian Alessa Receives Jean'ne M. Shreeve NSF EPSCoR Research Excellence Award



Dr. Lilian Alessa

The recipient of the 2020 Jean'ne M. Shreeve NSF EPSCoR Research Excellence Award is Dr. Lilian Alessa, University of Idaho professor and director of the Center for Resilient Communities. Alessa, in recognition of her work in building the research community and enhancing the global competitiveness of Idaho, received the award at the Idaho Established Program to Stimulate Competitive Research (EPSCoR) Annual Meeting, held virtually, on December 10, 2020.

Dr. Alessa is a Presidents' Professor at the University of Idaho's Moscow campus and is internationally recognized for her research and engagement in the areas of resilience and human adaptation to environmental change with an emphasis on security and defense. Her significant scientific contributions are evidenced by her biography, extensive publications, and diverse research projects. She uses her expertise in social-ecological and technological systems science to develop ways to improve domestic resource security for community well-being, particularly through the incorporation of place-based knowledge to refine technological innovation. Her diverse portfolio, vast networks and quiet professionalism have enabled her to make a difference by bringing Idaho know-how to bear on issues such as freshwater, social dynamics and advanced analytics to the rest of the Nation. As a result, several of her methods and tools have been incorporated into national plans and policies.

Alessa was an appointed member of the National Science Foundation's (NSF) Advisory Committee for Environmental Research and Education, reporting to the Director of NSF and is on the Science, Technology and Education Advisory Committee for the National Ecological Observing Network (NEON). She has served as a senior expert advisor to the Departments of Defense, Homeland Security and sits on a National Academy of Sciences, Engineering, and Medicine (NASEM) Committee examining the future Research and Development portfolios of the Intelligence Community. She has authored over a 150 publications, national reports and strategies and has led the development of two federal climate resilience toolbox assessments, the Arctic Water Resources Vulnerability Index (AWRVI) and the Arctic Adaptation Exchange Portal (AAEP). She continues to serve the University of Idaho through Intergovernmental Personnel Act assignments to the Department of Defense, bridging interests across Academia, Government and the Private Sector. As an Arctic Expert she has emerged as one of the Nation's most sought after advisors on issues related to security, well-being and resilience under conditions of rapid climate, economic and social change. As a woman of color she walks in many worlds and leverages the strengths that diversity brings to ensuring our communities and Nation are resilient, equitable and adaptive.

Inspired by University of Idaho Distinguished Professor Jean'ne M. Shreeve for her imaginative leadership of EPSCoR in Idaho for more than 20 years, Idaho EPSCoR established this award. It recognizes the accomplishments of faculty members at Boise State University, Idaho State University, the University of Idaho or other state institutions of higher education who have previously been active participants in the NSF EPSCoR program.

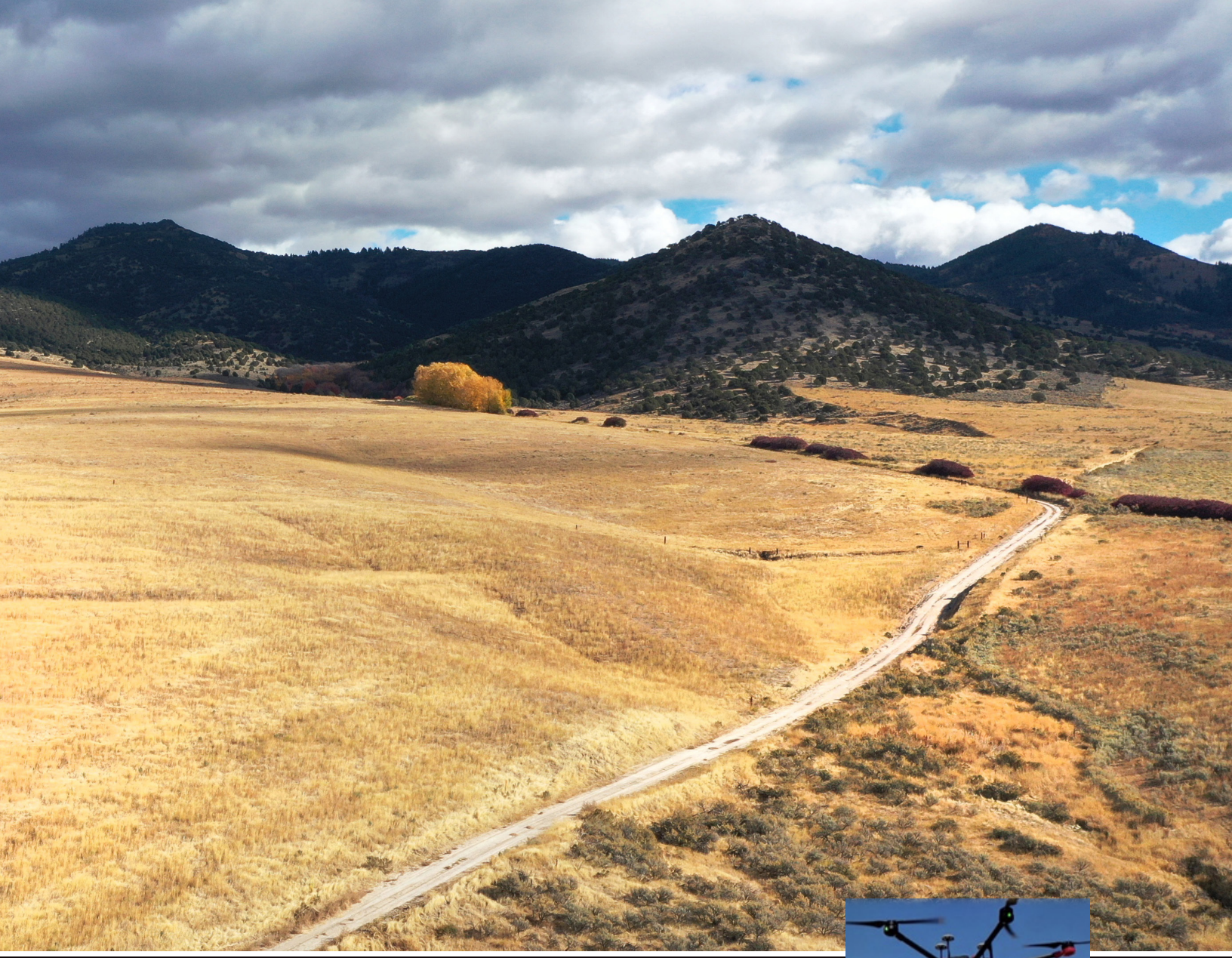
Freedom of Flight

By Caughlin Lab Drone

During the long winter, I wait patiently, arms folded beneath. I revisit memories of the glorious summer when I flew high above the sagebrush steppe. There is no freedom like the freedom of flight. Untethered to the earth's surface, the open sky a reminder of a limitless universe. Yet, my missions are highly prescribed and require meticulous attention to detail, as I carefully record details of land cover. Carefully turning and keeping track of my path, I capture reflected light from the plants below. I think of my flights like haikus: each one an opportunity to uncover beauty and insight within the confines of my mission. Now, dormant in the lab, I remember my triumphs from the past year. I soared over steep hillsides, cut through the hot summer air, and visited land in recovery, land in degradation, and land poised to go either way. My purpose will resume in the spring, when I will unfurl my propellers and launch into the sky, pulled upwards but looking below.

Landscape photo (on page 8-9) shows a UAS image of a sagebrush patch in Idaho, including a sharp transition from a burnt to an unburnt patch.

L-R: VIP undergraduate student, Cody Hall; GEM3 remote sensing analyst Anna Roser; and GEM3 Ph.D. student Andrii Zaiats.



GEM3 Seed Funding Feature

Award: Mapping and modeling to forecast ecosystem recovery after megafires in sagebrush steppe

Project Lead: Trevor Caughlin (BSU)

Co-Leads: Donna Delparte (ISU), Jodi Brandt (BSU)

Project Description: In response to the increasing prevalence of megafires and their impact on sagebrush steppe, a GEM3 team is developing demographic process models, or quantitative forecasts of sagebrush recovery, to assist in restoration efforts. With the use of remotely-sensed imagery from Unmanned Aerial Vehicles, the team will match time series of sagebrush population recovery with land management units, providing a direct link between human decision-making and sagebrush population dynamics.

Current Status/Outcomes: The GEM3 Seed Funding Award has resulted in training opportunities for graduate students and undergraduates at ISU and BSU in drone technology, five manuscripts in preparation, and three external grant submissions. The mapping data provided by the seed grant will assist GEM3 in understanding landscape processes in sagebrush ecosystems, including structure, demography, and thermal tolerance.

GEM3 Data Management

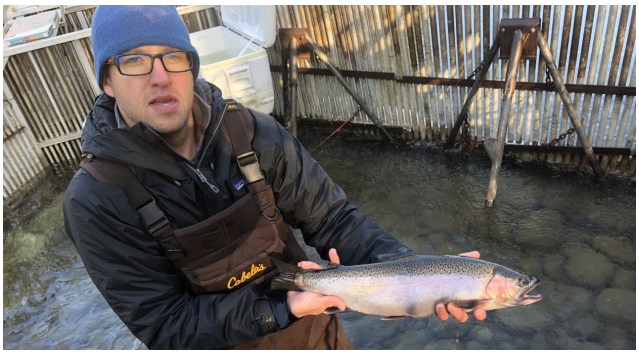
Meet Andrew Child – Statewide Environmental Data Manager

Dr. Andrew Child is an Idahoan, born and raised in the Coeur d'Alene/Post Falls area of the state. He was recently hired as the statewide Environmental Data Manager within the GEM3 project. His position is housed within the Northwest Knowledge Network (NKN) at the University of Idaho. He is excited to join the GEM3 team, and once again, expand his professional portfolio in a diversified research project that spans aquatic, terrestrial and social-ecological systems.

Andrew grew up camping, hiking, mountain biking (aka crashing), and fishing high mountain lakes throughout the Coeur d'Alene National Forest. In high school, Andrew was introduced to hunting by one of his close friends and grew to love the outdoors as he chased elk, deer and bears around the mountains of northern Idaho. Andrew started his educational journey at North Idaho College in Coeur d'Alene, and upon completion of an AA he transferred to Brigham Young University-Idaho where he completed a BS in Organismic Biology. It was problematic for him to pick one field or species on which to devote his career, but eventually his love for biological indicators and aquatic insects pushed him to pursue a graduate program that focused on aquatic environments as a complete system rather than to focus on one specific organism.

Throughout his graduate research, Andrew maintained his desire to diversify his research portfolio rather than encapsulate himself within a single research box. His research experience covers a wide variety of aquatic sciences including native salmonid conservation, limnology, watershed management, invertebrate ecology, biogeochemistry, stream ecology, and linked terrestrial ecology. He graduated with an M.S. and Ph.D. in Environmental and Natural Resource Sciences from Washington State University. He and his family fell in love with the rolling wheat fields of the Palouse. Upon graduation, Andrew completed a Post-Doctoral Fellowship (with support from EPSCoR MILES Program) at the University of Idaho-Coeur d'Alene Lake Social Ecological Systems Lab (LaSES). His work forecasted potential changes in toxic heavy metal mobilization/sequestration under future scenarios that could induce cyanobacteria blooms within Coeur d'Alene Lake. Following his post-doctoral research appointment, Andrew had the great privilege to join the Confederated Tribes of the Colville Reservation Fish and Wildlife team. As one of their Senior Biologists, Andrew oversaw their Resident Fish Research, Monitoring, and Evaluation project. His work was focused on the conservation of native interior Redband Rainbow Trout in the upper Columbia River watershed, but also aided in research and conservation projects including Burbot, wild origin kokanee, and other (less popular) native fish. His collaborative work also aided in projects that were aimed to reduce and prevent the expansion of Northern Pike and other non-native fish species.

Andrew's first task upon joining the GEM3 project was to compile an Interactive Data Map (**https://www.idahogem3.org/data-map**), which was introduced at the GEM3 seminar on January 26th, 2021. In the coming months, he will be working closely with faculty, staff, and students on: 1) compiling, defining, and connecting internal data flows among various groups within the GEM3 project, and 2) building web-based databases and repositories so that researchers can easily share new data with project modelers, collaborators, and others. Andrew looks forward to meeting all of the GEM3 researchers in a face-to-face environment and visiting research sites, once travel is prudent, so that he can find the best solutions to statewide data management needs.



Dr. Andrew Child, new GEM3 statewide Environmental Data Manager

GEM3 Website Features Spanish Translation

A Spanish translation team, Project Scientia, is leading an initiative to communicate STEM research in languages other than English. The project, which takes its name from the Latin word for "science," involves undergraduate students, graduate students, and faculty from Boise State University (BSU). It also receives support through the Idaho NSF EPSCoR GEM3 award.

The project team seeks to share GEM3 research findings with a broader Spanish-speaking audience and currently has their work featured on the GEM3 website. As noted on the site, "in the United States, 21% of the population speaks a language different than English at home and 13.5% of that population uses Spanish. In Idaho alone, 8.2% of the population are Spanish speakers."

Translating research findings is a first step to reaching the Spanish-speaking community. In addition to making science more inclusive and accessible through the creation of STEM dissemination materials tailored to Spanish-speaking audience, the team is also using podcasts and blog posts as a recruitment tool, with the ultimate goal of increasing numbers of Hispanic students entering STEM fields.

The BSU team members include Jen Forbey, professor in Department of Biological Sciences, Carolina Viera and Kelly Arispe, assistant professors in the Department of World Languages, and Fátima Cornwall, Spanish language coordinator. Student team members include doctoral students Cristina Barber Alvarez-Buylla and Carlos Linares, and undergraduate students Eduardo Canales, Karen Hernández and Yuliana Cisneros.

Eventually, with continued support, the team also hopes to translate material into additional languages, sharing research findings to an even broader audience. To see their work, including Project Scientia podcasts, visit: **www.idahogem3.org/spanish-translation-scientia**

Also see related BSU feature: **www.boisestate.edu/news/2020/12/04/project-scientia-spreads-science-celebrates-spanish/**

Project Scientia group, L-R: Yuliana Cisneros, Fátima Cornwall, Cristina Barber Alvarez-Buylla, Carolina Viera, Carlos Linares, Eduardo Canales, and Kelly Arispe. Photo credit: John Kelly

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KUDOS

Sonia Martinez, Idaho State University STEM outreach and diversity coordinator, recently received this year's Idaho State University Martin Luther King Jr. Citizen Appreciation Award. Martinez, who's office aims to increase the participation of students underrepresented in Science, Technology, Engineering, and Math (STEM) research fields, was recognized for her efforts in advising and mentoring students and her positive impact on the community.

Kaitlin Maguire has been recently appointed to interim Executive Director of the Idaho STEM Action Center, taking the place of Angela Hemingway, who recently accepted a position with T-Mobile as their National Education Advisor. Maguire, who has a background in ecology and evolutionary biology, will be working to build the Idaho STEM Ecosystem to serve Idaho students, educators, and communities.

Carolyn Hovde Bohach, Ph.D., University Distinguished Professor and Director of the NIH Idaho INBRE Program recently received the 2021 W. Fred Taylor Award. The award presentation took place February 9, 2021 at the Established Program to Stimulate Competitive Research (EPSCoR)/Institutional Development Award (IDeA) Coalition and Foundation virtual Annual Meeting. This award honors the commitment and service of W. Fred Taylor, Ph.D., whose NIH service focused on expanding opportunities for students, faculty and institutions in states and territories that have had historically low levels of NIH funding for biomedical research.